European Commission

RENEWABLE ENERGY

BEST PRACTICE PROJECTS YEARBOOK

1997-2000

ENERGIE

This Energie publication is one of a series highlighting the potential for innovative non-nuclear energy technologies to become widely applied and contribute superior services to the citizen. European Commission strategies aim at influencing the scientific and engineering communities, policy-makers and key market players to create, encourage, acquire and apply cleaner, more efficient and more sustainable energy solutions for their own benefit and that of our wider society.

Funded under the European Union's fifth framework programme for research, technological development and demonstration (RTD), Energie's range of support covers research, development, demonstration, dissemination, replication and market uptake — the full process of converting new ideas into practical solutions to real needs. Its publications, in print and electronic form, disseminate the results of actions carried out under this and previous framework programmes, including former JOULE-Thermie actions. Jointly managed by the European Commission's Directorates-General for Energy and Transport and for Research, Energie has a total budget of EUR 1 042 million over the period 1998-2002.

Delivery is organised principally around two key actions, 'Cleaner energy systems, including renewable energies' and 'Economic and efficient energy for a competitive Europe', within the theme 'Energy, environment and sustainable development', supplemented by coordination and cooperative activities of a sectoral and cross-sectoral nature. With targets guided by the Kyoto Protocol and associated policies, Energie's integrated activities are focused on new solutions which yield direct economic and environmental benefits to the energy user, and strengthen European competitive advantage by helping to achieve a position of leadership in the energy technologies of tomorrow. The resulting balanced improvements in energy, environmental and economic performance will help to ensure a sustainable future for Europe's citizens.

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Preface

It is a great pleasure to offer this yearbook of up-and-running best practice examples among Renewable Energy Projects, especially at the opening of the Sixth Framework Programme for RTD, and, in parallel, of the new programme “Intelligent Energy for Europe” (IEE) with its component ALTENER programme, also in support of Renewables market penetration. These programmes immediately follow on from the Fifth Framework Programme (Non-nuclear energy component or “Energie”) during which, and in many cases with support from which these hallmark projects have come on stream.

By disseminating Best Practice across the EU, the Commission hopes to provide real added value at European level to the Union-wide effort, now ongoing by both public and private sectors, to increase the share of Renewable sources in the EU energy mix. It is well known that these efforts are vital if the Union is to fulfil its international commitments under the Kyoto climate-change protocol, and also its own targets and policy challenges, both sectoral and general, as regards both environmental improvement and energy diversification. These are set out in the Commission’s 1997 White Paper on Renewables, with its Action Plan to 2010, and in the 2001 Green Paper on the Security of Energy Supply.

I hope that this latest Yearbook will above all help concerned actors across the Union to have access to a representative selection of excellent or in many cases state-of the-art installations, using all the commercial RE technologies. It is addressed especially to decision-makers and planners within local and regional authorities, and the professionals concerned with sustainable energy alternatives such as urban designers and developers, project developers, builders, architects and installers. Basic technical characteristics and results, replication potential, an outline of the financing structure, and of course contact details are provided in each case. The examples chosen, against the rapidly developing policy and technology background of the immediate past and present should be enlightening and, I may hope, persuasive. However size and format are such that it should also find a useful place in technical and scientific education and among concerned and committed members of the general public.

The yearbook is being distributed to a broad but carefully selected spectrum of both public and private sector bodies and made available also over the course of 2003 at major European-level conferences addressing Renewable Energy. Since it has been a joint effort, with Community co-financing, it is a pleasure to acknowledge the work of pre-selection and documentation, as well as the high quality of the result attained, thanks to the project’s co-ordinator and fellow contractors. These are the Spanish National Institute for Energy Development and Saving (IDAE), the Norwegian Institute for Energy Technology, the Netherlands Energy Research Foundation, and ECOTEC Research and Consulting Limited, UK.

Günther Hanreich

Director for New Energies and Demand Management,
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OVERVIEW OF THE RENEWABLE ENERGY SITUATION IN THE EUROPEAN UNION AND IN NORWAY

1. SUMMARY OF THE OVERALL SITUATION

The European Union accounts for only 6.4% of the world's use of Renewable Energy Sources (RES). Despite this low figure, however, the European Union is a world leader in terms of RES technology. The situation varies widely between individual Member States and current results are generally a long way short of the targets set. Nevertheless, significant progress has been made in recent years. This publication describes a set of interesting examples of projects implemented over the period 1997-2000 involving different types of renewable energy technologies (mini-hydro, biomass, wind, solar thermal, solar photovoltaic and geothermal energies) in the EU and Norway.

2. STRUCTURE OF RENEWABLE ENERGY IN THE EUROPEAN UNION

Power generation from RES in the EU in 1999 totalled 87 Mtoe, equivalent to 6.1% of the EU's gross inland consumption of energy. Of RES as a whole, biomass accounts for 62%, hydropower 30% with the other renewable sources accounting for the remainder (geothermal 2.3%, wind 1.4%).

Nevertheless, most of hydropower production comes from large power plants. Mini hydroelectric plantsv (power plants under 10 MW) produce only 15% of the total hydropower generation in the EU.

The countries making greatest use of RES are Sweden (27% of gross inland consumption, basically from biomass and hydropower), Austria (23% of gross inland consumption, also mainly hydropower and biomass), and Finland (22.5% of gross inland consumption, more than 80% of this production being biomass).

RES also account for a significant share of gross inland consumption in Portugal (13%, 71% of this being geothermal energy), Denmark (8.6%, 85% of its production being biomass), Italy (8.2%), Spain (5.8%), and Greece (5.7%).

The use of RES in the other Member States is still virtually negligible in quantitative terms.

More than half of the EU's production of power from RES in 1999 (53%) took the form of electricity generation and the rest (47%) was used as heat (98% of this consumption is biomass).

Production of electricity from RES accounts for 11% of total electricity generation in the EU (57% hydropower and 30% biomass). Austria (54%) and Sweden (34%) are the leaders in terms of their share of RES in electricity production due to the scale of their hydropower generation.

Outside the EU, Norway derives nearly all its inland electricity production from hydropower (nearly half of its domestic energy use).

Table 1 below provides the breakdown by Member States and technologies of the importance of RES with respect to gross inland consumption, inland power generation and final inland energy consumption, as well as the share of the energy supply provided by each of the individual technologies used to generate power from RES in each Member State.

TABLE I: RENEWABLE ENERGY SOURCES IN THE E.U [1]

Member State	% Gross Inland Consump-tion	% Inland Power Genera-tion	% Final Inland Energy Consump tion	Produc-tion Ktoe	% Hydro	% Biomass	% Wind	% Solar	% Geoth	% Other R.E.
Austria	23.3%	54.0%	10.9%	6,643	52.6%	46.2%	0.1%	0.9%	0.2%	0.0%
Belgium	1.5%	2.7%	0.9%	839	3.5%	80.2%	0.1%	0.1%	0.2%	15.9%
Denmark	8.6%	13.6%	3.1%	1,848	0.2%	85.3%	14.1%	0.4%	0.1%	0.0%
Finland	22.5%	19.3%	19.7%	7,326	15.0%	84.1%	0.1%	0.0%	0.0%	0.9%
France	7.2%	7.4%	6.6%	17,553	35.7%	63.5%	0.0%	0.1%	0.7%	0.0%
Germany	2.9%	4.2%	2.1%	9,942	17.0%	65.2%	4.8%	0.8%	0.1%	12.2%
Greece	5.7%	4.6%	6.0%	1,470	28.3%	62.1%	1.0%	8.4%	0.1%	0.0%
Ireland	2.1%	2.8%	1.6%	257	28.4%	65.0%	6.2%	0.0%	0.0%	0.0%
Italy	8.2%	15.1%	5.4%	13,706	28.5%	50.4%	0.3%	0.1%	20.4%	0.4%
Luxembourg	1.4%	29.0%	0.5%	46	17.4%	78.3%	4.3%	0.0%	0.0%	0.0%
Netherlands	2.4%	7.9%	0.7%	1,801	0.4%	82.0%	3.1%	0.4%	0.0%	14.1%
Portugal	13.1%	18.0%	11.6%	2,737	22.8%	70.6%	0.4%	0.7%	2.6%	3.0%
Spain	5.8%	7.3%	5.1%	6.205	31.7%	62.8%	3.8%	0.5%	0.1%	1.2%
Sweden	26.9%	33.9%	13.3%	13,556	45.5%	53.6%	0.2%	0.0%	0.0%	0.6%
United Kingdom	1.2%	2.4%	0.6%	2,626	17.5%	77.5%	2.9%	0.3%	0.0%	1.8%
European Union	6.1%	10.9%	4.4%	86,553	30.3%	62.1%	1.4%	0.4%	3.5%	2.3%

3. PROGRESS OF THE VARIOUS TECHNOLOGIES[2]

SMALL HYDROPOWER PLANTS(<10 MW)

The installed capacity of small-scale hydropower (<10 MWe) has increased by approximately 4% a year over the last decade, reaching an estimated figure of 4,284 MW by the end of 2000. Italy and France are the two main producers of electricity from micro-hydro plants, with installed capacities of 2,229 MW and 2,018 MW, respectively. The Spanish mini-hydro sector has also made considerable progress, Spain being the country where the increase in installed capacity has been greatest (570 between 1990 and 2000).

Despite these efforts, there is still considerable untapped potential. In fact, a strong push will be needed if the target of 14,000 MW forecast by the White Paper on Renewable Energy Sources is to be reached.

BIOMASS (BIOFUELS, BIOGAS, WOOD)

Biofuels

Two main sources of biofuels are currently being exploited: bioethanol (extracted from sugar beet, cereals and other crops), which is used in petrol engines, and biodiesel (derived from plant oils such as rapeseed, soybean, sunflower, etc.), which is used as a diesel substitute. Both modalities can be applied either in pure form or mixed with conventional fuels. Taken as a whole, European production has experienced buoyant growth, especially biodiesel, although a greater effort will be needed if the White Paper's targets are to be met.

France is playing a leading role in both segments, followed by a small number of countries. This situation is likely to change if the recently launched directives for the promotion of biofuels and corresponding action plan are finally adopted.

In the bioethanol market, France produced 91,000 tonnes in 2000. Spain, where a large-scale plant in Cartagena has been recently inaugurated, is positioned in second place. Finally,

1 Based on data for 1999 from the European Commission 2001 Annual Energy Review.

2 Based on information collected from the Eur-Observ'ER and the European Commission Communication on the implementation of the Community Strategy and Action Plan on RES (1998-2000).

Sweden has a small experimental plant that produces around 20,000 tonnes annually.

With respect to biodiesel, France produced 328,600 tonnes in the year 2000, followed by Germany (246,000 tonnes), Italy (78,000 tonnes), Austria (27,600 tonnes) and Belgium (20,000 tonnes).

Biogas

The share of waste incinerated with energy recovery differs notably between Member States (54% in Denmark, 0% in Greece and Ireland) and stands at an EU average of 14%. This percentage has been growing moderately during the past decade and, by the year 2000, more than 3,000 methanisation plants where in operation, with the United Kingdom as main producer (39% of the 2,304 ktoe obtained at the EU level).

Other countries that exploit a significant share of their waste as a source of power are Germany, with an estimated production of 525 ktoe in 2000 (primarily from agriculture), France, with 167 ktoe and Italy and The Netherlands, with 143 ktoe each.

In spite of these figures, the fact remains that achieving the targets established in the White Paper will require an annual growth rate of 30%, a figure that is well above the results obtained to date.

Wood

Wood constitutes the main primary renewable energy source used in the European Union, accounting for 58% of the total. Over the period 1990-1999, the production of electricity from biomass increased by 9% a year, as compared with 2% a year for heat. France, Sweden and Finland are, by far, the countries where this form of RE is most widespread, while performance has been fairly poor in other countries such as the United Kingdom, Greece or Denmark.

Although the main use of wood in terms of primary energy production is for heat, electricity generation has been gaining in importance over the past few years, and is expected to continue to do so in the future. According to the International Energy Agency, electricity generation in the EU using wood as a fuel stood at 17.3 TWh in 1999. This figure is still well below the objectives set for 2010, which may reflect the need to quickly solve the technical and financial problems encountered by energy plants.

Finally, it is important to stress that the figures presented under this section must be interpreted with particular care, given the fact that atomisation of consumption and the lack of reliable statistics often cause important divergences between statistical sources. In addition, the definition of biomass is not homogeneous, and can give rise to further confusion.

WIND POWER

Wind power holds pride of place among all the renewable energy sources, and Germany, Spain and Denmark are the leading countries in the field, both in terms of technological development and installed capacity. The European Union now represents more than 67% of newly installed capacity world-wide (compared with 25% for the United States) and this trend is expected to be maintained in the years to come. In fact, this is the only sector where current performance exceeds the targets set for 2010 in the White Paper.

Germany enjoys a particularly strong position in the wind power field, as with a total accumulated capacity of 8,750 MW it accounts for more than one third of the world total. This outcome has been possible thanks to solid political support and the implementation of economic incentives for the production of electricity using wind turbines. The same applies to Spain and Denmark, although the latter has recently reduced the level of support to this technology.

SOLAR THERMAL ENERGY

Although the White Paper set a target of installing an area of 100 m m^2 of solar collectors by 2010, by the end of the last decade, only 10% of this target had been achieved. The increase in the total area of solar collectors installed has mainly been concentrated in three Member States: Germany, Greece and Austria, while the other countries are not showing noticeable progress.

The analysis of the measures taken up in the different countries shows that there is a link between the implementation of public support measures (either compensation schemes or fiscal incentives) and the penetration of solar thermal technologies. The most outstanding example of this is the “Solar-Na-Klar” campaign in Germany, whose most recent report states that around 1 m m^2 were installed in the country in 2001 alone. In France, the effects of the “Plan Soleil” are beginning to be felt, with a total of 46,000 m^2 being installed in 2001 thus giving cause for optimism among the French public authorities and the view that the overall target of attaining one m m^2 a year seems perfectly attainable.

Prospects in the thermal solar energy sector remain good. If current trends are maintained, by the end of this decade, European capacity should reach 20 m metres. However, this figure falls short of the White Paper’s objectives.

SOLAR PHOTOVOLTAIC ENERGY

Photovoltaic solar technologies are growing at a pace of 35% a year, with most systems being of the grid-connected type. At the end of 2000, the EU’s photovoltaic capacity came to 183.5 MWp, an increase of 43.6% with respect to 1999.

As in the case of solar thermal energy, the leading country in this area is Germany, whose installed capacity represents 70% of the total in the European Union. Countries such as Italy, France, the Netherlands and Spain are also performing reasonably well. In most of these cases, an energy law exists supporting the production of electricity from RES.

Predictions are particularly difficult to make in this field as it is currently too heavily skewed towards a single country. A recent study from Observ’er foresees an average annual growth rate of 20% beginning in 2003, a percentage that may be well higher if support policies are implemented in the countries where no incentives currently exist.

GEOTHERMAL ENERGY

Geothermal technologies can have two distinct applications: the production of electricity (high and medium temperatures) and the production of heat (low and very low temperatures).

With regard to the first, only Italy and Portugal have registered noticeable progress, partly because of their genuine potential resources. France and Greece, however, are also seeking to increase their installed capacities. Thus, by 2010, Italy plans to reach 912 MWe, Greece 210 MWe, Portugal 24 MWe and France 19 MWe.

In the field of low temperature geothermal energy (production of heat), the number of installations is more difficult to ascertain as applications are very diverse and their sizes relatively small. In the European Union as a whole, geothermal energy for heat purposes represented a capacity of the order of 851 MWth in 2000, with France and Italy as the main producers.

The predictions that have been made seem to indicate that the spectacular growth undergone by heat pumps over the last 6 or 7 years will continue into the future, while the production of electricity will depend, to some extent, on whether the national plans on this field are implemented or not.

4. CURRENT STATE OF PLAY OF RENEWABLE ENERGY SOURCES BY COUNTRY

AUSTRIA

There is a long tradition of using environmentally friendly sources of energy in Austria. Most of the primary energy in Austria comes from fossil fuels (75.5% in 1999), the remainder being from renewables, of which about half is accounted for by hydropower. The country ranks third, after Norway and Sweden, in terms of the production of renewable energy per capita in Europe.

Renewable energy sources account for about 2/3 of gross electricity production and 2/3 of electricity generation from RES is produced by hydropower. This contributes substantially to the very low emissions of CO_2 per inhabitant. About 10% of the country’s hydroelectricity is generated by small hydro-power stations. The use of biomass as a source of energy is widespread in Austria, and biomass accounts for 2.6% of electricity production. The share of wind energy is very small, at only 0.1%.

Biomass is used for energy in residential buildings, where it provides space heating and domestic hot water. Both individual stoves and district heating systems are used for biomass-fired heating. Biogas is produced at farms, landfills and sewage processing plants and is burned in combined heat and power installations (CHP) for heating, hot water supply and electricity generation. The main types of biogas installations in Austria are municipal sludge digesters and agricultural installations. Biofuels showed remarkable growth in the 1990's, with output increasing to 27,600 tonnes in 2000. Currently, there are more than 80 biodiesel stations selling biofuels. The main biofuel in Austria is pure Rape Methyl Esther (RME), which is used in diesel engines.

There has been considerable growth in the use of wind power, which went from 20 MW in 1997 to 77 MW in 2000. Currently, the market is growing at about 24% a year. There is an excellent complementarity between the use of wind power and hydropower plants because each of these technologies have peak outputs in different seasons.

The solar thermal market in Austria grew considerably during the first half of the 1990s. However, at the end of the decade, the domestic market stagnated and the installed capacity per year decreased. By the end of 2000, approximately 153,000 Austrian households had solar domestic hot water systems. The total installed solar collector area amounted to 2.2 m m^2 in 2000. With this increase, the country ranks second after Germany on the European market.

Between 1996 and 2000, the market for solar photovoltaic energy grew at about 23% a year, which is higher than the average rate worldwide. About two-thirds of the installed PV capacity is connected to the electricity grid.

According to the RES-E Directive (2001), the share of electricity production from renewable energy sources in total gross electricity consumption should reach 78.1% by 2010. The Austrian government supports the utilisation of biomass, solar thermal collectors, photovoltaics, and wind energy from several subsidy programmes. Investment subsidies and private initiatives in the field of solar thermal collector installations have been particularly successful in Austria. There is a feed-in tariff system for solid and fluid biomass, biogas, wind energy, photovoltaics and geothermal energy. Current legislation obliges power utilities to raise the share of renewable energy sources in their production portfolio.

BELGIUM

The contribution of RES to the energy balance in Belgium is still very small. In 1999 RES accounted for about 1% of production as a whole (one of the smallest percentages in Europe).

Most of the competencies in this area were transferred from the State to the regions in the 80's, and the regions are currently responsible of energy supply policies, regulation of energy production and energy pricing and taxation.

The sustainable energy Framework is established by Federal Government and thus the role of the regional authorities is to translate it into a programme for implementation.

In April 99, Belgium passed a law implementing the EU Directive on the liberalisation of electricity markets, which will regulate third party access for eligible customers and negotiated access for transit and high volume transmission.

Generally speaking, the traditional form of renewable energy used in Belgium is biomass, in particular wood and wood waste. It alone represents 90% of the contribution of RES to the country's overall energy supply; 8% is from hydropower and the remaining 2% from waste incineration.

Other renewables such as wind and solar energy clearly play only a very minor role although, particularly in recent years, a gradual increase has been seen.

In this sense Belgium has been partially stimulated by the general re-launch of solar thermal and PV applications, particularly driven by Germany, and is also increasing the exploitation of wind resources in some coastal areas.

Most of these efforts are still very small compared with those in other countries, but they demonstrate a growing interest and commitment from the government side to the achievement of the Kyoto objectives by 2010.

To this end a variety of initiatives have been launched in recent years by a scientific Commission, the AMPERE Commission, which was specifically created in order to investigate the different options for electricity production in Belgium.

A national CO_2 emission reduction programme has also been launched, which includes several measures aimed at both the private and public sectors to promote RES, CHP and Rational Use of Energy initiatives.

However, no CO_2 tax has been implemented in Belgium and this limits the potential effectiveness of this programme.

Financial incentives have also been set up on investment for RES at federal and regional level such as the ECHOP programme (Wallon region), subsidies for companies investing in RES (20% for SME and 10% for MLE) in the Flemish region, support to R&D programmes and investments and incentives for the renewable electricity market (€0.05 per kWhe produced from wind and hydro energy and €0.025 per kWhe produced from other RES (mainly biomass).

A “Green Certificate” scheme is also under consideration.

At regional level some specifically conceived programmes such as SOLTHERM (Wallon region) have promoted ST use through incentives, while subsidy schemes have been set up for PV (Flemish region) and direct aids (€6,250 grant for a solar DHW system) again by the Wallon region.

DENMARK

Net domestic energy use was 813 PJ (226 TWh) in 2000.

In 2000 the production of renewable energy was 89 PJ, which is a 7.5 % increase compared with 1999. The largest contribution to the increase in energy production comes from wind power, which has increased from 5 PJ to 16 PJ between 1999 and 2000. The amount of biomass has remained much the same whereas use of waste increased by about 1 PJ between 1999 and 2000.

In 2000, biomass accounted for 40 % of the total output from renewable sources, waste 34 % and wind power 18 %. 50 % of biomass usage is accounted for by individual heating, 25 % for in district heating systems and 25 % in combined heat and power plants.

The installed wind energy capacity in 2000 was 2417 MW, which is an increase of 36 % with respect to 1999, reaching more than twice the capacity existing in 1997 and more than seven times the capacity recorded in 1990.The amount of electricity produced by wind energy is increasing rapidly. In 2000, 13 % of the country’s electricity was produced from wind energy, whereas in 1990 the amount was only 2 %.

The accumulated area of solar thermal collectors stood at 242,800 m^2 in 2000. There are about 35,000 solar heating systems for one-family houses and each system typically has 4-5 m^2 of solar collectors.

The installed solar photovoltaic capacity in Denmark in 2000 was 1.5 MW (more than three times the existing capacity in 1997).1.3 MW of this capacity is non-grid connected. A “300 rooftop” project, known as “SOL 300” was launched in 1998, and by the end of 2000 all 300 rooftop solar systems had been brought into operation. In the period 1997-2000 the installed capacity increased from 422 kWp in 1997 to 1460 kWp in 2000.

Since 1996 renewable energy has had a high priority in the Danish Energy 21 energy plan. The aim is to reduce the carbon dioxide emissions by 20 %, compared to 1998-levels, before 2005. The quantitative target for 2005 is 1,500 MW of wind power capacity and replacing 6% of coal with straw and wood.

The long-term target for wind power is 5,500 MW in 2030, which would mean that it would meet 50 % of the country’s electricity consumption needs.

The main incentive provided by Danish policy in favour of RES is the internalisation of external costs of non RES through taxation. There are also subsidies to the RES sector for activities in research and to help cover running costs and investments.

FINLAND

The energy situation in Finland is dominated by the large need to import fossil fuels, i.e. oil, gas and coal. The domestic energy sources are limited to nuclear power, hydropower and other renewable energy sources, including peat.

The total energy consumption in Finland was 1,300 PJ (361 TWh) in 2000.

Renewable energy sources, including large scale hydropower and peat contributed 29 % of total energy production in 2000. The major part of the contribution comes from wood-based fuels, which alone contribute 21 %.

The total electricity production in 2000 was 67 TWh. Electricity production is dominated by hydropower (22%), nuclear power (32%) and combined heat and power plants (36%).

Biomass contributed about 25 % of total energy production in 2000. From 1997 to 2000 The use of wood as an energy source increased from 5.7 Mtoe in 1997 to 7.5 Mtoe in 2000.

With respect to small-scale hydropower plants, the accumulated installed capacity stood at 320 MW in 2000. For wind energy, the installed capacity was 38 MW at the end of 2000. Wind energy only contributed 0.1 % to the total electricity production in 2000. However, as a consequence of liberalisation of the electricity markets, there has been an increase in the demand for wind power. The installed capacity in 2000 was three times that existing in 1997.

As regards solar energy, the accumulated area of solar collectors stood at 9,700 m^2 in 2000, which was a slight increase from the 9,000 m^2 installed in 1999. The installed capacity of solar photovoltaic was 2.6 MWp in 2000, of which 2.5 MWp was off-grid. The major use of solar PV is for small holiday homes, with typical sizes of 50-100 Wp per installation.

In 1999 the Plan for Renewable Energy Sources in Finland was approved. Currently, the annual forest growth exceeds biomass usage, thus supporting a strategy of focussing RES activities on biomass.

The main incentives under the Finish policy to promote RES take the form of taxation on non RES. There are also subsidies for investments in the RES sector and for information dissemination.

FRANCE

France is still behind most other European countries in terms of RES utilisation, particularly so given that it is not fully exploiting its considerable potential in some RES areas (especially biogas and wood) and the low level of take-up of RES such as PV and wind applications.

France has, for example, considerable biogas potential. This, however, is under-exploited and most primary energy from RES comes from wood. Nevertheless, it is the principal European biogas producer (47 % of EMHV – methyl ester from vegetable oil) and it is still the leader in terms of installed mini-hydro capacity. Moreover, solar thermal is clearly taking off once again.

In general terms, a particular effort has been made, especially over the last 2-3 years, to change this trend towards the underutilisation of the country's RES resources through the design and setting up of a legislative and financial framework encouraging RES applications. The initial results of this are becoming increasingly apparent.

However, French policy towards the use of RES has not always been very clear and effective. More recently though, the European initiative "Take off Campaign" for RES has clearly enhanced the French Commitment to achieving a situation where 21% of its energy needs are supplied by RES by 2010.

In the meantime, medium terms plans are being designed and adopted for each RES technology, between the State and its 26 regions, on the initiative of the ADEME (the French Energy and Environment Agency).

These contracts between central and regional government represent a privileged framework within which to foster the application of RES at regional level: the plans set activities to be undertaken each year up to 2006 based on indicative targets (tonnes of waste used, of CO_2 emissions avoided, etc).

Some of the ongoing initiatives which have been designed and carried out are:

- The "Bois energie" programme, launched by ADEME with a view to developing industrial and district heating by encouraging the rational utilisation of wood wastes.
- The "Plan Soleil" programme, aimed at bolstering solar-thermal installations with the ambitious, but not impossible, objective of reaching 1,000,000 m^2 of solar collectors installed by 2010.
- The "Eole 2005" programme, specifically focused on wind farm investments, and which has promoted the setting up of several wind farms in particularly favourable areas (i.e. the north coast and Mediterranean coast).
- The more recent "Batiment Bleus" programme, aimed at promoting grid-connected PV installations.

Taken as a whole, these initiatives, together with research activities, efforts to simplify administrative procedures and adapt current legislation and the considerable financial sources (€136 m from ADEME, plus €446 m of regional funds and €276 m of EU SF funds for the 26 regions over the period 2000-2006) clearly demonstrate a change in attitude and a likely shift in trends over the coming years.

GERMANY

The eastern part of Germany is almost entirely dependent on fossil fuels, while energy supply in the western part is much more diversified. More than half of the electricity generated in Germany comes from coal. A further 30 % of Germany's electricity is produced by nuclear energy.

Renewable energy sources account for 2.6 % of gross inland energy consumption for the country as a whole. Renewables account for 5.6% of overall electricity production, most of this being from hydropower (3.8 %), and about 36 % of Germany's hydro-electricity is generated by small hydro power stations (<10 MW). The second most important source of renewable electricity is wind power (1.0 % in 1999), followed by biomass (0.8 % in 1999).

More than one-third of the installed wind power capacity world-wide is located in Germany, and the country's total installed capacity came to 8,750 MW in 2001. Market growth of 43.7% was achieved between 2000 and 2001 mainly due to the feed-in tariff for wind energy in German Renewable Energy Law. The German market offers the most significant examples of the technological progress made in wind turbines, with average turbine sizes increasing from 470 kW in 1995 up to 1,280 kW in 2000. There is also a trend towards larger wind farms.

Germany is the European leader in terms of total installed solar collector area, with a total of 3.3 m m^2 in 2000. The German market has undergone considerable growth due to an effective campaign for promotion of solar thermal energy. Between 2000 and 2001, the growth rate was 46 %.

Germany is by far the European leader in installed PV capacity. Germany accounts for most of the growth of the European market. The German Renewable Energy Law (with a high feed-in tariff for PV) and the "100,000 Rooftops Solar Power Programme (1999-2003)" have been important drivers for the growth of the German PV market. This programme aims at the implementation of a total on-grid installed PV capacity of 300 MWp between 1999 and 2004 and offers loans on favourable terms to support this goal. Between 1997 and 2000, the total installed capacity increased from 41.9 MW up to 113.8 MW. In the year 2000, 44.3 MW of PV capacity was installed. Most of the PV capacity is grid-connected (88 % in 2000) and there is a trend towards an increasing average size of PV plants.

In Germany a large amount of wood (energy crops and forestry waste) is used for the production of heat and electricity. Primary energy production from wood came to 5.0 Mtoe in 2000. Other resources that are used for this purpose comprise various kinds of wastes, such as municipal solid and digestible wastes, and, to a lesser extent, solid and liquid agricultural wastes.

Germany is Europe's second largest biogas producer, after the United Kingdom. Gross annual production of biogas in 2000 was 525 ktoe. From all biogas resources, agricultural biogas has shown the greatest growth in Germany. In 2000, 400 new installations of this type went into operation. The total number of agricultural biogas installations was estimated at 1,050 units in 2000.

Germany is the second most important European biodiesel producer, with a share of 35% in European production. Production of biodiesel in Germany came to 246,000 tonnes in 2000.

The national indicative target for renewable energy sources in gross electricity consumption is set by the RES-E Directive at 12.5% in 2010. German renewable energy policy defined a long term target, i.e. a minimum share of power from renewables of 50% in 2050.

In April 2000, the Renewable Energy Law came into force, replacing the Feed-In Tariff Law. This law continues the system of guaranteed grid access (a purchase obligation on grid companies). It also features legally fixed feed-in tariffs for small hydropower, biomass (up to 20 MWel, and excluding sludges, mixed MSW and landfill gas), geothermal energy, wind power, and solar PV. The feed-in tariff system has a decreasing price element to stimulate continuous technological development and efficiency improvements.

GREECE

Renewable Energy Sources (RES) contributed a total of 1,403 ktoe to the Greek energy system in 2000. This corresponds to 5 % of the Total Primary Energy Supply in Greece. Biomass and hydroelectricity accounted for most of the renewable energy produced, with biomass (mainly in the form of wood, used as firewood in the domestic sector) being responsible for 67.42 % and hydropower for a further 22.63 %. Wind, solar heat and geothermal heat made up the remaining 9.95 %. Excluding biomass for household consumption and large hydropower, the contribution of other sources is 10.96 % of the total power from RES. This quantity represents the part of the energy produced by RES that is affected by national policies and measures and has increased from 253 ktoe in the year 1990, to 396 ktoe in 2000.

Electricity generation from renewables was 4,145 GWh in 2000, with a total installed capacity of 3,336 MWe. The largest contribution to electricity generation was from hydroelectric plants (3,693 GWh). Wind energy contributed a total of 451 GWh of electricity, while photovoltaics contributed only a small amount, mainly in off-grid installations.

Solar energy applications are almost exclusively used for water heating. Greece is the European Union's leader in terms of the area of solar panels installed for solar thermal applications (2.96 m m^2 collector area in 2000), with about 29 % of the total installed surface in the 15 EU member states and 28 % of total heat production.

The Centre for Renewable energy Sources (CRES) plays a key role in the coordination of the government's activities in renewable energy development and research. It plans, implements and executes R&D projects, provides technical support and disseminates information to interested stakeholders. It also investigates the technical and economic potential for renewables in the country.

Approximately 34 % of the Greek electricity market was opened up to competition in February 2001 in accordance with Law 2773/99 on the liberalisation of the domestic electricity market. Law 2773/99 contains two provisions that are of relevance to RES power projects. Firstly, an electricity-production license will be required for the construction and operation of an electricity-generating installation, and secondly, system operators are to give priority to generating installations using renewable energy sources or waste or producing combined heat and power when distributing electricity from different suppliers.

At present renewables are mainly promoted through financial incentives, such as tax breaks, direct subsidies and an attractive feed-in tariff system.

The two main financial-support instruments that provide substantial public subsidies to RES investment projects are the so-called "National Development Law" and the Greek Operational Programme for Competitiveness (OPC) of the Third Community Support Framework (CSF III; 2000-2006) for Greece.

During the period 1994-1999 the CSF II programme granted a cumulative total of about €92 m in public subsidies to 78 RES investment projects, which had a total budget of about €213 m (i.e. mean subsidy rate ~ 43%) and a total installed capacity of 161 MWe + 102 MWth. This programme was instrumental in encouraging substantial RES activity and in materialising a large number of commercial-scale RES projects in Greece, particularly in the period 1997-2000.

IRELAND

There are still a number of gaps in the development of renewable energy in Ireland, and generally speaking, use of RES is still very low. Traditional energy sources such as wood and mini-hydro are still used and some other sources, such as wind energy or solar thermal are slowly growing.

The energy sector is regulated at national level, in a policy document "Renewable Energy: a strategy for the future" published in 1996. In September 1999, the Green Paper on Renewable Energy was formally unveiled by the Minister of State. The Green Paper adds a systematic framework to the existing legislation and indicates how Ireland plans to progress towards the Kyoto Protocol, to which it is a signatory. A Renewable Energy Strategy Group has been set up reporting directly to the Parliament on the following main points:

• To increase targets for RES energy generation.

• To modify the existing AER scheme (Alternative Energy Requirement).

- To promote electricity market liberalisation.
- To address deployment constraints with a funding of €25 m.
- To encourage grid connection of existing isolated wind turbines owned by farmers.
- Fiscal measures and tax relief.
- Promotion of R&D.
- Strengthening of the Energy centre and its RES office.

Since 2000 the Electricity Regulation Act has been established in Law and a Commission for Electricity regulation has been working to regulate licensing and market liberalisation.

At present, the largest portion of RES come from industrial and traditional biomass, followed by large scale hydro power stations and, to a much lesser extent, by the other renewables such as wind and solar technologies.

Biomass (mainly wood and wood waste) has been used traditionally for many centuries in Ireland and recent increases of forest cover should contribute to enhancing the current capacity.

MSW (municipal solid waste) and landfill gas have been exploited by 5 large projects (total production 12 MW) erected around 1996-1997; however, there are still uncertainties due to poor waste management practices and legislation constraints.

Wind energy, mainly in the form of isolated installations run by individual farmers, is slowly growing and there is an increasing trend towards grid connected plants.

Finally, solar thermal and solar PV play a very small role within the Irish RES scenario, although efforts are ongoing to improve their application and spread the advantages of these technologies.

There are a number of support measures for RES projects, such as the AER (Alternative Energy Requirement), Third Party access, a Study Grant Scheme prepared by the Irish Energy Centre, corporate tax for equity investment, INTERREG energy challenge. The whole range of these incentives is currently being exploited in order to increase the use of RES throughout the country.

ITALY

Heavy dependence on oil and gas imports and the decision to close nuclear plants have concentrated Italian political efforts on the development of RES.

However, the share of inland consumption met by RES is still very limited (about 8.2%).

Half of RES production in Italy takes the form biomass, of which households consume 80%. Nearly 30% of RES production is from hydropower and 20% from geothermal energy. The contribution of other renewable source to total RES production is almost negligible.

The outlook for some technologies is positive. A programme called “Photovoltaic Roofs” is currently running and is due to be completed by 2003. Italy is the world’s fourth largest producer of geothermal energy and the Europe’s largest fuel cell plant (1.3 MW capacity) is located in Milan. There is also a considerable potential for wind energy, particularly along the long Italian coastline.

The “White Paper on the utilisation of Renewable energy sources” sets targets for 2010. The Italian government plans to double current energy production by 2010.

The legislative decree 79/99 liberalising the electricity market provides for rules supporting electricity from RES. From 2002 all new or re-powered electricity plants have the obligation to produce a certain amount of green electricity. Electricity from RES is also given priority in electricity dispatching.

RES are increasingly being promoted by regions, provinces and local authorities.

Incentives for RES production include investment subsidies, electricity feed-in tariffs and taxation. Certain promotional and demonstration programmes of a national importance for RES technologies have been defined (photovoltaic, solar thermal, biomass). Moreover, in the framework of the “2001 Financial Law” (Law 388/00) the Government has taken further steps to promote renewables through:

- financial support to District Heating fuelled with geothermal and biomass;
- reduction of the duty on production of bioethanol, ETBE and other additives from biomass;
- tax exemption on biodiesel production;

• fund creation, by setting aside 3 % of the income from the Carbon Tax;
• a specific fund for the Ministry of the Environment and Territory Protection, with €130 m over three years, for sustainable development including a greater use of RES.

The government's measures also include Law N. 112/98, which transfers competencies to regional Governments on local energy planning and RES exploitation.

LUXEMBOURG

Luxembourg has few indigenous energy resources, making it almost entirely dependent on imports of both fossil fuels and electricity. Using renewable energy sources contributes to diversification and thus helps to increase security of energy supply.

The share of renewable energy sources in gross inland energy consumption is very small. Renewable energy sources account for about 16 % of gross electricity production . The main renewable source for electricity production is small hydropower, which provides 9.3% of total gross electricity production in Luxembourg. These plants are located on the Moselle River. However, the limited resources on this river have largely been exploited now. Biomass is the second most important renewable source with a share of 5.0% of total gross electricity production (in 1999). Wind power has a share of only 1.7%.

In 1997, the first 3 MW of wind power capacity was installed, producing about 3 GWh of electricity. Installed capacity increased to 10 MW in 1999, with a production of 17 GWh of electricity.

Wood and municipal wastes are the most important biomass resources in Luxembourg. Small amounts of wood are used in the residential sector to provide heating and in 1999, primary heat production from wood (wastes) amounted to 644 TJ. Wastes, including animal products and gases from biomass, are important for the production of both electricity and heat.

For Luxembourg, the EU RES-E Directive states an indicative target for electricity production from renewable energy sources of 5.7 % of total electricity consumption by the year 2010.

Renewable energy sources are supported by a number of measures, for example, guaranteed electricity markets at favourable rates. There is a different feed-in tariff for producers with outputs of up to 500 kW and for those operating in the 501-1,500 kW range. The government grants investment subsidies to wind power projects and photovoltaic systems at private homes and public facilities.

THE NETHERLANDS

The development of Renewable energy sources in the Netherlands is still very limited, RES accounting for just 2% of gross inland energy consumption and 4.1% of electricity production. The main renewable source utilised is biomass, which accounts for nearly the whole of RES production (3.3% of electricity production). Wind and hydropower (0.7% and 0.1% of electricity production) complete the picture.

The country also utilises landfill gas and digestion of biodegradable wastes, which produce of 6% and 13% respectively of total biomass-energy production. Most of the biomass energy comes from waste incineration (43%). Wood burning provides about 38%.

Since 1994 solar thermal energy installations have increased substantially. In 1998 and 1999, the solar thermal market stabilised. The total solar collector area was of about 240,000 m^2 in 2000, more than half of which consisted of domestic solar boiler systems.

Solar PV has developed significantly in the Netherlands since the early 1990s and the market grew from 4.0 MWp in 1997 to 12.8 MWp in 2000. The annual installed capacity came to 3.6 MW in 2000. About two-thirds of Dutch PV systems are grid-connected.

The RES-E Directive sets the national indicative target for the share of gross electricity consumption to be met from renewable energy sources at 9.0% in 2010. The Dutch White Paper on renewable energy sets a target of achieving a share of 10% of energy consumption from RES in 2020 (the intermediate objective for 2010 is 5%). The share of RES in electricity production is targeted at 17% in 2020 (9% intermediate objective for 2010.

An important feature of Dutch energy policy is the Regulating Energy Tax (REB). Domestic users have to pay this tax on their electricity and natural gas consumption. The tax is paid to the utility companies, which in turn, pay it to the treasury. Producers of renewable energy receive a share of the tax collected. Electricity and gas generated from renewable sources are exempted from this tax., with the exclusion of hydropower and power from waste incineration. This policy measure is intended to stimulate both energy saving by final users and the market penetration of renewable energy technologies.

The Dutch government promotes the utilisation of renewable energy sources by means of various investment subsidy programmes and fiscal measures. In July 2001, the Dutch renewable electricity market was opened up to competition, and at the same time, a system of green certificates based on voluntary demand was introduced.

NORWAY

The net domestic energy use was 802 PJ (227 TWh) in 2000.

Hydropower accounts for more than 99 % of the electricity generated in Norway. During an average year with normal rainfall the production is about 113 TWh/year. Due to the large amount of low-cost electricity produced by large-scale hydropower, new renewable energy technologies have not been implemented to any great extent.

During the 90s new renewable energy sources have gained popularity in the energy sector and have attracted increasing interest from industry. In particular, wind energy, biomass energy (especially the use of waste) and heat pumps have all made good progress.

A governmental resolution for the future use of RES aims to obtain 3 TWh/year of wind power and 4 TWh/year of central heating based on RES by the year 2010.

The installed capacity of wind power in Norway was only 13 MW, with a production of 32.5 GWh in 2000. If the national target for 2010 of 3 TWh is reached, wind power will produce around 2.5 % of the country's electricity. In the period 1997-2000, 9 MW of wind power capacity was installed, which increased the national capacity by 70%.

In Norway there are no large commercial installations of solar collectors. There are, however, about 500 small installations with a total collector area of 6,000 m^2. With respect to solar photovoltaic electricity, the installed capacity at the end of 2000 was 6,030 kW, from which 94 % was off-grid.

Biomass contributes about 6 % of the total energy production in Norway. In 1998 and 1999 biomass produced about 13 TWh/year, from which 6 TWh was used by residential applications, and about 7 TWh by industry.

Small scale hydropower and geothermal energy do not play a significant role in Norwegian energy production from renewable sources.

The main national targets for renewable energy are:

- To construct wind turbines with production capacity of 3 TWh/year by the year 2010.
- To increase the use of central heating based on new RES, heat pumps and waste by 4 TWh/year by the year 2010.

There is a subsidy for wind electricity production and wind power investments are entitled to receive an investment subsidy of up to around 25%. Furthermore, all renewable energy technologies are exempted from investment tax.

PORTUGAL

The Portuguese energy system is characterised by a high degree of dependence on external energy sources. Nevertheless, Portugal is among Europe's leading countries in terms of the contribution of RES to the national primary energy supply (at approximately 10%). By source of RES, in 2001, the main figures, in terms of installed capacity, are as follows:

Small hydro power	308 MW
Wind energy	150 MW
Solar Thermal	225,000 m^2 (5,000 to 7000 m^2/year)
Solar Photovoltaic	1.2 MWp
Biomass	360 MW (wood, urban solid wastes, biogas)
	0.54 Mtoe (domestic wood)
	1.14 Mtoe (industrial wood)

Geothermal	12 MW (electricity production the Azores)
Wave energy	400 kW (Azores)

According to the "Report from the Forum for Renewable Energies in Portugal" the targets set for the installed capacity to be achieved by 2010 are as follows:

Small hydro power	600 MW
Wind energy	2,000 - 3,500 MW
Solar Thermal	2,800,000 m^2
Solar Photovoltaic	50 MW
Biomass	500 MW
Geothermal	30 MW electricity and 30 MW thermal
Wave energy	50 MW

The most recent energy strategy for Portugal is formulated in Cabinet Resolution no. 154/2001 of 19 October 2001 (E4 Programme). The strategy relies upon 3 main lines of action, one of them focused on RES: promoting the use of endogenous energy sources by establishing a highly dynamic compromise between technical and economic feasibility and environmental constraints.

By launching the E4 Programme, the Portuguese Government aimed to create the conditions to reach the indicative target of 39% of power generation from renewable sources in 2010 (Directive 2001/77/EC), as well as to reduce the GDP energy intensity.

The set of multiple and diversified measures contained in E4 have been launched gradually since the adoption of the Programme, in October 2001.

SPAIN

In spite of the progress made in recent years, particularly in the wind sector, the contribution of RES to final Energy consumption is still very limited in Spain. In 2001, a year marked by a very high level of hydropower production, this contribution reached 6.5%. In absolute terms, total RES production was 8,302 ktoe.

Large hydropower plants (capacity >10 MW) accounted for 37% of energy produced from RES and small hydropower (capacity ≤10MW) accounted for 5%, with 29 new mini-hydro plants coming into service in 2001.

Biomass technology (44% of RES energy consumption) continues to be the leading form of RES production in Spain. Installed capacity increased by 16.6 MW in 2001 to compare with 2.8 MW increase in 2000.

Spectacular progress has been achieved by wind energy. In 2001 wind power accounted for 8% of total production from RES. Installed capacity increased by 1,000 MW (60 new wind farms were brought into service in 2001). Spain is currently second in Europe in installed wind power capacity and Spanish technology in this sector is one of the world leaders.

The contribution of other RES technologies to overall output is negligible in quantitative terms in Spain. However important relative progress has been achieved recently. A total of 5,500 solar thermal projects out of a total of 8,000 RES projects were implemented in 2001 (27% increase in installed surface area compared with 2000) and the highest increase in photovoltaic capacity in recent years was registered in 2001 (+ 3.5 MWp). Current installed capacity is 15.6 MWp of which one third is grid connected.

The Plan for the Promotion of Renewable Energy in Spain, approved in December 1999, sets a target of 12% of Spain's energy demand being met from renewable sources by 2010 in line with the EU target defined in the European Commission White Paper for RES.

Incentives in Spain include research, promotion programmes and financial aid. On the electricity market, RES receive a differential premium on production depending on the technology used, with photovoltaic energy being by far the most favoured.

Central government gives direct subsidies for innovative and demonstration projects. Most of the autonomous regions also provide direct subsidies for the implementation of RES projects. IDAE (The Institute for Diversification and Saving of Energy) provides reimbursable finance for RES projects.

SWEDEN

The share of RES in total energy consumption in Sweden is very high, standing at 27% in 1999. More than half of this is biomass and 45% is hydropower. Solar and wind power are still in the development phase.

The installed capacity of wind power was 241 MW at the end of 2000. During 2000 these turbines produced 440 GWh. Wind turbines contributed about 0.3 % of total electricity production. From end of 1997 to the end of 2000 the installed wind power capacity increased from 122 MW to 241 MW.

The accumulated area of solar thermal collectors was 161,900 m^2 in 2000. The demonstration plant in Kungälv is currently the largest solar heating plant in Europe (March 2001).

The total installed PV capacity in Sweden was 2.8 MWp at the end of 2000 of which 2.7 MWp were off-grid. Most new installations are used for small stand-alone systems at remote holiday homes.

In 1999 the total use of bio-fuels was about 338 PJ (338 TWh). These fuels are mainly used in the forestry industry, district heating plants, detached houses and electricity production. More than 93.6 PJ (26 TWh) of bio fuel where used for district heating plants in 1999. The detached house sector used more than 43 PJ (12 TWh), mainly in form of firewood, and electricity production used 12.6 PJ (3.5 TWh).

The production of primary energy from wood was 8.3 Mtoe in 2000.

Finally, the estimated installed capacity of small-scale hydropower plants in Sweden in 2000 was 1,062 MW and the installed capacity of low temperature geothermal heat (excluding heat pumps) was 47.0 MWth with total energy production of 507 PJ (141 GWh).

This is a minor increase from 1999, where the installed capacity was 1,050 MW.

In 1997 the Swedish Parliament decided to phase out all nuclear power plants and in 1999 one of the reactors at the Bärsebäck plant was closed down. In order to fulfil the overall objective the Parliament has initiated a long-term research, development and demonstration programme (SEK 5.6 billion, €610 m) and a short-term subsidiary programme (SEK 3.5 billion, €382 m) to promote energy efficiency and electricity production from renewable energy sources. There is a plan to supply about 7% of total electricity consumption from wind power in a decade. Almost half of district heating consumption is accounted for by biofuels.

Swedish incentives for renewable energy include investment grants for biofuel CHP, wind power and small-scale hydroelectricity. Biofuels are exempted from taxation on the heat market and in the transportation sector.

UNITED KINGDOM

The government's target is for 10% of UK electricity to be supplied from renewable sources by 2010. Total generation from renewable sources in 2001 was 10,099 GWh. Biofuels and wastes accounted for 86% of renewable energy sources with most of the remainder from large-scale hydro electricity production. 2.5 % was contributed from wind power. Of the 3.1 m tonnes of oil equivalent from renewables, 2.4 m tonnes was used to generate electricity and 0.7 m tonnes to generate heat. Renewable energy use grew by 5% in 2001, and renewable energy accounted for 2.6% of electricity generated in the UK in 2001.

More renewables installations have been achieved in 2002, particularly in new and innovative technology areas. For example:

- Offshore wind is now starting to move forward as an expanding opportunity, with a number of locations being investigated in detail and planning underway for a number of installations around the UK coastline. In 2002, consent was given for one of the largest offshore wind farms in the UK: North Hoyle off the North Wales coast, which will comprise up to 30 turbines with a maximum capacity of 90 MW. Completion is anticipated in late 2003. Consent has also been granted for a 76 MW offshore wind farm at Middle Scroby Sands off the Norfolk coast.
- Photovoltaics applications are also expanding, for example eight new medium- and large-scale photovoltaic projects, totalling 350 kW, supported through the DTI's £20 m major photovoltaic demonstration programme.

- The first large-scale anaerobic digestion plant in the UK was commissioned, in Devon (south-west England), which generates power and heat from farm and food wastes.

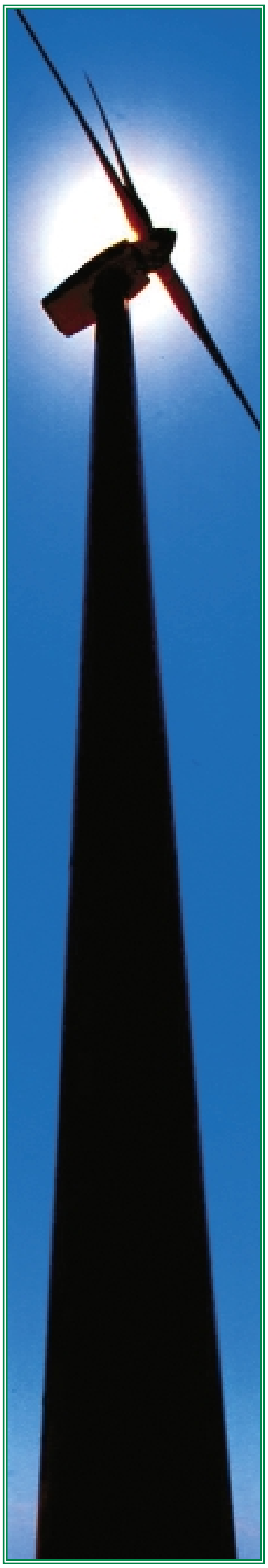
Government policy instruments to support renewable energy are now based around a programme of stimulating both established and emerging technologies to compete effectively in the market:

- The Renewables Obligation is placed on all electricity suppliers to provide an increasing proportion of their electricity from eligible renewable sources, rising from 3% in 2002 to 10% by 2010. This helps renewables power to obtain a premium compared with prices for non-renewables electricity.
- Renewables are exempted from the Climate Change Levy imposed on energy use by all businesses. This is worth up to 0.43 p/kWh. The Levy applies to energy supplied to business and the public sector.
- To support emerging technologies, there is a range of capital grants available for renewables, including support for offshore wind, biomass and energy crops, and photovoltaics. These grants are intended to help to lower costs for installations and establish biomass supply chains, and can therefore help to improve confidence in the technologies.
- The Carbon Trust has been established to help business and the public sector to move towards a low carbon future, exploiting opportunities and supporting innovation and new technologies. Through its Low Carbon Innovation Programme, it funds a range of projects aimed at developing low carbon technologies. Funds are available through the main stages of innovation into commercial reality.
- Renewables UK has been set up recently by the DTI to support the UK renewables industry, to help it to compete more effectively in the very competitive marketplace, both at home and abroad. The programme aims to build on domestic capabilities to exploit indigenous expertise, and in particular to maximise business opportunities from some of the emerging technologies e.g. offshore fabrication, wave, tidal, also in financing, consultancy and services.
- The economic benefits of renewable energy are often most apparent at regional level, and as a result renewable energy is included in every regional economic strategy.
- The DTI is currently preparing a UK Energy White Paper, to be published in 2003.

SMALL HYDRO

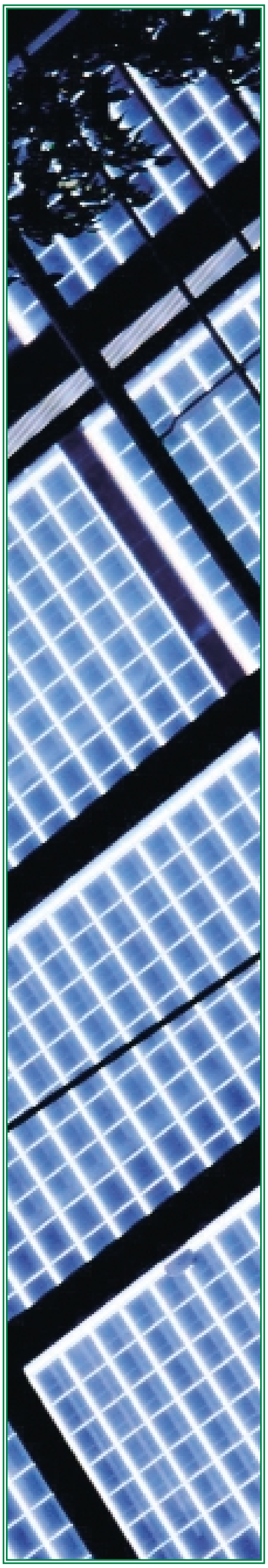
BIOMASS

WIND ENERGY



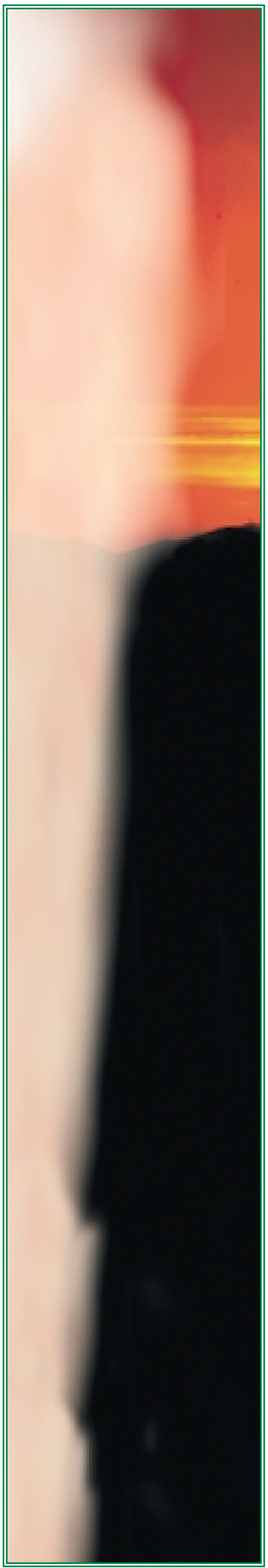
SOLAR THERMAL

SOLAR PHOTOVOLTAIC

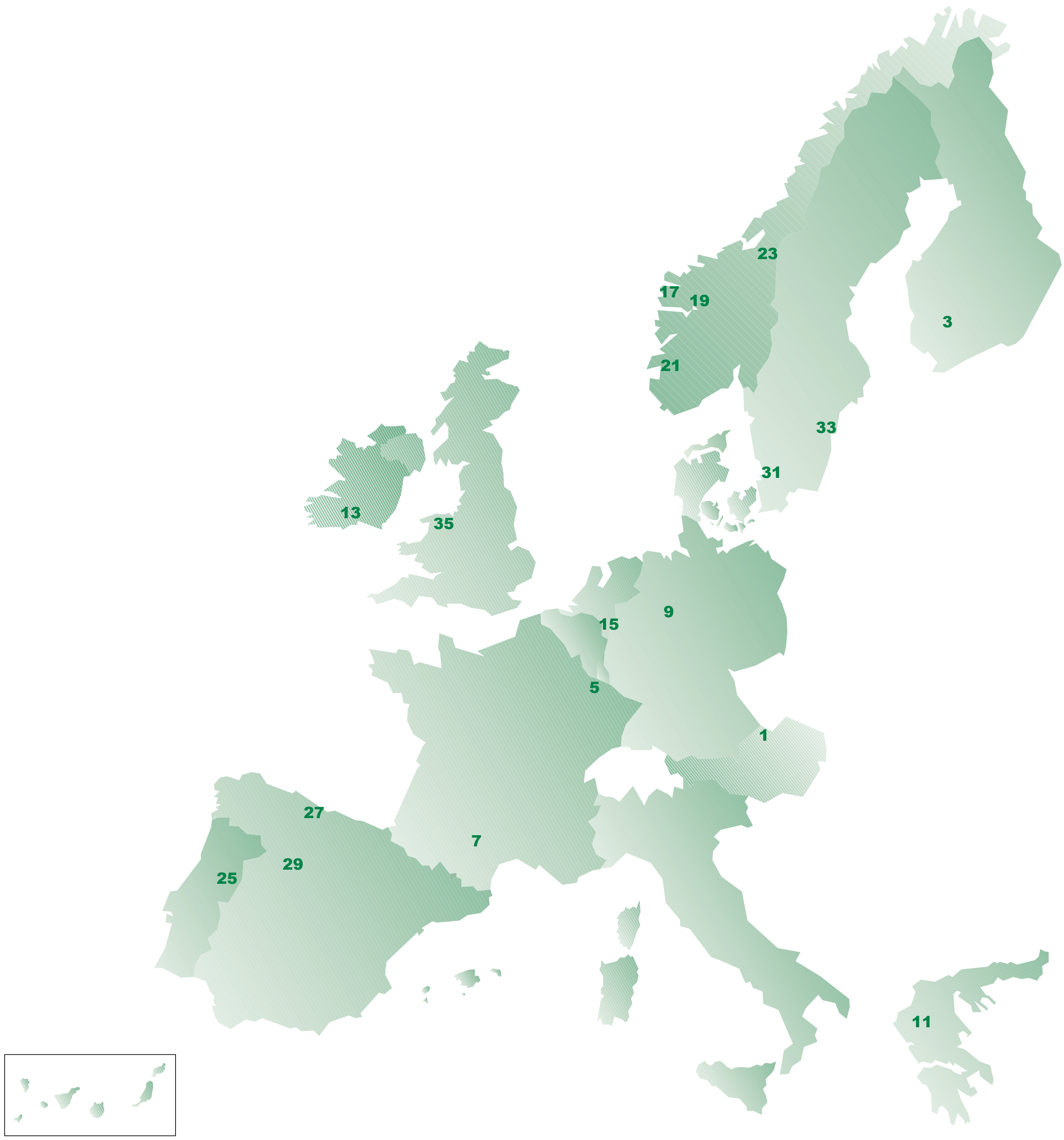


GEOTHERMAL

ENERGIE

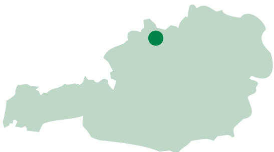


1 SMALL HYDRO



Sector: Small Hydro
Country: Austria
Location: Walding
Year: 2000

ENERGIE



WALDING, "GRIESMÜHLE" MINI-HYDRO POWER PLANT

The "Griesmühle" is an old mini-hydropower plant located in the hamlet of Walding, on the Great Rodl River, Upper Austria. It was built around 1850 and was used as a mill powered by a water wheel. In 1924, the mill was completely overhauled and the water wheel was replaced by two Francis turbines. The "Griesmühle" continued in operation until the end of the Second World War, when it was sold and used for small-scale commercial purposes. In the 1990's, the mill came into the possession of Mr. Priesner of Griesmühle Kleinkraftwerke (Griesmühle Small Hydropower Plants). It was renovated in 1999 and came back into operation in May 2000.

The objectives of this project included the revitalisation of the old small-scale hydropower plant by installing a powerful new water turbine and a modern control system. Moreover, the project aimed at renovating and converting the old mill into a modern low-energy building with 13 new apartments. All the energy used by the flats is supplied by the hydropower plant.

The revitalisation of this mini-hydropower plant is a pilot project being carried out as part of the more comprehensive EUREKA project ECOTRANS. The objective of the ECOTRANS project is to set up a new ecological traffic concept using electric vehicles that are powered by energy from hydroelectric sources. One of the aims of this project is to optimise the charging process, the type and the surface-structure of the accumulator batteries for vehicles.

Description

The rehabilitation of the "Griesmühle" hydropower plant involved renovation of the weir construction, which consisted of a concrete weir with a wooden section. The water inlets were modernised and automated. The embankment was protected with stones. Furthermore, the two Francis turbines in the installation were replaced by one Cink crossflow turbine, driving an asynchronous generator.

The power plant uses several new control and monitoring systems. The water level of the turbine, the turbine and generator room temperature, the transmission temperature, and the grid are all monitored. The weir inlet control, which is connected to the turbine drive, is controlled by the water level. The system is also equipped with high water level alerts and automatic closure of the inlets in the event of floods. The installation also has automatic "trash rakes" to remove debris and back flow of cleaned water.

The former mill was converted to a low-energy building comprising 13 new apartments, with a heat demand of 41 kWh/m² per year. Two heat pumps, which are driven mechanically directly from the turbine, produce heat for the building. A 40-kW groundwater heat pump provides space heating for the flats. A smaller air/water-heat pump with a capacity of 5 kW is used for the hot water supply. This heat pump utilises waste heat from the generator. In this way, the energy demand of the flats can be met entirely from hydro-electricity.

Project characteristics

Basin size [km²]	175.8
River discharge [m³/s]	3.46
Power capacity of the turbine [kW]	55
Turbine rotation speed [Turns/min]	85
Maximum turbine rotation speed [Turns/min]	153
Net rated head [m]	2.9
Gross rated head [m]	3.14
Extension discharge [m³/s]	1.8
Generator rotation speed [Turns/min]	1017
Generator voltage [V]	420
Generator power capacity [kW]	55

Promoters and parties involved

- Griesmühle Small Hydropower Plants (Griesmühle Kleinkraftwerke GmbH): owner and operator
- Cink Hydro-Electric Power Plants Ltd.: supplier of the Cink water turbine
- Ofner GmbH: administrative co-ordinator of the project, supplier of the electronic control system
- M-Tec Mittermayr: supplier of the heat pumps and the electronic control system (in co-operation with Ofner)

Financial resources

The total investment was approximately €1 m. The cost of rehabilitation of the hydropower plant was approximately €300,000, of which €230,000 was financed by Griesmühle Small Power Plants. The Austrian Municipal Credit Bank contributed the remaining €70,000. The cost of the low-energy house was about €700,000. This was financed by Mr. Priesner from private capital, with support of the Building Subsidy regulation (Wohnbauförderung) of the federal state of Upper Austria.

Results

The "Griesmühle" project succeeded in achieving the objectives of revitalisation of the old mini hydropower plant and renovation and conversion of the old mill house into a modern low-energy building.

Output from the plant is sufficient to cover the energy demand of the apartments. The average annual production of the plant totals approximately 300,000 kWh. Together, the two heat pumps produce about 68,000 kWh of heat a year. The 40 kW heat pump is able to produce 50,000 kWh of heat (38,000 kWh from ground water and 12,000 kWh mechanical energy) a year. The smaller heat pump can supply 18,000 kWh of heat (12,000 kWh from ground water and waste heat from the generator, 6,000 kWh mechanical energy). The total value of the energy produced is about €16,500 a year.

The project not only contributes to reducing polluting emissions but also benefits the fish in the river given that the whole weir channel can be used for trout breeding. This was achieved by constructing various shelters (roots, stones) for fish. The water turbine also increases the oxygen level in the water. Another environment benefit is that not all the water is diverted from the river. A flow rate of 100 litres per second in the old river course ensures the ecological balance is maintained.

Moreover, special precautions were taken to reduce the noise level of the vibration of the fixed mounted turbine to a value below 25 decibels, which is that set by local legislation.

Potential for replication

This project successfully combines the renovation of an old mill house, environmentally friendly energy generation by small hydropower and heat pump technology, and the building of a low-energy house. There are about 30,000 inactive mills in Austria and Germany, of which about 5-10% could be revitalised in a similar way to the "Griesmühle" mini hydro plant.

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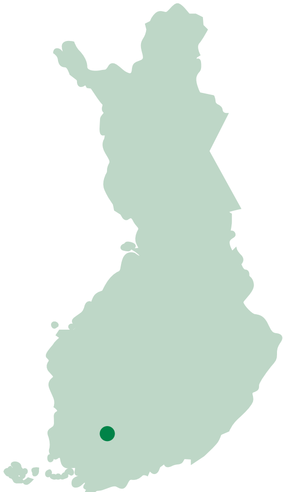
Sector: Small Hydro
Country: Finland
Location: Jokioinen
Year: 2000



RENOVATION OF A HYDROPOWER PLANT IN A PROTECTED BUILDING

The project involved the renovation of a small hydro power plant on the Loimi River, about 150 km from Helsinki, the capital of Finland. The plant was built in 1926 and consisted of three 120 kW Francis turbines.

Waterpumps WP Oy, a turbine development company decided to buy the plant in 1992 and set up subsidiary company (Jokioisten Voima Oy) to run the project.

Description

The old power station is a protected building on account of its historical interest and therefore the building had to be kept in its original form. The inlet for the three new turbines was located in the old water channel running underneath the building. The 100 m long wooden intake channel with concrete supports, was completely rebuilt with pine bars, and the trash rake was replaced to bring it in line with modern requirements.

The dam itself, with an available head of 9 m and a discharge rate of 9 m^3/s, did not require restoration, and only the dam sluices were replaced.

The units, developed by Waterpumps WP Oy, are direct driven, i.e. the rotor and generator are mounted on the same shaft and no gear box is required.

A dedicated computer programme provides automatic control. The level of upstream water is constantly monitored by a control panel, which determines the best combination of turbines to give maximum output, depending on the available flow.

Technical data

Head	9 m
Turbine capacity	215 kW
Total capacity (three units)	645 kW
Runner diameter	800 mm
Speed	600 rpm

The turbine, generator and sluice have been constructed as a compact module ready for installation. The sluice is a cylinder gate, which is able to close the water inlet very tightly. When opened, the gate retracts fully so as to cause no loss of flow.

Promoters and parties involved

The plant was developed by Jokioisten Voima and then sold to the utility company Espoon Sähkö Oyj. Waterpumps WP Oy delivered the plant as a turnkey installation.

Financial resources

Total investment

The total investment was €1,270,000.

Subsidy

Jokioisten Voima Oy received €350,00 in financial support from the parent company Waterpumps WP Oy and as a subsidy from the Ministry of Trade and Industry in Finland.

Source of revenue

The plant is delivering electricity to the grid.

Borrowing

The investment has come entirely from the company's own capital.

Payback period

The payback period is 15 years.

Results

The plant would have been built about five years earlier if the company had been able to obtain a loan for the investment. However, as the company had to save its own capital before construction could start the project was delayed as a result.

Once the finance for the project had been raised it was implemented on time and there have not been any major problems with operation.

Energy production

The plant generates about 3.2 GWh per year.

Potential for replication

There are at least 2000 hydropower plants in Europe with capacities in the range 100-500 kW which are currently out of operation and could be easily renovated using advanced turbine technology.

For more information

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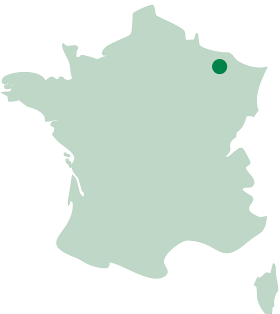
Sector: Small Hydro
Country: France
Location: Bresse
Year: December 2000



LA BRESSE SMALL HYDRO

Small-hydro plant “Cote 750” is located in La Bresse within the Des Ballons des Vosgues Regional Natural Park. There The municipality already had a company (Régie Municipale d’Electricité de La Bresse) generating and supplying electricity which aimed to cope with the 45 m kWh demanded by 5,191 inhabitants and 46 customers on an industrial tariff. However, with the five existing hydro-electricity plants the Régie could only partially meet the municipality’s electricity demand (13% of the total amount). A number of measures were analysed and evaluated with a view to improving the supply and the option finally chosen was the construction of this small hydro plant, within the framework of a more complex project.

Source: ADEME Délégation Lorraine

Description

The project consists of four main elements:

- An artificial basin with a capacity of 21,000 m^3 located at an altitude of 842.2 m, downstream of the Blanchemer plant, which comprises the La Lande (820 m) and Blanchemer (750 m) hydraulic stations (producing 1,800 kW and 300 kW, respectively). The water from these stations is stored in the basin prior to flowing to the small-hydro, which is located below. This water retention is necessary to mitigate the impact of the overflow weir from the plant of LA LANDE and BLANCHEMER and thus to control possible peak water levels.

- A system of water control piping water from the La Lande and Blanchemer hydraulic stations to the artificial basin.
  - A channel ensuring a constant flow of water from the La Lande dam to the Moselotte River (this flow is variable: 250 l/s from the 1st of June to the 30th of September and 145 l/s the rest of the year).
  - An underground pipe taking water from the artificial basin to the small hydro "Cote 750" with a diameter of 1,000 mm and a length of 2.4 km.
  - The small hydro station equipped with a horizontal axis FRANCIS type turbine, a 1,250 kWA asynchronous generator and a transformer. The main features of the plant are as follows:
    - Nominal installed power (rated capacity) 900 kW
    - Nominal water flow rate: 1,600 l/s
    - Gross head: 79,60 m
    - Net head: 71 m

The plant is equipped with a Francis horizontal axis group working at 1.6 m^3/second, with a 1,250 kVA generator: of the electrical installation as a whole enables the plant's 20 kV output to be fed into the Regie grid.

The installation is connected to the local owned public grid.

Promoters and parties involved

Developers

Municipality of La Bresse

Other involved agents

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Régie Municipale d'Electricité de La Bresse

Financial resources

Total cost of the project came to €3.1 m. It was financed by the Municipality of La Bresse, and partially subsidised by ADEME and the European Commission through the ERDF (European Rural Development Fund).

Results

It is anticipated that with the operation of this installation and together with the other five hydro-electrical plants it will be possible to meet 25% of the electricity needs of the municipality.

A set of actions was specifically carried out in order to minimise the impacts on the environment caused by this project (the installation is, besides, located in a protected natural area).

Potential for replication

The installation of a new mini-hydroelectric plant within a natural protected area is without doubt a complicated problem to be faced and solved in view of the strict environmental protection legislation applicable to it. In this case the point has been successfully treated and solved in an acceptable and accepted way, which can serve as an example for similar situations.

For more information

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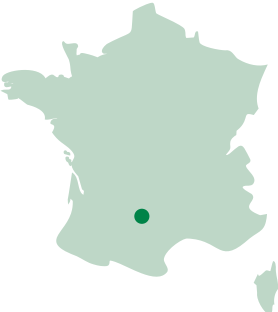
Sector: Small Hydro
Country: France
Location: River Lot (South-West France)
Year: Mayo 2000

ENERGIE



CAPDENAC SMALL SCALE HYDRO PLANT

Capdenat is a small hydro installation located on the River Lot. The main aim of the project was to rebuild and upgrade the existing plant, (which was built in 1903 and fitted with new components in 1968) by means of the application of very innovative technology.

The main aspects of this innovation were; 1) the use of downstream bearing-technology which transfers the bearing downstream of the runner hub at the extreme end of the rotating parts; and 2) a tubular propeller shaft solving problems linked with critical speeds in long shafts. These innovations made it possible to achieve a 10% saving on the overall cost of the plant.

Description

The installation consists of an asynchronous generator (2,350 kVA) coupled with a four-bladed, semi-Kaplan turbine equipped with a 3,150 mm runner, with a head of 5 m with an inclined axis. The whole structure is located in a concrete chamber. The flow rate is 45 m^3/s.

An accelerator from 120 to 750 rpm is also inserted together with a 5/20 kV transformer and a 20 kV switchyard.

Promoters and parties involved

Developers, owner, operation and maintenance

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Financial resources

Total cost of the project was €3.1 m, with an estimated payback period of between 8 and 9 years. A reason for this high cost was the need to test the technology to be applied in order to avoid problems after installing it (previous prototypes of downstream bearings were ruled out after a period of time due to performance shortcomings). It is believed that in the future the cost per installation will be reduced by €152,000.

The cost per kWh is €0.39 (this would have been €0.38 if the testing had not been carried out and €0.4 without the new design). Despite this, the cost of the new design was less than that of an equivalent Kaplan turbine because of the additional cost of the civil engineering works that would have been required.

The project has also obtained a subsidy from the THERMIE programme.

Results

After the system came into operation some problems arose due to the excessive flexibility at the downstream bearing end. Engineering (increasing the distance between the runner and the casing) and mechanical solutions (hub reinforcement) were adopted in order to solve these problems.

The installation was designed to produce 8,000 MWh a year.

Among the advantages obtained using this system are the reduction of the bearing diameter, improvement in the replacement of the bearing (replacement estimated to be required after 30,000 hours) and a larger diameter and reduced thickness of the shaft (having 25% of the weight of a conventional one).

Potential for replication

It is considered that when the cost has been reduced in the near future this technology can be easily replicated and implemented (for example in similar renovation projects).

For more information

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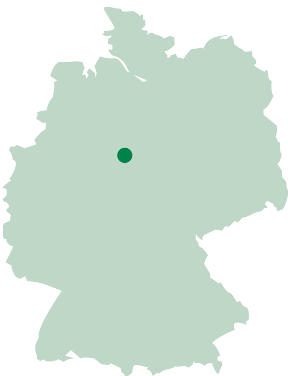
Sector: Small Hydro
Country: Germany
Location: Hanover
Year: 1999

ENERGIE



HANOVER, HERRENHAUSEN MINI-HYDRO PLANT

In 1992, the city of Hanover adopted the “Hanover Energy Concept”, which involved a commitment to reduce emissions of CO_2 by 25% from 1990 levels by the year 2005. Additionally, use of electricity from nuclear power in the city was to be phased out. Renewable sources of energy were assigned an important role in achieving these aims.

In 2000, the World Fair (Expo) was held in Hanover, with the motto "Humankind - Nature - Technology". With this, the city and the of Hanover aimed at demonstrating a sustainable energy future. One of the five exhibits of the Municipal Services, was the Herrenhausen small hydropower station, which came into operation in 1999. It was part of the Expo project called "The City as a Garden".

The Herrenhausen plant was intended to be an example of how, even in an area designated for countryside conservation and recreation, a technical structure can be implemented with only a minimal impact on nature. The installation was designed to fit into the existing area in an optimal way and was also equipped with a fish ladder, allowing the various species of fish in the river Leine to swim upstream past the weir.

Description

The small hydropower station at Herrenhausen utilises an average head of 2.10 m to generate electricity. The head varies with the water level in the river, which can be 3.50 m in summer. In times of high water (about 30 days per year), no electricity can be produced, because then the head is too small.

The plant is equipped with two running water Kaplan turbines with an electrical power capacity of 470 kW each. The turbines have a diameter of 1.95 m. The total water flow varies between 16 m^3/s at low water and 250 m^3/s at high water. The hydropower station was designed for the average flow in the river Leine of 50 m^3/s.

The maximum overall turbine efficiency of the hydropower station is 92.3% and the transmission and generator can achieve an efficiency of 94.5%. The overall utilisation factor of the plant varies between 86% and 92.5%.

The plant has been fitted with a fish ladder enabling fish to swim upstream past the weir. The ladder consists of 25 basins that fish can swim between. A grille has been fitted across the front of the turbine inlet to prevent the fish from being drawn into the turbine.

At Expo 2000 visitors from all over the world had the opportunity to see the hydroelectric plant for a period of six months.

Promoters and parties involved

- The city of Hanover
- Municipal Services of Hanover (Stadtwerke Hanover AG): operator and owner of the plant
- Naturstrom AG: supplier of electricity only from renewable energy sources
- Expo 2000 GmbH: financial aid
- ProKlima: environmental protection fund: financial aid

Financial resources

The total investment in the hydroelectric station came to approximately €5.1 m, of which about €3 m corresponded to the cost of the building. The turbine cost approximately €1 m. The remainder was spent on generators, planning and licence. The costs of the environmental compatibility study, including the compensation and replacement measures, came to about €100,000. Operation and maintenance costs for the project are about €51,000 a year.

The plant was financed by the Municipal Services of Hanover, with €409,000 coming from the Expo 2000 company. ProKlima, the local climate-protection fund, granted another €971,000. In addition, the State of Lower Saxony has granted a low-interest loan covering 50% of the investment.

Results

An environmental compatibility study covering on area of 24 ha was conducted to find the best way to minimise the impact of the project on its natural surroundings. The study suggested that the best solution would be to build the turbines into the existing weir.

All the main conservation groups and representatives of public interests participated in the authorisation process, which took a little over a year. Thanks to the degree of attention paid to minimising the project's environmental effects there were no major objections to it. Furthermore, trees were planted in the immediate vicinity of the hydroelectric plant as a compensation and replacement measure. Because the project did not encounter any substantial problems, it was possible to complete it a period of approximately 2 years.

The hydropower plant is able to produce an average of 4,800 MWh of electricity a year, which is sufficient to meet the electricity needs of 1,800 households. This is about 0.15% of the total electricity demand of the city of Hanover. The amount of energy that can be produced varies between 4,000 and 5,500 MWh a year, depending on the quantity of rain. With a feed-in tariff of 0.02 €/kWh, the annual revenue from electricity sales is about €96,000. The electricity generated by the project is sold by the Municipal Services of Hanover directly and via Naturstrom to residents who wish to have electricity from renewable sources of energy.

The project reduces the annual emissions of pollutants by 3,500 tonnes of CO_2, 1,600 kg of SO_2, 2,200 kg of NO_x, 400 kg of CO, and 80 kg of dust. It also reduces the amount of fossil fuels needed for electricity production by 750 tonnes of coal and 600,000 Nm^3 of natural gas per year, with the fuel mix of the energy production plants in Hanover as a reference.

Potential for replication

The Herrenhausen mini hydropower plant offers a good example of the construction of an electricity generating plant with a minimal environmental impact, thanks to both its overall design and features such as the fish ladder.

For more information

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Sector: Small Hydro
Country: Greece
Location: Anatoliki, Region of Epirus
Year: 1997

SMALL HYDRO PLANT AT ANATOLIKI

The Operational Programme for Energy (OPE) is a large fund half of which has been provided by the EU and the other half by the Greek State. In the first call for proposals under Measure 3.2 of OPE, (Investments for Renewable Energy Sources applications), 6 small hydro projects were selected for financing, from a total of 11 submitted proposals, with a total installed capacity of 7.85 MW.

Description

One of the six plants was the Small Hydro Plant in Anatoliki, in the prefecture of Ioannina, in the Epirus Region. The proposal was for a small hydroelectric plant with an installed capacity of 700 kW, a nominal discharge of 460 lt/sec and a gross head of approximately 210 m. The length of the penstock was 1.6 km, with an inner diameter of 600 mm. The generating set consists of a “Pelton-2” turbine and a synchronous generator.

Promoters and parties involved

'Ipirotiki Energiaki S.A.', and CRES (Small Hydro Department).

Financial

The total cost of the plant was estimated at approximately €1.03 m.

The capital subsidy was 45% of the total investment cost approximately €0.46 billion.

The budget allocated to equipment, software, materials, transport and installation may constitute the total budget of the investment and in any case it must be no less than 85% of the total budget. In contrast, there is a ceiling on the percentage of the auxiliary costs in the total budget, such that the total eligible auxiliary costs must be no more than 15% of the total budget.

Results

The construction of the SHP was completed at the end of 1999. The delay was due to the very difficult weather conditions (mountainous terrain, inclement weather, etc) and most of all to the delay of the construction of the line for connecting the plant to the national grid.

The target of the SHP, and the target of the OPE as a whole, is the production of electricity from RES and the substitution of fossil fuels. The investments where evaluated proportionally to the total annual energy produced, or to the amount of fossil fuel substitution.

The energy target of the SHP of Anatoliki was the production of 4 GWh annually.

Potential for Replication

So far hundreds of applications have been made in the framework of the O.P.E. and 150 licences have been approved and granted for power generation projects involving small hydroelectric plants. CRES is also among those, which have been granted such licences. Twenty such similar projects are due to begin next year (2003).

For more information

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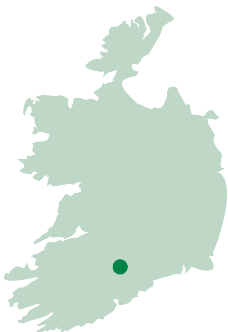
Sector: Small Hydro and Biomass

Country: Ireland

Location: Looby Farm, Ronga (two miles west of Clogheen, Cahir, Co. Tipperary)

Year: September 1998

ENERGIE



ECOBOOLEY (THE IRISH ECO-COTTAGE)

The Irish Eco-Cottage Tourism Development Project aimed to create a new "generic" branded and uniquely Irish product. Rural Ireland contains countless numbers of abandoned homesteads, all charming and important in their own way, and often located in remote and beautiful parts of the landscape.

Ecobooley uses only eco-friendly technologies and materials and furnishing it for use as a self-catering tourism outlet. Hence, it is focused on the expanding Eco-friendly tourism market. This project is part of "The Pilot Initiative on Tourism and Environment", which is being administered nationally by Board Failte.

Description

The project has consisted of the restoration of a labourer's cottage built in 1890 on the farm of Eamonn Looby in the foothills of the Knockmealdown mountains in South-West Tipperary.

Electricity is supplied by a mini-hydro plant constituted by a water-driven electric turbine, fed by a 700 m long heavy duty pipe (4 inch) which draws water from a large stream. Heating is provided by biomass by means of a wood burning stove, and surplus heat from the electricity supply is also used. The stove is an energy efficient, reduced emissions model, and includes a hot plate cooking surface, glazed screen doors, and is fitted with a black boiler, making it the state-of-the-art at this time. It thus provide the hot water and space heating requirements, providing also additional cooking surfaces, a centre-piece and the psychological comfort of an open fire, without the energy wastage of a traditional one.

The wall between the downstairs bedroom and toilet/shower room acts as a radiant storage heater as it contains a coiled hot water pipe surrounded by sand.

Some other elements contribute to the whole building energy performances such as roof insulation (treated sheep's wool) in order to avoid insect infestation and decay and internal walls are plastered by using a thick coat (one inch plus) of a lime and hemp (fibrous plant residue) mixture. The toilet is a composting type toilet, which eliminates the need for a septic tank. A willow garden is being used to soak up excess liquid and nutrients from the toilet and kitchen area.

Solar-Thermomax water heating panel were also taken into account for a possible installation if the budget could have been stretched to include this technology for water heating purposes, as it would have matched the summer-time load for hot water extremely well. However, the whole design of the building has been realised to allow possible future connection of this technology.

Promoters and parties involved

Management

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Adviser – overall co-ordinator

Eamonn Looby:
Farmer and owner of the Cottage
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John Devane:
Manager of Tipperary Leader Group
www.ecobooley.com

Financial Administrator

Garry Gleeson:
Technical Consultant and Builder
Garry Gleeson associates
Carrigmore, Clogheen, Co. Tipperary
IRELAND

Financial resources

Total budget for the project was €93,850.15 from which the restoration of the cottage accounted for €64,619.30. The other main budget items are detailed below:

Core Technical Research: €8,535.46

Monitoring, Landscaping, Misc: €1,587.45

Print and Dissemination of results: €5,569.21

Fees (legal, architectural, etc): €2,257.63

VAT: €11,281.10

A grant was approved for the sum of €69,835.6, which accounted for 74.41%. Matching finance of €24,017.1 was supplied by Eamon Looby, Ranga, Clogheen, Co. Tipperary, which is the Cottage owner (€19,046.1) and by Garry Gleeson, Carrigmore, Clogheen, Co. Tipperary, Enviro-Builder and Consultant (€4,971.02).

Results

The water driven electric turbine, which supplies power for lighting, cooking and heating, produces 1.4 kW of nominal power on a continuous basis all year around.

Potential for replication

As stated in the background section, the characteristics of this projectare such that it has a wide potential for replication in Ireland and elsewhere in locations where the isolated conditions can be profitably exploited by the use of endogenous RES (biomass and mini hydro in this case).

For more information

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Sector: Small Hydro
Country: The Netherlands
Location: Roermond
Year: 2000

ROERMOND, RESTORATION OF A MINI HYDROPOWER PLANT

On 8th September 2000 a small hydropower plant built in 1920 was brought back into operation after renovation. It is located at Roermond on the river Roer, a short distance upstream of the mouth of the river Maas. In 1926 it was acquired by Electro Chemical Industry (ECI), which wanted a cheap source of electricity for their electrolytical processes. The power station was blown up during the Second World War. It was repaired and brought back into operation in 1948. The electrochemicals factory closed in 1974, followed by the hydropower station. It had been closed down for 26 years when restoration was carried out.

During the past years, all kinds of organisations have aimed at bringing back the river Roer to its original state. Water quality has improved significantly and the fish stocks in a river of this kind need to be preserved. Because the fish might not be able to safely pass the hydropower station with its running turbines, a fish ladder was installed to guide the fish around the plant.

The Roermond hydropower plant was renovated with a view to operating the plant for another 40 years. The project aims at producing environmentally friendly electricity and demonstrating the possibilities for producing renewable energy using hydropower in an industrial monument.

Description

In the Roermond hydropower station, the river current and the height difference of the water are used to turn a turbine connected to a generator that produces electricity. The river Roer has an average water discharge of 22 m^3/s and a head of 2.30 m.

The installed electricity generating capacity of the plant is 250 kW. Use of new technology enabled a 25% increase in efficiency to be achieved. One of the existing Francis turbines is equipped with a new gearbox, generator and control mechanism. This turbine is relatively slow with 45 turns per minute. The other turbine was made available for visits by the public by shutting of the water flow.

For environmental protection, the hydropower plant has been fitted with a fish ladder guiding the fish around the plant. At the beginning of the fish ladder, a fish guidance system with light and sound signals and air bubbles will be installed to guide the fish to the fish ladder. This system, which is called ‘Bio Acoustic Fish Fence’ (BAFF) is unique in the Netherlands as it has never been used in turbid water before.

Promoters and parties involved

- Nederstroom, a joint venture of the Dutch utility NUON and the Belgium EcoWatt; operator.
- Nuon: utility company; study for and installation of a fish guidance system.
- District water board Roer en Overmaas: removal of slurry and restoration of the neglected river banks and the existing fish ladder, building of an additional new fish ladder.
- Municipality of Roermond.
- Fish Stock Management Committee Roer.
- Local fishing associations.
- KEMA and OVB: research on the impacts of the plant on the fish.

Financial resources

The total investment required for the project came to slightly over €2 m. A part of this investment concerns the restoration of the historic buildings and their installations. Low-interest loans from the National Restoration Fund were used to finance the project.

It is expected that the renovated plant will have a lifetime of at least another 40 years. The estimated pay back time is 25 years. This is relatively long, because revenues from the exploitation of the historic building itself have not been included in the calculation yet.

Results

The project encountered problems that are common in the process of restoring historic buildings and solutions were found for all of them. However, research is still underway to determine the possible damage to the fish stock.

There was a high degree of involvement in the project by local residents due to the role of this hydropower plant during the Second World War, when it produced electricity for the city.

The electricity output of the hydropower plant totals around 2,000 MWh a year. The project therefore decreases the amount of fossil fuels needed for electricity production and emissions of CO_2 are reduced by 1,000 tonnes a year. Another beneficial environmental effect is the protection of fish in the river Roer by means of a fish guidance system.

Potential for replication

The evaluation of the fish guidance system at this station is important for future hydropower projects, because relatively little experience has been acquired with measures to reduce possible damage to fish by hydropower plants. The outcome of this project significant as it will demonstrate whether small-scale hydro-electricity generation can be combined with the preservation of nature and conservation of fish stocks.

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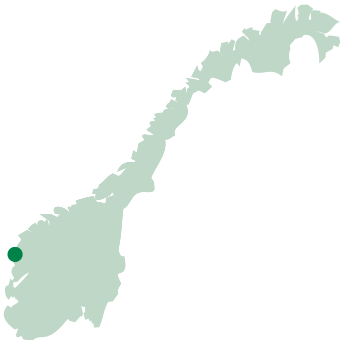
Photo by Karel Bingen, Roermond

Sector: Small Hydro
Country: Norway
Location: Førde Municipality
Year: Autumn 2000

ENERGIE



HYDRO POWER PLANT INTEGRATED WITH THE DRINKING-WATER SUPPLY

Sunnfjord Energi AS has considered developing the river Gilelva, using the Gravvatnet as a reservoir, since the beginning of the 1970's.

In the end of the 1980's Førde Municipality needed a new source of drinking water and investigations showed that lake Gravvatnet was suitable for the purpose. After some negotiation, Førde Municipality and Sunnfjord Energi AS agreed to cooperate on development. The aim was to reduce the cost of both electricity generation and supplying drinking water.

Sunnfjord Energi AS had implemented a similar project in 1982 in cooperation with Hyllestad Municipality.

Description

The project a mini hydropower plant and a large hydropower plant in the drinking water system.

The Gravvatnet reservoir is on a contour line 600.5 m above MSL (previous average water level). The total regulation of the lake is 6 metres. In the period 1st June to 1st September the reservoir water level needs to be kept above 600.5 MSL.

From the Gravvatnet reservoir, there is a diversion tunnel, running for about 5 km to the large Mo Hydropower plant. The outflow from the large Mo hydropower plant runs through a 2 km tunnel to the Movatnet. The Mo power plant is built 800 m into the mountainside.

The Refsdal mini hydropower plant was built at 180 m above MSL. The outflow from the power plant is delivered to the drinking water supply reservoir below the turbine. The power station therefore operates as a pressure reducer for the drinking water supply.

The catchment area for the two plants is about 14.1 km^2.

Technical data

	Mo	Refsdal
Turbine		
Type	Pelton	Pelton
Capacity	10.5 MW	421 kW
Head	550 m	400 m
Inflow	2.2 m^3/s	Approx. 0.12 m^3/s
Rotational speed	750 rpm	1,500 rpm
Generator		
Capacity	12.8 MVA	500 kVA
Voltage	6.6 kV	400 V

Sunnfjord Energi AS is committed to delivering up to 200 l/s water to the drinking water treatment plant. The capacity at the turbine at Refsdal is 120 l/s, but so far the average consumption has been 80 l/s and thus the capacity has been sufficient. If water consumption increases, Sunnfjord Energi could use the by-pass to increase the flow or install a new turbine with a larger runner.

Promoters and parties involved

Sunnfjord Energi AS owns the hydropower plants, which were supplied by Veidekke on a turnkey basis. The company NVK acted as a consultant.

Financial resources

Total investment

The total investment for Sunnfjord Energi was NOK 122 m (€17 m).

Subsidy

The project has not received any subsidies or support from external sources.

Source of revenue

The power plants are selling electricity.

Sunnfjord Energi AS has a NOK 40 m loan on the plants with 20 year repayment period.

Results

The project was realised as initially planned and both power plants have been operating in accordance with the initial requirements. There was a half-year delay in the project due to problems with the inflow reservoir.

Energy production

The annual energy output from the Mo power plant is 37.1 GWh and that from the Refsdal power plant is 2.2 GWh.

Financial result

The expected annual revenue is approximately NOK 1.1 m (€ 0.15 m).

Environmental benefits

The complete installation, apart from the drinking water treatment plant in Refsdal, have been constructed underground and therefore have negligible visual impact on the surroundings.

The inflow reservoir is regulated to 1 m during the summer. This is obviously visible, and the flow in the river Gilelva is reduced, but a weir has been built in order to preserve the depth. The minimum flow in the river is set at 100 l/s during the period from 15th June to 1st September.

The electricity generated by the plant replaces imported electricity generated by fossil fuels and thus contributes to reducing emissions of carbon dioxide.

Potential for replication

Experience from the project has shown that the integration of a hydropower plant and water supply can work well at a location where the conditions for both plants are good.

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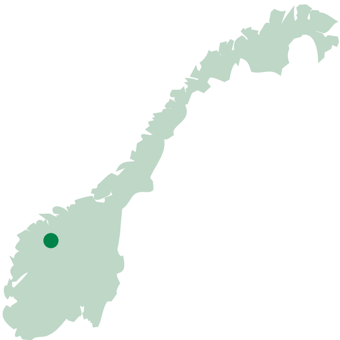
Sector: Small Hydro
Country: Norway
Location: Gloppen, Sogn og Fjordane county
Year: December 1999



PRIVATELY OWNED MINI HYDROPOWER STATION

The Ryssdalen hydropower station is located in Gloppen in Sogn og Fjordane county on the River Ryssdal. The section of the river used is about 1 km long with a gross head of about 195 m. The catchments area is about 8 square kilometres, of which about 50 %t is 900 m above mean sea level (MSL). There are no major glaciers in the region, but there are three smaller lakes and a sump area, which contribute some storage capacity for the hydropower station. The annual inflow for the period 1966 to 1995 was calculated to be about 0.64 m^3/2.

The company responsible for the hydropower plant is Ryssdalen Kraft A/S, which is wholly owned by the owners of the Ryssdalen farm. The farm is based on traditional activities with sheep and milk production.

The aim of this project was to make use of the available resources at the farm. The external conditions for traditional agriculture have become poorer over recent years and therefore a new possible source of income could contribute to maintaining the economic viability of the farm in the future.

The river had been considered a valuable resource for several years, and the falling cost of small hydropower station technology in recent years means such a plant is now potentially profitable.

Description

The inflow to the power plant was increased by guiding two smaller streams into the river along approximately 150 m of pipe.

The technical data is given in the table below:

Type of turbine	Pelton
Capacity	1,250 kW
Max operating flow	800 l/s
Min operating flow	Approx. 25 l/s
Gross head	195 m

Promoters and parties involved

The owners of the farm did not have the necessary skills to design and construct the hydropower station on their own and therefore engaged the local engineering company Ing Hermod Seim for this pupose. Ing. Hermod Seim was responsible for the whole of the design and installation and local contractors did most of the work. The owners assisted in all parts of the construction work.

Financial resources

The total investment cost of the plant was NOK 6.5 m (€0.87 m). The project received a grant of NOK 30,000 (€4,000) for the preliminary study from the authorities.

The owners have a loan from the local bank, Sparebanken Sogn og Fjordane of NOK 6 m (€0.7 m).

The sole source of income for the power plant is from supplying electricity to the grid. For practical reasons (long distances, difficult terrain etc.) the plant does not use its own electricity.

Results

The construction work was carried out without any major problems or delays. The contractors delivered the components on time and the installation process took place as planned.

Energy production

The estimate for the annual energy output was 5.7 GWh, although after three years of operation the average is somewhat below that figure. The reason for the low production is that there have been some very dry years. In order to increase output in dry seasons in future the owners plan to feed an additional stream into the river.

Environmental

Care has been taken to reduce negative impacts on the environment. The river used is not easily visible in the surroundings and a large portion of the materials used in the construction of the dam were natural. The penstock and the electricity cable from the plant are both underground.

Socio-economic benefits

Running a small hydropower plant without a large reservoir is relatively time consuming. Due to the large variations of inflow the plant needs to be supervised daily most of the year. Hence, the power plant has created extra (part time) work at the farm.

Financial result

The income from the power plant was low in the first few years after installation, but in the long term there are possibilities for a reasonable profit.

Potential for replication

No special design or building skills are needed to set up a hydropower plant of this kind, but enthusiasm and having the necessary time available to operate the plant are essential.

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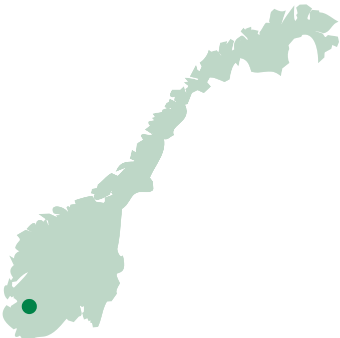
Country: Norway
Location: Jondal
Year: June 2000

ENERGIE



MODIFICATION OF EIDEFOSSEN HYDROPOWER PLANT IN JONDAL

The River Jondal flows through Hardangerfjorden, near Jondal. the hydropower plant is situated about 5 km east of the centre of Jondal.

The hydropower plant consists of two older units with capacities of 1,100 kW and 500 kW and a new 2,500 kW unit. Installation of the third unit has increased annual output from 9 GWh to about 16 GWh.

Description

The plant data is given in the table below:

Gross head	70 m
Average energy equivalent	0.162 kWh/m^3
Maximum operating flow	6.6 m^3/s
Utilisation period	4,200 h

The plant consists of 3 generating units. Units 1 and 2 were installed in the 1950's and 60's. Unit 3 was installed and commissioned in June 2000. The technical data for the three units is given in the table below:

	Unit 1 (1954)	*Unit 2 (1959)*	*Unit 3 (2000)*
Turbine type	Francis	Francis	Francis
Design head	68 m	68 m	68 m
Turbine output	1,100 kW	500 kW	2,470 kW
Speed	750 rpm	1,000 rpm	750 rpm
Generator output	1,200 kVA	500 kVA	2,700 kVA
Generator voltage	5,250 V	5,250 V	690 V

Plant modifications

The Francis turbine in unit 3 is fitted with the newly developed x-blade runner, giving the machine very high efficiency and excellent cavitation properties. This development made it possible to reduce the cost due to high synchronous speed. The x-blade design was developed for a large project in Venezuela with ten 700 MW units. This shows that small hydropower project may also benefit from developments aimed at large hydropower projects.

The original steel penstock, which supplies unit 1 and 2 was sand blasted and painted. Unit 3 was equipped with a new penstock with a length of 90 m, DN 1,200, PN 10 from Flowtite. The material of the penstock is glass fibre reinforced polyester, which has excellent properties for penstock purposes. The penstock has an inclination of up to 49 deg.

From the electrical point of view the new plant is not typical of small hydropower plants in Norway. The 22 kV bus bar at the plant is a critical component for the local utility, with 4 power lines and 3 generating units. The only connection to the to the 66 kV main grid comes in to the local area over this bus bar. Unit 3 is the only unit in the area that can operate in island mode and supply the Jondal community with electricity when the connection to the main grid fails. Hence, in electricity supply terms the plant is a hybrid of a typical small hydro power plant and a large power plant, due to the significance of this point to the utility grid.

The mini-hydroelectric design for the plant was supplied by Siemens, which also added additional standard modules in order to meet the requirements of more complex parts of the plant.

The generators for units 1 and 2 were kept, and only the cables and measuring transformers were replaced. The synchronous generator for unit 3, which was manufactured by Alconza, is a typical horizontal machine with a sleeve bearing, flywheel and overhung Francis runner. The machine is water-cooled.

The original transformers for units 1, 2 and the station supply were kept. The cast resin transformer for unit 3 is placed only few metres from the generator in the machine hall. This makes it easy to transfer the energy on bus bars from the generator to the transformer (approx. 2,600 A rated current).

The old 22 kV switchgear in the plant was removed and replaced with new SF6 isolated switchgear manufactured by Siemens, type 8DH10, 9 cubicles in total.

The generating units are monitored by an integrated protection and control system, based on Siemens Simatic PLC. The load control centre uses SCADA and the system may be operated from outside the centre using a portable computer (and a cellular phone), for instance. This allows a rapid response when the load control centre is not manned.

Promoters and parties involved

- The plant is owned by Jondal Energiverk.
- Spilde Entreprenør AS was responsible for the civil engineering work.
- Voith Siemens Hydro Power Generation AS was the contractor for the generator, transformer and control system.
- GE Hydro was the contractor for turbine, valve and penstock.
- Siv.ing S. Bendiksen provided consultancy.

Jondal Energiverk was involved in the installation work in cooperation with Voith Siemens and was responsible for project planning and construction planning.

Financial resources

Total investment:	NOK 16 m (approximately € 2.1 m).
Subsidies:	The project did not receive any subsidies.
Source of revenue:	The plant is delivering electricity to the grid.
Loan:	The project was financed with a 30-year loan.

Results

The project was implemented in accordance with the original plan. There were no major delays.

Energy production

The three units produce about 16 GWh annually.

Financial results

The electricity generated is sold on the electricity as “Green electricity”.

The price of the development is calculated at 1.51 NOK/kWh (0.20 €/kWh). At this price the plant made a profit from day one.

Environmental benefits

With the new unit installed the hydro power plant will produce an additional 7 GWh and thereby reduce the need for energy from other energy sources.

Potential for replication

The low cost of the development shows the large potential for replication on similar locations.

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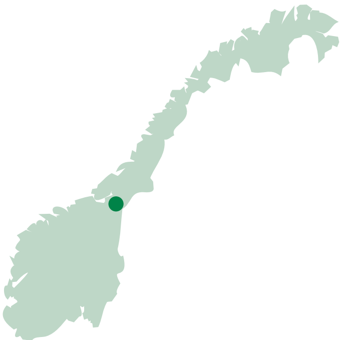
Sector: Small Hydro
Country: Norway
Location: Tydal Municipality, Sør-Trøndelag
Year: September 2000

ENERGIE



FOSSAN MINI HYDROPOWER PLANT

This project has demonstrated that small-scale hydropower installations can be integrated into large existing hydro power plant systems. At selected locations integration of small-scale hydropower installations within the existing system is possible without any major modification of the environment. This is the case for the Fossan small hydropower plant, where the existing diversion-tunnel for the larger Tya hydropower plant (37 MW) is used for the power plant, and the plant has been built underground.

Description

Fossan hydropower plant has been built underground so as to minimise its impact on the surrounding environment. The plant uses the existing diversion tunnel for the Tya power plant (37 MW). A sluice in the existing tunnel diverts the water into a new by-pass tunnel where the new plant is located. Downstream from the plant, the water is diverted back to the original tunnel and then out into the lake, which provides the water for the Tya power plant.

Access to the plant is via the local farm along a 150-m access tunnel.

The generated power is transported to the large Tya power plant via an underground cable and from there it is fed into the grid.

The integration of Fossan power plant does not disturb the draw-off period of the reservoirs connected to the Fossan and Tya power plants. Hence, the construction of the plant did not need a licence from the water authorities, only a permit from the local authorities.

Technical data

Gross head	28 m
Maximum inflow, turbine	10 m^3/s
Maximum power, turbine	2.5 MW
Maximum power generator	2.6 MVA
Optimal efficiency, turbine	94.8 %
Average annual electricity production	12.6 GWh/year
Average energy equivalent	0.068 kWh/m^3
Annual inflow	273 $*10^6$ m^3

Promoters and Parties Involved

Trondheim Energiverk Kraft AS (TEV), as owner of all the power plants on the river, and the main contractor Møller Energi AS agreed on a contract to build the integrated power plant in the summer of 1999. Møller Energi AS was the main contractor for the construction of the power plant and was responsible for the mechanical parts of the hydro power plants. The subcontractor responsible for the civil engineering work was Veidekke ASA and Voith Siemens AS was responsible for supplying the electro-technical components of the power plant.

Financial Resources

Investments:	Total investments: NOK 26 m (Approx. € 3.5 m)
Price of development:	2. 06 NOK/kWh (0.27 €/kWh)
Source of revenue:	The power plant delivers electricity to the grid
Borrowing:	100% equity financed

Results

An initial permit application was submitted in May 1998. In October 1998 the permit was approved and the same month contractors were invited to visit the site. The contract with the contractor was signed in June 1999 and construction work began in August 1999. The plant was commissioned in September 2000.

Energy production:	In a year with average rainfall the annual production is 12.6 GWh/year.
Environmental:	The projects will have no impact on the surrounding environment. The entire construction has been built underground inside the mountain and existing buildings of the Tya power plant have been used. The electricity generated is 100 % free of emissions of carbon dioxides.

Potential for Replication

The project could be replicated in locations were there is an existing large hydropower plant.

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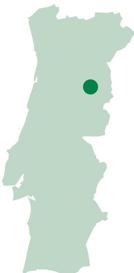
Sector: Small Hydro
Country: Portugal
Location: Manteigas
Year: April 2000

ENERGIE



SERRA DE ESTRELA SMALL HYDRO PLANT

The power plant is located in the heart of the “Serra da Estrela Natural Park”, which meant that its construction had to take into account the surrounding environment. The resulting plant is well integrated into the local landscape.

Description

The main technical features are:

- A small forebay with 1 m of head and equipped with a fish ladder.
- A net head of 317 m and a totally buried headrace with a length of 3.3 km and a capacity of 2.3 m/s.
- A partially buried powerhouse equipped with a horizontal axis turbine and an asynchronous generator (7 MVA).
- A power transformer and a power line (60 kV) leading the power station to the public electric grid.

Promoters and parties involved

The project is owned by Hidroeléctrica de Manteigas, a joint-stock company of which the majority shareholders are the Municipality of Manteigas and Generg.

Furthermore, since the outset, the project has been supported and evaluated by a multidisciplinary Accompanying Commission comprising technicians from the Natural Park, Environment Regional Directorate, Agriculture Regional Directorate and Local Environment Associations.

Financial resources

- Total investment : €6.48 m.
- Co-financing by “Programa Energia” (Portuguese support Programme): €2.6 m.
- Other details:

  A bank loan of €0.95 m.

  A loan from the EFTA Fund of €1.50 m.

  (both for a period of 24 months)

Results

No special problems were encountered, and from the outset the project was monitored by a multidisciplinary Accompanying Commission comprising technicians from the Natural Park, the Regional Environment Directorate, the Regional Agriculture Directorate and Local Environmental Associations.

- The expected energy production in an average year is about 16 GWh.
- €1.1m (value of the energy sold, data of 2001).

The all hydroelectric complex was designed to ensure full integration with the surrounding environment and the following features are worth highlighting:

A forebay, equipped with a fish ladder, and well integrated in the local landscape.

A totally buried hydraulic circuit, running alongside an existent rural road, special construction methods having been used in order to minimise any negative impact.

The powerhouse is partially buried and was built with local materials. It has been designed to as to harmonise with the building style of the region and minimise the noise caused by the equipment.

A power line designed to reduce to the minimum the environmental impacts.

Potential for replication

There are other sites in Portugal that have potential for the implementation of similar projects.

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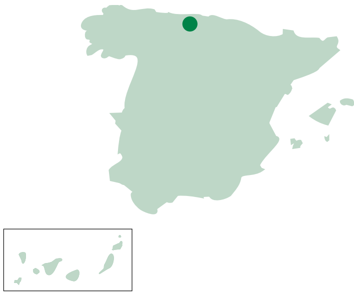
Sector: Small Hydro
Country: Spain
Location: Asturias (Northern Spain)
Year: March 2001

ENERGIE



PURÓN HYDROELECTRIC POWER STATION

The first concession to exploit the river Purón for hydroelectric purposes dates back to 1915 and the hydroelectric plant was based on an earlier one built in 1900.

During the 60's operation of the hydroelectric plant stopped and the entire hydroelectricity generating installation was abandoned, with the exception of the diversion dam and leat, which were used to supply a fish farm.

Subsequently (8th May 1995) Llanes Council (Ayuntamiento de Llanes) was granted the right exploit up to 1,500 l/s with a gross head of 27,301 m. On 28th October 1996 the rivers authority modified the concession, increasing the maximum utilisable flow to 2,250 l/s.

On 6th March 1997 Llanes Council and the Institute for the Diversification and Saving of Energy (Instituto para la Diversificación y Ahorro de la Energía, IDAE) signed a lease on the hydroelectric exploitation concession, granting the IDAE the right to operate the concession so as to modernise and expand the Purón hydroelectric power plant under a third-party finance (TPF) agreement.

Under the contract the Council is responsible for general cleaning work on the installations and renovation of the power station building and the return canal. For its part, the IDAE is to provide the investment for the electromechanical equipment, electrical system, control and electricity line, and the other civil engineering work (penstock, raising the dam, restoration of the leats and diversion dam, etc.).

The design of the building work at the station and associated installations, and the materials used in its façades and roofs have been selected to harmonise with the local architectural style.

Description

The profile of the dam has been modified in two ways. The diversion dam has been raised 372 mm to obtain the new flow rate through the plant and to improve its discharge capacity. At the same time, it has been given a more hydrodynamic shape than before.

A minimum flow of 115 l/s is guaranteed in the river to protect the river ecosystem. This is doubled in November, December and January to allow trout to spawn.

Electro-mechanical equipment

The generating set is located inside the power station building, together with the electrical panels and switchgear, transformers, hydraulic unit and auxiliary equipment.

The turbines are of the horizontal axis Francis type, directly coupled to the generator. The turbine and generator share a single shaft, with the turbine overhung. The turbine has a power of 413 kW and rotates at 500 rpm.

The generator is of the asynchronous, three-phase, horizontal axis type, with a nominal power of 480 kVA at 380 V and 500 rpm.

There is also a hydraulic unit to actuate the turbine distributor and guard valve.

Sufficient automatic control mechanisms have been built into the plant to enable it to operate unattended. No human intervention is required during operation or during starting and stopping in response to changes in the water level in the inlet chamber.

Electrical equipment

Once the electricity is generated at 380 V in the form of asynchronous alternating current, it is stepped up to 16,000 V by a 400/22,000-16,000 V transformer. This voltage is due to be changed to 22,000 V when the power utility modifies the grid operating voltage.

The power station is connected to the grid over a 24 kV line and three switch bays: the actuation bay, line protection bay and measurement and protection bay.

The low tension panel is of metal construction, comprising three connected panels referred to as the generating set panel, auxiliary services panel and control panel.

The system is controlled by a PLC, which performs both control and supervision tasks while the plant is operating automatically. In this operating mode the PLC is able to connect and disconnect the plant to and from the grid, and perform the necessary sequences of operations. Once the generating set is running the plant operates in level regulation mode.

Promoters and parties involved

The IDAE acted as the promoter and the sole partner involved is Llanes Council, participating as concession holder.

Financial resources

Excluding the cost of restoration of the power station building and the return leat, and of clearing the undergrowth from the site, the total investment, which came to €797,000 was financed by IDAE under a third-party finance (TPF) agreement.

Under the terms of the contract with Llanes Council, the IDAE will remain involved in the project until the investment has been recouped.

Llanes Council receives 20% of the income from the sale of electricity and the IDAE the remaining 80%.

Results

According to the forecasts made at the start of the project, the average annual output is estimated at 1,600 MWh, implying an annual income of €100,000 at a price of 6.36 €c/kWh.

The power station generates 138 toe (tonnes oil equivalent) a year of electricity from a non-polluting renewable resource with a limited environmental impact.

Potential for replication

The potential for replication is moderate.

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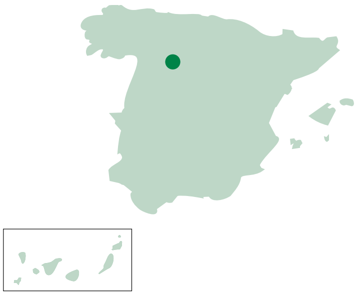
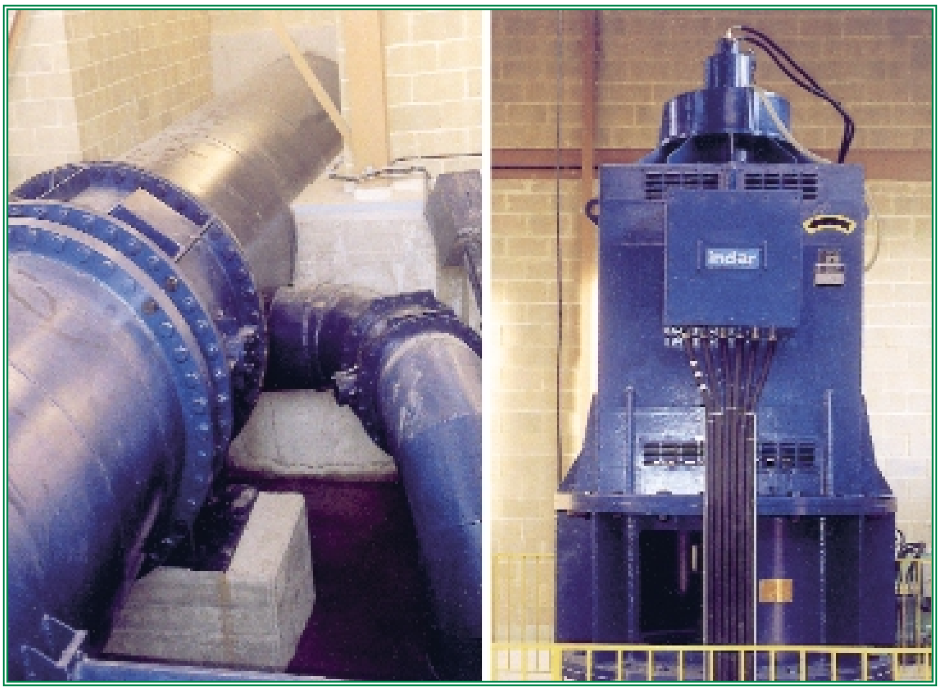
Sector: Small Hydro
Country: Spain
Location: Selga de Ordás (León)
Year: 1999

ENERGIE





HYDROELECTRIC POWER STATION AT SELGA DE ORDÁS

The Selga de Ordás reservoir, located on the course of the River Luna, is owned by the state and has been in operation since 1963. It is a gravity dam with a length of 232 m and a height above its foundations of 14.4m. Its purpose is to act as a secondary dam to the Barrios de Luna dam situated 19 km upstream, and to supply water to the city of Leon and irrigation water to an area of 45,000 ha.

By a resolution passed on 17th May 1994 the Confederación Hidrográfica del Duero (Duero river authority) granted the Institute for the Diversification and Saving of Energy (Instituto para la Diversificación y Ahorro de la Energía, IDAE) a concession to exploit the outflow from the Selga de Ordás dam for hydroelectric generation purposes, with a maximum permitted flow of 23 m^3/s. The resolution was modified by a further resolution on 5th July 1995, establishing a permitted flow under the concession of 6 m^3/s.

Under the terms of the concession only the flow set by the Confederación Hidrográfica del Duero can be used to drive the turbines. This flow is that leaving the Selga de Ordás dam via the river course.

The generating facility is owned by the IDAE. On 28th April 1999 the generator was connected to the grid, the relevant tests carried out and the station brought into commercial operation.

Description

The inlet is located in the abutment on the right-hand side of the dam. It does not affect the Acequia de la Plata irrigation canal, and has a minimum effect on the dam. A 1.7 m diameter circular hole was made. This was lined with steel and equipped with the auxiliary components necessary for a hydroelectric system, including a sluice gate and trash rake.

A 0.7 m diameter bypass pipe was also installed at the station. This takes off from the inlet pipe and flows out into the return channel. In the event of the generator's being shut down, the pipe is able to ensure the environmental minimum flow of 2 m^3/s is maintained in the river Luna while the turbine remains out of operation.

The by-pass valve has a hydraulic closure and counterweight opening mechanism.

The discharge channel is located adjacent to the power station building's access platform at a distance of about 5 m from the stilling pool to avoid undermining the footing of the dam.

The station's turbines are driven by water flowing at the rate permitted by the river authority, which is in the range of 2 to 6 m^3/s. Operation is based on regulation of the flow rate and monitoring of the level, as during operation the water level in the dam is between 963.70 and 961.00 m.

Electromechanical equipment

The generator set is located in the power station building, together with the switchgear, auxiliary equipment and transformer system.

The turbine is of the Kaplan type, with a vertical axis, double regulation and 450 kW maximum generating power at a maximum flow of 6 m^3/s and a rated head of 8.5 – 5.8 m. The rated speed of the turbine is 333 rpm and the turbine shaft is directly coupled to the generator.

The generator is a three-phase, asynchronous unit with a rated power of 450 kW. It delivers power at 380 V and 50 Hz at a rated speed of 333 rpm.

A 1,700 mm diameter flap valve with a hydraulic opening mechanism and counterweight closure has been fitted as a shut off valve.

The system also includes a hydraulic unit to operate the distributor blades, the runner blades, and the two valves. It also includes a pump system to remove water from the turbine pit.

Electrical equipment

The power transformer is a three phase unit with a rated power of 630 kVA, silicone insulation and a ratio of 15 kV/0.4 kV.

The transformer station is located inside the building. A specific area, which is directly accessible from outside the building, has been set aside for the power m. The transformer is connected to a new 241 m long electricity line linking it to the town of Selga de Ordás.

The power station's automatic controllers enable the station to be started and stopped automatically depending on the level of water available to run the turbine. The station has been designed for unmanned operation, thereby avoiding the need of personnel to be present while it is functioning.

The power station can be controlled on-site or remotely. To enable it to be controlled remotely a programmable logic controller has been installed and the necessary inputs and outputs set up. This PLC is connected to a personal computer at the power station and a communications modem to enable it to be controlled from the offices of the IDAE.

Promoters and parties involved

The owner is the Institute for the Diversification and Saving of Energy (Instituto para la Diversificación y Ahorro de la Energía, IDAE).

Financial resources

The investment in the power station came to €996,500, which was provided from the IDAE's own resources

Results

a) In energy terms

The power station supplies clean, renewable energy to the grid with a minimum environmental impact. It produces an output equal to 172 tonnes oil equivalent (toe) of energy.

b) In economic terms

According to the flow forecasts, an average annual output of 2,000 MWh has been estimated, implying an annual income of €134,626.

Potential for replication

The project has only limited replicability given the difficulty of finding similar conditions in terms of the location and the availability of hydropower resources.

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Sector: Small Hydro
Country: Sweden
Location: Ängelholm, near Helsingborg
Year:1998

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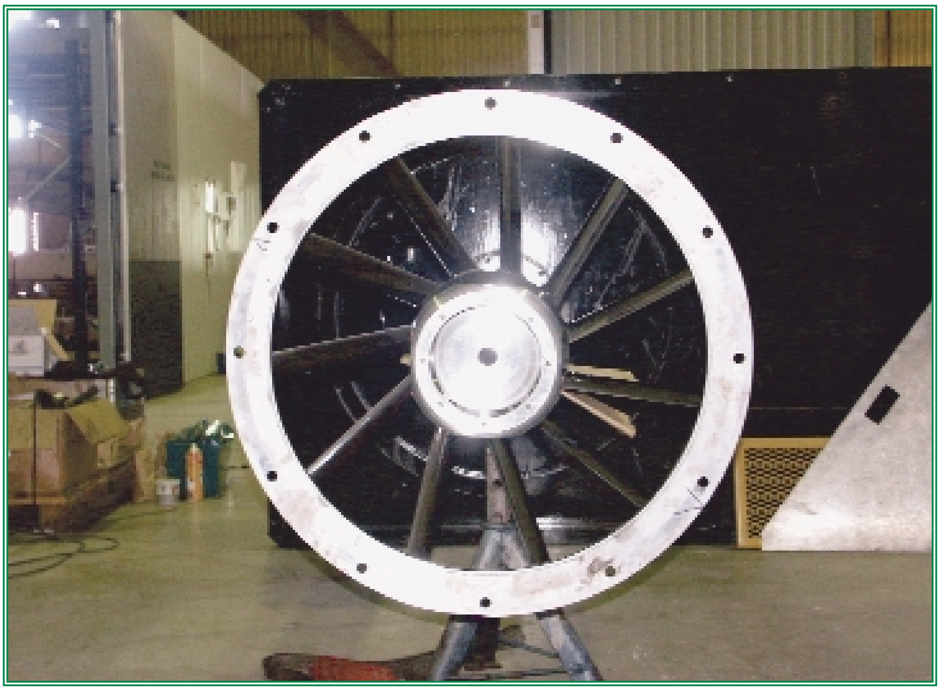

RENOVATED OLD WATER MILL WITH NEW PROTOTYPE TURBINE

In this project an old water mill building has been restored to house a catering firm. The existing Francis turbine in the old mill, which had not been used since the 1960's, could not be brought back into operation without major repairs and therefore a new turbine was installed. The chosen turbine is a new type of a semi-Kaplan turbine developed for very low head applications by the Swedish company Cargo and Kraft Turbine AB.

The aim of the project was to generate electricity for the catering company's own use.

Description

The old Fracis turbine in the mill was replaced with a new 700 mm diameter semi-Kaplan turbine. The renovation preserved many parts of the old generating station.

The head at the mill is 2.2 m and the average flow is about 3 m^3/s. About one third of the river flow bypasses the hydropower station allowing fish through and minimising the environmental impact.

The runner has flexible blades, which may be pitched so as to minimize drag and allow it to operate at idling speed.

The turbine is connected to an asynchronous generator with a capacity of 33 kW.

Technical data

General	Head	2.2 m
	Average flow (river)	3 m^3/s
	Discharge capacity	1.2 m^3/s
Turbine	Type	Semi-Kaplan with fixed guide vanes and adjustable runners
	Diameter	700 mm
	Mechanical power	30 kW
Generator	Type	Asynchronous
	Maximum power	33 kW
	Electrical power	22 kW

Dissemination activities

The project has been presented by the International Energy Agency in CADDET Technical Brochure No. 144, www.caddet-re.org.

Promoters and parties involved

The owner of the plant is the catering company Lunch & Partyservice i Skåne. The contractor was Cargo & Kraft Turbin AB.

Financial resources

Total investment

The total investment in the plant in 1997 was SEK 400,000 (€44,000), of which the electronic equipment accounted for SEK 40,000 (€4,400).

Source of revenue

The hydropower plant is reducing the catering firm's electricity bill as the plant covers most of its electricity needs.

Results

The plant was installed "in one day" without any problems and has been operating continuously from the outset.

Energy production

The hydropower plant generates about 100 MWh of electricity annually, which covers about 2/3 of the annual electricity needs of the catering company. Each year the company sells about 20 MWh to the grid, and buys about 50-60 MWh from it.

Financial results

The very low price of electricity in Sweden during the last few years makes mini-hydropower plants very sensitive to the number of hours of operation and maintenance. To date the plant has not needed any maintenance, but some work is involved removing leaves, for example.

Environmental results

The project utilises only one third of the average flow in the river. In addition, the owner does not utilise the full potential of the station in order to reduce the environmental impact of the plant. During an average year the plant generates about 100 MWh, and has a maximum generating capacity of about 130 MWh.

The station uses non-toxic lubricants to reduce the environmental impact.

Potential for replication

The low installation cost of the semi-Kaplan turbine makes this concept attractive in a number of other locations with very low head in Sweden, and elsewhere in Europe. The plant has shown itself to be profitable in Sweden, which has very low electricity prices, thus indicating significant potential in other European countries where the electricity prices are much higher.

For more information

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Sector: Small Hydro
Country: Sweden
Location: Hälla (near Söderköping)
and Ursäter (near Gusum)
Year: October 1997

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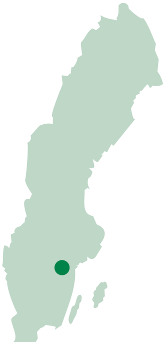

NEW HYDROPOWER PLANTS IN TRADITIONAL STYLE BUILDINGS

Hydropower has been utilized in the region since the Middle Ages, originally by means of watermills. Continuing this tradition, in the 1920's, a small generator was installed to produce electricity. Electricity generation ended in the 1960's.

In 1993 Forsaströms Kraft AB acquired the rights to the Yxningen dam, the largest in the area, and the possibility of generating electricity began to be discussed.

Forsaströms Kraft AB obtained the permits necessary to build the new power plants in the summer of 1996. In August of the same year work on the new Hälla and Ursäter power plants began. The official inauguration of the two power stations took place on 7th October 1997.

Description

The old dams and weirs have been rebuilt and new pools have been created as a habitat for fish. The new pools have regained their old function as places for bathing and are working as an effective nitrogen trap whereby aquatic vegetation takes up a large part of the excess fertiliser run-off from the surrounding fields[1].

The Yxningen Lake is large and therefore about half the annual inflow for the power stations is regulated by the lake. During normal operation the inflow is stored in the spring, summer and autumn and then used during winter when electricity consumption peaks. The power plants in Hälla and Ursäter have a capacity of 250 kW and 160 kW, respectively. Both plants are constructed for power production only, i.e. they cannot contribute to regulation of the small dams in connection with the plants. The annual production of the two plants is about 1.8 GWh.

The two power plants have been constructed in the traditional local style so as to blend in with their surroundings. The Hälla power station has been built with a wooden façade, which has been painted red, as it is traditional in Sweden. The old water mill on the site has been kept. The Ursäter power station is of brick construction, in the same style as the old power station beside it. Special care has been taken over noise reduction at both plants.

[1] *Euroenergy 21 Spring 00, Vattenfall (Available from www.vattenfall.se)*

Technical data

	Plant name	
General	*Hälla*	*Ursäter*
Gross head	6.5 m	4.3 m
Average inflow	2.4 m³/s	1.8 m³/s
Annual production (average)	1.1 GWh	0.75 GWh
Turbine		
Type	Axial	Axial
Runner diameter	Ø 1,000 mm	Ø 1,000 mm
Number of revolutions	428 rpm	369 rpm
Capacity	240 kW	150 kW
Transformer		
Capacity	315 kVA	200 kVA
Voltage	20/0.4 kV	20/0.4 kV
Generator		
Type	Asynchronous	Asynchronous
Capacity	250 kW	160 kW
Voltage	400 V	400 V
Number of revolutions	1,000 rpm	1,000 rpm

Promoters and parties involved

- Constructed by Vattenfall' s subsidiary Forsaströms Kraft AB
- Civil engineering work by SIAB
- Design by VBB (now Sweco AB)
- Turbines and generators supplied by Turab
- Forsastöms Kraft AB later sold the plants to Sydkraft AB. Sydkraft AB has again sold the plants to the present owner Tekniska Verken i Linköping AB

Financial resources

Total investment

The total investment in the plant was SEK 9 m (€985,000). The investments is divided into two major parts:

- Licence work, compensation for damage, consulting etc. cost about SEK 1.5 m (€160,000)
- The construction of the Hälla power station cost about SEK 4 m (€430,000) and the Ursäter power station about SEK 3.5 m (€380,000)

Source of revenue

The annual revenue from the plants is about SEK 550,000 (€60,000).

The economics of the project were considered good in the long term due to the advantages of its relatively large scale. At the time of the investment Forsaströms Kraft AB had 13 power plants in the region and therefore the operation- and maintenance costs were reduced.

Results

The project has met with a positive response from the local municipality for the renovation of the old dams along the river from the Yxningen dam. The renovated dams together with the new power station Ursäter are reducing the problem of flooding in the community of Gusum.

The dam at Hälla has been constructed with deep channels making it excellent for crayfish, which local residents are allowed to catch for free.

Small islands were constructed in the reservoirs behind the dams, creating improved nesting sites for local birds.

Energy production

The power plants generate about 1.8 GWh annually.

Financial results

The project has shown that it is possible to construct power stations in a traditional style with only a small increase in the cost.

Environmental results

The annual electricity generated by the plants would replace about 590 tonnes of coal and reduce emissions of carbon dioxide by approximately 1,400 tonnes if the electricity were generated by a conventional coal fired power station [2].

Potential for replication

The low prices for electricity in the market during recent years make it difficult to make projects like this profitable.

On the other hand, if it were possible to get compensation for the renovation of the old dams and power stations there would be quite a few projects in Sweden and Norway that might be profitable.

For more information

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Consulting and design

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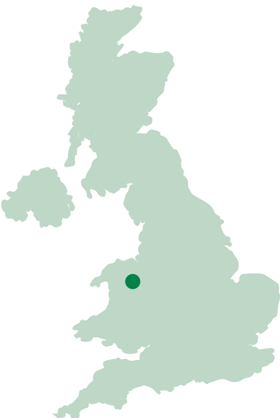
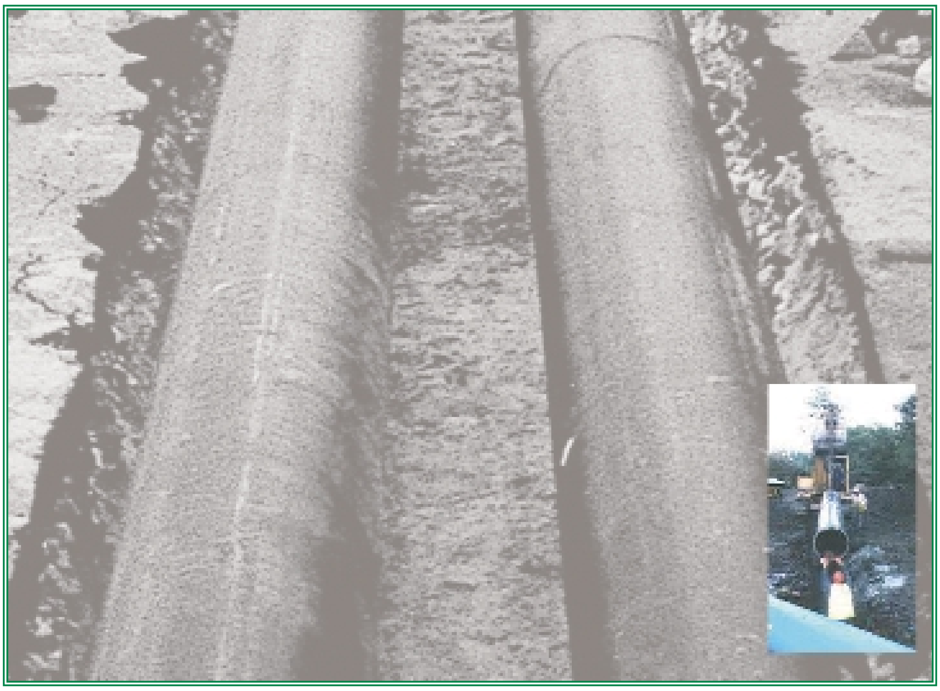
Photo by Kent Å Lindqvist

[2] Assumptions: Efficiency conventional coal fired power plant: 0.4, energy content coal 28,1 Mj/kg and CO_2-production from coal is 310 kg/MWh

Sector: Small Hydro
Country: U.K.
Location: Afon Iwrch river, Powys
Year: May 2000





AFON IWRCH SMALL HYDRO STATION

This small hydro station is located on the Afon Iwrch River (North of Llanrhaeadr-ym-Mochnant, in Powys), where the average annual rainfall of the 17.7 km^2 catchment area of the river is about 1452 mm (equivalent to an average river flow of 0.53 m^3/s).

It produces 1.26 m kW of electricity per year.

Construction began in October 1999 and it was commissioned in July 2000.

Description

The main technical features of the scheme are as follows:

A shaft-to-shaft direct coupling transmission and a horizontal-shaft 550-metre diameter Francis turbine, with a rotational speed of 1,000 rpm and a maximum power of 350 kW at 0.6 m^3/s.

Given the features of the river basin the maximum flow through the turbine is 0.6 m^3/s. The plant generates power by a synchronous, brushless, self-excited, self-regulated, two-bearing generator, which produces electricity at a 415 V at a rotational speed of 1,000 rpm.

The system takes water from the river via a pond with two weirs. The main lower wier, constructed across the river so as to form the small pond behind it, is about 1 m high and contains a device (a calibrated notch in the weir) designed to ensure the appropriate flow according to the requirements of the U.K Environmental Agency. It is only when the river's flow exceeds this residual level that the water flows over the second weir to one side of the pond, entering the intake chamber where it flows into the turbine inlet pipe.

A 10 mm mesh screen over the inlet prevents damage to the turbine by solid material and prevents fish from being sucked in. Apart from this, by means of ultrasonic sensors, the necessary flow of water feeding the turbine is guaranteed.

Water is returned to the Afon Irwch River from the turbine through a screened outlet pipe.

Additionally, and in order to ensure the monitoring of the operation of the installation telemetry has been included.

Promoters and parties involved

Owner and operator

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Financial resources

The total cost of the project (excluding VAT at 17.5%) was €800,000.

The installation awarded in 1997 a 15 year Non-Fossil Fuel Obligation (NFFO4) contract to supply 380 kW of electricity. Within the framework of this contract, electricity is sold for around 0.07 €/kWh. Considering that the operation and maintenance costs are very low, the payback period has been estimated to be 8.3 years for a working life of the plant of at least 20 years.

Results

The expected operating life of this plant is, at least, 20 years. Due to the natural variability of the flow (it is an upland river) it is expected that this plant will be operating 45% of the potential time.

It has been estimated that the plant produces enough electricity to meet the average needs of 330 homes.

In terms of emissions, it has been calculated that when compared with an equivalent output produced by a coal-fired station, the plant avoids the annual emission of about 950 tonnes of CO_2, 12 tonnes of SO_x and 5 tonnes of NO_x.

Apart from that, potential environmental impacts have been addressed with specific corrective measures in order to minimise them, following the instructions of the U.K. Environmental Agency.

Potential for replication

This project has considerable potential of replication, in particular considering that this was the first of a set of small-hydro installations (21) to be constructed in Wales by the same developer.

For more information

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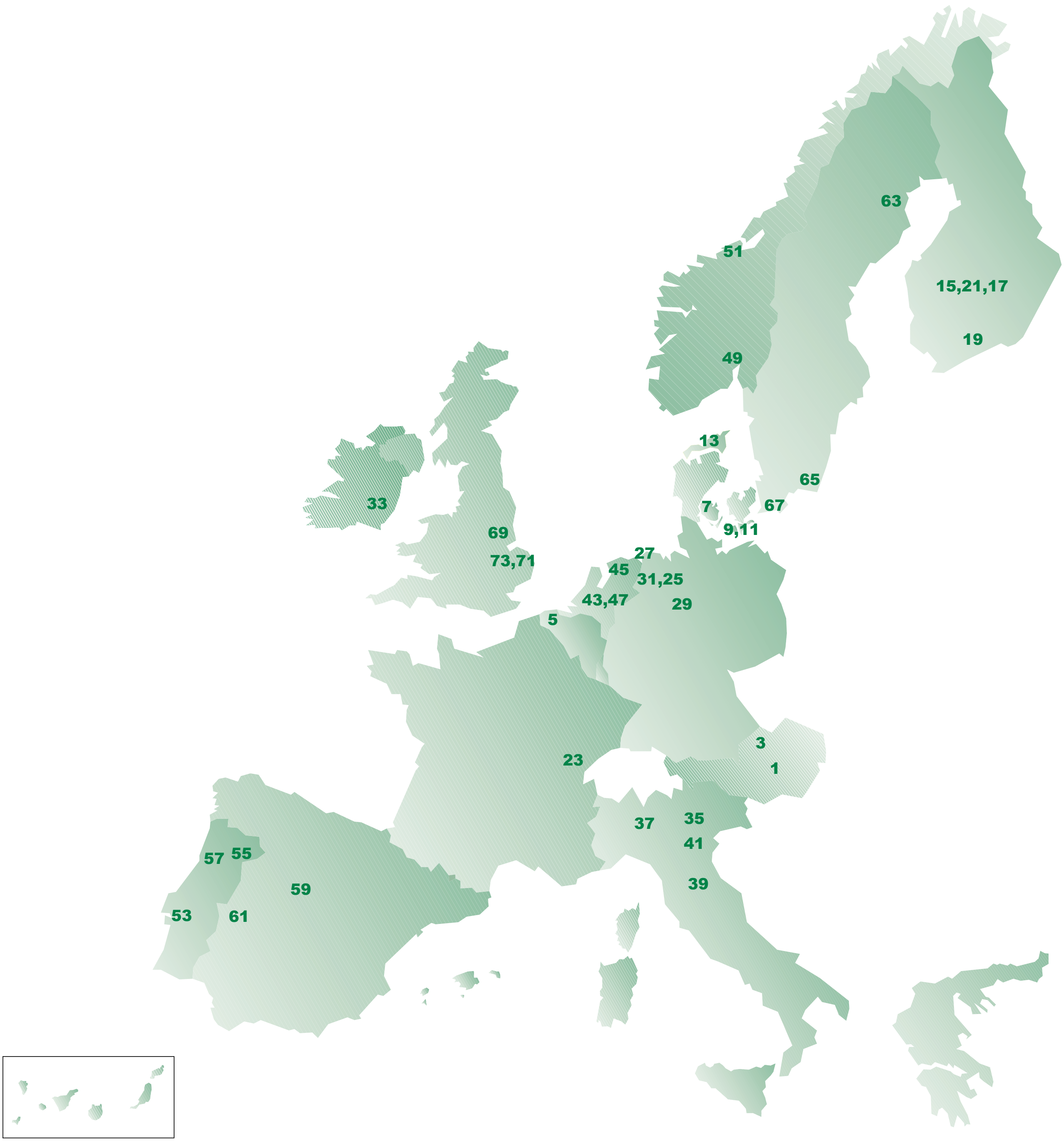
2 BIOMASS



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Sector: Biomass
Country: Austria
Location: Admont
Year: 1999

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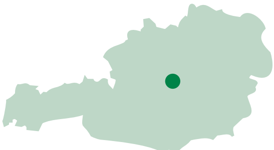

ADMONT, BIOMASS-FIRED CHP PLANT BASED ON AN ORC PROCESS

In 1999, a biomass-fired combined heat and power (CHP) plant based on an Organic Rankine Cycle (ORC) process, was implemented at the STIA timber processing factory in Admont. The objective of this project was to supply energy to, both the timber processing factory, and the local Benedictine monastery. It also substitutes fossil fuels and reduces emissions.

The STIA factory used to cover its process and space heat demand with one biomass-fired and two oil-fired furnaces. Three oil-fired furnaces provided heat to the Benedictine monastery. As these old combustion units no longer complied with technical standards, STIA timber processing factory decided to replace them with a new completely biomass-based system.

The project was the first demonstration within the European Community of a biomass-fired plant based on the ORC process. Previously ORC processes had mainly been used in geothermal installations and not in biomass-based systems.

Description

The plant uses sawdust and chemically untreated wood residues as fuel for its thermal boiler. This boiler is connected to the ORC plant via a thermal oil cycle. The ORC unit operates as a completely closed process utilising a silicon oil as its organic working medium. This is an environmentally friendly material. The oil is first pressurised and then vaporised by the thermal oil. Then it is expanded in a two-stage axial turbine, which is directly connected to an asynchronous electrical generator.

The thermal oil boiler covers the basic thermal load of the plant. If the heat consumption exceeds its capacity a standard hot-water boiler is brought into operation.

From the new biomass-fired unit, a 470 m district heating system supplies heat to the Benedictine monastery and the process heat consumers at the STIA Wood Industry.

Dissemination activities include a considerable number of visits by engineering companies, potential future clients and energy authorities in particular from EU countries. Furthermore, the new ORC technology has been presented at the 1st World Conference on Biomass in Seville and at the Austrian Biomass Conference, both in 2000.

Project characteristics

Biomass input [tonnes]	5,000
Nominal capacity of the thermal oil boiler [MW_{th}]	3.2
Nominal capacity of the hot-water boiler [MW_{th}]	4.0
Nominal electric capacity of the ORC process [kW_e]	400
Nominal thermal capacity of the ORC process [MW_{th}]	2.25
Auxiliary electricity consumption [W/kW]	10-13
Thermal efficiency of the thermal oil boiler [%]	70-75
Thermal efficiency of the hot-water boiler [%]	89
Thermal efficiency of the ORC process [%]	80
Electrical efficiency of the ORC process [%]	18
Overall thermal efficiency of the plant [%]	98
Thermal and electrical losses [%]	2

Promoters and parties involved

- STIA – wood processing factory: promoter, co-ordinator and owner of the project
- BIOS – BIOENERGIESYSTEME GmbH: planning, engineering and monitoring
- Kohlbach: combustion unit, flue gas condensation unit, rotational particle separator
- Turboden: ORC plant

Financial resources

The total investment costs for the biomass-fired CHP plant (excluding the hot-water boiler system) came to about €3,200,000 including monitoring and dissemination costs.

The project was partly financed by the Austrian Kommunalkredit AG, which contributed €890,000. The European Commission supported the project within the framework of the Thermie programme by a grant of €576,991. The rest of the project costs was financed by own capital and bank loans.

The operation and maintenance costs of the project amount to €381,000 per year, of which 67% are biomass fuel costs. The costs for maintenance and manpower are relatively low.

The revenues of the project consist of heat sales to the STIA wood-processing factory and to the monastery and electricity supply to the local utility. The payback period for the project is expected to be about 7 years.

Results

The performance of the plant was constant over the whole first year of operation. The plant was only shut down for a few days in the summer of 2000 for maintenance and due to minor problems related to incorrect measurement values on the instrumentation.

After installation and testing, two original components of the system - a glue water injection system and a rotational particle separator - had to be removed due to operational problems that proved impossible to solve.

The total net electricity production came to over 1,900 MWh in 2001 (4,750 full load hours of operation). The net electrical efficiency of about 18% could be maintained at partial load operation, which is very important for CHP plants in heat-controlled operation. The thermal energy output was equivalent to approximately 10,000 MWh. Revenues from heat and electricity sales total about €620,000 and €210,000 a year, respectively.

The new CHP plant substitutes fossil fuels at the Benedictine monastery and STIA wood-processing factory as well as electricity from fossil fuels by replacing the original five oil-fired combustion units. The oil-fired units at STIA are now only used as a stand-by. Furthermore, the new installation implies lower gaseous and particulate emissions, thus contributing to climate change mitigation and improvement of the air quality in the region. The emission reductions are about 68% CO_2 (2,800 toe/year), 86% SO_2 (15 toe/year), 48% NO_x (11 toe/year), 44% Total Organic Compounds (4 toe/year), 77% CO (21 toe/year), and 75% dust (10 toe/year).

Potential for replication

The results of the project have become a new technical standard for biomass-fired CHP systems in the 0.3-1.2 MW_{el} capacity range. In 2002, a new larger biomass district heating plant (1 MW_{el}) came into operation in Lienz as a follow-up EU demonstration project. Additionally, four more biomass-fired CHP plants based on an ORC process have been begun.

The project serves as a model for decentralised biomass combustion systems in the timber processing industry as well as regional biomass district heating systems with an appropriate demand for process/district heat with a view to producing electricity for in-house use or for grid supply.

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www.bios-bioenergy.at

Sector: Biomass
Country: Austria
Location: Ried im Innkreis
Year: Spring 2001

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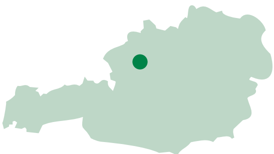

RIED IM INNKREIS, FISCHER/FACC BIOMASS TRI-GENERATION PLANT

Fischer is one of the world's leading manufacturers of skis and tennis rackets, and it is known for its technical innovations. The company employs about 590 people at its production facility in Ried im Innkreis. One member of the Fischer group is FACC (Fischer Advanced Composite Components), a specialist manufacturer of aeroplane components.

For about 30 years, the process heat demand of the high-tech Fischer production plant in Ried had been met by a steam boiler in conjunction with a back-up boiler, fired by heavy heating oil. Rather than convert this system to run on natural gas to reduce CO_2 emissions, the company decided to meet its energy needs using biomass. The reasons for this were environmental concerns and the company's conviction that renewable energy sources will become increasingly important in the future.

The biomass tri-generation plant at the Fischer factory came into operation in the spring of 2001. The new installation generates electricity, heat, and cooling for the manufacturing process of the factory. Furthermore, it provides space heating and air-conditioning for the production hall and the offices. This solution was provided under an "energy contracting" arrangement by a local consultancy firm Scharoplan. In this way, the project combines an innovative biomass installation with a modern financing scheme for the plant. Scharoplan received the Energy Globe Award 2001 for this project.

The 15-year-contract between Fischer and Scharoplan was signed in June 1999. It comprises targets such as the use of renewable energy in a high-tech industry, high security of supply and safety levels, reduction of regional emissions and contribution to the Kyoto commitments, and creation of socio-economic benefits for the region.

Description

The Fischer biomass tri-generation plant is fed by wood fuel, in particular bark, wood chips and sawmill wastes. Sufficient supply of good-quality biomass is ensured by the sawmill industry and the agricultural and forestry sector. About 180 m^3 of wood needs to be transported to the plant daily. The biomass is transported in an environmentally friendly way by using trucks on a railway branch line to deliver the fuel.

The biomass is fed into a combustion chamber. By means of a heat exchanger, water is heated to a temperature of 400°C at a pressure of 29 bar. The vapour then expands in a turbine, which is connected to an electrical generator. The water is condensed and transported back to the boiler. The remaining heat from the biomass boiler is used to provide process cooling and heating. Hot water at a temperature of 150°C goes into an absorption-refrigeration unit, where it generates process cooling of 18-22°C for the ski production unit. Process heat is delivered to the production unit at a temperature of 130°C. Process heat at 250°C and 290°C is supplied to two different manufacturing processes for aeroplane components. The heat produced is also used for space heating (100°C).

Project characteristics

Biomass input, bulk volume [m³/year]	50,000-60,000
Steam production [tonnes/hour]	10
Steam temperature [°C]	380
Maximum operating pressure [bar]	32 (safety valve)
Boiler rating [kW]	7700
Fuel heating rating [kW]	9625
Combustion chamber temperature [°C]	850-900
Electrical rating at the generator contacts [kW]	603
Turbine steam release pressure [bar]	4-6
Heat rating of the heating condenser and condensing refrigeration [kW]	6200
Condenser pressure [bar]	4-6

Promoters and parties involved

- Fischer/FACC: initiator
- Scharoplan: owner of the project, consultancy; planning, arrange funding (calling for tenders) and gather all necessary planning authorisations for this project.
- Urbas GmbH: suppliers of systems

Financial resources

The total investment came to about €5 m. Scharoplan financed 65% of this sum from the company's own capital and external finance. The remaining investment costs were financed by subsidies from the European Commission, the national government and the federal state of Upper Austria.

The financing of the plant was arranged via a third-party financing scheme, for which Sharoplan is responsible under the energy-contract with Fischer. The payback period for the project is estimated at 15 years.

Results

The most important problem during the construction phase was that the production process of the company Fischer/FACC could not be hindered or interrupted. Therefore, the work needed had to be carried out at weekends or during periods when the production process was shut down. Careful planning and close co-operation between Scharoplan and the technical management of Fischer made it possible to avoid significant interruptions occurring.

The annual output of the biomass tri-generation plant totals 26,000 MWh of heat, 1,000 MWh of cooling, 2,000 MWh of power, and 1,500 MWh of thermal oil. The total value of this output about €1,100,000 a year, of which 77% is heat production. The electricity generated each year has a value of €170,000.

By using biomass to cover its total energy needs, Fischer substitutes 3,000 tonnes of heavy heating oil per year. The project reduces CO_2 emissions by 9,456 tonnes per year. It also contributes to a decrease in the amounts of other polluting emissions in the region.

The socio-economic benefits of the project include the creation and preservation of jobs, totalling around 100,000 person-hours during the planning and construction phases, and three person-years for the operation of the plant. Furthermore, the project generates additional income for the agricultural and forestry sectors. Both sectors receive about €370,000 each from the purchase of their waste by-products by a new customer. The project also contributes to reducing the dependency on imported oil, which therefore benefits the Austrian economy.

Potential for replication

For a successful replication of this project at another site, the supply of the necessary biomass needs to be guaranteed. Furthermore, the project must comply with the conditions necessary for it to receive a subsidy.

For more information

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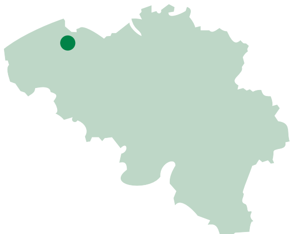
Sector: Biomass
Country: Belgium
Location: Ghent
Year: May 1999



GHENT BIOMASS PLANT

Built in the old dock area of Ghent, this plant is one of the largest of its type existing in Europe.

The plant is able to process several types of wastes: sewage sludge; organic waste from the food industry, pre-sorted biowaste such as fruit and vegetable scraps, fat sludge and abattoir residues.

200,000 tonnes of waste can be treated a year. Fuel is provided by the factories and farms located in areas located close to the plant (for this purpose, specific contracts were signed with the suppliers).

Description

The plant comprises four single-stage digesters with a total capacity of 12,000 m^3 (this configuration has been selected in order to guarantee adequate operation of the system and to improve the flexibility of the system according to waste type).

The composition of the waste treated by the plant is: sewage sludge, 25%; pig manure, 25%; industrial organic waste, 50%.

After preparing wastes for treatment in a suspension unit, they are fed into a buffer tank and finally to the digesters were anaerobic digestion takes place.

The gas produced from the fermentation processes (ranging between 30,00 and 40,000 m^3 per day) is piped to a non-pressurised gas tank and burnt in a CHP unit consisting of a Jenbacher 20 cylinder gas engine with 2.8 MW_e rated capacity and a synchronous generator, producing both electricity and heat. The electricity produced is sold and fed into the public grid.

Promoters and parties involved

Developers

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mav@jandenul.com

Financial resources

The total cost of the installation was €21 m and it was entirely financed by the private sector.

It has been considered that for a waste with 10% dry matter content the average price of processing is €24.8 per tonne. An average production of 10million m^3 biogas a year, with an equivalent primary energy potential of 250,000 GJ, was initially planned to be produced and converted by the CHP plant into 26,000 MWhe a year (sold to the public grid at an average price of 0.0595 €/kWh).

There is a partial subsidy of 0.0248 €/kWh due to the electricity being considered "green energy".

Results

Approximately 2.2 MWe of electricity is generated, at an electrical efficiency calculated to be 38.5%. Overall efficiency has been estimated to reach 87%. The electricity produced is used to supply the plant and the excess is fed in to the grid.

Additionally, heat and solid wastes are also produced. Heat is used for heating the four digesters where the fermentation takes place (keeping the temperature at about 35°C) and also for steam production (about 1.5 tonnes a day). In addition, the solid final product (around 15,000 tonnes a year) is used as compost or granulated fertiliser.

Potential for replication

One of the most specific characteristics of the plant is the flexibility of the process used, enabling it to treat different wastes in the same process. This feature is increasingly in demand when this kind of plant is installed, given the often strict legislative constraints, to which such plants are subject, particularly in terms of emission levels.

For more information

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Sector: Biomass
Country: Denmark
Location: Assens
Year: April 1999

ENERGIE

CONVERSION OF A DISTRICT HEATING SYSTEM TO USE A BIOMASS CHP PLANT

Assens Fjernvame Amba was founded in 1961 as a consumer-owned district heating plant running on oil. In 1984 a coal-fired plant was constructed and in 1989 the plant was modified to use wood pellets and dry wood chips.

In the mid 1990's the authorities requested that the district heating plant should be converted to a CHP plant. In 1997 the company decided to construct a biomass CHP plant, as natural gas was not available in the region.

The company used experience from the modified coal fired plant and know-how from Sweden in the design of the new plant.

Description

The boiler has been specially designed to burn a wide range of bio fuels, primarily wood chips with moisture content up to 55%, sawdust, chipped clean wood from industry and wood pellets. The plant utilises about 45,000 tonnes of wood a year. The wood used is 75% Danish, with the remaining 25% coming from the Baltic countries.

The bio fuels are carried from the biomass storage via a conveyor and a buffer silo to 2 pneumatic throwers, which blow the fuel into the furnace. Here, partial drying and gasification takes place while the fuel is still in suspension. The actual combustion takes place on a water-cooled vibrating grate with 3 air zones.

After leaving the boiler the flue gases travel through an electrostatic precipitator in order to clean the flue gas of fly ash, and subsequently through a condenser, if required.

From the boiler the steam is sent through a turbine with rotational velocity of 12,500 rpm. The remaining heat in the steam, not utilised in the turbine, is converted to heat in the district heating grid via two parallel heat exchangers.

Technical data

Energy input	17.3 MW
Electricity output	4.7 MW
Electric efficiency	27 %
Thermal output, net excl. flue gas condenser	10.3 MW
Thermal efficiency, net excl. flue gas condenser	60 %
Thermal output, net incl. flue gas condenser	13.8 MW
Thermal efficiency, net incl. flue gas condenser	80 %
Steam temperature, turbine	525 °C
Steam pressure, turbine	77 bars
Forward flow temperature	70-90 °C
Return temperature	30-45 °C

Dissemination activities

The plant is a part of the Danish Follow-up Programme for Small Scale Solid Biomass CHP plants established by the Danish Energy Authority (See www.ens.dk for more information).

Promoters and parties involved

The plant is owned by Assens Fjernvame and it was built by Ansaldo Vølund (now Babcock & Wilcox Vølund) with assistance from the consulting company COWI.

Financial resources

Total investments

The total investment was DKK 126 m (€17 m).

Subsidies

The Danish Energy Authority supported the project with DKK 25 m (€3.4 m).

Pay back period

The expected payback period is 15 years.

Results

The plant was built on schedule. It was commissioned in February 1999 and in March/April 1999 the plant was in commercial operation.

In addition to the usual teething problems, the plant suffered a turbine failure in December 1999 due to lack of lubricating oil.

The electrical efficiency has been less than expected during the start up period. Currently the plant is operating at an electrical efficiency one per cent lower than that guaranteed in the contract.

During the measuring period the availability was lower than guaranteed.

Energy production

The energy sold for the years 1998/99 to 2001/02 is shown in the table below:

	Heat sold [MWh]	*Electricity sold [MWh]*
1998/99	55,976	5,496(*)
1999/00	52,629	17,664
2000/01	54,635	23,589
2001/02	53,865	25,018

(*) The CHP plant was completed in April 1999.

The heat sold is calculated as the heat produced net of the heat loss in the grid. For 2000/2001 the heat losses were 13.1 GWh.

Financial result

The result for 1st June 2001 to 31st May 2002 shows that the CHP plant had a revenue of DKK 1.6 m (€215,000). The plant's revenue will contribute to lower heating prices for the customers in future years.

Environmental result

Energy production from wood is carbon neutral and does not result in increased overall emissions of carbon dioxide. The plant is contributing to fulfilling the aim set by the Danish government on increasing the amount of "green" energy production.

The plant has been constructed to comply with local emissions limits, which are:

CO, max	270 mg/Nm^3
NO_x, max	450 mg/Nm^3
Dust	40 mg/Nm^3

(Based on 10% oxygen in dry gas)

Potential for replication

Experience from the project has shown that the biomass could be bought on the international market, hence the most crucial factor in building a biomass CHP plant is to have a sufficient local heat demand.

For more information

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www.volund.dk

Sector: Biomass
Country: Denmark
Location: Nysted
Year: 1998

ENERGIE

NYSTED BIOGAS PLANT WITH CHP-UNIT

The biogas plant in Nysted is constructed and owned by the cooperative Nysted Biogas A.m.b.a. The plant is located in the village Kettinge in Lolland.

The cooperative's main goal from the plant was to utilise the biogas potential of manure and other biomass in an environmentally friendly way and to set up a financially profitable and ecologically sound solution to the problem of the storage, handling, and distribution of manure.

Description

The plant uses mesophilic digestion at 38ºC. The retention period in the reactor is about 21 days. The annual planned quantity of biomass is 87,000 tonnes, from which 65,000 tonnes is pig manure, 12,000 tonnes is cattle manure and 11,000 tonnes is other biomass. The plant may also receive source separated municipal waste. The digested biomass is sanitised at about 60ºC in 8 hours. The plant produces on average 8,500 Nm^3 of biogas every 24 hours, with an average methane content of 70 %. The biogas produced is utilised in the CHP unit at the plant. The CHP unit, which has a total capacity of 2,300 kW, delivers heat to the district-heating grid in Kettinge and electricity to the power grid. In addition to the CHP unit a gas/oil boiler is installed to cover the peek loads during winter and act as a backup during maintenance.

Technical data

Animal manure (planned)	75,000 toe/yr
Industrial waste	13,000 toe/yr
Biogas production	
• Planned	2.2 m Nm^3/yr
• Actual (2000)	2.9 m Nm^3/yr
• Actual (2001)	3.1 m Nm^3/yr
Digester capacity	5,000 m^3
CHP-unit	
• Heat, capacity	1,300 kW
• Electricity, capacity	1,000 kW
• Efficiency, total	89 %
Gas/oil boiler, capacity	2,500 kW

Dissemination activities

The project is described in the brochure: Danish Centralised Biogas Plants- Plants Descriptions, Bioenergy Department, University of Southern Denmark, 2000.

Promoters and parties involved

The project was initiated by local farmers. A feasibility study was conducted in 1997 with support from the Green Centre ("Grønt Center") in Maribo and the Danish Energy Authority.

Krüger A/S supplied the biogas plant. The owner and developer of the project is Nysted Biogas A.m.b.a.

Financial resources

Total investments

The total investment was DKK 43.7 m (€ 5.9 m). The biogas plant accounted for about DKK 32 m (€ 4.3 m).

Subsidies

The project has received DKK 9 m from the Danish Energy Authority.

Source of revenue

The main sources of revenue are the sale of heat and electricity and fees charged for manure disposal.

Results

During the two first years of operation there were a few problems with the operation of the plant due to errors in the design and inappropriate technical solutions, etc. The design capacity of the flue gas cleaning system (500 m^3/h) was inadequate, which resulted in problems with odour. This problem has now been solved by a new system with capacity of 2,500 m^3/h.

Energy production

The heat is delivered to 165 inhabitants in Kettinge and the electricity generated is fed into the grid. The annual electricity generated corresponds to the electricity consumption in about 1,200-1,300 households. During the summer excess heat of approximately 300 MWh per month is dissipated by cooling.

Financial result

The financial results during the first year of operation were not as good as the owners had expected. This was mainly due to the technical problems, but also lower fees on delivery and problems obtaining the required amount of municipal waste of usable quality. With the technical problems solved the owners expect improved financial results in the years ahead.

Potential for replication

Experience from the operation of the plant shows that care needs to be taken over the design when building biogas plants.

For more information

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Sector: Biomass
Country: Denmark
Location: Sakskøbing
Year: April 2000

ENERGIE

REDUCED OPERATING COSTS AT THE MARIBO-SAKSKØBING CHP

Government plans currently oblige power utilities in Denmark to use biomass to generate some of the heat and electricity they produce. In the eastern part of Denmark the envisaged annual consumption is 900,000 tonnes of biomass (wood and straw).

The Maribo-Sakskøing CHP was planned based on experience from a similar plant that was built some years ago at Vordingborg. The Masnedø CHP plant was commissioned in 1995. The aim of the project was to reduce the operating costs by at least 10 % compared to the Masnedø CHP.

Description

The plant has a straw-fired boiler. The technical details of the plant are given in the table below:

Pressure	93 bars
Temperature	542ºC
Amount of steam	12 kg/s
Consumption of straw	8.2 tonnes/hour
Heat capacity	20.9 MW_{th}
Electricity capacity	10.54 MW_e
Overall efficiency	87.5 %

Promoters and parties involved

Owner	Energi E2 A/S
Design	Energi E2 A/S, technical division
Design, buildings	Moe&Brødsgaard
Design, district heating system	Skude & Jacobsen
Architects	Hauxner, Krarup & Mortensen
Contractor, boiler	FLS Miljø/BWET
Contractor, turbine	ABB

Financial resources

- Total investment was DKK 300 m (€40 m).
- The project received a subsidy of DKK 20 m (€2.7 m).
- Sources of revenue: In addition to the energy sold, the power plant currently receives a grant of DKK 400 per MWh (€53.9 per MWh) of electricity generated.
- Other details: The project forms part of the company's general investments. There have not been any specific loans for the new plant.
- The payback period is calculated to be 20 years.

Results

- The process of establishing heating contracts took longer than expected. Therefore the construction period was shorter than originally planned, and ran from May 1998 to August 1999. Nevertheless, the budget for the construction work was not exceeded. The target of a ten per cent improvement in operating costs was achieved.
- Energy production: During 2001, the first complete year of operation the plant generated 42,074 MWh of electricity (net) and 96,231 MWh of heat. The consumption of straw was 37,481 tonnes and light fuel oil 42.7 tonnes.
- Socio-economic benefits: There have not been any major investigations in the socio-economic aspects of the new CHP plant. However, the benefits include the fact that there are 9 full time employees at the plant. In addition the plant buys straw from local suppliers for a value of DKK 17 m (€2.3 m), transport services for about DKK 2.2 m (€ 290,000) and other services for about DKK 0.5 m (€70,000).
- Environmental benefits: The heat production from the new plant replaces two older low-efficiency straw-fired plants in Sakskøbing and an annual oil consumption of 300 tonnes, and three pellet plants in Maribo which had no flue gas cleaning. The electricity the plant generates would otherwise have been produced mainly by coal-fired power stations. The architects have been focusing on reducing the visual impact of the plant in the open countryside of Lolland.

Potential for replication

A plant of this kind requires a heat demand of about 400 TJ (111 GWh) and the availability of a supply of about 40,000 tonnes of straw a year. The contracts to supply heat also need to be signed before construction, as the operating cost is not covered by the market price for electricity.

For more information

Owner

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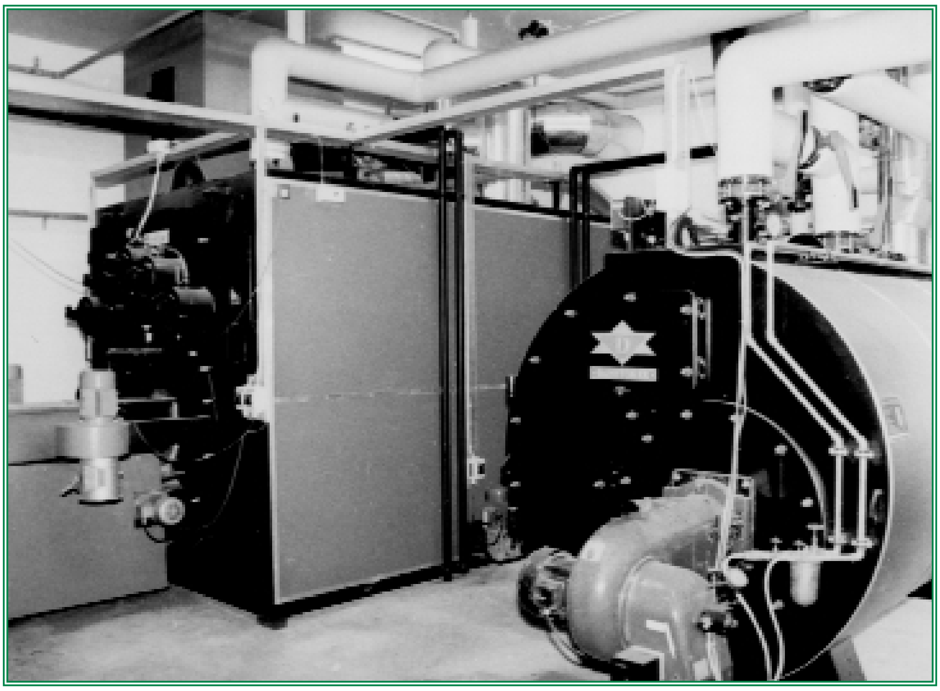
Sector: Biomass
Country: Denmark
Location: Søndre Nissum,
Ulfborg-Vemb Municipality
Year: Fall 1999



SØNDRE NISSUM 800 KW DISTRICT HEATING PLANT

The local authorities first investigated the possibility of installing a district heating system in Søndre Nissum in the early 1990's. The project was stopped as the calculations showed that the investment would be about DKK 10 m (€1.35 m), which exceeded the financial possibilities for the small community of Søndre Nissum, which only has 130 households.

Henry Toft, a local farmer had the idea of setting up his own district heating grid using the straw which was otherwise left to rot on his fields. He first investigated the possibility of selling the straw to existing straw-fired district heating plants, but realised soon that the price was comparatively low. He therefore decided to build his own heating plant.

Mr Toft' s calculations in advance of the investments showed that heat delivered from his district heating plant could reduce the cost of heating a typical detached house by a several thousand Danish kroner a year (several hundred €).

Initially his plan was to deliver heat to one large customer; the Ulfborg-Vemb Municipality, which had already shown itself favourable to the project and willing to buy district heat. The local population the village of Søndre Nissum soon wanted to join the heating grid and buy heat from the planned straw-fired plant. As a result of the local interest Toft had to buy a plant with twice the capacity intially planned.

Description

The straw-fired heating plant in Søndre Nissum has a capacity of 800 kW and it uses about 6-700 tonnes of straw bales a year. In addition there is a back-up oil-fired boiler, which is brought into operation when demand is too low for the main boiler or when the straw-fired boiler is shut down for maintenance.

The process is quite simple. The straw bales are fed through the straw shredder, and then directly to the cyclone. From the cyclone the straw is fed directly to the boiler. The heat is piped via the heating network to its customers.

Promoters and parties involved

Owner:	Sdr. Nissum Fjernvarme
Main contractor:	Lin-Ka Energy

Financial resources

Total investment

The total investment in the heating plant and infrastructure was about DKK 5.5 m (€740,000).

Subsidy

The Danish Energy Authority provided DKK 1.3 m (€175,000).

Source of revenue

The heating plant delivers heat to the local district heating grid.

Payback period

Henry Toft' s calculations show that the plant will have a payback period of ten years.

Results

Initially Toft had 34 detached houses connected to the grid, together with the municipal buildings such as nursing home, school and the local sports hall. The price of heat from the straw-fired plant has been low and local residents have been joining the grid so that currently there are 75 detached houses connected to the heating network.

Energy production

The annual energy production was 2 GWh from October 1999 to October 2000[1].

Financial results

The cost of operating the plant is low as there are no employees. The good economics of the project have resulted in low heating prices for the customers.

Socio-economic benefits

Mr Toft spends between 30-60 minutes a day operating the plant and his wife does the accounts.

Environmental benefits

The emissions of CO_2 from the power plant are the same as if the straw were to decompose naturally.

If the heat were produced by an oil-fired boiler, approximately 200 tonnes of oil would be used each year. The annual carbon dioxide emissions from an equivalent oil-fired would be approximately 600 tonnes[2] .

Potential for Replication

The low investment and the reduced operation and maintenance costs results in a low heating price and therefore the potential for similar small district heating plants is considered to be large.

For more information

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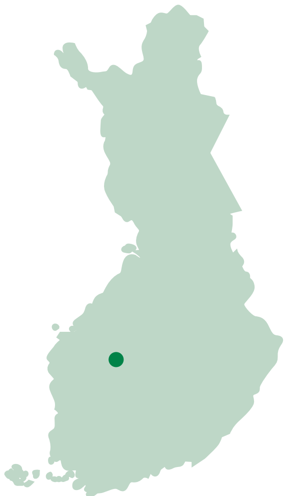
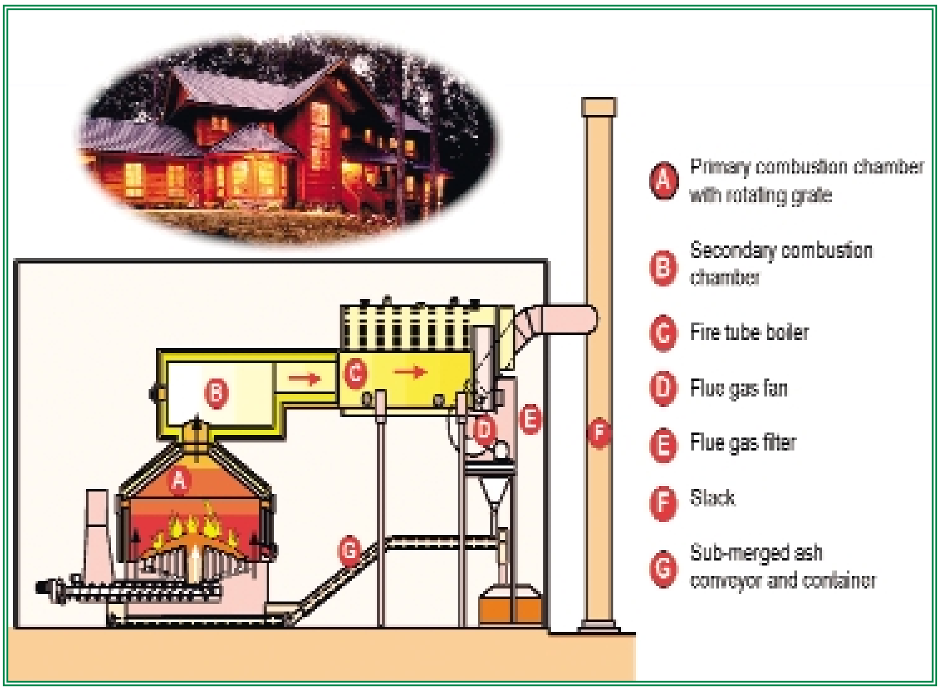
1 International Energy Agency: CADDET Technical Brochure No. 151.(www.caddet-re.org).

2 The CO_2 calculation is based on 90 % efficiency of the plant (Lin-Ka Energy) and the assumption that oil produces 265 kg CO_2/MWh. The specific energy content of oil used is 11.3 kWh/kg.

Sector: Biomass
Country: Finland
Location: Karstula
Year: October 2000

ENERGIE





CHP PLANT PROVIDING HEAT TO A SAWMILL AND TOWN CENTRE

Karstula is a town of 5,000 inhabitants in Central Finland, 100 km Northwest of Jyväskylä. The plant is located near to a sawmill Honkarakennne Oy. Honkarakenne produces 90,000 m^3 a year of sawn timber and logs for log cabins.

The background to this project is:

- Increased production at Honkarakenne Oy.
- Increasing energy demand for log drying and hot working.
- Possibility of using log-cabin factory's by-products, cutter shavings, bark and sawdust, as fuel.
- Extension of the district heating network in the town of Karstula.

Description

Honkarakenne Oy has made significant investments in developing its factories in Karstula. In order to meet the increased heat demand for dryers, it was decided to substitute old oil-fired boilers with a CHP plant running on timber waste, because the factory needed both more heat and electricity. The factory produces 400 truck loads (70 GWh) of wood residues a year which can be used as fuel. The measured average moisture content of the fuel (cutter shavings 44 %, bark 30 %, and sawdust 26 %) was 36 %. The moisture content depends on the combination of residues and in practice it will be higher because share of cutter shavings will be smaller.

The plant has a thermal capacity of 10 MW_{th} and produces 3 MW_{th} for the municipal district heating network, 3 MW_{th} process steam and 3 MW_{th} for Honkarakenne. In addition the plant produces 1 MW_e for the wood processing company.

Wärtsila Finland Oy supplied the plant as a ready-made package. The plant has a patented "BioGrate" combustion technique, capable of burning biomass fuels with moisture contents ranging from 30% to 65 %. The BioGrate boiler is equipped with an underfed rotating grate, which moves the fuel bed cyclically using hydraulics. The movement of the grate is adjusted in such a way that the fuel is distributed as an even bed over the whole grate. The fuel dries and ignites on the grate. The main advantages of the rotating grate are:

- There are no cold spots in the primary combustion chamber.
- The burning surface is even.
- Movements of the grate zones are smooth.
- The secondary combustion chamber ensures complete combustion.

Electricity is produced by a generator driven by a steam engine. This modern design of steam engine gives a high power to heat ratio when the heat load is matched and is therefore well suited to small electrical generating capacities. In this type of plant efficiency is high throughout the plant and it operation is fully automatic and unmanned.

The technical data is given in the table below:

Boiler	BioGrate 10 MW
Estimated electricity production	5 GWh
Estimated heat production	45 GWh
Moisture content fuel	34-45 w-%

Promoters and parties involved

The plant was supplied by Wärtsila Finland Oy . The owner of the plant is a new company called Puulaakson Energia Oy, which is owned by Honkarakenne Oy, Keski-Suomen Valo (an electricity utility) and the Karstula town council.

Financial resources

The total investment in the plant was € 4.54 m, and the project was supported by €1 m from the Finnish Ministry of Trade and Industry.

Results

Energy production

Estimated heat production will be 45 GWh and electricity production 5 GWh. The share of energy destined for the district heating network (11,000 MWh) does not meet demand, so the town of Karstula has its own district heat production as well.

Potential for replication

The large volume of wood residues produced by wood processing factories indicates that it should be possible to implement similar projects elsewhere.

For more information

Contractor

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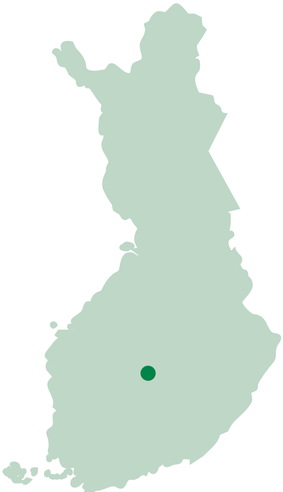
The information on this project was provided by the Organisation for Promoting Energy (OPET) Finland by VTT Process.

Sector: Biomass
Country: Finland
Location: Konnevesi (Northeast of Jyväskylä.)
Year: September 1997

ENERGIE



DISTRICT HEATING PLANT IN KONNEVESI RUNNING ON WET SOLID FUELS

Konnevesi is a town of 3,300 inhabitants, which is located 60 km to the north east of Jyväskylä. In the early 1980's a district heating network was built in the town. Originally there were two heavy-fuel-oil-fired boilers with thermal capacities of 1.3 MW and 0.6 MW. The demand for heat from the network increased and an investment in a new 1.25 MWth biomass heating plant was made at the beginning of 1997, extending the district heating network to accommodate the town's increased heat demand. The heating plant was commissioned in September 1997. Konnevesi Municipality owns both the plant and the heating network.

Description

The main fuel is wood chips (7,000 bulk m^3/a). In addition sawdust and peat have been used sporadically. Fuel is bought from Vapo Oy, which delivers wood chips to the plant.

The moisture content of fuel used has been extremely high, at up to 65 weight %. The 1.25 MWth biomass plant was supplied by Wärtsila Finland Oy. Wärtsila (formerly Sermet) developed and patented the BioGrate boiler, which is used in the plant. The boiler plant was delivered as a completely factory-made unit. The fuel store is equipped with push-bar unloaders. Fuel is transferred via drag-chain conveyors into the fuel bin in the boiler room and then fed into the primary combustion chamber by a stoker screw through an inlet in the centre of the grate. The grate is divided into sections, each of which can be programmed to rotate at the desired speed to ensure stable feeding and combustion of the fuel. The movement of the grate is adjusted in such a way that the fuel is distributed as an even bed over the whole grate. The fuel dries and ignites on the grate. The fuel feed is automatically controlled according to the outlet temperature of boiler water. The flue gas is cleaned by a multi-cyclone dust particulate separator.

The technical data for the plant is given in the table below:

Boiler	Underfeed rotating grate, 1.25 MW
Fuel	Wood chips, sawdust, peat
Annual heat production	5,000 MWh/yr
Efficiency	90 %

Promoters and parties involved

Wärtsila Finland Oy was the contractor responsible for the installation. The municipality of Konnevesi owns and operates the plant. Vapo Oy delivers bio fuel to the plant.

Financial resources

Investment costs for the plant were €437,000, including the extension of district heating network €605,000. The Ministry of Trade and Industry supplied a 30 % grant (€181,000). Further funding came from loans.

Results

Energy production

At almost 90 %, efficiency of the plant has been high in the whole range of capacities. The new biomass plant produces 5,000 MWh/yr, which accounts for 80 % of annual heat consumption by the district heating network. The remainder is produced by the old heavy fuel oil fired boilers, which are used for peak loads and in the summer, when heat consumption is small. The heated building volume in Konnevesi is about 100,000 m^3.

Potential for replication

For municipalities where there is an old heating grid based on heavy oil fired boilers, the possibilities of similar installations being feasible are good.

For more information

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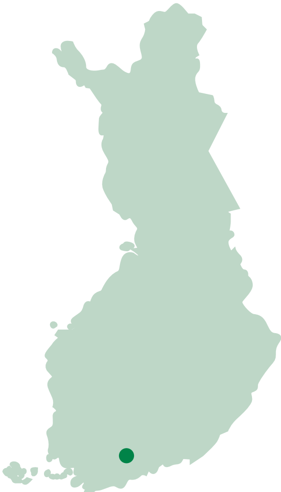
The information on this project has been provided by the Organisation for Promoting Energy (OPET) Finland by VTT Processes.

Sector: Biomass
Country: Finland
Location: Lahti
Year: January 1998



BIOMASS CFB GASIFIER CONNECTED TO A STEAM BOILER

The successful experience in developing the advanced Foster Wheeler Circulating Fluidised Bed (CFB) combustion system subsequently led to the development of the CFB Gasification Technology in the early 80's. The driving force for the development work was the dramatic increase in oil prices during the oil crises of that time. The primary advantage of CFB gasification technology is that it enables the substitution of expensive fuels (e.g. oil or gas) with cheap solid fuels.

The aim of the Kymijärvi Power Plant gasification project is to demonstrate on a commercial scale the direct gasification of wet bio fuel and the use of hot, raw and very low calorific gas directly in the existing coal fired boiler. The gasification of bio fuels and co-combustion of gases in the existing coal-fired boiler offers many advantages such as: recycling of CO_2; decreased SO_2 and NO_x emissions; efficient utilization of bio fuels and recycled refuse fuels; low investment and operating costs; and, utilization of existing power plant capacity.

Description

The atmospheric CFB gasification process

The atmospheric CFB gasification system is simple. The system consists of a reactor where the gasification takes place, a uniflow cyclone to separate the circulating bed material from the gas, and a return pipe to feed the circulating material to the base of the gasifier.

When the gasification air enters the gasifier below the solid bed, the gas velocity is high enough to fluidise the particles in the bed. At this stage, the bed expands and all the particles are in rapid movement. The gas velocity is so high that many particles are conveyed out of the reactor and into the uniflow cyclone. In the uniflow cyclone, the gas and circulating solid material flow in the same direction – downwards – both the gas and solids are extracted from the bottom of the cyclone, which is different from how a conventional cyclone works.

The Kymijärvi power plant

The Kymijärvi power plant went into operation in 1976. Originally, the plant was heavy oil fired, but in 1982 the plant was modified for coal firing. In 1986, a gas turbine generator set was installed at the plant. In the gasification project the biomass gasifier was connected to the coal-fired boiler. Gasification enables the utilisation of locally available low-price bio fuels and recycled refuse fuels (REF), with the equivalent energy content of 300 GWh (180,000 tonnes) annually, thus reducing the plant's annual coal consumption by up to 30%.

Dissemination activities

The project is part of the Thermie European demonstration programme.

Promoters and parties involved

The partners in this EU Thermie demonstration project are: Lahden Lämpövoima Oy from Finland, Foster Wheeler Energia Oy from Finland, VTT (Technical Research Centre of Finland) from Finland, Elkraft Power Company Ltd. from Denmark and Plibrico Ab from Sweden.

Financial resources

The total investment for the whole plant (including the fuel preparation and gasification plant) was approximately €11 m

The project received a €3 m grant from the EU's Thermie programme.

Results

The gasifier was connected to the main boiler on 7th December 1997 and after the refractory lining warm up the first combustion tests with solid biomass fuel were performed on 9th January 1998. The very first gasification tests were carried out on 14th January 1998 and the unit came into operation two weeks later.

The gasifier was shut down for the summer maintenance on June 2nd 1998 and because of the extremely low electricity price in Finland in summer/autumn 1998, the main boiler was put in operation in the beginning of September and the gasification plant two weeks later, i.e. 21st September 1998. During the first operating year approximately 4,730 hours of operation in the gasification mode was achieved and the availability of the gasification plant was 81.8 %.

Energy production

The results from the first three operating years are very encouraging. During three-year period 868 GWh of energy were produced from the gasifiers' biomass product gas. Several different types of fuels were successfully gasified: Biomass (wood chips, bark, saw dust, etc.), refuse (REF), railway sleepers (chipped on site), shredded tyres, plastics, etc

Environmental benefits

The NOx emissions decreased approximately by 10 mg/MJ (equalling a 5-10 % decrease) and the SO_x emission decreased by 20-25 mg/MJ. Due to the low-chlorine coal that is used in the boiler and the resultant low base level of HCl, the HCl emission increased approximately 5 mg/m^3, because of the chlorine originating from REF fuel and shredded tires that were used in the gasifier.

Potential for replication

This design offers an efficient way to utilize bio fuels and recycled refuse fuels, with low investment and operation costs, and the utilisation of the existing power plant capacity. Furthermore, only small modifications are required in the boiler and possible disturbances in the gasifier do not shut down the whole power plant.

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Sector: Biomass
Country: Finland
Location: Pylönmaki (Northwest from Jyväskylä)
Year: January 2000

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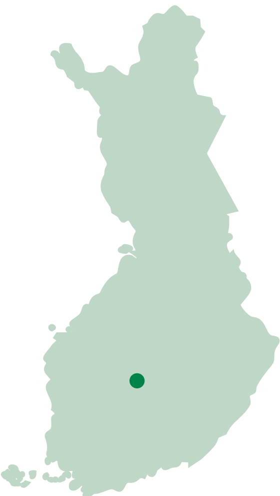

SMALL HEATING PLANT FUELLED WITH WOOD CHIPS

Pylkönmäki is small town of 1,300 inhabitants which lies 90 km to the northwest of Jyväskylä. In early 2000, a local firm, Tulostekniikka, delivered a wood fuelled container heating plant with capacity of 160 kWth to heat the municipal health centre. The plant is owned by a local private entrepreneur, who purchases the fuel, wood chips, and is responsible for running and monitoring the heating plant.

Description

The container includes two modules, a fuel storage module and a module including a boiler, a stack and conveyors. The roof of the fuel store can be opened hydraulically to allow filling. Drag conveyors are used for unloading the fuel from the store. The transportable container heating plant does not require normal foundations.The contract with the town of Pylkönmäki and the contractor is based on 200 MWh annual heat production and there is a plan to extend the heating network in the near future, given that the plant has a capacity of 400-500 MWh production per year. At the moment the volume of indoor space heated by the system is 2,505 m^3.

Consumption of wood chips is 1.8 bulk m^3 per MWh and the fuel store, which has a capacity of 20 m^3, has to be restocked every second week.

The old oil heating equipment has been kept as a backup to be used when the plant is shutdown (for maintenance or other reasons).

The technical data is given in the table below:

Boiler capacity	160 kW
Fuel	Wood chips
Heated building volume	2,505 m^2
Heat production	200 MWh (in the future 400-500 MWh)

Promoters and parties involved

The plant was built by a local company, Tulostekniikka Oy.

Financial resources

The total investment in the heating plant was €26,000 (163 €/kWth).

Results

The maximum daily heat consumption is 1 MWh, which implies that it will be possible to heat a nearby terrace of houses from the container plant in the future.

Potential for replication

This project has a fixed contract with the town (200 MWh/yr), which ensures a secure source of income for the plant. With similar contracts there would be possibilities for similar projects around Finland and elsewhere.

For more information

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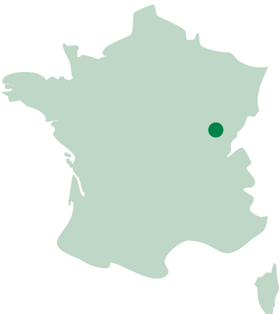
The information on this project has been provided by the Organisation for Promoting Energy (OPET) Finland by VTT Processes.

Photo by: VTT Processes, OPET Finland

Sector: Biomass (wood waste)
Country: France
Location: Dole
Year: September 1998



TWO BIOMASS HEATING PLANTS IN DOLE

A pair of wood-fired boilers with outputs of 3.2 MW and 900 kW were installed and commissioned in Dole, a town of over 25,000 inhabitants near the Jura Mountains in eastern France.

The two plants, which are a new addition to an existing plant, supply the Mesnils- Pasteur and the Sous-Plumont districts with heat using waste wood from the surrounding areas and from local industry (sawmills).

Description

The first plant, located in the Mesnils-Pasteur district has a new boiler with a capacity of 3.2 MW working in different phases in winter and summer (full capacity from October to May and variable capacity in summer), and its operation is fully automatic.

It is able to use 12,000 t of waste wood a year, which represents one third of the estimated resources in the area. The mixed fuel is mainly (80%) composed of bark from coniferous trees with the remaining 20% being other non-treated waste wood which is brought directly from factories and sawmills in the area.

The storage, handling and packing phases are carried out in a special-purpose 350 m^3 building able to store 4-5 days' supply of fuel.

The second plant is a 900 kW boiler installed to replace an obsolete natural gas boiler (which had previously been converted from oil) serving about 286 social housing units (flats) in the district of Sous-Plumont. Wood provides about the 80% of the installation's fuel requirements and natural gas is used only when the plant is stopped for maintenance. The amount of waste wood used is about 1,550 tonnes per heating season, equivalent to 3.570 MWh. The plant has been specifically designed to accept wood waste with a moisture content of up to 60%.

Promoters and parties involved

Municipality of Dole
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Financial resources

The total investment in the Mesnils Pasteur plant was €1,675 m of which 30% was financed by ADEME, 10% from the Jura regional government; 9% from the FNADT (funds for town and country planning) and 49% from the owner.

The Sous Plumont plant investment was €562,000, which was 68% financed by Dole's Social Housing body (OPHLM), 16% from the Jura regional government, and 16% from ADEME.

Results

The first plant supplies the heat requirements of the town in summer, while the second supplies 80% of the heat requirements of the district of Sous-Plumont as a whole.

It has also been calculated that these plants contribute to avoiding the atmospheric emission of 8,000 tonnes of CO_2 and 76 tonnes SO_2 a year.

Potential for replication

A strong commitment was necessary from the Council side to carry out these two projects in such a short time.

The important energy saving obtained and the rational use of local resources are key elements in the success of these plants. The benefits of the project also include local employment and the reinvestment locally of the money saved.

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Sector: Biomass
Country: Germany
Location: Leese
Year: 1997

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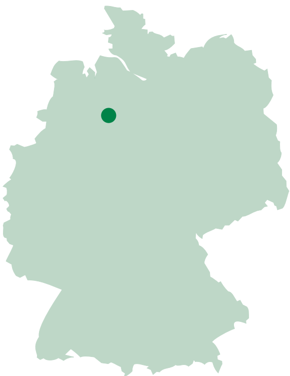

LEESE, MOBILE WOOD-FIRED HEATING PLANT

The Leese RWG (Raiffeisen Warengenossenschaft agil) has been cultivating energy crops since 1985. The company operated the first biodiesel fuelling station in Germany and in 1994 it established a plantation for fast-growing wood. The company also processes wood waste to produce wood chips.

In November 1997, a wood-fired heating installation came into operation. The plant provides Leese RWG's social areas and office space with heat in an environmentally friendly way. A remarkable feature of this plant is that it was pre-assembled and placed in a mobile container. The system operates completely autonomously and it supplies heat via underground heating pipes.

One reason RWG Leese chose this mobile concept was that in this way the installation is easily movable to another location on the industrial site if necessary. The plant can also be connected to a district-heating network in its vicinity due to its compactness. Another reason was that the fuel purifying takes place next to the location of the heat plant and because the company has its own transport vehicles available.

Description

The heating installation at the premises of RWG Leese uses several types of wood as input, e.g. wood chips from forestry, wood pellets, and wastes from sawmills. Because of the advanced control technology and the geometry of the combustion chamber, both dry and wet wood can be burnt in this plant without any increase in emissions.

The system is equipped with a fixed-bed gasifier-combustion chamber. This fully automatic boiler installation, the heat divider of the boiler, the control and monitoring system, and the fuel storage are all integrated in an insulated steel container. The installation is therefore very flexible.

The volume of the fuel storage vessel is sufficient for full load operation time of 13 hours. This means that during normal operation of the plant, refilling of the vessel is needed once a day. By means of the sliding base discharge, the fuel is transported onto a screw feeder. It is then moved to the combustion chamber on a stoker screw. Here, the wood chips are gasified and burned.

The flue gases from the three-pass smoke tube boiler are transported to a multi-cyclone flue gas separator. This unit removes the dust particles that result from the combustion process. The ashes are driven to an ash container via an automatic ash extraction screw.

The installation uses an automatic control system. One control loop adjusts the thermal capacity according to the consumers' heat demand. Furthermore, the combustion optimisation control modifies the material mixture in such a way that the optimal flame temperature is reached. A Lamba control device measures the residual oxygen in the flue gas and changes the combustion air mixture in order to minimise the flue gas emissions in the case of variations in the fuel quality. The air mixture control also ensures an optimal combustion air mixture, via actuators and speed sensors.

Such an extensive control system is needed, because the composition of the fuel is often heterogeneous. Even in this case, the control technology guarantees pollutant-free operation of the plant. The under-pressure control regulates the flue gas ventilator, which pulls the flue gases through the boiler. This control system ensures stable fuel states even when the thermal capacity or the fuel composition changes.

Project characteristics	
Installed thermal capacity [kW_{th}]	330
Thermal capacity range [kW_{th}]	80-330
Maximum forward flow temperature [ºC]	98
Maximum water content of the wood [%]	50
Storage volume silo [m^3]	170
Storage volume fuel vessel [m^3]	6
Volume ash container [l]	90

Promoters and parties involved

Raiffeisen Warengenossenschaft Leese agil (RWG Leese): operator

Schmid AG: boiler

Financial resources

The total investment for mobile biomass-fired heating plant came to approximately €60,000. Additional costs for the district-heating network and control electronics were a little over €10,000. Although the project was promised financial support by subsidies, it did not receive any in the end, thus the project was entirely financed by RWG Leese.

Results

No problems occurred during the planning phase and operation of the project. Experience with the project has been good and it has been operating successfully since 1997, when it came into operation.

By utilising wood, the project substitutes fossil fuels used for heat generation. The plant in Leese produces about 450 MWh of heat per year. In this way, it reduces the emissions of CO_2 by up to 200 tonnes a year.

The project resulted in considerable cost savings, as the RWG Leese collects and processes the wood fuel itself and therefore it is at the disposal of RWG Leese at lower costs than oil or natural gas. As the transportation distance of the wood from the fuel preparation to the combustion unit is very short, there is also an advantage with regard to transportation costs.

Potential for replication

Based on the good operating experience from this installation, a second (stationary) plant with a capacity of 850 kWth was built in 2000. This feed-grate station is also fuelled by wood chips. This plant is able to utilise biomass with a higher moisture content (up to 60%). At a location 20 km from Leese, another 360 kWth-plant has been built, which supplies heat to an outdoor swimming pool in summer and a school in winter.

The implementation of container installations is useful for locations with a lack of certainty about the specific location, or with possible changes of location on the short or longer term.

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Sector: Biomass
Country: Germany
Location: Norden
Year: 2000

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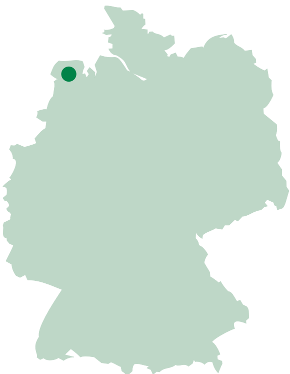

NORDEN, DOORNKAAT WOOD-FIRED HEATING PLANT

On a brown-field site formerly occupied by Doornkaat AG, Stadtwerke Norden (a public utility) installed a new wood-fired energy production plant by converting an old boiler house. With this project, the Stadtwerke Norden wanted to continue their business philosophy of using innovative technology and environmental protection for economically feasible energy production.

The former Doornkaat boiler house was very suitable for the combustion of solid biomass, because the building was originally planned to operate three coal-fired installations. Therefore, the required structure for the implementation of a new boiler system was available, such as water and electricity supply connections. Moreover, the building was in good condition and the foundation and the existing walls and roof were suitable for use. The building had ample space to accommodate both the boiler systems and fuel storage.

Being on a former industrial site, Doornkaat is located near to the city centre of Norden, thus large parts of this area are potentially able to receive heat produced by the new power plant.

Description

The heating plant uses two 2.4-MW grate-firing boilers. In this kind of boiler, the combustion takes place at an inclined grid, which consists of fixed and mobile steps. The movable elements are shifted back and forth, in this way transporting and turning the wood fuel. The combustion chamber has concrete walls that can resist high temperatures and is divided into a gasification zone and a burning zone. All four sides of the firing grid are cooled by the combustion air in a core with double walls.

The flue gas from the combustion process in the boilers is cleaned in two steps. The first unit, a multi-cyclone cleaner, consists of 35 small cyclones. In these spinning cyclones, particles are removed from the flue gas by powerful centrifugal forces. The second unit is an electronic filter.

"Low-NOX" technology, which controls the optimal gasification and combustion air stream dependant on the nitrogen content of the fuel and the moisture level, is used to reduce the emissions of NO_x.

The plant mainly uses untreated residue and used woods. In the future, it will also be able to process wood from forestry thinning. About 20,000 m^3 of wood is needed each year to run the plant. The fuel is controlled at the entrance. It is also analysed by an independent laboratory.

The fuel store holding the wood chips is accommodated in the boiler house. The fuel store, which is able to hold about 900 m^3 of fuel at a time, is 8 m high. The store is loaded from a silo on the street at the chimney side of the boiler house. The silo is locked by means of two accessible silo covers.

The systems uses three gas-fired boilers with a total installed heat capacity of 3.6 MW and four heat production block modules with a total thermal capacity of 590 kW driven by natural gas for peak load and summer load coverage. If the minimum capacity permanently falls below 20% of the nominal capacity in summer, the heat supply is taken over by the gas-fired boilers. For reasons of cost and efficiency two of the three gas boilers have been reused from the previous installation and the third boiler was completely new.

The length of the entire heat distribution network is 2,500 m. To achieve this size, two existing heating district-heating networks in Norden had to be connected to each other. Moreover, a substantial extension of the number of heat consumers and networks was necessary. With this network, heat consumers with an energy demand of 7.8 MW can be supplied with 14,500 MWh of heat.

Project characteristics

Thermal installed capacity biomass boilers [kW_{th}]	4,800
Thermal installed capacity gas boilers [kW_{th}]	3,600
Thermal installed capacity heat production block modules [kW_{th}]	590
Fuel storage volume [m^3]	900
Fuel input [toe/year]	5,000
Fuel input per boiler at full load operation [m^3/h]	3,200
Thermal efficiency boiler [%]	87
Flue gas stream [kg/h]	14,000
Flue gas temperature [ºC]	150-180

Guided tours have been run, demonstrating the principles of a wood-fired heating plant to numerous groups of visitors.

Promoters and parties involved

- Stadtwerke Norden: public utility of Norden; owner and operator of the plant
- Niedersächsische Energieagentur (Energy Agency of Lower-Saxony): project study, draft planning and support of permit planning
- K.-H. Kautz, Norden: architect and construction engineer
- Ing.-Büro E. Eickens, Norden: planning

Financial resources

The total investment in the project came to €2.8 m. The total investment for the project was provided by the Norden power utility (Stadtwerke Norden) and financed with a low-interest loan.

Results

Considering the size of the project and the fact that it has been implemented using existing infrastructure, i.e. the former Doornkaat area, relatively few problems occurred during its realisation. Some difficulties arose initially with the wood supply technology. Since these had been solved operation has been problem free. The main causes of difficulties are irregularities in the conditions of the fuel. The SPS-controlled control unit of the wood chip boiler operates without any problems.

The heat production of the biomass-fired system totals about 15,000 MWh per year (in 2001 this was 7.500 MWh). The switch from natural gas to biomass resulted in about 1,100,000 m^3 of natural gas being substituted in 2001. Because the wood-fired heating plant has not reached its final size, this will increase further.

With the use of natural gas for heat production as the reference situation, the annual reduction of CO_2 emissions is about 4,300 tonnes. The “low-NOX” technology used in this project reduces the NO_x emissions by 84%, i.e. 2000 kg per year (in 2001). With the flue gas cleaning system, the dust emissions are limited to 30 mg/Nm^3.

The project also entailed employment creation, i.e. two employees for maintenance and cleaning of the wood-fired boiler system and for the acceptance of the wood chips. However, these workers are not fully occupied at the heating plant itself.

Potential for replication

The wood-fired heating plant in Norden is a good demonstration project for similar systems which also need to be implemented using existing infrastructure. This project shows that it is entirely possible to place a relatively large installation, in particular the wood supply, in limited space in such a way that it leads to a sensible operating procedure.

Based on the positive experience of the Doornkaat project, the public utility of Norden has decided to construct a second wood-chip heating plant of similar size. In contrast to the first plant, a new building will be constructed for this heating plant, in which the operating procedure will be projected in an optimal way. The new plant is expected to come into operation by the end of 2002 or the beginning of 2003.

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Sector: Biomass
Country: Germany
Location: Verden
Year: 1998

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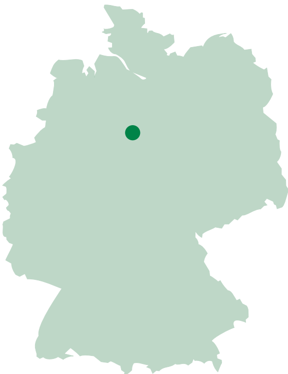

VERDEN, WOOD-FIRED BIOMASS PLANT AT A FORMER MILITARY BASE

The Lower Saxony Energy Agency drafted a study on behalf of the Municipal Services of Verden to explore the possibilities of supplying heat to public buildings and facilities by means of a wood-fired heating plant in Verden. This resulted in a plan for the construction of such a plant at a former British military base. The feasibility of this project was tested at two former military bases.

In co-operation with the planning bureau for the technical works and the constructor, a local architect designed a building for the heating plant. The design of the building met the requirements regarding both technical aspects and the public nature of the building.

A number of suitable heat consumers were found that were to be connected to the heating network. The first heat consumer was a swimming pool with a heat demand of 1,200 kW, which ensured there would be demand for heat all year round. Then another large customer (1,300 kW) was found, i.e. buildings of the district administration. The remaining heat is delivered to eight smaller customers with a heat demand ranging from 37 to 285 kW. These include schools, day-care centres, a gym, and the central kitchen of the city.

The project was registered as a decentralised Expo 2000 project in 1998.

Description

The Verden biomass heating plant building consists of two parts. The first part is a warehouse where the wood fuel is stored and fed to the boiler. The plant utilises softwood from forest thinning and waste wood. The wood store has been dimensioned so as to ensure, that during cold winter days, sufficient stocks to cover a full week's operation can be held. The other part of the building accommodates the boiler house.

The plant uses two grate-fired boilers with a thermal capacity of 1 MWth each. They are equipped with hydraulic wood feeding and ash removal systems. A gas-fired boiler covers peaks in the demand for heat and it is also used when the heat demand is less than the minimum output of one wood-fired boiler (e.g. in summer). Due to the thermal insulation of the building, the total thermal capacity of the plant is only used a few days per year.

The water used is cleaned before it is fed to the hot water cycle. The plant is equipped with a hydraulic switching scheme with pipelines for water circulation. Users can disconnect the water circuit at the boiler end by means of a hydraulic switch. This enables the water from the three heat generators to be disconnected from the user's circuit.

The plant's control system consists of a programmable control for the boiler installation and a control system for, among other things, the gas boiler and the network pumps. The network pumps can be operated either at constant network pressure at the outlet from the heating plant or at constant pressure at the end-point of the network. An adjustable minimal water flow at the network end-point ensures that sufficient inlet temperature is available at each point in the network.

The operation of the plant is fully automated. During normal operation, the plant is unmanned, except for a daily check and topping up the stock of wood fuel. The staff on duty are alerted of any disruptions directly by the plant's monitoring system.

Project characteristics

Total installed thermal capacity of wood-fired boilers [kW_{th}]	2,000
Peak load gas boiler thermal capacity [kW_{th}]	1,200
Length of heat distribution network [m]	1,200
Input of wood chips from the forest [m^3/year]	5,000
Input of wood chips from waste disposal [m^3/year]	5,000
Combustion chamber temperature [°C]	700-900
District-heating network temperature [°C]	80-90
Water content of the fuel wood [%]	35

Promoters and parties involved

- Municipal Services of Verden (Stadtwerke Verden): promotion, operation and management
- Wood industry Heidmark: wood supply
- Lower-Saxony Energy Agency: feasibility studies, contract test, elaboration of the EXPO registration proposal
- Urbas Energy Technology: supplier of boilers
- Viessmann: supplier of peak load gas boiler

Financial resources

Total investment costs for the wood-fired heating plant including the heat distribution network amounted to €1,840,000. The main investor in the project was Verden Municipal Services. The project received a subsidy of €445,000 from the national government's Renewable Resources Agency (FNR, Fachagentur Nachwachsende Rohstoffe). The project was also partly financed by a subsidy of €345,000 from the federal state of Lower Saxony (Renewable Energies subsidy programme). The Lüneburg local authorities also gave the project financial support in the form of a loan.

Results

The first two years of operation were not representative for the plant's overall operation. The installation came into operation in June 1998 with a boiler to provide energy to an outdoor swimming pool and by September, it had been completed. However the expected heat production in 1999 was not reached because of the conversion and extension of the swimming pool, the largest heat consumer of the heat plant. On April 1st 2000, the pool came into operation with the forecast heat demand of 1,200 kW.

Initially, only old long thin wood strips with a length of 10-25 cm were used to fuel the plant. However, this wood size caused disruptions in the hydraulic wood feeding system. Therefore, four months into operation, wood from forestry sources with a diameter of 5-8 cm was fed to the plant. This resulted in a clear decrease in the number of disruptions. However, the high water content of this type of wood (often over 50%) reduced the efficiency of the system, because a lot of heat energy was lost during evaporation of the moisture in the wood. On the basis of this experience it was decided to use a mixture of 50% of each type of wood.

The costs for untreated, cleaned waste wood proved to be higher than the estimate of the Lower Saxony Energy Agency due to increased market demand for wood waste of this type. Therefore, the operation of the wood-fired installation had not been balanced and is not yet profitable.

The plant produced 6,500 MWh of heat in 2000, which matches the planned figures closely. This heat is delivered to the heating network (the estimate was 7,000 MWh).

The project has enabled fossil fuels for energy generation to be substituted. The plant also contributes to the reduction of emissions of CO_2 by 1,213 tonnes a year.

Potential for replication

The project has the potential to serve as a model for other projects in northern Germany. Experience regarding the influence of large biomass power plants on the availability of waste wood can also be useful for other projects. In the south of Germany and Austria, there are already a considerable number of similar installations.

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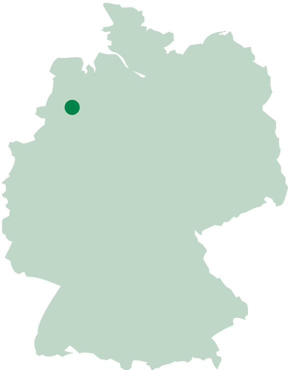
Sector: Biomass
Country: Germany
Location: Vrees
Year: 1997

ENERGIE



VREES, WOOD-CHIP HEATING PLANT

The area of Vrees, known as the “Village of 1,000 oaks”, produces large quantities of waste wood, which is difficult to utilise economically. In 1994 the municipality of Vrees decided to set up a district-heating network to supply heat to a new housing area from a heating plant running on wood chips. The plant came into operation in 1997.

The relatively short reach of the supply network and the low supply density due to fact that the homes in the area were houses rather than flats meant that several innovative technical and organisational measures needed to be developed for the Vrees biomass plant. These included, for example, the “Partner Concept” agreement for the maintenance and repair of the plant.

The wood-fired installation fits in well with Vrees’s environmental friendliness objectives, and the municipality also has several wind and solar power installations and a fuel-cell system. The plant also contributes to climate change mitigation, sustaining local forests, and promoting the sustainable development of rural regions.

The Vrees biomass plant is part of the “Exponel” tourism project and also a recognised decentralised project of the Hanover Expo 2000.

Description

The central unit of the plant in Vrees is a special grate-firing biomass boiler. The construction and the insulation of the combustion room enable an almost adiabatic combustion process. The peak load is covered by means of an additional oil/gas boiler.

The installation is able to use relatively large wood chips (with a diameter of 100 mm and a length of 500 mm), which means a wood shredder is not needed. This reduces the energy demand and investment costs for the plant. The fuel for the wood-chip heating plant consists of wood from forestry thinning and untreated wood residues from local sawmills. The fuel is stored in a silo next to the boiler room. A 200-m^3 warehouse was built to store the fuel, from where it is transported to the silo. On the horizontal floor of the silo, a connection rod delivery system supplies measured amounts of fuel to the boiler room. A magnet removes any ferrous metal waste from the fuel before it is fed into the boiler.

The plant is equipped with a multi-cycle flue gas cleaning system. The ashes are used as fertiliser for the forests, thus closing the nutrient cycle.

The plant uses several innovative and cost-cutting technologies to control and regulate the biomass-fired installation and its connection to the district-heating network and the consumer systems.

The operational safety of the plant is ensured by various measures, such as engine protection switches, hydraulic installations equipped with overpressure valves, temperature monitoring and level switches. The flue gases, the fire and the water in the boiler are also monitored.

Project characteristics

Nominal biomass boiler capacity [kW]	450
Peak oil/gas boiler capacity [kW]	350
Fuel heat capacity [kW]	500
Fuel use [kg/h]	220
Water volume of the boiler [l]	1,200
Operation temperature [°C]	99
Maximum operation temperature [°C]	120
Operation pressure [bar]	3 or 6
Boiler efficiency [%]	80
District-heating network main pipe length [m]	2,490
District-heating network house pipes length [m]	1,452
Network losses (with regard to wood) [%]	7

Dissemination activities for the project include a large number of visits, mainly from people involved in municipal policy and administration. In the first six months of operation the plant had over 2000 visitors.

Promoters and parties involved

- Municipality of Vrees: initiator, building of the installation, shareholder in Biowärme Vrees (1.5%)
- BWV Biowärme Vrees: owner, operator, heat supplier
- AgRo-Energieagentur: farmers and entrepreneurs; building of the installation, planning, shareholder in Biowärme Vrees (90%)
- Agro Forst Technik: building of the installation, maintenance and reparation, shareholder in Biowärme Vrees (8.5%)
- Kohlbach: supplier of the boiler
- Kusimex: supplier of the pipeline network
- Buderus Heiztechnik: supplier of the peak load boiler

Financial resources

The total investment costs of the project were €741,373. An total of €281,211 was provided through a loan from the ERP Environment and Energy Saving Programme. The Ministry of Agriculture in Lower Saxony gave a grant of €255,646. The Deutschen Bundesstiftung Umwelt (German Federal Environmental Foundation) supported the project financially through a subsidy of €100,725. A total of €102,258 was drawn from Biowärme Vrees's own capital.

Results

A number of minor problems occurred during the implementation and the operation of the biomass plant, none of which were sufficient to cause a shutdown of the installation. First of all, there were some problems with the software of the control system. Furthermore, the pipeline network caused some problems, which could be solved. Finally, a number of consumers of the heat from the plant were adversely affected by the continuing construction work and the further connection of new parts of the district-heating network.

An important aspect for implementation of the project was the so-called "Partner Concept", which was developed by the AgRo Energy Agency. This concept provides Biowärme Vrees with a secure basis for the calculation of costs, maintenance and insurance of the plant.

The installation produces about 1,200 MWh of heat a year (2001). Based on a heat price of 40.90 €/MWh, the annual revenues from heat sales are around €49,000. At the moment, 76 houses are connected to the network. There are 24 more possible building locations. The the biomass-fired plant is the sole source of heat for its consumers. When its heat production is not sufficient to cover demand, the gas/oil boiler is used to cover the peak load.

The project brings a number of benefits for the region of Vrees. Firstly, it reduces the amount of fuel needed for heat generation and the corresponding emissions of CO_2. Secondly, most of the value created by the project remains in the region because the biomass is supplied locally, local companies have an interest in the plant, and the heat is supplied by a company with a local majority interest. The project also secures and creates employment in the construction and supplier industry.

Potential for replication

Three further wood-chip heating plants have since been set up in the municipal district of Vrees. Two of them supply heat to agricultural buildings and the third is used to supply heat to a wood-working firm.

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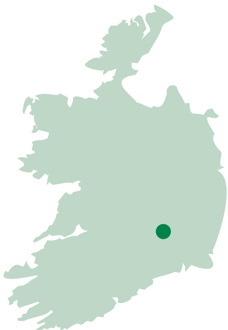
Sector: Biomass
Country: Ireland
Location: Ballytobin, Country Kilkenny
Year: December 1999

ENERGIE



ANAEROBIC CAMPHILL COMMUNITY

Ireland is considered to be among the countries of the EU with the greatest potential per capita for farm biogas. However, despite this potential, it was not until 1999 with the construction of Camphill digestion plant, that a decentralised anaerobic digestion plant was created in this country.

The main aim of the project was to test the development and operation of a centralised anaerobic digestion plant in Ireland in order to study the feasibility of using farm and industrial (from the agro-food industry) wastes as the basis of a profitable renewable energy enterprise.

The installation is located in the Ballytobim Camphill Community (a residential therapeutic centre for disabled children and adults, located within a 20 acre farm).

Description

Wastes feeding the digester come from farms and food-processing industries (a creamery and brewery) located close to the plant. The gas produced after the anaerobic digestion of the wastes is burned in a traditional CHP installation.

The solid effluent resulting from the process is composted and sold as organic garden compost.

Promoters and parties involved

BEOFS set up B.I.G. (Biogas Ireland Group), a partnership with the Department of Microbiology at NUI (Galway), the Tipperary Rural and Business Development Institute, and the Fachverband Biogas (German Association of Biogas Projects).

Financial resources

Total cost of the project was €140,000. It was financed by the Irish Government and by the European Commission through the Horizon Programme, LEADER II Community Initiative and the ALTENER programme (having received €70,000 within the framework of this contract).

Results

The electricity produced from waste treatment is used to meet the energy requirements (both heat and power) of the 90 people living in Ballytobin Camphill Community, estimated to be 150,000 kW of electricity and 500,000 kWh of primary energy for heating per year.

Moreover, employment in a rural enterprise has been created for people with disabilities.

Potential for replication

The final aim of this project was to test the model in order to determine if it was appropriate for replication by the creation of 15 similar biogas plants in Ireland (in the following 5 years), of variable sizes and to create the know-how that will make possible the proliferation of plants of this kind in Ireland (a country with a high potential for farm biogas).

It is expected that the B.I.G. partnership will make it easier to collect the modelling tools to replicate the model and to disseminate the programme properly.

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Sector: Biomass
Country: Italy
Location: Asiago (Vicenza)
Year: 1999

ENERGIE

SPACE HEATING AT A HOTEL USING A BIOMASS THERMAL PLANT

This biomass thermal plant in a hotel at a small town near Asiago was built by Ecoenergie srl in 1999. As the hotel is located in the north east of Italy, every year its thermal plant needs to be kept running for almost five months in order to provide space heating. The hotel has four floors and an area of 7,500 m^3. The cost of the natural gas consumed by the hotel's old boiler was a considerable burden on the hotel's balance sheet. This led the hotel owner to consider an alternative, more economical, solution. The area around Asiago is heavily wooded and timber production is a widespread activity, making biomass such as wood-chips very easy to obtain. For the hotel, therefore, the utilisation of a wood-chip boiler looked to be a good opportunity.

Description

The Plant

The plant, which replaced an old gas boiler, consists of a KÖB PYROT 220 kW biomass boiler with an automatic wood-chip feeder.

The burner is made up of a double system: an underfed burner and a mobile grate. Burnable gases are optimally mixed by way of the secondary airflow, which enters in a vortex. The spiral-shaped rotating fire drum extends the combustion time and facilitates total incineration.

Ignition is achieved using a time-controlled ignition blower.

The boiler's maintenance-free permanent operation is enabled by an automated advancer grating, which pushes the ashes across the whole surface of the grating into large ash hoppers. The ash removal system uses a large hopper, with an automated external hopper if required.

Fuels

The plant uses waste wood such as shavings, sawdust, and wood chips with a 30% moisture content. The fuel is supplied by a nearby sawmill, which ensures a steady supply of fuel over the whole season.

System controls

The "OKOTRONIC Modular" is a microprocessor control system developed by KÖB, an Austrian company. It regulates and monitors the whole system and controls it under all operational modes. Control circuits provide emission optimising operations (via a lambda sensor) and continuous performance adjustments using frequency converters, and to control the high-performance burners.

Promoters and parties involved

Ecoenergie srl is an ESCO offering energy services primarily in the renewables field, and providing both technological and financial solutions. The company has signed an agreement with the Bank of Etica to promote the diffusion of wood boiler.

Financial promoter

The Bank of Etica

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Financial Ressources

Total investment €36,000, of which €26,000 was the cost of the boiler.

Results

- Efficiency

  The boiler has a nominal efficiency of over 90%.

- Emisions

  Harmful substance ratings are at a minimum at all load levels. CO emissions are less than 10 mg/m³, usual NO_x values are considerably reduced. The increased efficiency associated with this noticeably reduces fuel consumption (by up to 25%).

Potential for Replication

A wide variety of fuels is now available to run this type of automatic wood-chip fed boiler and the boilers have no limit to power outputs, which may reach several MW. This technology is particularly suited to heating large and medium size buildings such as hotels, schools, hospitals, shopping centres and, in the agricultural sector, greenhouses. It enables the same level of efficiency and comfort to be obtained as with gas- and diesel-fired plants.

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Sector: Biomass / Waste
Country: Italy
Location: Brescia
Year: 1998

ENERGIE

TERMOUTILIZZATORE DI BRESCIA – WASTE/BIOMASS PLANT

In 1998 ASM Brescia Spa, a public utility company owned by the municipality of Brescia (share 99.5%), completed the construction of a 45 MWe biomass-waste CHP plant called "Termoutilizzatore" located in the municipality of Brescia in the north of Italy.

In the late 60's and early 70's, ASM introduced a new way of heating the town buildings in the form of district heating. Today, 120,000 inhabitants are supplied with heat through 400 km of double hot water pipes. The conditions in Brescia are therefore optimal for extensive use of energy recovered from waste and biomass, in the form of both electricity and heat, with a possible total efficiency of over 80%.

The plant is a valuable source of energy for the town of Brescia, thanks to the existence of the district heating system. The plant makes it possible not only to generate electricity (as in many other similar plants), but also to produce a remarkable amount of heat. In fact, the original design envisaged that with the plant running at its full initial capacity, it would produce 200 TWh of electricity and 350 GWh of heat per year, with an annual saving of 80,000 tonnes equivalent of oil. This corresponds to about a quarter of the energy supplied to Brescia by ASM.

Description

The construction of the plant was started in October 1995 and after two and a half years the new Waste to Energy plant of Brescia (2 x 88,3 MW_{th} – 2 x 23 t/h waste) began incinerating waste. The technical details of the plant are as follows:

Installed power:	58 MW
Heat output:	102 MW_{th} (district heating)
Electricity output:	45 MWe
Fuels:	municipal solid waste, industrial (non-hazardous) waste, dried sludge from sewage treatment plants, biomass.
Share of biomass fuels:	20%
Nominal capacity:	46 t/h (2x23 t/h) (at lower heating value of 3,300 kcal/kg - 13,816 kJ/kg)
Combustion lines:	2 (with allowance for a future third line)
Waste unloading:	in closed, negative pressure hall
Waste storage capacity:	30,000 m^3 (stored under roof in bunker)

For combustion lines(data referred to each line)

Combustion temperature:	>1,100 °C
Post-combustion temperature:	>950 °C for over 2 secs
Superheated steam pressure:	60 bar
Superheated steam temperature:	450° C

For Gas cleaning system (data referred to each line)

Gas conditioning inlet:	cooling to 135 °C with full heat recovery
Reagents injection:	dry gas cleaning
De-acidifying agent:	powdered lime $Ca(OH)^2$
Micro-pollution removal agent:	active carbon
Final filtering:	fabric filters
Filtering area:	5,000 m^2
Filter material:	ryton-rastex
Dust inertisation:	with cement + additives
NO_x removal:	SNCR type, with NH3 injection (supplier: Martin GmbH)

For energy recovery section

Equipment:	turbine generator unit (common to the combustion lines) (supplied by ANSOLDO)
Steam turbine:	condensation and extractions
Steam condenser:	air, dry
Condensation pressure:	0.1 bar at Tatm.=20 °C
District heating section:	P=16 bar Tmax=130 °C

For ash handling

During the design stage, particular attention was given to the problem of handling combustion end-products: each line has its own hermetically sealed system for the removal of residues and the removal of dust from the boiler and filters.

Finally, care has been taken to ensure that the Termoutilizzatore plant produces energy as efficiently as from a biomass fuelled plants, as this will ensure emissions are lower (per unit of net energy generated) than from conventional fossil fuel fired plants.

Promoters and parties involved

Project developer: ASM Brescia S.p.a.

Turn key supplier: Consortium of ANSALDO - MARTIN - ABB

In detail,

Supplier of stoker grate: MARTIN GmbH (Germany)

Supplier of steam generator:ANSALDO Spa (Genoa, Italy)

Supplier of gas clean system: ABB Sae Sadelmi (Sweden - Italy)

Fire safety control systems approved by the command of Brescia fire brigade.

Financial Resources

- Total investment: €175 m
- Personnel (80 persons): €3.3 m/yr
- Maintenance: €6 m/yr
- Bottom ash: €4.4 m/yr
- Gas cleaning residue: €3.5 m/yr
- Chemicals: €1 m/yr
- Others: €0.9 m/yr

Results

Up to October of 1999, 372,003 tonnes of waste and biomass (355,689 tonnes of waste and 16,314 tonnes of biomass) were utilised, with a net production of 278.3 GWh of electricity and 240.2 GWh of heat; 225.6 GWh of heat were supplied to the district heating network.

The emissions data (for 1999) are given in the following table:

NO_x	SO_2	Powders	CO_2	HCL
142.2t	26.05t	0.397t	350.045t	25.27t

Net annual energy recovery (LHV = 10.3 MJ/kg (2,500 kcal/kg)):

- electricity: 200 GWh/a
- district heating: 350 GWh/a

Saving of fossil fuel: 3,349 TJ =80,000 toe/year (tonnes oil equivalent per year)

Potential for Replication

According to some estimates, over the period from 2001 to 2010 the construction of a solid wastes-biomass power plant will cost about €1,200 m. The potential for replication of the Brescia plant may be strongly influenced by trends in financial market and by the current absence of an efficient and effective promotion policy. Nevertheless, installation of power generating capacity of 1,000 MW from waste-fuelled power plants can be envisaged by 2010.

For more information

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Sector: Biomass
Country: Italy
Location: Città di Castello (Perugia)
Year: 2000

BIOMASS POWER ON AN AGRO-TOURISM FARM

An agro-tourism company has shown that it is possible for a farm to meet its own energy needs for space heating by utilising biomass. The Agrituristica Monterosello Farm, located in the town of Città di Castello in the province of Perugia (north-centre of Italy), had the idea of developing a forestry management project utilising innovative techniques to produce a renewable fuel, namely wood chips for space heating.

SPI S.r.l. - Società Politecnica Italiana Ricerche e Progetti was entrusted with the task of building the wood-chip fired thermal plant to heat the farm's buildings. In a previous project it had built a biomass heating plant for a household located in the province of Vicenza, in the north-east of Italy. The house consisted of two apartments with a floor area of 160 m^2 plus a laundry in the basement.

Description

In order to heat the 2,200 m^3 of indoor space at the farm, a wood chip boiler manufactured by CMD Termomeccanica company was selected. The boiler has a utilisable thermal output of 115 KW, and is equipped with control, regulation and security systems, a fuel extraction unit and an ash cleaning centre. Moreover, an electric control panel permits automation of the fuel feed and ignition.

The chip extraction unit consists of a parallel screw system, which enables chips to be loaded automatically while regulating the quantity of fuel according to boiler's thermal power needs.

The thermal distribution line is made up of insulated steel pipes and has a length of about 100 m.

Promoters and parties involved

SPI S.r.l. - Società Politecnica Italiana, undertakes activities in the field of agronomy, agricultural and water engineering, industrial engineering and general farm planning. Over the years it has widened its field of activities to encompass research, designing energy-recovery systems, exploiting and appraising supplementary and renewable energy sources, water purification plants and waste disposal and recovery processes.

Financial Resources

The total investment was about €25,800, of which

- €5,150 was the cost of the boiler;
- €9,300 was the cost of installing the distribution line;
- €9,800 was the cost of the civil works, storage area and other auxiliary facilities;
- €1,550 was the cost of the project development and implementation.

It is worth noting that the construction of this biomass thermal plant took advantage of regional incentives covering 40% of the cost of the boiler, together with a 5.5% favourable interest loan for the remaining 60 %.

Results

The plant runs 120 days a year and consumes an average of 400 kg wood chips each day. This means the total yearly biomass consumption is 48 tonnes, equivalent to about 15,900 litres diesel oil.

If the cost of wood-chips is about 70 €/tonne; the annual cost of space heating is €3,400, just a third of the cost of obtaining the same heat from a traditional diesel oil boiler.

Potential for Replication

A number of studies of the potential of biomass resources indicate a positive trend for the development of large scale biomass plants both for heating and also for electricity generation in northern European countries. In the South a definite market niche for small and medium power single house heating plants, has traditionally existed. Promoting the utilisation of waste wood will increase fuel availability for biomass thermal plants, creating new employment opportunities at the local level.

For more information

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Sector: Biomass
Country: Italy
Location: Lupia (Vicenza)
Year: 1999

ENERGIE

SPACE HEATING FARM BUILDINGS USING A BIOMASS THERMAL PLANT

Ecoenergie srl, a company providing modern technologies for sustainable energy development in the north-east of Italy, built a biomass thermal plant in 1999 to provide space heating in the buildings of a farm in Lupia near Vicenza, Italy.

Description

The Plant

The biomass thermal plant, which replaced an old methane boiler, is based on a PYROMAT ÖKO 75 boiler made by Austrian company KÖB.

The boiler has a rated output of 60-80 kW, with a firebox of 550 mm in width, 300 litres in volume and weighing 1,040 kg.

The plant has two hot water tanks, each with a capacity of 1,500 litres; when the heating accumulator is set accordingly, it is possible to supply heat for 9 hours in winter and five days in summer from one single burner fill.

Fuel

The boiler is specially created for fuel versatility: pieces of timber, logs, waste wood, chips, wood shavings or sawdust.

Financial Resources

The total investment was €15,000, of which €9,000 was the cost of the boiler.

Promoters and parties involved

Ecoenergie srl is an ESCO offering energy services primarily in the renewable energy field, and providing both technological and economic solutions. The company has signed an agreement with the Bank of Etica to promote the diffusion of wood boilers.

Financial promoter

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Results

The plant is able to heat a whole volume of 2,400 m^3; and when the heating accumulator is set appropriately it is possible to generate sufficient warmth for up to three days from one single burner fill.

Efficiency

The plant is extremely reliable and well suited for heavy-duty operation. It is easily filled from the top, and very simple to operate. Ideal for stand alone and multiple residence housing units, farm-houses and industrial settings.

Emissions

The PYROMAT represents update combustion technology. The air vents are electronically controlled and combustion is optimised using lambda sensors. It keeps emissions well within the limits specified in the latest clean air regulations for the alpine provinces.

Potential for Replication

In the European Commission's Green Paper "Toward a European Strategy for the security of energy supply" the ambitions objective of doubling the share of renewable energy by 2010 relies mainly on the contribution of biomass. Biomass is the only renewable resource, which has to be produced and thus the development of biomass energy depends on the development of industrial, agricultural sectors and forestry: the integration of their outputs is a main factor to achieve sustainable development in this field.

For more information

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Sector: Biomass
Country: The Netherlands
Location: Cuijk
Year: 1999

ENERGIE

CUIJK, WOOD-FIRED POWER PLANT

The wood-fired plant in Cuijk, situated in the eastern part of the province of Noord-Brabant, came into operation in August 1999. The installation uses fresh, untreated waste wood to produce environmentally friendly electricity.

The project was originally set up by an energy supplier, PNEM (part of Essent since 1999) in order to contribute to its Environmental Action Plan. Like other energy supply companies, PNEM signed an agreement with the Dutch government to reduce the emissions of CO_2 by 3% in the year 2000.

The objective of the project in Cuijk was to contribute to reducing CO_2 emissions by generating electricity from biomass at a decentralised plant.

Description

The Cuijk biomass-fired plant produces electricity using a furnace based on an eddy-current fluidised bed reactor. Inside the furnace there is a pipe system in which water is heated to high-pressure steam. This is then transported to the steam turbine where it expands to drive the turbine, which in turn drives the generator.

To meet current emission standards an electrostatic filter is used to remove dust particles and fly ash from the plant's flue gases. In addition, a $DeNO_x$-installation reduces the emissions of nitrogen oxides. The ash remaining after the combustion process is filtered out and recycled for use in road building.

Strict controls are applied at the plant on the kinds of wood used. In particular, the chipped or shredded wood may not be contaminated with any chemicals, nor should it contain too much moisture or sand. The wood passes under a magnet to remove any ferrous waste from the fuel. The plant is able to process wood with a size up to 7 cm.

The wood fuel is stored in two silos and an outdoor storage. Wood is delivered mainly by lorry. When lorries arrive they are first weighed on a weigh bridge. Then a fuel sample is taken and is analysed with to determine its moisture content and quality. The price suppliers are paid depends on the outcome of this analysis.

The delivery of wood for the plant, by boat along the river Maas, has become increasingly important. A project has been initiated to realise the necessary facilities for fuel supply by boat, such as a landing stage and a crane.

Project characteristics

Fuel input [ktonnes/year]	270
Thermal capacity input [MWth]	85
Moisture content of fuel [%]	50
Electric power capacity [MWe]	25
Electrical efficiency [%]	32.7
High-pressure steam temperature [oC]	520
Storage volume silos [m³]	10,000
Outdoor storage area [m²]	4,500

Promoters and parties involved

- PNEM (now part of Essent): electricity supplier; incineration installation, owner and operator
- Heijmans: civil works
- Kvaerner Pulping: fuel system, boiler, flue gas cleaning
- Siemens: turbine, generator, control system
- Gansewinkel: wood supply
- NRC Fehring: wood supply
- Staatsbosbeheer (Dutch Forestry Commission): wood supply
- Rijkswaterstaat (Department of Public Works): wood supply
- Bio Houtstroom: wood supply

Financial resources

The total investment required for the plant came to €49 m. The project received a grant from the CO_2 Reduction Plan of €5.5 m. The remaining investment costs were financed entirely from the PNEM's own capital. Smaller projects in the preparation phase of the project were partly financed by Novem (The Netherlands Agency for Energy and the Environment) within the framework of the EWAB Programme (Energy Generation from Biomass and Waste).

The technical lifetime of the plant is estimated to be 15 years. The payback period is difficult to estimate, because it is strongly influenced by fuel prices and the price charged for the energy produced, which depends on Dutch energy policy measures, such as the REB regulation (Regulated Energy Tax).

Results

The most important delay in the preparation phase was caused by difficulties encountered in the permit process. This was due to the absence of an emissions regime for wood combustion plants on the scale of the Cuijk plant and the discussion about whether prunings should be considered waste or fuel. In the end, this was solved through extensive consultation, in particular with the Province of Noord-Brabant.

The installation has been operating well from the beginning. The most significant problems affecting operation of the plant have been caused by fuel logistics. The internal transport of fuel caused some difficulties, because the form of the wood appeared to be different from that expected. It was possible to solve this problem in consultation with the fuel suppliers.

Furthermore, foreign matter in the fuel, such as sand, stones and metal caused the sand bed in the reactor to become contaminated too quickly. An automatic sieving installation has recently been brought into operation to mitigate this problem. Currently, research is being done on agglomeration in the sand bed, in co-operation with ECN (the Energy Research Centre of the Netherlands).

The Cuijk biomass plant produces about 190,000 MWh of electricity a year, which is supplied to the public grid. The installation operates at full load for around 7,500 hours a year. The possibility of supplying process heat from the plant was taken into account during building, but it has been difficult to find a buyer for the heat produced. A contract with a heat consumer for the supply of heat has not yet been arranged.

Because the plant uses biomass as a fuel, this enables the substitution of fossil fuels for electricity generation. This leads to an avoided CO_2 emission of about 108 ktonnes a year, based on the average fuel mix for electricity production in the Netherlands as a reference.

Another benefit of the project is that, thanks to the positive value of the fuel, forest managers are able to finance the maintenance of their forests with the revenues from wood sales to the Cuijk biomass plant. As a result of this forestry maintenance, which was often not performed in the past, the forests will be kept healthier and so take up more CO_2.

Potential for replication

Technically, a project such as the biomass plant in Cuijk could be replicated elsewhere in the Netherlands without any problems. However, the financial feasibility of these plants is highly dependent on whether the payment of sufficiently high rates for environmentally friendly energy can be guaranteed during their economic lifetime (10 to 15 years). These tariffs are currently regulated by the Environment-based Taxes Law (WBM, Wet Belastingen op Milieugrondslag).

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Sector: Biomass
Country: The Netherlands
Location: Groningen
Year: 1999

ENERGIE

GRONINGEN, VAGRON BIOGAS CHP PLANT

Since 1987, VAGRON has been processing municipal and comparable industrial wastes from Groningen at its waste separation facility. The 10-year Waste Programme that began in 1992 suggested that separation and anaerobic digestion combined with incineration might be an attractive alternative for municipal waste processing in the Netherlands to deal with the problems of the waste separation system at the time. However, due to the low environmental efficiency and high cost of this system, the city of Groningen decided to stop separate collection of municipal waste in the city centre from January 1st 2000.

As a result, VAGRON decided to add an organic waste washing-digestion installation to its existing plant. This installation means municipal waste no longer needs to be kept separate by the public for depositing in separate bins. Instead, the plant mechanically separates the organic fraction from the “grey” waste.

The objectives of this project were to achieve higher levels of materials recycling, better utilisation of the energy content of municipal waste, and reduction of the amount of waste needing to be landfilled or incinerated. For the Netherlands, the VAGRON plant was the first installation of its kind to be based on the concept of separation-digestion-incineration.

Description

The VAGRON installation consists of four processing units. Firstly, in the (dry) mechanical separation system, the waste is separated by two consecutive drum sieves. These are able to process waste at a rate of 40 tonnes per hour. The overflow from the sieves consists of high calorific components. From this fraction, paper and plastics are split off and upgraded in another unit or used as a secondary fuel. From the remaining material, ferrous metals are removed for recycling using electromagnets. This waste stream is then incinerated. The fraction passing through the second drum sieve consists of mainly (wet) organic material and inert materials such as sand, glass and stones.

The biodegradable organic fraction is transported to a storage unit and then on to a washing installation. In this unit, raw materials such as sand and glass (20-30%) are removed. Additionally, this process improves the quality and workability of the remaining organic material (50-60%) that will be digested.

The biodegradable organic fraction is transported to mixing tanks where hot process water is added. This mixture is kept in a digestion unit at a temperature of about 55 °C for two or three weeks. Here bacteria convert about 70% of the organic material into biogas.

This biogas is used as fuel for a series of gas engines producing heat (3 MW_{th}) and electricity (2.5 MW_{e}). The plant itself utilises most of its own heat production and one-third of the electricity generated.

Promoters and parties involved

- VAGRON: waste processing company; owner and operator
- Grontmij Water & Waste Management: engineering consultancy firm, shareholder of VAGRON (50%)
- Essent Environment: part of energy distribution company Essent and shareholder of VAGRON (50%); incineration of the digestion residue
- Essent Renewable: part of energy distribution company Essent; utilisation of biogas and buyer of the electricity
- ARCG (Waste Processing Region Central Groningen): contract partner
- Province of Groningen

Financial resources

The investment costs for the entire waste separation installation came to €23.5 m, which was financed by private companies. Essent Environment and Grontmij Water & Waste Management, both partners in VAGRON, both made an equal contribution to the project.

A regional promotional fund was used to finance the project. Furthermore, the EIA regulation (energy investment deduction) was applicable to several components of the plant. In view of its environmental benefits, the project is also eligible under the Green Financing regulation.

The technical lifetime of the plant has been estimated at 20 years.

Results

A few unexpected technical hitches occurred at project start-up. These problems were caused by the inhomogeneous nature of the organic waste fraction serving as a medium in the washing unit and the digestion installation. Most of these problems have now been solved.

The plant successfully processes waste at a higher efficiency utilising the energy content of the waste in an optimal way. Furthermore, the separation and processing in the different units leads to a higher level of recycling of secondary raw materials.

As expected, the digested material is too contaminated to allow it to be used as compost. As a result of changes in the regulations while the plant was still under construction, the province of Groningen did not allow this digestion residue to be used as cover soil over landfill sites. This meant it would have to be incinerated at much higher cost. Due to a lack of incineration capacity, however, the residue is currently being landfilled. Research is in progress on the utilization of the residue as a component in the construction of the impermeable layer required as a top-lining for landfills.

The VAGRON plant as a whole is capable of processing 230,000 tonnes of waste a year, of which about 93,000 tonnes is organic. Over 9 m m^3 of biogas is produced annually from the organic fraction. This biogas is used to generate about 17,000 MWh of electricity per year, of which two-third is supplied to the grid. The installation also produces about 24,300 MWh of heat annually.

Because the plant supplies about 12,000 MWh of electricity to the grid, about 108 TJ of fossil fuels are substituted annually. This entails a reduction of CO_2 emissions of around 7,200 tonnes a year. Because not all the heat is used by the installation itself, the emission reduction could be increased further if additional heat consumers were found.

The project also has several other environmental benefits. By washing the organic fraction, two clean mineral streams become available for recycling, i.e. sand and so-called “coarse inert” materials, which consists of mineral fragments, gravel, and glass residues. The plant produces about 32,000 tonnes of these materials each year. Furthermore, digestion of the organic material reduces the amount of material that needs to be incinerated.

Potential for replication

Intermunicipal Waste Friesland, AVR (Rotterdam’s waste processor), and Grontmij have started a project to build a similar waste treatment installation in Friesland, based on the experiences of the VAGRON plant in Groningen. The waste separation and processing plant SBI Friesland is planned to come into operation in late 2002 or early 2003.

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Sector: Biomass
Country: The Netherlands
Location: Schijndel
Year: 1997

ENERGIE

SCHIJNDEL, WOOD-FIRED CHP PLANT

The Schijndel wood factory (Houtindustrie Schijndel, HIS) specialises in drying, planing, sawing, cutting and varnishing of wood for outside customers. Given the amount of waste produced during the manufacture of wood products, and the environmental problems involved in its disposal, the firm decided to build a biomass-fired plant to use the untreated sawmill and woodworking residues the company produces.

However, burning the entire wood waste output from the factory to produce heat would result in heat generation exceeding the company's heat demand. Because there were no other heat consumers located nearby, the company decided to use the excess heat to produce electricity, which is sold to the local grid. The heat generated by the installation is used in the factory. Thus, the project successfully completes the cycle within the factory and wood wastes no longer need to be transported off-site to be processed.

The project is an example of a decentralised combustion system producing electricity using a steam system. When it came into operation it was the first bio-energy plant of this type in the Netherlands.

Description

The Schijndel plant uses pulverised combustion technology. From four silos, wood is transported to the biomass boiler at a rate of 1,400 kg per hour. The fuel is burned there and the heat from this process is used to convert water into steam (at 420°C and 28 bar). The installation is equipped with a Dresser-Rand steam turbine, which is used to drive an electrical generator.

As the flue gases leave the boiler they first pass through an economiser. Then, an electrostatic filter removes fly ash in order to meet the requirements of the permit granted to the plant. Given that there is no further cleaning of the gases, ensuring the boiler runs at the correct temperature is crucial for emission control.

Project characteristics

Fuel input (tonnes/year)	14,000
Thermal capacity (input) [MW_{th}]	7.33
Gross electric power capacity [MW_e]	1.18
Net electric power capacity [MW_e]	1.03
Heat capacity [MW_{th}]	0.5
Net electrical efficiency (%)	15.8
Heat delivery efficiency (%)	4.8
Operating time [h/year]	7,500

Promoters and parties involved

- Wood Industry at Schijndel (HIS): owner and operator
- Vyncke: main contractor
- Essent: electricity supplier

Financial resources

The total investment of the plant came to about €3.3 m, including adjustments. The project is financed from company capital and by short-term loans from the private sector. Novem granted an investment subsidy of €408,402 within the framework of the EWAB programme. In 2000, a "green financing" scheme was set up. The wood-working firm and the utility company Essent set up a 50/50 joint venture for the project.

The lifetime of the project is estimated at 15 - 20 years provided adequate maintenance is carried out. The payback time of the project will be at least 10 years, partly as a result of the currently low feed-in tariff.

Results

During the construction phase of the project, the supplier had to wait for a number components, thus causing a delay to the project. A number of technical problems were encountered during the first two years of operation, such as the need to replace the superheaters and a defect generator, and a grid leakage. Although most of these problems were solved by July/August of 1999 and, consequently, the availability of the plant had gone up to 90% in August 1999, a few technical problems still existed after this period. The plant is currently operating in a stable way, and in 2001, an operating time of 7,800 hours was achieved, which is a sign of good technical performance. In September 2002, the turbine will be modified so as to give better efficiency and increase production by about 50 kWh per hour.

The composition of the wood fuel is crucial for the operation of the plant. Because the amount of fuel that the wood-working factory could supply was not sufficient, it is necessary to buy additional fuel of the same quality (dry hardwood with a high energy content).

Any change in the fuel composition also results in a change in the optimal process conditions. Initially, the plant could not adjust to these changes automatically and operators had to intervene. However, the optimal conditions can now be modified automatically, provided the fuel composition is reasonably constant. When a different fuel composition is used, it takes some time before the process stabilises and in this case an operator needs to be present. Otherwise, operation of the plant is fully automatic.

The plant supplies approximately 7,700 MWh of electricity to the grid each year. The revenues from sales of electricity are about €550,000 a year, depending on the Dutch Regulated Energy Tax regulation. Furthermore, it provides about 3,750 MWh of heat a year for the wood-working factory, which is used for drying processes and space heating. The heat supplied is compensated for by supply of the main part of the biomass needed for the plant.

The installation reduces the amount of fossil fuels used for electricity generation and it results in an estimated reduction of CO_2 emissions of about 4,500 toe/year. Moreover, the project provides a useful application of low-value waste products that result from wood product manufacture. These wastes are stored in silos directly so transport is avoided. Furthermore, the project avoids the use of energy for pelletisation of these wood residues.

Potential for replication

The bio-energy plant at Schijndel is technically suitable for replication elsewhere in the Netherlands. The feasibility of such a project depends on, for example, its competitive position with regard to CO_2 emission reductions compared to large-scale plants, biomass prices, and the feed-in tariffs for electricity and heat produced from renewable sources. If a suitable consumer is found for the low-energy residue heat produced by the plant, the profitability of the project increases significantly.

For replication of the plant in Schijndel, more attention should be paid to control of technical and project risks, for example, (long term) contracts for the possible purchase of biomass, and for sales of electricity and heat. Otherwise, these risks may lead to a considerable increase in the cost of the investment (or operation costs).

For companies producing wood residues, implementing a bio-energy plant is not their core-business. Therefore, such companies would be well advised to seek a project partner with technological expertise in the building and running of bio-energy plants. In the Netherlands, these are usually energy (distribution) and waste processing companies.

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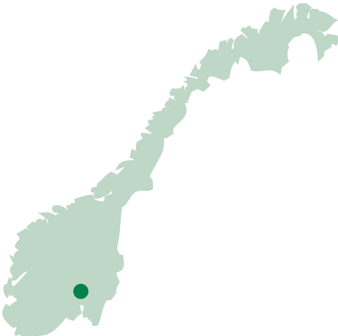
Sector: Biomass
Country: Norway
Location: Oslo Airport, Gardermoen
Year: October 1997



DISTRICT HEATING AT OSLO AIRPORT, GARDERMOEN

The heating system for Oslo's new international airport at Gardermoen is based on a district heating network relying on heat produced from bio energy. The system, installed by the company Gardermoen Fjernvarme (GFAS), was built at the same time as the airport and its related infrastructure. The airport opened to air traffic on 18th October 1998, but the heating system was started up a year earlier and used during the construction of the new buildings.

The initial planning of energy systems for Oslo's new international airport began in the early 1990's. A parliamentary resolution stated that the airport buildings should be as environmental friendly as possible.

Enquiries to fuel suppliers in the area showed that moist fuel was in greater supply and available at competitive prices. Therefore, it was decided to enter into interim contracts with fuel suppliers for the delivery of bark and wood chips with a moisture content of up to 65 %. The bio fuel plant was the first large-scale plant to be used for only district heating in Norway.

The biofuel boiler has a total output of 6 MW at 50 % fuel moisture. The flue-gas condenser provides 1.2 MW at 50°C return temperature and 50 per cent fuel moisture when the bio energy unit is running at full output. In addition to the bio energy unit, three 8 MW oil-fired boilers have been installed to help cover peak heating requirements and provide spare capacity.

Electricity prices have been low in Norway in recent summers. Therefore three electrical boilers were installed in 2000. The electrical boilers have a total capacity of 3.6 MW.

Description

The heating network is a "standard" district heating system designed to operate at 120°C and 16 bars. It is particularly noteworthy that the temperature in the network remains constant at 110°C from October to May, despite the fact that the airport's de-icing activity is based entirely on district heating. The required water temperature for the de-icing activity is 100°C. High return temperatures are avoided because all the buildings are volume regulated and yield a low return temperature. For example, the best building - an aircraft hangar - yields a return temperature of only 25°C from a supply temperature of 110°C – a difference of 85°C. This is highly favourable because less pump work is required, the piping can be used more efficiently and the condensation unit operates better.

The furnace is a traditional, moveable inclined grate. Combustion fans and fuel feed controls allow optimum combustion with high efficiency and low emissions. Preliminary measurements indicate oxygen (O_2) content in the flue gases of 3-4 % of the dry gas, which corresponds to an efficiency rate close to 90 % when the flue-gas temperature is below 150°C.

Condensation plays a key role in the system,where flue gases with a temperature of 65-70°C are cooled so that the steam is condensed and the heat is released. The hot condensate then contributes to heating the incoming district heat.

Maximum capacity bio energy	6 MW + 1.2 MW condensation
Oil fired boilers	3 x 8 MW
Electric boiler	3 x 1.2 MW

Promoters and parties involved

Gardermoen Fjernvarme AS, a company owned by the local utility Gjermå Energi and the utility Viken Energinett from Oslo was originally the owner of the plant.

At the same time as the liberalisation of the electricity marked the district heating company (Gardermoen Fjernvarme AS) changed its name to Fjernvarme Øst AS and is now owned by Hafslund ASA.

Enercon was the project manager during construction period and helped Gardermoen District heating with the feasibility study and the contracts with the different contractors.

Petro Ett AS was the contractor for the complete bio energy plant. The company delivered the fuel transportation system, furnace, boiler, exhaust cleaning equipment and the process control system.

In addition, Gardermoen Fjernvarme has had the following contracts:

- Oil boilers from Peder Halvorsens Kjelfabrikk, Norway
- Electric boilers from Varmeteknikk AS, Norway
- Distribution pumps from Processpumpar AB, Sweden
- Piping in the heat plant, Värmsvets Entreprenad AB, Sweden
- Building construction, Ragnar Evensen, Norway

Financial resources

The total investment cost of the district heating system and heating plant was NOK 54 m (€7.2 m) in 1998. During the first five years of operation there was a further investment of approximate 6 NOK m (€9.8 m).

Capital investment in 1998	*NOK m*	*€ m*
Bio energy unit, 6 MW	10	1.3
Oil-fired boilers 3x8 MW	5	0.7
Pipes, electricity, control system	8	1.1
Building, ground work	12	1.6
District heating and exchangers	15	2.0
Total	*50*	*6.7*
Investment fee	4	0.5
Subsidy from the government	-4	0.5
Total	*50*	*6.7*

The tax on investment is 7 % of the total investment, which is the same amount as the project has received in subsidy from the government.

The project was funded from share capital, a connection fee from the largest consumers and borrowing (approximately 50 %). The borrowing was complicated as investment companies are not used to working with projects of this kind with a long pay back period and large outlay.

The payback period for the bio energy unit has been calculated at about five years, compared with oil firing, and the total project has a pay back period of 10 years.

Results

The total heat delivered from the district heating system is 50-60 GWh a year.

The energy loss in the district-heating network is calculated at about 4 GWh a year.

The water volume in the district-heating network, customer heating plants and boiler plant is estimated to be around 600 m^3.

The cost of biomass fuel is about a third of that of oil, currently around 0.1 NOK/kWh (0.013€/kWh) for chips/wood compared with 0.3 NOK/kWh (0.040 €/kWh) for oil.

Annual maintenance and operating costs are estimated at NOK 3 m (€0.4 m)

Energy production/substitution of fossil fuels

During an average year bark and wood chips will replace fuel oil to produce about 35 GWh a year.

Environmental

By using wet biomass to meet the airport's heat requirements, the energy stored in forestry residues is utilised, avoiding the use of 35 GWh/year of fuel oil. Sourcing the biomass locally minimises the environmental impact of fuel transportation.

The emissions from the plant are quite low. The emissions of dust, carbon monoxide (CO) and nitrogen oxides (NO_x) are well below those permitted by the authorities.

The environmental integration with the local landscape is very good. The building is situated close to the main road carrying passengers to and from the airport.

Potential for replication

After that the Gardermoen plant was built a further 20-30 small bio energy plants (1-10 MW) have been built in Norway. Most of the plants use lower moisture fuel and all of them use a different feeding system to transport the fuel from the bunker to the furnace.

The potential for further development of similar project is Norway is quite good.

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Sector: Biomass

Country: Norway

Location: Tingvoll municipality,
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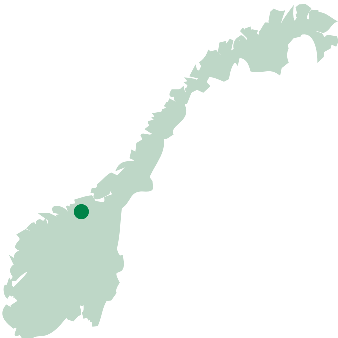
Year: Autumn 2000



BIO ENERGY PLANT AT NORD-MØRE

The municipality of Tingvoll has been a so-called “ecological municipality” since the end of the eighties. During this period Tingvoll has been a partner in a national programme to promote ecological management of local resources and a local information centre on environmental issues has been set up. The information centre, through the company Møre Biobrensel AS, has been working on promoting bio energy for several years. Møre Biobrensel has been an important partner in the process of implementing a new bio energy plant at Tingvoll.

Organic Power’s subsidiary Nordmøre BioEl AS owns the new bio energy plant at Tingvoll. Organic Power has therefore been using the plant for testing and developing the new technology.

The plant will replace oil-fired and electrical boilers by supplying hot water to the local district heating network. The district heating network includes Tingvoll Elementary School, Tingvoll High School, the Sports Centre, and the nursing home.

Description

The process

The plant uses plastic-wrapped compacted bales supplied from a waste recycling plant. The bales are batch-fed into the plant where they are gravity fed into the gasification and combustion zone in the primary chamber. At this stage the volatile fractions of the waste are gasified into low calorific carbon monoxide gas (CO). The CO gas is then fed into the second stage where the secondary gas is injected and gas combustion is completed. The hot flue gas is then led to a heat exchanger where it is used to produce the hot water that is supplied to the district heating network. The flue gas is cleaned by a filter before it is released via the chimney.

Technical data

The plant at Tingvoll has a generating capacity of 750 kW_{th}. Its maximum annual fuel capacity is 3,750 tonnes, depending on the calorific value of the waste.

Initially the plant will use about 900 tonnes of waste derived fuel annually and will supply the district heating network with 2.3 GWh of hot water.

Dissemination

The Tingvoll plant has been presented in several national newspapers and periodicals. The plant has also been presented by the International Energy Agency in CADDET Technical Brochure no. 157 (www.caddet-re.org). Møre Biobrensel AS, a company owned by local municipalities and some local energy utilities, has taken visitors to the plant to demonstrate the use of bio energy in the area.

Promoters and Parties Involved

Owner:

Organic Power ASA (Operated by the subsidiary Nordmøre BioEl AS)

Participants:

- The municipality of Tingvoll
- Møre Biobrensel AS (Einar Oterholm) was an active promoter of the project

Financial Resources

Subsidies:

The Norwegian Water Resources and Energy Directorate (NVE) supplied NOK 400,000 (€53,000) in subsidy.

Loan:

An “environmental loan” of NOK 2.7 m (€360,000) has been provided by NVE.

Payback period:

An example of the payback period for a typical 4 MW plant produced by Organic Power can be calculated by assuming:

- 100 % energy exploitation
- Energy price of 21 øre/kWh (2.8 €c/kWh)
- Tipping fee of NOK 450 (€ 60) per tonne

With these assumptions the payback period is 5.5 years for a 4 MW plant. (The payback calculation excludes the cost of plant infrastructure.)

Results

The commercialisation and continuous operation of the plant at Tingvoll has taken longer than originally expected as the plant will be operated continuously from the autumn of 2002. There are several reasons for this delay:

- The technology is still under development and thus there have been some teething problems.
- Due to the limited resources, Organic Power, the developer of the technology and the owner of the plant, found it necessary to focus on projects for external customers.
- The quality of the local waste did not meet pre-sorting requirements necessary to ensure a stable process. A temporary supplier has been identified and the original supplier is working on the process to ensure adequate quality of the waste.

Energy production

The plant will supply the local heating network with 2.3 GWh/year when operated continuously.

Economics

The economics of the plant rely on tipping fees for the waste-derived fuel and energy sale.

Socio-economic aspects

Organic Power’s energy recovery unit is a part of Tingvoll municipality’s environmental profile. The plant will supply the local sports centre and municipal buildings with energy in the form of hot water through the existing heating system. The municipalities plan to expand the existing district heating system and connect additional public buildings and thereby utilize a greater part of the plant capacity.

Environmental aspects

The flue gas passes through a filter system, which ensures that the emissions comply with EU 2000 standards. Emission tests have been carried out by Norske Veritas AS at Organic Power’s demonstration plant in Notodden. The tests show that Organic Power’s plant has emissions well below the EU directive on heavy metals, dioxins etc. and emissions of gases (CO, NO_x, SO_2).

The new bio energy plant replaces oil-fired and electrical boilers. If the oil-fired boilers delivered 50 % of the heat then approximately 130 tonnes of oil would have been used annually. The annual emissions of carbon dioxide would have been approximately 380 tonnes[1].

Potential for Replication

The Organic Power concept of waste-to-energy plants is flexible:

- It accepts fuels of varying moisture conten.t
- It is made up of modular units.

The flexibility in the design and the waste-derived fuel mixture makes them readily adaptable to customers’ specific requirements.

For More Information

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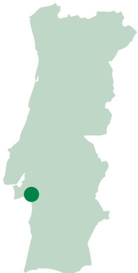
1 Assumptions: Heating value waste-derived-fuel: 3.2 kWh/kg (CADDET).

Sector: Biomass and Solar Thermal
Country: Portugal
Location: Alcácer do Sal
Year: May 1999

ENERGIE



HYBRID SYSTEM (BIOMASS AND SOLAR) FOR HOT WATER PRODUCTION AND SPACE HEATING AT A SWIMMING POOL

As the region has considerable potential renewable energy sources (RES), the municipality of Alcácer do Sal decided to use RES to supply energy for its swimming pool facilities, given the environmental benefits this would bring the region.

Description

The project was promoted by the Municipality of Alcácer do Sal to produce hot water for a municipal swimming pool (25x12.5 m) using renewable energy sources (biomass and solar). The biomass resource is pine-cone that is burned in a 300 kW boiler. The installation also includes a solar system with 120 m^2 of panels providing space heating and hot water. The main technical details are:

- The energy produced from biomass and solar power acts as energy back up source.
- Annual consumption of pine-cone scale - 150 toe.
- Automatic boiler feed in system.
- The installations are equipped with heat exchangers, a hot water storage tank, a dehumidifier and a unit for air treatment.

Promoters and parties involved

The project was promoted by the Municipality of Alcácer do Sal.

Financial resources

- Total investment: €184,000
- Co-financing: (50% Programa Energia)
- Payback period: 6.3 years

Results

It was necessary to adapt the automatic boiler feed system to modify the standard equipment that had been selected.

Furthermore, management measures relating to the overall management of the swimming pool were taken in order to improve the use of solar energy. Consequently, since then, the renovation of the water is carried out during the day and not at night as is usual in swimming pools.

Total annual energy needs of the swimming pool
517,860 kWh

Energy from the solar collectors
124,540 kWh/year

Annual savings (in relation to the consumption of propane gas)
€29,130

Internal Rate of Return (20 years)
18%

By using biomass the project is contributing to reducing the pollutant emissions and the equipment was designed and installed to ensure full integration with the local environment.

Potential for replication

Bearing in mind that almost all municipalities have swimming pools or similar sports facilities, there is clearly considerable potential for the replication of the project in similar contexts. In fact, this swimming pool could be considered a benchmark for the optimal use of renewable energies.

For more information

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Sector: Biomass and Solar Thermal
Country: Portugal
Location: Alfândeda da Fé
Year: June 2000

ENERGIE

BIOMASS POWERED HEATING AND COOLING NETWORK AT A HOTEL

Taking in account the abundance of the particular renewable energy resource (almond shells) and the concern for environment protection in a tourist region, the promoter (AlfândegaTur Company), took the decision to develop a project for the rational use and exploitation of the resource. Furthermore, the project aimed to avoid the consumption of conventional energies (thereby reducing emissions) and to demonstrate that the use of almond shells as a fuel can be an alternative or complementary energy supply.

Description

The project was promoted by AlfândegaTur (a tourism company) and envisages the use of almond shells, a locally available biomass resource, to provide heat and cooling at a hotel. For this purpose a system was installed comprising a 300 kW boiler running on almond shells, and a 100 kW propane gas boiler as a back-up energy source. The installation also includes a solar system (60 m^2) and a 220 kW absorption chiller. The system also comprises domestic hot water storage tanks and units for air conditioningThe Agência Municipal de Energia de Sintra (AMES) collaborated with AlfândegaTur during project implementation and also carried out dissemination activities.

Promoters and parties involved

The project was promoted by AlfândegaTur with the collaboration of AMES.

Financial resources

- Total investment: €274,338
- Co-financing: 50% from Programa Energia
- Payback period: 8.7 years

Results

The main problems encountered were linked to:

- The regulation of the control system for the needs of the hotel in connection with the absorption chiller and the burning of almond shells.
- Finding people from the region with the right skills to manage the equipment.

Annual consumption of almond shells – 194 toe

Total annual energy needs - 725,115 kWh

Energy from the solar collectors – 45,660 kWh/year

Annual savings (in relation to the consumption of electricity and propane gas): €31,489

Internal Rate of Return (20 years): 9.6 %

By using biomass, the project is contributing to reduce the pollutant emissions and the equipment was designed and installed to ensure full integration with the local environment.

Potential for replication

The existence of a significant number of similar tourism facilities suggests that there is considerable potential for the replication of similar projects using technology taking advantage of biomass resources, such as the one used in this project.

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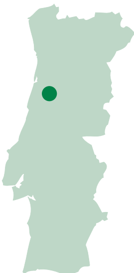
Sector: Biomass
Country: Portugal
Location: Mortágua
Year: August 2000

ENERGIE



MORTÁGUA POWER PLANT

The exploitation of indigenous resources, such as biomass could contribute to reducing Portugal's energy dependence and to diversifying its sources of energy. Furthermore, there is a need to introduce the concept as part of a global environmental-protection strategy to promote sustainable forestry and optimal utilisation of forest resources, as well as sustainable agriculture and production of energy from non-food crops. In this context, the Portuguese power utility, Electricidade de Portugal (EDP) with the collaboration of the Biomass Center for Energy has conducted a series of studies, leading to the implementation of the Mortágua power plant – a thermoelectric power plant generating electricity from forestry waste.

Description

- A storage area of 30,000 m^2 and weighing equipment, humidity control systems and equipment to chip the waste wood.
- The boiler was designed to burn wastes but it is also able to run on natural gas.
- Installed power: 10 MVA.
- Installed electric power: 9 MW.
- Gross efficiency: 26.5%.
- Capacity of the biomass store: 57,880 m^3.
- Humidity: 30%.
- Wood consumption: 8.7 toe/h.
- The power plant works 7,800 h/yr, corresponding to an availability of about 90%.

Both entities involved in the project, EDP and CBE, carried out promotional activities, such as giving presentations at events, publishing promotional leaflets and articles in the press.

Promoters and parties involved

- Promoters: EDP and CBE
- Overall project design and management: EDP
- Support for project design and identification of waste-wood resources: CBE
- Equipment supplier and installation: Soares da Costa (civil works), Ansaldo Volund, Ansaldo Energia and EFACEC
- Environmental impact study: EDP, Instituto Ambiente e Vida e Universidade Nova de Lisboa

Financial resources

- *Total investment:* €10,000,000
- *Subsidies:* co-financing received from Programa ENERGIA (Portuguese support programme for the energy sector)

Results

- No special problems were encountered bearing in mind that the project was designed in close co-operation with several public entities, including the Ministries of Interior and Economy, and local authorities.
- *Energy production:* 63 GW/year
- *Socio-economic benefits*: the project permitted promotion of sustainable forestry and best utilisation of forestry resources with a view to enabling a reduction in energy dependence. The power plant will also help minimise the risk of fires, contribute to job creation and to alleviate the rural exodus that is a serious problem in the region concerned.
- *Environmental benefits*: the power plant, which is located near a hydroelectric power station, more than complies with national or EU environmental requirements. To illustrate this, the values of the emissions from the Mortágua power plant and the corresponding EU limits are shown in the table below:

	Guaranteed emission by the power plant(mg/Nm^3)	Limit values in Europe (mg/Nm^3)
Particles	100	300
SO^2	300	2,700
No_x	340	1,500
CO	200	1,000

Potential for replication

As biomass is a significant indigenous energy resource, there is potential for the replication of facilities of this kind elsewhere. All future developments will depend on energy policy and on the strategy adopted.

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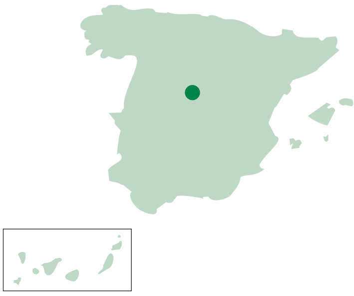
Sector: Biomass
Country: Spain
Location: Cuéllar (Segovia)
Year: January 2000



CENTRALIZED DISTRICT HEATING NETWORK IN CUELLAR

The district heating and domestic hot water project at Cuéllar (Segovia) enables use of wastes from woodland underbrush clearance and other types of biomass to be used as fuel for a heating plant where water is heated for subsequent distribution to users via a pre-insulated dual pipe system.

Centralized district heating systems supply energy directly to users, avoiding the need for them to oversee their own installations or handle and store fuels. Such systems have a long tradition in countries such as the United States and in the centre and north of Europe (in Denmark and Sweden they provide half of all heating). By contrast, in Spain the installation of such heating grids is still very new idea.

An additional important innovative feature of the project, which took place in Cuéllar is precisely the fact that the heating plant is fed on biomass. The use of this indigenous renewable energy source brings a variety of advantages. These are primarily environmental, given that it reduces the use of more polluting fossil fuels, but also social, as supplying the plant with biomass creates new economic activities in the vicinity.

An additional benefit for users of district heating systems is their lower cost compared with conventional systems. In the case of Cuéllar this can be quantified as a 10% reduction on previous heating bills.

At present twelve single-family homes, five housing cooperatives, a social centre, a school and a sports centre are supplied with heating and hot water from the plant. In the future it may be possible for new users to connect to the grid, as the plant has sufficient capacity to allow for this.

Description

Obtaining the biomass

Cuéllar Council (Ayuntamiento de Cuéllar) manages the supply of biomass used as fuel by the plant. The boiler allows for the use of a broad variety of fuels, including initially the use of wastes from woodland underbrush and brash clearance, bark, wooden packaging materials, pine cones, etc.

Main principles of the installation

The installation consists of the following main components:

Heating plant

The heating plant consists of the following components:

- Storage silo with a capacity of 100 m^3 and a fuel feed system.
- Main water tube boiler for the production of hot water, with a capacity of 4,500,000 kcal/h, with a moving grate com-

bustion chamber and a multi-cyclone exhaust fume precleaner with a heat recuperator.

- Auxiliary water tube boiler for the production of hot water, with a capacity of 600,000 kcal/h, with a moving grate combustion chamber and a multi-cyclone exhaust fume precleaner with a heat recuperator.
- Electric pump units for hot water circulation through the boilers and circuit.
- Transformer, expansion tank, control system and other auxiliary components.

Distribution grid

The distribution grid connects the heating plant with the consumer centres. The grid uses pre-insulated carbon-steel piping with polyurethane insulation and high-density polythene for external mechanical protection. The pipe runs underground along a trench about 1 m deep and incorporates all the necessary stop valves, expansion joints, etc.

Connections with users

Each consumption centre has one or two heat exchangers in parallel with the current generation systems, and where necessary a domestic hot water storage tank. In addition there are stop valves, control valves, control devices, interconnection, and the other necessary items.

Energy process

The biomass arrives at the plant by lorry, where it is deposited in the 100 m^3 silo. The fuel is pushed from the silo onto a series of belts by a series of hydraulic pushers at the base. These belts transport the fuel to the hoppers which feed the boiler.

In the boiler the water circulating in the coils is heated. This water exits the plant at a temperature of 95ºC, and is pumped around the 2 km distribution grid, which connects the various consumption points.

During the winter months when the system is providing heating and hot water, the main boiler is operated, whereas in summer, when only hot water is required, the auxiliary boiler is used and the grid operates at a lower flow rate.

Via the heat exchangers at the consumption points the water delivers the heat necessary to heat the secondary circuit, which provides the user with heat, and when necessary, hot water. Once it has delivered its heat, and thus at a lower temperature, the water returns to the plant via the return pipe, which runs parallel to the outbound pipe.

Promoters and parties involved

The project promoter was the Cuéllar Council (Segovia). EREN, the Castilla-Leon regional energy body (Ente Regional de la Energía de Castilla y León) and the IDAE (Instituto para la Diversificación y Ahorro de la Energía) participated in the financing of the project.

Financial resources

Implementing the turnkey system required an investment of €1,158,000. The financial resources needed to undertake this project were provided in equal parts by EREN, the Castilla-Leon regional energy body (Ente Regional de la Energía de Castilla y León) and the IDAE (Instituto para la Diversificación y Ahorro de la Energía), which signed a Participation Accounts contract for this purpose. A Third-Party Finance contract was also signed by Cuéllar Council.

The project benefited from a subsidy from the PAEE, the Energy Saving and Efficiency Plan (Plan de Ahorro y Eficiencia Energética) under the 1997 Order, for the sum of €220,252. The project also receives a subsidy from the Regional Government of Castilla-Leon (Junta de Castilla y León).

Results

a) In energy terms

The use of waste biomass as fuel for the plant entails the substitution of conventional fuel. In this case the fuel previously used was C grade diesel. Under normal conditions of operation of the plant, this has been estimated to result in an energy diversification of 644 toe/year.

b) In technology terms

First of all the innovative nature of this project in Spain should be highlighted. The installation is functioning satisfactorily.

The use of waste biomass to fuel a district heating network like that described is a replicable application. Applications of this kind do not need such a large supply of biomass as other projects, such as electricity generation.

c) Environmental

In addition to eliminating the risk of accidents existing with other types of fuel, the use of biomass entails a reduction in pollutant emissions.

d) Economic

The cost of the fossil fuel that would have needed to have been purchased if this project had not been carried out would have come to approximately €210,000 a year.

Potential for replication

The use of waste biomass in biomass thermal applications is particularly feasible in areas where there is forestry management and agriculture. Using this waste biomass in this way makes a contribution in terms of waste disposal and offers a service using a less polluting fuel.

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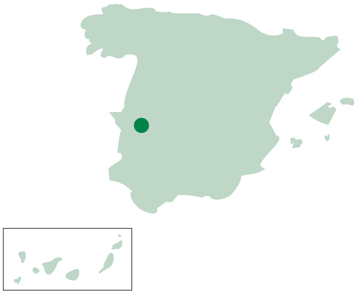
Sector: Biomass

Country: Spain

Location: Helechosa de los Montes (Extremadura)

Year: June 2000

ENERGIE



FULLY INTEGRATED BIOMASS ENERGY PLANT IN HELECHOSA DE LOS MONTES

The company Metarnhel, S.A. was created in 1996 with the purpose of implementing an electricity cogeneration plant running on forestry biomass. The electricity generating plant utilises biomass in the form of forestry waste from the company's own rock rose, pine and eucalyptus woodlands. The plant uses around 22,246 tonnes/year, with an NCV of 3,271 kcal/kg at 20% moisture. The plant generates electricity via a 1,300 kW generator. The electricity produced is sold to the grid under the "special system". There are plans to use the excess heat energy of 4,640,000 kcal/h in a second phase of the project.

Description

The plant's supply of biomass comes from brash and waste from woodland and scrub in the surrounding area (rock rose, pine and eucalyptus) in accordance with the plans established with the Consejería de Agricultura y Medio Ambiente de la Junta de Extremadura (Board of Agriculature and Environment of the Extremadura Regional Government) as a preventive measure (responding to the need to clear obstacles to the light, maintain nutrients and soil humidity; reduce the risk of forest fires; prevent disease and pests; and reduce rural depopulation). Rock rose is a bushy plant that forms dense undergrowth and which covers 13.5% of the land surface in the area in a 20 km radius around Helechosa de los Montes, providing a supply of 240,000 tonnes/ha. It is harvested with a specially designed cutter that allows it to be collected directly from the forest. Wood wastes from forestry and timber businesses in the area are also used (sawdust, pine bark).

A pilot plant has recently been set up to extract resin from the rock rose. This is for two purposes, firstly to avoid the formation of "vaults" in the silos caused by the sticky resin forming tangled mats of woody material, and secondly to use the resin for commercial purposes.

Technical details:

Unit: Boiler

Technology: Water tube boiler

Manufacturer: Buyo

Model: Water tube 10.000

Unit: Grate burner

Manufacturer: Sun Clean España

Model: HP-4000 II

Unit: Turbo-alternator

Technology: Steam turbine

Manufacturer: Tuthill Nadrowski

Model: B55-5-GVS

Unit: Condenser

Manufacturer: Tuthill Nadrowski

Model: AA43CD28/40 HJK 144

Promoters and parties involved

Owner/recipient: METARNHEL S.A., set up by the following entities:

Sun Clean España S.L: 69.31%

SODIEX: 14.80%

Helechosa Council (Ayuntamiento de Helechosa): 10.40%

Servicio Técnico, S.L.: 3%

Aprovechamiento de Recursos Naturales de Helechosa: 1.6%

Metarnhel S.A.: 0.89%

Financial resources

Investment in plant: €2,103,542

Investment subsidies (outright grants):

Ministry: €249,510

European Union: €831,705

Own resources: €1,272,222

Results

Energy details:

Electrical power: 1.300 kW.

Electrical output: 10,400 MWh.

Heat generation: 5,395 toe.

Consumption of renewable fuel: 8,278 toe.

Employment generated:

The plant has a workforce of 13 employees working four shifts. It therefore contributes to job creation and stemming the flow of the population away from the region, which is a serious problem in the area where the plant has been built.

Potential for replication

Agreements have now been signed with two groups of municipalities and two companies for the introduction of energy crops and integrated biomass utilisation for energy and industrial purposes. Once their feasibility has been determined, two power plants (with installed capacities of 2.5 MW and 3.6 MW) are planned to be built.

For more information

Consejería de Economía, Industria y Comercio (Board of Economy, Industry and Commerce). Junta de Extremadura (Extremadura Regional Government).
Dirección General de Ordenación Industrial, Energía y Minas (Directorate-General for Industrial Planning, Energy and Mines).

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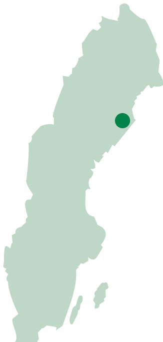
Sector: Biomass
Country: Sweden
Location: Dåva, Umeå
Year: September 2000

ENERGIE



ENERGY EFFICIENT WASTE TO ENERGY PLANT IN UMEÅ

The Dåva combined heat and power plant (CHP) is one of the most efficient power plants in the world thanks to its combination of innovative solutions. It is the first time compressor heat pumps have being used to recycle heat from the flue gases in a plant of this kind. Excess heat from electricity generation is also recovered.

Description

The waste derived fuel is converted to heat and electricity in three steps:

- Electricity is generated by passing the superheated steam through the turbine. The turbine converts heat to kinetic energy, which is then converted to electricity by the generator, (which delivers about 10 MW_e).
- Downstream of the turbine is the turbine condenser. The remaining heat is exchanged with the hot water in the district-heating network. The system has a heating capacity of about 40 MW_{th}.
- In the flue gas cleaning process the gas is cooled to about 25-35ºC. The moisture of the flue gas is then separated. The process uses a compressor driven heat pump and has a capacity of about 15 MW_{th}.

Technical data

Fuels	Household waste, waste from businesses and residual products from the forestry industry
Capacity	55 MW_{th} and 10 MW_e
Heating value waste	Approx. 3.2 MWh/toe
Waste bunker, volume	6,500 m^3
Incinerator, capacity	20 toe/h
Volume of waste used annually	140,000 toe/yr
Efficiency	Approx. 99%

Promoters and parties involved

The owner of the plant is Umeå Energi AB.

The main suppliers were:

- Svenska Von Roll and Götaverken Miljö (machinery)
- Konte (construction)
- NCC Änleggning (land)

Financial resources

The total investment in the plant was approximately SEK 650 m (€71.3 m).

Results

Energy production

The plant produces 350 GWh/yr of heat and 70 GWh/yr of electricity.

Environmental results

The plant includes a number of new technical systems for incineration and flue gas cleaning, which have resulted in a significant reduction in the environmental impact compared to previous production methods. For example, a non-bypassable textile barrier filter with active carbon is used ahead of the wet flue gas cleaning stage. The total emissions of dioxins, mercury and other heavy metals now meet the requirements of the Swedish Environmental Court ("Miljödomstolen").

The oil consumption in the district heating system has decreased by about 80 % following installation of the plant.

Potential for replication

The low emissions and the high efficiency of the plant make it an interesting option for similar plants elsewhere.

For more information

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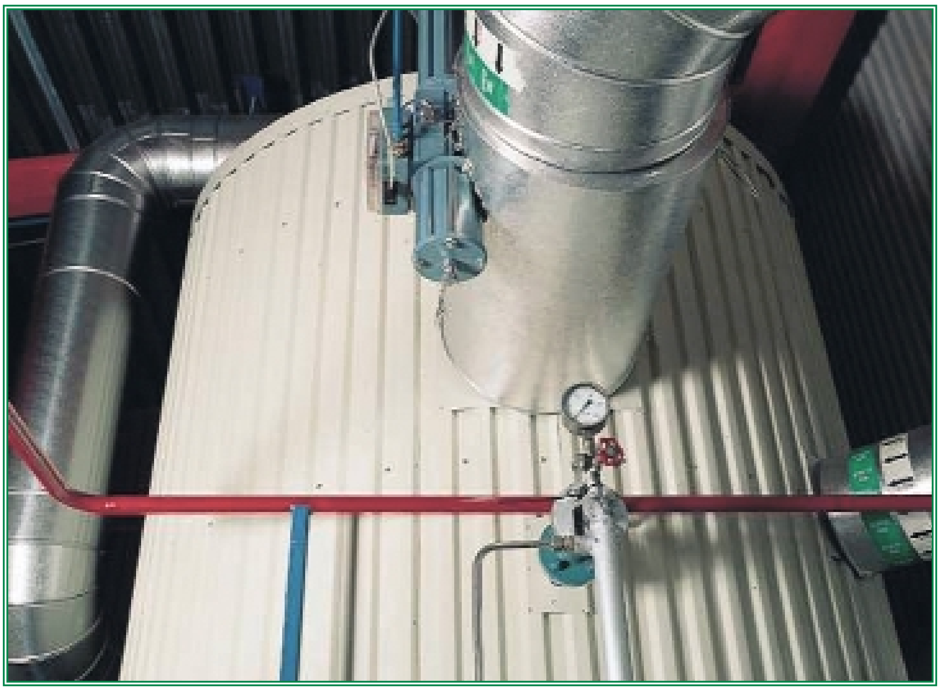
Photo by Umeå Energi (photographer Johan Gunséus)

Sector: Biomass
Country: Sweden
Location: Eksjö municipality
Year: Autumn 1997

ENERGIE



CONVERTING A HEATING PLANT TO CHP PLANT AT LOW COST

The Eksjö plant, a conventional biomass and waste heating plant, has a hot water boiler designed to operate at a pressure of 16 bars, in common with many Swedish heating plants and sawmills. However, when the plant was used for a district heating system it was operated at 6-7 bars. Now, by increasing the pressure to about 14 bars and converting some of the hot water into steam, electricity generation has been made possible without needing to replace the boiler. This meant that it has been possible to carry out the conversion at relatively low cost.

The newly developed system was installed in the autumn of 1997 by the Swedish company Vaporel AB and has been under evaluation since the spring of 1998. The Eksjö plant has a maximum electrical power generation capacity of 950 kW and produces 5,500 MWh of electricity annually.

Description

From the existing boiler, hot water is piped to the flash-box, where a small amount is converted into steam and the pressure reduced.

The steam generated in the flash-box releases some of its energy content during expansion in the Curtis turbine. The generator, which is connected directly to the turbine, converts the mechanical energy into electrical power. The role of the condenser is to cool down the exiting steam after the turbine to obtain additional electrical power. After having been heated, the cooling water is pumped to the municipal heating network, kilns or other users.

The Eksjö plant has a thermal capacity of approximately 8,500 kW and an electrical generating capacity of 950 kW. The electricity produced is used mainly for own purposes.

Technical data

Production pressure/temperature to flash box	14.5 bar(a)/197 °C
Pressure / temperature in the flash box	9.5 bar(a)/178 °C
Steam production	
- Flash water flow	107 kg/sec
- Steam generated	3.8 kg/sec
- Percentage generated steam of inlet flow	3.4 %
Condenser	
- Pressure	0.5 bar
- Temperature	81 °C
Generator voltage	400 V
Maximum generated electrical capacity	Approx. 950 kW
Annual electricity production	5,500 MWh/year
Heat production	Approx. 8,500 kW

Dissemination activities

The project has been presented in several magazines and newspapers, e.g. the Swedish Energimagasinet 2/99 (www.energimagasinet.com) and additionally by the International Energy Agency's CADDET, (www.caddet-re.org).

Promoters and parties involved

Eksjö Energi AB is the owner and operator of the plant.

Vaporel AB developed the flash-box (steam generator) and was the main contractor.

Financial resources

The total investment for the Vaporel CHP-design was about 7,000 SEK (approx €760) per installed kW electricity for a plant of this size. The specific costs are lower for larger plant with capacity above 1MW.

The total investment for the Eksjö plant's CHP conversion was 6.2 m SEK (approx. €568,000), from which 1.6 m SEK (approx. €147,000) was granted by the Swedish government.

Source of revenue

The plant supplies hot water to the local heating grid.

Pay-back period:

The pay back period is estimated at 5-6 years.

Results

• There were a few teething problems with electricity production during the first few months of operation.

• The control system took some time to be implemented.

• Since 1st January 1999 the plant has been operating without any major difficulties, and the operational availability has been about 99 %.

Environmental

The implementation of the steam generation the heating plant makes the plant self sufficient in electricity and thus contributes to reducing demand for electricity generation from other sources.

Financial

An economic analysis of the project has shown that the low investment and operating cost, due to the fact that it is providing electricity for own use, also makes this design profitable without a subsidy.

Socio-economic

The need to supervise the system has increased as a result of converting it from a heating plant to a CHP plant, which could therefore generate new employment.

Potential for replication

There are quite a few similar hot water boilers in Sweden, which could readily be converted to enable electricity generation as the design pressure of the boiler is higher than that needed for heat production. The low investment cost also makes this idea interesting for sawmills with drying processes.

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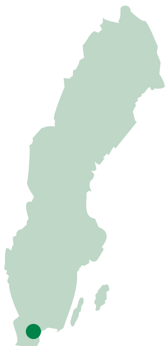
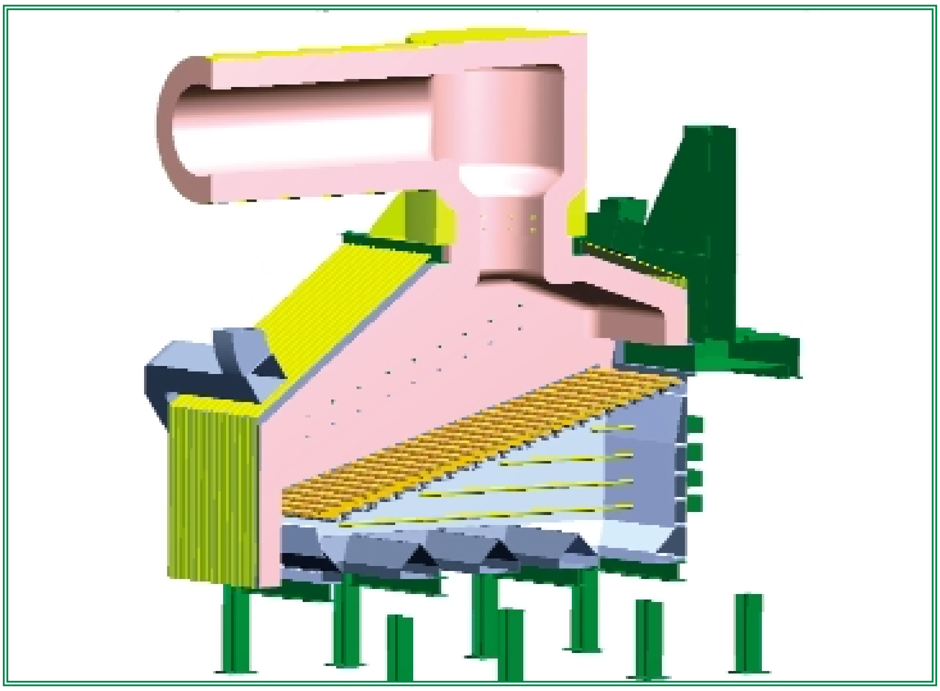
Sector: Biomass
Country: Sweden
Location: Höör, near Malmö
Year: 1998

ENERGIE





HÖÖR LOW-EMISSION BIOMASS PLANT

The municipality of Höör in Southern Sweden decided to invest in a new heating plant for the town centre. Biomass was the preferred source of fuel as it had already proven to be readily available and economically viable in Sweden.

The authorities set up strict emission permits as the plant is located in the city centre close to residential areas and a school. To meet these low emissions requirements the plant has been built based on new technology developed by Petro Ett AB (previously Ekotrans Termik AB) and Ermatherm AB.

Description

The method applied to reduce the emission is to combine particle cleaning with flue gas condensation, which is an expensive part of the installation. Ermatherm AB developed the method and Volvo Aero Supports, with support from the Swedish research programme NUTEK, tested the prototype

The biomass furnace has a capacity of 2.5 MW. The combination of cleaning and condensing of the flue gas added a further 0.3-0.6 MW, depending on the energy content of the bio fuel.

The biomass plant delivers about 15 GWh annually to the district heating network, which is about 85 % of the heat used by the network. Three 3.3 MW LPG boilers supply the remainder.

The furnace was supplied by Petro Ett AB. The furnace is equipped with a flue gas recycling system, which contributes to accurate control of the temperature and combustion of high energy content fuels. An additional feature of the recycling system is the reduction in emissions of nitrogen oxides.

To reduce emissions the flue gas is cleaned in a wet electrostatic precipitator before it enters the condenser. Inside the precipitator the flue gas comes into contact with the wet inside of the cylindrical duct and the positive charged dust particles are attracted to the water film on the wall. The flue gas exits the precipitator at the base, where it then travels upwards through a scrubber column.

The project is described in the International Energy Agency' s CADDET Technical Brochure No. 156, www.caddet-re.org and in the Swedish magazine "Energimagasinet", No. 5, 1998, www.energimagsinet.no (in Swedish). The contractor uses the plant as a reference plant for new customers.

Promoters and parties involved

The plant is owned by the municipality of Höör. The main contractor was Petro Ett AB (previous Ekotrans Termik AB). Petro Ett developed the furnace and Ermatherm AB developed the wet electrostatic precipitator.

Financial resources

Total investment

The total investment was SEK 11 m (€1.2m)[1].

The electrostatic precipitator cost SEK 1.6 m (€180,000), for which the Swedish National Energy Administration gave a grant of SEK 380,000 (€42,000).

The payback period for the plant is approximately 4 years.

Results

Energy production

The plant delivers about 15 GWh a year, of which the biomass plant delivers 13 GWh (85%).

Environmental results

The installation of the wet electrostatic precipitator increased efficiency and decreased emissions.

If the annual heat output of the biomass plant were to be supplied from LPG boilers, approximately 1,200 tonnes of LPG would need to be used, which would increase the emissions of carbon dioxide by about 3,000 tonnes.[2]

Potential for replication

There are currently a number of similar projects in Sweden and Norway. The potential for projects of this kind is increasing as environmental regulations are getting stricter. The focus on lower emissions within the European Union would contribute bolstering the potential for this technology.

For more information

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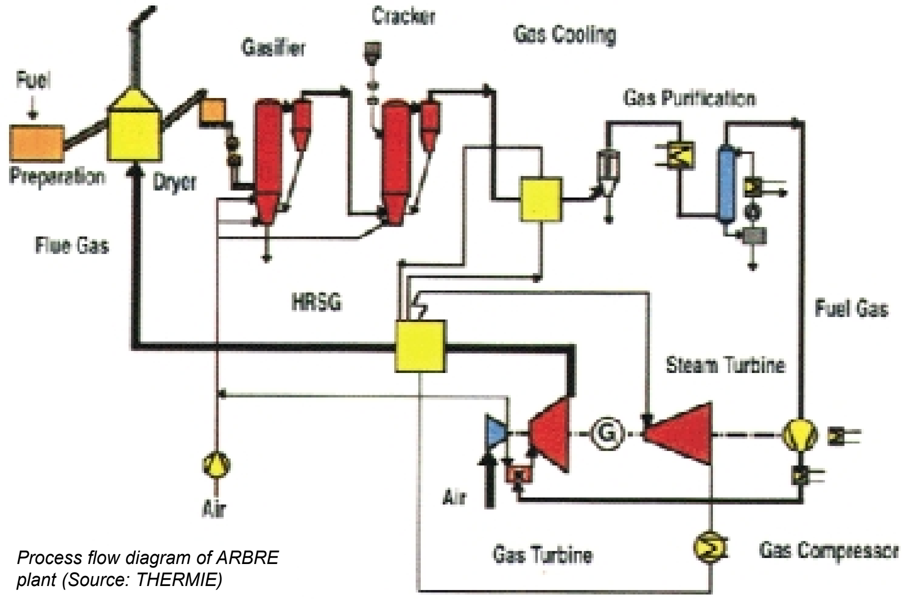
1 International Energy Agency, CADDET Technical Brochure No. 156, www.caddet-re.org.

2 Assumptions: Efficiency LPG boiler 85%, energy content LPG 46.1 MJ/kg and CO_2 factor LPG 206 kg/MWh.

Sector: Biomass
Country: U.K.
Location: Eggborough, North Yorkshire
Year: 2000

ENERGIE



Process flow diagram of ARBRE plant (Source: THERMIE)

ARBRE

ARBRE (the acronym of "ARable Biomass Renewable Energy") is an innovative commercial wood-fired power station utilising high-efficiency gasification technology (a forerunner was built in Varnamo, Sweden using this kind of technology, but it was at the demonstration stage). The installation is located at Eggborough in North Yorkshire and it has been supported by the European Commission's THERMIE programme.

The installation can be considered innovative in, at least, two ways: firstly in the typology of gasification technology applied (Biomass Integrated Gasification Combined Cycle, BIGCC), which is designed to increase efficiency and to reduce emissions from the combustion process; secondly, in promoting the creation of a market of wood for energy purposes in an area with potential for it, through Short Rotation Forestry (SRF) plantations.

The project was launched in 1996 and the plant became operational in 2000.

ARBRE plant. Source: Renewal Energy World. Nov-Dec 2000

Description

ARBRE is a Biomass Integrated Gasification Combined Cycle (BIGCC) power plant applying TPS atmospheric circulating fluidised bed (CFB) gasification technology.

The plant comprises the following elements:

1. Air-blown gasifier
2. Tar cracker
3. Gas cooler
4. Gas filter
5. Gas scrubber
6. Ash removal system
7. Effluent treatment plant and ancillaries (with sand and dolomite systems).
8. Inert gas generator
9. Gas flare

The installation is completed by a 4.75 MW Typhoon gas turbine (the first and only existing type of turbine specifically designed to work with a BIGCC power plant) and the gasification technology used is TPS atmospheric gasification.

In terms of its operation, wood is delivered at a fuel reception building with storage capacity for 3 days' fuel. Fuel, in the form of chips, is dried to 10-20% moisture content with warm dry air from the air cooler condenser (located downstream the waste heat boiler).

Chips are fed into the TPS circulating fluidised bed gasifier by an immobilised hopper system. This gasifier operates at temperatures ranging between 850 and 900ºC. Sealing gas is introduced into the fuel feed system .During this process tars are cracked catalytically to a simpler compound into a second circulating fluidised bed reactor.

Finally, after several other processes, the gas is compressed to about 20 bar and fired into a gas turbine. It then travels to a heat recovery steam generator, in which 5.5MW are produced using a steam turbine.

The whole process takes place in three different phases:

1. Gasification: fuel is carbonised
2. Filtration: cleaning of gas to remove impurities and recycling of gas into the gasifier
3. Conversion: gas is used to generate electricity

Promoters and parties involved

The whole project is a joint venture between First Renewables Limited (85%), TPS-Termiska Processer AB of Sweden (10%) and the Schelde Group (5%).

Developers and owners:

First Renewables Ltd (acquired in May 2002 by Energy Power Resources Limited).

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Coldharbour Lane. (Bristol) BS16 1EJ
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Termiska Processer AB

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Project management:

ARBRE Energy Limited.

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Gasification technology

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Gas turbine:

ALSTOM

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75795 Paris Cedex 16 (France)
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webmaster.internet@chq.alstom.com
www.alstom.com

Financial resources

The total cost was approximately €33.1 m.

The European COMMISSION´S THERMIE programme has supported the project with a grant of about €8.8 m. In addition, it was awarded a contract under the NFFO3 (Non-Fossil Fuel Obligation) to sell electricity to the local electricity grid for a period of 15 years.

The payback period for the project is estimated be 9.3 years.

Additionally, and in order to promote short-rotation coppicing, grants from the Forestry Commission were given for tree planting (£400 per ha in 1996 and subsequently £1000 per ha).

Results

The project was launched in 1996 and permission was obtained in 1997. The process relied on widespread consultations with, among others, local Councils and residents.

The plant produces 10 MW, with a net electrical output of 8 MW being fed in to the local grid. Overall thermal efficiency is 30.6% (which is almost comparable to that of a large coal-fired power station). It has been estimated that the electricity provided meets the domestic needs of 33,500 people.

The plant consumes 43,000 oven-dry tonnes per year of wood fuel, originated in ad-hoc created short rotation coppice on a three-year cycle and in existing forestry residues located in a radius of 60 km on arable set-aside land. Where possible, sewage sludge is used for the coppices. The plants´ root system is left in the ground so as to produce successive harvests every three years.

Agreements were signed with farmers. Although they were initially reluctant to plant for this purpose, very good results have progressively been obtained in this regard. In the year 2000, 1150 hectares of SRC had been established and 400 additional hectares were planned for the year 2001.

Some positive effects on the environment can be clearly identified, such us:

- Lower sulphur content of the emissions than produced from the combustion of fossil fuels.
- Some of the by-products generated (ashes, heat) are used as inputs to other parts of the production process. Additionally, sewage sludge from wastewater treatment plants is used to fertilise the plantation.
- The biomass plant is carbon neutral as the carbon dioxide released during combustion of the biomass is equal to the amount of carbon dioxide fixed during tree growth.
- Wood biomass crops have additional beneficial effects such us low fertiliser input requirements and an increase in the biological diversity of the area.

Potential for replication

A general intention to build more installations of this kind both in the U.K (were it was contemplated to build 10 additional plants) and elsewhere has been detected, although some important issues have still to be solved.

One issue is the cost of this technology, which is still high due to lack of commercial operation, although prices can be expected to fall as more plants are built. It is also expected that through this type of technology net efficiency to be achieved could range between 36 and 45% (variable according to the gasification technology used).

For more information

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www.arbre.com

Sector: Biomass
Country: U.K.
Location: Sutton, Cambridgeshire
Year: September 1998

ENERGIE

ELY STRAW-FIRED POWER STATION

Elean Power Station is the first straw fired installation in the U.K. and one of the largest of its kind in the world. Located in Sutton (near Ely, in Cambridgeshire) and covering an area of approximately 4.5 ha, construction began in September 1998 and finished in December 2000.

It has been estimated that the energy supplied by the plant is equivalent to that used by 80,000 homes.

Description

The plant has a net power output of 36 MW at 33kV and generates about 271.5 GWh of electricity a year.

It has a capacity of 200,000 tonnes of straw per year and was designed to be able to burn other bio-fuels and up to 10% natural gas.

The plant consists of a 25 m high central boiler plant, flanked by two 18 m high straw barns. It contains 4 feed lines to a single furnace working at a temperature higher than 850ºC; the two stage condensing steam turbine works at 92 bar and 540ºC.

The installation is equipped with an air-cooled condenser and has been designed and to keep emissions within the following limits:

- Particulate: <25 mg/m^3
- SO_x: <300 mg/m^3
- NO_x: <300 mg/m^3
- HCl: <30 mg/m^3

Its operating process consists of various phases: in the first, straw (previously collected by lorry) is delivered, weighed and stored in the barns by semi-automatic cranes (with a capacity of 2,200 tonnes –equivalent to more than 3 days´ operation-). In the following phase, fuel is unloaded (by automatic cranes), transported by a straw conveyor system and prepared for feeding in to the four straw kilns, where it is burned in a two-stage grate.

Effluent gases are first cleaned in a bag filter to remove particles and then neutralised in a lime scrubber.

The initial combustion phase is followed by a second residence time at temperatures of 850ºC in order to guarantee complete combustion. The temperature of the steam from the boiler is raised to 540ºC and 92 bars and later it passed through a two stage-condensing turbine in order to generate power by means of an alternator. The exhaust is cooled and condensed in the ad-hoc condenser unit.

Promoters and parties involved

Developer:

Energy Power Resources Limited (EPR) Ely (a partnership between EPR and Cinergy Global Power).

Design, build and operation of the plant

FLS miljØ a/a

Ramsingsvej 30, DK-2500 Valby, Denmark

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info@flsmiljo.com

www.flsmiljo.com/

Manufacturer:

Cinergy Global Power Services Ltd.

Cinergy Corp., 139

139 East Fourth Street

Cincinnati, Ohio 45202-4003

+800 544-6900

U.S.A

www.cinergy.com/default.asp

Financial resources

Total cost: €96 m .

A loan of £52 m was provided under a senior debt facility for the two years of construction (to be repaid over the first twelve years of operation) provided by Bayerische Hypo-und Vereinsbank AG and De National Investeringsbank NV.

A further £8 m was raised as equity in the form of ordinary and preference shares issued by EPR Limited & Cinergy Global Ely Inc (the latter having a 30% stake in the project).

Subsidies are also guaranteed on the electricity produced which is sold to the NFPA (power utility) under a Non-Fossil Fuel Obligation (NFFO) contract at an approximately rate of 0.096 €/kWh from commissioning until 28th August 2013 (after which time it will be sold at the existing market prices).

Results

Despite having obtained a contract to supply electricity in 1995 under the NNFO, the project was unable to start due to the impossibility of obtaining finance. Subsequent attempts made by other developers over the following three years later were also unfruitful. It was not until 1998 that work was able to begin. An ad-hoc Community Liaison with Parish representatives and Council Officers was created and met during the construction phase in order to follow up the process.

It has been estimated that the annual amount of energy produced is enough to supply 80,000 homes (or two towns the size of Cambridge) and the plant is expected to be operative for 20 years.

The about 200,000 tonnes of straw per year are supplied by farmers and contractors located within a 50-mile (80 km) radius. Straw is provided in the form of Hesston bales with a moisture content of under 25 % and an ad-hoc fleet of vehicles collect it for storage it in two barns.

In order to reduce the visual and acoustic impact of the installation and blend it into the landscape it was sunk 8 m into the ground (requiring excavation of 300,000 m^3 of clay) and trees were planted around it.

Emissions are kept at a minimum, and are as much as 50% less than the values that might be expected from a conventional fossil-fuel power station. A computer system to monitor emissions (including background information on the situation existing before the construction of the plant) was set up. Stack emission data can be accessed freely online and data is sent via modem to the Environment Agency of the Local Council.

Additionally, 50 long-term jobs have been created directly by the installation.

Potential for replication

The implementation of this plant has demonstrated that some of the main problems, which have often limited the setting up similar plants can be successfully overcome.

One of the difficulties is in fact often related to fuel collection (in this case straw), and its associated costs, which are sometimes too high to enable the plant to be operated profitably. Moreover careful integration with the landscape, the attention to the setting up of the complete filter system together with the transparency of the information regarding them have also contributed to the public acceptance of the Plant.

Both points can be considered as an example of good practice, which could be replicated in all those situations in which, for example, there is either manufacturing or agricultural industry concentrated in a limited area, which can provide the necessary fuel and at the same time solve a serious environmental problem.

For more information

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Sector: Biomass
Country: U.K.
Location: Thetford, Norfolk.
Year: October 1998

ENERGIE

FIBROWATT THETFORD POULTRY-LITTER POWER STATION

The Fibrowatt Thetford poultry-litter power station is one of the largest plants producing power from biomass in Europe and one of the three of similar characteristics existing in the U.K. (all of which were built by the same developer). The other plants are at Eye in Suffolk (12.7 MW, opened in July 1992) and Glanford North Lincolnshire (13.5 MW, opened in November 1993).

It is also the largest NFFO (Non - Fossil Fuel Obligation) scheme existing in the U.K. at present.

The project was awarded a NFFO3 contract in 1994, and construction began in August 1996. The plant was commissioned in October 1998.

Description

The plant has an output of 38.5MW of electricity (estimated, according to the plant's managers, to be sufficient to supply a town of around 93,000 homes- ten times the size of Thetford) and consumes approximately 400,000 tonnes per year of poultry litter complemented with other organic fuels. By way of comparison, it is worth noting that the calorific power of poultry litter when used as a fuel is about a half that of coal.

The main components of the installation are a 110 m high chimney and a 4,000 m^2 fuel hall.

The plant is equipped with a Foster Wheeler boiler with a capacity of 55 tonnes per hour and an Ansaldo turbine generator and grate system.

The process is a traditional one, organised in several steps. First, poultry litter is collected in covered lorries from nearby farms and brought the plant. The fuel is delivered to a 4000 m^2 hall (fuel hall) specially designed for this purpose. The fuel hall has a capacity of 10,000 tonnes (equivalent to 7 days supply) so no weekend deliveries are necessary.

Fifty five tonnes an hour of litter are fed to the boiler house by means of spiral screw augers, where the fuel is blown into the combustion chamber and incinerated at 850ºC. The water in the boiler is heated to 450º C and the steam produced turns a turbine connected to an electrical generator. The electricity produced is fed in to the local grid, steam is condensed to water by air-cooled condensers and subsequently recirculated into the boiler and residual ashes produced are used as fertiliser.

The power station is open to visits by local residents and educational groups.

Promoters and parties involved

Developers:

Fibrothetford Limited (member of Fibrowatt Group).

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+1842 752255
Fax: +1842 763434
www.fibrowatt.com

Owners

Fibrowatt Ltd (51%), Catamount Thetford Corporation (44%) and Foster Wheeler Energy Ltd (5%).

Operation and maintenance

Fibroplant Limited

Construction

TAYMEL (Taylor Woodrow Management & Engineering Limited).

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Engineering

Foster Wheeler Energy Ltd
Shinfield Park
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UK
+44 118 913 1234
Fax: +44 118 913 2333
www.fwc.com

Financial resources

The total investment came to €110 m and the breakdown according to type of investment was as follows:

Type of investment	*Amount*	*% of total*
Senior debt	€91 m	82.5
Junior debt	€12.8 m	11.5
Subordinated debt	€3.3 m	3.0
Ordinary share equity	€3.3 m	3.0
Total	€110.4 m	100

The senior debt was arranged by Bank of Scotland and co-underwritten with the Westdeutsche Landersbank Girozentrale. Subsequently, six other banks (based in countries where Fibrowatt plans to develop further projects) joined the syndication of the debt, which is due to be repaid over 12 years on a straight-line amortisation basis at commercial interest rates (with an interest rate of 150 points over LIBOR).

Moreover, Marubeni Corporation of Japan provided a mixture of junior and subordinated debt and Catamount Energy invested in a mixture of subordinated debt and equity.

Therefore, final balance of the equity is held as follows: Fibrowatt Ltd (51%), Catamount Thetford Corporation (44%) and Foster Wheeler Energy Ltd (5%).

Additionally, the project was partially subsidised by the UK Government as it was granted a NFFO3 (Non-Fossil Fuel Obligation) contract.

Results

Apart from energy production (38.5MW) the positive effects in terms of the environment and employment include the fact that the installation consumes more than 400,000 tonnes of poultry litter a year. This can be considered a positive result in terms of waste disposal, considering that over 1.5 m tonnes of this type of waste is produced annually in the U.K.

When compared with other potential alternative treatments for poultry litter, this option seems to prevent certain negative effects on the environment such as possible ground water pollution when it is used as manure and methane emissions from waste storage. The same occurs when compared with the by-products of other types of combustion. For example, combustion in fossil-fuel power stations generates sulphur dioxide and nitrogen dioxides, as well as producing CO_2.

The by-products and wastes from the plant are mainly gases and ash. The exhaust gas is treated in order to fulfil the legal requirements at UK and European level and the ash is sold as an “environmental friendly fertiliser” (Fibrophos), as it is rich in phosphates and potash and is nitrate-free.

Visual and odour impact were taken into consideration when the plant was designed, considering location (and depth) and implementing a specific ventilation system.

The plant has also had a positive impact in terms of job creation: about 300 people were employed during the building phase and around 30 permanent staff operate the plant.

Potential for replication

Some of the traditionally polemic issues considering this type of plant have been confronted and solved here, such as, for example emission control and odour and visual impact.

For this reason, studies are currently underway regarding the possibility of building more plants fed with this type of fuel in the U.K, other European countries, USA and Japan.

For more information

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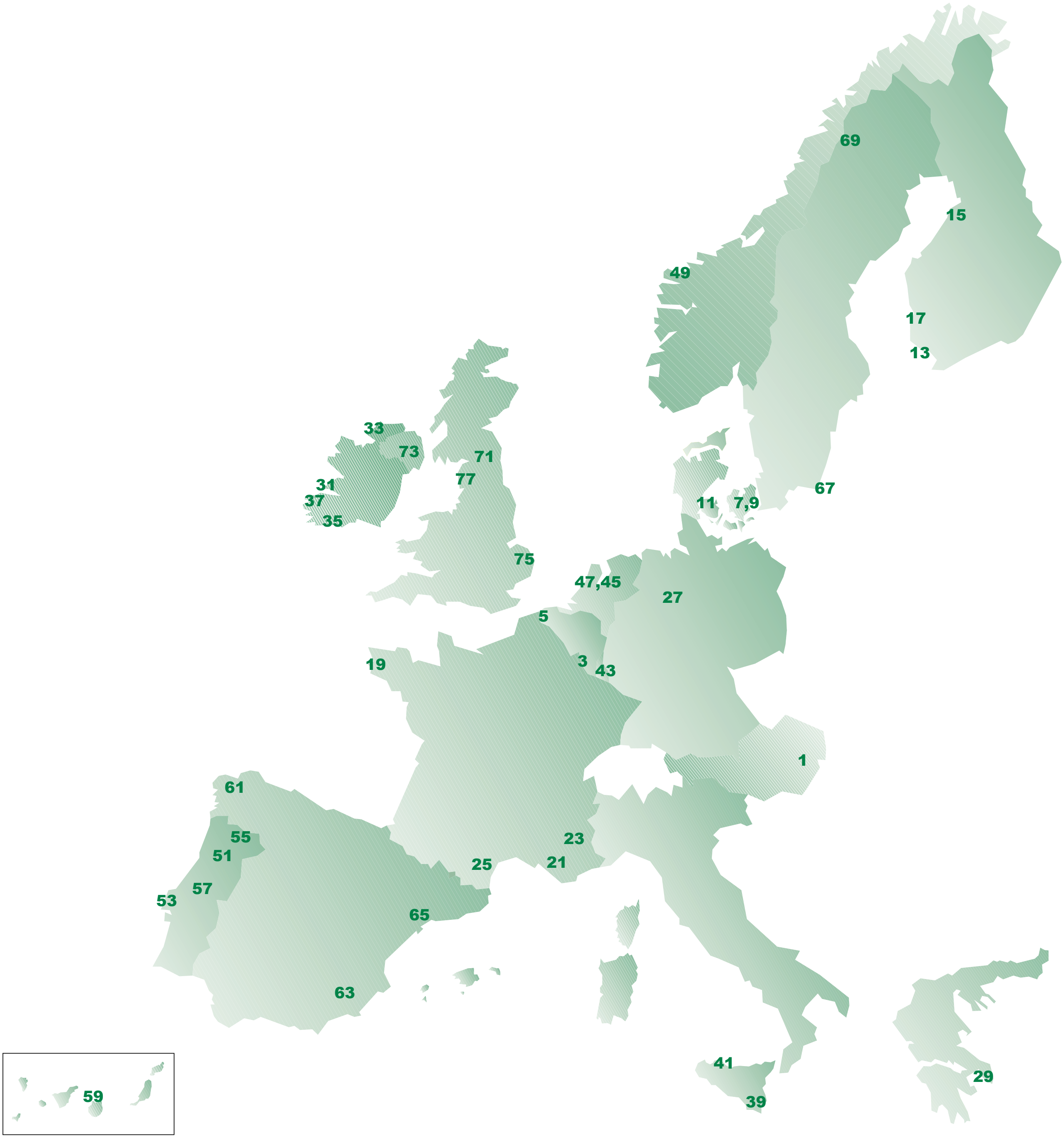
ENERGIE

3 WIND ENERGY



Sector: Wind Energy
Country: Austria
Location: Bruck an der Leitha
Year: 2000

ENERGIE

BRUCK AN DER LEITHA, WIND FARM

Work on the construction of the large wind farm at Bruck an der Leitha commenced in May 2000 and the wind turbines came into operation about five months later. The wind farm supplies electricity to the public grid and produces 1.5 times the electricity needed for the 3,500 households in Bruck. At the time of its installation, it was the largest wind farm in Austria, in terms of power generating capacity.

Since 1996 the town of Bruck an der Leitha has been a “climate alliance municipality” with an undertaking to reduce emissions of CO_2 by 50% before the year 2010. In order to achieve this goal, a plan was initiated by the Energy Park Association envisaging meeting Bruck’s entire energy demand from renewable energy sources in the municipal district. The first large project within this framework, a wood-fired biomass boiler connected to a district-heating system, came into operation in October 1999. This system supplies heat to private houses and several public buildings. The next phase was the construction of the wind farm.

The objectives of the Energy Park Association are to use all forms of renewable energy sources for which there are practical applications and to demonstrate the feasibility of an environmentally friendly energy supply using indigenous resources. The wind power project aimed at creating value that remains in the region and at strengthening of local industrial activities. It also aims to contribute to the promotion of tourism.

The future extension plans of the Energy Park Association include the construction of a biogas plant, two more wind farms, and a community PV installation, the restoration of a small hydropower plant and the application of biodiesel in transport.

Description

The wind farm at Bruck an der Leitha consists of 5 Enercon E-66/18.70 turbines with a nominal power of 1.8 MW each. This power is reached at a wind speed of about 45 km/h.

The foundations of the installation consist of a circular steel and concrete platform with a diameter of 12.6 m. The 65 m high towers have a diameter of 4.5 m at the base. The first wind turbine has a 60 m high observation deck, which can be reached by an internal spiral staircase with 279 steps during operation of the turbine. The rotors have three blades with a diameter of 70 m.

The generator produces alternating current, which is rectified within the nacelle. After being led down through the tower, it is transformed into an alternating current suitable for the public grid (400 V, 50 Hz). The electricity is transported to the public grid by means of a 20 kV cable. The whole system is controlled by a remotely monitored micro-processor control system.

Dissemination activities for the project include guided tours for visitors to the wind farm. A three-step information programme, called "Energy learning path", was also initiated for the visitors to inform them about renewable energy sources and construction materials, insulation materials and general energy-saving measures.

Promoters and parties involved

- Energy Park Association: initiator
- Municipality of Bruck: non-financial support
- Enercon: supplier of wind turbines
- Energiewerkstatt: technical planning
- 15 persons from the region: main partners in the wind park project
- local inhabitants: 200 persons involved in financing the project through "eco-building stones"

Financial resources

The total investment of the project was about €8.4 m, of which the cost of the wind turbines represents about €7.2 m.

The wind farm received an 8% grant, i.e. approximately €620,000, from Kommunalkredit AG of Vienna, which is funded by the Ministry of the Environment.

A financing scheme involving the participation of local companies and residents was used in the project. This enabled them to contribute financially to the project by buying one or more "eco-building stones" of €1,000 each. Under this scheme, participants provide a loan, which is paid back to them after 15 years. In principle, the minimum interest rate is 4% in the first 12 years. After the 13^{th} year, this is increased to 6%.

The source of revenue for the project is the sale of electricity. The payback time for the project is estimated at 12-15 years.

Results

The main problem affecting the implementation of the wind farm was that the feed-in tariff for electricity from wind energy was not guaranteed. This was not regulated until the Austrian Electricity and Business Organisations Law (EIWOG, Elektrizitäts- und wirtschaftsorganisationsgesetz) came into force in 1999.

The wind farm produced over 18,000 MWh of electricity in the first year of operation, from October 2000 to September 2001. This meant output far exceeded the expected amount of 15,500 MWh. The results for 2002 have also been very good, with an exceptional monthly output in March, which was 46% higher than the production in the same month in 2001.

The wind farm is able to produce about 18,500 MWh per year. With a feed-in tariff of about 0.07 €/kWh, the revenue from electricity sales comes to approximately €1.3 m a year.

The implementation of this project results in a reduction of CO_2 emissions of about 12,900 tonnes a year. The surrounding landscape was taken into account at the planning stage of the wind farm and the agricultural community was invited to participate. As a result, a distance of at least 800 m from the nearest settlement was ensured.

The project led to the direct creation of two new jobs. It also resulted in annual value creation for the region of €1.3 m.

The involvement of the local population in the project seems to have been successful. The wind farm is a citizens' project with 15 main partners and approximately 200 people involved in its financing through the "eco-building stones" scheme.

Potential for replication

Two new wind projects are currently being planned that use the same type of wind turbines as those at Bruck an der Leitha. These are the Petronell-Carnuntum wind farm, with 12 turbines with a total electrical power of 21.6 MW, and the Hollem wind farm, with 9 turbines with a total output of 16.2 MW.

For more information

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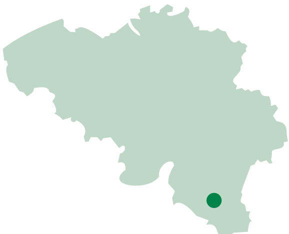
www.energiepark-bruck.at

Sector: Wind Energy
Country: Belgium
Location: Wallonia Region
Year: June 1998

ENERGIE



SAINT VITH

This small project consists of a 600 kW wind turbine located in Wallonia near to a main road. Its construction was promoted by the Saint-Vith District Council.

Description

The 600 kW three-blade wind turbine is an ENERCON E40. It has an upwind diameter of 40.3 m, active pitch control and clockwise rotation. The pitch control mechanism consists of three synchronised blade pitch systems with an emergency power supply.

It also comprises a direct-driven synchronous ENERCON ring generator.

The blades are made of fibreglass (reinforced epoxy), the hub height is 60 m and the total height of the structure is 82 m.

Some of the other technical parameters are: cut-in wind speed: 2.5 m/s; rated wind-speed: 12.0 m/s; cut-out wind-speed: 28-34 m/s; the grid feed-in is via an ENERCON inverter.

The installation is also equipped with an ENERCON SCADA remote monitoring system.

Promoters and parties involved

Developers

Energie 2030
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B 4700 Eupen
+32 87 561100
Fax: +32 87 743320
energie2030@gaia.de
www.energie2030.com

Wind turbines

ENERCON
ENERCON GmbH, International
Schwachhauser Heerstraße 299
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+49 421 249 920
Fax: +49 421 249 960
sales.international@enercon.de
www.enercon.de

Financial resources

The total investment was €525,000.

The power generated is sold at a price of €0.09 of which €0.03 is paid to Electrabel, €0.025 is a premium for RES production and a further €0.025 is a premium from the Saint Vith Council (800.000 FB/year during 15 years).

This financial engineering was enough to cover the cost of an Enercon E30 - 250 kW, but more than €157,894 was necessary to buy the more suitable Enercon E40.

For this reason, and because the narrow margins meant that obtaining a loan was not feasible, the companies involved decided to increase their capital share by opening it to other possible participants: the success of this initiative was immediate and they receives €52,000 from both new and existing shareholders. This capital increase permitted the start up of the initiative and its rapid conclusion, leading to the inauguration of the turbine in June 1998.

Results

It has been estimated that when operating 1,500 hours a year the installation produces an average of 750,000 kWh. The table shows monthly production over a three-year period.

Month	*1998 kWh*	*1999 kWh*	*2000 kWh*
January	-	135,584	102,760
February	-	76,408	108,640
March	-	87,019	83,440
April	-	65,583	75,950
May	-	46,232	60,690
June	44,191	60,554	32,620
July	61,009	44,464	47,110
August	32,980	46,739	22,540
September	80,488	60,480	
October	104,298	80,920	
November	62,719	80,254	
December	87,623	138,320	
Total	473,308	922,557	

Potential for replication

This project is an example Belgium's longstanding commitment to obtaining 10% of its power from RES by 2010. During the construction of this installation, visits and open days during the various phases of construction were run in order to inform and raise the awareness of the local population, and to help them understand its significance and advantages in environmental terms (this design of turbine is also very low noise) to strengthen its potential replication in similar contexts.

For more information

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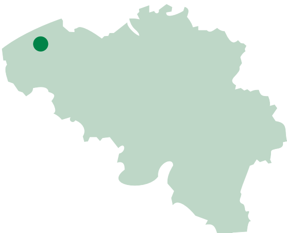
compagnons-eole@swing.be
www.compagnongs-eole.org

Sector: Wind Energy
Country: Belgium
Location: Zeebrugge
Year: 1998



ZEEBRUGGE OUTER HARBOUR ENLARGEMENT

Located in the North Sea, 2 km offshore in the outer harbour of Zeebrugge, Belgium, this is an example of the installation of wind turbines in coastal area where average wind speeds are high.

This wind farm has been operating permanently since 1986 (in fact it was the first in Belgium and one of the first to be created in Europe) but some important additions and improvements have been made recently, the latest in 1998 (the following case study places particular emphasis on the last one).

Description

Zeebrugge wind farm currently comprises 23 wind turbines generating a power of 5.2 MW. The old wind farm erected in 1986 had 21 turbines (20 of them of 200 kW and one of 175 kW), whereas the most recent turbines came into operation in late 1996 (400 kW) and in 1998 (600 kW). 11 old 200 kW turbines were replaced by 11 new 400 kW turbines in 2000 and it is presently planned to install two extra new 600 kW turbines. There are significant differences in terms of technical requirements between the oldest and the newest turbines, which testifies to the important technological developments that have taken place over the course of the decade.

The new 600 kW wind turbine is a T600-48 model that has an induction generator operating at 690 V with a rotation speed of 1,000 or 1,500 rpm.

The nacelle is a welded steel structure (like the tower), which weighs 35,000 kg. It is equipped with a hydraulic pitch regulation and active stall power control mechanisms, a fail-safe disk brake and an asynchronous induction generator of 690VAC. It has three blades made of glass-fibre reinforced polyester (the angle of which is computer controlled).

The rotor diameter is 48 m (as compared with the 22.5 m diameter of the oldest turbine on the site) and the turbine can operate at two different speeds: under conditions of low wind speed below 6.5 m/s at 15 rpm and at higher speeds at 23 rpm. In the first case it generates up to 120 kW whereas in the second over 120 kW. This is the largest diameter in the world for a rated capacity of 600 kW.

The turbines are able to operate in wind speeds of between 3 and 25 m/s. The rated wind speed is 12.5 m/s and thus these turbines are particularly well suited for inland wind conditions.

Promoters and parties involved

Developers and planning

Administration for Electricity and Electromechanics (belonging to the Ministry of Public Works) in collaboration with the Department of Science Policy.

Wind turbines

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www.turbowinds.be

Financial resources

No subsidies were given for the construction of the wind farm, which was an investment by the Local Utility Company.

Average electricity produced by the 600 kW wind turbine is estimated to be 2,300 MWh/year and 'buy-back' tariffs paid 3.2 BEF/kWh.

Investment costs for the most recently installed turbine came to 25.1 m BEF (about €627,500) and the depreciation period is 20 years. Annual operation and maintenance costs are estimated to be 3% and operation reliability 93 %. An average annual tariff of 3.2 BEF/kWh is paid.

The payback period has been estimated to be less than four years.

Results

Considering an average wind speed of 7.87 m/s, full capacity and an operating time of 3,600 hours, the new wind turbine can generate 2,300 MWh (as compared with the 1,200 kWh/year produced under the same conditions by a 400 kW turbine) This electricity is sold to Interelectra.

According to the calculations made, the generation of power by the wind farm implied emission avoidance of 3,068 tonnes/year of CO_2 in 1998.

Potential for replication

Zeebrugge represents a good example of a polity of expansion and improvement at an old wind farm (it is located in a very busy harbour), which has been perated by the company INTERELECTRA for many years.

The wind farm demonstrates how good planning and implementation, together with acceptance by the local authorities,can facilitate the development of installations of this kind, whose environmental benefits are well known and can be replicated in other similar locations (such as other ports with similar conditions).

For more information

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www.turbowinds.com

Sector: Wind Energy
Country: Denmark
Location: Hagesholm in Holbæk Municipality
Year: June 2000

ENERGIE

THE 2 MW WIND TURBINES AT HAGESHOLM

North-West Sealand Energy Supply Company (NVE) has erected six 2 MW wind turbines at Hagesholm in the municipal district of Holbæk. The turbines at Hagesholm have been erected as part of an agreement between the Danish Ministry of the Environment and the utility companies. NVE has made commitments regarding the erection of wind parks with a total capacity of 44 MW.

Description

The first turbine was erected at Hagesholm in August 1999. The turbine was one of the largest turbines ever erected and has been used for testing and further development. The turbine was developed by NEG-Micon based on experience with the 1.5 MW turbine and the smaller turbines.

The turbines have been designed to be simple, efficient and to fit into the surroundings. The renowned Danish design company Jacob Jensen Design assisted in the design of the turbines in order to ensure they are harmonious with their environment. One aspect of this is the streamlined nacelle, which fits nicely with the rotor blades.

Technical data:

Number of turbines	6
Capacity	6x2MW =12 MW
Hub height	68 m
Rotor diameter	72 m
Total height	104 m
Cut-in	4 m/s
Cut-out	25 m/2
Nominal wind speed	14 m/s
Forecast annual output	24 GWh/yr

Dissemination activities

The project has gain a lot of media attention and been presented at several conferences.

International Energy Agency's CADDET Technical Brochure No. 148 describes the project.

Promoter and parties involved

NVE installed the turbines in cooperation with the wind turbine manufacturer NEG- Micon. NVE was responsible for grid connection and NEG-Micon carried out the civil engineering work (new roads, erection of turbine).

NVE is the owner of three of the turbines and three more are privately owned.

Financial resources

The total investment for the six turbines and their associated infrastructure was about DKK 90 m (€12.1 m).

With a payback period of 20 years the investment yields an energy price of 0.38 DKK/kWh (0.051 €/kWh)[1].

Results

Energy production

The forecast power output from the turbines is 24 GWh/yr.

Environmental benefits

The turbines are design to blend in with their surroundings.

The power output of the turbines will result in an emissions reduction of 12,000 tonnes of CO_2 annually compared with electricity generation in a conventional coal fired power station.

Potential for replication

The aim of the project is to gain experience with large wind turbines given their interest as a means of tapping the huge offshore wind-power potential.

For more information

Owner of three of the turbines

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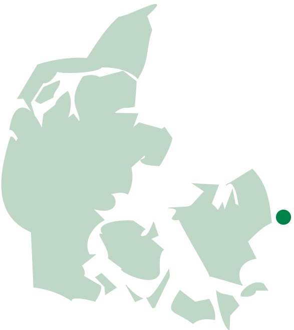
Fax: +45 5921 2129
nve@nve.dk
www.nve.dk

Photo by: NEG - Micon

1 Source: NIVE Energi og Miljøkontor, www.nive.dk

Sector: Wind Energy
Country: Denmark
Location: Middelgrunden outside Copenhagen
Year: 2000

ENERGIE



MIDDELGRUNDEN OFFSHORE WIND FARM

The Vindeby and Tunø 5 MW offshore projects, constructed in 1991 and 1995, showed promising results for the economics of the vast Danish offshore wind power potential. Against this background a broad investigation of offshore potential was carried out in Denmark between 1995 and 1997 and reported in Action plan for offshore wind farms in Danish Waters, SEAS, 1997. The conclusions of the report were that offshore wind energy could cover at least 50 % of the electricity use in Denmark at a much lower cost than previously expected.

On this basis a group of individuals started planning an offshore wind farm at Middelgrunden outside Copenhagen Harbour. In an early stage the local utility København Energi was involved in the project and in 1997 the project promoters received a €0.5 m grant from the authorities to investigate the environmental impact of the proposed wind farm.

The investigation concluded that the main issue for the citizens of Copenhagen arising from the planned wind farm was its visual impact. The initial plan was to construct three rows of turbines, but a public hearing led to a new plan in which all the turbines were in a single arc being adopted. The Copenhagen local authorities, and the public at large, changed their attitude to the project and after three further public hearings the project was approved December 15th, 1999 and brought in operation December 2000.

Description

The Middelgrunden Offshore Wind Farm has a rated power of 40 MW and consists of 20 turbines, each with a power output of 2 MW. The turbines installed on Middelgrunden are the first 2 MW turbines to be demonstrated offshore. The turbines were manufactured by Bonus Energy.

The wind farm is situated on a natural reef 3.5 km east of the Copenhagen harbour. For over 200 years the reef has been used as a dumping ground for harbour sludge and other contaminated waste. Special environmental impact studies and feasibility studies were therefore carried out.

An old dry dock at a former shipyard was used for casting the concrete gravity foundation. The foundation together with the lower section of the turbine mast, including the transformer and switchgear, was floated out to the site in the autumn of 2000. The abandoned shipyard was also used to assemble the rotor, which, together with the upper section of the tower and the nacelle, was floated out on a barge. A hydraulic platform was used to manoeuvre the turbine into position.

The technical details of the Middelgrunden Offshore Wind farm are given below:

Number of turbines	20
Capacity	20x2MW = 40 MW
Hub height	64 m
Rotor diameter	76 m
Total height	102 m
Foundation depth	4 to 8 m
Foundation weight (dry)	1,800 toe
Wind speed at 50-m height	7.2 m/s
Guaranteed/expected power output	89/100 GWh/y
Park efficiency	93 %.

Dissemination activities

The project has received a lot of attention from both national and international magazines and newspapers.

Furthermore, the project has been presented at a number of conferences, for example at the European Wind Energy Conference 2001 in Copenhagen.

Promoters and parties involved

The wind farm is owned and developed jointly by Middelgrunden Vindmøllelaug (wind turbine cooperative with 8,552 members) and København Energi. The wind power department at the utility SEAS was in charge of managing the project to set up the wind farm.

Organisation/companies

København Energi (Owner 10 turbines)

Middelgrunden Vindmøllelaug (Owner 10 turbines)

SEAS, Wind Energy Centre (Project management)

Københavns Miljø- og Energikontor, (KMEK) (Project management)

SPOK ApS (Project management)

Møller & Grønborg (Design)

Carl Bro A/S (Foundation design)

Bonus Energy A/S (Wind turbines)

Monberg & Thorsen A/S and Pihl & Søn A/S (Contractor foundation including sea work)

NKT Cable A/S (Contractor submarine cable)

Siemens A/S (Contractor, switchgear and transformer)

Financial resources

Total investments

The total investment was €49.2 m (including the grid connection).

Results

Energy production

Output in the first year of operation was 87 GWh. The reason for the low production, given the guaranteed output of 89 GWh, was that the wind speed was 80% of normal.

Online and historical energy production from each of the turbines is available on the Internet at www.middelgrund.com.

Financial result

Based on the guaranteed production (95% availability and 89 GWh/yr) the capital cost is 4.4 €c/kWh at 5 % interest rate over 20 years. The expected operation and maintenance cost is 0.9 €c/kWh, which gives a total cost of 5.3 €c/kWh.

Socio-economic benefits

The project has gained a lot of publicity and one example of the socio-economic benefits of the project is the lectures and tours offered to both experts and laymen.

Environmental benefits

With an annual production of 89 GWh this wind farm could replace about 29,000 tonnes of coal if the electricity were generated in a conventional coal-fired power station. The carbon dioxide emissions from the productions would have been about 69 000 tonnes.

Potential for replication

The Danish model of introducing wind energy through cooperative ownership has shown itself to be a successful way of helping to clear the way to further offshore wind farms.

For more information

Responsible for information on Middelgrunden Vindmøllelaug

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Sector: Wind Energy, Biomass, Solar Thermal and Geothermal

Country: Denmark

Location: Samsø

Year: 1998

RENEWABLE ENERGY ON THE ISLAND OF SAMSØ

In spring 1997 the Danish Energy Agency arranged a competition between 5 islands focusing on conversion of their energy supply systems to renewable energy. The competition was a part of the follow-up to the Energy 21 policy. The island of Samsø, situated between Jutland and Zealand, was selected as a demonstration community in November 1997.

The overall aim is for the island to become 100 % supplied by renewable energy sources within ten years, i.e. before 2008. Additional aims are to demonstrate not only Danish renewable energy technology, but also Danish energy planning and management. As a result of the actions the projects seeks to create 30 new jobs locally.

The most important means to achieve the targets set are:

- Increased efficiency and reduced energy consumption in providing heat, electricity and transport by employing technology and adjusting peoples' patterns of behaviour.
- Expansion of the collective heating supply system combined with utilisation of the local biomass resources.
- Expansion of individual heating systems by using biomass boilers, heat pumps, solar heating etc.
- Erection of 11 onshore wind turbines to cover electricity consumption.
- Erection of 10 offshore wind turbines to cover electricity demand from the transport sector.
- Gradual conversion of the transport sector from petrol and oil to electricity (i.e. via hydrogen).

Description

The Island Samsø is located in the Kattegat covering 11,400 ha with a population of 4,400. There are ferry routes to Jutland and Zealand, and the island is visited every year by a large number of tourists.

During 1998 and 1999 a whole series of measures were implemented in rural areas to promote individual renewable energy installations. The following RE installations were set up:

- Approx. 50 thermal solar units
- Approx. 20 biomass boilers (wood pellets, wood chips, grain, etc.)
- Approx. 20 heat pump units, mainly geothermal

More installations will be set up in the coming years.

In the period March to August 2000, the 11 onshore turbines, each with capacity of 1 MW, supplied by Bonus Energy A/S, were erected. The annual guaranteed production from each turbine is 2,600 MWh/yr, which yields a total annual production of about 29,000 MWh/yr. The production covers close to 100 % of the electricity consumption on the island.

The 10 year project is due to run until 2008. 2002 will be "the construction year" with installation of the offshore wind turbines and district heating plants (biomass and solar thermal). When completed, about 57 % of the island's energy will be provided by renewable energy sources.

The Energy Plan for the 10-year period can be seen on the Internet: www.veo.dk.

Dissemination activities

The project has received a lot of media attention from around the world.

The project has participated in the European Union ALTENER programme and was awarded "The best renewable energy island in Europe in the year 2000". Samsø Energy Company has presented the island at several exhibitions, including the EXPO 2000 in Hannover.

The island is presented in the European Union's document on Renewable Energy for Europe, Campaign for Take Off, http://europa.eu.int/ comm/ energy/en/renewable/idae_site/index.html (awarded "best 100% community" in 2000).

Promoters and parties involved

The promoter of the project is Samsø Energy Company. The other parties involved in the project include: The Danish Energy Authority, Samsø Municipality, Samsø Commercial Council, Samsø Farmers' Association, Samsø Energy and Environment Office, NRGi, PlanEnergi.

Financial resources

Total investments

It is estimated that the total investment for the complete 10-year programme will be around DKK 590 m (€79,000).

The total investment for the 11 onshore wind turbines was approximately €9 m.

Subsidy

The Danish Energy Authority has been an active partner in the project. It has supported the establishment and operation of Samsø Energy Company and Samsø Energy and Environment Office. In addition, some of the projects have received an investment subsidy.

The new government elected in 2001 has stopped most of its support to renewable energy projects and therefore in the future subsidies from the Energy Authority could cease. The project is therefore looking for new sources of support, mainly from within the European Union.

Results

Energy production

The installation of individual biomass boilers contributed to increasing the gross consumption of pellets from 1.7 TJ (0.47 GWh) in 1997 to 8.4 TJ (2.3 GWh) in 1999.

The 11 onshore wind turbines delivered 57 TJ (15.8 GWh) in 2000, the year of installation, and 95 TJ (26 GWh) in 2001[1] . With normal production, 29 GWh,the turbines supply close to 100 % of the island's electricity.

Socio-economic benefits

The individual heating installations (solar, biomass and heat pump) creates about 1.5 man-years locally in connection with operation and maintenance.

The 11 onshore wind turbines created about 11 man-years of work during the building phase and 0.5 in connection with operation and maintenance.

Environmental benefits

The onshore wind turbines supply 100 % of the island's electricity from clean renewable energy. Until the erection of the wind turbines Samsø imported about 100 TJ (28 GWh) of electricity annually. The electricity imported was mainly generated by coal-fired power plants, which implied the use of about 9,000 tonnes of coal. The annual emissions of carbon dioxide from these coal fired power plants would have been approximately 22,000 tonnes[2] .

Potential for replication

The planning and organisation method used for the project has shown to be successful and could be adapted by other projects.

For more information

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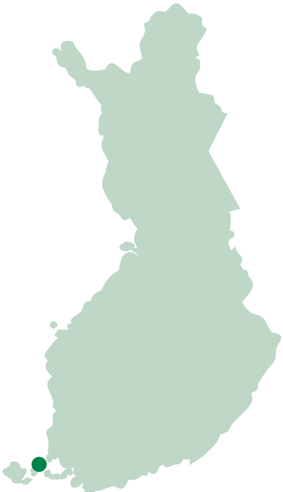
plan@veo.dk
www.veo.dk

1- The wind conditions in Denmark were about 20 % below average in 2001, therefore the turbines generated less than the guaranteed production (www.vindstryrke.dk).

2- Assumptions: Conventional coal fired power plant, efficiency 0.4, energy content coal 28.1 MJ/kg and CO_2-factor coal 310 kg/MWh.

Sector: Wind Energy
Country: Finland, Åland Islands
Location: Kökar
Year: October 1997

ENERGIE



THE WIND TURBINE AT KÖKAR

The history of "modern" wind power on the Åland Islands started in the early 1990's when the government of Åland, Ålands Landskapsstyrelse, decided to set up a trial wind turbine. The project was run by Ålands TeknologiCentrum and in January 1992 the first turbine was installed on the island of Sottunga. The turbine, a VESTAS V27 225 kW was a success and the interest among wind power enthusiasts grew. This led to the establishment of the first private-owned wind power company, Ålands Vindenergi Andelslag (ÅVA).

ÅVA erected their first turbine, a VESTAS V39 500 kW, in the summer of 1995. The interest in wind power grew rapidly, and in the autumn of 1997 five new wind turbines, (four VESTAS 600 kW V44 in Knutsboda and one ENERCON 500 kW E-40) were installed on Kökar island. During 1997 a second private wind power company was founded, Ålands Vindkraft AB. The company owns one of the turbines at Knutsboda, one turbine is owned by Ålands Skogsägarförbund (forestry owners' federation) and the remaining two at Knutsboda and the turbine at Kökar is owned by ÅVA.

Kökar Island is situated in the southeast of the Åland archipelago. The island has 320 inhabitants and is visited by a lot of tourists during the summer months. The island has one 10 kV undersea cable, which supplies the island with electricity. The cable has a relatively limited capacity, which was a factor that was taken into account when choosing a turbine for the island. ÅVA started discussions with ENERCON, because the company's turbine was known to be suitable for weak grids. ENERCON's policy at that time was to sell only complete wind farms, not single turbines, but after some negotiation the company agreed to sell and install a single turbine at Kökar. A part of the contract was that ÅKA should be responsible for operation and maintenance after training at ENERCON.

Description

The project consists of one ENERCON E-40 500 kW wind turbine. The turbine has a hub height of 40 m, a rotor diameter of 40 m and a calculated yearly output of 1,200 MWh. The site is located on a small hill one the east side of the island with good wind conditions. This was shown in the first year of operation when the turbine generated 1,500 MWh. The annual production covers about 50 % of power consumption on the island.

Promoters and parties involved

The turbine is owned by ÅKA, and the turbine was supplied by ENERCON.

ÅKA is owned by more than 1,000 people (mainly from Ålans Islands), the idea being to sell shares in the plant, with the incentive that the owners get renewable electricity at lower prices than electricity produced by conventional methods, (each shareholder receiving 1,200 kWh/yr). To cover the total electricity consumption a household with an oil-fired boiler would need about 5-6 shares and a household using electricity for heating would need about 20 shares.

Financial resources

- The total investment came to FIN 2,898,000 (€487,376).
- Subsidies were granted by the local government, Ålands Landskapsstyrelse. The total subsidies were FIN 1,267,000 (€213,094) or 43.7 % of the total investment.
- The source of revenue is the sale of the electricity generated. During the period 1997 to 1999 the power was sold at fixed prices, but is now sold at the prices set by NORDPOOL.
- The company borrowed money over the short term to cover import taxes.
- The payback time is the same as the depreciation time at 15 years.

Results

- The project has been very successful and has demonstrated that semi-offshore installations on the archipelago of Åland Islands enjoy excellent wind conditions with undisturbed winds. For several years now the turbine has been the leader in its class among turbines in Finland and Sweden.
- Energy production from the turbine year by year from the start up date to the end of September 2002 is given below.

Year	Generated electricity (kWh)
1997 (Start Oct., 10)	319,184
1998	1,484,383
1999	1,387,408
2000	1,401,022
2001	1,458,937
2002 (to end of Sept.)	905,637

- When the company installed the new turbine in 1998 one person was employed full-time. Today, the company has one person on full-time and four persons are working for the company on an hourly basis.
- The turbine is a proud symbol for the community of Kökar (see www.kokar.aland.fi). The inhabitants want a further turbine on the island, but this is not possible at the moment as the authorities insist that any new turbines should be constructed in wind farms.
- Erection of wind turbines reduces polluting emissions to the Baltic Sea. Today there are 12 turbines, which produce about 5-6 % of the total electricity consumption on the islands.

Potential for replication

The project has demonstrated that the best sites for wind turbines are out on the southern Åland archipelago. After the installation at Kökar, a turbine was erected at Föglö, in 1999, and that turbine was also a success. Today, the companies ÅVA and Ålands Vindkraft AB are working on a semi-offshore project called Project Nyhamn, in the archipelago south of Mariehamn (the capital of the Åland Islands). This project consists of seven turbines in the 2 MW class. The production from this project is calculated to be 38,500 MWh/yr. The amount of electricity generated by renewable energy sources will then increase from today's 5-6 % to about 25 %.

For more information

Owner

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al.vindenergi@aland.net
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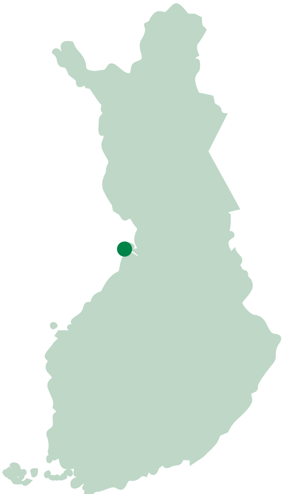
Sector: Wind Energy
Country: Finland
Location: Lumijoki outside Oulu
Year: March 1999

ENERGIE



LUMITUULI SEMI-OFFSHORE WIND TURBINE

Lumituuli Oy is a customer-owned wind power plant in Finland. The company installed a single wind turbine (Vestas V47 / 660 kW) on an artificial island in Lumijoki in March 1999 and has sold electricity on the Finnish market since then.

Lumituuli Oy was established in February 1998. Founding the company and introducing the business concept was possible since the electricity market was gradually deregulated in Finland in 1998. The new idea of wind power plants owned by customers was originally started by the residents of Lumijoki, who tried to make the idea a reality in 1995-1996. However, the investment base proved too narrow and the project was not realised. The idea was rediscovered in 1997 by the group of members of Dodo ry, a Finnish environmental organisation. Together with the help of local residents the project was carried out in 1997-1999. At the moment the company has about 1,000 shareholders, which include private citizens, companies, communities (Lumijoki, Liminka) and non-profit organisations. About one third of the shares are owned locally. The share capital of the company is about €800,000, consisting of about 3,700 shares. At the moment the company is free from debt.

The aim of Lumituuli Oy is not just to be a wind electricity producer but also to take part in electricity policy making by communicating the company's experiences to the public and decision-makers.

Description

An ice road was built to enable the construction of an artificial island and the foundation for the plant in the Gulf of Bothnia where the salinity of the seawater is low and winters are cold, making ice-road construction relatively easy. The total cost of the road was about €6,700. Using the ice road made the whole construction process much cheaper than it otherwise would have been. A different type of foundation would need to have been chosen if the turbine had been erected in open water.

Basically an ice road is a thick plate of ice floating on the water. It may be constructed simply be removing the top layer of snow and pumping cold water onto the ice. As soon as the ice forms and is thick enough to carry light machinery, it is kept clear of snow with a snowplough. This is enough when temperatures are low (-20ºC or colder) to keep the ice gaining thickness. If the temperature is a bit higher (between -10ºC and -20ºC) water needs to be pumped onto it. This is done using a standard agricultural tractor with a large drill. The drill makes a hole through the ice and is kept rotating in the hole, thereby pumping water onto the ice. The lanes of the road become about 30 m wide, and are thicker at the centre and thin towards the edges. The procedure produces good quality ice with a high load-bearing capacity.

Building the island and a concrete foundation took about 2 months. The shape of the island is a modified horseshoe. It is large enough for the crane to drive onto, but special care was taken to keep the island as small as possible. It also features small breakwaters and a pier to make it easier to access even in bad weather. The pier makes it possible to float a crane out on a raft while the water is clear of ice and drive the crane onto the island. The island is protected from erosion caused by moving ice sheets and waves. The power cable was lowered onto the seabed with the aid of the ice saw normally used to prevent formation of ice dams in rivers during spring flooding.

Dissemination activities

- The project has received a lot of attention in national newspapers and magazines.
- It won the Vision of the Year price in Finland, 1998.
- It was presented at the Nordic Wind Energy Conference 2000 in Trondheim, Norway, 13th-14th March 2000.

Promoters and parties involved

Owner	Lumituuli Oy
Operator	Lumituuli Oy and partner Graninge Kainuu Oy (utility)
Planning works (electrical and civil)	PV0 Engineering
Electric works	Suomen Voimatekniikka Oy
Construction work	Uunila Oy
Crane company	Hongisto Oy
Wind turbine manufacturer	Vestas Wind Systems A/S

The local farmers and fishermen have been involved in erecting of the turbine and they are responsible for simple service and maintenance work.

Financial resources

Total investment

The wind turbines built by Lumituuli Oy were financed by share issues targeted mainly at the public (not companies). The first issue sold all 3,000 shares of €210.

The total cost of the turbines and infrastructure were €900,000, of which the island and foundation accounted for about €240,000.

Subsidy

- The project received a subsidy from the Finnish Ministry of Trade and Industry covering 37 % of the total project cost.
- In addition, the electricity from the turbine receives a production subsidy of 7 €c/kWh

Revenue

Lumituuli Oy mainly sells electricity to its shareholders. Each share, which has a value of €210, entitles the holder to buy 500 kWh of wind electricity from the company. The part of production, which is not sold to shareholders, is sold to Graninge Kainuu Oy.

Results

The installation work of the turbine was carried out without major problems during wintertime, exploiting the fact that the sea is frozen over at that time.

Energy production

The turbine produces about 1.8 GWh annually.

Socio-economic benefits

The local community has gained much publicity in connection with the wind turbine.

Environmental benefits

The company has invited local residents to report any bird casualties they observe. So far there have not been any reports, which indicates that the turbine has been appropriately sited to avoid having an impact on the bird-life in the area.

Potential for replication

The project has demonstrated that significant cost reductions can be achieved by utilising the ice cover when constructing offshore wind power in very shallow water. This approach was made necessary by the severe difficulties in operating in shallow water. However, there is insufficient knowledge and a lack of experience concerning the maximum loads ice roads are able to withstand. The project relied on the standards put forward by the Finnish road Administration and the Finnish Army. Therefore, the findings of this project are restricted to turbine sizes of under 1 MW, since the standards for the ice roads are limited to 70 tonnes and the weight of components for larger turbines exceed these limits considerably. The technique used to lower the submarine cable can be applied much more widely, as the machinery used to lay the cable weighs less than ten tonnes.

For more information

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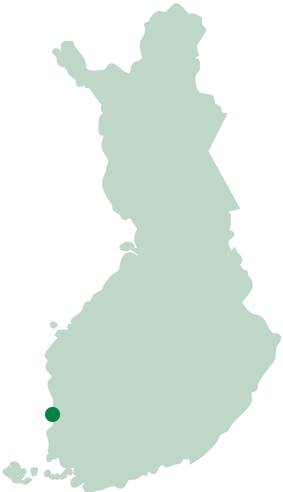
Sector: Wind Energy
Country: Finland
Location: Pori
Year: June 1999



MERI-PORI WIND PARK

In 1993, Pori Energia (Pori's municipal power & heat utility) installed a 300 kW test turbine to obtain practical experience in wind power production. Already during that time, the utility had plans to invest in more wind turbines in the future.

As a result of the trial, public attitudes in Pori became much more favourable towards wind power (before the installation of the test turbine, there had been some concerns about noise and visual impact). The location of the test turbine in the vicinity of the harbour and industrial area played a major role in convincing the locals of the value of wind power as an environmentally benign form of energy production.

When a general plan for the region of Meri-Pori (encompassing the coastal areas and archipelago of Pori) was prepared some years later, additional areas were set aside for wind power development. These areas were identified as having sufficient potential and being environmentally acceptable in a regional wind power study that was conducted by Electrowatt-Ekono in collaboration with local authorities and the utility immediately after the installation of the 300 kW test turbine. During the planning process, there were no objections from the local inhabitants regarding the areas designated for wind power generation.

Deregulation of the Finnish electricity market began in 1995. From September 1998, the private consumers were able to choose their supplier without having to invest in expensive hourly kWh metering. The anticipated demand for green electricity encouraged electricity suppliers to initiate wind power projects in early 1998.

Pori Energia started negotiations with other major municipal utilities to initiate a cooperation project to install "the largest wind farm in Finland". Altogether, nine large municipal utilities showed an interest in the project, and the project company Hyötytuuli Oy ("Beneficial Wind") was created.

Description

Total capacity	10 MW
Turbines	8 x 1 MW + 1 x 2 MW
Annual production	25 GWh
Hub height	50/60 m for the 1 MW turbines, 80 m for the 2 MW turbine
Rotor diameter	54 m (1 MW), 76 m (2 MW)
Turbine Supplier	Bonus Energy A/S, Denmark

The turbines are located in three groups:

- 5 MW (3 x 1 MW + 1 x 2 MW) in the deep-water harbour of Tahkoluoto
- 4 MW (4 x 1 MW) along a causeway between the mainland and the archipelago
- 1 MW on the Reposaari breakwater, adjacent to the 300 kW test turbine

To ensure public safety, the four 1 MW turbines along the causeway are equipped with an intelligent ice-prevention system developed by Kemijoki Arctic Technology, Finland.

In the vicinity of the four 1 MW turbines, there is an 87 m high measurement mast. An extensive monitoring programme was carried out to ensure the safe and reliable operation of the ice prevention systems, to check the power curve and power quality of the turbines, and to acquire further information about the wind resources and icing at higher altitudes.

Promoters and parties involved

Owner: Hyötytuuli Oy, a consortium of nine major Finnish municipal utilities.

Owner's Engineer: Electrowatt-Ekono Oy

R&D service provider: VTT (State Research Centre)

Financial resources

- Total investment about € 8 m
- Subsidies
- The project received an investment grant of 33 % provided by the Ministry of Trade and Industry, Finland
- R&D finance for the monitoring programme was provided by the Technology Development Centre TEKES, Finland
- The electricity produced is sold by the owners of Hyötytuuli, who sell it as a separate wind power product or as a part of their normal sales mix to their customers
- Loans were provided by Nordic Investment Bank (NIB) and a private investment bank

Results

- The development and implementation of the project was relatively straightforward; the project did not face substantial opposition, the permit process ran smoothly, and the project was completed on schedule. The main challenges were technical: the erection of large turbines on narrow roads and breakwaters, the traffic arrangements during erection, the development and installation of ice prevention systems, etc. However, none of these challenges caused any delays or unexpected costs.
- The Meri-Pori wind farm produces some 25 GWh of emission-free electricity annually.
- The wind farm has greatly improved knowledge of the achievable wind resources in the coastal areas of Finland, the reliability of large wind turbines and ice prevention systems, the environmental impacts and public acceptance of wind power, etc.
- According to an opinion poll conducted in 2000, 97% of the inhabitants of Pori approved the wind park and supported the idea of further wind power development in the region. As a consequence, Hyötytuuli started a feasibility study of a 100 MW offshore wind farm in 2000. The study will be completed at the end of 2002 and the installation may start in 2005.
- Pori Energia is now also providing repair and maintenance services to other wind farms in Finland.

Potential for replication

All the turbines are located in a rural environment in the vicinity of an industrial area or at various similar coastal sites in Finland, where the implementation of wind farms of similar size should not cause any major conflicts with local inhabitants or environmental impacts, etc. Therefore, the potential for replication is assumed to be good. The major obstacle for the replication at the moment is the low demand for green electricity.

For more information

Engineering

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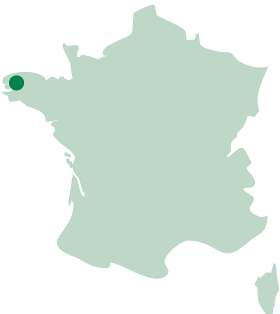
www.electrowatt-ekono.fi

Sector: Wind Energy
Country: France
Location: Northern France, Cap Sizun, Finistére
Year: 2000

ENERGIE



GOULIEN WIND FARM

The Goulien wind farm is located at the end of the peninsula Cap Sizun on the north-west coast of France, in, in the Finisterre area. It was selected in 1997 within the framework of the programme EOLE 2005.

This 6 MW wind farm came into operation in March 2000 and its output benefits about 6,000 people.

Description

The area was selected because of its powerful and constant winds blowing from north-east to south-west. It is located on a flat terrace at a height of 90 m overlooking Douarnerez Bay.

The north eastern end of the area was subject to strict environmental constraints which prevented siting a major installation there: moreover, this mainly agricultural region includes a number of environmentally protected areas, including a wild fowl reserve.

The wind farm is formed by 8 three-blade NEG-Micon NM48 750kW turbines with a total installed power of 6 MW: these machines have a 48 m diameter with a hub height of 45 m.

The average wind speed is about 7 m/s measured at 50 m above the ground, which permits an estimated production of about 14 m kWh/year. This electrical power is produced at 690 V and is stepped up to 20 kV so it can be fed into the grid. The wind farm has a 25 year contract to sell electricity to EDF, the power utility.

Promoters and parties involved

Main contractor

ALSTOM Enterprise (former CEGELEC) realised more than 40% of the whole project and
ALSTOM Contracting
Enterpise sud-Ouest
11, impasse des arenes
31082 Toulose cedex 1
+33 05 613160 28
Fax: +33 05 61594120

Exploitation and construction

The joint-stock company CEG, Centrale Eolienne of Goulien (Goulien wind farm)
(35% ALSTOM and 65% NEG micon)

Studies and Assembling

Espace Eolien Developpement Sarl
16, Rue Faidherbe
59000 Lille, France
+33 320 740400
Fax: +33 320 740407
eed@espace-eolien.fr
www.espace-eolien.fr/lille/centrdon.htm

Technology supplier

NEG MICON
Alsvej 21, DK 8900 Randers, Denmark
+45 8710 5000
Fax: +45 8710 5001

Financial resources

The total investment was €6.8 m, of which 5% was drawn from the company's own capital, 14% was subsidised with a combination of Local regional and European funds and the remaining 81% was provided by a bank loan.

Results

Estimated output is 15 m of kWh of electrical energy, corresponding to the consumption of about 6,000 people in terms of heating hours: if compared with a conventional natural gas plant this wind farm will also avoid 7,500 CO_2 emissions a year.

Potential for replication

A careful and well targeted information and promotion campaign was set up by Goulien Council in order to exploit the wind farm's possibilities for tourism and educational purposes (it being the first wind farm in the Brittany region).

This activity will enhance public acceptance of wind farms and encourage similar develoments in other areas.

For more information

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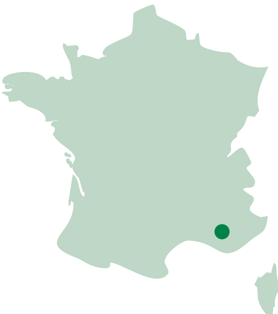
Sector: Wind Energy
Country: France
Location: Region Aude
Year: July 1998

ENERGIE



SALLÈLES-LIMOUSIS WIND FARM

The wind farm is located in the département of Aude (Languedoc-Roussillon) in the south of France, within the municipality of two small villages, Sallèles-Cabardès (150 inhabitants) and Limousis (88) inhabitants). It comprises 10 Windmaster turbines each with a rated power output of 750 kW.

Initial wind speed measurements in the area begun in 1993, but construction only began in 1997 works started and the wind farm was commissioned in July 1998.

Description

The 10 twin-blade turbines have a rotor diameter of 43.4 m, a hub height of 48 m and a rated capacity of 750 kW each when working at a wind speed of 15 m/s.

The nacelle houses a multiplier connected to an asynchronous generator. The turbines have pitch regulation and blades can be feathered automatically when power production exceeds 750 kW.

The plant is equipped with a number of safety systems such as pitch regulation (to preserve nitrogen pressure) and also double hydraulic control circuits.

All the turbines are directly connected to the grid and each of them is equipped with an internal PC controlling the grid connection and peforming metering and monitoring functions.

The entire output of the wind farm is sold to EDF (the power utility) at the legally established wind tariff. EDF owns the local grid, which operates in the medium voltage range (20,000 V). The turbines are connected to the grid via an underground medium-voltage cable.

Promoters and parties involved

Developer, owner and Turnkey construction of the plant

Ènergie Nouvelles Sallèles Limousis
Leads a group of companies CEGELEC-WM formed by:

CHARTH (of the EDF group) for the 40%

CEGELEC for the 30%

WM for the 30%

Énergie Nouvelles Sallèles-Limousis
Rue de la Forge
11600 Sallèles Cabardes

Wind turbines

Wind Master Nederland BV
Zuiveringweg 26, 8243 PZ lelystad
Netherlands
+31 320 254940
Fax: 31 320 254576

Financial resources

The total investment was approximately €7.5 m, which was financed by Ènergie Nouvelle Salleles-Limousis through a syndicated loan from a group of banks (BNP, SAPAR and CCF) .

The project received subsidies equal to 18% of the total investment costs from EDF, the regional Council of Languedoc-Roussillon and ADEME.

Results

The wind farm produces 7,500 kW of electricity, which is sufficient to supply the needs of about 42,000 people (the equivalent of the total inhabitants of the nearby town of Carcassonne) . The plant sells electricity to the grid at an average price of 0.04 €/kWh, which is EDF's standard tariff for electricity generated by wind power.

More than 35 % of the installation was manufactured locally (foundations and grid connections) or nationally (tower fabrication, electric cables and assembling) and local technicians were employed in construction.Moreover, the Local Authorities involved benefit from the wind farm both financially (in terms of the taxes they receive from the company) an in terms of tourism, given the numbers of tourists being attracted to the wind farm, who also enjoy of the natural and historical setting.

Potential for replication

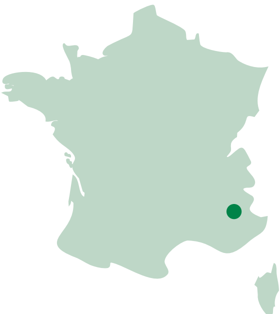
The project has permitted the developers to develop in-depth know-how which can be applied in similar installations in the area, in addition to demonstrating the feasibility and good performance of such plants and thus potentially stimulating replication.

For more information

Énergie Nouvelles Sallèles-Limousis
Rue de la Forge
11600 Sallèles Cabardes
espace-eolien.fr/sud/centrsl.htm

Sector: Wind Energy
Country: France
Location: Southern France, town of Donzere
Year: 1999

ENERGIE



DONZERE WIND FARM

The site for this wind farm was identified within the framework of a study and a measurement survey carried out between 1993-1995 in the Lower Rôhne Valley .

The area has very good wind potential , which is also enhanced by a “Venturi” effect, which accelerates the predominant north wind (Mistral) through the valley.

The 3 MW wind farm came into operation in June 1999.

Description

The project is located at the end of the Donzere Valley, near the main road. The economy of the area is mainly agricultural (wine), with small-scale commerce and handicrafts and some manufacturing. An important element of the local economy is that the electricity supply is mainly provided by hydroelectric plants (Poincaré and Chateauneuf-du-Rhone) and the two nuclear plants of Tricastin and Cruas-Meysse.

Erecting this small wind farm in this context is therefore particularly significant. The wind farm consists of five 600 kW NORDEX turbines with a rotor diameter of 43 m and hub height of 50 m. The nominal power output is 600 kW at an average wind speed of 13.5 m/s. No new access routes to the area were required, as those existing were adequate. This meant the environmental impacts and costs could be minimised.

The turbines are located in two parallel lines facing the prevailing wind direction.

The entire electricity output is sold to EDF (the national power utility), within the framework of a contract under the EOLE 2005 initiative, promoted by ADEME in order to stimulate and encourage the development of wind energy exploitation all over France.

Promoters and parties involved

Project management was by SINERG, which is a branch of the “Caisse de Depots et Consignations”.

The project was implemented by the engineering firm SPIE TRINDEL.

Technology supplier

NORDEX
Svindbaek, 7323 Give Denmark
+45 75 734400
Fax: +45 75 734147
nordex@nordex.kd
www.nordex.dk

Financial resources

The project was prepared and presented by SPIE TRINDEL (Toulouse branch) and was selected, on the basis of a report in 1996 within the framework of the first phase of the call for tender of the EOLE 2005 programme.

The project also benefited from financial support from the regional Council of Rhone-Alpes, which met the additional cost of the grid connection.

Results

The building permit was granted in November 1998 and the wind warm was commissioned in June 1999. It currently sells its entire output to the local EDF grid.

Potential for replication

The Donzere Council, together with COGEMAS and SPIE TRINDEL were particularly active in promoting and disseminating a parallel programme of visits and information to the general public with a view to fostering a positive public attitude towards the wind farm.

Erection of a wind farm in this location is a good example of use of renewable energy in a reliable and effective system with considerable potential for replication elsewhere in the area.

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www.espace-eolien.fr/lille/centrdon.htm

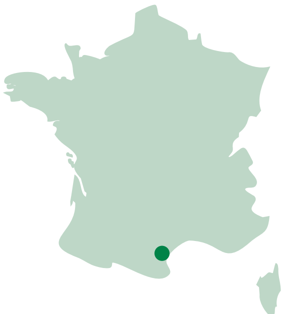
Sector: Wind Energy

Country: France

Location: Southern France, town of Sigean and Port-la-Nouvelle – Aude Region

Year: May 2000

ENERGIE



CORBIÈRE MARITIME WIND FARM

This was an existing 5 turbine wind farm, erected between 1991 and 1993, which was recently upgraded and enlarged with 10 new turbines, which are producing 2.6 m kWh.

The wind farm, which is now the largest in France with its 15 turbines, has an installed power of 8.8 MW and serves a population of about 10,000 inhabitants. The wind farm was set up with an environmental friendly approach and is quiet, particular attention having been paid to the environmental impact assessment.

Description

The wind farm is located 20 km from the town of Narbonne and about 40 km north of Perpignan. It stands on a plateau called Garrigue Haut in the district of Sigean and Port-la-Nouvelle within the Aude Region.

The area was identified and selected a decade ago as being of interest for wind power given the speed and constancy of the wind.

For this reason the wind farm has been progressively enlarged and now has a total installed power of 8.8 MW. The 15 turbines are about 60 m high and produce electricity which is sold to the EDF grid within the framework of the Eole 2005 scheme.

In all, the wind farm has the following turbines:

- 10 turbines of 660 kW set up in May 2000.
- 4 turbines of 500 kW set up in September 1993.
- 1 turbine of 200 kW set up in July 1993.

The output of the wind farm can serve a population of about 10,000 inhabitants and in industrial terms it provides 40% of the power used by nearby Ciment Lafarge Factory.

Promoters and parties involved

The Compagnie du Vent was the main promoter of the initiative together with the Councils of Sigean and Port-la-Nouvelle and the Cimenterie Lafarge which provided part of the land.

Compagnie du Vent
650 Rue louis Lepine – Horizon 21
34000 Montpellier – France
+33 4 99 52 60 35
fax: +33 499 526471

Technology supplier

Gamesa Eolica
Poligono Agustinos Calle A
E 31013 Pamplona
+34 948 309010
Fax: +34 948 309009
www.gamesa.es

Industrial participants

Cabinet Germa
www.cabinetgerma.com

Financial resources

The total investment was €9.1 m, which was partly financed by the promoter Compagnie du vent and the rest obtained through a bank loan.

Results

The total annual production is 25 m kWh and it has been calculated that generating electricity from the wind farm avoids total emissions of 20,000 tonnes of CO_2 (the equivalent to the amount sequestered in about 1.2 m trees).

Potential for replication

The enlargement or renewal of a good site that is already being used for a wind farm is always very effective and makes it possible to benefit from existing investments (access roads, electric cables etc), which are usually very expensive. This makes this project is a good replicable example that could be followed elsewhere.

For more information

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650 Rue louis Lepine – Horizon 21
34000 Montpellier – France
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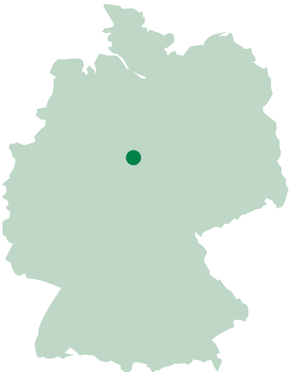
fax: +33 499 526471

Sector: Wind Energy
Country: Germany
Location: Edemissen
Year: 2000

ENERGIE



EDEMISSEN, OELERSE WIND FARM

The WindStrom Group from Edemissen, near Hanover, has been implementing wind energy projects since 1992. The company has already implemented over 100 wind power installations in the Megawatt range in the federal states of Brandenburg, Saxony Anhalt and Lower Saxony. Offices in Italy and Poland are part of the international wind farm activities of WindStrom.

Planning of the Oelerse wind farm began in 1998. Three members of the WindStrom Group were involved in the project: WindStrom Innovative Energiesysteme GmbH, WindStrom Betriebs- and Verwaltungsesellschaft mbH (the society for the operation and management of the wind farms) and WindStrom Beteiligungs GmbH & Co. Oelerse IV Infrastruktur KG.

The objective of the project for WindStrom was to contribute to the economic development of wind energy projects.

Description

The project consists of 17 "AN BONUS" 1.3 MW/62 wind turbines, divided into three sections with a total capacity of 22.1 MW. The nominal power capacity of the turbines is reached at a wind speed of 15 m/s.

The three-blade installations with a constant number of revolutions per minute operate by the "CombiStall" principle, which is especially very successful at inland locations. It combines the beneficial properties of Stall and Pitch control, which enable low wind speeds to be utilised well.

An adjustment of the rotor blade angle prevents the generator from being overloaded in high winds. Moreover, the system can be operated in full load mode up to the cut-off speed of 25 m/s. The installations are fitted with a hydraulic brake system. The construction of the main bearings at the base area enable balanced power conduction from the tower. The weight of the rotor on the one side compensates the weight of the transmission and the generator at the other side.

The wind turbines operate in grid-parallel mode and they are connected to the electricity grid via a 110 kV substation.

Promoters and parties involved

- WindStrom Innovative Energiesysteme GmbH: planning, project development, marketing
- WindStrom Betriebs- und Verwaltungs-GmbH: management and monitoring of the wind turbines
- WindStrom Beteiligungs GmbH & Co. Oelerse IV Infrastruktur KG: owner and operator of the substation
- Thopa GmbH & Co. Oelerse V KG, WindStrom Oelerse Betriebs-GbR and others: owner and operator of the wind turbines
- Avacon AG: utility
- E.on: utility
- AN Windenergie GmbH: manufacture of the wind turbines and service

Financial resources

The total investment costs for the project were approximately €25.2 m (taxes excluded). This amount includes the construction of the 110 kV substation, which was planned and built by WindStrom.

The project was financed by Thopa and WindStrom and other private investors. The project did not receive any subsidies.

Results

No significant problems occurred during the planning, construction or operation of the windfarm. Before the area could be approved as a location for a wind farm under overall regional plans, the relevant official bodies conducted a number of environmental and wind resource studies. The windfarm site is relatively flat and the villages in the surrounding area are at least 1 km away.

The windfarm produces about 45,000 MWh of electricity a year. This electricity is supplied to the grid belonging to the utility companies Avacon and E.on. With the current feed-in tariff of 9.0 €c/kWh in 2002, the annual revenue from electricity production is about €4 m.

Part of the revenues from the sales of electricity produced by the operation of the wind turbines has been set aside to sponsor the Oelerse beneficial society, which was created by WindStrom. The sponsorship money is to be used only for non-windenergy projects, such as childrens' activities, a kindergarten, sport activities and the restoration of official buildings and infrastructure. This measure helps enhance the degree of acceptance of the Oelerse wind farm by the local residents.

Over 50% of the electricity produced in Germany is generated in coal-fired power stations. With this as a reference, the Oelerse wind farm reduces the emissions by about 43,200 tonnes CO_2, 28.4 tonnes SO_2, 29.7 tonnes NO_x, and 1.8 tonnes dust per year[1].

Other environmental benefits from the project include compensation measures, i.e. the creation of a new biotope within the local surroundings of about 10 ha in total (approximately 6,000 m^2 per wind turbine). This was financed by WindStrom.

Employment was created at WindStrom Betriebs- and Verwaltungsgesellschaft due to the operation, maintenance and service activities that need to be caried out at the windfarm.

Potential for replication

WindStrom is working on many windfarm projects. Every project is subject to different conditions, due to grid capacity, topography, local policies, turbine type, etc. WindStrom´s aim is to come to an understanding with all parties involved in a project such as windfarm Oelerse. The success of the implementation of a wind farm relies on a good partnership between all parties involved in the project.

For more information

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WindStrom Oelerse Betriebs- and
Verwaltungsgesellschaft mbH
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Fax: +49 5176 9204-10
info@windstrom.de
www.windstrom.de

1 German coal-fired power plants produce the following emissions per kWh electricity: 960 g CO_2, 630 mg SO_2, 660 mg NO_x and 40 mg dust (for the year 2000, VDEW Germany, VDEW-Materialien M-21/2002).

Sector: Wind Energy
Country: Greece
Location: Lavrio
Year: 2000

ENERGIE

DEVELOPMENT OF WIND-TURBINE AND BLADE TECHNOLOGY IN GREECE

Within the framework of efforts to support national R&D activities in the fields of environmentally friendly technologies and new materials and manufacturing processes, this project aimed to enhance national technology in the wind energy field and in particular Wind Turbine (W/T) manufacturing. The methodology followed to accomplish this target included design, construction, installation, operation and testing, followed by feedback activities to enable optimization. Special emphasis was given to W/T controllers and W/T rotor blades, which were domestically designed and manufactured for the first time.

In particular, the project targets were:

- Development of domestic technology suitable to enable Greek manufacturers to exploit the country's considerable wind power potential through products aimed at the national market, which could subsequently also be suitable for export.
- Detailed and integrated design, manufacturing, installation and operation of a prototype W/T in the range of 400 kW - 500 kW (the state of the art at the time of the project).
- Detailed design, manufacture, full-scale testing of W/T blades in the range of 6 m -20 m in length (20 m blades represented the most advanced technology at the time), of fitting of rotors on an existing W/T and operation.

Description

The EPET#573 project was divided into two main parts, focusing on national technology development:

1. W/T technology applicable to the terrain of Greek wind power sites
2. W/T blade technology, suitable for sites characterised by high wind speeds and complex terrain

A. W/T in the range of 400 - 500 kW

The design of a variable speed, constant pitch 450 kW horizontal axis W/T was based on a Greek 100 kW W/T, erected on the island of Skyros. Special emphasis was placed on wind turbine safety issues. The W/T was designed according to the international standard IEC 61400-1 for class I wind turbines. Estimate of the aerodynamic loads and the strength verification of the structural parts, as well as calculations for the dynamic response and fatigue loads covering all operational conditions were performed by use of detailed finite - elements models in combination with simplified mathematical models such as beam theory. The calculations included all the structural details of the tower and nacelle, such as supports, joints. The tower was designed according to the National Standards for the Concrete Structures and Seismic Action. PYRKAL SA conducted the manufacturing and assembling of the main parts of the wind turbine. The prototype wind turbine was installed at the CRES testing site in Lavrio. During the commissioning period CRES performs tests, such as the power curve and power quality measurements, load and noise measurements.

B. W/T Blades

Blades of three types, namely 9.3 m, 14 m and 19 m in length, were designed, manufactured and subjected to full-scale testing during the project. The integrated blade design phase comprised aerodynamic, structural and aeroelastic calculations. Aerodynamic design of the new blades, was based on an optimization procedure developed during this project, with criteria such as, a low drag coefficient, a specific value for the lift coefficient and specific wind conditions for the airfoils and maximum power production at sites characterised by complex terrain and high wind speeds, while ensuring minimum loads on the rotors and blade level. Scale models were used in wind tunnel tests to verify the design of the new aerofoils. The structural design of the blades was conducted according to the international standard for WT class I, IEC61400-1. Aeroelastic calculations, including static & fatigue strength analysis, together with modal and buckling analysis were conducted by state-of-the-art tools developed during the project by the R&D partners, in combination with commercially available Finite Element software. To determine the mechanical properties of the composite material, a series of experiments were conducted as a part of the project.

The R&D partners, responsible for the blade design, cooperated closely with the industrial partner (GEOBIOLOGIKI S.A.) to form a strong team to work on the design and construction of the blades. The static and fatigue strength, and the dynamic response of the blades, were assessed by means of full-scale blade testing at the CRES W/T blade testing laboratory, thus concluding the design and construction verification. A 9.3 m rotor was built and fitted to a small 100 kW Wind Turbine in at the CRES testing site. The aeroelastic performance of the blades was monitored of over a one-year period, and power production measurements were taken. A 19 m blade rotor is ready for installation on the prototype 450 kW W/T, after the full commissioning of the turbine.

Promoters and parties involved

- Centre for Renewable Energy Sources – CRES (Project coordinator, Test & Measurement of W/T & W/T blades, Verification of design and construction, R&D)
- University of Patras – UP (Structural design of W/T tower & W/T blades, composite materials specialists, R&D)
- National Technical University of Athens – NTUA (Aerodynamic design of W/T blades & Electrical/electronic design of W/T controller and electrical parts, R&D)
- PYRKAL SA (W/T tower, nacelle, hub, etc. manufacturing, W/T installation, manufacturer)
- GEOBIOLOGIKI SA (W/T Blade manufacturer)
- The Public Power Corporation of Greece – PPC (W/T design, Owner of prototype W/T 450 kW)

Financial resources

Total investment: €1,922,000

From this public funding: €1,390,000

EPET II #573 was conducted within the framework of the EKBAN national programme.

Results

- During the project strong cooperation was established between the domestic R&D and industrial partners, resulting in technology transfer and implementation of contemporary products. Although at the beginning of the project some small difficulties were encountered in the collaboration between ththose groups, these were soon overcome and successful production of a prototype W/T and three types of rotor blades was achieved.
- One of the benefits of this project in terms (mainly) of national renewable energy production, (except for the prototype W/T operating on at the CRES site), is that there are two industrial partners capable of producing W/T parts, therefore lowering the cost of purchasing and installing wind turbines in Greece. Also, lower start-up costs mean that more investors will be interested in operating W/T at Greek sites, thus boosting wind energy production and allowing for more fossil fuel substitution.
- From the socio-economic point of view the benefits of developing national technology on for a state-of-the-art product are obvious, as this project has enabled the partners to strengthen their position not only at the domestic level but also internationally.
- Environmental benefits were only a secondary feature of this project, as the main focus was on enhancing domestic technology capabilities in the wind energy field and less on immediate environmental benefits.

Potential for replication

The project aimed at developing national state-of-the-art technology in the wind energy field and, from this point of view it was highly successful. The underlying principles of this project are continuously applied in nationally and international project R&D funding, where there is a need to boost technological capability in areas of special interest. Pure replication of the project is, therefore, possible in countries were the renewable energy potential is high enough to allow successful exploitation, in combination with the national need for domestic technology enhancement.

For more information

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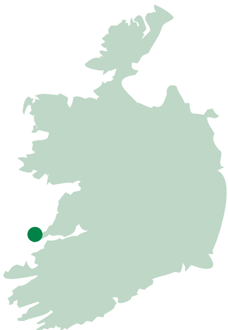
pvioni@cres.gr

Sector: Wind Energy
Country: Ireland
Location:Beale Hill, Ballybunion Co. Kerry
Year: Spring 2000

ENERGIE



BEALE HILL SINGLE TURBINE WINDFARM

This is a commercial wind energy project in receipt of a Thermie grant. It is doubly unique in that it is the tallest wind turbine installed in Ireland, and it is also the only single-turbine wind farm connected to the grid. It was the second of the three wind farms currently operational in Co. Kerry and was guaranteed a 15 year Power Purchase Agreement due to its Thermie funding.

Description

The wind farm, set up with the close collaboration of a local farmer, rapidly became something of tourist attraction of the area soon after construction started. Prior to installing the wind farm, the land owner had begun measuring wind speeds at his farm in 1994 and several years later, after having acquired two partners, he set up this installation.

It comprises a single 1.65 MW wind turbine with a height of 67 m a weight of 192 tonnes, and a blade length of 33 m.

Some hard work was necessary to build it including the provision of a road, the erection of a substation with transformers within the farmyard itself and a proper pipe to transport the produced electricity to Ballybunion town, five miles away.

The whole project was supported by a careful environmental impact analysis.

Promoters and parties involved

Owner: First Electric and Sure Engineering Europe Ltd., 29 Lr. Leeson Street, Dublin 2.

Financial resources

Total investment: Private Investment of €2.4 m.

Subsidies: Cofinanced by the EU Thermie programme. Government offers 15 year Power Purchase Agreement to all wind farms in receipt of a Thermie grant at the prevailing Alternative Energy Requirement scheme price.

Results

A full planning application was made in July 1998, and permission was granted in September. There were neither appeals nor objections. Construction began in early 1999 and operation commenced in early 2000.

The plant has an installed capacity of 1.65 MW and generates enough energy for approximately 1,100 homes. The electricity produced by the wind turbine helps to avoid the emission of over 4,000 tonnes of CO_2 annually. The power is supplied to the national grid with a varied payment system.

Potential for replication

The project can be considered as a real success in terms of acceptance from the area's inhabitants, also because it is the result of a long planning and a careful direct information campaign, which slowly overcame the initial reluctance towards the unknown technology. The owner is applying for planning permission for other six smaller turbines, which would add another 5,000 homes to his capacity and there is a growing interest in similar applications among community farmer groups and villages.

For more information

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+ 353 23 29145
wind@reio.ie
www.irish-energy.ie/reio.htm

Sector: Wind Energy
Country: Ireland
Location: Cronalaght
Year: 1997

ENERGIE

CRONALAGHT WIND FARM

This 3 MW wind farm is located in in the Cronalaght area in the north west of Ireland, a remote part of the island with prevailing winds from the Atlantic Ocean. The area was identified as one of the most suitable sites in Ireland for wind generation in a study done in 1989.

The Cronalaght wind farm was the first to be constructed under the AER scheme and it was developed by an Irish Company owned by local businessmen.

Its construction is part of a wider strategy aimed at improving the penetration of wind energy in areas were electricity grids are weak, while preserving the quality of supply. In fact, initial studies indicated that the local grid would have to be reinforced to cope with connecting the wind farm, making the project uneconomic.

For this reason some technical innovations were introduced by the promoters, so that output from the wind farm is managed in such a way as to ensure grid parameters are kept within normal limits under all operating conditions.

The first phase was inaugurated in June 1997 (five 600 kW turbines) and a second one was built in 2000 (three 660 kW turbines).

Description

The installation comprises 5 three-blade upwind, horizontal axis turbines, each of which has a rotor diameter of 39 m, a hub height of 40 m, continuous pitch regulation and a rated output of 600 kW. The second phase, built in 2000, consisted of three 660 kW turbines with a 47 m rotor length.

The total installed capacity of the first phase is 3 MW and it supplies about 3,000 households, while the output from the three additional turbines is purchased by AIRTRICITY and supplied around the area.

The project included a number of technical innovations, which were specifically developed for wind farms located in areas with weak electrical infrastructure. Thus it incorporates novel generator control and fast blade pitch regulation system in the turbine design, plus a specifically designed voltage control unit (VCU), which manages the outputs in order to maintain existing grid parameters within their operating limits.

Promoters and parties involved

Developers and owners:

Gineadoiri Gaoithe Teoranta and others
(Irish company owned by local businessmen)
Crolly, Lettrekenny, Co, Donegal

Ireland
T+353 075 32000

Wind turbines: VESTAS

Voltage Control Unit : Riso

Financial resources

- Total investment was completely private and came to 1,6 m Irish Pounds (about €2 m).
- Subsidies: the project was awarded a THERMIE grant of €600,000, mainly aimed at developing the innovative Voltage control Unit.

Results

During its first year of operation the wind farm generated approximately 11 GWh with a capacity factor of 42.4 %. The system availability over this period was 96 %.

Moreover its environmental benefits in terms of avoided emissions have been calculated at 80 tonnes of sulphur dioxide, 55 tonnes of nitrous oxides and 13,000 tonnes of carbon dioxide avoided annually.

Potential for replication

The whole project, and in particular the development of the innovative VCU was specifically developed in such a way as to make a significant contribution to power supply without causing undesirable fluctuations on the grid, caused by wind farm outputs outside acceptable limits in weak grids. This innovative technology having now been demonstrated, it is set to make a major contribution to the spread of wind farms in areas with similar grid connection problems.

For more information

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Sector: Wind Energy
Country: Ireland
Location: Currabwee, Dunmanway, County Cork
Year: November 1999

ENERGIE

CURRABWEE WINDFARM

This is a commercial wind energy project in receipt of an Irish Government grant. It is noteworthy as it was one of the first to be undertaken by local landowners (two brothers) as opposed to specialist developers.

This was the first wind farm constructed in County Cork and also the first under the AER3 scheme.

Description

The wind farm has an installed capacity of 4.62 MW, provided by 7 two-speed 660 kW wind turbines.

At wind speeds below 6 m/s, a smaller generator is used with 20 rpm rotor-blade speed for quieter operation. At higher wind speeds, the speed is increased to 26 rpm and the bigger generator switches in.

5 of the turbines have a hub-height of 45 m, whilst two have a hub-height of 55 m. However, the differences in hub-heights are not apparent to the observer due to the excellent design of the sloping site.

Promoters and parties involved.

The promoters and developers are the site owners

John & Pat Kingston, Currabwee, Dunmanway, Co. Cork.

Technology supplier, operation and maintenance

Vestas Celtic Wind Technology (operates the warranty and maintenance agreement.).

Project management

Scan Energy & Environmental Services,
Abbey Street, Howth, Co Dublin, Ireland.

Firm responsible for civil engineering work

Keohanes, Rossmore, County Cork, Ireland.

Electrical infrastructure

ESB Contracts.

Financial resources

The total private investment in the wind farm was €6.4 m.

A subsidy was obtained by the Government AER 3 scheme 15 year Power Purchase Agreement.

Results

A full planning application was submitted in July 1998, and permission was granted in Nov 1998. There were no appeals or objections and construction began in the summer of 1999. Operation commenced in November 1999.

The 4.62 MW wind farm generates about 15.4 GWh of electrical output annually, providing enough energy for approximately 3.000 local homes. The wind farm helps avoid the emission of 12.000 tonnes of CO_2 annually.

The project has been well accepted, and welcomed, locally. It has increased the general awareness of, and interest in, renewable energy locally, and of the associated environmental benefits. Construction implied local investment of over €1 m, and the wind farm employs a local part-time caretaker. The Turbine supplier also employs maintenance staff locally due to the number of wind farms in South–West Ireland.

Before construction it was estimated that the wind farm would generate electricity for about 3.000 homes.

Potential for replication

It is an ideal model for small scale wind farm development in the Irish landscape.

For more information

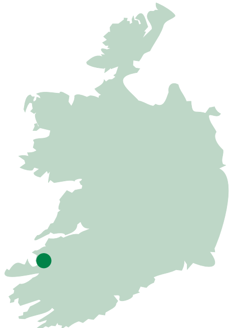
Renewable Energy Information Office.

Shinagh House,
Bandon,
Co. Cork,
Ireland
+ 353 23 29145
wind@reio.ie
www.irish-energy.ie/reio.htm

The site is also included on Irish Wind Energy Association website www.iwea.com.

Sector: Wind Energy
Country: Ireland
Location: Tursillagh, Tralee, County Kerry
Year: August 2000

ENERGIE



TURSILLAGH WIND FARM

This is Ireland's largest wind farm and is a fully commercial venture (in fact, it belongs to the Irish Wind Energy Association). It is located approximately 8 km North East of Tralee in Country Kerry in the south west of Ireland.

The project started in 1993 with the purchase of the 60 ha site on which the wind farm is located, but it was not until November 1999 that the construction of the wind turbines began. Work was completed in August 2000.

Description

The wind farm, with a total installed capacity of 15.18 MW, consists of 23 wind turbines situated in 5 rows and located on a gently sloping peat bog at an altitude of 300 m above sea level.

Each 660 kW turbine has a 47 m rotor diameter (Vestas V47 model) and a 50 m hub-height.

Electricity is generated when the wind speed is between 4 and 25 m/s. At higher speeds the 23.5 m glass-fibre reinforced epoxy are feathered to shut down the turbine.

All the wind turbines have a transformer in the base to step the voltage up from 690 V to 20 kV. The transformers are all connected to a single 20/38 kV grid transformer.

In order to provide information about the new installation, dissemination activities have been run and the wind farm received visits from a wide variety of groups (students, associations, the general public). Additionally, basic information about the farm is being disseminated through the Saorgus Website.

Promoters and parties involved

Developers:

Saorgus Energy Ltd, Tralee, Co. Kerry & Powergen Renewables. Ireland Ltd.

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Tralee,
Co. Kerry,
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www.saorgus.com/

Powergen Renewables Ltd

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Owner, operation and maintenance:

Tursillagh Windfarms Ltd (a 50/50 joint venture between Saorgus Energy Ltd, Tralee, Co. Kerry & Powergen Renewables. Ireland Ltd.).

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Manufacturer of the civil engineering:

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Wind turbines:

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Fax +45 96 75 24 36
vestas@vestas.dk
www.vestas.dk/

Financial resources

The total investment came to €8 m. The project was partially co-financed by the Irish government in form of a bid for a 15 year Power Purchase Agreement (PPA) under the third round of the Alternative Energy Requirement (AER3).

Results

The main results of this project are:

The 15.18 MW wind farm generates approximately 50 GWh of electricity annually, providing enough energy for local homes and also for street lighting and industries (this amount is equivalent to that used in about 12,000 homes). The wind farm is connected to the local underground electricity grid though a 38 kV cable. The produced electricity is sold to ESB (a power utility).

It has been estimated that the installation helps to avoid the emission of about 40,000 tonnes of CO_2, 500 kg of SO_2, 167 kg of NO_x and 2,750 kg of ash and slag annually.

Moreover, the wind farm has generated local employment in the phases of design, engineering, financing, construction, operation and maintenance.

Apart from that, it should be highlighted that no negative effects in public health in towns located close to this wind farm have been detected (unlike what might have been expected if a fossil-power station had been built instead).

Potential for replication

The general positive effects of the installation will lead to an enlargement of this wind farm which is expected to take place (Tursillagh 2) with the implementation of 8 new turbines.

For more information

Further information about this project can be obtained from:

Renewable Energy Information Office,
Shinagh House
Bandon, Co. Cork, Ireland
+353 23 29145
wind@reio.ie
www.irish-energy.ie/reio.htm

Sector: Wind Energy
Country: Italy
Location: Carlentini (Province of Syracuse)
Year: 2000

ENERGIE

CARLENTINI WIND FARM

ERGA – Enel Group has built a wind power farm at Carlentini (Sr). The Carlentini project aims to increase ERGA's electrical energy production capacity by use of renewable sources.

Description

The Carlentini wind farm, the first of three wind farms planned for the Province of Syracuse, has been erected on land belonging to the Carlertini municipality and comprises 11 wind turbines located at the top of Santa Venera Mountain. Each of the turbines has an installed capacity of 660 kW. The plant has a total generating capacity of 7 MW, which is fed into the national grid, managed by Enel.

The wind turbines are three-blade Vestas V47s with a rotor diameter of 47 m and a tower height of over 50 m (approx.). The turbines run at a wind speed of 4m/s or more.

Promoters and parties involved

The Carlini wind farm is owned and operated by Erga (part of Gruppo Enel).

Erga is the biggest operator of renewable energy plants in the world; it manages 2,500 MW of hydroelectric, geothermal, photovoltaic, biomass, biogas and wind plants and plans to invest around €1,600 billion over the next three years.

Erga has also begun to expand overseas, by buying CHI Energy, the biggest independent producer of energy from renewable sources in the U.S.A., and Energia Global International.

Financial resources

Total investment: €6,200,000.

Results

The 11 turbines of this wind farm are sufficient to meet needs of 8,000 families. Over the next few years, it is planned that the number of wind turbines installed in Carlentini will rise to 30, with a total power output of 25 MW, producing 45 GWh of energy a year (equivalent to the energy consumption of 26,000 families), avoiding CO_2 emissions of 32,500 tonnes/year.

Potential for Replication

As at the end of 2000 the installed wind power generating capacity in Italy had reached 417.95 MW, which was a long way from the potential power generating capacity, which is estimated at 3,000 MW. However, according to various estimates, by the end 2010 the figure should reach between 2,000 and 2,500 MW.

For more information

Owner and operator

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intili.roberto@enel.it
www.enelgreenpower.enel.it/it/index.html

Sector: Wind Energy
Country: Italy
Location: Sclafani Bagni (Palermo)
Yeaar: 2000

ENERGIE

SCLAFANI BAGNI WIND FARM

In 2000, ERGA – Enel Group completed the first phase of construction of a wind farm in the municipality of Sclafani Bagni (in the Province of Palermo, Italy).

The Sclafani Bagni project aims to increase ERGA's electricity generating capacity through the use of renewable sources, in particular wind energy and, moreover, to study innovative technology for small-scale wind turbines suited to the local conditions.

Description

The Sclafani Bagni wind farm has been erected on Sicily, in the Incatena-Cutugno district. It consists of 11 three-blade wind turbines with a rotor diameter of 47 m and a tower height (approx.) of over 50 m; each with an installed capacity of 660 kW. All the wind turbines are Vestas V47s, made by Vestas Wind Systems A/S (the Vestas Group's Italian subsidiary) and produce a total power output of 7.3 MW.

The wind turbines work at a wind speed of 4.5 to 25 m/s and produce approximately 16.4 GWh a year of electricity. The turbines are connected to ENEL's distribution grid. All the electrical connections within the wind farm area are made via underground cables. The plant is therefore able to satisfy loads of 9,500 families.

It is foreseen that, during the second phase, 16 wind turbines will be installed with a total installed power of 12 MW.

Promoters and parties involved

The Sclafani Bagni (Pa) plant is owned and operated by Erga (part of Gruppo Enel). Erga is the biggest operator of renewable energy plants in the world. It manages 2,500 MW of hydroelectric, geothermal, photovoltaic, biomass, biogas and wind plants and plans to invest around €1,600 billion in RES over the next three years.

Financial resources

Total investment €7,200,000.

Results

Finally, the Sclafani Bagni Plant will have a power generating capacity of 20 MW in total, producing 43 GWh/year, thus meeting the electricity needs of 25,000 families while avoiding CO_2 emissions of 31,000 tonnes a year.

Potential for Replication

Considering the particular geographic structure and complex terrain of Italy, the distribution of wind sources and the electrical grid requirements, it is reasonable to foresee that the majority of wind farms will be built in mountainous areas such as Frosolone, Collarmele and in other other areas located in the Apennine hills.

As at the end of 2000 the installed wind power in Italy had reached 417.95 MW. According to various estimates, the figure should reach between 2,000 and 2,500 MW by the end of 2010.

For more information

Owner and operator

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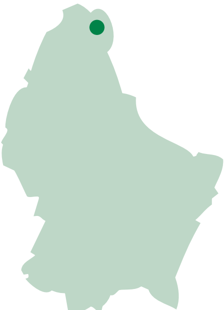
www.enelgreenpower.enel.it/it/index.html

Sector: Wind Energy
Country: Luxembourg
Location: Heinerscheid
Year: 1999

ENERGIE



HEINERSCHEID. HEINERSCHEID WIND FARM

A three-phase wind farm was constructed in the municipal district of Heinerscheid in the north of Luxembourg. The first phase (3 wind turbines) came into operation in November 1998 and was followed by the second phase (5 wind turbines) one year later. The final phase, consisting of 3 more wind turbines, each with an output of 1800 kW, will be commissioned in spring 2003.

In 1993, the Luxembourg Energy Agency retained a consultant to chart a “wind map” showing average wind speeds at a height of 30 m across the whole country. The map showed the Heinerscheid district to be one of the most favourable locations for a wind farm. Additional wind measurements were carried out at the site over a one-year period by the Luxembourg Energy Agency, on the authority of Heinerscheid council. The location also met requirements regarding the minimum distance from residential areas (with respect to regulations on noise protection and shading caused by the wind turbines), protected areas such as nature reserves, and the electricity grid.

Another factor in favour of the construction of a wind farm at Heinerscheid was the fact that the feed-in tariffs for electricity produced from wind power, which were set by the Grand-Ducal regulation of May 30th, 1994, have been set at a level enabling wind farms to be operated profitably.

In March 1998, the Wandpark Gemeng Hengischt S.A. was set up in order to build and operate the wind farm in the municipal district of Heinerscheid. This is a limited liability company with six shareholders, including Heinerscheid council, the Luxembourg Energy Agency and a number of companies with experience in the energy field.

The Heinerscheid project aims at increasing the share of electricity produced from renewable energy sources and thereby reducing CO_2 emissions. The municipality of Heinerscheid has ensured local residents are involved in the project so as to increase acceptance.

Description

The first phase of the Wandpark Gemeng Hengischt project consisted of three NEG Micon wind turbines, type NM 600-150/48. In the second phase, a further 5 NEG Micon wind turbines, type NM 1000-60, were installed. These wind turbines were chosen because of their tried and tested design, a deliberate choice not to implement prototypes having been made.

The distance between the wind turbines is at least 8 times the rotor diameter. The wind turbines are connected to a 65 kV transforming station belonging to the electricity utility Cegedel.

Project characteristics

NM 600-150/48 turbines	3 units
Installed electric capacity [kW]	600
Hub height [m]	70
Tower weight [tonnes]	72
Nacelle weight [tonnes]	24
Rotor weight [tonnes]	17
Number of revolutions / rotor [1/min]	21/14
Number of revolutions / generator [1/min]	1,500/1,000
Nominal wind power speed [m/s]	ca.13.5
NM 1,000-60 turbines	5 units
Installed electric capacity [kW]	1,000
Hub height [m]	70
Nacelle weight [tonnes]	32
Rotor weight [tonnes]	22
Number of revolutions / rotor [1/min]	18/12
Number of revolutions / generator [1/min]	1,500/1,000
Nominal wind power speed [m/s]	ca. 16

Promoters and parties involved

- Wandpark Gemeng Hengischt.: owner and operator of the windpark
- Municipality of Heinerscheid: initiator; shareholder (22.5%)
- Agence de L'Energie (Luxembourg Energy Agency); shareholder (2.5%)
- Cegedel-Participations: electricity supply company; shareholder (20.0%)
- Hëpperdanger Wandenergie: shareholder (25.0%)
- Société Electrique de l'Our: electricity producer; shareholder (20.0%)
- Wand & Wasser: renewable electricity producer; shareholder (10.0%)

Financial resources

The total investment was €9.7 m for the first and the second phase of the project, of which €6.7 m was the cost of the wind turbines.

About €1.1 m of the total investment was financed through subsidies granted by the national government. The remainder of the finance was provided by the shareholders of Wandpark Gemeng Hengischt (about 20%) and bank loans (about 70%).

The technical lifetime of the windmills is expected to be at least 30 years. The payback period for the project is estimated at 10-15 years.

Results

No substantial problems occurred during the planning of the project. During the planning phase of the Heinerscheid wind farm's implementation a variety of consultancy firms conducted impact studies and studies on the noise produced by the turbines. The municipality of Heinerscheid and the other authorities in charge of granting permits to projects of this kind were involved in the authorisation procedure.

Once the wind farm was in operation, a number of problems arose with the gearboxes of the wind turbines. New gearboxes therefore needed to be fitted. Two propellers were also replaced during the warranty period.

The wind farm produces 11,100 MWh per year (2001), which is sold to electricity utility Cegedel. This results in annual revenues from electricity sales of about €1 m.

The environmental benefits of the project include the substitution of fossil fuels used for electricity production and the reduction of emissions of CO_2 by about 8,190 tonnes a year (2001). Moreover, the project meets the environmental conditions regarding noise limitation and shading and the minimum distance from nature reserves.

Potential for replication

Another wind farm, located between Heiderscheid and Kehmen, is due to be implemented by the summer of 2003. It consists of 7 wind turbines with a power generating capacity of 1800 kW each.

The wind farm in Heinerscheid serves as an example for most other wind parks in Luxembourg. A lot of other municipalities who have been considering the building of wind farms in their areas asked the municipal administration of Heinerscheid for information.

Experience from the Heinerscheid wind farm has shown that municipal authorities can play a useful role as coordinator for the construction of a wind farm in the area for which they are responsible.

For more information

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Mrs. Françoise Wilwert
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2010 Luxembourg
Luxembourg
+352 44 9021
Fax: 00352 45 13 68
wilwert@seo.lu
www.seo.lu

Sector: Wind Energy
Country: The Netherlands
Location: Almere
Year: 2000

ENERGIE

ALMERE, WIND FARM JAAP RODENBURG

The Jaap Rodenburg wind farm was built at Muiderhoek, near the city of Almere. The site was chosen because it is near the IJsselmeer, the biggest fresh-water lake in the Netherlands, where wind conditions are favourable for a wind farm. The location was decided upon following consultations with environmental and bird-protection organisations. The wind farm has a planned lifetime of 15 years, because after this time, the site is needed for the expansion of the city of Almere.

At the time of construction, the wind turbines used were the biggest to be installed in the Netherlands. To give the project an additional value, the turbines have been painted red, orange and yellow. The colours were chosen by schoolchildren aged 10 to 12 from various elementary schools in Almere. The children were allowed to choose from four different colour designs and a design called "Fire" was most children's favourite.

The project aims at producing environmentally friendly green electricity (known as Natuurstroom in Dutch).

Description

The Jaap Rodenburg wind farm consists of 10 Vestas V66 wind turbines with an installed electrical capacity of 1.65 MW each. The turbines have axis heights of 67 m and rotor diameters of 66 m. The power is controlled by adjusting the rotor blades. The wind farm's control system can be extended by means of an output power control module. The system is equipped with a two-revolution asynchronous generator. A Vestas Opti-Slip system has also been installed.

In the turbines, a voltage of 700 V (generator voltage) is converted to 10 kV in the nacelle. Locating the transformer used for voltage conversion actually inside the nacelle was a novelty at the time of the construction of the project.

The wind farm is connected to the electricity grid by means of a 10 kV cable to a newly built 150 kV substation in Almere. The substation was built specifically to serve the wind farm, and was constructed earlier than scheduled.

Promoters and parties involved

- Nuon: utility; owner and operator
- Elementary schools from the city of Almere
- Municipality of Almere
- Mary Fontaine: artist who produced the four different colour designs

Financial resources

The total investment costs for the project came to about €18 m. A number of fiscal policy measures were used in the financing of the project, such as EIA (energy investment deduction regulation), VAMIL (regulation on flexible depreciation of environmental investments) and exemption from REB (Regulating Energy Tax) via a sale and lease-back scheme.

The payback period of the project is approximately 10 years.

Results

Rapid implementation of the project was crucial to both the utility company Nuon and the municipality of Almere. The total development period of the project was 2 years and 3 months, which is very short for a project of this size in the Netherlands. This was largely due to the efficiency, with which the municipality of Almere handled all the administrative procedures. With this, the city wanted to demonstrate the possibility of such a project within its borders.

The project did not encounter any objections from local residents. This was mainly due to the fact that the area surrounding the wind farm (within a radius of 2 km) is only lightly populated. The lack of objections certainly made it possible to speed up implementation of the project. Furthermore, the municipality and Nuon had reached an agreement beforehand with the local environmental group.

The wind farm blends in well with its surroundings, because it was constructed in such a way that it would fit into the division of plots at the selected location. The turbines were built along the ditches that separate the plots from each other.

No substantial problems occurred during the building and operation of the plant.

The plant produces about 35,000 MWh annually. The revenues from green electricity sales from the wind farm are about €2.55 m a year.

The Jaap Rodenburg wind farm enables energy generated from fossil fuels to be substituted. This is estimated to result in an emissions reduction of about 20,000 tonnes of CO_2 a year.

Potential for replication

Because locations for wind energy projects are scarce in the Netherlands, Dutch utility companies are strong proponents of the implementation of high-capacity wind turbines, like those used in this project. The successful replication of similar projects at other sites largely depends on support of the municipality and environmental groups.

For more information

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Sector: Wind Energy
Country: The Netherlands
Location: Niedorp
Year: 1999

ENERGIE

NIEDORP, GROETPOLDER WIND FARM

Falling prices for agricultural produce led a group of seven Dutch farmers to look for an additional source of income besides the sales of potatoes, sugar beet and grain. In 1994, this resulted in a plan to set up a wind farm on a polder located in the municipal district of Niedorp. This was considered an attractive alternative source of income because its revenues could be reinvested in the agricultural area and its development. Moreover, subsidies were available to increase the profitability of the project.

The Niedorp wind farm came into operation five years later, on 18th September 1999. It was built on farmland belonging to seven landowners, who formed a partnership by setting up a limited company, Windpark Groetpolder BV, to run the project. The electricity generated by the wind farm is supplied to the public grid and it has sufficient generating capacity to provide about 10,000 households with electricity from this renewable energy source.

Apart from generating electricity from an environmentally friendly energy source, the wind farm project aims to contribute to agricultural development by providing extra income for local farmers, thereby enabling them to keep their land in agricultural production.

Description

The Groetpolder wind farm consists of 19 NEG-Micon wind turbines with a total generating capacity of 11.4 MW. The wind farm is located on a polder of about 850 ha of agricultural land with highly fertile clay soil. This area was reclaimed in 1844 and is located near the villages of Lutjewinkel and Winkel, in the municipal district of Niedorp.

The turbines have been erected in a row on farmland belonging to the seven farmers involved in the project. To minimise interference between them, they have been spaced 187 m apart. Five kilometres of roads were built for the maintenance and operation of the turbines.

The turbines reach their maximum power output at a wind speed of 15 m/s. They generate electricity at a nominal voltage of 690 V, which is stepped up to 10,000 V by a transformer. The electricity is transported by two 10 kV cables over a total length of 15 km from the transformer to a 50 kV station near Hoogwoud, where the electricity is supplied to the public grid.

Project characteristics

Installed electric power capacity [kW]	600
Rotor weight [tonne]	14.6
Nacelle weight [tonne]	20.8
Tower weight [tonne]	42.0
Rotor diameter [m]	43
Hub height [m]	46
Nominal voltage [V]	690
Rated current [A]	509
Nominal frequency [Hz]	50
Rotor revolutions [1/min]	27/18

Windpark Groetpolder BV organised several information and participation meetings for the local inhabitants so as to involve them in the project and keep them informed. These meetings aimed, for example, at clarifying any possible nuisance caused by either noise from the turbines or the masts casting a shadow. In addition, extensive documentation was compiled for local residents. Each year the people living nearest to the wind farm receive a present at the end of the year and a sum of money.

Promoters and parties involved

- Windmolens Groetpolder BV: owner and operator of the wind farm
- NEG-Micon: wind turbines
- Municipality of Niedorp
- Lichtveld, Buis & Partners: engineering consultancy; noise calculations
- ECN (Energy Research Centre of the Netherlands): noise calculations
- Wind Service Holland: shadow-hindrance calculations
- KEMA: electricity yield calculations
- Fichner Oranjewoud: consultancy; integration into the landscape of the wind farm
- Spaansen: opening up of the area
- Jimmink: opening up of the area
- Schouten: electrical connection
- Dekker: concrete works

Financial resources

The total investment came to €11.3 m. Approximately €227,000 was needed to complete the construction work. An sum of approximately €113,000 was spent on consultancy activities. The seven farmers in the Windmolens Groetpolder BV partnership financed the total investment for the project. They also receive the revenues from electricity sales.

A 100% financial lease scheme was used to finance the project. The benefits of the EIA (energy investment deduction regulation) and the VAMIL (regulation on flexible depreciation of environmental investments) went to the bank. They are deducted from the terms of payment to be paid by Windpark Groetpolder BV.

The payback period for the project is approximately 9 years. The lifetime of the turbines is estimated to be 15 years.

Results

During the development process of the project, the promoters experienced a number of problems, for example, obtaining the necessary permits for the wind farm. This was partly due to the fact that at the time the urban plans for the area had not yet been officially authorised. Although the Niedorp municipal authorities had been very co-operative from the start, they did not have the right expertise to deal with the very complicated procedures involved in implementing a wind farm. It is a small municipality and it was the first time it had been confronted with such an initiative.

The wind turbines have been operating without problems. However, the wind farm had to be shut down for some time due to problems with melting connection muffs in the electrical wiring. These problems are currently under control but they have not been solved yet.

The Groetpolder wind farm is able to produce about 25,000 MWh per year, which is supplied to the public grid. With this environmentally friendly electricity production, the project contributes to reducing fossil-fuel use and therefore to reducing emissions. Furthermore, the project contributes to the development and maintenance of the rural area, thus keeping it available for recreational activities and enabling future generations to carry on the agricultural activities of the area.

Potential for replication

Windmolens Groetpolder is planning to extend the existing wind farm with the installation of 11 new windmills. These turbines will have a power capacity of 2.5 up to 3 MW each. The current wind turbines will be exported abroad. Whether the extension project will actually be realised strongly depends on the developments of Dutch energy policy, with regard to long-term security of financial support measures for renewable energy sources.

For the replication of a similar wind project like the wind farm in Groetpolder at other sites, the involvement of local inhabitants is crucial. It is important to let them participate in the project and to provide them with information and a person they can contact near the wind farm. Avoiding shadows and noise are important issues that should be taken into account. If there are any complaints from the inhabitants about this, they should be complied with.

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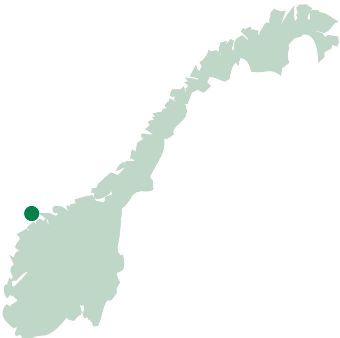
Photo by Novem/Hans Pattist

Sector: Wind Energy
Country: Norway
Location: Harøya, Sandøy municipality, Møre og Romsdal county
Year: December 1999

ENERGIE



INSTALLATION OF WIND FARM ON AN ISLAND TO REDUCE GRID LOSSES

The idea of installing wind turbines on the island of Harøya in Sandøy municipality was first proposed while steps were being taken to renew the operating licence for the local electricity grid. The application for renewal of the licence needed to include proposals for providing the future energy consumption in Sandøy, a description of possible energy conservation efforts and, a description of the voltage quality in the grid and future demands.

The future electricity demand and the electricity grid requirements on Sandøy had been investigated in the early 80's. The project concluded that the energy need per household would increase by about 1-2 % a year. According to these calculations the power required in 1998 would be approximately 4,000 kW and this would result in problems arising on some of the islands in the north of the region.

Sandøy Energi A/S therefore investigated what options the company had to meet these requirements for renewal of the licence for the local grid. The increase in capacity could be bought in the market, but the company anticipated problems given the low grid capacity. Improving the local grid and constructing a new cable from the island to the main land could comply with energy conservation demands. To meet power quality requirements, additional compensating mechanisms would have to be put in place.

To fulfil these requirement Sandøy Energi AS realised that local energy production would be the best alternative. However, the problem for Sandøy Energi A/S was the lack of available energy sources, given that neither hydropower nor natural gas was available. The use of a diesel plant was found not to be suitable. The idea of installing wind power came somewhat by chance, from Kraftmonasje A/S, a company that was interested in selling electricity from wind turbines at Harøya to Sandøy Energi A/S.

Construction of wind turbines would solve a number of specific problems:

- Larger capacity would meet future electricity demand
- Energy conservation would be achieved by reducing the grid loss from 1,700 MWh to 600 MWh annually by installing 5 turbines of each 750 kW
- Power quality would be sufficient provided wind was available at peaks in power demand

Sandøy Energi A/S decided to set up a subsidiary responsible for constructing the wind turbines. The company was called Sandøy Vindkraft A/S and was created on 20th November 1997.

Description

The turbines installed at Harøya were manufactured by NEG-Micon. Each turbine has a generating capacity of 750 kW, giving a total installed capacity of 3,750 kW.

The technical data for the turbines is given in the table below:

Operational parameters

Nominal output	750 kW
Power regulation	Stall
Nominal wind speed	16 m/s
Cut-in	4 m/s
Cut-out	25 m/s
Rotor	
Rotor diameter	48.2 m
Rotor speed	22/15 rpm
Drive train	
Ratio	1:67.5
Generator	
Nominal voltage	690 V
Name plate rating	750/200 kW
Tower	
Hub height	50 m

For further details on the technical specification of the turbine refer to NEG-Micon' s Internet pages: www.neg-micon.dk.

Promoters and parties involved

Owner:	Sandøy Vindkraft A/S
Main contractor:	Kraftmontasje AS
Turbine supplier:	NEG-Micon A/S
Towers:	Langeland og Skei AS and Meier Industri A/S
Turbine hubs:	Kristiansands Jernstøperi AS
Transformer:	Siemens AS

Financial resources

Total investment:

- NOK 29 m (Approx. €3.9 m)

Subsidy:

- 25 % of the construction cost from The Norwegian Water Resources and Energy Directorate (NVE).
- 5.65 øre/kWh (0.75 €c/kWh) subsidy for the produced electricity delivered to the grid.
- Construction of wind turbines is exempt from tax on investment (7 %).

Source of revenue:

- The wind farm is delivering electricity to the grid.
- During 2001 Sandøy Vindkraft A/S reduced the bill to grid owner by NOK 65,250 (€8,700), which corresponds to approx. 0.6 øre (0.08 €c) per kWh generated.

Results

A few operational problems were experienced after installation:

- One turbine stopped due to an overload.
- One turbine had cut-out at 20 m/s as a result of vibration.
- One turbine was stopped due to trouble with the transformer.

All these problems were solved after few months of operation.

There was a generator breakdown during the summer 2001. A new generator was delivered under the warranty.

There were a lot of thunderstorm in the period after the turbines were installed. Even if though the turbines have been struck by lighting, which causes slag to form on the blades, there have not been any problems with them as a result.

Energy production:

The wind park produces approximately 11.1 GWh annually (forecast). However, due to there being less wind than expected output has been below 9 GWh. With normal wind conditions in the autumn of 2002 the output in 2002 will be about 10 GWh.

Financial result:

With the subsidies described above, Sandøy Energi A/S needs 14 øre/kWh (1.87€c/kWh) during the warranty period to cover capital and operating costs. Due to lower production than expected and the expiration of the warranty period Sandøy Energi needs currently about 18 øre/kWh (2.4 €c/kWh).

Environmental benefits

The grid losses have been reduced by about 65 % from 1.7 GWh to about 0.6 GWh annually, which makes this project a very good energy conservation project.

About 99 % of the electricity produced in Norway is generated by hydropower, and thus there are no emissions of carbon dioxide. Nevertheless, during the last few years electricity has been imported from neighbouring countries. If the 10 GWh electricity generated annually were produced from a conventional coal-fired power station then about 3,200 tonnes of coal would have been used. The emissions of carbon dioxide would have been about 7,800 tonnes annually[1].

Potential for replication

Building wind farms on remote islands to reduce the grid losses could be practical in quite a few locations along the Norwegian coast and possibly in other locations around Europe as well.

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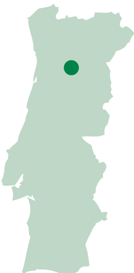
1 Assumptions: Efficiency of coal fired plant 0.4, energy content of coal 28.1 MJ/kg and emission factor (CO_2) for coal 310 kg /MWh.

Sector: Wind Energy
Country: Portugal
Location: Lamego
Year: April 1998

ENERGIE



VILA LOBOS WIND FARM

Consistent with the aim of the company ENERSIS (Portugal) to produce renewable energy (small hydro and wind), this wind farm project was first one to be built on a site at Serra das Meadas, in the far north of Portugal, at an altitude of about 1,100 m above sea level.

Description

The wind farm has 20 wind generators, each with an output of 500 kW, making up a total capacity of 10,000 kW (Enercom).

The average annual production is 27 GWh.

Promoters and parties involved

The owner is PESM, Lda. – Parque Eólico da Serra das Meadas, which is owned by Enersis SGPS, SA a private company that owns small hydro power plants and wind farms.

Financial resources

Total Investment	€11.68 m
Subsidies: POE (1)	€5.52 m
Sources of Revenue: Sales of renewable energym	
Borrowing	€2.14 m
Payback	9 years

Results

- Short summary on the development of the project.

The project was implemented in a relatively sparsely populated area and was not subject to any major environmental constraints. The cooperation with the local authorities and nearby inhabitants was very good.

- Energy 27 GWh
- Financial ~75 € /MWh
- Socio-economic benefits : 2 jobs were created in the area, and an annual rent is paid to the municipality and the local landowners.

Potential for replication

This project has already been replicated at other locations with wind farms of different sizes, one of which is in the same municipality.

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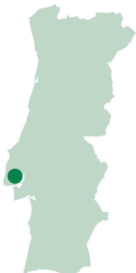
Sector: Wind Energy
Country: Portugal
Location: Mafra
Year: August 1999

ENERGIE



MAFRA WIND FARM

Consistent with the aim of the company ENERSIS (Portugal) to produce renewable energy (small hydro and wind), this wind farm was the second the company built on a site about 30 km NW of Lisbon at an altitude of around 300 m above sea level.

Description

2 wind generators (Vestas), each with a generating power of 1,650 kW, thus providing a total of 3,300 kW

The yearly average production is 8.7 GWh.

Promoters and parties involved

The owner is ENERFLORA, Lda., which is owned by Enersis SGPS, SA (a private company that owns small hydro power plants and wind farms) and by the Municipality of Mafra.

Financial resources

Total Investment	€3.34 m
Subsidies: POE (1)	€1.64 m
Sources of Revenue: Sales of renewable energy	
Borrowing	€1.11 m
Payback	11 years

Results

- The project was implemented in a relatively sparsely populated area and there were no major environmental constraints. The cooperation with the local authorities and nearby inhabitants was very good.
- Energy 8.77 GWh
- Financial ~75 € /MWh
- Socio-economic benefits: 1 job was created in the area, and an annual rent is paid to the municipality and the local landowners.

Potential for replication

This project has already been replicated at other locatoins, with wind farms of different sizes, one of them in the same municipality.

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Sector: Wind Energy
Country: Portugal
Location: Montalegre
Year: April 2000

ENERGIE

CABEÇO ALTO WIND FARM OF CABEÇO ALTO

Consistent with the aim of the company ENERSIS (Portugal) to produce renewable energy (small hydro and wind), this Pursuing the aim of the company group (ENERSIS, Portugal) of producing renewable energy (small hydro and wind) this wind farm project was the second one to be built build using an area at the very-on a site at Serra de Larouco in the far north of Portugal, Serra de Laroucoat an altitude of at about 1,300 m above sea level.

Description

9 aero wind generators of with a unit power of 1,300 kW were installed, each withgiving a total of 11,700 kW (Nordex).

The yearly average production is 27 GWh.

Promoters and parties involved

The owner is PESL, Lda. – Parque Eólico da Serra de Larouco, which is owned by Enersis SGPS, SA a private enterprise company that owns small hydro power plants and wind farms, and by EHATB, SA a local company owned by the municipalitieslocal authorities, which is are also involved, in renewable energies.

Financial resources

Total Investment	€14.20 m
Subsidies: POE (1)	€6.10 m
Sources of Revenue: Sales of renewable energy	
Borrowing	€4.40 m
Payback	8.5 years

Results

The project was implemented in a quite low-density populationrelatively sparsely populated area and without was not subject to any major environmental constraints. The cooperation with the local authorities and nearby inhabitants was very good.

- Energy 27 GWh
- Financial ~75 € /MWh
- Socio-economic benefits: 3 jobs were created in the area, and an annual rent is paid to the municipality and the local landowners.

Potential for replication

This project was has already been replicated in other placesat other locations, with different sizes of wind farm, one of them which is in the same municipality.

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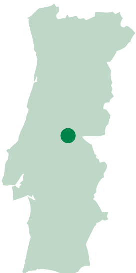
Sector: Wind Energy

Country: Portugal

Location: Serra Cabeço da Rainha, (municipalities of Oleiros e Sertã).

Year: March 2000

ENERGIE



CABEÇO RAINHA WIND FARM

ENERNOVA Novas Energias, S.A. was created in 1994 and is part of the EDP group.

Following on from a series of studies, ENERNOVA erected its first wind farm in Fonte da Mesa (Serra das Meadas) consisting of 17 Vestas wind generators each with a generating capacity of 600 kW. The plant came into operation in August 1996.

This was followed by a further wind park in Pena Suar (Serra do Marão), consisting of 20 wind generators of 500 kW each, which came into operation in January 1998.

Two years later, in March 2000, the Cabeço Rainha wind farm was commissioned. This installation comprises 17 Enercon wind generators with a unit rated power of 600 kW. Later, in June 2001, a further wind farm consisting of 17 Enercon machines with 600 kW came into operation in Cadafaz/Góis.

Another wind farm, located in Serra do Barroso and consisting of 6 wind generators Vestas (with a unit rated power of 2,000 kW) is currently underway and is expected to come into operation by the end of March 2003. At the same time, 3 Enercon turbines with a unit power of 2,000 kW each are being installed at the Cabeço Rainha wind farm.

Description

The Cabeço Rainha wind park currently comprises:

- 17 synchronous, variable speed wind turbines with a rated power 600 kW each, giving a total installed capacity of 10.2 MW.
- 17 transformers with powers of 15/0.4 kV, 630 KVA.
- 1 substation equipped with 60/15 kV transformer and having a nominal power of 17.5 MVA.
- 1 building for control and management.
- 2 meteorological towers.

The wind generators are connected by underground cables to the substation located in the building housing the control room and auxiliary equipment.

Guided tours are regularly organised for members of the public and organisations, schools, etc. interested in renewable sources of energy.

Promoters and parties involved

ENERNOVA is the promoter and owner of the wind farm.

Financial resources

The investment, which provided by ENERNOVA, came to approximately €11,500,000.

By the time of project implementation the Programa Energia (Portuguese incentive programme for the energy sector), which is supported by the European Community, had been created. The value of the subsidy (48%) is reimbursed over 12 years.

Loans and a capital increase (52%) had been asked for from the shareholders.

The expected payback period at an interest rate of 8% is about 12 years.

Results

The main difficulties affecting project implementation and which contributed to the delay in the installation's coming into operation were:

- The existence of several antennas that limited the space available for the substation and wind generators, thus limiting possible locations.
- Some of the wind generators had to be fitted with beacons to warn air traffic.
- It took about 1 year to obtain approval from the Ministry of Environment on the site selected for the wind farm.
- Due the presence in the area of birds belonging to protected species, monitoring studies were carried out before and after the installation of the wind farm.
- The point of connection to the public grid is a long way from the wind farm, which necessitated the construction of an electricity power line with a length of about 14 Km.

The expected annual energy output is 30.1 GWh, which is equivalent to that produced by burning 7,000 tonnes of fuel oil a year.

The average value of the energy sold each year is €2,200,000.

Socio-economic benefits

- rational use of an indigenous resource
- positive impact on the commercial and industrial sectors.
- benefit to local residents from payment (by ENERNOVA) or rent on the land and tax paid to the local authorities.
- educational development.
- rehabilitation of access roads.

Furthermore, it is worth mentioning that the project has created 4 local jobs.

Environmental benefits

Under the legal framework in force at the time the project was implemented, no environmental impact study needed to be carried out. Nevertheless, several studies had been made such as the "Study of Environmental Adequacy (1997)", "Study of Archaeological Prospective" and "Study of Local Fauna Monitoring (since 1999)", that aimed at minimising any environmental impact.

The pollutant emissions avoided by the wind farm are summarized in the table below:

CO_2	NO_x	SO_2
19,543	56	185

The entire affected by the project implementation was rehabilitated through the adequate landscaping and other appropriate measures.

Potential for replication

The replicability of this type of project depends on the results of the evaluation studies on the wind potential of the specific sites.

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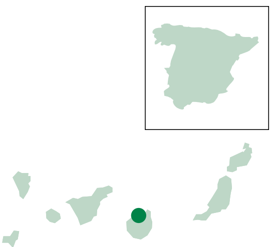
Sector: Wind Energy
Country: Spain
Location: Gáldar-Gran Canaria (Canary Islands)
Year: March 2001

ENERGIE



MONTAÑA PELADA WIND FARM

The company Agragua, S.A., which is registered in the town of Gáldar, on the island of Grand Canary, was set up on 10^{th} February 1990 with the purpose of constructing and operating a sea water desalination plant to produce water for both agricultural use and for the general public supply. Initially Gáldar Council (Ayuntamiento de Gáldar) held a 60% stake in the company. In July 1997 the company took on its current shareholder structure, whereby it has over 500 shareholders from the agricultural sector.

Following the construction of a desalination plant with a capacity of 10,000 m^3/day in 1991 and its subsequent expansion in 1998 to its current capacity of 15,000 m^3/day, AGRAGUA S.A contacted the IDAE with a view to setting up an installation to reduce its energy bills and at the same time bring significant social benefits to the local area. Of the possible solutions put forward, that selected as being most favourable from the technical and economic point of view was the construction of a wind farm.

The Montaña Pelada wind farm is a wind power facility producing energy primarily for the operator's own use, as on average it does not feed more than 50% of the power generated into the grid and its main activity is not electricity generation. The desalination plant has an estimated annual electricity consumption of 25,000 MWh and it is envisaged that a large part of its energy requirements will be supplied by the new wind farm.

Description

The wind farm has an installed capacity of 4.62 MW and comprises 7 wind generators with a unit rated power output of 660 kW. It is located on a hill of the same name as the wind farm, south east of Gáldar. The wind generators are at a height of between 95 and 165 m above sea level and face the prevailing wind direction. This area is marked by steep slopes and was not used for any particular purpose. It has a number of access tracks which have been used by the wind farm.

The average annual wind speed is estimated to be 8 m/s at the hub height, and the main orientation is north-northeast. The seven wind generators stand perpendicular to the dominant wind direction (trade winds) with a NWW-ESE orientation. They are arranged in two groups of 3 to 4 wind generators.

The net equivalent number of hours over the long term is estimated at 2,835 (capacity factor: 32 %).

The wind generator are AE-46/I models, with a 46 m rotor diameter and 45 m hub height. The turbines control input power by aerodynamic loss. The generators used are of the asynchronous, double-winding type with reactive compensation and have proven themselves to be robust and reliable. The rotor turns at two speeds, a fact which, as well as increasing the power output, also reduces the noise emissions significantly. This model of wind turbine has been certified as class I.

The wind generators produce alternating-current electricity at a voltage of 690 V. This is stepped up to the wind farm's internal grid voltage (20kV) by dry-type 700 kVA transformers located inside the towers. The power is conducted along a 3.5 km underground three-phase line (so as to avoid the visual impact of overhead electricity cables) to the substation at the desalination plant. Here it is used to power the reverse osmosis equipment and the excess is fed into the grid operated by UNELCO (ENDESA Group), which buys the electricity for distribution on the island of Grand Canary.

Promoters and parties involved

The promoter is AGRAGUA, S.A. The IDAE was responsible for procurement of the installation as a whole (call for tender, analysis of offers, contracting and supervision of the assembly, installation, commissioning and testing) and project management. MADE was selected as the supplier for the wind farm, which was delivered on a turnkey basis.

Financial resources

This wind farm received finance under the SMEs programme run by the IDAE with funds from the Institute itself and from the European Regional Development Fund (ERDF). Small and medium-sized companies interested in implementing rational energy use and renewable energy projects, and which were located in regions of Spain considered to be "Objective 1" in 1998, were eligible for the programme.

The installation required an investment of €3,691 m, which was entirely financed through the IDAE-ERDF programme for SMEs at an interest rate equal to the MIBOR (Madrid Inter-Bank Offered Rate) minus three points, with a lower limit of the forecast CPI (reviewed annually) for the duration of the period financed (set at 8 years).

The project received a subsidy of €0.601m from the Energy Saving and Efficiency Plan (Plan de Ahorro y Eficiencia Energética, PAEE), 30% co-financed by the Directorate-General for Industry and Energy (€0.180m) and 70% co-financed by the ERDF (€0.421 m).

Results

a) In energy terms

It is envisaged that the plant will produce 13,100 MWh/year, equivalent to 2,835 hours a year of operation at its rated output. This is equivalent to the domestic consumption of approximately 4,000 Spanish households, and is equal to approximately 1,125 toe/year in terms of primary energy.

During the first six months of effective operation of the wind farm (April to September 2001) the electricity generated was 7,768 MWh.

b) In environmental terms

The wind farm avoids the atmospheric emission of approximately 12,300 tonnes a year of CO_2 (the main greenhouse gas).

c) In social terms

In addition to the energy it provides and its overall environmental friendliness, the wind farm has also created direct and indirect employment totalling 60 man/years during the design and construction period. This has had considerable impact on the local area, and in particular, civil engineering, electrical infrastructure and erection of the installation have all be contracted locally on the Canary Islands.

Potential for replication

The replicability of this wind power installation producing electricity for use by a desalination plant is of particular significance in the Canary Islands given the scale of demand for electricity and fresh water. The Canary Islands had 115 MW of installed wind power at the end of 2000, which represents 5% of the national total (2,270 MW). The Spanish renewable energy promotion plan (Plan de Fomento de las Energías Renovables en España), approved in late 1999, sets as its target for wind power the installation of a total of 250 MW electricity generation on the Canary Islands by 2010.

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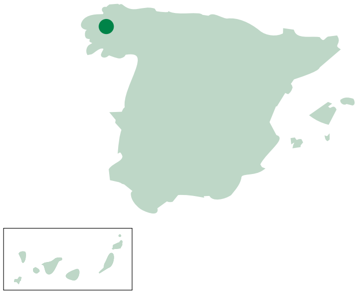
Sector: Wind Energy
Country: Spain
Location: La Coruña (Galicia)
Year: November 2000

ENERGIE



SOTAVENTO WIND FARM

The Sotavento wind farm is a novel project in Spain as it has been built using the latest-generation of wind turbines based on a variety of technologies currently being implemented in Galicia in line with the sector's strategic plans drawn up in 1995.

The Sotavento wind farm serves two purposes. Firstly, it is a "shop window" demonstrating to a wider public the technologies employed in the wind energy sector, and secondly, it acts as a comparative framework for the various types of turbine available. It is therefore the ideal setting for investigating possible innovations that may be applied to future wind-turbine development projects.

Description

Construction began in March 2000, and the wind farm came into operation in November of that same year.

The facility includes 24 wind turbines, with a total power of 17.56 MW. The most advanced technologies available in the national wind-turbine market have been used, including two prototypes developed entirely in Spain by MADE Tecnologías Renovables, S.A.

The site on which the wind farm has been located covers a length of approximately 4 km and is both privately and publicly owned. It is about 10 km south of As Pontes de García Rodríguez, which is home to one of the largest coal-fired power stations (which runs on Spanish brown lignite and imported hard coal) in Spain (1,400 MW).

The turbines produce a/c electricity at voltages of between 690 and 1000V, depending on the turbine model. This is stepped up to 20 kV via dry transformer stations located inside the masts.

The wind farm also includes a transformer substation (20 MVA) stepping the voltage up again to 132 kV, which is the voltage at which the power leaves the site along a 9 km-long single-circuit aerial high-tension line connected to the line owned by Unión Eléctrica FENOSA, near the Mourela sectioning station.

The wind farm was supplied as a turnkey installation by ELECNOR, S.A.

The visitors centre at the wind farm has the form of a three-bladed cross and was designed by a prestigious Galician architectural firm. It has been designed in a way that is both innovative and human-centred, following the traditional guidelines of bioclimatic architecture.

Promoters and parties involved

The company operating the wind farm, SOTAVENTO GALICIA, S.A. (SOTAVENTO), was founded in Santiago de Compostela on 28 July 1997. Its corporate purpose is to promote and operate energy generating facilities using renewable energy sources, in particular wind energy.

SOTAVENTO is 51% owned by public bodies (Sodiga Galicia, INEGA and the IDAE). The rest of the capital was provided by the following companies: Unión Fenosa Energías Especiales, Endesa Cogeneración y Renovables, Iberdrola Diversificación and Engasa.

Financial resources

The installation required an investment of approximately €16.2m and received financial support in the form of subsidies of €3.5m (Energy Saving and Efficiency Plan: €1.6m; Xunta de Galicia: €1.3m; Interest subsidy from the European Investment Bank: €0.6m). The company has own funds of €3m (share capital: €0.6m; loans from shareholders: €2.4m). Long-term finance has been provided by the Instituto de Crédito Oficial and Caixanova, through a syndicated loan of €12m.

It is estimated that, at current electricity prices, the installation will have an annual turnover of around €2.4m (fixed price: 6.26c€/kWh wind power in 2001). Assuming the average operating costs (O & M, technical management, administration, insurance, lease of land, national and local taxes, etc.) over the lifetime of the project to be 20% of turnover, the payback period for the investment will be 9 years.

Results

At the end of 2000 the Autonomous Region of Galicia had 617 MW in wind-power electricity generating capacity, accounting for 27% of the national total (2,270 MW).

During the first five months of effective operation (December 2000 - April 2001) the electricity produced totalled 19,935 MWh. Benefiting from a windy winter, this exceeded initial forecasts for this period by 15%, even though the wind farm was still at the testing stage, with a higher than usual number of incidents, and that it includes various prototypes, thus demonstrating the speed with which it has been possible to obtain high technical availability from the facility.

Results in energy terms:

It is envisaged that the wind farm will produce 38,500 MWh/year, equivalent to 2,200 hours operation at nominal power output. This corresponds to the average annual domestic electricity consumption of around 12,000 Spanish households and is approximately equal to 3,300 toe/year in terms of primary energy.

Results in environmental terms:

A noteworthy environmental benefit of this wind farm is the avoidance of atmospheric emissions of approximately 36,000 tonnes of the main greenhouse gas, CO_2, a year.

Results in economic terms:

In addition to the energy the wind firm provides and the environmental benefits of the installation, it has brought about the creation of direct and indirect employment. This totalled 225 man/years during the design and construction phase. The operation and maintenance of the wind farm will provide stable employment for 4 people over its operating lifetime, which is estimated at 20 years, as well as a number of additional jobs created by the unique characteristics of the plant.

Potential for replication

At present the medium-term technically utilizable wind power potential in the Galicia region is considered to be around 3,500 MW. The Promotion Plan for Renewable Energy in Spain (Plan de Fomento de las Energías Renovables en España) approved at the end of 1999, sets as the target for Galicia for 2010 the installation of a total of 2,500 MW of electricity generation from wind power.

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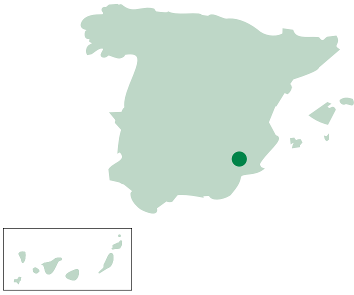
Sector: Wind Energy
Country: Spain
Location: La Unión (Murcia)
Year: November 2000

ENERGIE



LA UNIÓN WIND FARM

This low-power wind farm (5.28 MW) is the second wind farm to be built in the region in which it is located. There were three main reasons for its construction: the reuse of a brown field industrial site (the wind farm has been built partly reusing semi-abandoned facilities of a mine); generation of electricity to power a sea water desalination plant; and obtaining economic benefits in terms of both return on investment and the positive impact of the project on an otherwise depressed area.

The wind farm is fully integrated in its environment and existing infrastructure has been reused, including tracks, 20 kV power line, and a 20/66 kV transformer substation.

Description

The wind farm comprises 8 wind generators with a unit power of 660 kW. It has improved the utilisation of the wind potential compared with the other wind farm in the region by using higher towers and larger rotors.

Energy details:

Electrical power: 5.28 MW.

Electrical output: 10,000 MWh

Technology:

Equipment: Wind generators

Manufacturer: MADE

Model: AE46

The high educational value of the site is worth highlighting as it is being used by a number of teaching centres.

Promoters and parties involved

Owner: Parque Eólico de la Unión, S.A. Sierra Minera. La Unión. Murcia.

Financial resources

The project received financial support from national government and the European Community through the Energy Saving and Efficiency Plan (Plan de Ahorro y Eficiencia Energética).

Investment: €4,262,920

PAEE/ERDF subsidy: €601,812

Results

The results have exceeded the initial forecasts and an electrical output of 10,035 MWh was obtained in 2001.

Potential for replication

The potential for replication depends on the possibility for use of the power generation by a desalination plant producing water for agricultural use at an economically viable price. This price is estimated at 0.24 €/m^3.

For more information

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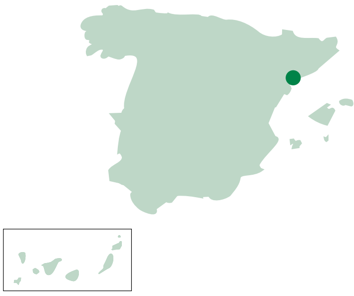
Sector: Wind Energy
Country: Spain
Location: Tarragona (Catalonia)
Year: April 1999

ENERGIE



TRUCAFORT WIND FARM

Activities aimed at utilizing wind energy in Catalonia began in 1984 with the installation of a pilot wind farm in Ampurdán.

Subsequently a variety of wind turbines were set up, mostly supplying power to farms. A small wind farm was built at Cabo Creus and in 1995 the first medium-sized wind farm, with a generating capacity of 4 MW, was built at Tortosa, Tarragona. By the end of 1998 a total of 20 MW of installed capacity existed and a further 39 MW was under construction.

Building work on the wind farm at Trucafort began in March 1998 and the first 15 MW phase came into operation in December of that year. In April 1999 the second phase came into operation, thus completing the 30 MW installation, the largest in Catalonia.

Description

The land occupied by the wind farm covers an extension of 85 ha, which has been leased by the owners. Although it was formerly used for grazing, it is not currently used for agricultural purposes.

The first evaluation station assessing the wind energy resources on the site was set up in February 1993. Subsequently the site was characterised by measuring the wind at fifteen different points, which has allowed a highly reliable estimate of output from the wind farm to be arrived at despite the complexity of the mountain terrain.

The wind farm has a nominal generating capacity of 29.85 MW and comprises 66 wind turbines with a rated unit power of 225 kW and 25 wind turbines with a rated unit power of 600 kW. The turbines were all manufactured by Ecotecnia.

The mountainous terrain, and in particular the width of the strip of land available, made it advisable to combine turbine types so as to obtain maximum efficiency from the site, considering the wind direction with greatest wind power potential to be W-WNW.

The optimal solution adopted was to distribute the turbines in two parallel rows, with the larger turbines (600 kW) on the east side and the smaller ones (225 kW) on the west.

The turbines produce alternating current at a voltage of 400 V (225 kW machines) and 690 V (600 kW machines). The power is collected at a number of transformer centres and fed into the wind farm's internal grid at 20 kV.

The substation on the wind farm site steps up the voltage to 110 kV to feed it on to the FECSA electricity grid.

The site has a monitoring and data capture system which enables optimization of the management and operation of the wind farm. This system makes it possible to ascertain the general status of the wind farm and the specific status of each individual wind turbine, as well as incidents, wind data, outputs, electrical interconnection equipment status, etc.

The data bank, which shows the functioning of the installation and of each of the wind turbines, enables maintenance scheduling, report generation and evaluation of the results.

Technical characteristics of the wind turbines

As mentioned, the wind farm comprises two types of wind generator. Their main features are as follows:

The 600 kW turbines are fitted with two asynchronous generators, each with a rated output of 300 kW at 690 V at 1,500 rpm.

The multiplier is of the TWIN parallel-shaft type, with two symmetrical outputs for each generator.

The multiplier of the 225 kW machine is a three-stage parallel shaft type.

The generator is of the 4-pole induction type with a voltage of 400 V and speed of 1,500 rpm.

Both types of wind turbine have a tapering tubular tower with direct access to the interior of the nacelle.

Promoters and parties involved

The firm Societat Eólica de L'Enderrocada, S.A. (SEESA) was created in Barcelona on 5 December 1996 with the purpose of building and operating a wind farm with an installed capacity of approximately 30 MW, located in the districts of El Priorat and El Baix Camp, in the province of Tarragona.

The company's share capital is €5.73 m, and ownership is distributed as follows:

- Energías Ambientales, S.A. (EASA): 80%.
  This company in turn is owned by A.C.S. (60%), Unión Fenosa Energías Especiales (30%) and Ecotecnia S.C.C.L (10%)
- Eficiencia Energética (EFIENSA, belonging to ICAEN): 10%
- The IDAE: 10%

The installations at the Trucafort wind farm were supplied by the Ecotecnia-Energía y Recursos Ambientales, S.A. joint venture as a turnkey project.

Financial resources

The wind farm required an investment of around €28 m and received backing in the form of a grant of €2.76 m under the Spanish Industry and Energy Ministry's Energy Saving and Efficiency Programme.

External finance from Banco Central Hispano and Caja Madrid was also obtained.

Results

a) In energy terms

It is envisaged that the plant will produce 79,000 MWh/year, which is equivalent to 2,650 hours of operation at its nominal power output. This output is equivalent to the average annual consumption of around 25,000 households.

b) In environmental terms

One of the major benefits from an environmental point of view is that producing electricity from this wind farm avoids the emission of 74,200 tonnes of CO_2 a year.

c) In social terms

In addition to the power provided by the wind farm and its environmental benefits, the wind farm has also created direct and indirect employment totalling 400 man for 7 years, during the design and construction phases. The wind farm will provide stable employment for at least 3 people over its operating lifetime, which is estimated at 20 years.

Potential for replication

Current estimates of Catalonia's technicallly utilisable wind resources stand at around 1,300 MW. The experience acquired from this wind farm, with its relatively complex mountainous terrain, enhances the prospects for the utilisation of other wind resources in similar areas.

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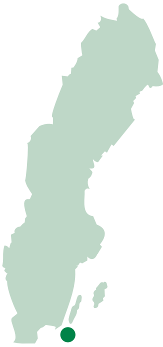
Sector: Wind Energy
Country: Sweden
Location: Baltic Sea, Kalmar Sound, Sweden
Year: December 2000

ENERGIE



UTGRUNDEN 10 MW OFFSHORE WIND FARM

The enormous offshore wind resources in Europe offer huge potential for electricity generation using wind power. Countries such as Denmark, The Netherlands, the United Kingdom, Germany and < have aleady announced plans for wind power development at sea. Building wind farms offshore makes wind farms generating several hundreds of megawatts possible.

GE Wind Energy started to develop Utgrunden Offshore Wind Farm in 1997. The project was built using the tried and tested GE Wind Energy 1.5 s turbine, which has a 1.5 MW rated power and an integrated tower and monopile design. The use of variable-speed technology ensured good compatibility with the relatively weak grid on the Öland island.

One particular reason for building Utgrunden Offshore Wind Farm was to study the environmental effects on the one million seabirds migrating through Kalmar Sound every season. The relatively small size of the project limited the environmental risk for such research.

Dissemination activities

The wind farm has attracted a lot of attention from the media with more than 350 articles about the project.

Results of the project will be disseminated through a Swedish research project covering design verification, grid integration, metrology, operation and maintenance, and a bird study.

Description

Seven GE Wind Energy 1.5 s turbines were installed at water depths between 7.2 and 9.8 m. The monopile foundations are simple steel pipes with a diameter of 3 m and length of 30 to 33 m and which weigh 100 to 110 tonnes. The site is situated 12.5km east of the port of Bergkvara where the service station is located. The annual average wind speed accounts for approximately 8.5 m/s at 65 m hub height.

Promoters and Parties Involved

Owner of the project is Energi E2 Renewables AB, a subsidiary of the large Danish utility Energi E2. The project was implemented by GE Wind Energy on a turn-key basis. Major subcontractors for installation were Hydro Soil Services, BE and ABB, SE.

Financial Resources

Investments for offshore wind power are considerably larger than for onshore installations. It is expected that further developments will make prices decrease.

Results

- *Short summary:* After four years in the permitting process the turbines were installed between 7th September and 18th October 2000. The project was handed over to the client on 21st December 2000. Operation is proceeding without problems.
- *Energy:* The energy production was estimated at 38 GWh/year, although in 2001 the actual production came to only 30.5 GWh/year as a result of exceptionally low wind speeds. Output is equivalent to the consumption of 6,000 Swedish households and reduces carbon dioxide emissions by 30,700 tonnes a year.
- *Socio-economic:* The wind farm has been well received by the local community and politicians would like to see the project extended. In the local community more than 80% of people are in favour of offshore wind power. The service station created five local jobs. The project has become a tourist attraction with an exhibition and a boat tour.
- *Environment:* Bird studies have been running since 1998. Preliminary results show that the seven wind turbines have had no impact on the intense migration of the million seabirds that pass through the area. About 2 km in advance the birds see the turbines and change direction or altitude of their flight route. The birds avoid the turbines and no accidents have been recorded. The turbines are clearly visible during good weather conditions. Radar investigations on bird migration during the night and under foggy conditions are currently ongoing.

Potential for Replication

The results show that it is feasible to build offshore wind parks on glacial moraines in water depths of around 10 m. The integrated tower and foundation design used reduced the investment cost. Projects should be built with more, and larger, turbines in order to bring down the foundation costs further.

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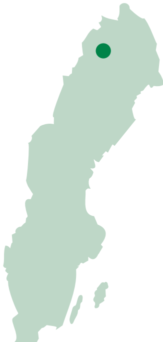
Sector: Wind Energy
Country: Sweden
Location: Suorva
Year: October 1998

ENERGIE



SUORVA - ARCTIC WIND TURBINE

The Vindmannen wind power plant at Suorva, 100 km north of the Arctic Circle, near the source of the river Stora Luleälven and close to the Vietas hydro power station, was built by Vattenfall. The area is surrounded by mountains with peaks 1400-1500 m above sea level and the turbine stands on a small ridge in a valley at 470 m above sea level. The entire infrastructure in the form of power lines and roads was already in place.

The Suorva project aims to increase knowledge and experience of building and operating a wind turbine in arctic conditions. Factors such as the operation and maintenance of the turbine, public acceptance, environmental impact, generating capacity, meteorology, acoustics, ice formation and loads have been studied in a three-year evaluation programme.

Description

The tower is 40 m high and stands on foundations that are anchored to the rock with 40 iron rods secured 6 to 8 m into the rock. The turbine is a three-bladed Bonus Mk IV, specially equipped for arctic conditions. The rotor is an upwind model with a 44 m diameter and 1.520 m^2 of swept area. The rotor speed is 27 rpm or 18 rpm, depending on the wind speed. The output is 600 kW from an asynchronous generator at 690 V. This is transmitted by a 20 m cable to an 800 kVA transformer (690 V to 12 kV).

The extra equipment for operation in a cold climate consists of a blade heating system, heated sensors for the measurement of wind speed and wind direction, an ice detector for the control of the blade heating system, a heated gearbox and low-temperature oils. This means that the plant can be operated at temperatures as low as -20^{0}C. Heating begins following a signal given by the ice detector when it senses that ice is forming. The energy required for the heating system is less than 1% of the energy generated by the plant.

Promoters and parties involved

Vattenfall owns the power plant jointly with a local association "Vindkraft i Suorva". The local association, through Mikael Segerström, Bertil Thelin and Bengt-Göran Gustavsson, took the initiative to set up the project and started the wind measurement.

Uppsala University was responsible for evaluating meteorology and acoustics,

FOI, the Swedish defence research agency, for studying ice formation, loads and generation capacity, Hammarlund Consulting for public acceptance, Vattenfall for operation and maintenance and SwedPower for environmental impact.

Financial resources

- Total investment €645,000 (including three years evaluation)
- Swedish National Energy Administration paid 30% as a grant

Results

- The evaluation reveals that the turbine is one of the most efficient in the world of its size. One of the reasons for the high level of generator output, apart from the good supply of wind, is that the wind in the area is cold. Cold air is dense and therefore contains a lot of energy. The plant is also located in a wide, very deep valley and provides exceptionally good wind conditions.
- The heating system used to counteract ice formation has worked very well. Previous trials with plants in extreme climates using other heating systems have not given such good results.
- In 1999 and 2000, electricity generation came to approximately 1,800 MWh a year, which corresponds to the normal electricity consumption of 360 households.
- The acceptance study of the public's attitude to wind power in the mountains shows a positive attitude in an environment that has already been affected.
- The Vindmannen plant has a permit to operate for 10 years. A plan for the restoration of the area has been made. The access road was constructed by covering the existing ground with loose materials in order to facilitate the removal of the road in the future. The connection cable to the network has been laid above ground in such a way that it blends in with the rocks and low vegetation. The transformer building is grey in order to reduce the visual impact on the landscape.
- Vattenfall has also investigated the plant's impact on biological diversity using the biotope method. The results show that the impact on biological diversity resulting from land encroachment is extremely limited.

Potential for replication

Most of the indications are that wind power can be used successfully in the Swedish mountains, providing that attention is paid to the environment and local conditions.

For more information

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Photo by Jan Norling, Vattenfall Utveckling AB

Sector: Wind Energy
Country: U.K.
Location: Blyth, Northumberland
Year: December 2000.

ENERGIE

BLYTH OFFSHORE WIND FARM

The wind farm is located 1 km offshore of Blyth Harbour (in Northumberland) and very close to the already existing Blyth Harbour Wind farm in waters 8 m deep. This was the first offshore wind farm installed in the U.K. It consists of two 2 MW wind turbines generating enough electricity to meet the needs of about 3,000 average homes.

Construction started in July 2000 and finished 5 months later.

Source: British Wind Energy Association.

Description

The wind farm comprises two Vestas V 66 wind turbines with a total capacity of 4MW generating 10,512 MWh of electricity per year.

The turbines have a rotor diameter of 66 m, hub heights of 60-78 m and are equipped with an OptiSpeed System, (which allows the three-bladed turbines to rotate at variable speeds). The energy generated by the generator is converted into electricity suitable for the grid by means of a special-purpose converter.

The turbines are equipped with microprocessor-controlled pitch regulation that enables continuous adjustment of the angle of the blades according to the prevailing wind.

Promoters and parties involved

Owner, developer and operator

Blyth Offshore Wind Limited (a consortium comprising Powergen Renewables, Shell, Nuon and Amec)

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Financial resources

Total cost of the project came to €6.4 m.

The project was initially awarded a contract under NFFO4 (Non-Fossil Fuels Obligation). However, as a consequence of the use of more powerful turbines (2 MW) a second contract was obtained.

Additionally, it received co-funding from the European Commission within the THERMIE programme.

Results

It has been calculated that the amount of energy produced is equivalent to that required to supply the needs of 3,000 homes.

The installation offers a number of environmental benefits in comparison to other types of energy production systems. For example, when compared with an equivalent power output produced by a conventional coal-fired station, it avoids the annual emission of: 9,040 tonnes of CO_2, 105 tonnes of SO_2 and 32 tonnes of NO_x.

Potential for replication

The programme is currently being monitoring and evaluated within the DTI's (Department of Trade and Industry of the UK) Wind Energy Programme (aimed at enabling offshore wind power development and support for UK industry).

The project is considered the precursor of a number of similar projects currently planned on the coasts of Ireland, the U.K, the Netherlands, Belgium, Denmark and Sweden.

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Sector: Wind Energy
Country: U.K. (Northern Ireland)
Location: Brockagh, Balleybofey, Correy Donegal
Year: December 1997

ENERGIE

CARK WIND FARM

Cark Wind Farm is located in a rough mountainous region near Letterkenney in Correy Donegal (in Northwest Ireland). It stands on a 4.4 ha area of peat 350 m above sea level, ten miles from the nearest public road. This area is leased from local farmers and close to a commercial forestry plantation owned by a state forestry organisation.

Cark was awarded a contract under the AER1 initiative (first Alternative Energy Requirement) and it was the third wind farm to be built in Donegal. Officially commissioned in May 1998, it began generating power in December 1997.

Description

The 15 MW wind farm comprises 25 turbines. Each of the stall-regulated Micon 1,500 600 kW wind turbines, which weigh 77 tonnes, has a 43 m rotor diameter and a 43 m hub height. The three-bladed rotor can rotate at different speeds (18 and 27 revolutions/minute) so as to accommodate varying wind conditions.

The turbines have a transformer in their base to step the voltage up from 690V to 20 kV, and all the transformers are connected by underground cables to a single transformer where the voltage is stepped up to 38 kV and taken by pylons to Letterkenny station.

Promoters and parties involved

Developers and owners:

Renewable Energy Systems Ltd (RES) and B9 Energy Services, (which have formed a joint venture called Cark Ltd).

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Financial resources

The total cost of the project came to €14 m. Finance was provided by two banks: ORIX Ltd and Mees Pierson (from Japan and Holland, respectively).

In addition the project is partially subsidised by the government as it was awarded a contract under AER1.

Results

The amount of produced energy is estimated to be enough to satisfy 14% of the annual energy requirements of Donegal (equivalent to 15,000 homes). This electricity is sold to the Electricity Supply Board (ESB).

The difficult road access and the inclement weather conditions were the main challenges for the erection of the turbines during August and September.

Environmental aspects were taken into account throughout. Specific studies on the potential impact of the project were carried out before permits to build the wind farm were obtained.

Two key elements in the success of the process were information about the construction process (in the form of leaflets, presentations, meetings, etc.) and participation of the stakeholders.

Potential for replication

As in the development of many other wind farms a key element to take into account is the need for an information and awareness-raising campaign to inform all potential stakeholders. The fact that as many issues as possible were considered during the construction and operational phases of the wind farm made a significant contribution to its acceptance at regional and national level.

For more information

Renewable Energy Systems Ltd (RES) and B9 Energy Services, (which together set up a joint venture called Cark Ltd).

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www.b9energy.co.uk

Sector: Wind Energy
Country: U.K.
Location: Norfolk
Year: July 2000

SOMERTON WIND FARM

It consists of a single 1.5 MW wind turbine located in West Somerton in Great Yarmouth in Norfolk. Commissioned in July 2000, the turbine was erected in four days. It produces sufficient power to supply 5% of the domestic electricity requirements of the Great Yarmouth area.

One of its main features is that is that it is a direct drive variable speed turbine.

Source: British Wind Energy Association

Description

This wind tower holds a 1.5 MW turbine Enerco E-66. The nacelle is 65 m above the ground and the rotor diameter is 70 m. The turbine has 3 blades each of which is 33 m long.

One of the most interesting features of the turbine is that it is both variable speed and direct drive. This means that, firstly, the device has no gearbox or drive train components and, secondly, that this type of turbine can rotate according to the prevailing wind. The mechanism enables all the moving parts of the turbine to rotate at the same speed (10-22 rpm according to the wind speed), increasing the reliability of the turbine. The fact that the wind turbine can rotate at variable speed also optimises the extraction of energy from the wind.

Promoters and parties involved

Developer, owner and operator

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Wind turbines

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Financial resources

The project was awarded a NNFO4 (Non-Fossil Fuels Obligation) contract.

The energy payback period was 5 months.

Results

The annual energy production totals 4.5 kWh, which has been estimated to be enough to meet the needs of 5% of the domestic electricity requirements of Great Yarmouth (equivalent to 1364 homes).

It has been calculated that compared with an equivalent fossil-fuel plant, this turbine will prevent annual emissions of 3,870 tonnes of CO_2, 39 tonnes of SO_2, 13 tonnes of NO_x and also several tonnes of ashes and slag.

Additionally, as a consequence of the technology applied (direct drive variable speed wind turbine) the mechanical or tonal noise produced is less than in the case of a turbine with a gearbox.

Potential for replication

The extremely short time taken to install the machine was widely publicised and is certainly one main feature to be taken into account for similar projects. It demonstrates in particular that installing a small-scale wind farm need not entail technical risk or lengthy construction times. This will no doubt further encourage private investors to develop such installations.

For more information

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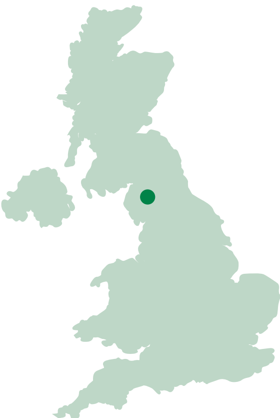
Sector: Wind Energy

Country: U.K.

Location: West Farm, Kirkheaton (Northumberland)

Year: May 2000

ENERGIE



KIRKHEATON WIND FARM

This is a small installation (it can generate a maximum power of 1.8 MW) located near Hexham, in Kirkheaton where there is an average wind speed of 7.7 m/s. It is owned by Kirl Wind Farms, which is a joint venture between Northern Electric Generation Ltd and Hexham Wind Ltd. Its construction started in October 1999 and was completed in late March 2000.

Civil works, including building foundations, connection and the access road were carried out by a local contractor.

Source: British Wind Energy

Description

The wind farm comprises three 600 kW Nordex N43 turbines, with a maximum capacity of 1. 8 MW . Each of the hubs is located 45 m above the ground and blade diameter is 43 m.

The blades are mounted on a hub in front of a nacelle, which houses the gearbox, the generator and the hydraulic actuators controlling the angle of blades.

The blades rotate at 27 rpm, whereas the gearbox output runs at 1,500 rpm.

The towers are equipped with a high voltage transformer that converts the electricity generated to 20,000 V AC and so it can be fed onto the grid. Power and control signals are carried via cable to the tower base and the transformers are connected to switchgear via high voltage cables, linking each of them to the Northern Electric Grid

Promoters and parties involved

Owner.

Kirkheaton Wind Farms (a joint venture between Northern Electric Generation Ltd and Hexham Wind Ltd).

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Designer, operator and developer

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Wind turbines

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www.nordex-online.com/

Financial resources

It was awarded a power purchase contract under NNFO4 (Non-Fossil Fuel Obligation) and, additionally, it received financial support from the European Commission though the THERMIE programme.

Results

It has been estimated that with the electricity generated (4,730 MW) is possible to supply 1,100 average households.

Regarding environmental issues, it has been calculated that when compared with a coal-fired power station the wind farm will avoid the annual emission of 4,068 tonnes of CO_2, 47 tonnes of SO_2, and 14 tonnes of SO_x.

Potential for replication

This is one of numerous small wind farms which have recently sprung up in many parts of the countryside in the UK. Although environmental legislation and local authority permits have been getting stricter in recent years, public acceptance of installations of this type remains generally good and there is potential for replication in the form of similar projects in other suitable areas.

For more information

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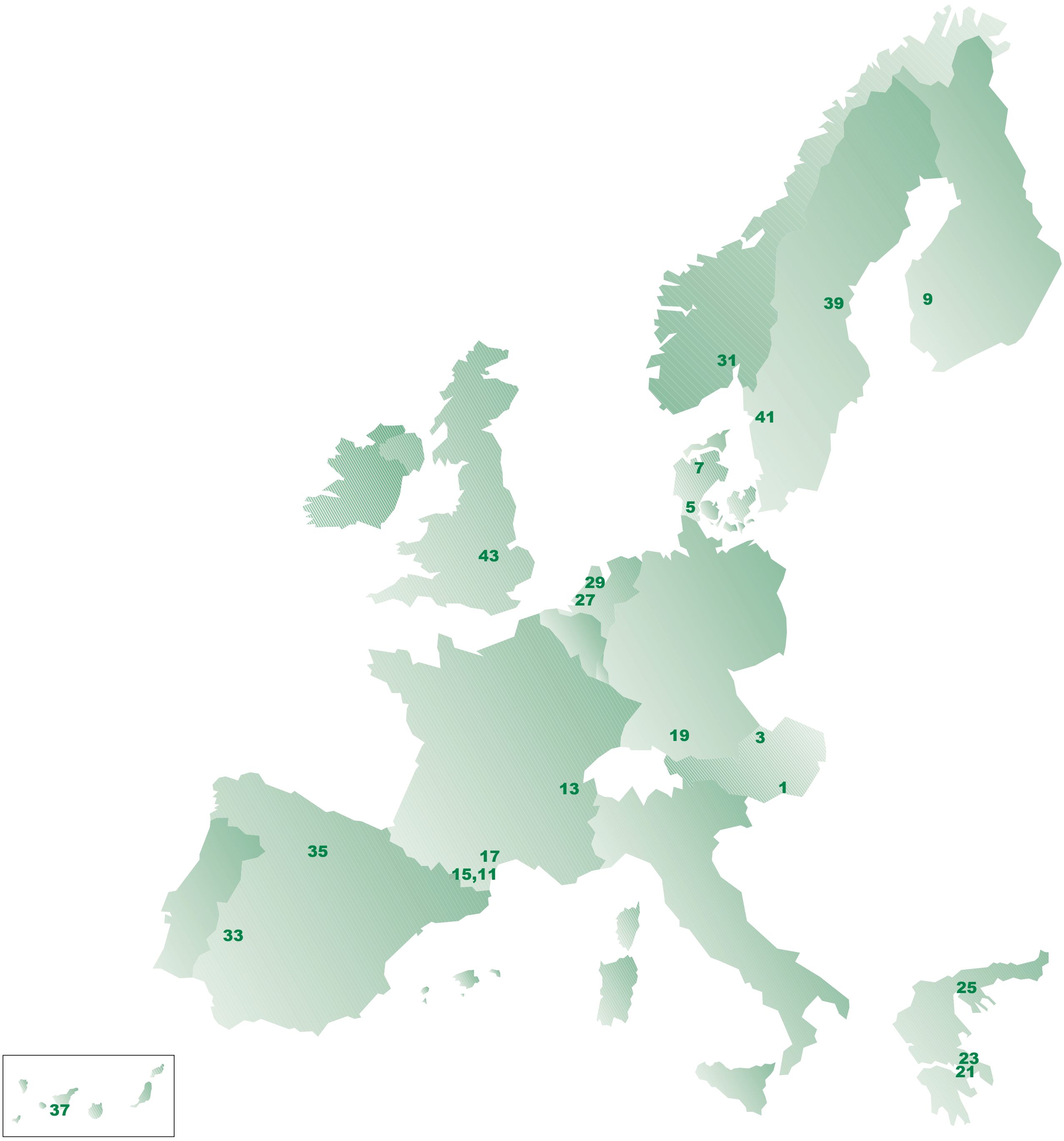
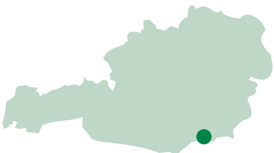
ENERGIE

4 Solar Thermal



Sector: Solar Thermal and Biomass
Country: Austria
Location: Eibiswald
Year: 1997



EIBISWALD, SOLAR THERMAL COLLECTOR INTEGRATED WITH A BIOMASS PLANT

Farmers in Austria not only tend croplands and meadows but forests as well. These woods are very important for the landscape, clean air and good spring water and also generate employment in the region. A portion of the wood produced by this forestry is unsuitable for sale on the market as timber. Nahwärme Eibiswald was founded in 1991 with the aim of turning this waste wood into a source of income for farmers by using it as a raw material for heat generation. The company initially had 18 members, of whom 16 were farmers. Besides creating an additional source of income, further objectives are to contribute to climate protection and disposing of waste material.

In 1992, part of the district-heating network was constructed and subsequently a biomass-fired boiler came into operation in 1994. The plant delivers its heat to two schools, a rest home, 75 households and several companies. Because in summer only 5% of the net capacity of the biomass-fired boiler is needed to supply heat, the efficiency of the system declines dramatically. Therefore, the system was supplemented with a supporting solar thermal collector system in 1997. This system, which is equipped with a storage facility, enables the plant to cover 90% of the heat demand in July and August from solar energy, thus enabling the biomass-fired boiler to be shut down during this period. The additional heat demand is met from an oil-fired boiler, which is installed in a school.

Description

The solar collector system is installed on the roof of the wood chip store and on the roof of the heating system building. The installation is operated in Matched-Flow mode and the store can be loaded at two different levels. The storage facility is partly integrated with the boiler building. In the case of surplus of heat produced in summer, the collector can be used with an air/water heat exchanger to dry the biomass.

Due to the dimensioning of the collector system and the possibility of drying of wood chips, the solar collectors can be utilised continuously under normal operating conditions. In the case of a system shut down, an over-pressure valve opens at its response pressure and the water/anti-freeze mixture is caught in a reserve tank. When energy consumption resumes, the water/anti-freeze mixture is pumped back into the collector cycle by a high-pressure pump.

The plant is connected to a district-heating network, which extends over 5,000 m. Consumers of the heat from the network have a guaranteed temperature of 60ºC all year round.

If the network feed temperature needed is not reached in summer, after-heating takes place using an oil-fired boiler installed in the main school.

Project characteristics

Net total solar collector surface [m^2]	1,246
Storage volume [m^3]	106
Storage height [m]	12
Maximum biomass boiler capacity [kW]	2,000
Total heat delivery to the network [MW_h]	4,500
Total heat consumption [MW_h]	3,650
Heat production from biomass [MW_h]	4,040
Heat production from oil [MW_h]	105
Heat production from solar collector [MWh_h	125
Specific collector yield (gross collector surface) [kWh/m^2 per year]	415
Transportation losses in summer [%]	65
Annual transportation losses [%]	16
Cover by solar collector in summer [%]	90
Average annual cover by solar collector [%]	8

Promoters and parties involved

- Nahwärme Eisbiswald GmbH, Eisbiswald: principal and operator
- FA. S.O.L.I.D GmbH, Graz: planning of solar thermal installation
- Institute for heat technology, Technical University Graz: scientific assistance
- Ökotech GmbH, Graz: solar collector
- AF Industrieanlagenbau GmbH, Frauental: storage facility

Financial resources

The investment amounts to €276 per m^2 of collector surface (this includes costs of the solar system, the storage facility, construction, etc.). This is €298 per m^2 in terms of the net collector surface. This means the total investment is about €343,000. The estimated lifetime of the plant is 20 years.

The project was partly financed by the members of Nahwärme Eibiswald. Additional finance was provided by the Austrian government and the government of the state of Styria.

Results

During the monitoring period from June 1997 to June 1998, the system was optimised by the operator while the system was running and it functioned without interruptions.

The solar collector system is able to produce 516 MWh of heat annually. The heat produced by the solar system costs €0.05 per kWh without the subsidy and €0.03 per kWh with the subsidy.

Potential for replication

So far, two biomass-fired heat generation plants have been equipped with solar collectors in the region of Eibiswald. The possibilities for replicating the Eibiswald project elsewhere depend on government plans (at the Austrian and the European Union levels) with regard to the fulfilment of the CO_2 emission reduction objectives of the Kyoto agreement. Furthermore, the replication potential is determined by fossil fuel prices and people’s willingness to set up and run plants such as that at Eibiswald. The most important experience from this project is that it is essential to respond to heat consumers’ needs.

For more information

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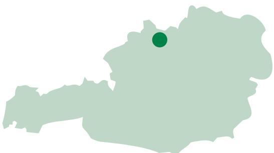
Sector: Solar Thermal
Country: Austria
Location: Rohrbach
Year: 1999



ROHRBACH, ENERGIEPARK SCHEIBLBERG

The Energiepark Scheiblberg in Rohrbach, Upper Austria, comprises a new office and warehouse building for the company Solar-Partner. The company is specialised in complete installation works in the field of solar, heating and rainwater systems, and also controlled ventilation installations. It employs 12 people.

In the autumn of 1998 the need arose to build a new building for the company Solar-Partner. The partner families Mandl and Hintringer chose to build a low-energy building, and in December 1999, Solar-Partner settled into the new accommodation.

The Energiepark Scheiblberg low-energy building is heated by an innovative solar thermal system. This is combined with an innovative energy technology for ventilation, an energy management system and the use of ecological materials. The building relies entirely on solar energy for its energy supply. With this, the project aims to demonstrate the application of renewable energy technologies in an industrial building.

Description

The solar collector system of the Energiepark Scheiblberg building is integrated in the façade and covers a surface area of 150 m². It is installed on the southern wall of the building with a slope of 70º. The SOLPA roof-integrated solar collector system used for this project was specially adapted to allow it to be built into the wall of the Solar-Partner company building.

The solar energy yielded during summer and in-between seasons, is stored in a 70,000 litre well-insulated seasonal storage buffer. This storage is fed through an external heat exchanger. The 10 m high buffer is loaded using an innovative system with controlled pumps and a three-time switching option for the loading height. In this way, the load of the storage is used optimally. The building also has a concrete store of 125 m³.

The low-energy building was constructed from wooden bars with insulation strengths up to 33 cm. Furthermore, energy-saving windows were used with a U-value of 0.6 W/m²K to reduce the energy demand yet further. The controlled ventilation system with heat recovery and air pre-heating through ground collectors is used for cooling purposes in summer. The building is also equipped with exemplary control and building management technologies.

To complete the energy concept of the building, its roof has been constructed in such a way that a solar PV system can be installed any time. Furthermore, a system for the utilisation of rainwater has been installed.

The solar thermal system of the building is connected to a biomass-fired heating system using wood chips, which is run by IGNIS an industrial company located close to the Solar-Partner building. This has made construction of a combined solar and biomass district-heating system possible. In summer and in-between seasons, hot water produced by the solar heating system is supplied to the neighbouring firm IGNIS. If the solar energy is not sufficient for the building of Solar Partner, heat from the biomass-fired system can be used.

The modern energy technologies used in this project are presented in an exhibition room.

Promoters and parties involved

- Solar-Partner: planning, building, initiator and owner of the project
- HTL Neufelden: control technology, development of data registration with process display
- Fröhling: seasonal buffer storage system, layer-loading unit, solar heat exchanger

Financial resources

The total costs for the company building of Solar-Partner came to approximately €930,000. About €202,000 was used for the innovative parts, i.e. the energy technology and the energy-optimal building technique. The project was supported with a grant of €94,500 from the state government of Upper Austria, within the framework of the ETP-Energy Technology Programme. The project was financed by the partners of Solar-Partner and loans.

Results

Some problems occurred during the project. The documentation and display of the energy yields has not been solved satisfactorily. It was the final examination work for students at a higher technical educational institution and the candidates are now involved in other activities so not available to Solar-Partner for the optimisation of the system.

Due to the energy-saving technologies applied, less energy is required to heat the building. In the first period when heating was required (in the winter of 1999 – 2000, from November to April), only 5,520 kWh were needed for a heated area of approximately 1,000 m². This was provided by the wood-chip heating plant of the neighbouring firm. This corresponds to approximately 1,126 kg of wood pellets. If the Solar-Partner building had been built using standard building techniques, then it have needed approximately 136,000 kWh (about 27,755 kg of pellets). Because the company reduces its energy needs and because it takes care of its own heat supply, the energy bill for the company is lower.

Potential for replication

The Energiepark Scheiblberg demonstrates the possibility of enormous energy-saving potentials and the application of solar energy in the field of industrial company buildings., The project can therefore serve as a demonstration project for other such buildings.

For more information

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Sector: Solar Thermal
Country: Denmark
Location: Augustenborg
Year: 1998

ENERGIE

SOLAR HEATING AT AUGUSTENBORG HOSPITAL

The Augustenborg hospital is a large institution with large areas to heat. A central gas-fired heating system covers the heat demand. The heat is distributed to the control rooms via the internal heating grid.

The hospital is in use all year around, which makes integration of solar heating attractive.

Description

The annual heating demand at the hospital is about 600 MWh, where losses due to circulation account for about 75 %. The heat is distributed from the gas-fired heating system to the decentralised control room, which supplies the various different buildings with heat and hot water. The hot water demand is constant through the year. The existing hot-water boilers are operating at low utilisation rates.

The installation of solar heating, which uses the old boilers to preheat the hot water, together with installation of new boilers for primary hot water heating will therefore improve the efficiency of the heating system. The operating conditions for solar heating are favourable as the solar heating will cover most of the heating demand for hot water during summer and could add heat to the gas boiler system during the spring/autumn.

The solar collectors are mounted on the roof of the hospital close to the decentralised control rooms.

To fit the solar collectors in with the existing boilers, the solar collector area of each installation is 75 m^2 In total there are four installations, which together give a total installed solar heating collector area of 300 m^2. The solar heating system covers 21 % of the annual heat demand for hot water production.

Promoters and parties involved

Esbensen was responsible for design of the solar heating installation at the hospital.

Financial resources

The total investment for the 300 m^2 installation was DKK 960,000 (€130,000) (excl. VAT).

The project received a 30 % subsidy from the Danish authorities.

The hospital is saving about 34 MWh/yr, which saves the hospital DKK 18,700 (incl. VAT) (€ 25,000) annually, based on an energy price of 0.55 DKK/kWh (€0.074).

The annual operation and maintenance cost is calculated at DKK 2,000 DKK/yr. (€ 270 a year).

The payback period is calculated at 12 years.

Results

Energy production

The solar collectors are expected to produce 127,770 kWh annually.

Financial results

It is estimated that the project will reduce the annual energy bill by DKK 17,000 (€2,300).

Environmental

Emission reductions achieved by the 300 m^2 solar heating plant at Augustenborg are given in the table below:

	SO_2 (kg/yr)	NO_2 (kg/yr)	CO_2 (kg/yr)
Reduced emissions due to reduced gas use (4025 Nm^3/yr)	0	-18.8	-25 000
Increased emissions due to increased electricity use (3000 kWh/yr)	+3.3	+5.2	+2 500
Reduced net emissions	+3.3	-13.6	-22 500

Potential for replication

There are many institutions with central heating systems where solar heating could be integrated into the heating system in a similar way as in this project.

For more information

Contractor

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Sector: Solar Thermal
Country: Denmark
Location: Skive municipality
Year: 1997

ENERGIE

SOLAR HEATING IN THE MUNICIPALITY OF SKIVE

Since 1986 the municipality of Skive has invested about DKK 25 m (€ 3.3 m) in energy saving equipment for municipal buildings.

After the energy crisis in 1973, the municipality started an effort to reduce energy use in response to the sharp increase in energy prices.

In the initial phases of the project the focus was on minor modifications such as better insulation, new glazing in windows etc., but in 1983 a target was set and resources allocated to reduce energy use. The first step was a survey of energy use, followed up by continuous monitoring of energy use.

In 1994 the municipality installed a large solar thermal plant at the Højslev school. The aim was to reduce the heat consumption by 25 % at the school. To fulfil this goal 375 m^2 of solar collectors were installed.

The renewable energy installations set up so far (August, 2002) include:

- Installation of 19 large solar thermal installations at ten schools, one senior citizens' club, one sports centre and several day time institutions.
- Installation of heat recovery systems using heat pumps.
- Setting up a monitoring centre supervising resource exploitation, and use of electricity, gas and central heating.

In this case study the focus is on the third step of the programme, which was implemented in 1997, and in which 6 large and 3 small solar heating installations were created.

Description

During 1997 the municipality mounted 9 solar thermal installations on larger buildings. Among the 9 installations 6 were between 125 and 175 m^2, and 3 between 21 and 42 m^2.

All the installations have been set up at visible and easily accessible locations. The installations have energy measurement equipment, which makes them of value for educational purpose.

The installations brought in operation during 1997 include the following:

Installation	Solar collector area [m²]	Annual forecast solar heat output [kWh]
Brårup school	175	70,000
Skivehus school	150	60,000
Resen school	125	50,000
Åkjær school	125	50,000
Dalgas school	125	50,000
Møllegården, Senior Citizens Club	125	50,000
Ørslevkloster school	42	16,800
Rønbjerg school	28	11,200
Nr. Søby school	28	11,200

In addition two PV installations were set up at two of the schools:

- Resen school, 10 m², approx. 750 Wp
- Åkjær school, 12 m², approx. 900 Wp

The solar thermal installations have been constructed using traditional technology, apart from the variable rotational speed circulation pumps. Two of the large-scale plants include auxiliary solar cells aiming to demonstrate that solar cells can produce enough electricity to run the circulation pumps.

Two different control systems have been used for the cells. In both systems very high energy density (permanent magnet) DC motors connected directly to the solar cells have been used, thus avoiding loss of energy when converting DC to AC.

At the Åkjær school automatic controls were chosen enabling the variable speed DC to be controlled directly depending on the temperature difference in the solar heat exchanger.

At Resen, the pump is connected directly to the solar cells, except for a relay which is there to disconnect it when the voltage is too low and reconnect when the voltage is high enough. During the first year of operation the relay was not fitted and thus no controlling mechanism was used for the system. This meant that when the solar cells delivered enough electricity to run the DC pump, then no voltage was necessary to start it. This has the advantage that when there is little irradiance on the collectors the solar cells deliver only a small amount of electricity, turning the pump only slowly while the heating array is slow to heat up. This method implies that when the sun has finally heated the fluid in the solar collectors to the required temperature, the piping and insulation has already been heated for "free". The solar collector control unit can start the secondary pump and the heat is transported to the heat exchanger.

Promoters and Parties Involved

Owner and initiative:	Skive municipality
Main contractor (solar collectors):	Arcon Solvarme A/S

Financial Resources

Total investments	€397,300
Subsidy (30%)	€119,200
Net investment	€278,100
Solar PV cells	€9,300
Miscellaneous costs	€5,900
Net investment solar heating 1997	€293,300

Subsidy

The Danish Energy Authority provided a 30 % subsidy for the solar collectors DKK 894,000 (€119,200).

Results

The calculations done prior to installation of the solar cells showed that approximately 700 W was necessary for pumping the 2000 litres per hour required through the solar collectors, with a pressure difference of about 1.5 bars. Experience in operation, however, has shown that about 300 W would have been enough to deliver the necessary flow rate. This would reduce the solar cell area to 6-7 m². This experience will be of use if new solar cells are implemented in the future.

The energy output from the plants has been monitored since start up. The produced heat is given in the table below for the years 1998-2001.

Plant	Produced [kWh]				Forecast annual production [kWh]
	1998	1999	2000	2001	Forecast
Brårup school	51,655	64,903	53,160	61,260	70,000
Skivehus school	54,040	58,590	49,044	47,057	60,000
Resen school	47,392	60,344	51,521	53,244	50,000
Åkjær school	30,358	32,560	26,410	29,360	50,000
Dalgas school	37,916	42,967	29,200	43,482	50,000
Møllegården, Senior Citizens Club	31,263	41,369	29,566	33,279	50,000
Ørslevkloster school	8,764	11,246	9,639	10,768	16,000
Rønbjerg school	5,476	9,335	7,541	8,159	11,000
Nr. Søby school	5,089	7,522	7,063	6,414	8,000

The main socio-economic benefits arising from the project derive from the fact that the solar collectors have been installed at schools, which may therefore contribute to generating interest in renewable energy sources among the pupils and other users of the school.

Potential for Replication

The implementation of solar cells in connection with the solar collectors has produced valuable experience that could be used by other projects.

For More Information

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Main contractor (solar collectors):

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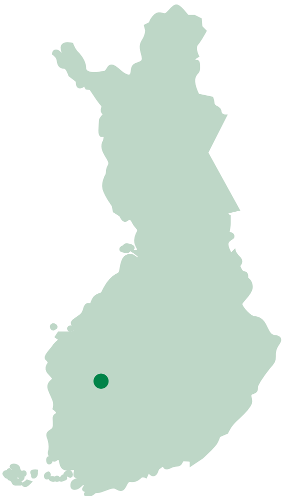
arcon@arcon.dk
www.arcon.dk

Sector: Solar Thermal and Geothermal
Country: Finland
Location: Kurikka town
Year: September 2000

ENERGIE



"HOT & COLD" SOLAR AND GEOTHERMAL HEATING SYSTEM

The cumulative annual solar radiation in sub-artic regions is about 1,000 kWh/yr (southeast + south + southwest). Conventional solar systems can produce hot water and space heating, but typically these systems work as independent parts without, "intelligent" overall optimisation of the system.

To improve the coefficient of efficiency, solar radiation can be transformed and stored. This improves the building's overall energy balance when the energy is used by the building itself.

To construct an installation for this purpose Shield Oy combined geothermal heating with a large number of solar collectors. The result is a low exergy production system called "Hot&Cold". The first installation was carried out on a 15-apartment housing development in the town of Kurikka in central Finland.

Description

The system has been designed with a focus on the problems facing utilisation of solar and geothermal heating in northern countries. The problems identified include:

- Solar thermal
    - Considerable heat losses during the spring/autumn period
    - Huge variation in solar radiation between winter and summer
    - Maximum load and low radiation culminate at the same time of the year
    - The collectors produce "too much" heat in the summer
    - Large thermal reservoirs are expensive
- Geothermal
    - The ground temperature is low (typically +6…+9ºC)
    - Bedrock easily gets too cold (around zero) and resulting in a low operation coefficient
    - Radiator heating requires high temperatures and operating coefficients are low

The basic principles of the system developed by Shield Oy are:

- Thermal heat wells/pumps (units I, II, III, etc.) running all the year round.
- Solar collectors which come into operation if intensity is sufficient.
- Collectors produce temperature:
    - o *T_{out} or $T_{bedrock}$ +ΔT, where ΔT is typically low*
- Thermal heat is always stored in the bedrock (long term / short term).
- "Old" and "New" geothermal heat is combined as low temperature energy storage.
- Temperature cooling of bedrock is (over) compensated.
- Low temperature floor heating used instead of radiators.

Promoters and parties involved

- Designed by Shield Oy.
- The multi-occupancy residential buildings are owned by Kurikka council, which has been closely involved in the project.
- Arkkitehtitoimisto Juhani Jäsperlä (an architecture firm) designed the building and the necessary additional construction work for the "Hot&Cold" system.
- VTT Technical Research Centre of Finland, Building and Transport section created the "Hot&Cold" simulation software. The Kurikka project is part of IEA Annex 37 Low Exergy Systems for Heating and Cooling of Buildings. Internet: http://www.vtt.fi/rte/projects/annex37.

Financial resources

Total investment

- The total investment for the four multi-occupancy residential buildings, with a total dwelling area of 825 m^2, was €1,100,000
- The total investment for the multi-occupancy building was € 1 m, the "Hot&Cold" system was €59,000 (purchase price) and the trial cost approximately €150,000 (five year programme).

Subsidies

- Finnerva plc, a state owned company specialising in offering financing services to promote domestic operations in Finnish business supported the project.
- Funds from The National Technology Agency, TEKES, were awarded through the Ministry of Trade and Industry.

Results

The project was implemented as originally planned. The equipment has been working as intended, but there is still much work to do on testing different application modes. The test period will last for another three years.

Energy production

The efficiency of the solar collectors has been improved. During the heating period from March to October the efficiency of the solar collectors is about 60-70 % compared to about 20-25 % for conventional solar collectors. The cumulative energy production in a typical year is about 800 kWh/m^2.

Environmental result

The "Hot&Cold" system does not have a significant visual impact. The heat wells and the solar collector batteries have no impact on the inhabitants' daily lives. This has been one of the main focus areas in the design of the system.

Potential for replication

Shield Oy has several domestic and international projects underway on hybrid renewable energy systems. The company has had a lot of inquiries about the "Hot&Cold" concept and further systems will probably be installed in 2003. Further development of the "Hot&Cold" concept involves integration of a vertical wind turbine.

For more information

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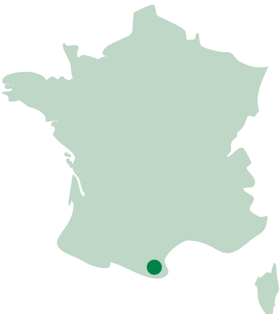
Risto.Kilpi@shield.fi
www.shield.fi

Sector: Solar Thermal
Country: France
Location: Perpignan
Year: April 2000

ENERGIE



GUARANTEED SOLAR HOT WATER FOR THE FORMULE 1 HOTEL

Formule 1 is the reference hotel chain for low cost accommodation. Each hotel (350 spread over 10 countries) ensures a good night's rest at competitive prices. This hotel, with 97 rooms, which are occupied from 50 to 100% throughout the year, is one of the first Accord Group hotels with roof solar collectors. The solar installation ensures that the hot water supply is preheated before using an electric water heater.

The performance of the solar installation had to be guaranteed over a period of at least ten years, in order to ensure the return on the investment.

Description

In many ways this is a classical solar water heating system for a hotel. However the Formule 1 Hotel in Perpignan is one of a chain of 350 similar hotels spread over 10 different countries. Thus the solar system can be easily and inexpensively adapted to any one of the other hotels of the chain, and their solar performance had to be guaranteed with minimal maintenance.

The solar system includes a roof-top solar collector area of 76 m^2 and a 4,000 litre hot water storage tank. The installation is covered by a Guaranteed Solar Results (GRS) contract.

The main innovation of the installation can be found in the Solar Supervision System (3S), which was developed with support from the European Commission CRAFT programme. The first "3S" prototype is being tested in this hotel. It consists in an IT device permitting computer control of the operational phases of the plant.

Promoters and parties involved

The hotel is part of the ACCOR group which signed a co-operation agreement with ADEME (the French National Energy and Environment Agency) in 1999, concerning energy saving and the development of solar energy applications.

The solar system for this hotel in Perpignan was installed within the framework of this agreement and the ADEME "Hélios 2006" procedure was used to provide financial support.

Financial resources

Total investment : €50,358 (663 €/m²).

Subsidies : ADEME provided 49% of the total investment.

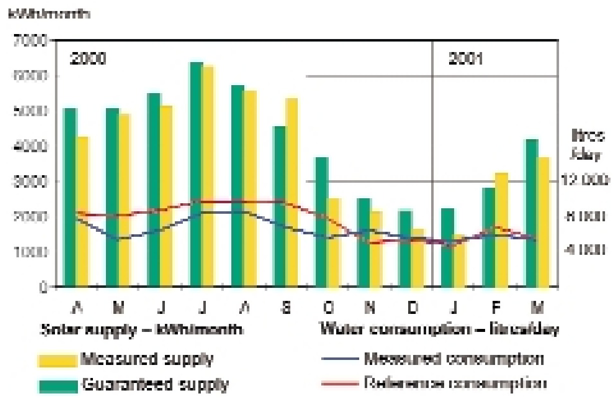
Languedoc-Roussillon Region provided 25% of the total investment.

Results

The Guaranteed annual production was calculated in 49.845 kWh, which corresponds to 658 kWh/m².

The Measured solar energy supply is 46,116 kWh which is 608 kWh/m², that is 7% less than the guarantee amount during the first year, mainly due to bad weather during the autumn and winter months of the first year.

The following diagram shows the performance of the installation over a one-year period:



Potential for replication

This hotel being one of a chain of 350 similar hotels belonging to the ACCOR group, which also owns more than a thousand other hotels worldwide, the potential replicability is very high. Moreover, this project showed how inexpensive remote supervision and monitoring over long time periods can be successfully achieved. This opens the way to guaranteed solar performances during the relatively long pay back times for solar installations, something which has always been a serious barrier to the development of thermal solar installations in commercial buildings.

For more information

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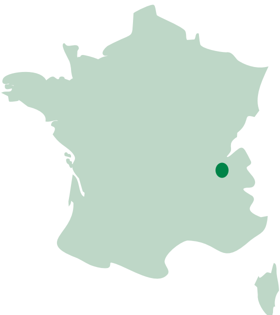
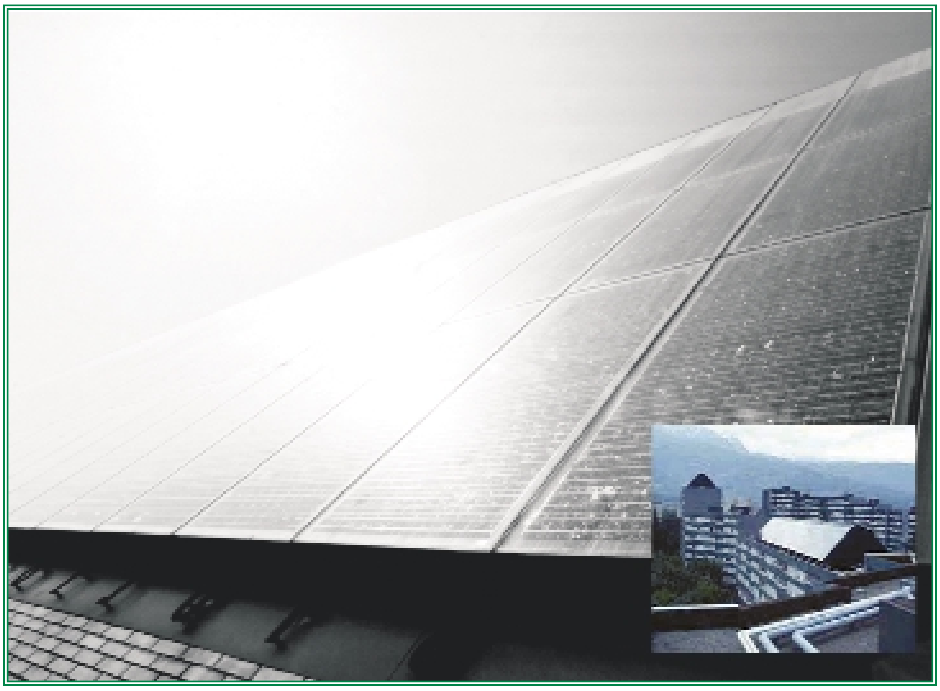
info@tecsol.fr
www.tecsol.fr

Sector: Solar Thermal and Photovoltaic
Country: France
Location: Echirolles, (Isère)
Year: October 1999

ENERGIE





GUARANTEED SOLAR ENERGY FOR SOCIAL HOUSING IN ECHIROLLES

Since 1994 the town of Echirolles, located near the Alps in the Isére region, has been running a district programme aimed at enhancing the social and urban rehabilitation of a number of social housing estates. For several years 50% of the town's buildings have been connected to the Grenoble district heating grid, which uses several types of biomass and waste for heat production.

Within this strategy, the council estate in the area of Serieux has been undergoing refurbishment including the fitting of better insulation, low-consumption lighting and the installation of 705 m^2 of solar thermal collectors and 95 m^2 of PV panels.

Moreover the hot water production is connected with the existing district heating sub-stations, and the whole operation is taking place within the framework of a GSR (Guaranteed Solar Results) scheme.

Description

The buildings where the solar system has been installed are typical of construction techniques used before the oil crisis, and are characterised by their having little or no thermal insulation and no attention having been paid to the rational use of energy.

The refurbishment of the social housing (505 units) has taken into account the conclusions of a global energy analysis and alternative energy solutions are being applied.

The main aim was to reduce the tenants energy bills by upgrading and improving the building structure (new insulation, better window frames, double glazing) and the systematic use of low-consumption lighting. The use of renewable energies was also a key element in the operation, with a view to enhancing awareness of energy management issues. The 705 m^2 of solar collectors were installed under a three year GSR contract and contribute to the production of DHW (domestic hot water) for 505 flats; moreover, 95 m^2 of PV panels, producing 10 kW in a grid-connected system are used to power the lighting in common areas and to run the motors controlling the mechanical ventilation in a block of 122 flats.

The visual impact of the technologies within the existing building has been carefully studied by an impact assessment, which proposed solutions for their optimal functioning and integration (an upper floor was added to house the solar panels to ensure optimal orientation and the multi-crystalline PV panels were integrated with the facade).

The four installations are connected to three substations, which supply additional power.

Promoters and parties involved

The promoter of the initiative was OPAC 38 (Office public d'aménagement, département d'Isére) together with Echirolles Council.

Mairie d'Echirolles
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1, pl de la Libération
F 38130 Echirolles
Tel. 33 476 20 6300

Financial resources

Total investment: the total investment was €1.83 m, of which €1.07 m was accounted for the solar installations.

Subsidies: the"solar" subsidies as a a whole came to nearly 50% of the corresponding investment, that is €533,570, which was subdivided as follows:

- EU funds: €259,000 (THERMIE programme)
- Rhone-Alpes Region: €244,000
- Isére area: €30,490
- The remaining part was supported by PAULOS finance and by own funds.

Results

For the years 1999-2000 the results show an output 35% higher than that envisaged and the ST installation as a whole produced 400,000 kWhs, while the PV panels produced 6,581 kWh of electricity.

The avoided emissions each year totalled 130 tonnes of CO_2, 470 kg of SO_2 and 300 kg of No_x.

From the social point of view the whole OPAC 38 programme permitted a saving of about 95 €/home/year.

Potential for replication

The key to the success of this project was the close collaboration between the various different partners, including tenants, local and regional Authorities, and the social housing company, all of which have collaborated to bring about a significant change in attitudes.

For this reason this project can offer a good example for similar situations (i.e. refurbishing social housing), in which a collaborative approach is crucial for the results of the activity.

For more information

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Energie – Cités
2, Chemin de Palente
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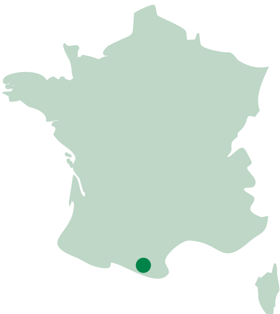
+33 381 653680

Sector: Solar Thermal
Country: France
Location: Font Romeu (Languedoc-Roussillon)
Year: 1997

ENERGIE



FONT ROMEU SPORTS CENTRE

The installation is located in the Font Romeu Sports Centre in the Languedoc-Roussillon region. Since 1984 the Sports Centre has been equipped with 390 m^2 of solar collectors, which are used to pre-heat the water in the Olympic swimming pool.

When the new system was built in 1997, the Sports Centre had the largest solar installation in the Languedoc-Roussillon region (with about 500 m^2 of solar collectors). The new solar heating system has been designed to preheat the water used to prepare the surface of the skating rink.

Description

The installation consists of 87 m^2 of Giordano type solar collectors with a total effective collecting surface of 75 m^2.

The installation has been designed to satisfy 61% of the sports centre's estimated energy needs (86,295 kWh per year). Considering an annual solar production of 52,756 kW, the estimated productivity per m^2 of the effective surface of solar collectors is 703 kWh.

The installation is also equipped with a remote control system that monitors the operation and performances of the plant as a whole making it possible to obtain data and detect anomalies.

Promoters and parties involved

Developers

Lycée Climatique et Sportif de Font Romeu
Avenue Pierre de Coubertin
66120 Font Romeu (France)

Operation and exploitation

SOMETH
Cité Maruejouls
Boulevard Paul Langevin
11000 Carcassonne (France)

Design

Bureau d'Etudes TECSOL
105 rue A Kastler BP 434
66000 Perpignan (France)

Equipment (Solar collectors) supplier

J. GIORDANO Industrie
Z I des Paluds
529, avenue de la Fleuride
13685 Aubagne

Other parties involved in the partnership

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34965 Montpellier Cedex 2 (France)
Languedoc-Roussillon Region
201, Avenue de la Pompignane
34000 Montpellier (France)
www.ademe.fr/languedoc-roussillon

European Union

Directorate General for Energy and Transport
226-236 Avenue de Tervuren
B-1150 Brussels (Belgium)
europa.eu.int/comm/energy/index_en.html

Financial resources

The cost of the solar installation totalled €77,088. In addition, the plant required a remote sensing control system (€4,552) and additional engineering work (€11,296).

Maintenance and follow up over a period of 4 years cost, €1,703 and €2,561, respectively.

This project is included within the European Project Sunergie and has also been awarded a GRS contract (Garantie de Rèsultats Solaires) for three years, signed by the developers and the rest of the agents involved in operating the installation. Under this contract, and regardless of the weather conditions, a solar output of the 80% of the estimated production is guaranteed. Initially, output was set at 42,205 kWh.

Results

After the commissioning of the installation it was detected that the consumption of hot water that had initially been planned had been overestimated (the real consumption was 26% less than initially forecast). As a result, the guaranteed solar production was re-calculated at 32,259 kWh per year. After the first year of operation the output of the installation came to 39,786 solar kWh (19.6% more than the guaranteed amount).

Potential for replication

The GSR scheme has been a very effective procedure for re-launching solar thermal installations which had suffered, in many Mediterranean countries, from their bad results in terms of performance and maintenance of installations built in the 70's and 80's.

Solar hot water is a traditional application in sporting and recreational facilities and can thus, reinforced by these guaranteeing be widely applied in similar situations and climatic conditions.

For more information

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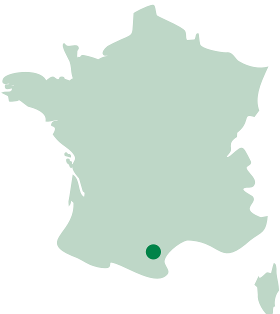
Languedoc-Roussillon Region
201, Avenue de la Pompignane
34000 Montpellier (France)
www.ademe.fr/languedoc-roussillon

Sector: Solar Thermal
Country: France
Location: Town of Carcassonne
Year: 1997

ENERGIE



HOT WATER FOR SOCIAL HOUSING AND THE OFFICES OF THE FIRE BRIGADE IN CARCASSONNE

In 1987, "l'Office Publique Départamental HLM de l'Aude" set up a 340 m^2 solar installation to provide primary energy to a heat pump delivering heating and domestic hot water to 40 social housing units (flats) and the offices of the fire brigade.

The owner's original intention was that after 18 or 20 years the existing installation would be converted to natural gas, but instead it was decided to supply domestic hot water (DHW) using solar thermal energy. The roof-integrated solar collectors were installed in order to preheat the DHW supply to the flats and the offices of the fire brigade.

Description

The 87.6 m^2 of new roof integrated solar collectors have been designed to supply an average daily consumption of 5.6 m^3 at 45ºC degrees. The installation has a rated power output of 35,067 kWh/year, which is 47% of the estimated energy needs (74,434 kWh/year) and represents a productivity of 590 kWh per m^2 of working collector. The whole project as a whole has been set up under a GSR (Guaranteed Solar Results) scheme.

Remaining heating needs are met by the gas boiler in order to maintain a constant distribution temperature.

Promoters and parties involved

Developer and owner

Office Public Départemental HLM de l'Aude
1, Place Saint-Etienne - BP 97
11022 Carcassonne Cedex

Designers

Bureau d'Etudes TECSOL
105 rue A Kastler - BP 434
66000 Perpignan
Cabinet Gerber
Les Perdrigals
11510 Treilles

Installer

Société SIRET
Z.I de l'Estagnol Rue Copernic
11000 Carcassonne

Technology supplier

J. GIORDANO Industrie
Z 1 des Paluds
529, avenue de la Fleuride
13685 Aubagne

User

SOMETH
Cite Maruejouls
Boulevard Paul Langevin
11000 Carcassonne

Financial resources

The total cost of the solar installation was €50,399. Apart from this, the plant required a remote monitoring control system (€4,494) and additional engineering work (€5,442). Maintenance and follow up for 4 years cost €1,540 and €2,561, respectively. Altogether the total cost of the system came to €64,436.

This project is included within the European Project Sunergie and was awarded a GRS contract (Garantie de Rèsultats Solaires), signed by the developers and the rest of the agents involved in the operation of the installation.

Results

After the installation had been brought into operation it was found that the initially planned consumption of hot water had been overestimated (the real consumption was 18.5% less than that forecast). As a consequence, the guaranteed solar production had to be re-calculated because the solar energy production was more than 12.4% over the amount guaranteed. After the first 10 months of operation this production was 22,441 kWh.

Potential for replication

The Guaranteed Solar Results scheme has proved to be very effective in cases where the potential user was reluctant to rely on solar collectors due to bad experiences (in terms of maintenance and production performance) with such systems in the 70's.

This scheme can therefore be considered extremely useful in all potential similar projects, in which climatic conditions favour the installation of solar panels for hot water production.

For more information

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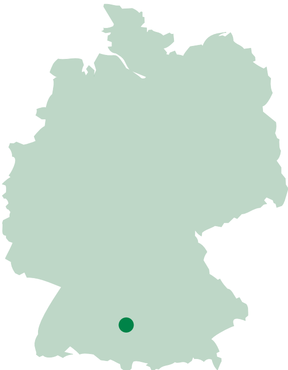
119 Ave J. Cartier
CS 29011
34965 Montpellier Cedex 2

Sector: Solar Thermal
Country: Germany
Location: Ulm
Year: 1998

ENERGIE



ULM, SOLAR ASSISTED SMALL-SCALE DISTRICT HEATING

The city of Ulm is located at the mouths of two tributaries of the Danube, the rivers Blau and Iller. It has 110,000 inhabitants and is a regional economic centre in southern Germany, best known for its automobile industry (Daimler-Benz). Ulm (and Neu-Ulm) have a focus on sustainable business that is also part of the corporate philosophy of their wholly owned utility, Stadtwerke Ulm (SWU). Stadtwerke Ulm has set itself the goal of promoting and dissemination of renewable energy concepts.

The commitment of Stadtwerke Ulm is illustrated by its projects in the fields of solar cells and solar heat. To speed up the introduction of renewable sources of energy and innovative technologies the city of Ulm and/or the Stadtwerke Ulm group of companies opted for a combination of instruments.

On the one hand their approach features subsidy oriented services. In 1996, Stadtwerke Ulm and the cities of Ulm and Neu-Ulm founded the Ulm & Neu-Ulm Solar Foundation (Solarstiftung Ulm/Neu-Ulm). The foundation uses the interest revenues from its own capital and an annual contribution of Stadtwerke Ulm of €150,000. This adds up to about €230,000 a year to be invested in solar-energy projects. The targets of the foundation include introducing solar thermal units in practice, awareness-raising among planners and craftsman, as well as users and scholars, and supporting firms and institutions in the solar-power industry based in the region. Furthermore, it aims at a market-oriented development of photovoltaic applications and development of integrated energy concepts. Expenditure on subsidies for purposes of the foundation in 1998 came to €210,000.

Additionally, they make use of market oriented instruments like one-stop solar thermal systems and marketing of electricity from renewable sources of energy. Of special importance is the GRS (Guaranteed Results from Solar collectors). Since there was not much experience with solar collectors at first it was difficult to estimate the actual amount of heat they would supply. To handle this uncertainty, several municipal utilities got together in 1993 with experienced planners and well-known manufacturers. Their aim was to install solar collector projects with 'guaranteed results'. In these GRS projects, the annual amount of heat supplied by a solar collector is guaranteed by the manufacturer. If the actual heat yield falls below the guaranteed value a means of compensating the operator or investor for the shortfall is agreed. This makes it possible to prepare more exact cost-benefit calculations and to plan customized systems with simulation programs. This exact planning eliminates over-dimensioning and thus reduces the overall cost of the system as a whole.

In addition, the Stadtwerke Ulm implemented numerous pilot projects, sometimes partly subsidized with EU funds and with regard to solar energy also stimulated by a relatively high feed-in payment for the solar electricity.

Description

In Ulm-Jungingen, 150 m² of flat collectors assist a district-heating scheme that supplies heating and hot water to a residential area comprising 86 residential units. A gas-fired combined heat and power plant covers the majority of the heat demand. Solar collectors produce the rest of the heat. This solar heat always gets priority over the heat produced by the combined heat and power plant. The heat is stored in three tanks, connected in series with a total volume 6 m³. The buffer-storage tanks are insulated with bulk biomass material. The tanks are filled according to the expected heat demands. To deal with peaks in the heat demand a gas fired condensing boiler is connected parallel to the buffer storage tanks.

Project characteristics	
Solar collectors	
area [m²]	150
Inclination angle	15°
Orientation angle	180°
Heat storage [m²]	6
CHP unit	
Gas engine	
Thermal power [kW]	115
Electrical power [kW]	60
Gas boiler	
Thermal power [kW]	460
District-heating	
Forward temperature [°C]	70
Backward temperature [°C]	40

Promoters and parties involved

- SWU (Stadtwerke Ulm): energy distribution company; coordinator of the project, owner and operator
- Municipality of Ulm and Neu-Ulm

Financial resources

The total investment cost of the solar assisted district-heating project in Jungingen was €76,694. The project was wholly subsidised by the city of Ulm.

Results

The solar collectors produce about 45,000 kWh of heat a year without any emissions. The combined heat and power unit is able to produce about 690,000 kWh of heat a year with a 50% CO_2-reduction compared to a gas boiler heating. Due to a subsidy paid by the city of Ulm for the solar collectors, the heat prices are on the same level than conventional heat costs.

Benefits of the project include an avoidance of fossil energy use of about 900 GJ per year. The annual CO_2 emission reduction comes to about 52 tonnes per year.

Potential for replication

The project has been replicated in the solar district-heating network of Böfingen, which has a collector size of 180 m² and a 60 kW combined heat and power unit planned.

For more information

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+49 731 166 1530
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info@swu.de
www.swu.de

Sector: Solar Thermal and Photovoltaic
Country: Greece
Location: Athens
Year: 1998

ENERGIE

AVAX S.A. "SMART" BUILDING

This unique building, which has been built in the centre of Athens is the headquarters of the construction company 'AVAX S.A.'. It was designed following the principles of "cutting-edge bio-climatic architecture". The feasibility study for the construction of the building received a 50 % subsidy from the "Energy Comfort 2000" project of the THERMIE Programme of The European Commission.

The building was to be monitored for one year, so as to register its monthly energy performance and estimate both its innovative characteristics and the reaction of the people working in the building. The principle aim in the design of the building was to ensure a comfortable workplace for its users, while saving energy and using the latest technology and low-maintenance, environmentally friendly construction materials and techniques. Thanks to its design there is a 50% energy saving in comparison to equivalent conventional buildings.

Description

In view of these aims, the main concern was to adapt the building to the local climatic conditions, so that it can 'exploit' the local, natural elements through an automated control system.

The building is located on a hillside in central Athens and has a floorspace of 500 m^2. The building faces east and it is therefore exposed to sunlight throughout the morning. From the west it is shadowed by neighbouring buildings, whereas it is joined to other buildings on both the north and south sides. The entire concept in the design of the building was to be oriented eastbound as to take advantage of natural heat and light. This is made clear by the fact that the surface of the east side is 45 % covered by windows in contrast to the west side, where windows cover only 10 % of the surface. The various offices inside are positioned in such a way as to obtain as much natural light as possible.

Hot water production in the building is achieved by means of solar collectors and the ground floor is lit by power from photovoltaic panels, which can also function as back-up energy in the event of a power cut.

The entire electricity network is automated and controlled through the building's central control panel. As mentioned above, the electrification can be supported by the photovoltaic panels.

The electric lighting has been designed in such a way as to supplement natural lighting rather than replace it. This is mainly achieved by a number of features:

- The walls are painted white so as to diffuse the light.
- Most areas are provided with high performance fluorescent lamps.
- General lighting is switched on and off through sensors that detect the presence of people.

The aim of the building's design in thermal terms was to minimize the usage of air-conditioning through the use of natural lighting, cooling and ventilation.

This principle was implemented based on the following parameters:

- The control of the cooling loads of the building by using external shades on hot days.
- The 'pre-cooling' of the building through mechanical, night-time ventilation and air exchange.
- The use of roof ventilators controlled by users.
- The use of a central cooling system, combined with a cooling storage system.

The air-conditioning system used is one of the 'smartest' attributes of the building. This comes on when the system's sensors detect the presence of people. This is very important, since it helps economize on energy given the fact that the system only runs when it has to cover the air-conditioning needs of the space people are actually occupying.

Promoters and parties involved

CRES (Centre for Renewable Energy Sources), TEAM-Engineering Consultants, Tombazis Architectural Office.

Financial resources

The THERMIE Programme's "Energy Comfort" financed 50% of the feasibility study for the construction of the building.

Results

Given the orientation of the building and its limited depth, the entire interior space is satisfactory exposed to natural lighting, thanks mainly to the large glass surface of the east side. This made it necessary to emphasize a widespread and uniform distribution of natural light (for visual comfort).

The results so far indicate that as far as ventilation and air-conditioning are concerned, that the air current from one side is absolutely satisfactory. In addition, the ventilation can be improved substantially by opening the doors and windows at the back of the building.

Inside the building, there is an electronic-digital 'building management system' (BMS) for the management and the regulation of the system as whole. This was necessary to ensure constant functioning, data analysis and energy management from the control room. Moreover, the BMS is based on the decentralized processing and the 'intelligence' of all auxiliary and peripheral systems that comprise it. The BMS is also responsible for:

- supplying hot water
- fire safety
- detecting human presence in the rooms
- night cooling
- energy consumption per floor
- elevators

Potential for Replicability

An complete 'package' of new technologies for buildings was applied in the construction of the AVAX building. This 'package' is the so-called B.E.M.S.

(Building Energy Management System). The B.E.M.S. has been applied to other buildings as well, either partially or entirely, depending on the needs and the peculiarities of the building. In fact, the B.E.M.S. has been extensively applied at many Greek airports, as well as in many hotels, particularly in the framework of the O.P.E. (Operational Programme for Energy). The 'smart' AVAX building, however, represents a complete application of the B.E.M.S.

A new building has been built recently in the premises of CRES utilizing the same B.E.M.S technology.

For more information

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19009, Pikermi, Greece
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abotzios@cres.gr

Sector: Solar Thermal
Country: Greece
Location: Inofyta
Year: 1999

ENERGIE

WAREHOUSE COOLING AND OFFICE HEATING FOR A COSMETICS IMPORTER

The objective of the SARANTIS S.A solar cooling system, subsidised by the national EPE (Operational Programme for Energy) of the Greek Ministry of Development is to promote energy efficiency and demonstration.

This programme envisages a 50% subsidy for energy saving investments (rational use of energy, energy efficiency, renewable energy) in buildings in both the manufacturing and services sectors. The subsidy is received on the condition that the system's energy saving is consistent with the amount stated in the call for tender, otherwise, a proportional cut in the subsidy is made.

Description

The hot water from the closed-loop hydraulic circuit of the solar collectors is used by two absorption chillers (total refrigeration capacity, 668 kW) to provide cold water (70°C) to the air handling units in the warehouse. Hot water leaving the solar storage tanks is also used to heat the water in a 2,500 litre closed storage tank via an internal heat exchanger. In the winter, the hot water from the solar collector array is used to preheat the water entering the steam boiler, which is used to heat the office space and provide hot water for the bathrooms.

Collector area:	2,700 m²
Angle of inclination:	30 ° due South
Hydraulic circuit:	Closed-loop water/ethylene glycol
Volume of solar storage tank:	2,500 litres
Function of solar system	:Cooling of warehouse and heating of offices 19.5°C wet bulb
Temperature of process water:	7/12°C (summer) 45/40°C (winter
Backup cooling:	3 air-cooled chillers (1,050 kW refrigeration capacity)
Backup heating:	2 steam boilers (1,700 kW heating capacity)

Promoters and parties involved

The solar cooling system was manufactured by SOLE S.A.

Financial resources

Total cost : € 1.2 m

50% subsidy under the EPE Programme.

Results

After its first year of operation, the solar thermal system delivered approximately 700 kWh/m^2/year of hot water to the cosmetics warehouse. In the summer this was used to provide cooling for the warehouse through the absorption chiller system, and in the winter it was used to heat the offices and provide hot water for the bathrooms.

Potential for Replication

Since its installation and operation, two more solar cooling systems have been installed in Greece (two hotels in Crete with 400 m^2 of collectors and 100 kW cooling capacity each).

For more information

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Sector: Solar Thermal
Country: Greece
Location: Thessaloniki
Year: 1999

ENERGIE

USING SOLAR POWER TO PROVIDE HOT WATER FOR A DAIRY COMPANY

The objective of MEVGAL S.A solar thermal plant, subsidised by the Greek Ministry of Development's national EPE (Operational Programme for Energy) programme is to promote and demonstrate energy efficiency.

The programme envisages a 50% subsidy for energy saving investments (rational use of energy, energy efficiency, renewable energy) in both the manufacturing and services sectors. The subsidy is received on the condition that the system's energy saving is consistent with the amount stated in the call for tender, otherwise, a proportional cut in the subsidy is made.

Description

Hot water from the closed-loop hydraulic circuit of the selective flat plate solar collectors heats the water in two closed 2,500 litre solar storage tanks via an internal heat exchanger. The hot water leaving the solar storage tanks is then used for the washing machine. Any auxiliary heating required is provided by the steam boilers. The hot water from the closed-loop hydraulic circuit of the CPC and flat plate solar collectors heats the water in two, closed 2,500 litre solar storage tanks via an internal heat exchanger. The hot water leaving the solar storage tanks is used for preheating the water entering the steam boiler.

Backup heating:	3 steam boilers (total power capacity = 12MW) – heavy oil
Factory operation hours:	24 hours a day, 7 days a week
Hot water consumption:	120-150 m^3/day
Temperature of process water:	a) washing machine: 20-80ºC b) Other processes: 20-130ºC
Area of Collectors:	a) 168 x 2.4 m^2 = 403.2 m^2 (selective collectors) b) 108 x 2m^2 = 216 m^2 (flat plate collectors) c) 40 x 2.7m^2 = 108 m^2 (CPC collectors)
Tilt of flat-plate collector:	45º due South
Hydraulic circuit:	Closed-loop water/propylene glycol
Connection (selective):	14 parallel branches with 12 collectors in each branch
Connection (CPC):	8 collectors in parallel
Connection (flat plate):	9 parallel branches with 12 collectors in each branch
Volume of solar storage tanks:	2 x 2.5 m^3 (in series) – selective collectors 2 x 2.5 m^3 (in parallel) – CPC + flat plate collectors

Promoters and parties involved

The solar-thermal system was manufactured by INTERSOLAR S.A.

Financial resources

The MEVGAL S.A solar thermal plant was financed through a Third-Party Financing scheme. The initial cost of the solar thermal system was paid for in the following way:

- Centre for Renewable Energy Sources (CRES): 72.5 %
- MEVGAL S.A: 20 %
- Agricultural Bank of Greece: 6.5%

The system is remotely monitored by CRES and the cost of the kWh supplied each month is paid to CRES by the dairy at a price fixed set in the contract. This will continue until the investment of the system, including interest, is paid back, at which point MEVGAL S.A becomes the sole owner of the system.

Results

After its first year of operation, the solar thermal system provided roughly 660 kWh/m^2/year of hot water to the dairy plant.

Potential for Replication

Since this plant was installed and commissioned, another solar thermal system in a dairy plant has been installed (TYRAS S.A, 1,000 m^2 of solar collectors).

For more information

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Sector: Solar Thermal
Country: The Netherlands
Location: The Hague
Year: 2000

ENERGIE

THE HAGUE, ZUIDERPARK SWIMMING POOL

The Zuiderpark swimming pool was the oldest open-air swimming pool in the Netherlands until it was demolished in 1998. The swimming pool was closed in 1991 and the site was subsequently redeveloped by Hevo and the Development Group Zuiderpark. The developers created a large complex with the original shape of the old pool, which now houses an indoor pool, a police station and a large bowling alley. The swimming pool complex includes a competition pool, instruction pool, recreational pool, outdoor pool and two (small) children's pools.

As of 1st January 2000 the Dutch government regulations in force demand that new swimming pools have an Energy Performance Coefficient (EPC) of 2.2. The lower this coefficient, the higher the energy-saving performance of the building. The department of Education, Culture and Welfare of the Municipality of The Hague requires the energy efficiency of new buildings to be 15% better than that laid down by the national legislation. The Zuiderpark swimming pool achieves an Energy Performance Coefficient of 1.6. With this, it even saves 30% more energy than other swimming pools complying with the legal standard. This was achieved by implementing several packages of energy-saving measures. This also included the use of a renewable energy source, namely a solar thermal system, to supply hot water.

The project serves as a demonstration project for the "National Sustainable Building Package". This package comprises a broad range of energy-saving measures for the built environment and their beneficial environmental effects.

Description

The Zuiderpark swimming pool uses a solar energy system to produce hot water for the showers. The system consists of 26 solar collectors with a total surface area of 100 m^2. It was built on the roof, which was the optimal location given the archtectural design of the building and its orientation towards the sun. The solar energy is buffered in insulated tanks in the plant room. For heat generation, the building also uses a high-efficiency gas-fired boiler in conjunction with a combined heat and power (CHP) system and a heat pump. The CHP installation also produces electricity which is for use by the swimming pool complex.

Energy and water efficiency measures have been implemented throughout the complex. These include a Cantherm system heat wheel by which 90% of the heat in the exit air can be reused. Furthermore, all the air-conditioning systems are equipped with heat recovery. For central heating of the building, a low-temperature system (40-60ºC) is used to reduce the energy demand. The electricity need is reduced by implementing, among other things, high-frequency fittings for lighting and sensors indicating the presence of people combined with automatic shut-off systems for lighting and water pumps.

Additionally, the building is very well insulated. This includes walls, floors, the roof and windows. The use of insulation means less heat is lost, thus reducing the energy demand of the swimming pool. The insulation materials used on the walls and floors are of a type that does not absorb water and has a high vapour density to ensure they keep their insulating properties. The curved roof, facades, floors and the support structure of the pools have an insulation value (Rc-value) of between 2.5 m^2K/W (support structures) and 4 m^2K/W (curved roof).

Besides the energy use, the water use of the building has also been minimised by means of a cascaded water purification system. After filtration, the rinse water for cleaning the swimming pools is reused as swimming water. When the water is filtered once more, part of the water is used for the toilets. Another part is transported to the membrane installation, where it is cleaned again for reuse as swimming water.

All the equipment in the swimming pool is monitored by a building management system. This enables energy use to be monitored and controlled.

Promoters and parties involved

- Municipality of The Hague: owner of the swimming pool
- Hevo: construction management company; project development
- Hellebrekers Technologies: advice, feasibility study and implementation
- Gesman: building company
- Atelier Pro: architect
- DHV: consultancy and engineering company; advice and control

Financial resources

The total investment for the Zuiderpark swimming pool was approximately €10 m. The cost of the fifth package of energy-saving measures, in which the solar thermal system was included, was about €950,000. The cost of the solar thermal system was about €51,000.

The project received €90,756 from the Energy Saving Implementation Plan of the municipality of The Hague. Additionally, the Ministry of Economic Affairs provided a grant of €226,890. The City Council of The Hague financed €635,292 of the investment costs. Energy company Eneco contributed another €45,378.

Results

The package of energy-saving measures was commissioned one or two years after the turnkey contract for the development of whole complex had been signed. This led to additional costs due to both the energy saving measures themselves and adjustments to the technical design and calculations. During the long period between signing the contract and opening the swimming pool, new insights and developments took place in innovative technologies, which led to technical adjustments that had not initially been planned for. This problem was solved through the necessary agreements and an additional budget.

The Zuiderpark swimming pool uses 30% less energy than the regulatory limit under Dutch law on energy and water saving measures. These measures result in a 70% lower electricity demand (500,000 kWh), a 55% lower use of natural gas (170,000 m^3), and a 35% lower water use (24,000 m^3), compared to the national standards. With this, it contributes to a reduction in fossil fuel use for energy generation and emissions. Moreover, because the Zuiderpark swimming pool produces its own chlorine, road transport of dangerous substances is avoided.

Potential for replication

The municipality of The Hague sets itself ambitious goals for the building of energy-efficient and sustainable buildings. However, for the development of a new low-energy and sustainable building, the lessons learnt from the development of the Zuiderpark swimming pool should be taken into account.

First of all, the targets for a sustainable and energy-efficient building need to be clearly set out right from the beginning of the development process and in the commissioning of the building project. Moreover, it is sensible to include a sufficient budget for additional work to achieve cost savings.

The Zuiderpark swimming pool is used for various target group activities, such as swimming for senior citizens and match sports. These different activities can require variations in the water temperature of several degrees. If this is the case for a future project and if the swimming pool is well insulated, it should be investigated whether the water can be cooled naturally or whether additional technical measures need to be implemented.

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Sector: Solar Thermal and Solar Photovoltaic
Country: The Netherlands
Location: Zaandam
Year: 2000

ZAANDAM, BRANDARIS APARTMENT BUILDING

The 14-storey Brandaris building in Zaandam is a high rise block of 384 flats. The building, which was constructed in 1968, has long facades facing east and west. In order to adjust the apartment building to the current market demands, it needed to undergo radical improvements, however, instead of demolishing the building, the Patrimonium Housing Association decided to renovate it. This renovation was combined with the implementation of energy saving measures and the use of solar energy to supply the flats with power.

A new collective heating system was installed to replace the existing individual boilers and the complete installation was renovated. This old installation had suffered from a number of problems, such as low comfort and indoor air quality and poor control of mechanical ventilation and space heating. This resulted in high energy use. Now a solar boiler feeds the new heating system from a large collector area mounted on the flat roof.

Before starting the project, a considerable amount of research had been done to determine the right technical specifications of, for example, the solar boiler, collector installation, glazed balconies, and transparent isolation materials. Exchange of information at a European level has also led to new insights and applications at the Brandaris building.

The building serves as a National demonstration project for Sustainable and Energy-efficient Building and is also part of the Thermie programme of the European Commission (SHINE).

Description

A total of 278 solar collectors were installed on the roof of the block of flats These consist of a 0.2 mm thick black copper plate absorbers under a panel of glass. Water heated in the collectors flows to a large storage tank on the ground floor via 10 mm pipes. Copper was chosen instead of steel because of its higher thermal conductivity and lower susceptibility to corrosion. Furthermore, the material is easy to process. Four storage tanks serve as the heat buffer of the system supplying hot water and space heating.

The solar boiler provides about 10% of the energy demand for both domestic hot water and space heating. If there is not enough solar energy to heat the water over 60°C, a Combined Heat and Power (CHP) installation and four gas-fired boilers are used.

The rooftop pavilion, which gives visitors a good overview of the installation and the surrounding area, is powered with PV cells.

New glazed balconies improve both the appearance of the building and indoor comfort. They are also an attractive option to save energy and provide sheltered outdoor space. Low-energy glazing is used to replace the existing single glazing to save energy.

The whole construction can be broken down very quickly. Moreover, the collectors are easily dismantled and can be recycled completely.

Project characteristics

Total solar collector area [m^2]	760
Total PV area [m^2]	30
Installed PV capacity [kW_p]	3
Installed CHP thermal capacity [kW_{th}]	1,000
Installed boiler thermal capacity [kW_{th}]	3,100
Total storage volume [m^3]	40

Promoters and parties involved

- Patrimonium Housing Association Amsterdam: promoter and owner
- W/E Consultants Sustainable Building: consultant
- ERA Bouw BV: main contractor
- Hans van Heeswijk: architect
- Cees Vellekoop: architect
- Feenstra West: installations
- Zonne-energie Nederland BV (AGPO/ZEN): producer of the solar collectors

Financial resources

The total investment for the project came to about €12.5 m, of which most was financed by the Patrimonium housing association. For the innovative parts, the project received a subsidy of 802,546 ECU from the European Commission within the framework of the Thermie programme.

The payback time for the project is estimated at 10-15 years.

Results

The project was finished within a period of approximately 2 years. The implementation went well (more details on this will be published in an evaluation report by the end of 2002).

The annual heat production of the project totals 320-350 kWh/m^2 a year. This means the whole collector area produces between 243 and 266 MWh a year. The PV system produces about 2500 kWh of electricity a year.

The total energy conservation resulting from the energy saving measures and the use of solar energy is about 50%. This means about 425 m^3 of natural gas for space heating and domestic water supply is saved per flat per year. This leads to an estimated reduction of the energy bill of €150 a year.

With this project, about 400 GJ of fossil fuels is substituted. Furthermore, the project results in a reduction of CO_2 emissions by 275 tonnes a year. Other beneficial effects include improvement of the domestic environment and re-use of an existing building. Moreover, the project combines an extension of the life span of the building by at least 20 years with a reduced environmental burden.

Potential for replication

The project succeeded in its integrated approach. It combined stringent reduction of energy demand and use of passive and active solar energy with a standard renovation of a building at relatively low additional cost. Solar boilers appear to be a good alternative to individual boilers in current collective installations and/or open kitchen boilers. The Brandaris project thus shows new opportunities for other existing buildings.

As a follow up, Patrimonium Housing Association Amsterdam and W/E Consultants Sustainable Building initiated the Regen-Link project (for more information: www.regen-link-org), including a new renovation at the Brandaris scale in the Bijlmermeer in Amsterdam, taking the lessons learned a step further.

For more information

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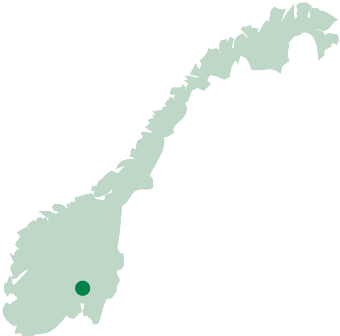
Photo by Hans Pattist/Novem

Sector: Solar Thermal, Active and Passive
Country: Norway
Location: Oslo
Year: March 2000

ENERGIE



ECOLOGICAL BUILDING IN OLD DISTRICT IN OSLO

The project aims at implementing and demonstrating new and innovative solar-based technology for new urban housing - a family apartment complex with 35 units - in the older parts of Oslo. Besides the energy related aspects, the demonstration project has focus on logistical aspects of urban ecology such as: optimisation of materials, indoor climate, simplified building details, water saving and -cleaning installations, reuse of ecologically cleaned water, garbage sorting, and greening of outdoor areas. This means that also the impact on the environment will be significantly reduced.

The Klosterenga housing co-operative is located in a part of Oslo called Gamlebyen (Old Town). As a part of an urban revitalisation project, USBL wished to establish a housing co-operative with an ecological profile. USBL was given the responsibility of the northern part of Gamlebyen with totally 900 apartments, and the inhabitants of Gamlebyen voiced their opinion about the plans. The planning of Klosterenga began at the end of 1995. In the spring of 1999, the complex was completed – six-storey high with 35 apartments.

Highlights

Description

- Designed for utilisation of passive solar energy
- Active solar energy system
- 127 kWh/m^2 annual energy consumption with a fair opportunity to reach 105 kWh/m^2
- Grey-water purification in backyard

Energy efficient buildings normally have an annual energy consumption of 140 - 180 kWh/m^2. Because of the favourable orientation to the south, the aim for Klosterenga was set to 100 kWh/m^2.

Description

The building itself is formed like a solar collector for the optimisation of active and passive solar energy systems. Rooms that need to maintain a high, stable temperature were placed in the middle (kitchen and bathroom), and rooms that are normally kept at lower temperatures were orientated to the north. Rooms for which a variable temperature is acceptable were orientated to the south (living-room).

The active solar energy system consists of 240 m^2 water based solar collectors installed at the rooftop. This solar system produces 75.000 kWh/year. The total energy consumption for heating is 195.000 kWh/year, and for hot water consumption is 105.000 kWh/year. Hence, the solar collectors deliver 25 % of the required energy for heating and hot water consumption throughout the year. In the three summer months, the solar collectors deliver enough energy for heating and hot water consumption.

The heat is stored in 15 m³ water tanks before it is distributed to the apartments through a low-temperature waterborn floor heating system. Individual energy meters are installed in each apartment.

The southern façade is double-glazed and provides passive pre-heating of the ventilation air. A Venetian blind between the double-glazing ensures shading and better control of the indoor climate, in addition to passive preheating of ventilation air during spring and autumn.

Annual energy production, solar collector [kWh/m²]	20
Annual energy consumption [kWh/m²]	127

Measures have been taken to reduce construction and operating waste. Water-saving installations have been installed in bathrooms and kitchens, and every apartment has equipment for measuring heating consumption. The grey water is purified in the backyard. The purifying system includes park elements (sculptures etc.) and rainwater. After the cleansing, the water flows into the garden. To ensure the quality of the indoor climate, the building is equipped with individually controlled balanced ventilation. In addition, bricks used in walls give breathing and moisture-controlled construction.

The solar collector consists of two twin-wall sheets of high temperature resistant plastics, fixed in an aluminium frame. The absorber has a channel structure to distribute the circulating water. The cover shield lets light through, but isolates from heat loss through radiation and convection.

The solar radiation is converted to heat in the absorber sheet. Pure water is trickling through a channel structure, absorbs the heat, which is deposited in the absorber and carries the heat to a heat store. The solar system is operating automatically by means of a pump controller. In periods without possibility for solar harvesting, the controller stops the circulation, and the liquid in the collectors is draining away within few minutes.

As part of the fourth frame programme of EC named SUHN/SHINE, the results are spread throughout the network of EHEN in Europe.

The project was one of two Norwegian projects in Green Building Challenge in Vancouver, Canada in 1998, it is presented in the book Housing Project of the Century in Norway, it was presented as the winning project 2000 of the Nordic NBO Environmental Price, it was presented at Sustainable Building 02 in Oslo in September 2002, and it is documented as a part of the CADDET-presentation in 2002.

There have been visits at the project by more than 500 specialists within construction and housing in the period 1999-2002, and a lot of articles have been published in reviews for specialists and in magazines.

Promoters and parties involved

USBL; Organizing and finansing

GASA Architects AS; Development architect

Arktitekskap Development, architect

SolarNor AS; Solar collectors

Grindaker AS; Backyard/ purifying system

The Norwegian Agricultural College (NLH); Backyard/purifying system.

Financial resources

The total investment of the project is €7,5 m.

The project is partly an R&D-project to document effects of the features. The project has received in total €780.000 in subsidies from different sources – covering part of the R&D-costs of the renewable energy and the other features in the project:

It is supported by grants from EC through EHEN within the fourth frame program with €200.000, The Norwegian State Housing Bank with €170.000, The Municipality of Oslo with €170.000, The Norwegian Research Council with €100.000, E-CO Partner (previous Oslo Energi Enøk) with €70.000 and The Norwegian Water Resources and Energy Directorate (NVE) with €70.000.

The costs of this building are 15 – 20 % higher than the reference building at the nearest site. The value of this is partly lower maintenance costs, better living conditions and lower load to the environment.

The different features have a payback time from 5 to 20 years. The solar collector has a payback time of 15 years.

Results

The monitoring report shows that the energy-savings are close to the budget for single occupied apartments – 104 kWh/m² yr, but slightly higher than expected for apartment occupied by 3 persons (128 kWh/m² yr). It is also observed that the indoor temperature is higher than expected, and this of course affects the energy consumption. Total energy consumption was estimated at 104 kWh/m² yr in the budget.

Monitoring also shows that the double-glazed wall works as predicted, both concerning heating and shading.

The reduction of the energy bill is appr. 30 %. The indoor climate is significantly better than in comparable apartments, and will reduce infections and diseases related to respiration.

This project gives the area a social lift with its new good-quality standard apartments with a high profile concerning urban ecological solutions.

Potential for replication

Because most of the issues are a result of architecture integration, architects use the “systems” and general approach widely in new projects at the moment. The monitored results are very important as documentation when discussing ecology in new projects with other clients. The combination of low temperature floor heating systems and double glazed walls are widely accepted as a smart solution in both residential and office projects, due to the results documented in the Klosterenga project.

For more information

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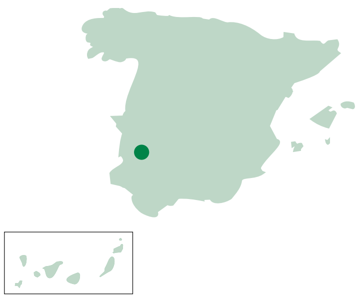
Sector: Solar Thermal
Country: Spain
Location: Badajoz (Extremadura)
Year: November 2000

ENERGIE



SOLAR-THERMAL SYSTEM AT THE EL RAPOSO SPA

The El Raposo health resort was built in 1922 to exploit the medicinal mineral waters from springs on the site and it was declared to be of "public utility" in 1926. With a view to offering improved and more competitive services, the operating company Herederos de Antonio Cortes SCR decided to install a solar heating system to produce hot water for use at the spa and thereby reduce diesel usage.

Description

The system comprises a solar collector array of 150 flat solar panels, with a south-facing useable surface area of 315 m^2 sloping at 30º to the horizontal. The storage system comprises five 5,000 litre tanks, a forced circulation system with an independent heat exchanger, auxiliary energy system and a remotely controlled electrical system for control and monitoring the performance of the system.

Energy data:

Design values:

Solar panel area:	315 m^2
Usable annual solar power:	188.122 kWh
Energy demand:	253.431 kWh
Fuel substituted:	18.54 toe
CO_2 emissions avoided:	166 tonnes
Technical details:	
Unit:	Solar collector
Manufacturer:	Made
Model:	4,000 E
Unit:	Storage tank
Manufacturer:	Lapesa
Model:	LPR-5,000
Unit:	Heat exchangers
Manufacturer:	Alfa-Laval
Unit:	Water circuit
Technology:	Disol

Promoters and parties involved

Owner: Herederos de Antonio Cortés SRC, a company whose main business is the establishment providing hospitality services and thermal waters.

Financial resources

Investment in system:	€127,286
Own resources:	€61,025
Investment subsidies:	
Outright grant from PGE/Junta Extremadura:	€19,878
ERDF/IDAE:	€46,383

Results

As the installation is fitted with a remote monitoring system it has been possible to evaluate its energy performance. This has been found to be better than the design values, with an increase of 12.1% in the energy demand and 19.48% in the energy supply. Work is therefore underway to expand the system so as to make use of the excess thermal energy to offer new services at the spa (swimming pools, cafeteria, etc.)

Potential for replication

The positive experience acquired in the implementation of this project makes implementation of other similar installations among the large number of spa resorts in Spain a real possibility.

For more information

Consejería de Economía, Industria y Comercio (Board of Economy, Industry and Commerce). Junta de Extremadura (Extremadura Regional Government).
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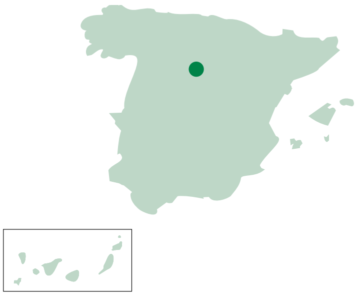
Sector: Solar Thermal
Country: Spain
Location: Palencia (Castilla y León)
Year: 1999

ENERGIE



"SAN JUAN DE DIOS" HEALTH CARE CENTRE

The San Juan de Dios health-care centre is located near Palencia, within the boundaries of the city's municipal district.

Its function is that of a psychiatric care centre and residential hospital. It also provides treatment for drug addicts, including detoxification and social integration through programmes run in the therapeutic community.

The centre has a capacity for 600 patients and is fully occupied all year round given the nature of the service it provides.

The object of the installation implemented is the production of hot water using a low-temperature solar-thermal system, so as to partially replace the use of conventional energy sources, thereby reducing operating costs and using a source of energy which is both clean and renewable. The hot water produced is used in a number of the services provided by the centre, such as showers, treatment areas, kitchens, etc.

Description

The installation has been designed to heat cold water taken from the water mains, raising its temperature by between 27 and 35ºC so as to bring it up to a useable temperature of 45ºC.

The previous installation consisted of conventional boilers running on gas oil C, and a storage system with a capacity of 45,000 litres. The overall efficiency of the conventional hot water system is estimated to be 70%.

The average daily usage of hot water at 45ºC is 50 litres per person a day. Bearing in mind that the average annual occupancy remains constant at 600 persons (450 in the San Rafael zone and 150 in the Sagrada Familia) and usage by the kitchens and other services is 15,000 litres/day, the average daily hot water consumption is 45,000 litres/day. This remains constant throughout the year, thus total consumption is 16,425 m^3. The annual energy requirement to heat this volume of water is approximately 515,529 therms.

The average daily solar radiation incident on a horizontal surface in the location where the installation is sited is 3.97 kWh/m^2.

The installation comprises a primary circuit in which the heat transport fluid circulates, and a secondary circuit to which the fluid transmits its heat via a heat exchanger. The secondary circuit stores the hot water produced for subsequent use. The main characteristics are:

Capture system and primary circuit:

The capture system comprises a total of 318 flat panel solar collectors, making up a useable collector surface of 667 m^2. The panels have been installed on the roof of one of the buildings at the health-care centre, and two metal structures similar to those already existing have been added to support the full set of panels.

The 318 solar collectors have been divided between three structures (with 180, 117 and 21 panels) with groups of six collectors each, connected in parallel, with a row spacing of 1.60 m. The panels face magnetic south and have an inclination to the ground of 45º to achieve maximum solar energy capture efficiency during the winter months.

The four existing rows of panels are gradually being raised to prevent them from shading the other panels and to improve the integration of the installation with the architecture of the building.

Galvanized steel supporting structures have been used and have been anchored to structures fitted on the roof of the building.

The primary circuit is completed with a circulation pump, heat exchanger, pipes, connection fittings, insulation and a 500-litre expansion vessel.

Storage and distribution system:

The hot water storage system for the solar installation consists of 3 existing tanks located in the boiler room, each with a capacity of 6,000 litres, to which have been added a further two tanks with a capacity of 4,800 litres. The total storage capacity is therefore 27,600 litres.

Temperature sensors have been fitted in a number of locations: at the water intake from the mains supply; at the outlet from the solar storage system; at the outlet from the conventional water tank; in the collector array; at the bottom of the solar storage tank; and, at the inlets and outlets to and from the heat exchanger.

The secondary circuit is completed with the distribution system, including a circulation pump, heat exchanger, pipes and fittings.

Regulation and monitoring system:

The operation of the system is controlled by a regulation and monitoring system. A system has also been installed to enable remote monitoring and control of the parameters describing the installation's operation.

Promoter and parties involved

Finance for the project was provided by the Institute for the Diversification and Saving of Energy (Instituto para la Diversificación y Ahorro de la Energía, IDAE) through a third-party finance contract with the Orden Hospitalaria San Juan de Dios. The Castilla-León Regional Energy Agency (Ente Regional de la Energía de Castilla y León, EREN) and the supplier (MADE) also took part in the financing of the investment through a "participation account".

Financial resources

The investment took the form of a third-party finance (TPF) operation, the main details of which are:

Investment:	€213,292
Energy Saving and Efficiency Plan (PAEE) subsidy:	€142,410
Maintenance cost (% of production):	4%.
Energy production:	368,555 therms/year.

The Castilla-León Regional Energy Agency (Ente Regional de la Energía de Castilla y León, EREN) and the supplier (MADE) provided 40% and 20% of the investment, respectively.

Results

a) In energy terms

- Installation of one of the largest solar installations for the production of hot water in Spain in recent years (677 m^2).
- Optimization of the design of the installation.
- Guaranteed correct operation.

b) In environmental terms

- Utilization of a renewable energy source, using a non-depletable and environmentally friendly resource.
- Improved environmental impact resulting from the energy saving and emission reduction of around 350 tonnes of CO_2 avoided each year.

c) In economic terms

- The third-party finance formula, in conjunction with the participation to differing extents of the regional energy agency and the supplier through a participation account has made it possible to maximize the involvement of all the parties in such a way as to optimize implementation of the project.
- The San Juan de Dios health-care centre will obtain a reduction in its energy bills and once the investment has been recouped, it will own the installation.

Potential for replication

The positive experience from this project makes the implementation of other similar installations by various health centres and hospitals in Spain a real possibility.

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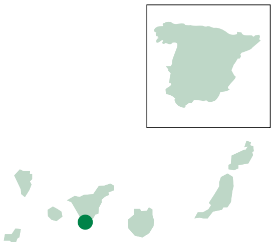
Sector: Solar Thermal
Country: Spain
Location: Tenerife (Canary Islands)
Year: 1998

ENERGIE



TENERIFE SUR APARTMENTS

The “Tenerife Sur” apartments are located in the Playa de los Cristianos tourist area in the municipal district of Arona (Santa Cruz de Tenerife), on the south side of the island of Tenerife, less than 15 km from Reina Sofía international airport.

The complex includes 216 apartments, each with an independent double bedroom, full bathroom, kitchenette and lounge dining-room. The building has a capacity for a maximum 590 people. At the complex guests can enjoy a heated fresh-water swimming pool, children’s pool, sauna, squash courts, games room, restaurant, snack bar and supermarket.

The installation is intended to meet the hot water needs of the Tenerife Sur apartments by means of a solar-thermal energy system, which partially replaces the use of conventional sources of energy.

Description

The installation has been designed to heat cold water from the water supply in such a way as to increase its temperature by between 20ºC and 25ºC, prior to its use at a temperature of 45ºC.

The installation it replaced was highly inadequate and consisted of a heat pump with a heat output of 76,000 kcal/h, a conventional propane boiler with an output of 30,000 kcal/h and a hot water storage system.

On the basis of the average annual occupancy rate, hot water usage varies between 53.1 m^3/day in February and 38.2 m^3/day in July. The total annual hot water usage is 16,000 m^3/year, which determines the maximum energy needs for heating this volume of water, which comes to a total of 400,000 therms/year.

The installation comprises a primary circuit in which the heat transport fluid circulates, and a secondary circuit to which the fluid transmits its heat via a heat exchanger. The secondary circuit stores the hot water produced for subsequent use. The main characteristics of the system are:

Capture system:

The capture system comprises a total of 145 flat panel solar collectors, making up a useable capture surface of 246.5 m^2.

The collectors have been installed on the flat roofs of two of the buildings in the complex, where they are not affected by any shade and are at a height of approximately 15 m above the boiler room.

Galvanized steel supporting structures have been used. These are firmly anchored to the building and are able to withstand winds of up to around 100 km/h.

The panels face magnetic south and have an inclination to the ground of 35.5º to achieve maximum efficiency of solar energy capture during the winter months.

Primary circuit:

To form the primary circuit the collectors have been divided up into 29 groups of five collectors each, connected in parallel with inverted outlets to balance their flow rates and efficiencies. The rows are spaced at a distance of 1.60 m.

The primary circuit is completed with a circulation pump, heat exchanger, pipes, connection fittings, insulation and a 100-litre expansion vessel.

Storage and distribution system:

The hot-water storage system used in the solar installation consists of 3 adequately insulated storage tanks giving a total storage capacity of 15,000 litres.

Temperature sensors have been fitted at the water intake from the mains supply and at the outlet from the tank.

The secondary circuit is completed with the distribution system, including a circulation pump, heat exchanger, pipes and fittings.

Regulation and monitoring system.

The operation of the system is controlled by a regulation and monitoring system. A data gathering system has also been installed so as to enable remote monitoring of the parameters describing the installation's operation.

Promoters and parties involved

The Institute for the Diversification and Saving of Energy (Instituto para la Diversificación y Ahorro de la Energía, IDAE) participated in the financing of the project, which was managed by the Instituto Tecnológico de Canarias (ITC), through a participation account in which the supplier of the installation (PROCALOR, S.L.) also has a stake. The percentage shares of ownership of the participation account are: 40% owned by the ITC, 40% by the IDAE and 20% by PROCALOR.

Financial resources

The investment took the form of a third-party finance (TPF) operation, the main details of which are:

Investment:	€ 78,023
Energy Saving and Efficiency Plan (PAEE) subsidy:	€ 50,773
Maintenance cost (% of production):	8%.
Energy production:	147,000 therms/year.

The third party finance contract will remain in effect until total output has reached 1,473,375 therms, at which point the involvement of the IDAE and the other participants will cease and the installation will become the property of the client.

Results

a) In energy terms

- Implementation of a solar installation for the production of hot water, fully integrated with the establishment's energy system.
- Optimization of the design of the installation.
- Guarantee of correct operation.
- According to the dimensioning of the system the installation's energy output will be 147,000 therms/year, implying 37% (solar contribution) of total energy requirements.

b) In environmental terms

- Utilization of a renewable energy source, using a non-depletable and environmentally friendly resource.
- Improved environmental impact resulting from the energy saving and emission reduction of around 56 tonnes of CO_2 avoided each year.

c) In economic terms

- The third-party finance formula, whereby the regional energy agency, the IDAE and the supplier each provided differing percentages of the overall finance, has ensured the full involvement of all the parties, thus enabling optimal implementation of the project.
- The company operating the holiday complex will obtain a reduction in its energy bill, and when the investment has been recouped, it will become the owner of the installation.

Potential for replication

The positive experience from this project makes the implementation of other similar installations among the numerous hotels on the Canary Islands and elsewhere in Spain a real possibility.

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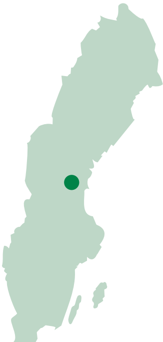
Sector: Solar Thermal and Biomass
Country: Sweden
Location: Fränsta
Year: 1999

ENERGIE



RE-HEATING USING SOLAR POWER AND BIO-FUELS IN FRÄNSTA

Fränsta is a rural community of around 3000 inhabitants located in the municipal district of Ånge. It is situated approximately 70 km west of Sundsvall. The community has developed a vision of sustainable ecological development in co-operation with the regional Energy Office of Västernorrland. Education is also one key element in the regional development and, for example, the Mid Sweden University runs courses in environmental building design. The primary energy sources used in Fränsta are electricity, oil and bio-fuels, where the electricity is produced in hydropower plants from the nearby river of Ljungan. To achieve increased use of renewable energy sources new technology is required and the community of Fränsta was planning to rebuild the entire district heating network in the mid 1990's. One initial objective was to convert the district heating network in Fränsta from fossil fuel to a combination of bio-fuels and solar power. One common type of bio-fuel is wood pellets, and this was also the choice for the new RE-heating plant in Fränsta.

Description

In all 1,650 m^2 of collectors have been installed, of which 1,250 m^2 takes the form of conventional flat panel collectors and 400 m^2 that of concentrating collectors (MaReCo). The system also includes a 2 MW bio-fuel boiler. The system solution is flexible and it can easily be expanded if the energy demand increases. The system is organised in a decentralised way with the collectors placed on the roofs of the houses with best orientation. The delivered energy is then fed into the district heating network that connects all the users. Ånge buys the heat through a "Ready Heat" deal whereby customers pay the actual amount (kWh) of heat they receive, which is provided by a mixture of solar and bio-fuel heat. The central heating plant and the decentralised solar heating systems can be controlled with remote control in a cost-effective solution.

Promoter and parties involved

The municipality of Ånge and the Västernorrland Energy Office were the initial promoters. The utility Vattenfall AB owns the Fränsta heating plant and the roof integrated solar collectors. The district heating network is owned by Ånge Energi AB. A further participant is Ånge Fastigheter AB, which owns the buildings in central Fränsta.

Financial resources

Fränsta is a rural community with limited financial resources. The municipality of Ånge does not give economic support, but does promote and guide the development of RES within the community. In the case of the Fränsta project the financial solution was to let Vattenfall AB erect the plant as a “Ready Heat” deal. This means that Vattenfall finances the plant and the community pay for each kWh delivered over the 15-year investment period. If plant is still operational at the end of that period, there is an option for the municipality to extend the contract.

- Total investment €1.5 m.
- A subsidy was given for 50 % of the solar investment. The investment was co-financed by the Swedish National Energy Administration and Vattenfall AB.
- The payback period for the complete district heating plant is calculated at 15 years.

Results

- The new technology with decentralised solar heating systems connected to a district-heating network did encounter some initial problems with the controller system for the “virtual solar heating plant” network. This was solved during the first year of operation.
- In total the annual load on the district heating network is 10 GWh and the solar heating system is dimensioned to supply 100% of the load during the summer months, which accounts for 10-15 % of the annual load in Sweden.
- The specific cost of solar heating is €0.08 per kWh.
- The cost of bio-fuel heating is €0.035 per kWh.
- Socio-economic benefits in the area are increased interest in renewable energy and increased awareness of environmental issues.
- The main environmental benefits are reduced emissions, and a reduced requirement for fuel transport (when the system combination of “bio-fuel plant” and “solar + bio-fuel plant” is compared).

Potential for replication

The feasibility of replicating the project at other sites with district heating systems is generally good. The solar collectors can be erected on carefully selected, appropriately oriented buildings, while enabling all the solar heat output to be available to all buildings connected to the district heating system. The specific hydraulic system used in the district-heating network should be of the low temperature type.

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Photo by Margareta Olsson, Vattenfall, SwedPower

Sector: Solar Thermal and Biomass
Country: Sweden
Location Kungälv
Year: March 2001

ENERGIE

LARGE SCALE SOLAR HEATING PLANT IN KUNGÄLV

The specific aim of the project is to demonstrate a full-scale solar district heating application comprising a large ground-mounted collector array using large-module collectors with improved components. The general aim is to promote a wider utilisation of renewable energy sources, in particular solar heating applications, by improving thermal efficiency of common solar collectors.

The collector modules are designed with a new, more efficient and durable absorber and a new anti-reflex coated cover, both produced in environmental friendly processes and together increasing the thermal efficiency by up to 10% compared to existing collector modules with a common absorber and ordinary solar glass.

Description

The project has been implemented in Kungälv, a small city of about 20,000 inhabitants situated about 25 km north of Göteborg. The solar heating plant has been sited on land close to the Munkegärde district heating plant. The used land area has poor soil and was previously used for farming.

The installation comprises a solar heating plant with 10,000 m^2 of solar collectors (design power 5,000 kW) connected to an existing district heating plant with a design power of about 30 MW. The solar heating plant has been implemented under a turnkey contract including improved components based on experience from similar but smaller installations.

The Munkegärde district heating plant was set up in 1997 to replace nearly 40 local (oil) heating plants. The present annual heat load is about 100 GWh and the heat distribution system will be expanded to cover a larger load over the next few years. The heating plant was initially equipped with three boilers, one 12 MW wood chip boiler (including heat recovery from the exhaust gases), two 12 MW oil boilers and buffer storage holding 1,000 m^3 of water. The solar system was connected to the district heating plant primary circuit in 2000. A new 12 MW wood chip boiler was installed in 2001.

The ground-mounted solar collector array comprises an anti-freeze mixture (40% glycol including corrosion inhibitors and 60% water) and is connected to the heating plant via a heat exchanger. In most cases solar system heat exchanger, pumps, valves, expansion vessels, meters, etc. are placed inside the heating plant. Here, the equipment is placed in a small 'solar building' directly connected to the heating plant due to lack of space in the heating plant itself.

The solar collector array is situated on a plot of land about 300 m north of the district heating plant. The collector array is divided in three sub-arrays in order to fit into the plot available.

In total there are 800 collector modules with 12.5 m^2 aperture area comprising a total of 10,000 m^2 of collector area. The innovative part is that the collectors are equipped with a new sputtered absorber and anti-reflex coated glass for improved thermal efficiency.

The new collector is equipped with a new sputtered absorber from Sunstrip AB with 95% solar absorption and 12% emission, which is slightly lower than that previously achieved, which was about 15% when an electro-chemical process was used. The sputtered absorber has since been further improved to 96% solar absorption and 7% emission. The new collector is also equipped with an anti reflex coated glass from SunArc A/S, which will improve transmission by about 4% making the overall thermal efficiency of the collector to be improved by 8-10%.

Dissemination activities

The project is presented in the ENERGIE publication Solar Heating Plant- 5,000 kW, Doc. No. REB 266/98, Ver.3-June 2002, and on the Internet at:

www.hvac.chalmers.se/cshp/kungalv_eng.htm.

Partners in the project held an oral presentation at EuroSun 2000.

The project will be presented at ISES Solar World Congress 2003 (International Solar Energy Society, www.congrex.com/ISES2003) in June 2003. Furthermore, the project is presented at the list of European large scale solar heating plants on the Internet,

www.hvac.chalmers.se/cshp,

and by the International Energy Agency's CADDET http://www.caddet-re.org/assets/RENL1_02.pdf)

Promoters and parties involved

Company	*Part in project*
CIT Energy Management AB	Project management
ARCON Solvarme A/S	Project management, solar collectors
Sunstrip AB	Project management, absorbers
Kungälv Energi AB	Project management
AFG Industires Inc.	Glass
SunArc A/S	Anti-relex coating
Alfa Laval Sverige AB	Heat exchanger
Grundfos AB	Pumps

Financial resources

Total investment:

The total investment was €2,730,000 (273 €/m^2 collector area).

Subsidy:

The project is part of the European Union's Fourth Framework Programme for Research, Technological development and Demonstration (RTD). The European Community (Directorate-General for Energy and Transport) provided subsidies of €459,000 and the Swedish government provided about SEK 3.7 m (€406,000).

Source of revenue:

The solar collector is delivering heat to the district heating plant.

Pay-back period:

The payback period for the project has been calculated at 15 years.

Results

The project can be considered a success in general terms. It has been implemented in accordance with the project description without any unexpectedly good or bad performance from the components.

The attention focused on the use of anti-reflex coated glass in the project has contributed to a considerable increased use of anti-reflex coated glass in ordinary solar collectors.

Energy production

During 2001 the solar system produced 2.8 GWh of heat. Estimates show that in 2002 the solar collectors should produce close to 4 GWh.

Environmental

The main positive environmental impact due to the solar heating plant is here reduced emissions of CO_2 through substitution of fossil fuels corresponding to 3,000 MWh or 850 tonnes of CO_2 per year.

Financial

Large-scale solar heating is not yet commercially competitive, but the project has improved the possibilities of making the technology commercially viable in the near future.

Potential for replication

The implementation of the solar heating plant in Munkegärde, Kungälv, has once more shown that it is possible to apply solar heating to an existing district heating plant based on the same requirements as other district heating components without any major problems.

Calculations done for the project show that a wider use of the technology would make it possible to reduce the total investment to well below €2 m and thereby reduce the payback period to 10 years.

For more information

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Sector: Solar Thermal
Country: U.K.
Location: Leicester
Year: 1998

ENERGIE

PHOENIX HOUSE

The aim of the project was to use solar energy to meet the energy needs of Phoenix house (which is one of the Leicester City Council´s larger office buildings and is the workplace for around 140 people).

Due to the high cost of maintenance of the boiler and in order to reinforce the 1990 City Council's sustainability commitment (contemplating an increase in the use of renewables, to reduce energy consumption and the city's CO_2 emissions, and to improve some localised air pollution problems) and after a specific study carried out by the Leicester Energy Centre in order to study the existing possibilities, the boiler was replaced by the current one in 1997.

The interesting features of this system include the efficient low NO_x gas-fired boiler and the incorporation of solar collectors.

Description

The main elements of the installation are a 225 kW capacity Viessmann Vertomant low-NO_x gas-fired condensing boiler and 2 m^2 Viessmann DuoSol evacuated-tube solar collector located between the cold- water tank and the boiler. The collector pre-heats the water from 3-10°C (from the mains) to a maximum temperature of 45°. The collector has therefore enabled the boiler workload and gas consumption to be reduced considerably (the boiler supplies water at a temperature of 85°).

An innovative characteristic of this system is the use of the solar collectors to pre-heat water for a condensing boiler.

Additionally, it is worth highlighting that the system is connected to the council's computerised Building Energy Management System (EMS), which monitors energy consumption and water temperature on the council's sites remotely. This system enables data to be obtained from the installation and any anomalies that might occur to be detected.

The following data gives an overall idea of the climatic conditions under which the installation operates (data refer to 1999):

- degree days (basis 15.5°C): 2,063
- annual mean temperature: 10.6°C
- annual total hours of sunshine:1,572

Promoters and parties involved

Manufacturer

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Financial resources

Leicester Council has set up an Energy Capital Fund to pay for the marginal cost of energy-efficient equipment (i.e. the difference in cost between the more energy-efficient equipment and its conventional equivalent) and this installation was included within this funding scheme.

Total cost of this installation amounted to €22,240.

Payback of the extra cost of using this technology instead of a conventional equivalent (amounting to €6,400 was achieved (as demonstrated by the reduction in gas bills) in 2.7 years).

Results

Initially, the installation suffered problems with the temperature of the water pre-heated by the solar collector. After having exceeded 100°C the summer when it started working, it was adjusted to a maximum temperature of 45°C.

The installation is sufficient to meet the hot water requirements of the Phoenix building.

In terms of environmental benefits, it has been estimated that when compared with the use of a conventional installation, the emission of about 18 tonnes of CO_2 is avoided.

Potential for replication

The potential for replication is very high due to the fact the installation has been mounted on a public building thereby ensuring it a high profile and potential for use as an example of “best practice”.

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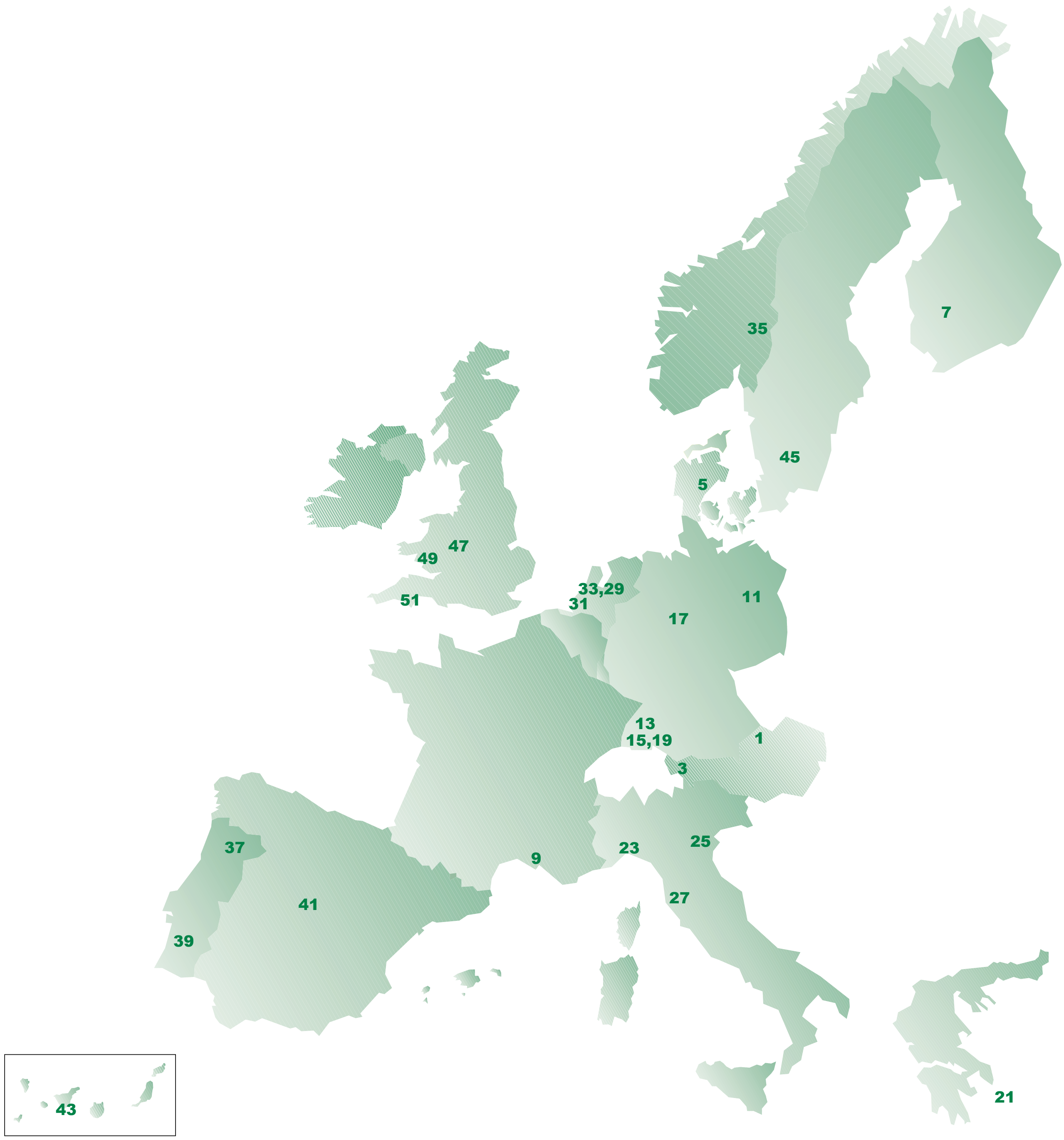
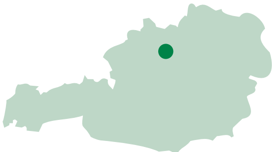
5 SOLAR PHOTOVOLTAIC

ENERGIE



Sector: Solar Photovoltaic
Country: Austria
Location: Linz
Year: 1999

ENERGIE



LINZ, SUNTRACKING PV SOLAR CONTROL LOUVRES AT WIRTSCHAFTSHOF LINZ

In 1994, the city of Linz launched an architectural competition for the new “Wirtschaftshof Linz”. The rules of the competition required the architects to integrate an energy concept right from the initial stages of the design of the new office building.

The aim of this project was to design a building with a low total energy consumption which, moreover, used energy from renewable sources. At the same time, the working environment was to offer optimal conditions of heat and light. The outcome was an energy-conscious architectural design for the building, with solar photovoltaic louvres integrated into the façade. A thermohydraulic drive system was installed to continuously adapt the PV façade to the changing position of the sun and to user demands.

This demonstration project combined a passive thermohydraulic drive system with PV shading louvres and a light guidance function for the first time. The project was awarded the Austrian Solar Energy Award in the cities/municipalities/public utilities category in 2000 run by EUROSOLAR Austria.

Description

The PV plant consists of twelve arrays, each with an output of 1,575 kW, and one array with an output of 1,181 kW. The arrays all have different orientations along the semicircular facade, varying from 70° to 192° from due north.

The cells at the lower end of the façade serve as shading elements. The shading function of the PV modules is completed by sunscreens, which can be adjusted individually. This reduces the air-conditioning load. The upper end of the PV system guides the sunlight, which contributes to space heating and reduces the demand for electricity for artificial lighting.

Thermohydraulic drives are used to enable the PV modules to track the sun. The orientation of the shading louvres is set to match the shading angle. The application of this technology not only gives a better shading function but enables a higher energy yield to be obtained from the façade-integrated PV system as well.

The building has also been equipped with controlled ventilation including heat recovery. This combines high indoor air quality with low heat demand. The solar modules are exposed to air ventilation in front of the façade, which minimises efficiency losses. Furthermore, an overhead slab cooling system was installed, which is run with industrial water.

Project characteristics

PV cells	
Type	Single Crystal
Size [mm²]	125 x 125
Power [W]	2.14
Current [A]	4.5
Voltage [V]	0.476
Total installed power [kWp]	20
Inverter	
Input voltage [V]	120-300 (DC)
Output voltage [V]	230 (AC)
Output frequency [Hz]	50
Inverter efficiency at rated power [%]	93
Inverter efficiency at 10% of rated power [%]	87

Dissemination activities for the project include publication of results of the project in papers and articles in architecture and PV journals, presentations at international PV or architecture conferences, a symposium and a TV report.

Promoters and parties involved

- Linz Service: project co-ordination, financial and technical administration, data acquisition system, and owner of the PV installation
- COLT International: design, engineering and installation of the PV plant including the thermohydraulic drives
- ZSW- Centre for Solar Energy and Hydrogen Research Badem Württemberg: planning and assembly of the construction of the thermohydraulic drives, technical administration, evaluation of data
- TAS-Schreiner: building and daylight simulations
- DI Helmut Schimek: architecture
- Siemens Solar: solar cells
- Fabrisolar: PV modules
- Multi-Contact: plugs and wires
- Mandl + Eckl Stahl- und Metallbau: façade building
- Fronius Schweissmaschinen: inverter
- Schnaidt: materials
- VA TECH ELIN EBG: electric installation

Financial resources

The total investment for the project was initially budgeted at €512,608, but the actual cost came to €587,753 (excluding VAT), of which €104,000 was subsidised by the EU. Linz Service and COLT International financed the additional costs. At the beginning of the project, the payback period was estimated at 30 years.

Results

A series of minor technical and organisational difficulties caused a three-month delay in the installation and commissioning of the system. In addition to component delivery problems, installation of additional electrical (safety) equipment also delayed the project. This equipment had to be added because of different national and international standards and technical guidelines for grid-connected PV power plants laid down by the regional power supplier. During the project, the planned upper light-guiding louvre was omitted and the thermohydraulic drives were adjusted.

The total investment costs for the project were about 15% higher than expected due to additional safety installations, greater demands for the exchange of information, additional tests on the thermohydraulic drives and measurement of the energy balance of the building.

The total electricity production of the plant was 9,025 kWh in 2000. Due to less favourable weather conditions, this was lower in 2001 at 7,556 kWh. This is sufficient to cover 50-60% of the electricity needs of the building. The value of the electricity produced by the PV system is about €1,450 a year. Only about 1% of the generated electricity is delivered to the grid, which yields less than €20 a year.

The shading by the PV modules and the sunscreens creates comfortable thermal conditions. During the winter, the incident solar radiation contributes to space heating. The upper louvre offers high daylight autonomy (above 75%) and thus reduces the electricity demand for artificial light to less than 4 kWh/m² a year.

By producing electricity from solar energy, the installation directly reduces the emissions of CO_2 by 7,200 kg a year. The multifunctional PV modules also reduce energy demand for cooling, heating and lighting. This results in an additional avoidance of CO_2 emissions of 5,000 kg a year.

Potential for replication

The results of the monitoring of this demonstration project, which will be continued at least until the end of 2003, will be of value to other architects and engineers. The energy concept for this office building and also the combined shading device and PV power plant is is a useful model for future buildings. The energy production of this project is 10-20% higher than comparable building-integrated installations.

ZSW (Centre for Solar Energy and Hydrogen Research) is still working on improvements to the thermohydraulic drives, partly on the basis of the experience with the system used in Linz. During the time that the Linz installation has been in operation COLT International and ZSW have built three other integrated PV systems, two of which were also equipped with thermohydraulic drives. Future “Shadovoltaic” installations will need to take optimal orientations into account given the considerable differences in energy yield between the different arrays at the project in Linz.

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Sector: Solar Photovoltaic and Solar Thermal
Country: Austria
Location: Satteins
Year: 1999

ENERGIE

SATTEINS, ENERGIEPARK WEST

“Energiepark West” in Satteins, Vorarlberg, was completed in 1999. The so-called energy park is the first industrial complex in Austria to draw its energy supply almost entirely from renewable sources. The building consists of 1,330 m² of manufacturing space and 473 m² of offices. Currently, it accommodates three companies in the solar energy field: AKS DOMA Solar Technology, Photovoltaik Stromaufwärts and S.A.G. Solarstrom.

The project aims at combining advanced energy technology and a functional building with an interesting architectural design, the use of environmentally friendly construction materials and low building costs. By producing energy from renewable sources, the project contributes to the protection of the environment by reducing the use of fossil fuels, with their attendant CO_2 emissions, or the need for nuclear power.

Another objective of the Energiepark West is to establish an information and development centre for solar technology and other renewable energy sources. It aims at improving clean energy awareness through activities such as events for architects, site visits, discussions, and lectures. The energy park tries to create a cluster of companies able to join forces to achieve a breakthrough in the use of renewable energy sources.

In 2000, Energiepark West was awarded the Austrian Solar Energy award, which is run by EUROSOLAR. In the same year, the project also received the European Solar Award for the most innovative project in the “company buildings” category.

Description

The Energiepark West building has been constructed on a 1,580 m² site and encloses about 14,000 m³ of space. The height of the building is 8.7 m. The most eye-catching feature of the building is the 230 m² south-facing façade.

Two-thirds of the surface of the south façade is covered with high-capacity polycrystalline PV modules. A smaller PV system has been installed on the west side of the building. Another PV system, the largest one installed at the Energiepark West, was integrated with the structure of the roof. All three PV systems are connected to the electricity grid.

The remaining part of the south façade is used for a solar thermal collector system. This installation provides heat used for the hot water supply and space heating for the whole building. The heat is delivered to the office wings via wall-mounted heating systems, which have been specially developed for the purpose by AKS Doma. In the manufacturing area, pleasant radiant heat is supplied through the floor. The floor of the hall is also used as a heat storage system.

During extended periods of bad weather or extremely cold periods, two biodiesel (RME) block-type plants are used as back-up systems for the production of heat and electricity.

The heat load of the office building totals approximately 50 kWh/m^2 a year. This is achieved by the high heat insulation of the light wood construction of the roof of the building and the passive energy yield due to the optimal north-south orientation of the building.

Project characteristics

Installed electrical capacity PV on south façade [kW_p]	17.16
PV module surface on south façade [m^2]	143
Installed electrical capacity PV on west façade [kW_p]	4.14
PV module surface on west façade [m^2]	32
Installed electrical capacity PV on roof [kW_p]	45
PV module surface on roof [m^2]	450
Installed thermal capacity solar collector on south façade [kW_{th}]	32
Solar thermal collector surface on south façade [m^2]	82
Total installed electrical capacity biodiesel plants [kW_e]	10.4
Total installed thermal capacity biodiesel plants [kW_{th}]	20

Dissemination activities for the project include visits by architects and architecture students, education of customers, press events and other PR measures.

Promoters and parties involved

- AKS DOMA Solar Technology: solar thermal system
- stromafwärts Photovoltaik: façade-integrated PV system
- S.A.G. Solarstrom AG: roof solar PV system
- MHM (Dornbirn): architecture
- Gruppo Sportivo (Bludenz): architecture

Financial resources

The total project costs totalled €1.75 m. Of this amount, €160,000 was accounted for by the PV façade. Costs for the biodiesel heating plants and the solar thermal system were €45,000 and €22,000, respectively.

The project was financed by AKS DOMA Solar Technology, except the roof-top PV system, which belongs to S.A.G. Solarstrom. The project received a subsidy of 30% of the investment costs for the PV façade from the state of Vorarlberg. The source of revenue is the sale of electricity to the regional utility company.

The payback period for the project is estimated at 15 to 20 years. However, for the decision to implement the project, the CO_2 neutral manufacturing of the solar collectors of AKS DOMA and the role of the project as a model for other similar initiatives were much more important.

Results

No substantial problems occurred during planning and development. In the first year of operation of Energiepark West, it was demonstrated that the system functioned well, despite the relatively severe winter and long periods of bad weather. With these results, Energiepark West demonstrates that a factory and office building can realise an energy supply which is almost CO_2 free.

The electricity output of the project exceeds the demand from the building. In 2001, the PV system on the southern façade delivered 11,000 kWh to the Vorarlberger Kraftwerke (VKW) grid. In the case of the west façade, the excess power generated was 2,970 kWh. The biodiesel plants generated about 27,800 kWh. The roof-top PV installation yielded approximately 43,800 kWh of electricity. The biodiesel plants also produced about 100,000 kWh of heat. For the solar collector integrated into the façade, this was approximately 25,000 kWh.

The electricity is sold by S.A.G. Solarstrom in the form of "solarplus + packages". Participants actively prevent the import electricity from nuclear sources. The energy produced by the project contributes to the avoidance of fossil fuels and emissions.

Potential for replication

The project is a good example of combining environmental concerns, namely the low-energy architectural design, the use of renewable energy sources and environmentally friendly building materials, and economy, i.e. low building costs. Moreover, an expansion of Energiepark West is planned within the next 2 years.

The project could be replicated at another site any time. So far, three other large solar power plants are planned.

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Sector: Solar Photovoltaic
Country: Denmark
Location: Brædstrup
Year: 1998

ENERGIE

THE SOLAR PROGRAMME SOL-300: BRÆDSTRUP

In 1998, the largest solar power project in Denmark to date was set in motion. SOL-300 is one of the biggest programmes of its kind in Europe and builds on experience from the SUN CITY Project, which ran from 1996-1999, and in which 30 single-family houses were supplied by photovoltaic systems.

In the SOL-300 project PV systems have been installed on 300 roofs of houses in Jutland and Funen. Most of the houses have been equipped with systems in the 0.9-6 kWp range, and the total capacity on all the houses is 750 kWp.

The aim of the programme is to contribute to increased use of solar cells in the Danish electricity sector. This can be subdivided into five subsidiary goals:

- To contribute to continued reduction in the price of grid-connected solar systems
- To stimulate the development of Danish solar technology
- To contribute to the setting up of quality assurance schemes
- To develop and extend the electricity sector's commitment to using solar technology as a future business area
- To increase general knowledge of PV technology

Description

There are 8 residential areas participating in the programme. Each area has between 19 and 70 roof top installations. The project has focused on mounting techniques of PV systems. Most of the units are installed as part of standard systems, but a few special solutions have been developed to test new mounting and construction techniques.

The solar community Brædstrup.

There are 70 mixed houses participating in the project in Brædstrup, with a total installed capacity of 179.8 kWp.

In Brædstrup a few different mounting designs have been tested:

- Ten PV modules have been integrated into the roofs of new houses. The ten modules are distributed with two 1.02 kWp modules on each house. The test has shown that roof-integration is expensive even if the cost is reduced due to less conventional roofing material being needed.

- Semi-integrated mounting. Replacement of some roofing sheets and conventional mounting has been carried out in the case of one 4.08 kWp installation.
- Combining solar-thermal collectors with PV systems has been tested with a system comprising 2.99 kWp of PV capacity and 4 solar collectors.
- The roof of a new pergola has been built using PV modules. The capacity of the modules is 2.38 kWp.
- A new thin film technology has been tested as a roof covering. 40 m^2 of the thin film delivers 2.97 kWp.

Dissemination activities.

The project has received a lot of media attention. Project brochures have been produced and visitors are frequently shown around the installations.

The project is presented on the Internet at www.sol300.dk. The pages include a description of the projects and production data for the PV systems for all the houses involved in the project.

Promoters and parties involved

A steering group consisting of members from Eltra, The Danish Energy Agency and EnCon Enterprice (EnCon is now a part of EnergiMidt Enerprice A/S) manages the SOL-300 project.

Eight utilities in Jutland and Fuenen are participating in the project: ELRO, SEF, EnergiFyn, Sydvest Energi, Vest Energi, SE Energi, ESV/ENV and Energiselkapet EnCon.

Three companies/consortia have been selected as suppliers for the project: Shell Solar/Gaia Solar, BP Solar (Rachell A/S) and IBC Solar Technick, Scanpoon & Oi Electric.

EnCon is responsible for the installations in the Brædstrup project and the solar panels were supplied by Shell.

Financial resources

The total investment for the complete project came to DKK 49 m (€6.6 m). The investment is financed partly by the Danish Energy Agency and Eltra and by user charges paid by the families living in the 300 “solar houses”.

The payback period is calculated to be approximately 10 years.

Results

- Compared to the prices on the previous SUN CITY programme the prices have decreased by about 20 %. The turn-key price achieved in this project was about 50 DKK/Wp (6.7 €/Wp).
- As the project could not contribute to technology development of solar cells it has focused on mounting and integration techniques instead.
- The annual energy production from the project is about 550,000 kWh/year.

Potential for replication

The results from the project will be developed further in the new solar electricity project SOL-1000.

For more information

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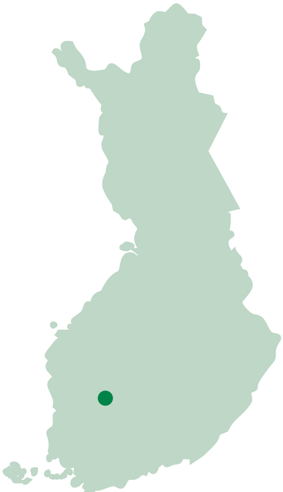
www.energimidt.dk

Sector: Solar Photovoltaic
Country: Finland
Location: Lielahti
Year:Summer 2000

ENERGIE



SOLAR MODULES INTEGRATED INTO THE ROOF OF A SUPERMARKET

Kesko, a Finnish marketing and logistics company, which develops retail concepts and operating models, has its own environmental strategy and policy. Its goal is to find and implement innovative solutions that help to preserve the environment.

In accordance with its environmental strategy, the company wanted to implement renewable energy resources during the renovation of the Lielahti Citymarket in Tampere, Southern Finland.

Naps Systems supplied the solar modules that were mounted on the roof of the supermarket. Altogether, the modules have a surface area of 330 square m^2 and a maximum output of about 39 kW.

Description

Photovoltaic array peak power	39 kW
Solar module surface	330 m^2
Grid connection	20 inverters
Solar modules	100 W each

Promoters and parties involved

The system is owned by Kesko, a Finnish marketing and logistics company, and the solar modules that were installed on the roof of the supermarket were supplied by Naps Systems.

Financial resources

- Total investment: €340,000 (approx.).
- Subsidies: The project received a 40 % subsidy in the form of a grant from TEKES, the National Technology Agency in Finland.

Results

The electricity generated by the modules is used by the supermarket. Solar electricity is ideally suited to applications such as this where the power is used for purposes such as cooling and air conditioning, with peak loads during the day-time when solar electricity production is at its highest.

Apart from the ability of such a system to even out the building's power demand from the grid, it also cuts electricity costs. During the summer the solar modules produce 4-5% of the buildings total energy needs.

The modules need only minimum maintenance, as they have no moving parts. Being grid-connected the system operates without any batteries, thereby reducing its impact on the environment.

The system began to pay for itself right away by producing electricity. As the electricity is generated where it is consumed, transmission and distribution losses are avoided.

The improvements that were made according to the environmental strategy decreased the environmental loads of the premises by about 6 %.

Potential for replication

Mounting the solar modules over the existing building envelope on roofs or walls is still in many cases the most economical solution. However, new modules made specifically for building-integrated applications can now be used to create more appealing architectural effects. In addition to electricity production, they serve as parts of the exterior envelope of the building, thereby replacing conventional building materials without any massive extra investment. The market for building-integrated solar electric systems installations is expected to grow at an average of 30 % a year.

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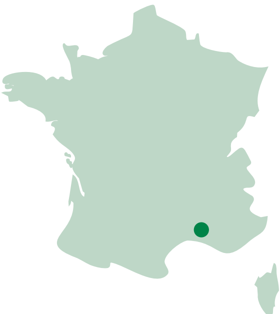
www.napssystems.com

Sector: Solar Photovoltaic
Country: France
Location: Aude and Herault regions
Year: 1999

ENERGIE



RURAL ELECTRIFICATION IN LANGUEDOC ROUSSILLON

This project was implemented in a part of the region, in which there were a number of houses permanently isolated from the EDF (national power utility) electricity grid.

The project was the outcome of the local Syndicat Départemental d'Électrification du Gard's confidence in the significant body of experience built up by APEX BP Solar in the installation of this kind of system in similar contexts.

Thus, the main objectives of the project was to increase the number of power appliances, which can be used by the houses connected to the system and thus to enhance the functioning of some applications, which were previously very limited, such as lighting, radio and TV, fridges and water pumping. The systems came into operation in June 1997.

Description

In order to ensure an adequate electricity supply, the project involved the design, manufacture, installation and maintenance of 15 PV generators serving about 200 houses in a sparsely populated area, which is not reached by the electricity grid. As in many other similar cases, the cost of extending the grid to reach these homes was prohibitive, making a standalone system the most cost-effective option.

The installed generators conform to the technical specifications laid down by the ADEME-EDF-SEN Quality Chart and have been subjected to strict component quality control and application of the standards of the relevant certification institutes (DTU,AFNOR,ISO, etc.)

The systems comprise hybrid photovoltaic-diesel generators producing 220 VAC. The systems have been equipped with data gathering and measuring devices.

Each solar PV array is made up of 24 modules producing 1,200 w (with a solar radiation of 1,000 w/m^2).

The company responsible for manufacturing and installing the plants also carries out all maintenance and the plants can be monitored remotely. The maintenance contract envisages site visits by the company's technicians when needed and in some specific cases this may take place with the involvement of EDF technicians.

Promoters and parties involved

EDF/GDF Gard Cévennes was the Work Direction and the beneficiaries were the owners of the isolated houses.

EDF (Electricite de France) ensure the maintenance together with APEX Bp Solar.

Technology supplier

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Fax: +33 0 499 622 623
www.apex-bpsolar.com

Financial resources

The total investment came to €1.1 m and the project as a whole was supported by ADEME/FACE (Fonds d'Amortissement des Charges d'Electrificaction). It also receives a concessionary rate from EDF for the electricity it produces.

Results

200 houses are currently served by the system, thus improving their otherwise very limited electricity supply by providing them with reliable and efficient electricity generation, which is furthermore guaranteed by the power utility (EDF) and maintained by the services of a prestigious and experienced firm.

Potential for replication

As in many other cases PV represented an optimal and efficient solution to meet the basic power needs of users located in isolated settlements with no connection to the grid.

Although this project is not particularly innovative, its high reliability and the guarantee of competent maintenance by an experienced firm enables and encourages its replication in other similar situations.

For more information:

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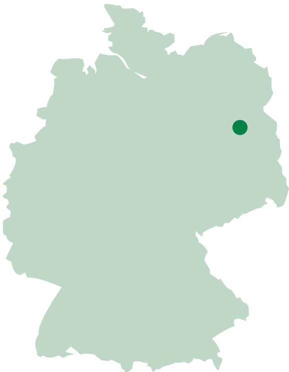
Fax: +33 0 499 622 623
www.apex-bpsolar.com

Sector: Solar Photovoltaic
Country: Germany
Location: Berlin
Year: 1998

ENERGIE



BERLIN, INNOVATION CENTRE FOR ENVIRONMENTAL TECHNOLOGY

Since 1998 a number of solar installations have been implemented at the site belonging to WISTA, the Berlin-Adlershof Centre for Science and Business. The first project at this location was a multifunctional PV façade on the office building of the Innovation Centre for Environmental Technology (UTZ).

The PV façade on the Innovation Centre for Environmental Technology building combines CO_2-free electricity generation with modern and functional architecture. The façade elements not only produce energy, but they also shield the glazed entrance hall against excessive sunlight, thus providing shade. Grey polycrystalline thin-film silicon cells were used, also making the PV façade a remarkable design feature. The application of this type of solar cells was a technical novelty in Berlin at the time of the implementation of the project.

Description

The thin-film polycrystalline silicon solar cells are integrated into the southern façade of the building, with an orientation of 10º (south-south-east). The PV installation has a total surface area of 180 m^2, providing an installed electric capacity of 14.4 kW_p. There are 56 modules in total, arranged in seven arrays. The modules are double-glazed and frameless.

The PV system is electrically connected via an array of three inverters (with a capacity of 2.6 kW), which incorporate built-in monitoring and fault indication. The modules directly supply electricity to the local power utility public grid.

A new digital video display was installed at the Innovation Centre for Environmental Technology to provide information about the total system output, the yield in the current year and the cumulative yield of all systems installed on the different rooftops on the premises of the Berlin-Adlershof Centre for Science and Business.

Promoters and parties involved

- Berlin Energy Agency: project development, planning construction, financing, operation, service, trouble-shooting, and maintenance
- WISTA Management: initiator and building owner
- WISTA Solar: initiator of the project
- Sunbeam Ecoconsultants: visualisation
- ETA Energy Technology Installations: set-up and operation
- AstroPower: PV modules
- Solon: PV modules
- BTB (Blockheizkraftwerks-Träger- and Betreibergesellschaft mbH Berlin): power utility company; financial support
- Aixcon: string converters and monitoring

Financial resources

The construction costs for the solar system came to €98,000. The project was partly financed by the Berlin Energy Agency, and the power utility BTB contributed to the investment and operation costs. BTB also granted a negotiated fee for electricity supply by the project of 0.28 €/kWh. The project received a contribution to the cost of construction from the Municipal Services and the building contractor.

WISTA Management also helped to finance the project. This company was able to utilise the cost of the shading elements originally planned for, which were replaced by solar modules, for the realisation of the PV plant at the same building cost.

The payback period for the solar PV system is 15 years. A contract of this same duration was signed by the Berlin Energy Agency and the utility company BTB to set the terms under which the power generated could be fed into the local electricity grid. There was also a contract between the Berlin Energy Agency and the building owner WISTA Management for an extra contribution amounting to the cost of the conventional shading elements system during the construction phase.

Results

Construction of the project commenced in August 1998 and the PV modules came into operation in October. As a result of measurements, the electrical circuit of the single modules was adjusted in early1999. After construction of the project, it appeared that the orientation of the individual stelae was not optimal, because they are often partially shaded, especially the upper section. The weather also appeared to be cloudier than expected.

The PV system at the Innovation Centre for Environmental Technology produces 7,200 kWh of electricity a year (calculated value; the measured value is lower). The revenue generated by the project is about €2,000 a year, according to the fee granted by the local utility.

Because the project produces electricity from a renewable source, it substitutes fossil fuels for electricity generation. Furthermore, the project reduces the emissions of CO_2 by 7 tonnes a year.

Potential for replication

After the construction of the PV façade at the Innovation Centre for Environmental Technology building, four PV systems with a total power capacity of 126 kW_p were installed on the roofs of four university buildings at the Berlin-Adlershof site of the Centre for Science and Business. These four installations form part of a trial to compare the performance of various types of photovoltaic systems over a long period of time. Moreover, two identical systems (66 kW_p) with monocrystalline silicon cells were located on two other building rooftops.

The Berlin Energy Agency also operates three other PV systems in various parts of Berlin.

The PV project at the Innovation Centre for Environmental Technology combines the production of “green” electricity with an eye-catching architectural design. This makes it exemplary for innovative enterprises working in the field of environmental technologies.

For more information

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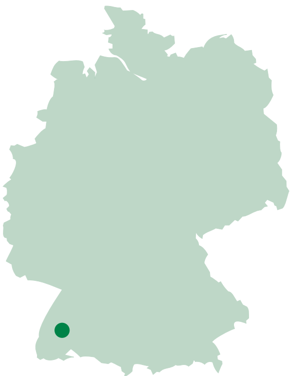
www.berliner-e-agentur.de

Sector: Solar Photovoltaic
Country: Germany
Location: Freiburg
Year: 1999

ENERGIE



FREIBURG, DREISAMSTADION SOLAR PV SYSTEM

In 1999, a S.A.G. Solarstrom AG solar PV system was constructed on the roof of the new eastern tribune of the Dreisamstadium. This is the soccer stadium of the sports association in Freiburg. It was the company's third PV system to be connected to the grid in the space of a year. The first project consisted of a 70 kWp solar PV system on the roof of the Ganter private brewery. In the second project, a solar PV installation was located at a car park, with an installed electric capacity of 90 kWp. The soccer stadium is equipped with two PV systems and one solar thermal installation.

The electricity is sold to the Freiburg Energy and Water Supply utility (FEW). The company bases its energy supply on the so-called "regional principle" whereby electricity is generated near to where the users live. Solar energy is highly suitable for such a regional energy supply, because solar systems can be built almost anywhere without a significant impact on the natural surroundings.

The success of the supply of solar electricity in Freiburg is partly due to support from citizens, who opted for a secure, clean, regionally produced and socially acceptable electricity supply. With the Dreisamstadion PV project, S.A.G. Solarstrom caters for a specific market demand with a focus on the origin, security and quality of electricity supply.

Description

	1999	2000
PV module area	600 m²	1,050 m²
Installed electric capacity	60 kWp	105 kWp
More technical details about the plant:		
Number of modules	528	1194
Area per module	0.96m²	0.96m²
Efficiency	12 %	12 %
PV module type	SF 115	SF 115
Inverter type	Solarmax DC 30	Solarmax DC 30
Nominal power per module	115 Watt	115 Watt
Nominal voltage	16,8 Volt	16,8 Volt
Power density	6.9 Amps	6.9 Amps
Orientation angle	0° South	0° South
Angle of inclination	20°	20°
Connection to the electricity grid	Parallel	Parallel

Promoters and parties involved

- S.A.G. Solarstrom: owner and operator of the plant
- Freiburger Energie- und Wasserversorgung AG (FEW): energy and water distribution company; buyer of the produced electricity
- Solar Factory Freiburg: supplier of PV modules
- Solar Energie Systeme GmbH, Freiburg / Germany (Technical Engineering and Realization) was involved in the project as consultancy
- Sputnik/Niedau from Switzerland is the supplier of the inverters

Financial resources

The investment finance for the PV project was provided by the shareholders of S.A.G. Solarstrom. The total investment was €380,000. The project was 25% financed with stock capital of S.A.G. Solarstrom AG and for 75% with credit under the 100,000 roofs promotion programme. This programme made interest-free capital available for the installation of solar systems.

The S.A.G. Solarstrom AG was the first company that financed solar plants with stock capital through the distribution of stock certificates in 1999. The expected payback period is 18 years.

Results

The annual electricity production of the PV installation is approximately 56,000 kWh. Supported by the renewable energy law (Erneuerbare Energie Gesetz EEG) the annual revenue from electricity sales is approximately €28,600. The solar project in the Dreisamtstadion results in a mitigation of approximately 44.8 tonnes of CO_2-emission a year. The project supports the transition to a sustainable energy supply. S.A.G. Solarstrom AG also expects new employment to be created by the projects.

Potential for replication

SAG Solarstrom AG's aim is to build Solar systems at unusual locations with a view to bringing solar electricity generation closer to the people. From this point of view a football stadium is an excellent place to show people that solar systems not only generate clean and secure electricity but also can be used as an integral part of a building's architecture. Additionally it is important to the S.A.G. Solarstrom AG that the solar energy becomes part of the company communication. The Solar system on the roof of the eastern tribune is more often a motive for news coverage of the media, but also makes its appearance in the stadium periodical. The solar system is a pilot project and an example for other sport complexes. Following the example of the Soccer stadium in Freiburg there are now other soccer stadiums equipped with solar systems. Examples are the arena in Schalke, the new stadium in Mönchen Gladbach and the stadium in Essen.

For more information

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www.solarstromAG.de

Sector: Solar Photovoltaic and Small Hydro
Country: Germany
Location: Grenzach-Wyhlen
Year: 1998

ENERGIE

GRENZACH-WYHLEN, SOLAR PV AND HYDRO INSTALLATION

A photovoltaic (PV) system was installed directly on the roof of a historical small hydropower station in the municipality of Grenzach-Wyhlen. The rooftop installation took six weeks to complete and the combination of hydro and solar is the first of its kind in Europe. The advantages of distributed generation make this combination of generation attractive. Taking that into account is for S.A.G. Solarstrom AG the key for an environmental energy revolution. Within this revolution, PV has a special role because it can be applied anywhere, either stand-alone or grid-connected. The solar energy generated is sold exclusively to the Power Company Naturenergie AG, which is also resident in Grenzach-Whylen.

S.A.G. Solarstrom AG was founded in Freiburg in 1998 and is the issuing body for the first “solar-stocks” in Germany. Since 6th April 1999 these “solar-stocks” have been traded on the Munich exchange. The target of the partnership is to stimulate solar energy by offering interesting financial instruments and financial service offerings. The stock capital serves only the purpose of financing, constructing and operating solar power stations. S.A.G. Solarstrom AG values high grade technique because solar modules and inverters that are highly efficient are more likely to guarantee returns from solar power over the long term.

Description

Project characteristics	
PV module area	720 m²
Installed electric capacity	72 kWp
Number of modules	630
Area per module	0.96 m²
Efficiency	12 %
PV module type	SF 115
Inverter type	2 Solarmax 30 / 3 Convert 4,000
Nominal power per module	115 Watts
Nominal voltage	16.8
Power density	6.9 Amps
Orientation angle	- 24° East
Inclination angle	41°
Connection to the electricity grid	Parallel

Promoters and parties involved

- S.A.G. Solarstrom: owner and operator of the plant
- Solar Factory Freiburg: supplier of PV modules
- NaturEnergie: energy distribution company
- Solar Energie Systeme GmbH, Freiburg / Germany (Technical Engineering and Realization) was involved in the project as consultancy
- Sputnik/Niedau (Switzerland) supplied the inverters

Financial resources

The PV project was financed by the shareholders of S.A.G. Solarstrom. The total investment was €430,000. S.A.G. Solarstrom AG started financing solar plants from stock capital with the distribution of stock certificates in 1999 and was the first company to do so. The project in Grenzach-Whylen was 100% financed from the stock capital of S.A.G. Solarstrom AG. The expected payback period is 18 years.

Results

The annual electricity generated in Grenzach-Whylen is approximately 67,000 kWh. This results in annual revenues from electricity sales of €34,200 thanks to legislation favouring renewable energy (Erneuerbare Energie Gesetz EEG). About 53.6 tonnes of CO_2 per year are avoided through the solar project. The project supports the transition from fossil fuels to a sustainable renewable energy supply and is expected to create jobs in the new economy.

Potential for replication

Following liberalization of the German energy market fierce competition ensued. About 1,000 energy companies faced the need to make a strategic choice to survive the competition from the big energy companies. The key question was how smaller utilities and energy companies would be able to retain existing customers and win over new ones. According to S.A.G. Solarstrom AG solar energy can play a significant role in the positioning of the smaller utilities because it enables them to create their own regional energy market and commercialise their own unique energy products.

As the demand for clean power is increasing S.A.G. Solarstrom AG plans to build more regional power plants. The more households and private companies switch to power generated by renewable power stations, the earlier 'brown power' will be replaced by 'green power'. Therefore, S.A.G. Solarstrom AG is searching more actively for roof areas of 800 m^2 or more in size in Germany and Switzerland, on which to locate further solar power systems.

For this kind of project there are two enablers: the S.A.G. Solarstrom AG gets enough stock capital to enable it to continue its mission, or alternatively there are other parties interested in participating in similar projects.

For more information

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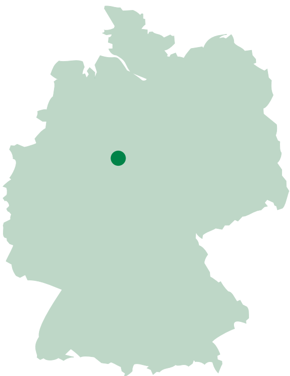
Sector: Solar Photovoltaic
Country: Germany
Location: Laatzen
Year: 1998

ENERGIE



LAATZEN, SOLAR PV STATION ON THE ADAC ADMINISTRATION BUILDING

The administrative building of the German automobile club (ADAC) in Laatzen is perfectly suited to the integration of solar power technology and it has a useful surface of approximately 6,300 m^2. The aim was to produce a building that was both original and forward-looking, while taking local conditions into account. It also needed a personality, with which members and employees alike could identify: the blue solar modules employed as a sunblind contrast well with the corporate colour yellow. The PV façade used on the ADAC building is, with an output of 55 kWp, the biggest installation integrated on an exterior wall in Germany.

The building's concept seeks to achieve a synergy between the façade and integrated PV panels so as to promote energy-consciousness and energy use in an environmental- and resource-saving way. The power generation techniques used are not an add-on but rather form an integral part of the design of the façade and roof of the building and thus define its appearance.

Description

The ADAC building uses the PV panels in a multifunctional way. On the façade, the panels are used to provide shade, generate electricity and as a lean-to roof. A PV panel is also used to provide shade in the glass roof over the atrium, where to ensure sufficient natural illumination in the inner part of the building semi-transparent PV modules have been used. Furthermore on the top of the building there are experimental double-sided PV modules mounted on a highly reflective roof. The construction of the ADAC building also makes good use of passive solar energy using the solid internal building materials as a sink for energy storage and thermally insulated glass in the building envelope.

The roof-top PV generator is divided into three systems with 6 (the façade has as many as 25) different types of solar modules (the smallest of them being 1.7 m^2 the largest 3.6 m^2), which have been tailored to the ADAC building. The inclination of the PV generators is 30º and the orientation is almost due south (14º west). All the inverters are housed in the electrical installation room on the third floor. The eastern part of the roof houses technical equipment such as the cooling and ventilation systems. The experimental area fitted with doubled-sided modules is in the middle part of the roof. The western part of the roof has a skylight, covered by solar panels substituting for the otherwise essential shading elements. The 10 mm distance between the solar cells enables a balance to be struck between a high level of natural illumination and good shade. The transparency of the modules is approximately 30%.

PV module area on the façade	645 m²
Number of modules façade	236
PV module area on the roof	225 m²
Number of modules on the roof	122
	(including 36 double-sided modules)
Silicon solar cells (10 by 10)	55,000
PV net cost per m² façade	1,000 DM/m²
Efficiency	14%
Performance PV installation façade	55 kWp
Performance PV installation roof	23 kWp
Total PV capacity	78 kWp

The installation is equipped with an extensive data acquisition system that collects all the main data of all subsystems (roof and façade), some module temperature and additional meteorological data. The data enables the technicians of the ADAC building to control the system, as well as a more detailed investigation of the PV systems by the German institution for solar energy research (ISFH). In particular, they are interested in:

- Module temperatures on the façade in comparison with those on the roof.
- Performance of the double-sided PV system.
- Comparison of the subsystems facing different directions.

The building receives a lot of visitors as the ADAC uses it for member support activities, meetings, travel bureau services, etc. PV technology, the PV system installed on the building, and the system's performance are explained to visitors who are interested by a computer with a touchscreen monitor. The data displayed is directly controlled by the data acquisition system.

Promoters and parties involved

- ADAC (Allgemeiner Deutscher Automobil Club): owner and operator
- Husemann / Dr. Wiechmann Architekten und Ingenieure: architects
- Kindereit Ingenieure: consultancy on the façade and building technique
- Ingenieurbüro Mencke & Tegtmeyer: monitoring of the PV-installation
- ISFH (Institute für Solarenergieforschung GmbH Hameln): research institute on solar energy
- Osmer Elektrotechnik (Lilienthal): general contractor for the PV project
- Solarnova (Wedel): PV module producer
- ASE (Heilbronn): manufacturer of the mono-crystalline Silicon cells
- ASE (Alzenau): manufacturer of the double-sided PV modules

Financial resources

The PV installation on the ADAC building was delayed because of disputes regarding the financing. The Ministry of Research withdrew its letter of intent on co-financing the project and obtaining co-financing from the Expo-society and the German Foundation for the Environment also turned out to be impracticable. For this reason the PV system could only be installed after the building was brought into use. Co-finance for the project was finally only received from the State of Niedersachsen, meaning that 80% of the investment had to be provided by the ADAC.

Total investment	DM 1,988,000
ADAC investment	DM 1,560,000
Niedersachsen (co-finance)	DM 428,000
Return/energy yield p.a.	DM 60,700

Results

Forecast 1997	KWh/year	DM/kWh	DM/year
Electricity used	420,000	0.22	93,700
Own PV generation	63,000	0.175	11,000(12%)
Difference			82,700
Results 2001			
Electricity used	690,000	0.1302	89,800
Own PV generation	61,340	0.99	60,700(68%)
Difference			29,100

It is forecast that the PV system will produce a total of approximately 63,000 kWh a year, equivalent to an average final yield of 810 kWh/(kWp). Generating this amount of electricity from the mix of conventional sources used in Germany would have resulted in polluting atmospheric emissions of 4.9 kg of dust, 50.9 kg of nitrogen oxide, 30.9 kg of sulphur dioxide and 43.6 tonnes of carbon dioxide a year.

Potential for replication

Customisation of the PV modules and using a variety of module types were made necessary by the fact that the building had already been designed at the time the PV system was planned. This meant the sizes of the modules had to be adapted to the areas available on the façade of the east wing. Specially designed modules harmonising with the profile of the building were also used. These modifications served as an example for integration of PV systems on building exteriors. The ADAC building demonstrates the application of solar modules in the design of both roofs and façades. Apart from generating solar energy they also provide shade, help to keep an agreeable climate in the interior of the building on sunny days, and protect the building against the weather by serving as a lean-to roof. Moreover the ADAC building, with its PV façade, has been designed to integrate perfectly into its environment, in keeping with urban planning requirements for the area.

Because the solar systems cannot yet be justified economically, the advantages of showing concern for the environment as a part of building an image or brand also played an important role in the ADAC's decision to invest in solar technology.

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Sector: Solar Photovoltaic
Country: Germany
Location: Waldshut -Tiengen
Year: 2000

ENERGIE

WALDSHUT-TIENGEN, SOLAR COMMUNITY HOSPITAL

The "German Environmental Aid" (Deutsche Umwelthilfe e.V.) and S.A.G. Solarstrom AG nominated Waldshut-Tiengen for the title of solar community in 2000. To be eligible for this title at least 10% of the electricity bought by the municipality has to be generated with solar power, and in general the municipality should actively contribute to the promotion of solar energy. Waldshut-Tiengen earned their title "solar community in 2000" thanks to the solar PV installation constructed on the roof of the municipal hospital. The total PV power, including the installed electric capacity on the roof of the municipal hospital came to 43.2 kWp.

The electricity produced is supplied to the Municipal Services of Waldshut-Tiengen, which offers the solar electricity to its customers with a new product called "Upper Rhine Electricity plus (Hochrheinstrom plus)". This is partly regionally produced electricity, generated from solar energy and hydropower. With this new product, the Municipal Services are responding to the increasing demand for environmentally friendly electricity that has been generated in the region. Of the electricity produced by the solar roof on the hospital, the municipality itself uses 10%. The remaining 90% is directly sold to inhabitants of the city.

Description

Installed electric capacity	30 kWp
Number of modules	264

More technical details about the plant:

Total module area	253.44 m²
Area per module	0.96 m²
Efficiency	12%
PV module type	SF 115
Inverter type	Solarmax DC 30
Nominal power per module	115 Watt
Nominal voltage	16.8 Volt
Power density	6.9 amps
Orientation angle	0° South
Angle of inclination	30°
Connection to the electricity grid	Parallel

Promoters and parties involved

- S.A.G. Solarstrom: owner and operator of the plant
- Municipal Services of Waldshut-Tiengen (Stadtwerke): buyer of the electricity
- Solar Factory Freiburg: supplier of PV modules
- Solar Energie Systeme GmbH, Freiburg / Germany (Technical Engineering and Realisation): involved in the project as consultancy
- German Environmental Aid (Deutsche Umwelthilfe e.V.)
- Sputnik/Niedau from Switzerland: supplier of the inverters

Financial resources

The project was financed by the shareholders of S.A.G. Solarstrom. The total investment was €180,000. The community is supported by the financial and marketing concepts of S.A.G. Solarstrom and "German Environmental Aid" (Deutsche Umwelthilfe e.V.). The long-term contract between Municipal Services and S.A.G. Solarstrom AG for the supply of solar electricity provides security of returns.

The S.A.G. Solarstrom AG was the first company to finance solar plants with stock capital, which it did with an issue of stock certificates in 1999. This project was also wholly financed from the stock capital of S.A.G. Solarstrom AG. The expected payback period is 18 years.

Results

After a relatively short building time the annual electricity production is approximately 28,000 kWh. The electricity generated is sold as renewable electricity, for which the price is 0.04 €/kWh more than normal electricity. The greater part of the raise is used for the promotion of environmentally friendly energy (€c3). The rest (€c1) is used for administration costs.

The installation yields revenues of €14,300 a year from solar electricity sales. The solar project is responsible for about 22,4 tonnes of CO_2 –emissions avoidance a year. The project supports the transition from fossil fuels to sustainable renewable energy supply. S.A.G. Solarstrom AG also believes this project will create jobs in the new economy.

Potential for replication

Public buildings are an ideal location for large-scale solar installations in order to stimulate local sustainable strategies in the framework of Agenda 21, as such installations raise awareness in the community about solar energy and may serve as an example for local people. Solar systems like the one on the roof of the hospital symbolise the responsibility that the municipality takes for a sustainable future. S.A.G Solarstrom hopes that this will encourage citizens to consider their own home as a place to generate solar electricity. Altogether 700 municipalities throughout Germany have expressed an interest in the "Solar-municipality" campaign. Very often the obstacles that have to be overcome are of a political nature. In the case of Waldshut-Tiengen the decision making process was carried out very efficiently.

Projects of this kind could be repeated in the future if S.A.G. Solarstrom has enough stock capital to invest. Alternatively it could also be implemented under a joint-ownership scheme if there is enough support for it within a particular municipality.

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Sector: Solar Photovoltaic
Country: Greece
Location: Sifnos island
Year: 1999

ENERGIE

INSTALLATION OF 60 KWP MODULAR PV SYSTEM ON THE GREEK ISLAND OF SIFNOS

The project concerns the installation of a total of a 60 kWp grid-connected PV plant on the island of Sifnos. The main objective of the project was to demonstrate the benefits of installing PVs on Greek islands by means of a real application and so initiate the larger scale introduction of PV technology in the Greek market. The work was performed within the framework of the European Commission's THERMIE A Programme. Sifnos is one of the Cyclades islands, located in the Aegean Sea. The island's electricity is produced by a standalone diesel power station, which generates power at a higher cost than that of electricity from the main Greek power grid. Given the amount of tourism the island receives, electricity demand is higher during the summer, thus creating favourable conditions for PV generation. Sifnos was therefore selected as a typical Greek island for the installation of a photovoltaic plant.

Description

The PV plant was installed as a centralised system, but a modular approach was taken so as to allow for future replication in plants of different sizes and enable the system to be implemented in a distributed configuration.

The PV plant consists of 33 identical sub-units, which are each electrically independent. Each sub-unit comprises a PV array and a dedicated DC/AC string inverter.

A distribution transformer is used for the connection to the medium-voltage local grid, where all the solar electricity produced is delivered.

Promoters and parties involved

The organisations involved in the project were CRES (Greece, main contractor), PPC (Greece), ANIT (Italy), SMA (Germany).

Financial resources

Total Budget: €1,095,000

EU Contribution: 40%

National Contribution (Ministry of Infrastructures and Public Works): 9%

Partners' own contribution: 51% (CRES: €130,000)

Results

The PV plant came into operation in October 1999, since when it has supplied power continuously. Prior to the end of the project, in 31st March 2001, it had produced 102 MWh of electricity. The project confirmed that the "weak" grid of the island was not an obstacle to the operation of PVs, and that similar systems could be installed on other Greek islands currently facing high electricity generating cost.

Potential for Replication

As far as the project's replication is concerned, it is worth noting that the project demonstrated there to be no problems with installing small PV units connected to the electricity grid of a small island. Moreover, it indicated that a modular approach of this kind could easily be adopted in the case of both small grid-connected and non grid-connected networks, which means it could be applied on many other Greek islands.

Finally, within the framework of the national O.P.E. (Operational Programme for Energy), similar installations have since been set up on the island of Crete.

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Sector: Solar Photovoltaic
Country: Italy
Location: Alberga (in Savona Province)
Year: September 2000

ENERGIE

"DOMENICO TRINCHERI" INSTITUTE, ALBERGA – SOLAR PHOTOVOLTAIC PLANT

S.E.I. Sistemi Energetici Integrati srl, a company specialising in the development and application of innovative technologies, such as photovoltaics, optoelectronics and telemetrics, has designed and built a photovoltaic plant on the roof of a building belonging to the “Domenico Trincheri" Institute located in Albenga City, in the province of Savona Province in the north-west of Italy.

Description

The photovoltaic plant has been installed on the south-facing slope of the roof, which is the optimum position for electricity production and at the same time ensures good public visibility. The construction of the roof was completed in September 2000 and started working one month later.

The plant has an installed power of 11 kWp, consisting of 132 high efficiency solar silicon mono-crystalline modules. The solar modules are BP 585 photovoltaic modules manufactured by BP solar. The premium laser-grooved buried-grid monocrystalline cells provide a premium power performance of 85 W nominal maximum power and 12 volts of nominal output for DC loads, or with an inverter, AC loads. Moreover, the BP 585’s high efficiency is particularly suited for applications, which need maximum energy generation from a limited array area.

A series of sensors and instruments have been included in the plant to monitor functioning of the plant, as a whole.

Promoters and parties involved

S.E.I. is an official distributor for BP solar in Italy, specialising in developing and applying PV projects in many Italian regions.

Financial resources

As a grid-connected plant,

- Cost per installed kW: about €6,700 - 8,300 (VAT not included)
- Cost per kWh: around €0.34

Results

The PV plant is grid-connected with an annual electricity production of about 13,000 kWh.

The plant has been built as a free-standing structure and is well integrated in the school building.

Potential for Replication

The recent technological development of photovoltaic components with high potential for integration in buildings has opened up new possibilities for the utilisation of this renewable resource. For example, besides grid-connected photovoltaic plant, which supply the electricity directly to the grid, a small-scale stand-alone plant could be installed to meet some or all of the energy needs of a single house, a water pumping system, radio repeater, telephone equipment, street lighting, bus shelter, railway station, etc.

Unfortunately, up until now, the high cost of photovoltaic systems has limited the extent, to which they have been taken up by the market. Thanks to public incentives, over the last few years, the installation of small-scale of photovoltaic plants (1.5 to 3 kW) is becoming more and more widespread in Italy. In early 2001, the Italian Ministry of Environment and Protection of Territory launched the “Tetti Fotovoltaivo” (“Photovoltaic Roof”) programme to promote and diffuse photovoltaic technology. This envisages co-financing projects (up to a maximum of 75% of the cost of the installation) applying small-scale photovoltaic systems. It is envisaged, therefore, that many further projects will be implemented as a result of this incentive.

For more information

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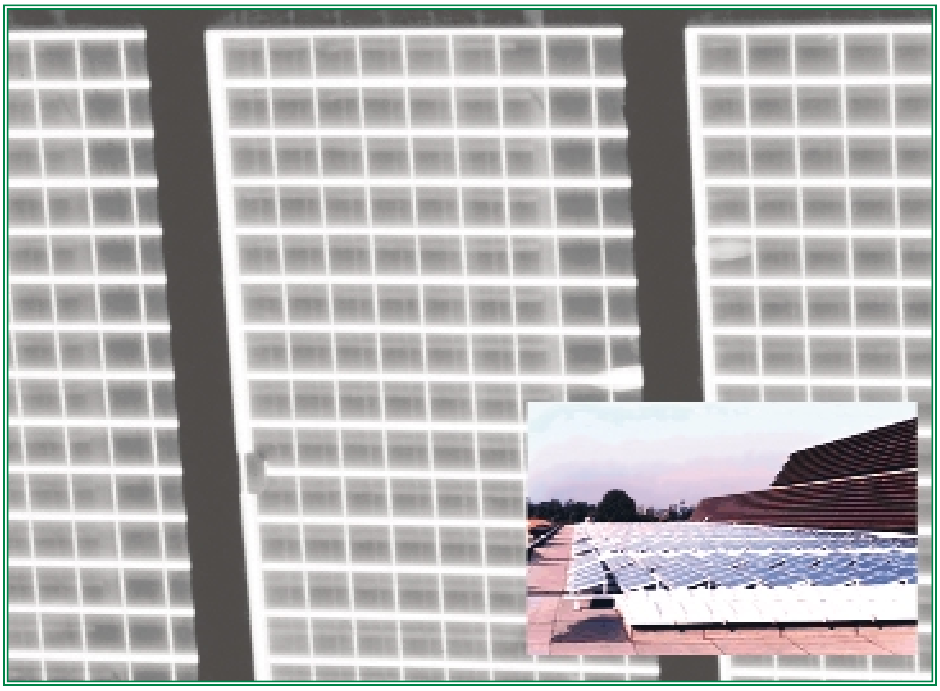
Sector: Solar Photovoltaic
Country: Italy
Location: Bologna
Year: 1998



SOLAR PHOTOVOLTAIC GENERATOR IN BOLOGNA

Eurosolare S.p.A., a subsidiary of Eni SpA, has been in the photovoltaic business since the early 80's and is the only Italian firm to operate with a vertically integrated cycle, from raw material to systems. Eurosolare has built a solar photovoltaic generator at Marconi airport in Bologna, Italy, which is intended to meet the airport's energy needs.

Description

The generator has a power output of 80 kW but does not use a charge regulator or battery. It comprises 1,161 PL800 modules and 2 SUNWAY/T 40 KW inverters.

The modules are of the polycrystalline silicon type, each having a maximum power output of 72 W and weighing 8.5 kg. The design life of the modules is more than 25 years.

Promoters and parties involved

The solar photovoltaic generator is owned by Eurosolare.

The company, manufactures standard mono- and multicrystalline PV modules with power outputs ranging from 16 to 155 Wp and can supply made to order PV modules for architectural design and special purposes.

Moreover, apart from the sales of solar modules, Eurosolare provides technical advice, from sizing systems to "turn-key" installations.

It is among the foremost photovoltaic manufacturers world-wide, both for commercial applications and for the development of advanced technologies, such as silicon thin films.

Financial resources

As a grid-connected photovoltaic plant, the turn-key cost per installed KWh is about €6,700 to €8,300 (VAT excluded).

Results

Each photovoltaic cell has an efficiency of about 10 – 13%. The surface area of the modules is approximately 580 m^2. The annual energy production is approximately 87,000 kWh.

Potential for Replication

Solar photovoltaic technology is still far from being economically competitive. Nevertheless, its fundamental long-term role in reducing greenhouse gas emissions justifies special monetary/governmental incentives. For this reason, the Italian Government is due to launch the "Photovoltaic Roofs Programme", with the aim of installing a total power of 250 MW over a 6-year period.

For more information

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Sector: Solar Photovoltaic
Country: Italy
Location: Montenero (Livorno)
Year: August 2000

ENERGIE

MONTENERO FUNICULAR – SOLAR PHOTOVOLTAIC GENERATOR

S.E.I. Sistemi Energetici Integrati srl, a company specialising in the development and application of innovative technologies, such as photovoltaics, optoelectronics and telemetrics, has built a photovoltaic roof of the funicular station of Montenero, which is on a hill close to the city of Livorno in centre/west of Italy.

The Montenero funicular has being functioned for about 90 years and was renewed in 2000. Montenero hill is not only a popular residential area but also a notable religious site, given that a famous shrine is located on the hilltop. Thus, as the cable railway enables direct access from Livorno City, it is used very frequently by local people. For the Jubilee, Livorno City Council decided to upgrade the power supply system of Montenero funicular by integrating renewables, S.E.I. was assigned the task of constructing a photovoltaic plant on the roof of the station.

Description

The photovoltaic roof of the station has an installed power of 36 kWp, based on 352 solar silicon modules. Annual electricity production is about 40,000 kWh, covering the total load of the funicular. The PV plant runs in parallel with the grid, making it possible to change electricity source.

The plant has been well integrated in a building of high architectural value with no impact on the surrounding landscape.

Promoters and parties involved

S.E.I. is an official distributor for the BP solar company in Italy, specialising in developing and applying PV projects in many Italian regions.

Financial resources

The implementation of this project was partly supported by the European Commission.

As a stand-alone plant,

- Cost per installed kW: about €9,800 (VAT not included)
- Cost per kWh: around €0.6

Results

As the Montenero PV plant is able to meet whole energy needs of the funicular, it enables Livorno City Council to obtain a considerable economic saving, additionally the plant ensures the Montenero funicular station is able to continue operating in the event of a power cut.

Potential for Replication

The use of renewable energy sources (RES) will play a key role in achieving the goals set in the Kyoto Protocol. Thus, white papers by both the the European Union and the Italian Government envisage a doubling of the contribution made by RES by 2010. For this reason the Photovoltaic Roofs Programme, one of the government's incentive schemes to promote RES, has been launched by the Italian Ministry of Environment. It is envisaged that a total of 250 MW will be installed through this programme over a 6-year period.

For more information

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Sector: Solar Photovoltaic
Country: The Netherlands
Location: Amersfoort
Year: 1998

ENERGIE

AMERSFOORT, NIEUWLAND HOUSING PROJECT

Preparations for building Amersfoort's new housing area, Nieuwland, began in 1992. Two years later, REMU, the local utility, initiated a "1 MW project" for Nieuwland to stimulate the application of renewable energy in the built environment. This project led to the implementation of 1.35 MW_p of solar PV systems, with a total area of almost 12,000 m^2. These were placed on the roofs of over 500 houses, a sports hall, a school, a child care centre, and over parking bays. This project has provided important insights into technical and cost aspects of the implementation of solar energy in residential areas. Furthermore, the project aims to promote the social acceptance of solar PV by both users and the building industry. The project also makes a contribution to reaching the REMU target of generating at least 3.2% of the total electricity supply from renewable energy sources by 2000.

In addition to this 1 MW PV project, 19 of the 28 luxury owner-occupied houses in a part of Nieuwland called Lage Hoven have been fitted with solar roofs. With this "Thomasson Dura" project, REMU wanted to explore the possibilities of solar energy in the private sector, and in particular, its use with owner-occupied houses. It aims to gain insight into the legal aspects of implementing solar projects in the private housing sector. The reason being that the application of PV involves different requirements regarding the relationship between the owner of the solar panels and the owner of the house. In addition, the project aimed to examine the possibility of prefabrication of solar roofs, which is a cost reduction option for this technology.

Description

Three different configurations of solar roofs have been fitted to the 19 houses in Lage Hoven. Five roofs have 27 panels each, seven roofs have been fitted with 30 panels each, and another seven have 33 panels per roof. On each roof, three panels are connected in series, so that the roofs contain 9, 10 or 11 series of arrays each. Each array supplies a direct current voltage of 99 V. The maximum current is 3.1 A. For each house, the arrays are connected to an inverter that transforms the direct current into alternating current. The maximum power from each inverter is 2.5 kW. The inverters are located in a cabinet at the front of the houses. A display in the door of these inverter cabinets leads to instantaneous power output of the arrays. The electricity generated is supplied to the grid.

Besides the implementation of solar PV panels, the houses have also been aligned so as to make extensive use of passive solar energy. Together with optimal insulation measures, this results in a relatively low energy demand for heating. High-efficiency (HR+) boilers, fired by natural gas, are used to supply heat. Furthermore, the houses are equipped with a balanced heat-recovery ventilation system. This enables about 90% of the ventilation heat to be retained.

Dissemination activities for this project include a series of leaflets about Nieuwland and a leaflet with information about this specific project for the fitting of solar roofs to 19 owner-occupied houses.

Promoters and parties involved

- REMU NV: regional energy utility; initiator of the project and owner of the solar installations
- Thomasson Dura BV: main contractor
- Artès Architects and Consultants
- Shell Solar Energy: supplier of solar panels
- De Groot: supplier of prefab roofbox
- URSUS BV: supplier of heat recycling system
- Municipality of Amersfoort

Financial resources

The total investment costs for the PV system were approximately €435,000 (excluding VAT). This amount was partly financed by REMU (51%) and Novem (49%).

The cost of the heat-recovery system came to about €43,000. The investment costs for the extra insulation and high-efficiency gas boilers were not specified.

The estimated lifetime of the project is 20 years.

Results

One of the objectives of the project was to test the possibilities of prefabrication of complete roof assemblies at the factory. However, two problems were encountered: , firstly, it appeared that the vulnerable aluminium profiles and the solar panels could easily be damaged during transportation; secondly, the roof elements did not fit together exactly enough to close the aluminium profiles properly. This resulted in additional assembly work being necessary, thus cancelling out the logistic advantages of pre-production of the roof.

Six houses were completed later than the other 13 because the construction site was not available in time. No substantial problems occurred during operation of the system. The design of the roof boxes proved successful.

The project was also intended to gain insight on the legal aspects of installing solar panels owned by a third party on private owner-occupied houses (the houses are private property whereas the solar panels are owned by REMU). The relationship between the owner of the house and REMU was set out in agreements between Thomassen Dura and the individual homeowners. For the latter, the solar panels serve as a waterproof roofing. The residents do not have to pay for construction and maintenance and they receive an allowance for the use of their roof. But in return, they are required to avoid shading the panels and they are not allowed to make changes to the solar roof. Homeowners also have to allow REMU access onto the property in the event of system failures. For its part, REMU is also responsible for any leaks from the roof. During the project an agreement was also reached on the division of costs for possible replacement of the solar panels by standard roofing tiles after the project ends in ten years' time.

As each roof produces about 2,250 kWh of electricity a year the total annual output is about 43,000 kWh. The entire production of electricity by the 19 houses is supplied to the grid, resulting in an annual revenue of approximately €5,000 .

The energy-saving measures implemented in the houses mean a reduction in the amount of fossil fuels needed for heating purposes. In quantitative terms 4,750 m^3 (additional insulation), 2,850 m^3 (heat-recovery) and 1,900 m^3 (high-efficiency gas-fired boilers (HR+) of natural gas usage is avoided. The total reduction of CO_2 emissions comes to about 38 tonnes a year.

Potential for replication

Experience with the testing of pre-production of complete roof assembles and the insights on the legal aspects of solar panels on privately owned houses acquired in this project may be very useful for similar projects in the future.

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Sector: Solar Photovoltaic
Country:The Netherlands
Location: Noordwijkerhout
Year: 1998

ENERGIE

NOORDWIJKERHOUT, LEEUWENHORST CONFERENCE CENTRE

The Golden Tulip Conference Hotel Leeuwenhorst is situated in Noordwijkerhout, in the western part of The Netherlands, close to the beach resort of Noordwijk. The hotel's accommodation comprises 444 rooms, 58 executive rooms, 75 meeting rooms, and numerous facilities such as restaurants, bars, a fitness centre, and business facilities.

When Leeuwenhorst Conference Centre expanded in 1997, an canopy made of solar PV panels was integrated into the new wing of the building. This system is part of a package of energy-saving measures implemented at the hotel. The PV installation was completed in April 1998.

The objective of this project was to demonstrate the commercial viability of PV in combination with low-energy design for commercial building owners. Furthermore, it aimed at showing that solar PV can be applied in a multifunctional context. The PV system not only produces part of the energy needed for the conference centre, but it creates a pleasant indoor climate as well. Furthermore, the PV canopy creates a surprising, architectural effect of light and shadow, making it an eye-catching feature of the building as a whole.

Description

The canopy consists of 180 m^2 of semi-transparent PV panels, letting through 5% of the sunlight. The system is made up of 12 elements with a surface area of 15 m^2 each. Each of the elements has a power output of 1.5 kWp, altogether yielding a total installed capacity of 18 kWp. The panels are partly oriented towards the south-east and partly to the south-west, with a slope of 30º. The panels are attached to steel canopy frames. The system is equipped with six inverters with an output of 2.3 kW.

The PV system is combined with other measures to reduce the energy demand of the building, i.e. additional thermal isolation and an optimal and advanced control systems for lighting and heating.

An electronic information display has been installed showing the current performance of the PV system to visitors of the hotel.

Promoters and parties involved

- Golden Tulip Conference Hotel Leeuwenhorst: main owner and operator of the PV system
- Ecofys: project supervision, consultancy and research (i.e. the optimisation of the energy needs of the new hall during its design)
- Energy and Water Supply Rijnland (EWR) (now part of Nuon): utility company
- C. Zorge: architect
- Shell Solar Energy: supplier of solar panels
- Van der Laan, Zwaag: construction contractor

Financial resources

The total investment costs for the PV project came to €206,059, of which €166,310 were the cost of the PV system. This means the investment costs for the PV system are 9.24 €/Wp.

The project was financed by three organisations. The conference hotel met most of the costs (which came to €101,220). Novem (the Netherlands Agency for Energy and the Environment) and the utility company Energy and Water Supply Rijnland (EWR, now part of Nuon) contributed €82,424 and €22,689, respectively.

Results

No substantial problems occurred during the project. The new wing of the Conference Centre had already been developed before the idea to implement solar PV panels on the roof arose, so the construction of the PV system was not included in the original design of the building. However, this did not cause any problems, because it was a straightforward matter to attach the steel construction of the PV panels onto the steel frame of the building. Then the PV panels were mounted onto the steel construction. No problems were encountered during the operation of the PV system.

The PV canopy at the Leeuwenhorst Conference Centre produces 13,000 kWh of electricity a year. By producing environmentally friendly electricity, the project contributes to the avoidance of the use of fossil fuels for energy generation and the concomitant emissions, such as CO_2.

Potential for replication

This project is a good example of building-integrated PV. Architectural impact is an increasingly important aspect of PV panels for office buildings. The replication potential of this project at other sites depends on the state or design of the building. In the case of the Leeuwenhorst Conference Centre, the design of the building made it easy to install the PV system on the roof of the new wing.

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Sector: Solar Photovoltaic
Country: The Netherlands
Location: Ouderkerk aan de Amstel
Year: 1998

ENERGIE

OUDERKERK AAN DE AMSTEL, ENERGY HIGHWAY A9

A new housing estate, comprising 700 houses, was recently constructed in the municipality of Ouderkerk aan de Amstel. The estate is located near the A9 motorway, which is one of the most heavily used roads in the neighbourhood of Amsterdam and Schiphol international airport, which meant a noise barrier had to be constructed along the highway to reduce the level of noise reaching the houses. It was decided to integrate a large-scale grid-connected PV system into the upper part of the noise barrier so as to produce environmentally friendly electricity. The design of the noise wall is innovative because on account of its relatively high structures and bridge construction, crossing a river, and the fact that it incorporates PV modules as an active part of the noise barrier.

The aim of the project was to evaluate the technical, architectural and economic aspects of this kind of PV system and to find ways to reduce overall system costs by enhancing the volume, design integration and prefabrication of the AC modules. Moreover, the performance and impact of a large number of parallel AC-modules on the electricity grid was investigated. The energy distribution company Nuon sells the electricity generated by the project under its “Green Tariffs” programme.

Description

The section of the A9 motorway where the noise wall is located runs east to west, which means the 1,650 m wall faces south. The wall is 5 m high, of which 4 m consist of concrete elements, above which the solar panels are mounted.

The solar PV installation on the noise wall consists of 2,160 polycrystalline PV-AC modules (Shell RSM 95). There are 12 grid-connection points (cabinets) located near the noise barrier, which are distributed over the whole length of the plant. A set of 180 AC-modules is connected to each cabinet.

All the modules are equipped with their own individual AC-inverter, which was a relatively new concept when the system was built. All the AC-modules operate independently, so the installation effectively consists of 2,160 separate PV systems. Several different types of inverters were installed so as to be able to compare their performance. The inverters convert the direct current (DC) from the modules to 220 V alternating current (AC), which is then supplied directly to the grid.

1- Based on: 6 GJ of primary energy per kWh of electricity and 68 kg of CO_2 emissions per GJ of fossil energy.

Project characteristics

PV modules	
Nominal power (DC) [W]	95
Nominal voltage [V]	33
Module area [m²]	0.95
Module efficiency [%]	10.0
Cell area [m²]	0.72
Cell efficiency [%]	13.2
Whole PV plant	
Nominal power (DC) [kW_p]	205
Total module area [m²]	2,052
Total cell area [m²]	1,555
Inclination angle [°]	50
Orientation angle [°]	200
Power density [Wp/m]	124

Promoters and parties involved

- Nuon International/Renewable Energy: energy distribution company; coordinator of the project, owner and operator
- ECN (Energy research Centre of the Netherlands): PV monitoring
- TNC Energy Consulting GmbH: technical specifications for tenders, evaluation of offers, dissemination report
- TNC Consulting AG: technical specifications for tenders, evaluation of offers, dissemination report
- Fraunhofer Institute for Solar Energy systems (Fraunhofer Institut für Energiesysteme, ISE): special measurements, testing of key components and commissioning of the system
- Shell Solar Energy: main subcontractor, supply and installation of the complete PV systems
- Mastervolt Solar: supplier of 1440 inverters
- NKF Electronics: supplier of 720 inverters
- Municipality of Ouderkerk aan de Amstel
- Bouwfonds Woningbouw: building company

Financial resources

Total investment cost of the PV project on the A9 motorway was almost €2.4 m (excluding the monitoring system). An total of €1.9 m was spent on the PV system itself.

The project was partly financed by the Thermie-A programme of the European Commission with a subsidy of 633,600 ECU. Novem (Netherlands Agency for Energy and the Environment) granted about €538,000 within the framework of the NOZ-PV programme of the Dutch Ministry of Economic Affairs. The partners within the project contributed financially, but the bulk of the finance was provided by the energy distribution company Nuon.

Results

The mounting and installation of the prefabricated module-frames onto the noise barrier proved to be successful. The large-scale testing of 2,160 AC modules, with different makes and types of inverters, was an excellent opportunity to find out what kind of teething problems these relatively new AC modules might suffer from. Both types of inverters used in this project suffered from problems, such as temporary automatic shut-offs as a result of grid interference. These problems were solved either by modifying the inverters or replacing them with an improved model supplied by the manufacturer.

The thorough testing and evaluation of the key components caused a delay to the project of 6 months. The connection to the grid and the installation of two mid-voltage transformers for the two sections of the PV noise barrier resulted in higher project costs. Nevertheless, the actual costs for the project as a whole only exceeded the planned costs by 1%.

The A9 noise barrier produced 147 MWh in 2001. In 1999 and 2000, energy production from the plant was 10-20% lower than expected, mainly due inverter interruptions. During 2002 it is anticipated that the energy plant will produce the estimated 156 MWh.

Benefits of the project include an avoidance of fossil energy use of about 880 GJ/year, which corresponds to an annual CO_2 emission reduction of about 60 tonnes[1]. As well as reducing the noise caused by the motorway, it demonstrates to the thousands of people travelling along the motorway that PV modules can play this dual functional role.

Potential for replication

One conclusion that may be draw from the A9 project is that PV modules which operate well individually may not automatically function well when a large number of them are connected to the same feed-in point on the electricity grid. Therefore, in future similar projects, the mutual interaction of inverters should be taken into account. It is also recommended for large-scale PV projects using AC-modules to equip all inverters with embedded monitoring or/and an indication of the operating status of the inverter, which is easily accessible via a dedicated database or directly over the power line.

The project also demonstrated that by prefabrication, pre-wiring and secure mounting of multiple modules onto a frame, efficient installation is possible and theft of individual modules can be prevented.

The lessons learned from the A9 motorway project are being used for new projects, such as a PV programme in the Netherlands to install 40,000 AC modules on the roof of private houses (SunPower®).

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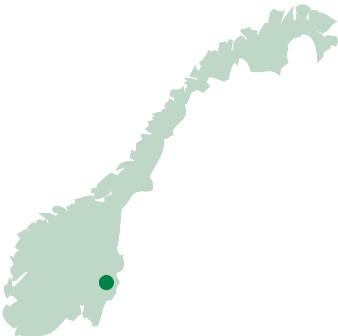
Sector: Solar Photovoltaic
Country: Norway
Location: Grue Municipality, Hedmark County
Year: November 1999

ENERGIE



STAND-ALONE COMBINED PV AND CHP SYSTEM FOR REMOTE AREA

Eidsiva energinett AS, the power utility in Hedmark, is obliged to deliver electricity to some very remote areas. The cost of connecting some of these areas to the electricity grid is high, given the very long distances and relatively small customer numbers. Therefore, Eidsiva energinett AS has been investigating alternatives that could give better value and provide customers with a satisfactory electricity supply in terms of security, quality and comfort.

Description

The system at Venberget is a stand-alone system designed for a single detached house. The stand-alone solution is able to cover all energy needs of the household.

The primary energy sources for the system are solar radiation and Liquefied Petroleum Gas (LPG). The major energy converters are the solar photovoltaic and the LPG fuelled micro-CHP (combined heat and power) unit.

The available solar radiation controls the PV unit, and the CHP unit is controlled by the demand for electricity. The electricity produced by the PV generator and the CHP plant is stored in the battery unit. Heat produced by CHP unit is stored in the water tank. The system can therefore work independently of user demand. The user may use gas directly, for example for the gas cooker.

The CHP unit does not operate continuously, but cuts in when the battery capacity has dropped to below 60 %. The CHP unit normally operates primarily to produce electricity. However, during the winter, when heating demand is at its highest, the CHP unit is turned on to meet the requirement. When this happens an electric boiler in the hot water tank uses the excess electricity. During the summer, when the need for electricity is large and the CHP unit is used, the heat produced is dumped.

The PV system is designed to produce enough electricity to meet demand during the summer. In winter, the solar irradiance contribution is negligible and the CHP unit is used to produce all the electricity required. The household's electricity consumption is almost constant throughout the year as the house is heated by gas. Heat demand, on the other hand, peaks in winter and is very low in summer. This means the system is highly energy efficient. When the heating demand is low the PV generator can produce enough electricity. If the CHP-unit were operated alone the heat produced would have been lost.

Technical data

Unit		Capacity/Size	Efficiency
LPG unit	Electricity	5.5 kW	0.27
	Heat	12.5 kW	0.61
	Total	18 kW	0.88
PV generator		2 kWp/18m^2	
DC/AC inverter		30 A 108 V DC/220 V AC	
Battery unit		108 V 0.46 kW for 24 h, 1.0 kW for 10 h and 1.9 kW for 8 h	
Heat storage		46 kWh, 1m^3	
LPG Tank		2.5 m^3	

The overall efficiency of the system is calculated by comparing the energy supply and useful energy during measurements for a single year:

Energy supply	Energy [kWh]
LPG, CHP Unit	22,541
LPG, Direct use	1,664
Electricity from PV	1,600
	25,805
Energy losses	
CHP Unit	2,247
Dumped heat	946
System losses	4,911
	8,104
Useful energy	
Heat consumption	13,091
LPG, direct use	1,664
Electricity consumption	2,945
	17,700

The overall energy efficiency for the system is thus 69 %.

Dissemination

A detailed report on the project has been published. The report is called Frittstående elforsyningsanlegg-TESS/Venberget, NVE Report No. 7, 2001. (Written in Norwegian.) The report is available from the library of The Norwegian Water Resources and Energy Directorate (NVE).

NVE has published an information leaflet about the project and written an article for the International Energy Agency (CADDET). The CADDET article is available on the Internet at www.caddet-re.org

Promoters and parties involved

The partners involved in the project are:

HEAS(now Eidsiva energinett)
Project management, electricity to the customer

The Norwegian Water Resources and Energy Directorate (NVE)
Financing, dissemination

Enfo (now Norwegian Electricity Industry Association EBL)
Financing

Satema (delivery: LPG unit)
System surveillance, battery charging

Solarnor (delivery: Heat storage)
Heating system for the customer

Statoil (delivery: LPG Tank)
LPG delivery to the customer

Financial resources

- Total investment cost in 1999 was NOK 515,000 (approx. €73,000).
- The project received a subsidy on the investment of approximately 50 % from the government.
- Annual cost of operation and maintenance (including capital cost) are about NOK 80,000 (approx. €10,700). The main cost are gas (LPG) and new battery/battery servicing.
- The battery unit is assumed to have a life time between 5-10 years, the other components about 20-30 years.

Results

- The system has proven satisfactory and can deliver energy with about the same security as conventional grid solutions.
- Annual production of electricity is about 4,000 kWh.

Potential for replication

The project has shown that the stand-alone solution is competitive if the distance to the existing grid connection is more than 2 km.

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Sector: Solar Photovoltaic

Country: Portugal

Location: Municipality of “Peso da Régua” (Vale Douro Norte region)

Year: September 2000

INNOVATIVE STAND-ALONE PV BUS-SHELTER LIGHTING SYSTEM

In the municipality of Peso da Régua, as elsewhere, bus shelters need to be renovated from time to time to ensure passengers’ safety and comfort. Bearing in mind that the bus shelters in the area are frequently used by students waiting for buses to school/college, the need for a lighting system was envisaged given that students may often need to travel to and from classes during the hours of darkness during the winter months.

A bus shelter was therefore designed in collaboration with the Gabinete de Apoio Técnico do Vale do Douro Norte, that not only took into consideration the need for integration with the local landscape by using local materials, but through the involvement of the Regional Energy Agency of Vale do Douro Norte (AREVDN), each shelter was designed to have lighting system powered by solar photovoltaic energy, forecast to work 5 hours a day.

The use of solar PV systems was tied to the fact that many of the shelters were located in isolated places, far from the public grid, thus making PV the most cost-effective solution. The municipality’s use of this innovative renewable-energy-based system has led to other municipalities in the region expressing an interest in adopting similar solutions, and the implementation of similar projects in the near future is anticipated.

Description

The main components of the PV systems installed in each shelter (35 in all) are:

- Photovoltaic panel of 55W
- Stationary battery of 110AH – 12V
- Photovoltaic regulator – 12/24V
- Switch/timer – 12V
- 2 low-consumption lamps - 12V and 11W

The photovoltaic panel is integrated into the roof of the shelter or in the rear wall, depending on the location of the shelter, in order to obtain a south-facing position, and thus ensure optimum electricity generation. The lamps are built in the side walls of the shelter, the other equipment is stored under the seat in the shelter, in an adequately closed and ventilated cabinet.

The project had been presented recently as a model for the use of RES in the XI Congresso Ibérico e VI Congresso Ibero-Americano de Energia Solar, which was held in Vilamoura (Portugal) from 29th September to 2nd October 2002. The municipality of Peso da Régua and AREVDN envisage organising a presentation of the project to the media in the near future. This presentation will seek to highlight the most significant technical, economic and social features.

Promoters and parties involved

The promoter of the project was the municipality of Peso da Régua, with technical support, from Gabinete de Apoio Técnico do Vale do Douro Norte for the design of the shelter (civil works) and from AREVDN for the design of the PV system. AREDVN also managed the project and is now in charge of the future maintenance of the installation.

Financial resources

- *Total investment: €203,000.00 (35 shelters).*
- Civil works : €168,334.00.
- PV system: €34,666.00.
- Subsidies: the project was 90% co-financed by the Portuguese Directorate General for Road Transportation (DGTT), and the municipality of Peso da Régua supported the remaining 10%.

Results

- As mentioned, the project was the outcome of the need to renovate the bus shelters and to install lighting. Given the commitment of the municipality and its interest in alternative sources of energy and the involvement of a Regional Energy Agency, no significant difficulties were encountered.
- Energy production/ substitution of fossil fuels: N.A.
- Socio-economic benefits: to permit better conditions and greater comfort for the users of public transport, mainly students, thus a powerful way of promoting and creating incentives for the use of RES.
- Environmental benefits: the PV equipment is perfectly integrated its environment.

Potential for replication

There are many bus stops in similar conditions all over the country (and elsewhere in the EU), thus the potential for the replication of this type of projects is very high.

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Sector: Solar Photovoltaic and Wind Energy

Country: Portugal

Location: Santana da Serra Village, region of Ourique

Year: September 2000

ENERGIE

OURIQUE HYBRID SOLAR AND WIND POWER PLANT

This project sought to provide an independent supply of electricity by means of wind and photovoltaic (PV) power to three isolated settlements in the region of Ourique, in the south of Portugal.

A total of 55 houses with 120 inhabitants benefit from the PV energy supply. Besides domestic purposes, the energy supplied is also used to irrigate 50 ha of surrounding farm land and to provide public lighting.

Each village is supplied by an independent generating unit dimensioned so as to match the electricity supply with that provided by the electricity grid. Each settlement has been given an energy performance guarantee of 3 kWh of power a day.

A variety of solutions were conceived for each plant, in order to evaluate the best performances under similar meteorological conditions and consumption profiles.

Besides the generation and experimental value of the project, the three plants enabled a unique demonstration Centre for Renewable Energy to be set up in Portugal, which since commissioning has been visited by public and schools from all over the country.

Description

The dwellings were distributed among three villages: Cismalhas, Monte Sambro and Monte Corte Coelho. The three plants are situated near the hamlets, with the exception of the “Cismalhas” power plant, which supplies electricity to three different hamlets (Cismalhas, Cerro do Guincho and Cegonhita).

The Cismalhas plant is a hybrid PV/Wind plant, with the PV modules integrated in the roof of the building that houses the power equipment. A total capacity of 21 kWp of PV power were installed, complemented by two 15 kW wind turbines.

The Monte Sambro Plant is also a hybrid PV/wind plant but has only one 25 kW wind turbine with a 10.5 kWp ground mounted PV system.

Finally the Monte Corte Coelho unit is a stand-alone 10.5 kWp system mounted on the ground.

Each unit is equipped with its own 15 kVA diesel generator as a backup power supply.

The project was presented to the Public, the Portuguese Scientific Community and market actors at a series of seminars and workshops held in Portugal. Dissemination activities were based on articles released to the general media and to specialised magazines.

Promoters and parties involved

The Ourique project was set up within the framework of the European Commission THERMIE Programme. The project is the outcome from two integrated projects, one covering PV generation (Ourique – PV, THERMIE contract Nº SE/184/97/PT/DE), and the other one wind generation (Europeole Portugal, THERMIE contract Nº SE/254/97/FR/PO

The organisations involved were:

ADENE - Portuguese Agency for Energy

Sun Power Solartechnik – Inverters Supplier

EDP (Electricidade de Portugal) – Main Portuguese Utility

Câmara Municipal de Ourique – Ourique Municipality

Vergnet – Supplier of the wind generators

F.F. Sistemas – PV supplier and Installer

Financial resources

Total investment:	€1,200,000
Thermie Program:	€340,000
Energia Program (Portuguese National Program):	€257,000
Private:	€603,000

The project was a pilot project therefore it cannot be used as reference for the economic aspects of the project, only for the technical aspects. No borrowing was necessary.

Results

No special problems were encountered since commissioning benefited from a major effort at the project conception and design stage. The main difficulties encountered were related to the integration of two very different Support Programmes (Thermie and Energia), which required a great deal of time and effort to overcome.

Potential for replication

The success of the project opens up considerable potential for replication in developing countries Portuguese-speaking world (mainly Africa). The utility EDP has already expressed its interest in evaluating the possibility of replicating the project, profiting from the experience and knowledge already gained.

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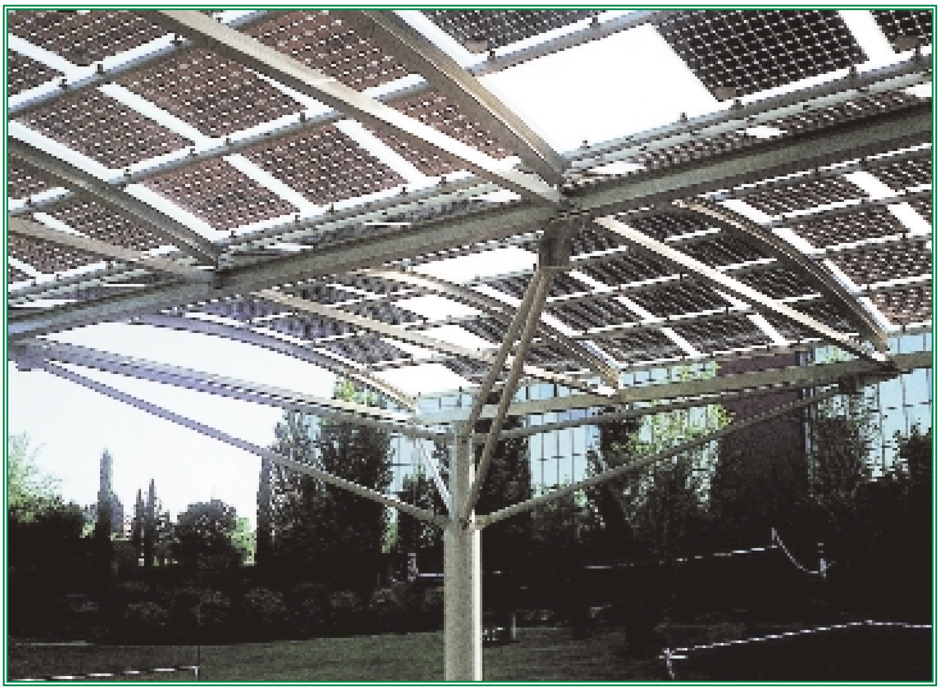
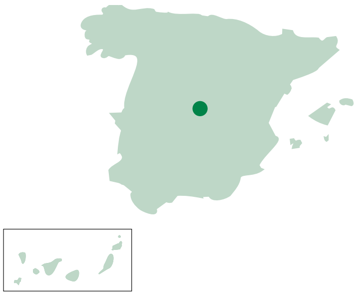
Sector: Solar Photovoltaic
Country: Spain
Location: Palacio de la Moncloa (Madrid)
Year: 2000

ENERGIE





THE MONCLOA PERGOLA

Under a cooperation agreement between the Ministry of the Presidency and the Institute for the Diversification and Saving of Energy (Instituto para la Diversificación y Ahorro de la Energía, IDAE) an innovative solar photovoltaic system has been installed in the gardens of the Moncloa complex, the official seat of the presidency.

The project involved installing a 41.4 kWp grid-connected photovoltaic generator in the grounds of the Moncloa complex. The numerous innovative aspects of this installation include its design, in which special care has been taken to ensure it is in harmony with its setting, and the aesthetic aspects of the components, which have involved close cooperation between technicians and architects.

The siting of this installation in such a high-profile location will help create a positive and favourable public attitude towards solar photovoltaic energy, thus serving to promote this type of renewable energy, which has clear environmental benefits.

Description

The project concerns the installation of a photovoltaic pergola in the grounds of the Moncloa presidential complex. The pergola is intended to be used for receiving guests, holding press conferences, and other functions.

The incidence of the sun, the need to harmonize the pergola with its surroundings and to ensure its visibility were factors taken into particular account.

The special-purpose structure was built to act as a support for the photovoltaic panels that make up the 41.4 kWp grid-connected solar installation. Anticipated average output is 45,000 kWh/year, equivalent to 1,100 hours of operation of the photovoltaic installation each year. The main features of the installation are:

Capture system. Photovoltaic modules:

The installation is made up of 324 square frameless glass-tedlar modules. The modules are of three types: 144 x 144 Wp 100 cell modules, 144 x 144 Wp 64 cell modules and 36 modules without photovoltaic cells.

The installation has been connected in such a way as to form two arrays of modules, each with a single type of module, each array consisting of 4 parallel branches of 36 modules in series. The active models in each array are connected to give a nominal power output of 20,736 Wp, thus totalling 41,472 Wp for the installation as a whole. The nominal voltages arriving at the d/c control cabinet are 345.6 V from one branch and 280.1 V from the other.

The photovoltaic modules were supplied, fitted and installed by a joint venture comprising Atersa, BP Solarex and Isofotón, the only suppliers based in Spain.

Conversion. Inverters:

Two inverters are included, one for each collector array. The inverters have a nominal power of 18 kW per unit and an output voltage of 380V at a frequency of 50 Hz.

The efficiency obtained is approximately 95% of nominal power. The inverters were supplied by Enertrón and are standard self-switching ACEF-Solar units with IGBT semiconductor bridges, able to supply the maximum instantaneous power produced by the photovoltaic generator to the grid at all times provided solar radiation is above a certain minimum threshold.

Monitoring and Control:

The installation includes an automatic monitoring and demonstration system enabling operating data and meteorological parameters to be gathered at the installation. This information is necessary to monitor the technical performance of the installation.

Connection to the low-voltage electricity mains grid:

It was decided that the optimal solution would be to connect the PV system to the low-voltage grid.

Promoter and parties involved

The project is a joint initiative by the Instituto para la Diversificación y Ahorro de la Energía (IDAE), the Instituto de Energía Solar (IES) and the electricity utility IBERDROLA, S.A.. Support was also provided by the Centro para a Conservaçao de Energía (CEE), Portugal. The project received backing from the European Community THERMIE Programme and the Consejería de Economía y Empleo de la Comunidad de Madrid, within the framework of the Energy Saving and Efficiency Plan (Plan de Ahorro y Eficiencia Energética).

Financial resources

The investment finance was provided by the IDAE through the third-party finance scheme, whereby the IDAE retains ownership of the fixed assets and will recoup its investment via the income from the sale of the electricity generated. The main parameters are as follows:

Investment:	€517,471
THERMIE subsidy:	€195,930
PAEE subsidy:	€43,998
Energy production:	45,000 kWh/year
Forecast income from electricity sales:	€9,734
Maintenance and operation:	IDAE

Period of validity of the TPF contract: Until production target of 1,100,000 kWh is reached

Results

a) In energy terms

- Implementation of one of the largest grid-connected solar-photovoltaic installations in Spain (41.4 kWp).
- Optimization of the design and integration of the installation.
- Guarantee of correct operation.

b) In environmental terms

- Use of renewable energy, based on non-depletable environmentally friendly resources.
- Use of solar energy to supply electricity.
- Improved environmental impact resulting from the energy savings and a reduction in emissions of around 44 tonnes of CO_2 avoided each year.

c) In economic terms

- The adaptation of the third-party finance technical/financial instrument, previously used with other types of renewable energy sources, to the case of solar-photovoltaic energy, deserves highlighting.
- The Moncloa complex will obtain a reduction in its energy bills, and once the investment has been recouped, it will own the facility.

Potential for replication

The positive experience from this project increases the likelihood of the implementation of other similar installations at other high-profile publicly owned locations in open spaces of notable architectural or historic merit, thus helping create a positive and favourable public attitude towards solar photovoltaic energy systems of this type.

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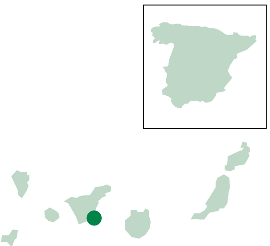
Sector: Solar Photovoltaic
Country: Spain
Location: Tenerife (Canary Islands)
Year: November 1998

ENERGIE



480 KW PHOTOVOLTAIC CONCENTRATOR SYSTEM

The project consists of a photovoltaic concentrator system using parabolic through collectors for the first time.

The outstanding feature of this project, and the objective of concentration for photovoltaic conversion is to reduce the cost of the electricity generated compared with flat photovoltaic panels, so as to bring the cost down to levels, which are acceptable to the current energy market. The project is at an intermediate point between research and the commercial stage, and represents a significant innovation in the solar photovoltaic energy field worldwide. The technology employed is state of the art, and much of the development work for the project was done in Spain.

Description

The PV plant stands on land belonging to ITER, in the Granadilla industrial estate (Tenerife, Canary Islands), alongside other installations using various other renewable energy technologies for experimental and demonstration purposes.

It comprises 14 rows of collectors, each row being 84 m long. The total installed capacity is 480 kW. The rows lie on a N-S axis and all the collectors have a single-axis solar tracking system. The plant is connected to the grid via inverters, each of which has a rated power of 68 kW.

Energy data:

Installed capacity: 480 kWp

Electrical output: 846 MWh/year.

Technology data:

System/Device: PV modules
Technology: Si-mono
Manufacturer: BP Solar
Model: SATURNO concentrating

System/Device: Reflectors
Technology: Al + Sylverlux
Manufacturer: Alcoa; 3M

System/Device: Radiators
Technology: Al fin
Manufacturer: Alussuisse

System/Device: Tracking structure
Technology: 1 axis N-S
Manufacturer: JUPASA

System/Device: Tracking electronics
Technology: open loop
Manufacturer: INSPIRA

System/Device: Inverters
Technology: three-phase
Manufacturer: ITER
Model: TEIDE

Promoters and parties involved

The project was initiated by ITER (Instituto Tecnológico y de Energías Renovables), which is the owner of the system and acts as coordinator of the project, with BP Solar and IES (Instituto de Energía Solar de la Universidad Politécnica de Madrid), as project partners, based on the EUCLIDES (European Concentrated Light Intensity Development of Energy Sources) prototype developed in Madrid by IES.

Financial resources

Investment from own funds of €2,854,807.

Subsidies of €1,532,580 (€270,455 from the Energy Saving and Efficiency Plan - Plan de Ahorro y Eficiencia Energética, PAEE, and €1,262,125 from the EC Thermie Programme).

Results

On the basis of the experience obtained from the project a broad range of new fields for R&D have been identified in the following technologies:

- Photovoltaic modules for grid-connected solar concentration plants.
- Weeather-resistant parabolic half-cylinder mirrors and reflective materials.
- Single-axis tracking systems, which learn during normal operation.
- High-efficiency three-phase and single-phase inverters.

Potential for replication

The main advantage offered by the EUCLIDES concept is that most of the components of the plant can be manufactured and assembled at the destination, without the need for complex techniques or sophisticated equipment. This considerably increases the replicability of the modules and therefore facilitates construction of plants in accordance with customer requirements, and involving the customer's own personnel, thus reducing costs.

In parallel, given that the current legislation in Spain places a premium on the output of photovoltaic plants producing a maximum of 5 kWp, ITER has also designed modules using the same concept as the EUCLIDES plant, but on a smaller scale, suitable for use under these more favourable economic conditions. The scalability has, however, been maintained, thereby protecting the initial investment in the case of plants that need to increase their power output in the future.

For more information

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Sector: Solar Photovoltaic
Country: Sweden
Location: Älmhult
Year: September 1997

ENERGIE

IKEA OFFICE BUILDING WITH AN INTEGRATED PV POWER PLANT

TI interest in building integrated PV installations has been growing in recent years. In 1997 IKEA installed a 60-kW_p grid-connected solar electricity system at an office building in Älmhult. The aim of the project is to gain experience with solar electricity that could be used for power production at other IKEA buildings (e.g. shopping centres) in the future.

Description

The system is mounted at the roof and façade at the IKEA office building in Älmhult in the south of Sweden.

The roof-integrated system consists of:

- 450 modules delivered by NAPS with a total of 49.5 kW_p
- 45 sub-systems with 10 modules in series per inverter
- A total module area of 378 m^2
- The modules are installed in four rows and have an angle of inclination of 40º

The façade-integrated system consists of:

- 312 Millenia MST modules from Solarex- 10.9 kW_p
- 13 sub-systems with 24 modules all with separate inverter
- A total module area of 250 m^2
- The modules are mounted vertically on the façade

Dissemination activities

The project is part of the Swedish SOLEL 97-99 programme. The aim of this programme is to find possible ways of integrating PV systems into the existing power systems on reasonable financial terms.

The results from this project have been published in a report entitled *Solel 97-99, Et branchgemensamt FoU-program, Slutrapport*, Elforsk report no. 00:09, February 2000 (In Swedish with an English summary.) The report is available at Elforsk' s Internet pages: www.elforsk.se.

The project is presented by the International Energy Agency in the CADDET Technical Brochure No. 142, www.caddet-re.org.

Promoters and parties involved

- The owner of the plant is IKEA International AB.
- Energibanken i Jättendal AB was responsible for project planning and development and for the monitoring programme (SOLEL 97-99).
- The main contractor for the roof system was Fortum AES Sweden AB.
- The main contractor for the façade system was Sunwind Gylling AS.

Financial resources

Total investment

The total investment was approximately €430,000.

Subsidy

The NUTEK-programme (The Swedish National Board for Industrial and Technical Development) subsidised approximately 40 % of the cost of the project (about €172,000)

The monitoring project as part of the SOLEL 97-99 was sponsored by the Swedish National PV programme organised by ELFORSK AB.

Results

Measurements were taken as part of the SOLEL 97-99 programme over the period 1997 to 1999. The solar electricity production is mainly a function of the solar radiation, but the shade and ambient temperature can also have an influence. For the roof-system there are periods of shade in winter as the days are quite short. The ambient temperature affects output by increasing the temperature of the solar cells and thereby reducing the generated capacity by about 0.4 %t per degree Celsius.

The measured solar radiation and output is given in the table below:

Month	Solar radiation, roof	Generated electricity, roof	Soalr radiation, façade	Generated electricity, façade	Average tempera-ture
	[kWh/m²]	[kWh]	[kWh/m²]	[kWh]	[º]
January	13.1	347.2	11.2	38.5	0.0
February	39.2	1,317.4	40.7	198.9	-1.5
March	63.9	2,584.5	47.2	233.3	2.3
April	100.0	3,970.4	65.1	368.8	7.2
May	142.2	5,499.2	77.1	417.4	9.7
June	142.3	5,423.0	71.8	344.6	14.6
July	165.4	6,139.9	87.4	503.7	17.7
August	135.5	5,058.0	81.8	488.6	15.7
September	117.7	4,578.3	87.0	559.2	14.4
October	56.9	2,361.2	48.8	268.0	7.3
November	28.6	1,049.1	29.2	137.7	3.9
December	16.1	263.8	19.3	59.9	-0.1
Annual	1,020.9	38,592.0	666.6	3,618.6	7.6

The normal way to calculate the performance of the system is to take the ratio of the electricity generated (kWh) and the maximum capacity of the solar cells (kW) (Final Yield). For 1999 the final yield for the roof and façade system was:

$Y_{f,\ roof}$ = 780 kWh/kW$_p$

$Y_{f,\ façade}$ = 332 kWh/kW$_p$

The final yield is dependent on the available solar radiation at the location and therefore the performance ratio (PR) is used to compare with other locations. PR is calculated by dividing the Final Yield by the solar radiation:

PR_{roof} = 76 %

$PR_{façade}$ = 50 %

These results show that the Performance Ratio is high compared to other solar electricity projects, e.g. the German 1,000-roof project where the average Performance Ratio was 65%.

Potential for replication

The price of solar electricity is still too high to be competitive with conventional sources, but the high performance ratio of the roof mounted systems shows that valuable experience has been gained during this project.

For more information

Project management and monitoring activities

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Host

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Sector: Solar Photovoltaic
Country: U.K.
Location: Bretforton in Worcestershire
Year: November 1999

ENERGIE

PV- LIGHTING AT BUS STOPS

This is an innovative project for the UK (in fact, it seems to be the first known project of its kind in the UK). Original conceived of as a pilot project, it has turned out to be successful and replicable. With the permission of the Worcestershire County Council, SEPCO installed a PV lighting system for bus shelters in the Parish of Bretforton in November 1999 for a trial period, in order to test the performance of the technology.

Description

The main components of the installation, (which has been adapted to the climate of Great Britain) are:

- A solar power panel with 2 single-crystal units of 1293x330x35 mm working at 50 Watt Peak Power.
- A 12VDC battery and with a total capacity of 75 Ah, (which can store and supply power for 19 days without sunshine).
- A controller mechanism (Lighting Control Unit and Real Time Clock Controller), warrantied for three years, operating between –20 and 70 ºC at a maximum humidity of 100%.
- A compact fluorescent 2 pin 9 watt lamp with a rated average life of 10,000 hours, located inside the bus stop.

The system has been designed to take into account the fact that the low voltage-disconnect automatically resets upon the first dawn cycle to ensure that the fixture will operate every night regardless of the charge received during the day and it functions properly even when other types of natural or ambient light are present.

The trial was successfully completed and the system has been installed permanently at additional bus shelters, while other Councils have also ordered the system for other communities in the area.

Promoters and parties involved

Developers (project consortium)/operation and maintenance

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Owner

Worcestershire County Council

Financial resources

Total investment:

The cost of the system was around €2,560, including hardware development. This calculation does not take the energy cost savings from operation of the system into account.

Results

The system performed as designed and provided reliable power to the bus shelter throughout the period (a year) following installation on 12th November 1999. Only two external factors were the cause of failures in the installation: vandalism (though the systems has some anti-vandal features) and rain water leaks.

During the trial period, the overall energy produced by the installation was 21.44% of the system capacity, whereas the PV utilisation (energy produced divided by theoretical production) came to the 40% of the system capacity.

Results obtained from illumination point of view were also very satisfactory as showed by the luminance values: 20.5 Lux under light.

The solar panels fitted were sufficient to generate the power needed to charge the battery and supply electricity to the light under the bus shelter for up to 9 hours a day , i.e. from dusk to 00:15 h. (after the last bus left) and before 6:00 A.M (first bus of the day) to dawn. Controller equipment was essential to control the operation of the system during this time interval.

The project has been well received locally. Moreover, it has shown its potential usefulness in areas where other systems are not viable, as well as its positive effects in terms of providing security in unlit public areas.

Negative impacts (especially in terms of damaging emissions) of this installation are insignificant when compared with other those of energy production methods.

Potential for replication

The characteristics of the system and the results obtained imply that the potential for replication is very high. In fact, the Council has already replicated it by installing the system permanently in other bus shelters, and other local authorities are also in the process of implementing similar systems in their areas.

The system also has additional applications in other fields. For example: a solar illuminated bus timetable recently installed outside County Hall in Worcester (the first of its type in U.K.) which makes it possible for waiting passengers to read the timetable during the hours of darkness; telephone kiosks; solar-powered illuminated traffic signals, etc.

For more information:

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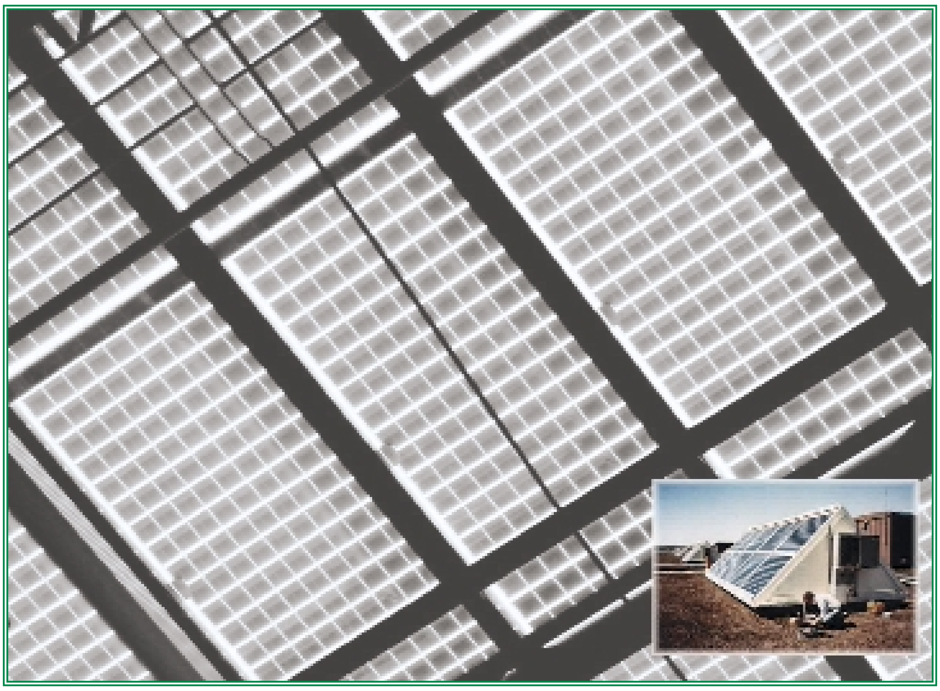
Sector: Solar Photovoltaic
Country: U.K.
Location: Bridgend, Gwent
Year: March 1998

ENERGIE



PV ROOF AT BRIDGEND FORD PLANT

Located on the roof of Ford's Bridgend plant in South Wales, U.K., this large grid-connected photovoltaic system is one of the first of its kind to be installed at a car factory any where in the world.

This project is part of the Ford' s Factory of the Future Programme aimed at investigating the feasibility of the introduction of energy saving, energy efficiency and renewable energy measures at car plants. This project specifically aims to test the feasibility of using solar energy in a factory.

The installation contributes to the plant's power and lightning requirements and also allows natural light to reach the workspace (thereby reducing artificial lighting requirements).

Description

The system comprises 26 solar units (inverted v-shaped units) each measuring 9 x 5 m located on the 139,000-m^2 roof of the factory. The north face is clear glazed (allowing natural light to enter the work area located below) whereas the south face made up of photovoltaic cells.

Each unit contains 1,540 photovoltaic BP Solar high efficiency Saturn cells arranged in 10 large-area laminates (each including 154 cells) measuring 1.9 x1.55 m and generating a peak output of approximately 100 kW and an annual capacity of 110,000 kWh.

Each unit is equipped with a Microtech inverter so as to convert the 140-160 V DC to 240 V single phase AC. The single phase supplies are connected to a system distribution board, so as to produce a 415 V three-phase supply for connection to substation bus bars (from which lighting distribution is drawn).

Promoters and parties involved

Project management, financial administration

Ford

Manufacturer, project developer, design and manufacture of PV system

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Financial resources

The total cost of the installation was €2.4 m. It was funded jointly by Ford, the European Commission (through the Thermie Programme) and the DTI (United Kingdom's Department for Transport and Industry) trough the N&RE Programme (€160,000).

Thermie programme also provided co-finance of a total of 543,200 ECU.

Results

Energy savings have been estimated to be 77,600 kWh per year.

In addition to the electricity saved, it has been calculated that by means of this installation the factory will avoid the release of 4,400 tonnes of CO_2 during the 30-year life of the plant.

Apart from these aspects, it has been taken into account that the installation will allow natural light to pass into the work areas located below the installation.

Potential for replication

The project is part of a wider programme carried out by FORD, which is well known and represents a very good example for all those industrial groups aiming to invest in environmental-friendly technologies as part of their development strategy.

The indirect marketing effects of these measures for the company's image are estimated to be highly positive.

For more information

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www.pv-uk.org.uk

Sector: Solar Photovoltaic
Country: U.K.
Location: Capton, Darthmouth
Year: August 1999

ENERGIE

KELBECHAN HOUSE

This solar powered house, built in the South West of England started feeding electricity into the grid in August 1999 after having received authorization from Western Power Distribution Ltd.

Main objectives of the project were as follows:

1. To build the first grid-connected PV system in this area of the U.K.
2. To learn from the experience in terms of the tasks associated with the implementation of this type of system, such as planning, designing, procurement, commissioning and monitoring.
3. To demonstrate that this system has considerable potential for replication and can be incorporated at a low cost in similar houses.
4. To demonstrate the advantages of the technology used (amorphous silicon) compared with the conventional equivalent.

Description

The 1.35 kW installation comprises 27 BP 850 (formerly, Solarex MST-50) amorphous silicon cells; this material has a much lower temperature coefficient of power than the crystalline silicon that is to say less than 0.1 %/°C vs 0.4 %/°C).

Moreover, it is formed by a SK60V glass/glass laminate embodied in Schuco aluminium curtain-walling system. The laminates form the roof over a greenhouse and conservatory extension to the property and are tilted at 40°. Finally, the system has an SMA 1,100 E inverter, where the power produced at a nominal 144 Vdc is converted to 230 Vac in order to be introduced in the local low-voltage utility network.

Promoters and parties involved

Installation (manufacturer)

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info@becosolar.com
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Financial resources

Total cost was approximately €4,000.

All the costs of connection, commissioning, metering, meter reading, and purchasing exported kWh at the same rate as the owner purchases them, have been provided by SWEB's Green Electron Scheme (a scheme to support power generation from renewable resources by providing a “green” tariff to electricity consumers, which has been in operation permanently since 1997 in the U.K).

Considering a low maintenance cost (amorphous laminates are maintenance-free apart from cleaning) and an amount of annual energy production of 1,200 kWh, the payback period has been estimated to be around 25 years.

Results

The amount of energy produced per annum is about 900 kWh (though initially and assuming an annual ESH of 2.5 for a South facing array tilted at 40° the initially estimated performance of the system was more than 1,200 kWh/year), an amount equivalent to 40% of the house's electricity needs). When this amount is large, the excess is exported to the grid through an export meter (which is considered to be the most cost-effective solution considering the price differences between imported and exported electricity).

A relevant advantage of this system from an environmental perspective is that at least 40% of the electricity consumed by the house has been produced with a system that helps to reduce CO_2 emissions to the atmosphere (an initial estimation of 540 kg CO_2 emissions avoided was calculated considering an annual production of 1,200 kWh).

Potential for replication

Considering the objectives of this project and the results obtained, it may be considered as a pilot trial with considerable potential for replication both in similar conditions and also with some more general uses.

For more information

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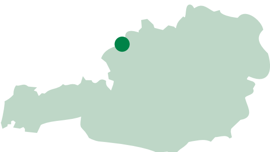
ENERGIE

6 GEOTHERMAL

Sector: Geothermal
Country: Austria
Location: Altheim
Year: January 2001

ENERGIE



ALTHEIM, GEOTHERMAL ORGANIC RANKINE CYCLE PLANT

For a number of years 2,000 of the 5,000 inhabitants of Altheim, Upper Austria, have been supplied with heat from a geothermal plant drawing hot water from a single well. In December 1997, the plant was extended to improve its technical and economic performance. A second well was sunk, allow reinjection of the used thermal water.

Hot water from the geothermal source is now used not only to supply heat to the district-heating network of Altheim, but also to drive an Organic Rankine Cycle (ORC) turbine to produce electricity. The cooled thermal water leaving the Organic Rankine Cycle is reinjected into the new well to preserve the aquifer. As this is a closed water cycle, the water composition remains unchanged.

This project aims to contribute to protecting the environment by reducing harmful emissions and improving of the security the city of Altheim's energy supply.

Description

The Altheim geothermal plant uses both a production well and a reinjection well. The latter originated from the second drilling operation and its distance to the first drilling hole underground is 1,700 m. While it was being drilled, the second bore hole was slowly directed towards the first an angle of 54 degrees at a depth of 460 m.

The first bore hole, used as the production well, is connected to an existing district-heating network, where heat is provided to 650 houses at a temperature of up to 90°C. The return flow of the thermal water, which is cooled to about 60°C, is piped to the reinjection well.

The production well is also directly connected to an electric power generation plant, which uses Organic Rankine Cycle technology. In this project, a special working fluid is used. The organic working fluid used is a refrigerant of the fluorocarbon class. Use of this non-toxic and environmentally friendly fluid is one of the innovative features of this plant. Moreover, it has no ozone depletion activity and it is non-flammable, unlike many other fluids used in geothermal power plants. The fluid has a boiling point of 30°C.

Another innovative aspect of the project is the variable nozzle turbine design with enhanced partial load behaviour allowing a high degree of adaptation to different geothermal feeding flow rates.

In the Organic Rankine Cycle, the working fluid is evaporated using heat from the thermal water. The vapour is then expanded in a turbine, which drives a generator producing electricity. The water leaves this cycle at a temperature of 60ºC to 65ºC. This heat can (optionally) be supplied directly to a heating circuit which supplies a school and thermal baths. The water that leaves the Organic Rankine Cycle is also fed to the reinjection well.

The plant is completely automated. The presence of an operator is required only to start up the plant and periodically check its status. The Programmable Logic Control (PLC) system controls the normal operation of the plant, as well as the start-up and shut down procedures. The emergency procedures are also automatically handled by the Programmable Logic Control.

Project characteristics

Production well depth [m]	2,306
Re-injection well depth [m]	2,150
Re-injection temperature [°C]	50-60
Generator capacity [kW_e]	1,000
Net electric capacity to the grid [kW_e]	500-600
Thermal power to heating network Altheim [kW_{th}]	9,000
Thermal power to heating circuit school/baths [kW_{th}]	1,000
Nominal geothermal water inlet temperature [°C]	106
Nominal geothermal water outlet temperature [°C]	78.3
Nominal geothermal water flow rate [kg/s]	81.7
Nominal Cooling water flow rate (estimated) [kg/s]	340
Nominal Cooling water inlet temperature [°C]	10,0
Full load operation hours	approx. 7,500

The Altheim geotherfimal plant project has been presented at several conferences, workshops, etc. in a number of countries including the USA, Germany, Austria, and Switzerland.

Promoters and parties involved

- Municipality of Altheim (Marktgemeinde Altheim): promoter and co-ordinator
- Turboden: supplier of Organic Rankine Cycle system
- Geotherma and Terrawat: design of reinjection bore hole, expansion of the production hole, and the control system
- Energie AG Oberösterreich: regional electricity supply company

Financial resources

The total costs for the project were €5,084,090. A subsidy of €1,565,184 was granted within the framework of the Joule-Thermie programme 1994-1998 of the European Commission. The project was also funded by the federal state of Upper Austria and the Austrian government, which together contributed €792,968. A further €367,610 was provided by the municipality of Altheim. Later Energie AG, the electricity supply company, paid €981,083 as compensation for a low energy price. The remaining part of the total project costs consisted of a loan of €1,377,245. The sources of revenue from the project are the sale of heat and electricity.

Results

There were some control system problems regarding the integration of the electricity production with Altheim's existing district-heating system. The cleaning of the cooling water drawn from a small river in the vicinity of the plant also turned out to be difficult. This led to some shut down periods of the plant. This was also due to problems affecting the turbine caused by strong fluctuations of the geothermal water flow rate. After some time, all these problems were solved and the plant has been running successfully since November 2001.

The geothermal plant in Altheim is able to produce about 3,500 MWh of electricity a year, with a value of about €140,000. The annual supply to the district-heating system (which exists from 1989) is about 14,000 MWh, with a value of about 700,000 euros.

As a result of this project, about 69 TJ a year of energy from fossil fuels has been substituted and emissions of CO_2 have reduced by around 4,500 tonnes a year. Furthermore, implementation of the plant implies an annual reduction of SO_2 and NO_x, of around 4.7 and 19 tonnes, respectively. Another environmental benefit is that because the thermal water is reinjected after use, no thermal water is wasted and the balance of the aquifer is not disturbed. The project has also contributed to job creation and security in the region.

Potential for replication

Experience drawn from the geothermal plant at Altheim is being used for some other geothermal projects in Germany (such as Bad Urach, Karlsruhe, Unterhaching, Bruchsal). Another application for the experience acquired in this project is in the construction of a similar plant to that at Altheim, which is due to be built in Kamtschatka (Russia).

For more information

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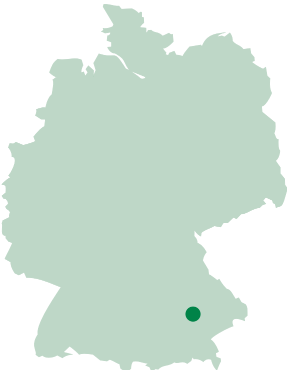
Sector: Geothermal
Country: Germany
Location: Erding
Year: 1998

ENERGIE



ERDING, GEO-HEATING PLANT

The town of Erding, Bavaria, uses thermal water both as a heat source and as a raw material. To exploit this resource, a district-heating system has been implemented, covering several residential neighbourhoods, and the area's new thermal baths.

The hot spring was discovered while sinking an exploratory well during oil prospecting. The discovery led the City and County of Erding to consider how this source of hot water from deep underground might be exploited commercially. A continuous pumping trial was performed, and plans were drawn up to provide hot water to the Erding Country Hospital, other municipal facilities, and a number of newly built homes. However, this consumer structure would have resulted in their being considerably more demand in winter than in summer. The plan was therefore extended in 1994 to include supplying hot water to thermal baths nearby, so as to ensure a permanent base load.

The foundation stone for the Erding Geo-Heating Plant was laid in October 1996 and the plant officially came into operation in March 1998. The geothermal water from the well is supplied to the district-heating system, thermal baths, and to Erding's drinking-water system. The project was designated a decentralised project in the renewable energy field for the Hanover Expo 2000.

Description

The plant consists of a direct heat-exchanger unit, an absorption heat pump, and two hot-water boiler units. Using three heat exchangers, the filtered deep-well water heats the district-heating water, which circulates in a separate loop. The well water, having cooled to about 48°C, is cooled down further to about 20°C by the absorption heat pump. In this way, the district-heating water is heated to almost 80°C. The water is fed to the district-heating system at a final temperature of up to 100°C. The hot water reaches customers via a district-heating network extending over a length of 9,800 m. After use, it returns to the heating plant, at a temperature of 45°C.

After the utilisation of its energy content, which leaves the quality of the water unchanged, the thermal water flows into a degasification tank, where its methane content is reduced. Then it is treated with ozone in two stages, and passed through biological filtering units. Pressure relief in an open pure-water tank causes dissolved gases to be emitted. The conditioned water is pumped into the Erding municipal waterworks, where it is mixed with tertiary water, conditioned again, and fed into the drinking water system.

Project characteristics

Well depth [m]	2,350
Deep-well pump depth [m]	230
Total thermal capacity [MW]	18
Direct heat-exchanger thermal capacity [MW]	2
Absorption heat pump capacity [MW]	7
Total hot-water boiler capacity [MW]	10
Thermal water temperature [°C]	65
Output geothermal water flow rate [l/s]	55

Dissemination activities for the project included a presentation of the project by the State of Bavaria at the Expo 2000 in Hanover, under the heading of "Environment and Development".

Promoters and parties involved

- City of Erding
- Zweckverband für Geowärme Erding ("Erding Geothermal Special-Purpose Association"), formed by the City and County of Erding: development, co-ordination and operation of the project
- Saarberg-Fernwärme: planning, construction and operation of the heat acquisition and distribution facilities and collection of payments, leases the installation from Zweckverband Geowärme
- Wund group: construction and operation of the thermal baths, receives thermal wasser from the Zweckverband Geowärme and heat from the Saarberg-Fernwärme

Financial resources

The total investment for the heat acquisition and distribution facilities came to approximately €15 m, which was financed by the Zweckverband Geowärme.

The innovative parts of the project, the renovation of the well equipment and bringing it up to operational readiness, were subsidised by the State of Bavaria with a €204,000 grant, covering 50% of the cost. As part of the subsidy programme "Efficient Energy Production and Use", the state of Bavaria granted a further €2.74 m.

Within the framework of the European Union's Thermie programme the absorption heat pump received approximately €920,000 in subsidies in 1992, and the thermal water treatment plant received approximately €300,000 in 1996, in the form of a grant covering 40% of the eligible costs.

The payback period for the project is about 20 years, depending on the form of finance.

Results

No substantial technical problems were encountered. However, some problems of a commercial or market-related nature did occur. At the start of building work on the new housing in 1993-94, substantial investments in setting up the district-heating scheme were necessary, since the supply of heat had to be available as soon as the first apartments were ready for occupancy. For this reason, partial networks were operated at first by means of mobile gas-heated units, until the wells had been sunk and the heat pump and peak-load boiler had been installed.

Since the housing developments planned in the early 1990's have not been built and occupied as expected, the project does not have the number of consumers originally planned. Of the planned 23 MW in 2002, only 12 MW had been implemented by mid-1999, including 500 households in the new housing developments. The Zweckverband Geowärme is therefore attempting to make up for this shortfall by acquiring existing residential areas and facilities of some size as customers.

Over 50% of the town's heat demand is generated without pollution by utilisation of geothermal energy. The remaining heat demand is covered by the heat pump, driven by natural gas and light heating oil.

The geothermal well is able to produce 540,000 m^3 of hot water a year, with an energy content of 28,000 MWh. The project results in the substitution of about 3 m litres of heating oil a year.

Use of the geothermal well leads to a reduction in emissions of about 70% CO_2 (7,000 toe/year), about 87% SO_2 (5,700 kg/year), about 70% NO_x (5,600 kg/year), and about 80% dust (150 kg/year).

Potential for replication

The geothermal plant in Erding uses the hot water from the well at a temperature of 65°C, which is a normal temperature level for a depth of 2,350 m. Therefore, the technical and economic lessons learnt here can be of use in other similar projects.

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Sector: Geothermal
Country: Ireland
Location: Cork
Year: Autumn 1997

ENERGIE

KNOCKFREE SPORTS COMPLEX

A thermal heating system was installed on the grounds of a new sports complex in Churchfield, Ireland in the autumn of 1997. The complex comprises six all-weather pitches and a pavilion. Changing rooms are heated using heat extracted from the underlying rock and soil.

The project uses two different types of geothermal heat collectors as sources for four heat pumps, a horizontal heat collector and two vertical heat collectors. Each of the heat collection systems provides energy for the heat pumps.

Source: http://www.corknrg.com/CHURCHFIELD.htm

Description

The geothermal heating at Knockfree sports complex is made up of two different types of geothermal heat collectors which feed two heat pumps. There is a horizontal heat collector comprising 600 m of 1” light gauge LDPE (Low-Density Polyethylene) tube buried at a depth of 0.5 m over a ground area of 300 m^2. This system was already in use, for the exploitation of heat from soil, at other sites in Ireland. The system also includes four vertical heat collectors, each of which was lowered into a 60 m long borehole (150 mm diameter) which has a LDPE loop installed to extract geothermal energy from rock and soil. Both systems used water with a 30% anti-freeze solution.

Promoters and parties involved

Owner of the site

Cork Corporation
City Hall
Cork
IRELAND

Manager

Leisureworld Company
Bishops Town
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Designer and supplier of the system

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Coordinator

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Cork Institute of Technology (CIT)
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Hidrogeologist
Brian T. Connor Associates
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Financial resources

The total funding for the project was provided by Cork Corporation. The heat pump and plant room installation cost €14,000 and the vertical collectors cost €16,000. The project did not benefit from any subsidies. The envisaged payback period is seven or eight years.

Results

The horizontal heat collector and the two vertical heat collectors were designed to provide energy for the heat pumps, each having 4.4 kW nominal power input and 17 kW nominal output. The space heating for the complex is being produced from geothermal sources all year round. However, this is supplemented by heat from a gas-fired boiler on site.

Potential for replication

This project, which was innovative when it was originally conceived, has largely proven to be very interesting and successful. This is demonstrated by the emergence of several companies (now seven) specialised in the design and installation of geothermal systems of this type, which started to be replicated in many other areas of the country.

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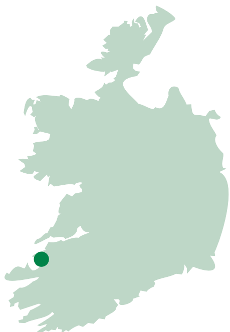
Sector: Geothermal and Solar Thermal
Country: Ireland
Location: Tralee (County Kerry)
Year: August 1999

ENERGIE



TRALEE MOTOR TAX OFFICE BUILDING

This building, which was built in 1999 as offices for the motor-tax authorities, is located in County Kerry and has a floor area of 1,500 m^2. It is equipped with five different types of energy systems: geothermal heating and cooling, solar water heating, controlled ventilation, energy efficient lighting and building management.This case study, however, will only look at the geothermal and solar systems.

Source: Sustainable Irish Ireland

Description

The building is heated and cooled using a geo-thermal heat pump unit that comprises two fully independent refrigeration circuits. The heat pump operates by extracting low grade heat from a source such as the ground adjacent to the building increases the temperature of the water by means of a reverse refrigeration cycle. The heat pump operates at its most efficient when the heat source is reasonably constant in terms of temperature and availability and the heated temperature required is not very high. These are precisely the conditions that apply at the Motor-Tax Office, where the heated water is used to heat under floor radiant coils at approximately 35º C.

In cooling mode the heat pump takes water at approximately 10º C from the ground and uses it to cool air in the carrier ceiling cartridges. The system installed has the ability to remove heat from one side of the building and deliver it to a section of the building requiring heat.

A “Satchwell” BMS controls the heat pump. However, the software / graphic interface for the BMS does not show time settings, which can be accessed by entering the individual mode programs.

The heat pump itself has two compressors, which operate in series. During the milder months of the year a single compressor is capable of meeting the heating and cooling demand of the building.

Hot water is produced by six UFE Eurostat Tx 24 solar collectors mounted on the south facing roof and installed in August 1999. Alongside the six solar collectors, other components included one 2 kW immersion heater, one 25-60 circulating unit, one C20 Eurocon digital controller, three PT 6 temperature sensors with one fitted to the solar collectors, together with two Purg Inox automatic air vents also fitted to the solar collectors.

Promoters and parties involved

Solar water heating system provider

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Financial resources

The geothermal heat pump cost approximately €70,000 and the solar collectors cost €10,000. The pay back for the geothermal system has been calculated at 4.1 years and for the solar system at 14.2 years.

Results

An independent energy evaluation has been carried out, and has stated that the energy and functional performance of the building is excellent. Further proof of this is the considerable energy savings obtained as a consequence of the construction criteria used in this building (it has been estimated that the annual energy costs for the building are around €2,500 less than in an office of similar size and use).

The heat pump has a heat output of 130 kW.

The total collector area is 14.40 m^2 with a thermal output of 700 kWh/m^2/year, which means an annual output of approximately 10,000 kWh.

For the Motor Tax Office the energy consumption requirement was calculated at 7,068 kWh a year and the panels are capable of meeting all of the building's hot water requirements.

Potential for replication

This building is the result of a strong commitment to trying to exploit and systematise, by means of BAT (best available technologies), all possible energy sources, including passive ones. The integration of all these elements together with the high visibility given by this public building can have a significant impact in terms of replication in similar contexts.

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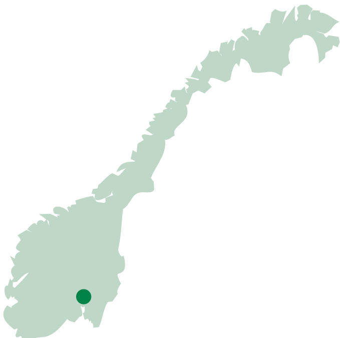
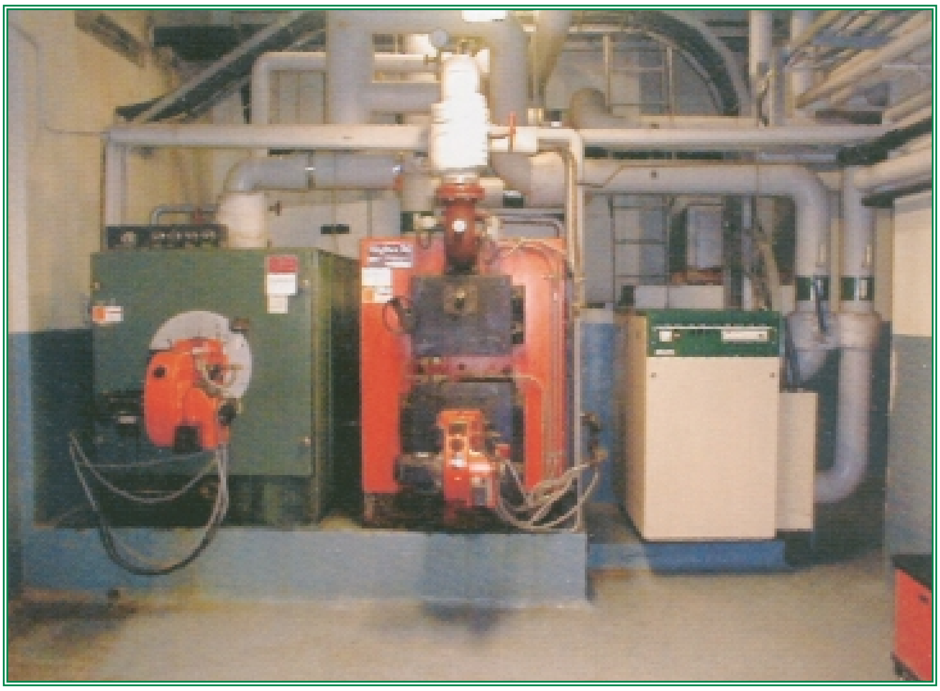
Sector: Geothermal
Country: Norway
Location: Oslo
Year: 1999

ENERGIE





GEOTHERMAL ENERGY AT AN OFFICE AND LABORATORY BUILDING IN OSLO

A geothermal heat system was installed during renovation on a former industrial building in Oslo in1996. The block had previously been used for industrial purposes, but after renovation has been used for offices and laboratories. During the planning of the rehabilitation the possibility of using heat pumps to extract geothermal heat was considered. To study the potential available energy in the ground, Oslo kommune Kontobedriften, the owner of the buildings, hired Oslo Energi Enøk (now ECO-Smart) to conduct a preliminary study of the available energy. ECO-Smart used a heat collector sunk to the current (economically viable) depth. A rig was connected to collector, and water at 25ºC was pumped down to the collectors. A data logger recorded the energy recovery. The result of the study was that the potential was good enough for an interesting project using the geothermal heat.

Description

The selected solution has 20 wells with a total depth of 175 m. In each of the wells a U-tube heat collector, made of polyethylene with a weight at the end was inserted. A mixture of water and glycol flows through the pipes. When the fluid is flowing through the heat collector it is heated from the hot ground. The fluid flows through the cooling part of the refrigerating machine (heat pump) and is then cooled from 0ºC to -3ºC. Hence, the heat could be taken out of the ground and transfered to a higher temperature level and condensed.

Technical data heat pump system

Maximum heat capacity	223 kW
Maximum cooling capacity	350 kW
Heat pump contribution rate	78 %
Heat pump heat factor	3.75
Heat pump energy factor (including cooling)	2.37

Operation

There are three different modes of operation for the heat pump system in Maridalsveien 3:

1. Autumn and winter conditions
2. Spring
3. Summer

During the autumn and winter the heat pump runs continuously. The system collects energy from the heat collectors and the water surrounding the heat collectors is cooled to the point where it starts freezing.

When the temperature is increasing during the spring the need for cooling of the building predominates. The frozen water in the ground means cooling is available for free, and the cooling machine (heat pump) is unnecessary. During this period the heat pump is disconnected (not in use), and thus if there is demand for heat the electrical boiler is used.

When the air temperature rises further during the summer the temperature in the reservoir increases to about 12 ºC and the cooling machine (heat pump) is needed to cool the building. When the heat pump is used as a cooling machine the hot cooling water from the condenser will be dumped and thus the heat reservoir will increase further to about 17-18ºC. In this way the cooling process accumulates heat for the reservoir and therefore less energy is needed during autumn and winter for heating purposes.

In addition to the heat pump system, there is one electrical boiler and two oil boilers, which may be used to meet peak heat loads.

Dissemination activities

The project is described in a leaflet by Oslo kommune Kontorbedriften. The engineering consultant company Theorells AS had a student writing his MSc thesis working on the heat pump system. A technical description, based on his work, has been made for the operational experience during 2000 (in Norwegian).

Promoters and parties involved

Owner (and responsible for building):
Oslo kommune Kontobedriften

Preliminary potential study:
Oslo Energi Enøk (now ECO-Smart)

Heat pump consulting:
Therorells AS

Heat pump contractor:
Greåker VVS AS

Drilling contractor:
Hallingdal Bergborring AS

Financial resources

Additional investment for electricity and oil heating
NOK 2.2 m (€298,000)

Investment in wellhead system
NOK 1.2 m (€163,000)

Heat pump
NOK 360,000 (€49,000)

Pay-back period
Approx. 6 years

Results,

The heat pump solution has been implemented within the existing heating system. There have been problems with the integration of the heat pump with the existing electrical and oil boilers. Due to these problems the integration process has needed more time than expected. Some minor problems are still under investigation, but the system is operational.

Energy production

The heat pump solution replaces the oil-fired and electrical boilers. The energy delivered from the system is:

Maximum energy delivered per year	1,100 MWh
Use of energy per year	300 MWh
Free cooling per year	125 MWh

Environmental results

The annual emission reductions achieved by replacing the oil boilers are:

Emissions of CO_2	313,000 kg
Emissions of SO_2	590 kg

Potential for replication

The owners found that the implementation needed more time than expected. We believe that we can provide valuable advice for others interested in implementing a heat pump solution within an existing heating system.

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The network of organisations for the promotion of energy technologies (OPET), supported by the European Commission, helps to disseminate new, clean and efficient energy technology solutions emerging from the research, development and demonstration activities of Energie and its predecessor programmes. The activities of OPET members across all Member States, and of OPET associates covering key world regions, include conferences, seminars, workshops, exhibitions, publications and other information and promotional actions aimed at stimulating the transfer and exploitation of improved energy technologies

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NOTICE TO THE READER

A great deal of information on the European Union is available on the Internet. It can be accessed through the Europa server (http://europa.eu.int).

The overall objective of the European Union's energy policy is to help ensure sustainable energy system for Europe's citizens and businesses, by supporting and promoting secure energy supplies of high service quality at competitive prices and in an environmentally compatible way. The European Commission's Directorate-General for Energy and Transport initiates, coordinates and manages energy policy actions at transnational level in the fields of solid fuels, oil and gas, electricity, nuclear energy, renewable energy sources and the efficient use of energy. The most important actions concern maintaining and enhancing security of energy supply and international cooperation, strengthening the integrity of energy markets and promoting sustainable development in the energy field.

A central policy instrument is its support and promotion of energy research, technological development and demonstration, principally through the Energie sub-programme (jointly managed with the Directorate-General for Research) within the theme 'Energy, environment and sustainable development' under the European Union's fifth framework programme for RTD. This contributes to sustainable development by focusing on key activities crucial for social well-being and economic competitiveness in Europe.

Other programmes managed by the Directorate-General for Energy and Transport, such as SAVE, Altener and Synergy, focus on accelerating the market uptake of cleaner and more efficient energy systems through legal, administrative, promotional and structural change measures on a trans-regional basis. As part of the wider energy framework programme, they logically complement and reinforce the impacts of Energie.

The Internet web site address for the fifth framework programme is:
http://www.cordis.lu/fp5/home.html

Further information on Energy and Transport DG activities is available at the Internet web site address:
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