Energy 2010

Energy plan for the municipality of Gotland

year 2007-2010

adopted by the Municipal Council, December 18, 2006

Energy plan for the Eco Municipality of Gotland

It is difficult to imagine Gotland as a place with anything other than a sound environment and a clean countryside. The island has so many great things to offer, which we simply take for granted. There is also a strong interest in preserving and developing Gotland in a sustainable way. The Eco Municipality of Gotland has travelled a long way towards the goal of creating a sustainable community on Gotland within the next 20 years.

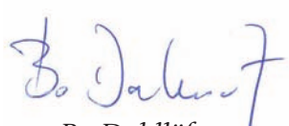
Every era has its own challenges, and over the past few years, energy issues and the threat of serious climate change has dominated the debate. News reports regularly mention catastrophic droughts, severe weather conditions, melting polar caps and species under threat. Scientists around the world are increasingly in agreement that human activities have a great impact on the climate of the planet. So how does this affect us who live on Gotland? What can we do about it? And does what we do on Gotland have any significance whatsoever?

Yes, of course it has! Every positive change made by households, companies, associations, the authorities and others in the environmental and energy areas means that fewer resources are being wasted, and reduces emissions to the environment. Investment in local renewable energy production, sustainable energy systems and new infrastructure also generates new jobs, and this, in turn, promotes economic growth on the island. With Energy 2010 as our tool, and by adopting targeted measures, we have the opportunity to become a leading region in the areas of energy and sustainable development. This will subsequently focus attention on Gotland as a sustainable community in the middle of Europe.

The municipality's climate change strategy forms an important part of the energy plan. In Climate Change Strategy for Gotland, we have adopted the long-term target of 100% carbon dioxide-neutral energy production for Gotland. The municipal council's decision to make the island a zero emissions zone has strong links to energy usage. An island with renewable energy forms a major part of the idea of zero emissions and provides a stable base for sustainable development.

The energy plan demonstrates the great opportunities open to Gotland.
Now we have to realise them.

Eva Nypelius
Kommunstyrelsens ordförande



Bo Dahllöf
Regiondirektör

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Summary

The energy plan for the Municipality of Gotland, *Energi 2010*, describes the energy situation on Gotland in the years 2005/06, and includes a number of different measures aimed at refocusing energy consumption to make it economically and environmentally sustainable. The plan applies to the years 2007–2010, while the long-term planning horizon extends to the year 2025. A sub-target is that by the year 2010, a maximum of 55% of the energy consumption on Gotland will be based on fossil energy. By that date, preparations must also be completed for infrastructure investments aimed at achieving climate-neutral and long-term sustainable energy production by the year 2025. This will be achieved through more efficient use of energy, new infrastructure for electricity, heating and transport and, within the framework of sustainable development, increased usage of local renewable energy resources.

During the first years of the 21st Century, total energy consumption on Gotland has remained fairly constant at almost 4,200 GWh per year. This is equivalent to approximately 73 MWh per person per year, compared with the national average of around 66 MWh per person per year. 65 % of the energy used on Gotland is produced by fossil fuels. In 2004 and 2005, there was a clear reduction in the amount of oil delivered to Gotland compared with previous years. In the community on Gotland, excluding the cement industry, energy consumption is divided fairly evenly between heating, electricity and transport. The municipality has no direct influence over the majority of energy consumption on Gotland. As required by the Municipal Energy Plan Act, the plan sets general targets for the energy situation in the municipality as a whole. The measures adopted affect the municipality's own energy consumption and municipal information efforts, as well as the focus of the municipality's own operations, development projects planned by the municipality and municipal governance.

Around 90 % of the atmospheric emissions from the fossil carbon burned on Gotland is controlled through the system for trading in emission rights. After cement production, the greatest consumer of fossil fuel on Gotland is the transport sector. It is, therefore, important to work on the transport sector's energy consumption and adopt measures which benefit the market for environmentally-compatible vehicles and fuels on Gotland in the same scale was as on the mainland. Oil is in process of being phased out as a heat source for residential properties. So far, the phasing out of oil in other sectors has been insignificant. The market for biofuel has experienced a positive trend.

The aim of the energy plan is to create a common basis for how municipality-controlled operations will deal with energy issues to ensure that the overall regional and municipal targets are achieved. The plan specifies how responsibility for various measures is to be allocated, how feedback is to be provided and how overall energy issues are to be dealt with by the municipality. This includes the municipality using tools such as networks and projects to exercise a positive influence over energy consumption outside the municipal decision-making sphere.

RAPESEED FIELD WITH WIND TURBINES • PHOTO: GUNNAR BRITSE

1. Introduction

The energy plan for the Municipality of Gotland is based on the vision of the whole of Gotland contributing to a sustainable community and, more specifically, on the Municipality's aims and targets for ecologically sustainable development, in which energy consumption plays an important role. It intertwines with the Municipality's overall plan, regional development programmes, *Agenda 21/environmental programme**, transport and waste disposal planning. It is also mentioned as a sub-target in the county administrative board's environmental targets for Gotland. The target is a sustainable community with safe, sufficient and CO_2-neutral energy production by the year 2025. The vision is that energy consumption on Gotland will be refocused to contribute to socially, economically and environmentally sustainable development. The climate change strategy for the Municipality of Gotland forms part of this energy plan.

The aim is that, through the municipal energy plan, decisions are taken on how municipally-controlled operations should work to ensure that overall regional and municipal targets are achieved, how responsibility for the various measures is to be divided, how general energy issues are to be dealt with by the municipality and how feedback is to be provided. Feedback must show how the energy consumption trend on Gotland as a whole contributes to a reduction in the climatic impact, and the rate at which the various targets in the plan are achieved. The energy consumption trend will be reported, and the aim is also to report on the socioeconomic effects generated by a change in energy consumption. Within the municipality's own operations, decisions on energy and environmental measures are also taken within the various areas of responsibility of the committees. These must comply with the climate change strategy in the energy plan and fall within the framework of the municipality's *Agenda 21/environmental programme.*

Energy consumption within the municipality's own operations is reported annually in "green key figures". Follow-up of the energy plan and environmental programme is coordinated for the municipality's own operations to the extent that they involve energy and the climate.

Under the provisions of §3 of the Municipal Energy Planning Act (1977: 439), every municipality must have an up-to-date plan for the supply, distribution and consumption of energy within the municipality. As part of the energy planning, municipalities must, with the help of the businesses affected, analyse and utilise opportunities for collaboration with energy-intensive businesses within the municipal borders. Under supplementary clauses from 1991 and 2004, the energy plan must also contain a description of environmental consequences, the formulation of which depends on the focus and scope of the plan.

For the national environmental target "Excellent urban environment", the parliament has adopted a sub-target for planning documents for the year 2010. Several parts of this touch upon the energy plan. In accordance with the Swedish Parliament's targets, programmes and strategies must be adopted on how the supply of housing, workplaces, services and culture can be designed to reduce the need for car travel and improve the conditions for environmentally-compatible and resource-economising means of transport. The parliament also aims to preserve and expand green areas and waterways in urban areas, and to stop the expansion of surfaced areas.

* *The 1998 edition of Agenda 21 for the Municipality of Gotland will be revised during 2007, and a change in the title of the programme may be considered.*

Many of the national environmental targets adopted by Parliament, particularly the Limited Climate Change target, involve energy issues.

All energy consumption has, in some respects, a negative impact on the environment. The plan highlights the environmental effects of different energy production systems. Comparing the environmental impact of various fuels and electricity generation methods with their share of energy consumption on Gotland demonstrates the opportunities for reducing the environmental impact of energy consumption on the island. Every conceivable effect of the community's energy consumption on health, the environment or natural resource management cannot be included in the statement of the plan. Instead, the effects most clearly linked to energy consumption on Gotland have been selected. One target is to invest in energy systems with the smallest possible negative impact on the environment. Another energy planning target is to increase economy in the municipality, both in the municipality as a geographical region and in the municipality's own operations.

The municipality's climate strategy and measures for energy transition include measures which must be decided upon by the municipal council, one of the committees or the boards of municipal companies. Many of the measures needed to achieve the plan's targets are at such detailed level that their implementation is decided by the municipality's committees, in accordance with the municipality-wide aims decided upon at a strategic level. The local energy company, GEAB, Gotlands Energi AB, is also a very important player. Vattenfall owns 75% of GEAB, while the municipality owns 25%, so local control in GEAB is limited. Providing businesses and private householders with the incentives and motivation necessary to change their energy consumption is also of the utmost importance to the fulfilment of the plan's objectives. The plan sets out targets for the information provided to the public by the municipality, as well as for the focus of the municipality's own operations, municipal planning and governance. It also identifies the areas of responsibility of the various municipal operations. Most of the energy consumption on Gotland is, however, outside the direct control of the municipality.

The energy plan may also provide businesses and operations on Gotland with an excellent basis for involvement in various projects and partnerships within the energy area. Information efforts, networking, and projects are municipal tools which can be used by the municipality to exercise a positive influence over energy consumption outside the municipal decision-making sphere.

BIOFUEL ROAD TANKER • PHOTO: GUNNAR BRITSE

2. Energy in figures

Total energy consumption on Gotland has remained fairly constant at almost 4,200 GWh per year during the period 2000–2005. This is equivalent to an annual consumption of 73 MWh per resident of the island, just over 10 % above the national average for Sweden as a whole. Almost 65 % of the energy consumed in 2005 came from fossil fuels.

2.1 Distribution of the various types of energy used on Gotland

Some of the heating and electricity is produced by local bioenergy, recycled energy and windpower. Small-scale production of biodiesel, RME, takes place on the island. In 2005, only just over 10% of the total energy used on Gotland for heating, electricity and fuel came from local electricity generation or local bioenergy. Local windpower provides around 20 % of the electricity consumed on the island.

Distribution of energy carriers on Gotland in 2005 (GWh)

Energy carrier	GWh	Share in %	Total
Electricity; mix of various power production methods, via mainland cable	754	18	
Coal & petcoke, industry	1 213	29	
Fuel & heating oil[1]	962	24	
Recycled fossil fuel, industry	427	10	
Sub-total of fossil energy 2,602 GWh + all other electr. via mainl. cable		**81**	**3 356**
Wind power, local production	173	4	
Heat pumps, net[2]	67	2	
Biofuel, quarry industry	172	4	
Biofuel, district heating[3]	179	4	
Biofuel, other[4]	133	3	
Recycled energy[5]	49	1	
Solar heating	1	<1	
Sub-total of renewable energy		**19**	**774**
Total Gotland			**4 130**

Source: Cementa AB, GEAB, Statistics Sweden, prepared by Energibyrån Gotland and the Municip. of Gotland

[1] *Statistics Sweden's statistics for regional oil deliveries in 2005*

[2] *GEAB district heating: 27.4 GWh + estimated heating from heat pumps in individual properties: 40 GWh*

[3] *Biofuel in GEAB's district heating system*

[4] *Heating from pellets (40 GWh import), wood and chips (80 + 15 GWh local) in individual boilers (Source: chimneysweep register and companies)*

[5] *Recycled energy from Cementa approx. 40 GWh, in the Visby district heating system approx. 9 GWh, 2005*

The amount of energy consumed on Gotland excluding Cementa in 2000 & 2005 (GWh)

Energy source	Year 2000	Share %	Year 2005	Share %
Petroleum imports	993	48 %	962	47,6 %
Electricity imports	567	28 %	480	23,8 %
LPG imports	15	< 1%	< 1	< 1 %
Sub-total imported energy	**1 575**	**76%**	**1 442**	**71,4 %**
Wind power	138	7 %	173	8,6 %
Heat pumps	100	5 %	67	3,3 %
Biofuel in district heating	138	7 %	179	8,9 %
Biofuel other usage	86	4%	133	6,6 %
Recycled	20	1%	25	1 %
Solar heating	1	< 1%	1	< 1 %
Sub-total of renewable energy	**483**	**24%**	**578**	**28,4 %**
Total Gotland (GWh/år)	**2 058**		**2 020**	

A sub-target* for 2010 is that a maximum of 55 % of energy will be produced using fossil fuels. In Gotland's energy system, this means an increase of just over 330 GWh of renewable energy, provided that energy consumption remains at the current level. The target may seem low, but to achieve this in only three years, the energy transition rate must be greater during the period 2007-2010 than in previous years. In addition, planning and project planning must be carried out within the next few years, to ensure that the energy transition rate continues to increase after 2010, with the aim of ensuring a sustainable energy supply by the year 2025.
At the same time, it is important to ensure a reduction in total energy consumption and that energy can be used more efficiently. The proportion of energy from fossil fuels is largely dependent on developments in the cement industry. The sub-target for 2010 can be achieved if more players take action within their own operations. A possible scenario aimed at meeting the target may include the following:

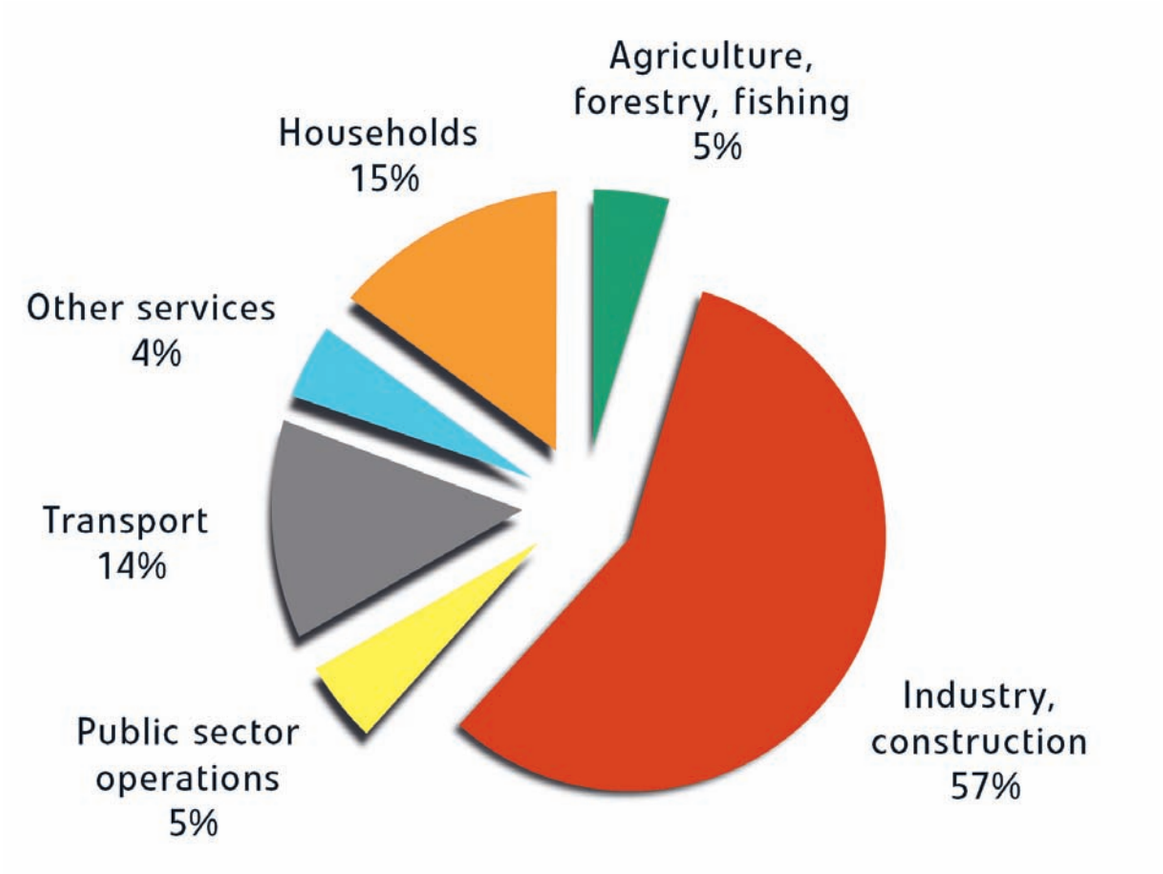
- Cementa increases its use of biofuels by 130-150 GWh by 2010, without a significant increase in the plant's total fuel consumption.
- The market for environmentally-adapted vehicles and fuels grows at the same rate on Gotland as on the mainland, and achieves 30–50 GWh per year from biofuels.
- Households and businesses manage to replace at least 150 GWh or half of their current consumption of heating oil with renewable or recycled energy.

* *Also sub-targets in the county's regionalisation of national environmental targets.*

2.2 Who are the greatest energy consumers on Gotland?

On Gotland, energy consumption is characterised by the quarry industry's huge demand for fuel for lime-burning. In the Gotland community, excluding the cement industry, energy consumption is fairly equally divided between heating, electricity and transport. If shipping and air transport are included, transport is the single largest consumer of fossil fuel on Gotland, apart from the cement industry. The impact on the climate of the emissions generated by transports and the transport sector is increasing. Electricity consumption by households is also increasing. Despite rising electricity prices, total electricity deliveries to Gotland have again increased over the past few years.

Energy consumption in various sectors on Gotland (%)



Source: Statistics Sweden's municipal energy balances for 2003

RAPESEED FIELD • PHOTO: GUNNAR BRITSE

3. Climate strategy for energy transition

The Municipality of Gotland will work actively to create a sustainable community

In an eco municipality, the ecological dimensions must be given prominence in the work of achieving sustainability. As in all other eco municipalities, four principles for ecological sustainability form the basis for the environmental strategy for Gotland. They also form the basis for the municipality's climate change strategy. Energy issues play a central role in the environmental work focused on achieving a sustainable society, since energy consumption does to a significant extent, affect the environment.

We achieve ecologically sustainable community development by

1. **reducing the distribution and use of new materials extracted from the Earth's surface**
2. **reduce the environmentally-harmful emissions from the community's production and energy consumption**
3. **preserve the production capacity of nature and conserve natural diversity**
4. **create a community with excellent and efficient usage of resources which helps to meet the basic needs of all humans**

For a transition to a sustainable energy production, the social and economic aspects of sustainable development are of equal importance. The energy transition will create new local jobs and improve the local economy. Indicators for the socioeconomic aspects will be developed and included in the follow-up of the energy plan.

3.1 Climate strategy to 2010:

A long-term, carbon dioxide-neutral energy production is one of the targets for the Municipality of Gotland. The target was first adopted in the over-all *Vision 2010* plan. The plan contains targets for an increased share of renewable energy, improved energy efficiency and a reduced need for imported energy. These are also included in the municipality's *Agenda 21*, in the previous *energy plan* and in the municipality's declaration for involvement in the EU's CTO project, a campaign for renewable energy.

Reduced need for fossil fuels

The dependence on fossil energy and nuclear power will be phased out through more efficient energy consumption, as well as through increased use of long-term, sustainable energy sources.

Access to renewable and recycled energy will be developed locally. Within the framework for economically and socially sustainable development, the energy resources must be able to balance the island's energy requirement for transport, heating and electricity.

Organise the need for transport and develop sustainable communication methods

Built-up areas, services and infrastructure for transport will be developed with the aim of supporting a more efficient use of energy and a sustainable lifestyle.

Reduce the energy requirement in buildings

As part of new development or redevelopment, buildings will be designed to ensure that they are as environmentally compatible and energy-efficient as possible, based on what current technology and existing buildings allow.

Choose technical equipment carefully

Choice of technology and active environmental work can limit the damage to the countryside, cultural heritage and people's health, and also reduces the impact on the climate.

3.2 Success factors for the municipality's energy transition

One step on the way to sustainable and carbon dioxide-neutral energy production is the adoption of 10 success factors. These are areas which will require successful measures to be implemented by 2010 to achieve the overall target by 2025. They apply to all municipal operations, but may also be used for other operations on Gotland.

- Each and every one of the municipality's operations must, in some way, contribute to an increase in renewable energy as a proportion of the total amount of energy consumed by the community on Gotland.
- The use of oil for heating buildings will be phased out by 2010.
- Electricity usage will be investigated and made more efficient.
- Measures aimed at improving the efficiency of electricity consumption in properties will be implemented.
- Measures aimed at reducing the need for fossil fuels will be implemented.
- Environmental targets will be applied when procuring transport and planning journeys.
- When vehicles are replaced, environmentally-compatible vehicles will be chosen where these are an alternative.
- The amount of transport-related energy consumed per municipality employee will be reduced by 5 % between 2005 and 2010.
- Emissions of carbon dioxide from fossil fuels in the municipality's operations will be reduced by 10 % between 2005 and 2010.
- The municipality's operations will contribute to the achievement of the municipality-wide targets for a reduction in emissions and increased utilisation of local renewable energy resources.

The success factors will be reported through follow-ups of the energy plan's Chapter 6.3: Action plan with municipal allocation of responsibility.

The climate strategy complies with *Environmental strategy for Gotland*, which is included in the revised version of *Ecoprogramme for Gotland*, drawn up in 1996.

4. Options for renewable energy on Gotland

4.1 Energy on Gotland – situation and opportunities

From an energy perspective, Gotland is unique. Its isolated location in combination with its large energy requirement, particularly with reference to the quarry industry and transport sector, makes energy production a particularly demanding issue. Its clear demarcation and the fact that the island, due to the quarry industry, has a large demand for heating and electricity, also make the island an interesting subject for energy production, distribution and consumption studies. There are excellent opportunities for developing local production using wind power and biofuels, but we are, at present, completely dependent on energy procured from other regions.

Almost two-thirds of our energy production is produced during fossil fuel. There are economic and environmental benefits in replacing a large part of this with local bioenergy, various forms of recycled energy and in measures aimed at improving energy efficiency and reducing energy consumption. There is also an untapped potential in the continued expansion of wind power. From the point of view of reducing the climate change effects of energy consumption, it is essential, as soon as possible, to improve the efficiency of energy consumption and replace fossil fuels with biofuels and other carbon dioxide-neutral energy sources. Increased exploitation of renewable local energy resources could, in addition, improve the local economy. Replacing energy from external sources with locally produced electric power and biofuels increases the value of Gotland's own resources and reduces the stresses on the environment. Improved energy efficiency and energy savings also generate financial savings.

4.1.1 Why renewable energy

Renewable energy is independent of finite resources, reduces the need for risky transports and does not have the same damaging environmental impact as today's energy consumption.

Current use of fossil fuels for heating, electricity and transport is the cause of the largest global environmental problem - climate change. Reducing climate-changing emissions is now a common goal, from UN to local level. Our energy consumption also has a negative impact on the local environment and health through exhaust gases and fumes.

The raw material production of the fossil fuels used in our energy consumption is currently carried out in areas with poor control over whether the production process is acceptable from an environmental and health perspective. Renewable energy can be extracted from local resources and this ensures a reliable supply, creates local jobs, which in turn increase Gross Regional Product and provides the opportunity for control and local influence over the production process.

4.2 Local availability of renewable energy

4.2.1 Bio energy

4.2.1.1 Forest fuel

Gotland has around 124,000 hectares of productive forest, 96,000 hectares of which can, at present, be regarded as commercial forest consisting primarily of spruce and pine. The average standing stock is 81 m^3 forest/hectare. 240,000 m^3 forest was felled in 2004, and for many years, around 200,000 m^3 forest has been felled on an annual basis. Growth is, however, in excess of 300,000 m^3 forest per year, and this ensures a plentiful supply of standing stock. The forest normally generates around 100–120 m^3 forest/hectare during regeneration felling on Gotland. Over the next few decades, there will, in addition, be a huge acreage in need of clearing and thinning in both the commercial forests and in other areas, e.g. in broadleaf forests and some of the land reserved for countryside management purposes. This, too, will provide a certain amount of forest fuel. Bioenergy from the forest is the local energy source which, for 2005, was estimated to have provided the largest local addition to the island's energy consumption, around 200 GWh.

Only about a third of this potential has been utilised. The following tables describe two scenarios for the extraction of biofuel in the Gotland forests. Sources: The Federation of Swedish Farmers (LRF) on Gotland and the County Administrative Board.

Table 1. Probable extraction of timber and energy wood in accordance with short-term targets for forestry operations on Gotland

Type	volume (m^3sk)	% to energy	Energy content GWh (500 m^3sk=1GWh)
Sawn timber, incl. logs	154 449	62 %	192
Pulp wood	43 368	50 %	43
Wood	55 368	100 %	111
Branches and tops	13 454	100 %	27
Annual extraction	**266 639 m^3forest**		**373 GWh/year**

Around 700 hectares of regeneration felling per year, as well as some other forms of felling, including countryside management felling operations, windfall, felling for pasture etc. 700 hectares of first thinnings and 1,300 hectares of other thinnings. In these scenarios, digester chips are also used for energy production.

Source: LRF and the County Administrative Board.

Table 2. Potential for felling and energy extraction within the framework of long-term sustainable forestry operations

Type	volume (m^3sk)	% to energy	Energy content GWh (500 m^3sk=1GWh)
Sawn timber incl. logs	219 203	62 %	272
Pulp wood	62 924	50 %	126
Wood	74 924	100 %	150
Branches and tops	27 801	100 %	56
Annual extraction	**384 852 m^3forest**		**604 GWh/year**

Around 1000 hectares of regeneration felling per year, as well as some other forms of felling, including countryside management felling operations, windfall, felling for pasture etc. 1000 hectares of first thinnings and 2,000 hectares of other thinnings. Logs provide a lower timber yield than wood.

Source LRF and the County Administrative Board.

If the total potential for biofuel extraction from all forest areas on Gotland was utilised, the extraction would be even greater than 600 GWh per year. This scenario is, for a variety of reasons, not appropriate. The problem today is, in fact, that the level of forestry activities is too low, both as regards final felling and in the area of commercial forest management. The probable forest extraction of timber and biofuel at the full rate of forest growth in the areas where active forestry is taking place, but within the framework of sustainable forestry management methods, could provide the values in table 2 above. This does not mean that all forest is used for energy production, but that the extraction of sawn timber is optimised. Unlike today, however, all pulp wood would remain on the island and be used as an energy source. Bearing in mind Gotland's currently large number of passive forest owners, maximum felling volumes in the forests is unlikely. But with the timber extraction currently demanded by the island's wood industry and the investments made in increased activity in the forestry area, a conservative estimate is for a simultaneous extraction of biofuel worth 370 GWh/year. The question is at what point pulp wood will become more economically interesting as an energy source than as a source of paper. Today, a fairly large quantity of pulp wood is already used in energy production. With an increase in demand for forest fuel, there is a potential for greater fuel extraction from clearing and thinning operations. In spring 2006, the price of energy chips was only SEK 10/m^3s lower to the forest owner than the price of digester chips.

Financially, the forest fuel potential is worth SEK 150 million/year, with a minimum price of SEK 0.25 per kWh chip heating. In 2005, around 200 GWh of local forest fuel was utilised. Over and above this consumption, there is, in principle, the potential to replace most of the heating oil which arrived in Visby harbour in 2005, and to run the entire Visby district heating system on forest fuel. Increased extraction of forest fuel would, at the same time, add a number of local year-round jobs in the forestry and bioenergy market areas, over and above the jobs provided by timber production. The Swedish Bioenergy Association has estimated the effect of biofuel on employment to be around 300 year-round jobs per TWh extraction. For the local bioenergy extraction, this was equivalent to 60 year-round jobs in 2005, but the potential is for 180 year-round jobs. To this can be added the work involved in installation, operation and maintenance.

4.2.1.2 Bio energy from fields

The farming industry can produce many forms of bioenergy, and its role as an energy producer is expected to grow throughout the EU. On Gotland, there are almost 87,000 hectares of fields, 15–20 % of which could be used for energy crops without a negative impact on the space used for crops which are currently processed locally. The profitability of growing energy crops on arable land is not determined solely at local level, but is also affected by agricultural policy decisions made within the EU. With 3,000 hectares of sugar beet, 2,000 hectares of oil crops, 5,000 hectares of winter wheat and 5,000 hectares of barley, the harvest from 15,000 hectares of energy crops on Gotland could, for example, provide an energy source equivalent to 375 GWh per year. With a different division of acreage and possible use of new crops, the energy harvest could be even greater. The energy yield from hemp, for example, is estimated at 31 MWh/hectare if 70 % of a harvest of 10 tonnes/hectare per year is used for energy production. Willow (energy forest) grown as a field crop may also have some future on Gotland. The simplest use of biomass from fields is the direct use in heat and district heating production. The most effective use of biofuels is as replacement for fossil fuels, but they may provide the greatest socioeconomic benefit if they are refined into fuel for the transport sector. Despite the fact that conversion losses reduce the net energy produced and the cost of refining is higher, the energy would still have a high process value in the form of vehicle fuel. The yield calculated as energy harvest per hectare of field is shown in the following table. These values are based on average harvests on Gotland.

Gross energy harvest for the most common crops on Gotland

Crop	Harvest tonnes/ha	Energy harvest/ha and year	Factor*
Winter wheat	5,0	21 MWh/ha	7,0
Barley	4,0	17 MWh/ha	8,2
Winter rape**	2,3	16 MWh/ha	5,9
Spring rape**	1,6	11 MWh/ha	4,1
Sugar beet	43,0	50 MWh/ha	11,8
Grass, dried in fields	7,0	7 MWh/ha	2,5
Grass, plastic-covered	7,0	8 MWh/ha	1,8

* *conversion factor = energy crop/energy in inputs*

** *approximately 50 % in the oil*

Source: the Gotland County Administrative Board

4.2.1.3 Biogas from the agricultural sector

Gotland offers great potential for biogas production. This potential is greatest in the agricultural sector, where waste products such as manure, straw and other biological waste from production represent a hitherto untapped resource for the production of fuel, electricity and heating. A fairly conservative estimate is that waste products from the agricultural sector on Gotland, after expansion on market terms but with initial support for the first plants, could be producing 150 GWh of biogas per year by 2010. Energy in the form of biogas from the agricultural sector would then correspond to the energy content of the agricultural sector's total energy procurement. The potential is even greater. In the long term, biogas from the agricultural sector on Gotland can, when mixing manure with appropriate waste products from the food processing and grocery industry to ensure more effective gas production, provide at least twice as much, or 300–400 GWh per year. Appropriate additives from food industry waste includes high-fat sludge and hard waste from, for example, the dairy, slaughter and processed foods industries.

As a fuel, the gas is worth approximately SEK 7 per kWh. This means that biogas could attract investments if the gas can be sold as a fuel. If the energy in the gas is used to produce 1/3 electricity and 2/3 heating, there must be opportunities for both forms of energy to generate payments to ensure that the investment is financially competitive compared with other types of energy. Biogas can also be used as a raw material for other liquid or gas fuels. In 2005, the municipality's pilot plant at Lövsta agricultural centre was the only agriculturally-based biogas plant on the island, but work is being carried out at Lövsta and by the island's biogas association to create more plants. In 2004/2005, a pilot study was carried out in the form of a LBU project to produce outlines for a number of model farms on Gotland. A regional development project aimed at planning farm-based biogas plants was carried out in 2005. This did not receive any climate investment support from the government in 2006, but the planning may still form the basis for future investments.

4.2.2 Wind power

Gotland offers excellent opportunities for a continued expansion of wind power. Its location in the middle of the Baltic Sea, as well as the island's flat topography, ensures a plentiful supply of wind, both on land and at sea. The energy content of wind in some locations along the Gotland coast and in the sea off Gotland is around 6,000 kWh/m^2 at 80 metres above sea level. These locations are, in fact, some of the best for wind power in Sweden. Some inland parts on the island, where the wind energy content at 80 metres above sea level falls below 3,000 kWh/m^2, are currently of less interest for the expansion of wind power. On the basis of the potential within the current expansion and planning areas for wind power on Gotland, the island's wind power producers have expressed an interest in installing wind turbines with an additional output of just over 1,000 MW to produce a total of 2,460 GWh of electric power per year with a total of approximately 500 turbines. The expansion of windpower is estimated to include around 15 groups of 2-3 generators, existing individual turbines and 15-16 larger wind power farms in clearly demarcated areas, which include existing wind power farms. All proposed facilities (apart from one part of Tofta firing range which, if it goes ahead, will be the largest) are already described in the municipality's detailed overall plan/proposed plan for wind power. With an electricity price of SEK 0.35 per kWh for wind power-generated electricity*, this would correspond to a production-worth just over SEK 860 million per year for 20 years, compared with a total investment of SEK 13,000 million with an investment cost of SEK 12 million per MW for newly-added wind power. Experience shows that 1,000 MW installed output generates 100 permanent year-round jobs just in the maintenance and operation of the plants. Preconditions for the development of wind power on Gotland in accordance with the above include the increased transfer capacity for electricity between Gotland and mainland Sweden planned for 2010 at the latest.

4.2.3 Solar energy

The conditions for using solar energy on Gotland are good by Swedish standards. During an average year, Visby has around 1,900 hours of sunshine (>150W/m^2 solar radiation). At present, solar panels provide approximately 420 kWh/m^2 per year on Gotland. This means that a normal installation of 10 m^2 in a single-family house contributes around 4,200 kWh/year to the energy consumed in the house. This is sufficient for all hot water used throughout the summer, and reduces consumption from other heat sources in spring and autumn. An expansion to 17–20 GWh solar heat could be financially viable on Gotland. Today, only about 5 % of this potential is utilised.

Electricity production using solar cells has so far only been a practicable option in installations where connection to the mains network has been impossible or too expensive in comparison with the electricity required. Technical development may make other applications possible. New technology will, however, not make a noticeable contribution to electricity production by 2010. In the scenario for sustainable energy production 2025, the calculations include a limited quantity of electricity from solar cells.

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* *Price not including environmental bonus or the equivalent.*

4.2.4 Recycled energy

Recycled energy may be of either fossil or renewable origin. The greatest use of recycled energy on Gotland is Cementa's incineration of waste products. In 2005, just over a third of the factory's fuel was made up of waste products. 9.5 % of the heating in the factory is produced using waste product fuels classified as biofuels. Some of the surplus heat at Cementa is generated by the electricity used in the factory, and the district heating plant in Slite is a primary recipient of heat from Cementa. Incineration of various types of waste is being discussed on Gotland. In the district heating boiler in Visby, trials have been carried out involving the incineration of egg-laying hens who have served their time. In 2006, mixed household waste and ground slaughter waste with an annual energy value of around 40 GWh* was sent for incineration on the mainland, where it was converted into district heating produced in special waste incineration plants. By 2008 at the latest, household waste will be collected in a dry, combustible fraction which can be incinerated at Cementa in Slite, and in a wet fraction for biological processing. District heating systems also use some surplus heat from other operations. For example, heat pumps and heat exchangers are used to utilise surplus heat. Their use in individual properties in the areas of industry and housing is increasing.

4.3 Sustainable energy production on a local basis?

4.3.1 Avoiding unnecessary energy consumption

A great deal of current energy consumption can be made more efficient. In autumn 2005, the government appointed a commission with the task of finding ways in which Sweden could break away from its oil dependence by 2020. One of the five main strategies in the commission's report is to make society as a whole far more energy efficient.

4.3.2 Local production of electricity and heating from renewable energy

4.3.2.1 Biofuel in district heating and local heating

Gotland has a great potential for increasing the proportion of energy it obtains from biomass. The single largest users of biomass are the heating plants which generate heat for the district heating networks in the urban areas. Current heating plants will gradually be replaced by new ones, and this provides the opportunity for the introduction of combined electricity and heating plants. Issues relating to the classification of various biofuels have caused uncertainties about which fuels may be used in boilers not approved for waste incineration. A clear strategy aimed at increasing the number of people connected to the district heating system will allow more biomass from forests to be used in the production of heat and electricity. A power and heating plant with a total output of 60 MW can produce 100 GWh (20 MW) of electricity and around 225 GWh (40 MW) of heating. GEAB has expressed an interest in electricity from combined power and heating plants, since electricity production from these ought to be fairly even, and the variations in heating requirements largely mirrors those for electricity on an annual basis. Here, too, the limiting factor is that all electricity production linked to the main electricity network must fall within the 70 MW output remaining before the capacity of the network can be regarded as fully utilised.

Both wood-fired installations and air heating pumps may cause problems in urban areas. Close collaboration between, for example, authorities which approve grants for conversion to non-fossil fuel heating installations and the supervising authority which may receive complaints from neighbours is, therefore, essential.

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* *In household waste 12.2 kton/year (annual average 2000–2005, source: the Municipality of Gotland) and 2.7 MWh/ton energy content at 50% ts, (source: Regional Energy Agency Southeast Sweden), the remainder of the energy comes from slaughter waste.*

Visby town centre is a special case. The area inside the Visby town wall is extremely densely populated, and this makes wood-burning an unsuitable option due to the risk of smell problems, while air heat pumps are unsuitable due to the risk of noise pollution. The most suitable alternative form of heating is district heating. For this reason, it is important that the parties affected promote and facilitate the expansion of district heating. The municipality plays an important part in this. The second-best alternative is pellet incineration in an environmentally-approved plant, preferably in combination with solar panels. For this reason, pellets should not be subject to the same restrictions as other solid fuels, and the installation of solar panels should be permitted wherever they do not cause inconvenience.

The option of building local heating plants, which are owned and operated by local entrepreneurs or cooperatives is, at present, of interest in housing areas or similar with a sufficiently high energy requirement within a closely connected area. At present, woodchip is the most financially viable fuel, but a number of plants can be made more flexible as regards the fuel used.

Individual property owners have great opportunities to use bioenergy for heating and hot water. In urban areas, district heating, pellets or, to some extent, wood or chips are the preferred methods. In rural areas, the best bioenergy alternatives for individual properties are chips, wood and pellets. The pellets for sale on Gotland in 2006 were not produced locally. From an environmental point of view, it ought to be acceptable to transport pellets to Gotland by sea from areas with surplus materials and surplus heat from the timber industry. Gotland itself has no surplus of sawdust suitable for pellet production. The alternative here would be to grind down and dry pulp wood and then to use it to produce fuel pellets. As a result of the increasing cost of energy and a rise in the cost of importing pellets to and exporting pulp wood from Gotland, the economic opportunities for processing pulp wood locally instead of shipping it to the mainland are improving. At 10,000 tonnes per year, the pellet markets on Gotland is estimated to provide opportunities for local production. The start-up of local pellet production, initially for 5,000 tonnes per year, is planned for autumn 2007.

4.3.2.2 Biogas

There is great potential for biogas production on Gotland, and some of this resource will be used for electricity production. This can be achieved by combining heating and electricity production in large biogas plants, which can produce around 50 GWh electricity (10 MW) and 100 GWh heating (20 MW) per year. Production of heating alone in these plants can provide a maximum of 100 GWh per year. By 2010, some farm-based biogas plants, with the opportunity of diversified use of the gas, could be up and running on Gotland. There are, as yet, no plans for a larger plant. The benefits of farm-based plants include the proximity to the distribution area for biowaste. At present, a limiting factor is that all electricity production linked to the main electricity network must fall within the 70 MW output which remains before the capacity of the net is fully utilised.

4.3.2.3 Wind power

The expansion of wind power which has been included in the scenario for sustainable energy production on Gotland can, with some additions, be sited on the former military areas which have already been identified as suitable for the establishment of wind power plants in the municipality's detailed overall plans for wind power. The capacity of the island's electricity network and its connection to major electricity networks on the mainland is a limiting factor. At present, it is estimated that the electricity network on Gotland will be able to cope with an installed output of 160 MW and around 320 GWh produced electricity per year. If the wind power potential is to be utilised to a greater extent, the installed output will soon have to exceed 160 MW. It is, therefore, important to invest in the electricity transmission infrastructure. One problem is how the cost of expanding the network is to be distributed.

In the event of continued expansion of wind power on Gotland, wind power will increasingly frequently generate a surplus of electricity on Gotland. The capacity of electricity transfers from Gotland is currently limited by the HVDC* link to the mainland, as well as the need to guarantee quality and availability in the electricity network on Gotland when electricity is exported from the island. If the great wind power potential on Gotland is to be tapped fully, it will be necessary to either increase the transfer capacity between Gotland and the mainland, to establish hydrogen production or some other form of storage, or to ensure that surplus energy can replace other local energy consumption instantaneously. Overall, current known wind power projects exceed the 70 MW installed output that remains to be built before the capacity of the network is fully utilised. Various solutions to the transfer problem may include investment in infrastructure in the form of a new mains network on Gotland, the laying of an international link for the Baltic area across Gotland, allowing income from wind power to generate incentives for the subsequent financing of investments in a new link and the development of facilities for storage of energy on Gotland for use at a later date.

The municipality's detailed overall planning for wind power suggests a number of new development locations and a more efficient use of existing wind power locations. Spaces and/or areas where wind turbines should not be built have also been identified. The emphasis of the plan is to concentrate wind power developments with the aim of minimising the conflict with other public interests. Apart from smaller farm generators, planning permission for erecting wind turbines outside the exploitation areas listed in the general plan would normally require a detailed plan for the area. The municipality's work on the detailed overall plan for wind power on northern Gotland is continuing.

The expansion of wind power must always be weighed against other interests and against the effects on people living nearby. This is particularly the case on Gotland, where large areas with excellent wind conditions are of national interest for other reasons as well, including open-air recreation, and nature and cultural heritage conservation. Good planning and open communication with all affected parties is necessary to achieve local acceptance and continued successful expansion of wind power.

4.3.2.4 Solar heating

Apart from in permanent residences, there is great potential for companies involved in the tourist industry on Gotland to use solar energy, since many require large amounts of hot water during the tourist season June-August when solar panels are at their most effective. The curve for the numbers of hours of sunshine coincides elegantly with the occupancy rate at tourist facilities. In 2005, there were around 3,000 m^2 solar panels installed on Gotland. These are primarily used for hot-water production between May and September, and provide around 1.3 GWh per year in total. If solar panels are of the right dimension and correctly installed, they can also make a contribution to the heating of houses. It may also be financially viable to connect the district heating network to solar panel plants if this means that other plants can be shut down during the summer months. If solar panels for hot water and heating are installed in accordance with the table below, Gotland will be using 20 GWh solar heating per year.

* *HVDC = High Voltage Direct Current*

Example of possible scope of solar panel surfaces on Gotland

Type of property	No. of properties	Solar panel surface per property, m^2	Total solar panel surface, m^2
Single-family houses	2 000 (15 %)	10	20 000
Holiday homes	2 000 (15 %)	5	10 000
Apartments	50 (5 %)	100	5 000
Industrial plants and tourist companies			5 000
District heating network*			8 000
Total			**48 000**

** Assuming that solar heating can compete with biofuels in the district heating network.*

4.3.3 A sustainable transport system

Gotland's future development is dependent on good communication with the world outside the island. It is important to find sustainable solutions for the availability and capacity of physical communications by sea and air travel, but at present, no such solutions are available.

4.3.3.1 Road transport

The aim should be to find energy-efficient transport solutions, and to reduce the car traffic proportion of overall traffic. During physical planning and planning of transport infrastructure, the aim must be to create efficient passenger and goods transport solutions. Good access for public transport, pedestrians and cyclists, as well as plenty of opportunity to choose these forms of transport, must be developed through investment in appropriate operations. Through its responsibility for public transport services, physical planning and traffic planning, the municipality plays an important part in this work. By creating better conditions for cyclists in urban areas and on the open road, and by providing the majority of inhabitants in the municipality with access to public transport services at the right time, the municipality can contribute to a reduction in the amount of car traffic.

4.3.3.2 Environmentally-compatible fuels

The lowest proportion of renewable energy is currently found in the transport sector. The legal requirement which came into force on 1 April 2006 did not create immediate access to fuels based on renewable energy. On Gotland, there are two filling stations which sell RME, as well as one which sells E 85 (autumn 2006). The filling stations with RME sell about 30 m^3/year.** 2 % RME is also blended with the 20,000 m^3 or so of diesel MK1 sold on Gotland every year. This means that on Gotland, RME is used to a much greater extent as a low-level additive than as a vehicle fuel in its own right. In early 2006, small-scale farm-based production started on the island with the aim of expanding the production to up to 10 GWh/year within a few years. The growing conditions for oil crops are a limiting factor for production. There must be a market for RME, as well as for the by-product rapeseed cake, to make production financially viable.

As of February 2006, 95-octane petrol with 5 % ethanol added has been delivered to Gotland. Along with the addition of RME and possibly ethanol to diesel, this is, to date, by far the easiest way to increase the proportion of renewable energy in the transport sector. The availability of bioethanol

*** Information from Lantmännen on Gotland.*

produced in Sweden is limited, but expansion is under way for both cellulose-based and starch-based production.

Bioethanol production using renewable, local and sustainable energy resources would be one step towards a sustainable transport system, provided that ethanol can be produced in a way which both produces sufficiently large quantities of net energy and which is financially viable. A production of 60 GWh/year (around 10,000 m^3) could replace approximately 10 % of the fossil vehicle fuels used on the island. In the early 21st Century, the surplus of grain on the island is no greater than this. The rest of the grain harvest is processed locally as cereal or animal feed. The future of beet-growing on the island is uncertain. New rules and quotas for sugar production within the EU means that beet-growing for food sugar will cease on Gotland. There is a significant interest among beet-growers in trials with beets as energy crops and a raw material for ethanol production. Beet-growers on Gotland, along with the county, the municipality and LRF (the Federation of Swedish Farmers), have approached the Swedish Board of Agriculture with a proposal that Gotland should be provided with financial support for the construction of a biogas and ethanol fuel production plant with agricultural produce, especially beets, as the main raw material. The proposal is to use the special support provided within the EU to regions where food sugar-related beet-growing is ceasing as investment in such a plant. The food sector is calling for increased livestock production on the island to maintain the industry. Other crops, along with rising energy prices and changing production conditions, including changes to fallow land requirements or increased feed costs for the agricultural industry may provide even greater opportunities for local ethanol production or other new agro-based fuels. Such opportunities depend on, among other things, future agricultural policy decisions and the outcome of the EU's programme for rural areas.

At present, the development of biogas production on Gotland appears to be the safest way to process agro-based energy and turn it into a local resource in a sustainable transport system. Biogas can be produced by utilising the energy in waste products from the agricultural and food processing industries, as well as from the grocery trade. A possible short-term scenario of 150 GWh per year, without encroachment on acreage used for food and feed production, may result in a significant reduction in the environmental impact of transport. At the same time, the rotting down of manure and other substrates would generate great environmental benefits for agricultural production in the form of reduced leaching of nitrogen on arable land, reduced emissions of climate-changing gases from the storage of stable manure, reduced need for fertilizers and reduced smell from manure spreading.

Investment in biogas production plants can not, at present, be completely financed by the agricultural industry, since the market for the gas must expand first. Since potential vehicle gas customers must be convinced that the correct quality of gas can be delivered at the right time and in the right quantities before they change their vehicle fleets, alternative uses for biogas must also be permitted to expand with the help of investment support.

Within the local transport sector, taxi drivers and hauliers have expressed an interest in biogas as a fuel, but the number of vehicles which can fill up at a small number of filling stations on the island and also be acquired within a short period of time is limited. Experience from other areas has, however, shown that if vehicle gas is made available, demand will follow. This assumption is, however, not a sufficient guarantee to obtain bank loans to finance biogas-related investments. This requires additional financing which improves the calculations.

The rapid replacement of fossil fuels within the transport system requires continued political control measures, both at national and European level.

5. Current supply of energy to Gotland

5.1 The largest energy providers

Cementa, which is the island's largest energy user, has a separate company which enters into agreements regarding suitable fuels, and has its own harbour. Cementa's energy consumption is not included in the energy plan measures, but is included in several overall targets for Gotland. The operation is regulated partly by environmental permits and emission rights. Cementa's fuels are responsible for around 1,800 GWh per year.

All petrol, diesel and heating oil sold by oil companies to householders and businesses on the island first arrive at the oil depot in Visby harbour. Some companies bring in oil via Cementa's harbour. All the oil companies share a single depot. One drawback with Gotland being an island and having a limited market is that new products, such as petrol with 5 % ethanol added, come into use on Gotland far later than on the mainland. Gotland has also fallen by the wayside in the expansion of ethanol and biogas filling stations which some fuel companies have initiated on the mainland. Imports of oil to Visby harbour remained fairly constant at around 89 ktonnes oil per year for 20 years, but in 2004 and 2005, imports fell to 74 and 67 ktonnes respectively.

Vattenfall owns the electricity cable which links Gotland's electricity network to the mainland. It carries almost 900 GWh of electricity per year. On the island, the network owner GEAB is in charge of distribution. In the early 21st Century, wind power on Gotland supplied around 180 GWh to the electricity network. The rest of the electricity distributed through GEAB's electricity network comes via the mainland cable.

GEAB is also in charge of the district heating system of around 230 GWh per year. Visby Energi is a major subcontractor for heating in the network in Visby, while Gotlandsflis supplies fuel for the district heating systems in Visby, Hemse and Klinte.

The pellets industry is growing slowly but surely on the island. In 2005, the estimated output from fuel pellets was around 40 GWh. There are several agents for pellets on the island, but no collective statistics. The market for individual heating systems with local forest fuels in the form of chips and wood is probably twice as large, but is difficult to estimate.

5.2 Distribution

5.2.1 Fuels

The distribution of fuels on Gotland is well provided for. A number of players are active in the market. All vehicle fuel imported to the island for sale through public filling stations does, however, pass through the same oil depot in Visby harbour, and this may be a weakness. New vehicle fuels introduced in Sweden frequently reach Gotland as one of the last regions in the country.

5.2.2 Distribution of heat through district heating

The district heating networks on Gotland are owned by GEAB. Other important players are Visby Energi AB and Gotlandsflis AB. Visby Energi operates two biofuel boilers which produce around 135 GWh per year, 70 % of the district heating in Visby (total requirement 200 GWh). The total output from the chip boilers is approximately 30 MW, and these are fully utilised during the central heating season. They are not designed to produce electricity, since this was of no financial interest when they were built. The renewable energy in the district heating system in Visby consists of chip heating from Visby Energi and two gas boilers which burn methane gas from the landfill site and the water purification plant. These produce around 5 % of Visby's requirements. GEAB has an oil boiler which is responsible for some of the energy production during peaks when Visby Energi and the gas boilers are insufficient. The remainder of the energy comes from the heat pump at the water purification plant. GEAB has also four small oil boilers as backup.

5.2.3 Delivery reliability and preparedness for the electricity system

Since the early 1990s, the electricity network on Gotland has gradually changed from an electricity network built to distribute electricity to users, to an electricity network which both receives and transfers locally-produced electricity from several connection points, and distributes electricity to the island's electricity subscribers.

GEAB works continuously to improve the reliability of the electricity system and considers that it is well ahead in this compared with other regions in Sweden. GEAB has come a long way in the replacement of overhead wires with underground cables, which reduces the risk of power cuts due to trees brought down by storms. Every year, large amounts of money are reserved for improvements to the reliability of electricity network supplies.

The backup power capacity is excellent, and consists of gas turbines and diesel units. The capacity of the gas turbines equals the maximum load on the electricity network, 160 MW. There is also the oil-powered power station at Skrubbs. The availability of sustainable backup power is limited, but GEAB keeps enough fuel in stock for four days' backup power which is estimated to be more than enough with the world in its present state. GEAB estimates the backup power capacity for companies and public service operations which require immediate access to backup power as sufficient. There is, at present, no need to increase the capacity for backup power.

To reduce the risk of interruptions to the distribution network, GEAB has installed 230 sectioning isolators. These limit the damage caused, for example, by short circuits in the electricity network, and make it easier to both locate the cause of a power cut and to reduce the number of affected subscribers. The level of electrical self-sufficiency is achieved partly through increased local electricity production and partly through reduced total power consumption.

A 70 km HVDC-light cable between Näs and Visby has been installed to handle the power supply from Näs. HVDC-light, which is a technology used in the efficient transfer of electric current, has attracted a great deal of international attention within in the energy sector, and has generated visits from more than 30 countries.

By making it possible to change the direction of transmission in one of the links to the mainland connection, it is now possible for power to be transferred from Gotland to the mainland electricity network at times when wind power is generating more electricity than is required locally on Gotland. Simultaneous change-over of both links will not, according to GEAB, take place for reasons of delivery reliability. There is a risk that the electricity network on Gotland would suffer a fault while electricity is being transferred to the mainland. A drop in frequency in the electricity network on Gotland would, in this event, cause major problems for GEAB and its electricity customers. According to GEAB, one link ought to remain in standby position to allow electricity to be brought to the island as fast as possible and avoid a drop in frequency.

A robust electricity network in terms of voltage and frequency is achieved partly through the mainland connection regulating the frequency on the island's network, and partly through the synchronous generators that play a vital role in the functioning of the electricity network on Gotland. Investment in upgrading switchgear and transformers is carried out on a continuous basis. The stability of the electricity system has also been improved to allow it to receive electricity from the 160 or so wind generators on the island. Further improvement of the electricity network depends on external factors. GEAB's network will be expanded over time, in line with rising demand.

VISBY HARBOUR • PHOTO: GUNNAR BRITSE

6. Energy transition and the Gotland community

The target of achieving an energy situation by 2025, in which locally-produced renewable energy in the form of electricity, heating and fuel covers 100 % of the energy requirement, is based on the municipality's objective of creating a sustainable society within a single generation. Gotland has great potential for using renewable energy from local resources, as described in Chapter 4 above. The greatest part of this development will take place outside municipal operations, and this means that the focus has to be on issues relating to infrastructure, financing and ownership.

6.1 Success factors for a community-wide energy transition

6.1.1 Implementing the plan

Increasing the utilisation of renewable energy in the energy supply on Gotland, with the aim of achieving a long-term sustainable and carbon dioxide-neutral energy supply, requires active participation by all sectors. Local plans and ambitions have, to date, been decisive for the outcome. The municipality can play an active part and provide inspiration by increasing the proportion of renewable energy in its properties and transport operations. The municipality also plays an important part by providing information on how renewable energy can be introduced and can replace other forms of energy consumption. The municipality can also help in the development of an infrastructure which provides access to renewable energy for heating, electricity and transport. It is also important to prioritise sustainable development in plans and decisions.

6.1.2 Infrastructure

If a large-scale development of renewable energy is to be realised, parts of the current infrastructure will have to be redeveloped or expanded. This includes the island's electricity network and filling stations. To ensure the necessary long-term infrastructure, government funding will probably be necessary. At present, there is virtually no open debate about the development of renewable energy as a whole, but high energy and transport costs are a hot issue. Transport, in particular, will require investment in public transport infrastructure to create conditions which may bring about a change in behaviour. In its climate strategy, the Swedish Road Administration has identified three important investment areas, which also apply to Gotland:

- The improvement of energy efficiency within the transport sector in the short and long term.
- Large-scale introduction of renewable fuels within the road transport sector.
- Influence transport demand and increased collaboration between different forms of transport.

6.1.3 Financing

The financing of renewable energy development requires access to large amounts of capital. Here, too, government funding will be necessary, at least in the short term, to ensure the right economic conditions. One example of how this may be achieved is the introduction of the green electricity certificates, but households and small companies are increasingly demanding support in the form of investment in sustainable energy supplies for homes or businesses.

6.1.4 Ownership

Achieving a high level of local ownership in renewable energy plants is important to provide the permanent population with influence over the development, and to ensure that the local population is given the greatest possible financial benefits from the exploitation of the natural resources of Gotland. This will, in turn, generate increased purchasing power and local jobs.

6.1.5 Incentives

In the business sector, prices, customer demand and conditions laid down in an operation's environmental licences constitute decisive means of control. Support in the form of investment can, however, be the factor which decides whether an environmental investment, which has not come about as a result of legal requirements, will be realised.

6.2 Targets for energy consumption on Gotland as a whole

The targets measure the result of energy switchover and climate-related work. They are, in part, the same for the county and the municipality.

Targets for renewable energy on Gotland as a whole.
The municipality contributes within its areas of responsibility.

1. By 2010, a maximum of 55 % of all energy used for electricity, heating and transport on the island will, in accordance with the regional environmental targets, come from fossil fuels. The use of renewable energy must increase on Gotland, which is in line with a move towards a sustainable energy system. The municipality has signed up for the regional environmental target which means that, by 2010, at least 45 % of energy will be renewable or recycled energy. In addition, at least 75 % of the energy must be renewable and/or recycled even if fossil energy is included in the item recycled energy. The municipality follows up the results, based on information from the business sector and public statistics, and contributes to the fulfilment of the targets through measures in its own area of responsibility.
2. Between 2006 and 2010, wind power will be expanded to an installed output of at least 160 MW through the construction of already planned installations. Solutions are planned for an increase in the electricity network's capacity, with the municipality being involved in the planning process.
3. By 2010, at least 57 % of the district heating on Gotland will come from biofuels. 95 % of the energy will come from renewable and recycled energy sources. Decisions taken by GEAB will be decisive in whether or not the target will be achieved.
4. By 2010, the proportion of renewable energy in the fuels sold on Gotland will be 8 %. Through procurement, planning and possible projects, the municipality will work to ensure that the target is met. The target will be followed up on the basis of data provided by the fuel suppliers on the island.

Targets for improving energy efficiency and energy thrift

5. Energy efficiency and energy thrift, as well as internal and external information on energy-saving measures, must be improved in the municipality's operations through efforts by the administrations affected, primarily TF, SAK and MHK.
6. Up to and including 2010, an annual reduction in the energy requirement of the municipality's properties as a result of measures aimed at improving energy efficiency is to be reported by the relevant administration. The target will be followed up within the municipality's operation.
7. By 2010 at the latest, there must be a programme for an environmentally-compatible and resource-saving transport system and new, sustainable solutions for public transport services. This is a regional environmental target, where the municipality is responsible for part of the planning, especially with reference to public transport services.

8 The number of travellers who choose to travel by public transport or bicycle rather than car when commuting to and from work on an everyday basis must increase every year. The target will be followed up through statistics for the public transport services and through travel habit surveys.

Targets for electricity consumption

9 The use of electricity in central heating must be cut. This is a sub-target for energy advisors. The municipality's properties must be able to demonstrate a fall in the proportion of electric heating. Follow-up via energy statistics.

10 Electricity consumers on Gotland must increasingly select electricity from renewable energy sources. Follow-up via electricity suppliers.

Targets for emissions from the energy and transport sectors

11 Sulphur dioxide emissions on Gotland must be less than 550 tonnes/year in 2005. This is a regional environmental target which the municipality has signed up to. After 2005, emissions should continue to fall. Follow-ups will probably be carried out by following up regional environmental targets.

12 Nitrogen oxide emissions on Gotland must be less than 3,000 tonnes/year by 2010. This is a regional environmental target which the municipality has signed up to. Follow-ups will probably be carried out by following up regional environmental targets.

13 Carbon dioxide emissions from the burning of fossil fuels, on Gotland excluding Cementa, must, by 2010, be at least 15 % lower than in 2000. This is a regional environmental target which the municipality follows up in partnership with the county administrative board, using data from Statistics Sweden and local companies.

14 By 2010, the emission of ozone-depleting substances on Gotland must largely have ceased. This is a regional environmental target which the municipality has signed up to, which will probably be monitored through the follow-up of regional environmental targets. The municipality contributes to this target through the processing of scrapped fridges and freezers, and by replacing its own equipment.

15 The harmful hydrocarbon emissions (VOC) from the energy and transport sectors on Gotland will, by 2010, amount to a maximum of 2,555 tonnes, a 50 % reduction on the figure for 1993. This is a regional environmental target which the municipality has signed up for, which will probably be monitored through the follow-up of regional environmental targets.

Targets for energy advisory services

16 The municipality must provide private individuals and small businesses with energy advisory services, as and when the need arises. The municipality is responsible for determining the appropriate level.

17 The electricity system on Gotland must continue to maintain a high level of delivery reliability, despite an increase in the number of electricity suppliers to the network and increased demand for voltage quality. GEAB's responsibility.

Targets for following up energy consumption on Gotland

18 Annual follow-up to be carried out on total energy consumption on Gotland, the fossil carbon dioxide emissions generated by energy consumption, the proportion of renewable and recycled energy in the energy system overall, and how energy consumption is divided between heating, electricity and transport. The annual follow-up is carried out in association with the municipality's environmental report. A complete follow-up of the targets of the energy plan to be carried out by 2010, when the plan will be revised. The municipality's responsibility.

6.3 Action plan with municipal allocation of responsibility

The role of the municipality

The municipality has the opportunity to take action and to act as an arena for work carried out locally. This generates positive effects, including an improved living environment, cleaner air and lower energy costs. Measures aimed at reducing climate change are a powerful driving force for technological innovation and improved local economy.

Municipalities can influence energy consumption through their direct or indirect control over:

- Transport, traffic planning, streets, parking areas, public transport, access for cyclists and pedestrians
- Regulations for and planning of land-use
- Planning permission and building permits, advice on energy issues to the general public
- Management of recycled and waste material
- Waterworks, sewer systems and sewage works
- Public procurement of goods and services which impact on the environment and the climate
- Education and training, consumer guidance and citizens' information
- The municipality's own energy and fuel consumption

Success factors and targets apply to all municipal operations, but particular responsibility rests with the municipal executive board, the local government committees for social construction, GotlandsHem and the energy company, GEAB, in which the municipality is a minority shareholder. Each operation must, within its area of responsibility, implement measures and report on measures adopted in accordance with the success factors and targets of the plan.

The municipal executive board is responsible for

- Allocating resources to ensure that project applications for appropriate energy projects at EU and national level are submitted under the municipality's auspices. Deciding on project funds for local energy projects with the potential to increase the use of local energy resources, generate more efficient energy usage and reduce the environmental problems associated with energy usage.
- Allocating resources for the implementation of the energy plan's objectives and the regional and socio-economic consequences of changes to energy usage and increased utilisation of local energy resources.
- Including requirements for improved energy efficiency and changeover to renewable energy in municipal procurements by improving the knowledge of staff involved in placing orders.
- As part of the budget work, taking particular note of the committees' requests for measures which generate energy savings and a transition to sustainable energy usage.
- Providing resources so that, if necessary, the publicly-financed energy advisory service in the municipality can be expanded to at least one full-time position.
- Ensuring that access to environmentally-adapted transport systems and information about these are expanded within the municipality.
- Updating the energy plan every four years, with the next update due in 2010.

The local housing committee is responsible for

- Using planning and information to increase the opportunity for collaboration between different operations, with the aim of increasing the use of renewable energy and waste heat.
- Planning the locations of various operations in such a way that environmentally-compatible transport systems can be developed within the municipality and the dependence on cars reduced.

- Contributing through planning to renewable energy and, primarily, district heating being utilised as a heating supply in newly-developed areas.
- Providing information on energy-efficient construction methods and energy-saving measures for properties in connection with the planning application process.
- Allocating resources for the planning of wind power, to ensure that planning does not slow down the development of wind power in areas on Gotland where community planning allows the use of wind power and where there is an interest in expansion when the capacity of the electricity network is improved.
- Ensuring efficient and competent administration of questions relating to wind power in line with local and national objectives for the expansion of wind power.
- Promoting an increased installation of solar heating plants, particularly in properties with a great need for heating and hot water during the summer months.
- In collaboration with the Environmental Health Committee, setting appropriate environmental standards for the installation of new biofuel boilers and heating stoves.
- Using planning to contribute to the establishment of filling stations for renewable fuels.
- Ensuring that there is active and accessible municipal energy advisory services on Gotland.

The technical committee is responsible for

- Highlighting the work of improving the energy efficiency of, and changeover to, renewable energy in the municipality's properties and operations.
- Allocating resources aimed at phasing out heating oil by 2010, carrying out a survey of the proportion of electricity use in buildings and adopting measures aimed at reducing the use of electricity for heating.
- Allocating resources for increased installation of solar heating plants, particularly in municipal properties which require heating and hot water during the summer months (e.g. the municipality's sheltered accommodation and sports facilities).
- Prioritising the renovation and upgrading programme for the municipality's properties, with the aim of utilising any existing potential for improved energy efficiency.
- Allocating resources for an energy survey in accordance with new legislation, including proposed measures for all municipal buildings.
- Increasing the use of bioenergy for heating of municipal properties which cannot be connected to a district heating network.
- Continuing to procure Bra Miljöval electricity or at least the same environmental standard of electricity for the municipality's operations.
- After every major new construction or major redevelopment of municipal properties, ensuring that the 95 % of the electricity and heating used in the property comes from a renewable energy source.
- Contributing to the environmental adaptation of public transport and municipal transport services by adopting environmental requirements in the procurement process, by planning sustainable transport and by purchasing environmentally-compatible vehicles for use in the municipality's own operations.
- Through traffic planning, contributing to a safe and easily-negotiable traffic environment for cyclists, pedestrians and public transport users.
- By managing recycling material, residual products and waste, contributing to the material being utilised in the most energy-efficient way possible.
- Ensuring safe processing and phasing out of products with ozone-depleting properties.

The environmental health committee is responsible for

- Providing targeted information to property owners who burn wood in old wood-fired boilers, with the aim of convincing them to change to more modern units with accumulator tank and environmentally-approved combustion technology.
- Providing information which contributes to the phasing out of products with a negative impact on the ozone layer.
- Updating environmental requirement directives for heating plants, and processing applications for borehole-based and trench-based geothermal installations etc.
- Providing information on safety measures in the installation of heat pump systems (e.g. noise- and chemicals-related issues).
- Processing complaints regarding noise, air and odour problems in relation to energy plants.
- During planning consultations, contributing views regarding environmental and energy issues.
- Carrying out inspections and processing referrals when energy installations are being scrutinised.

The energy advisory service is responsible for

- Providing information to private individuals and small companies on the various alternatives for improving energy efficiency and energy thrift, as well as the options for phasing out oil-fired and electrical heating systems.
- Providing information on the technical alternatives available to reduce the use of electricity in electrically-heated houses.
- Providing targeted information to property owners who burn wood in old wood-fired boilers, with the aim of convincing them to change to more modern units with accumulator tank or other environmentally-approved combustion technology.

GotlandsHem is responsible for

- Carrying out an energy survey and proposing measures for all GotlandsHem's properties.
- Reporting the results of energy efficiency-enhancing measures and the exchange of experiences from reduced energy usage.
- Increasing the use of bioenergy as a heating source in properties which cannot be connected to a district heating network.

GEAB is responsible for

- Facilitating connection of local electricity production plants to the electricity network at such a rate that the local electricity network does not become a limiting factor in the development of wind power on Gotland.
- Utilising the opportunities for increasing the collaboration with appropriate industrial operations as regards renewable energy, waste heat and connection of the district heating networks.
- Facilitating a rapid connection to the district heating network of properties in Visby judged suitable for this purpose but which have not yet been connected, as well as newly-built areas.
- Using its influence, nationally as well as locally, to make district heating connection of individual homes and industrial operations profitable for all parties concerned.
- Continuously working to improve the reliability of supplies in the electricity system, by carrying out effective maintenance and improvement measures on the electricity network.
- Working for the implementation of measures aimed at further reducing the vulnerability of the electricity system.

Why is this so important?

One of the greatest problems of our time is society's dependence on oil and coal. The greatest threat to the plant is the climate changes caused by increased levels of greenhouse gases in the atmosphere. These are largely caused by coal-fired and oil-fired heating systems. Transports powered by fossil fuel have also had a very large impact on the environment. A large part of fossil carbon dioxide emissions is generated by private homes. Climate change is one of the clearest examples of global spread - the problems often arise far from the source of the emissions.

6.4 Future scenarios

THE SKRUBB HEATING PLANT • PHOTO: GUNNAR BRITSE

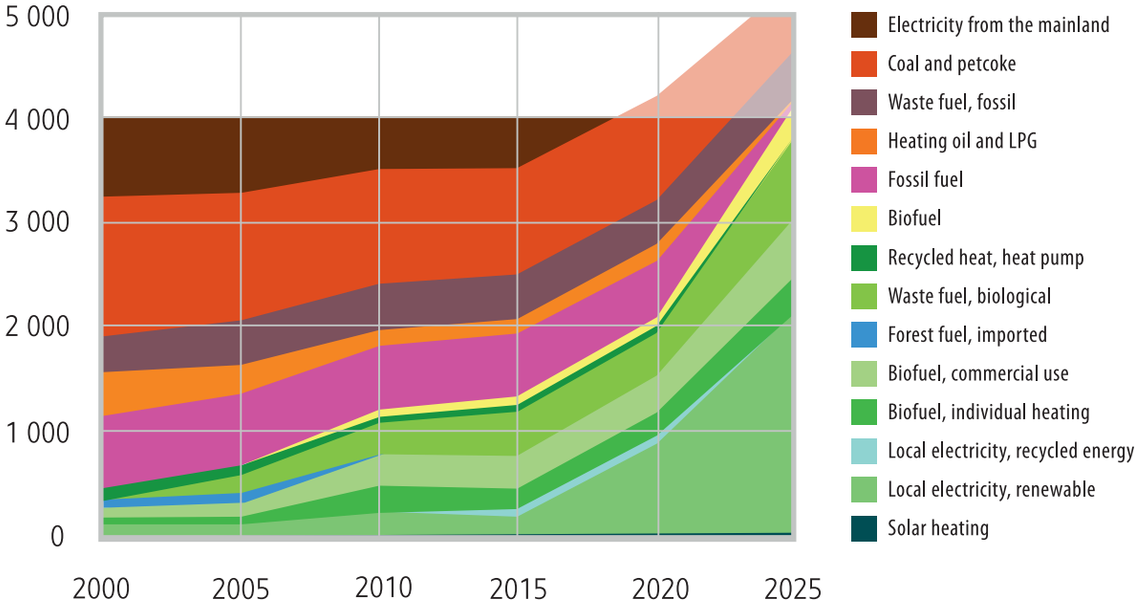
The following two scenarios from the investigation into Gotland's options for achieving a CO_2-neutral energy supply by 2025, which was part of the EU project *"100 % REN-ISLES"*, show a possible outcome for 2025. The first scenario shows the result of an active switch in the energy system, while the second shows the outcome of a neutral stance in energy issues. The scenarios have been slightly revised in *Energy 2010*.

6.4.1 Scenario for switching Gotland's energy system to a CO_2-neutral energy supply by 2025

The scenario involves changes where the efficiency of energy consumption on Gotland is improved in accordance with the success factors and targets in the energy plan, and amounts to 3,930 GWh/year by 2025. A certain amount of imported coal and fossil fuel is offset by a certain amount of exported biofuel and a large amount of exported wind-generated electricity. Most of Cementa's use of coal has been replaced by energy from waste products. Expanded wind power is responsible for just over half of the local supply of renewable energy. Local bioenergy covers a significant part of the heating requirement on the island, while biofuel is used in most transports on the open road.

Scenario 1: Energy supply Gotland (GWh/year)

With unchanged energy consumption and large local investment in renewable forms of energy. There is further potential for improving efficiency. Export of windpower and biofuel offset continued but reduced use of fossil fuels.



To allow a follow-up of the scenario, it is based on data from national statistics and major businesses and energy-users in the region. Energy consumption from heat pumps and recycled energy in businesses or households can only be reported to some extent. There is further potential in energy recycling, greater bioenergy production in fields and a somewhat increased power production to meet the energy requirements of transports between Gotland and the mainland as well. This is only partially included in the national statistics on oil deliveries. Unutilised technology, such as hydrogen gas production and wave power, is, at present, not included in the scenario.

Scenario 1: Renewable energy equivalent to 100 % of energy consumption in 2025

- Economic growth on Gotland has provided a 1.5 % annual increase in activities which have led to new, added energy consumption. At the same time, energy efficiency-enhancing measures have reduced the energy requirements of various sectors by about 1.75 % per year. As a result, total energy consumption on the island in 2025 is about 3,910 GWh per year, compared with 4,130 GWh in 2005.
- Over a 20 year period, active expansion for a higher consumption level of locally-available, renewable energy and a necessary expansion of the infrastructure for renewable energy have taken place.
- The use of electricity for heating purposes has fallen dramatically. Where electricity is still used for heating purposes, it is used to power heat pumps.
- Improved energy efficiency in industry has resulted in an approximately 10 % drop in the energy requirement in this area. This is partly due to the introduction of a new generation of more efficient electric motors and improved control and regulation systems.
- Heating oil used for heating has been replaced by solid biofuels or biogas.
- Petrol and diesel has been replaced by fuels made from renewable raw materials. The agricultural industry has taken on a new role as fuel producer.
- The energy requirement for transports is the same as in 2000, despite increased mobility in the community.
- Grain and other energy crops are grown for the production of biofuels in gas or liquid form. The rotting of certain waste means that both the energy and plant food in the waste are utilised. All agricultural land is used, either for food or energy production.
- The extraction potential for biomass from the forestry sector is fully utilised. Regeneration felling carried out by the forestry sector corresponds to the annual growth in the island's commercial forests. Pulp wood, branches and tops and brushwood from clearing operations, as well as waste from lumber production, are used as energy sources.
- Wind power is expanded to approximately 1130 MW installed output and generates 2,100 GWh/year. A new HVDC link to the mainland electricity network facilitates substantial generation of electricity for export to areas outside Gotland.
- Cementa has significantly increased the proportion of biofuel and recycled fossil fuel it uses, but since its fuel comes primarily from an external source, it is offset in the energy balance by the electricity surplus exported from Gotland.
- Solar panels for heating and hot water production are fitted as standard on new buildings and when old installations are replaced.
- Solar cells have become commercially viable due to the improved performance and significant falls in price generated by a multiple increase in production. 15,000 m^2 is used to produce electricity both for buildings connected to the network and for stand-alone systems.
- Household waste is used in heat production at Cementa to a limited extent. Extensive sorting-at-source of waste into several reusable and recyclable fractions means that the combustible fraction is small.

Comments on the sustainable scenario

This scenario includes a significant production of energy from wind power which is not used on Gotland, in quantities which correspond to, for example, Cementa's consumption of energy from fossil fuels. In this way, renewable energy can be produced on Gotland in quantities which equal the total energy consumption on the island. The result is a long-term sustainable and CO_2-neutral energy balance for the island.

Current impediments

The expansion of windpower is limited by transfer capacity, among other factors, but there is interest in an expansion of the stated magnitude.

At present, neither customer quality requirements, the environmental permits for the plant or the financial implications for the production process permit Cementa's production to use larger proportions of waste products as fuel, but the proportion of alternative fuels is increasing constantly.

The infrastructure for biofuels has to be expanded to increase the interest in environmentally-compatible vehicles and to secure a market for locally-produced biofuels. Increased forestry operations would generate biofuel from the forest as a by-product.

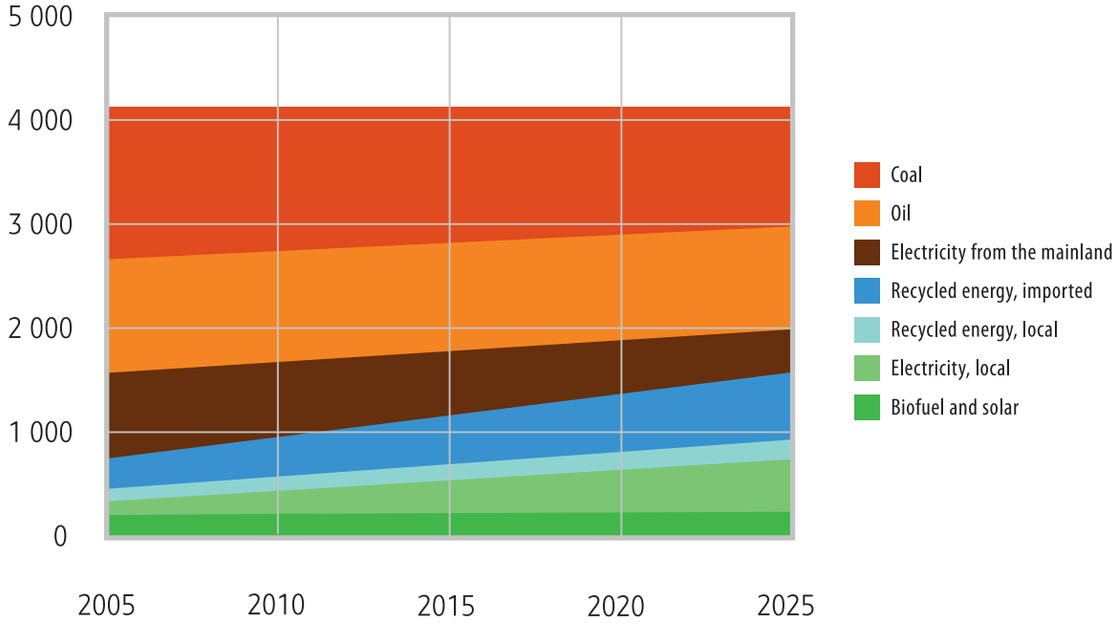
Many householders and businesses on the island have a limited ability to invest. This prevents a switch-over to new technology, despite the fact that a switch-over ought to prove profitable.

6.4.2 Scenario for the 2025 energy system without measures to promote a sustainable development

The following comparison describes a possible scenario for the development of the energy system on Gotland up to and including 2025, if no active measures are adopted at local, national and supranational level to support a transition to a sustainable energy system.

Scenario 2: Energy supply Gotland (GWh/year)

With unchanged energy consumption and without active measures aimed at increasing the use of renewable types of energy on Gotland.



BIOFUEL CAR • PHOTO: GUNNAR BRITSE

Scenario 2: Life goes on without active efforts to encourage an energy transition

- Increased growth on Gotland results in an increase in activities and consumption in the community as a whole. At the same time, there is an increase in energy efficiency-enhancing measures, and the island's energy requirement settles at around the 2005 level of 4,130 GWh.
- No active measures are taken to increase the availability of renewable energy (e.g. solutions to the energy network transfer capacity problem), either by businesses or the local or national authorities.
- Improved energy efficiency in buildings and within the transport sector is offset by increased consumption.
- The use of electricity for direct heating has fallen, but this is offset by an increasing number of heat pumps and the use of electricity for technical equipment.
- Despite rising prices and leaner engines, fossil fuel is used for transports largely to the same extent as at present. Mobility in the community continues to grow.
- Biogas is produced to a very limited extent. The gas is primarily used for heating and for some electricity production.
- Wind power is limited by the existing electricity network infrastructure. The full capacity of the cable is used to transfer surplus energy to the mainland: 160 MW installed output from GEAB, or just over 300 GWh annual production of electricity from wind generators. Some further local production can be added to this.
- The use of biomass for heating of individual houses and in district heating systems increases.
- Cementa, the island's largest industrial operation, has increased its use of waste products as fuel, but most of the fuel used is still coal.
- Within the transport sector, some bioethanol and RME is being imported as fuel. This is equivalent to just over 10 % of the fuel used for road transport.
- The number of solar panels used for heating and hot water production have increased, but these are still only used to a limited extent by tourist facilities since there has been a lack of interest in investment.

6.4.3 Sketch of one possible transformation of the energy supply: Total 3990 GWh/ yr

of which 2485 from solar & wind, 1200 from forest & field, 305 from recycling & heatpumps

A Power **B** Fuel **C** Recycled **D** Renewable (RE) **E** RE of local origin

	Energy supply I=installed effect MW E=Energy supply, GWh/yr		2000 result	2005 result	2010 adopted objective	2015	2020	2025 visionary objective
A	Wind power	I	75	90	160			1 150
		E	138	173	330			2 460
	Solar cells	I	0,005	0,005	0,6			3
		m²	50	50	4 000			15 000
		E	0	<0,1	0,6			3
	Biofuel *CHP*	I	0	0	0			30
		E	0	0	0			150
	Biogas *power*	E	0	0	30			50
B	Biofuel *community heating*	I	45	45	45			80
		E	138	179	250			300
	Biogas *heating*	E	10	20	50			100
	Biofuel *single use**	E	70	133	150			200
	...part of it is wood pellets	E	6	10	20			50
	Solar heating	I	840	1 260	6 300			12 600
		m²	2 000	3 000	15 000			48 000
		E	0,8	1,3	6			22
	Heat pumps	I**	15	20	25			25
		E	100	67	150			160
	Biofuel: Ethanol	E	0	0	30			160
	Biogas	E	0	0	50			240
C	Recycled energy *(waste, heating and electricity)****	E	20	25	75			145
D	Total supply of renewable energy	E	483	578	1 162			3 990
	Renewable share of total use of energy	%	11	18	29			Balance
E	**Produced electrical power**	E	**138**	**180**	**361**			**2 663**
	Produced heat and transport fuel	E	**345**	**481**	**741**			**1 327**
Energy supply, local origin		E	483	661	1 102			3 990
Total use of energy		E	**4 240**	**4 130**	**4 028**			**3 990**
Improved energy efficiency compared to year 2000		%	0	2	5			6

** Wood, logs, chips & pellets ** Peak effect *** Cement factory's usage of waste fuel of fossil origin not included*

7. Support for sustainable development

Municipal planning aimed at supporting the development of a sustainable community must include plans for a transition of and efficiency improvements for the energy system. Gotland has the opportunity to create an environmentally-sustainable energy system with the potential to generate socio-economic benefits and make a positive contribution to the development of the region. The municipal executive board has adopted the target of switching Gotland to an ecologically-sustainable and CO_2-neutral energy supply by the year 2025. To realise this vision will require strong political will and the capacity to create the resources necessary for a switch-over at local, national and EU-level. A great deal of local entrepreneurial spirit will also be required if we are to achieve the objective of developing and utilising the opportunities generated by local energy resources on Gotland. The municipality must also demonstrate consistency in all local decisions which impact on parts of the energy and transport system on Gotland.

7.1 Reduced environmental impact

The climate-changing emissions generated by energy consumption must be reduced through a switch-over to and improvement in the efficiency of energy and transport systems. The target for the planning period is to reduce climate-changing emissions by 15 % in total in the community as a whole (not including emissions generated by Cementa). A reduction of around 2 % is considered to be achievable through the introduction of more renewable fuels on the Gotland market and an increase by 5 % by volume in the ethanol added to petrol and RME added to diesel. More efficient transport through the introduction of energy-efficient vehicles and greater use of public transport services could contribute an estimated 3 %, and the replacement of heating oil with pellets, wood chip, wood, district heating and heat pumps around 10%. This reduction means a fall in carbon dioxide emissions from 5.4 tonnes per capita to 4.6 tonnes per capita (based on a population of 58,000).

(CO_2) emissions from fossil fuels on Gotland, 1993–2005

(the value of any CO_2 emissions from the production of electricity delivered to Gotland is not included)*

Category		Ton CO_2 year 1993	Ton CO_2 year 2000	Ton CO_2 year 2004	Ton CO_2 year 2005
Cementa's fuels**		490 000	673 000	596 000	502 666
Cementa's process emissions		670 000	974 000	940 000	960 702
GOTLAND EXCLUDING CEMENTA	**Road transports** (petrol + diesel)	**201 000**	**170 000**	**191 000**	**173 000**
	Heating (EO1-5 + LPG)	**134 000**	**92 000**	**88 000**	**79 300**
Sub-total, excl. Cementa		**335 000**	**262 000**	**279 000**	**252 300**
Total for Gotland, fossil CO_2		1 495 000	1 909 000	1 815 000	1 715 668

Source: Estimates for road transports and heating for 2000–2005 based on Statistics Sweden's statistics for oil imports. This does not include bunker oil for the ferry services or fuel for air services. The figures for Cementa AB have been provided by the company and is based on a calculation model used by the World Business Council for Sustainable Development. The amount of carbon dioxide produced when biofuels are used is not included in the table, since they do not cause an increase in climate-changing emissions.

** For example, the Climate Investment Programme and national statistics only include CO_2 emissions from local burning in the regional emission values, i.e. not electricity produced in a different location.*

*** Cementa's energy consumption includes a large proportion of incinerated tyres and plastic, which forms part of the recycled fuel category. According to guidelines issued by the IPCC, the UN climate panel, these fuels are of fossil origin, and should be included in fossil-based CO_2 emissions.*

(Compilation: the County Administrative Board's figures for 1993, the Gotland Energy Agency and the Municipality of Gotland for Energy 2010)

As demonstrated by the table above, the need, but also the potential, to reduce the climate-changing impact of operations on Gotland is great. In the first few years of the 21st Century, there was no significant change in the amounts of oil imported to the island, but this has been followed by a clear drop from 2004 onwards. An encouraging sign is that the proportion of wood-based fuel has increased and is replacing the use of heating oil.

7.2 The start of a transition on Gotland

7.2.1 Follow-up of the previous energy plan, Energy 2005

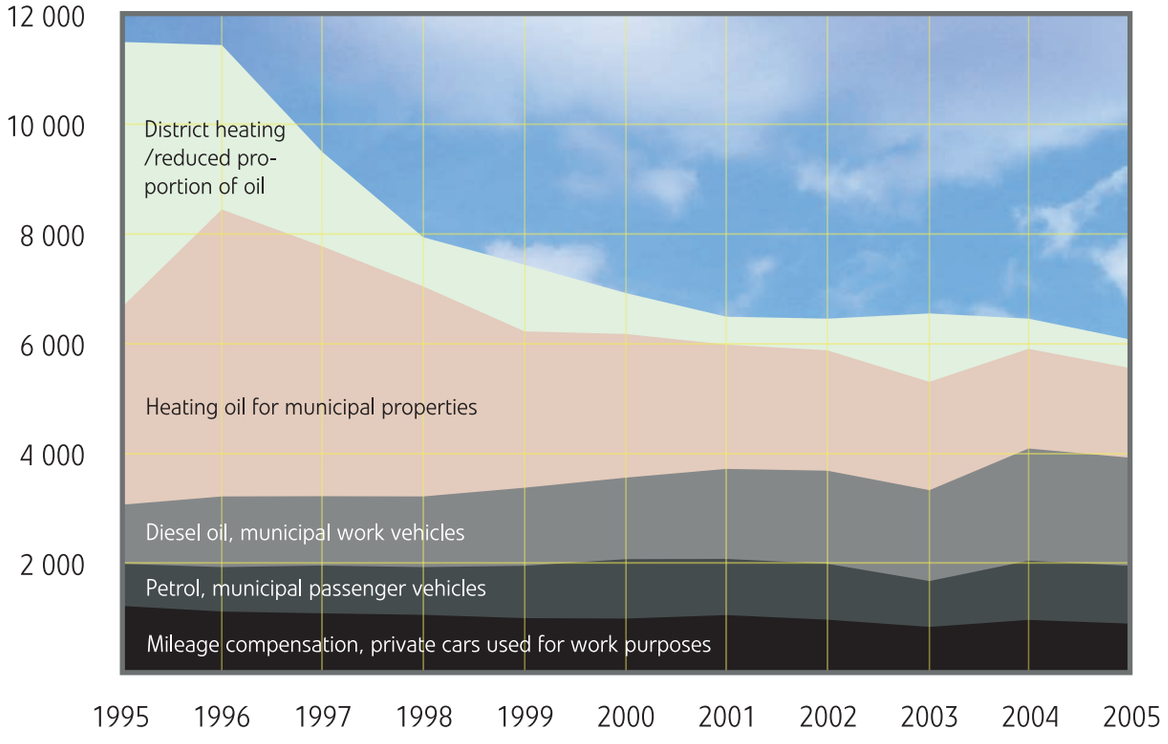
Since *Energy 2005* was adopted, the municipality has acted as a partner in the EU's "Campaign for Take Off", which is aimed at increasing the proportion of renewable energy in the EU. The energy-related targets in various governing documents for the municipality formed the basis for the municipality's partnership.

Energy 2005 illustrated two development scenarios leading up to 2005. The "zero scenario", which did not involve any active efforts to bring about an energy switch-over, and the "development scenario", in which the measures included in the action programme of the Energy Plan had been fully implemented. To date, the outcome has been somewhere between the two scenarios, with the results on many points closer to the development scenario. The outcome for energy advice provided by the municipality, the number of solar heating units installed, the environmentalisation of the

transport sector and the rate at which Cementa is changing to new types of fuel are, however, rather poorer. Examples of successes which have brought us closer to the development scenario include:

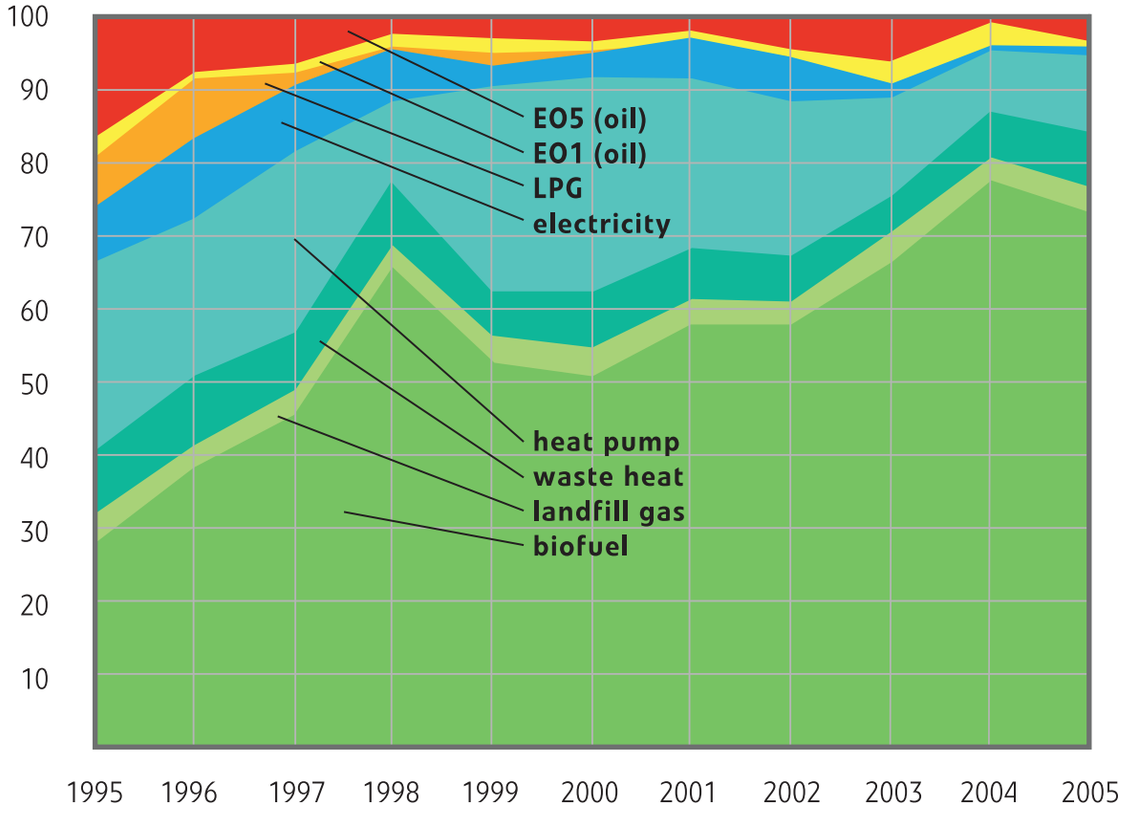
- In 2000, the community on Gotland, excluding Cementa, had already lower carbon dioxide emissions than those predicted in the development scenario in *Energy 2005*.
- The carbon dioxide emissions from fossil fuels produced by the community on Gotland, excluding Cementa, have fallen by at least 20 % between 1993 and 2005.
- The proportion of renewable energy on Gotland has increased, primarily through an increased proportion of wind-generated power in the electricity system and increased use of biofuels for heating purposes. The proportion is, however, still very low compared with the rest of the country. In 2005, the proportion of locally-produced heating and electricity from renewable energy sources on Gotland was just over 14 % of the total energy consumption. Around 20 % of the island's total energy consumption comes from local wind power.
- The target of 120 MW installed output in 2005 has not been achieved. The drawn-out permit application and administrative processes for the sea-based wind turbine farm, Klasården 42 MW, has delayed the start of operations on several occasions.
- The energy consumption in the municipality's properties has fallen significantly, and around 85 % of the heating and 100 % of the electricity used comes from renewable energy sources. The municipality has also unveiled several buildings which are exciting from an environmental and energy perspective. These include the Almedalen Library and the Gråbo school house.
- Carbon dioxide emissions from fossil fuels generated by the municipality's own operations have fallen from 11,470 tonnes/year in 1996 to 6,092 tonnes/year in 2005, in accordance with the municipality's green key figures.

CO_2 from fossil fuels in the Municipality of Gotland's operations (tonnes CO_2/yr)



- District heating has been expanded on Gotland by around 15 GWh between 1999 and 2005, half of which is in the town centre and the rest mostly in other parts of Visby. Sales have not increased - the energy savings are increasing in parallel with expansion, so the targets for increasing the proportion of district heating used for central heating purposes set out in the previous energy plan have not been achieved.
- In 2005, 95 % of the district heating on Gotland was produced using renewable and recycled energy. The phasing out of fossil fuels and electricity in the district heating mix has progressed more rapidly than predicted in the previous energy plan.

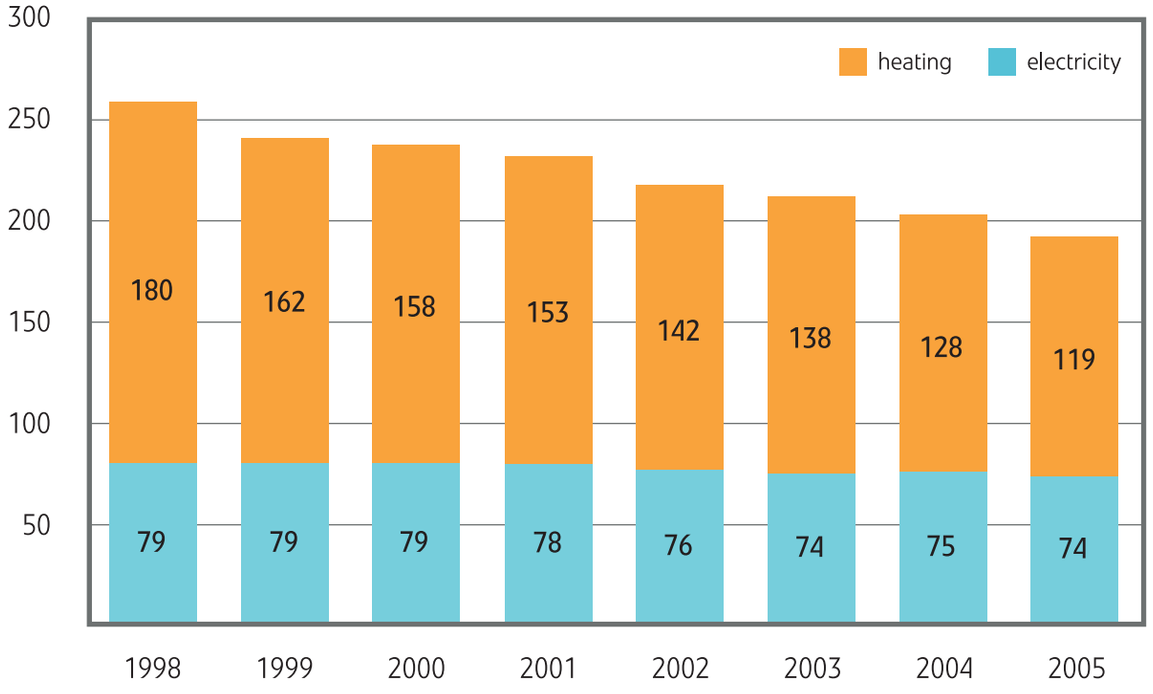
Fuel mix in district heating operations on Gotland (%)



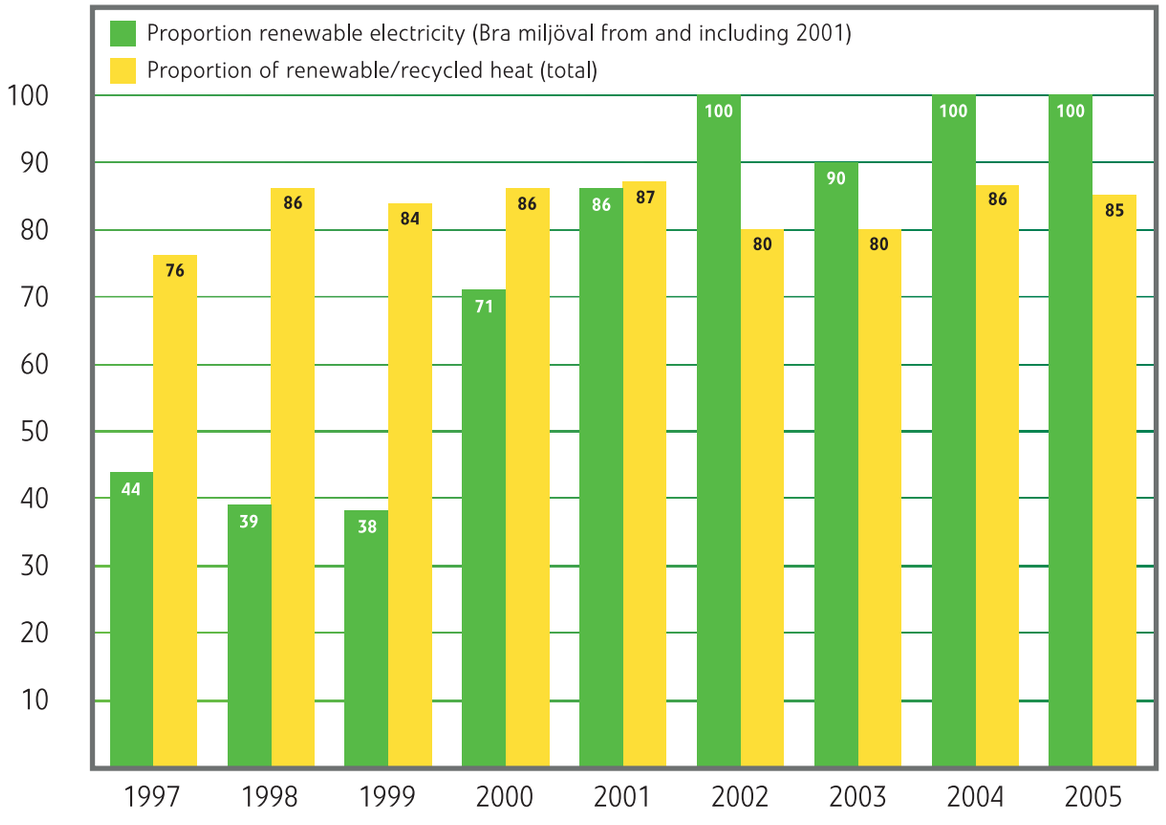
7.2.2 Measures which have already generated results in the municipality

- Improved energy efficiency and changeover to biofuel in municipal properties.
- Investment in RME for municipal vehicles has provided the island with RME filling stations.
- The municipality has procured ″green electricity″ following a decision by the Technical Committee.
- Car policy: small, fuel-efficient vehicles replace the use of privately-owned vehicles.
- Biofuel, district heating and improved energy efficiency has reduced the use of heating oil in municipal properties. Most municipal properties are connected to the district heating system.
- The municipality's building and planning department has set ambitious environmental and energy targets for every new construction or redevelopment project within the municipality.

Electricity and heating consumption in the departments (kWh/m² year)



Proportion of renewable electricity and renewable/recycled heat in the municipal departments (%)



- Campaigns aimed at increasing the proportion of solar heating and biofuel used for heating private properties are under way.
- A plan for ensuring that new buildings erected on municipal land are environmentally-compatible and resource-efficient has been adopted.
- The first ethanol vehicles have been added to the municipal vehicle park. These are flexifuel vehicles which can be run on either ethanol or petrol.

7.2.4 Encouraging examples from the development of wind power on Gotland

- The EU projects which the Municipality of Gotland and wind power companies on Gotland have been involved in have proved highly informative and this has resulted in a large number of study visits to Gotland, as well as a number of subsequent projects.
- More than SEK 1,000 million has been invested in renewable energy on Gotland over the last 15 years.
- 1,500 - 2,000 households on Gotland own shares in wind turbines, and a significant part of the capital invested has been provided by financiers on Gotland.
- In total, more than 50 % of the yield from wind power remains on the island.
- The expansion of wind power on Gotland has facilitated the establishment of small businesses in the areas of electricity generation, project development, operation and maintenance. These companies are now not solely tied to Gotland, but have national and international operations as well.
- Gotland University College offers a range of wind power-related courses. The courses have been developed over a number of years and an increasing number of students are applying for places on them. The wind power courses will be included in the college's course package for integrated coastal area management.
- The work of developing sustainable energy solutions has generated a great deal of expertise at a local level. An example is that the local network company found a solution to the problem of an annual average of 20 % wind-generated electricity in the local electricity network.
- The college has taken the initiative in setting up a wind power information centre, CVI, with the aim of increasing knowledge and providing information on wind power-related issues. A national centre for wind farming is being discussed by the government, and Gotland is one of the locations under consideration.

7.3 Working in partnership

Collaboration with the county administrative board and within local networks involved in the energy transition in accordance with local, national and international targets.

Since the previous energy plan, *Energy 2005*, was adopted, the municipality has been a partner in the EU 's "Campaign for Take Off" which is aimed at increasing the proportion of renewable energy within the EU. The energy-related targets in the various governing documents of the municipality formed the basis for Gotland's declaration of partnership within the *100 % REN-ISLES* category. The county administrative board and the municipality have jointly developed regional sub-targets for the national environmental targets, as set out in *Gotländska miljömål* [Gotland's environmental targets]. These will form a common basis for the environmental work on Gotland. The local targets in *Energy 2005* were based on the municipality's overall plan, *Vision 2010*, and the municipality's *Agenda 21*.

Infrastructure for sustainable energy supply and municipal energy projects on Gotland

Picture: examples of energy projects which form an important part of the ongoing energy switch-over, alongside local projects within the business sector.

Future measures which require collaboration between multiple players

- Cross-industry collaboration aimed at reducing negative effects on the environment.
- Heating from biofuel, solar heating, biogas and other energy sources.
- Expansion of electricity production using renewable energy sources.
- Development of transports using renewable fuels.
- Expansion of local bioenergy production and distribution chains.

7.2.1 Collaboration

In 2006, the county and the municipality sent a joint letter to the government in which they declared their interest in making Gotland a pilot area for a switch-over to a sustainable energy supply, in line with the proposals presented by the government's oil commission in 2006.

In the continuing work on the municipality's energy plan, the municipality intends to invite the major players in the Gotland energy system to a "Forum for sustainable energy supply on Gotland". The aim is to gather information on planned changes to the energy system, create a platform for any development projects and increase the business sector's commitment to combating climate change on a local basis.

7.4 The role of the business sector in the energy transition

Serious commitment from the business sector and the general public is essential to bring about a transition of the energy system. The driving factor may be personal commitment to development issues. Equally frequently, however, it is external factors, such as market advantages through customer demand, and various forms of economic control measures, including a tightening of the taxation and environmental legislation. Support in the form of investment for energy measures may be of great significance. In addition to financial support, such investment is also proof that a company is investing in a way which wins the approval of the community as a whole.

7.4.1 Energy companies

GEAB, the local company responsible for electricity and district heating deliveries and other services, enjoys a unique position in the energy sector on the island, and plays a key role in the switch-over of electricity and heating supply. To date, GEAB has integrated 20 % wind-generated electricity into the electricity system on Gotland, and supplies district heating with a high proportion of recycled and renewable energy. GEAB has noticed the improvement in energy efficiency in the community; new customers equivalent to 2-3 GWh per year are connected to the district heating network, but the amount of heating sold has remained constant.

Contractors on the island can supply everything from fuel chips and locally-built chip boilers to complete heating based on pellet-fired boilers of various sizes or ready-to-use heating from chip boilers in the district heating network. There is a great deal of interest and commitment, but for many it just provides a secondary income.

The wind power industry is made up of a small number of companies. Almost 2,000 households on Gotland has invested in shares in wind turbines, and this gives them ownership of their own electricity production. New construction of wind power plants has been delayed partly through appeals against decisions made by various bodies following considerations in accordance with construction and environmental legislation. Uncertainty over the long-term future and future economic conditions of electricity certificates has, for some time, also had a depressing effect on the development of wind power.

7.4.2 The cement industry

On Gotland, the largest energy consumer, Cementa, has already moved some way towards replacing coal with waste products and improving the energy efficiency of its operations.

Cementa's use of waste products amounted to one-third of the fuel in 2005, and energy equivalent to 14.5 % of their electricity consumption was recycled as electricity or district heating. The fuel consumption is significant - every tonne of cement requires around 900 kWh of heating. Vattenfall and Cementa have, through a joint electricity generation project, managed to use some of the surplus heat to generate electricity back to the plant. The surplus heat is used to power steam turbines. The project received environmental funding from the government as part of the municipality's LIP programme in 1999. Both Cementa's and Vattenfall's operations on Gotland come under trading in emission rights. Cementa's target is to increase the proportion of biofuel in the fuel mix to 10 % with the aim of reducing the

climate-changing emissions from fuel, and to increase the proportion of waste products in the cement raw material as well, with the aim of reducing the carbon dioxide emissions generated by processing. Cementa has signed up for the government's voluntary programme for enhanced energy efficiency, PFE. The commitment is to improve the efficiency of energy consumption and to introduce a quality programme with a systematic approach to electricity-saving measures.

7.4.3 Tourist organisations

Within the tourist industry, there are companies which invest in environmentally-compatible energy. This is an area where it is financially viable to use solar heating to generate hot tap water and possibly central heating during the tourist season. As a bonus, the companies gain a better environmental profile. The industry has expressed interest.

7.4.4 Agricultural businesses

Within the agricultural industry, LRF and other interested parties are working to increase the proportion of locally-produced bioenergy on Gotland. There is a substantial market in bioenergy for boilers used in district heating systems and individual properties. The food sector has also expressed an interest in energy and sustainability issues. The farm-based biogas production plant built at the island's agricultural college is expected to be replicated on other farms over the next few years. There is a biogas association set up by interested parties, primarily from the agricultural industry. The association's goal is to promote the role of biogas in Gotland's energy system. During 2006, beet-growers' associations and LRF in partnership with the county and municipality, sent a letter to the Swedish Board of Agriculture, stating that the financial support sent to Gotland as a result of the EU's new sugar policy will be used to build a biofuel plant on Gotland.

7.5 Benefits to the local economy

On Gotland, there is great potential in various renewable energy sources. The exploitation of this potential could contribute significant regional economic benefits, such as investment, jobs and income. Gotland requires extensive quantities of imported energy. In 2005, electricity and fuel worth at least SEK 1,105 million (SEK 0.76/kWh, average prices excl. VAT) were imported to the island to supply the Gotland community, excluding Cementa. For householders, the energy price was around SEK 1/kWh. For reasons of regional economy, it is desirable to replace this imported energy with locally-produced energy.

Utilising the renewable energy potential on Gotland could double the island's gross regional product in the energy sector. Construction work could generate around 130 permanent local jobs if the work was distributed over a 20-year period. The number of permanent local jobs required for the operation and maintenance of the plants would amount to just under 500. In total, full exploitation could create around 600 permanent jobs, with an annual tax revenue of approximately SEK 42 million, according to a study of the socio-economic consequences* of full exploitation of renewable energy resources on Gotland.

Exploitation could also be expected to be financed on market terms. In the long term, technology and cost trends will make renewable energy a realistic alternative, even without subsidies, but regions which become involved in the switch-over at an early stage would probably benefit from this.

In the long term, an exploitation of the energy potential is a matter of creating an active and steadily expanding community on Gotland, with a diversified business sector and a high quality of life.

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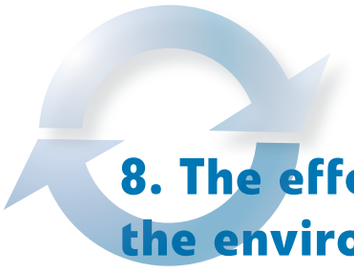
* *Michael Timmonen, Batchelor of Arts at the University of Lund, on behalf of Energibyrån Gotland [the Gotland Energy Bureau], 2000..*



8. The effects of energy consumption on the environment, health and management of land, water and other resources

For all large plants with energy-demanding operations, heating and electricity production or processing of fuel, environmental impact descriptions have been drawn up in connection with licence applications for the plants.

8.1 Environmental effects of energy consumption

8.1.1 Coal, mineral oil and the environment

The consumption of oil gives rise to risks of local oil disasters through spills and leaks entering the groundwater. Regionally, the risk of oil disasters in the Baltic poses a significant threat to the sensitive eco-system of an inland sea, as well as to tourism and fishing in the area. The 2,000 movements of various ships per day off Gotland's eastern coast make the island an area exposed to maritime discharge. The increase in oil transports through the Baltic has made the exposure more serious, partly due to the fact that the number of oil transports in waters close to Gotland have increased, and partly due to Russia accepting the proposal for minimum requirements for maritime standards for the Baltic, as adopted by the UN's maritime organisation, the IMO*, within the Baltic's classification as a specially protected inland sea. For Gotland, avoiding oil disasters in the Baltic is of central importance, and this alone ought to be sufficient reason to reduce the island's own dependence on oil.

On a global basis, accidents, wars or sabotage in areas where mineral oil is extracted or transported represents a threat both to human society and to vulnerable natural environments. Mineral oil in various products, from petcoke to worn-out vehicle tyres, is responsible for around 40 % and coal for around 20 % of energy imports to Gotland. The burning of coal and oil counteract the environmental targets of reducing climate-changing effects, fresh air, natural acidification only, a toxin-free environment and a sound urban environment. Thanks to efficient incineration and a high level of flue-gas cleaning, emissions and the environmental effects of burning fossil fuels have been generally reduced. Carbon dioxide emissions do, however, remain at the same high level notwithstanding incineration technology and flue-gas cleaning (using present-day technology). Such carbon dioxide emissions hasten the global warming which is currently regarded as one of the most significant environmental problems by far.

Sulphur dioxide emissions have fallen substantially over the past 30 years, and no longer constitute a health hazard. It is, however, a contributing factor in acidification. On Gotland, the fall is primarily the result of measures in the cement production process. Since 1995, the Slite plant has reduced its sulphur dioxide emissions by more than 4,000 tonnes per year, down to 47.2 tonnes in 2005.

A major exception to the trend of falling sulphur dioxide emissions is the maritime sector. Here, only some of the regular ferry services, including Gotlandstrafiken, have demonstrated a fall in emissions. In the maritime sector, very high levels of sulphur in fuel are still largely permitted. On Gotland, the damage caused by acidification is most obvious where it affects listed sandstone and limestone buildings. These are affected by acid rain with sulphur dioxide levels above 5 microgram/m^3.

* *International Maritime Organisation.*

8.1.2 Road transports and the environment

The use of fossil fuel is the area of the environmental impact of road transport operations primarily affected by the energy plan. Other significant environmental factors include road accidents, noise, fumes and the generation of dust from tyres and road surfaces.

In addition to a reduction in the proportion of fossil fuel, measures must also be introduced which will lead to improved efficiency in traffic operations, reduced energy and fuel consumption in the transport sector and increased coordination of transports. For the municipality, decisions on these types of measures should be taken in the operations affected, in accordance with the municipality's general environmental targets.

The environmental effect on species through emissions, animals killed by traffic and the pull of roads are not covered by the objectives of the energy plan, but are an important aspect of road traffic.

8.1.3 Electricity production and the environment

All forms of electricity production impact on the environment, but the environmental problems frequently occur a long distance away from the electricity consumer. For this reason, electricity is frequently regarded as emission-free in comparison with other types of energy. The electric power which is supplied to Gotland via the mainland cable is primarily hydroelectric and nuclear power. A smaller proportion comes from district-heating power plants and other types of electricity production, such as wind power and coal-fired power stations. The environmental effects of nuclear power production are significant in areas with, and downstream of, uranium extraction sites. Such environmental effects include the spread of land exploitation, acidification, contamination of water and the effects of radioactive quarrying residues such as sludge and slag. The environmental effects of the large-scale development of hydroelectric power are well known in Sweden. Such developments have caused significant changes to the local ecosystem and local communities in areas used for hydroelectric power production. The changes have been caused by the expansion of dams, with the resulting flooding of land areas, and by changes to flow variations which have affected aquatic ecosystems downstream. While the effects of uranium extraction are becoming more severe over time, changes due to the development of hydroelectric power are once-and-for-all events. On Gotland, wind generators are discussed from an environmental perspective, not only in the context of the positive environmental effects they produce through the production of emission-free electricity, but also with reference to the fact that they are seen as a blot on the landscape and the potential problems caused by cable-laying operations, sound, movement and the shading effect the generators may have on the people, flora and fauna in the immediate area of the plants.

8.1.4 Environmental impact of biofuel

The largest environmental benefit of biofuels is that they are climate-neutral fuels. Extraction of biofuels has a local impact on land use and biological diversity, and may affect the air quality through emissions from poor combustion. The ash from biofuel used in district heating systems is partly made up of fly ash, which is sent to Cementa where it is used in the cement production process, and bottom ash which is spread on arable land. The amount of ash is 2 % per tonne of raw material. Biofuel from forests is, in general, more energy-efficient than biofuels from arable land. While arable fuels produce a crop with more than ten times the energy used in growing and harvesting operations, forest fuels can produce more than fifty times the energy invested in the forestry operations.

The areas of Gotland which are the primary suppliers of biofuel are land used for arable and forestry purposes. The production of bioenergy can contribute to keeping these in cultivation.

8.1.5 The need for MKB for the energy plan

The environmental impact assessment regulation (Regulation for changes to the regulation (1998:905) for environmental impact assessments (SFS 2005:356), § 4), lists a number of different plans and programmes which, as a rule, are assumed to require environmental assessments. These include "Municipal energy plans".

These plans are included in the regulation since they often include conditions for the processing of licence applications for operations and measures which may have an impact on the environment, and this is the starting point for EU directive 2001/42 for environmental assessments of plans and programmes.

Justified decisions

The proposed energy plan, *Energi 2010*, cannot be regarded as specifying conditions for processing licences for operations and measures as listed in Appendices 1 and 3 to the environmental impact assessment regulation. The focus and objective of the municipality is described, but without specifying or guiding conditions for the processing of licence applications.

The energy plan demonstrates how the transition to a fossil fuel-free Gotland can be made. Many of the operations and measures necessary to fulfil the objectives of the plan are not subject to application processes. In no way does the energy plan lay down conditions or guide the development of any project. The judgement is that the energy plan, in this case, does not require an environmental impact assessment, as specified in Chapter 6 of the Environmental Code.

Through the energy plan's focus on attitude and its impact on significant environmental factors, there is, generally speaking, no such level of detail in the plan that would enable it to undergo an environmental impact assessment more than what has been said in the plan's illustration of the general environmental effects of the use of various energy sources and the environmental consequences of the implementation of the plan, as described above.

8.2 Health impact of energy consumption

A large number of health problems may arise as a result of air pollution linked to various types of energy consumption. Tropospheric ozone is generated by a reaction between sunlight and air pollutants, primarily nitrogen oxide and volatile organic compounds (VOC). These form in traffic fumes and in inefficient combustion processes. They can be produced both in the incineration of fossil fuels and biofuels. Small-scale wood burning in old-fashioned plants is responsible for 25 % of VOC emissions. Tropospheric ozone causes headaches, eye irritation and breathing problems. In Sweden alone, more than a thousand people per year are believed to die prematurely due to tropospheric ozone and particles. Particles are produced in the combustion of both fossil fuels and biofuels, and by wear on the road surface caused by studded winter tyres. The largest sources of particle emissions on Gotland is Cementa, processing machines, transports and small-scale wood burning with poor combustion. Volatile organic compounds (VOC), such as benzene, are carcinogenic and also produce the same health problems as tropospheric ozone.

Wind turbines can generate noise and light effects which may cause problems in their immediate vicinity and, therefore, have some negative effects on the health of people living nearby. The noise is caused by the machine housing (in older turbines) and the rotor blades. The noise generated by a wind generator is between 95 and 105 dBA. At a distance of 350–775 metres from a wind generator, the noise level falls to 35 dBA. The guidelines (NV standard RR 78:5) for noise levels from wind generators, i.e. max 40 dBA at the outer facade, apply to homes, holiday homes and workshops without noisy operations. Fixed distance criteria, from and between wind generators, are used as a recommendation during the planning phase. Wind power plants are at their noisiest at wind speeds of between 3–4 m/s (start-up wind) and 8 m/s. At speeds over 8 m/s, the sound from the wind generators is drowned out by the sound generated by the wind itself and the movement of vegetation.

The number of complaints to MHK relating to noise from operational wind generators is very low. Complaints are normally received in connection with building permit process.

Carbon dioxide emissions on Gotland contribute to climate changes which will cause health problems on a global scale. As the planet becomes warmer, there will be more floods, droughts and rising sea levels. Health effects include more accidents and deaths, more infectious deceases, more psychological problems, famine and more illnesses caused by infections carried by insects. Malaria could become a problem in Sweden. Mould problems in homes may increase as a result of increased humidity. Borrelia and TBE will spread northwards.

8.3 Management of land, water and other resources

Production of bioenergy from agricultural land and forests

Gotland has physical resources in the form of agricultural land and forests, which can be used in the production of energy raw materials. With rising energy prices and an increased market for bioenergy, the economic yield per hectare of forest and hectare of arable land may be the same for energy production as for conventional food production. From a socio-economic point of view, it generates local employment and reduces the need to purchase external fuel. Unlike other possible land use, increased production of raw materials for energy does not have a solely positive or negative impact on biological diversity and the productivity of the eco systems on Gotland. Since the production of raw material will help to keep the land cultivated, the positive effects should, however, outweigh the negative, especially since the value of the Gotland countryside is often linked to its traditional agricultural landscape.

Areas for wind power

On the basis of the municipality's wind power plans, the national planning target for wind power can, as far as Gotland is concerned, be increased substantially on condition that a new electricity cable is in place by 2010 at the latest. The effects of local wind power plans on other land use will become clear when a new general plan for Gotland is produced.

Areas for solar collectors and solar cells

Plans for how, where and when solar panels and solar cells are to be fitted to improve the utilisation of solar radiation on Gotland has, so far, not been regarded as of immediate concern. Solar cells are not expected to have a breakthrough on Gotland within the planning period, so this issue has been referred to future energy plans. Areas for solar collectors are, however, of interest in the current planning work.

Areas required for transport infrastructure

Gotland will not experience any major expansion of the transport infrastructure in the form of new roads or airports. This is primarily an issue for the town architect's office in connection with the planning of areas for new development. Future plans should focus particularly on infrastructure for new fuels.

The general public's commitment to the energy plan

The general public is involved in the implementation of the plan through various projects and public information campaigns in various areas. In 2004, 2005 and 2006, the municipality organised or participated in several public events for pellet and solar heating, climate information, planning of local biogas on Gotland and themed events on the opportunity for local production of bioethanol on Gotland.

Equal involvement in the planning and implementation of measures under the plan

Measures aimed at improving the energy efficiency of and energy supply to properties seem, looking at the gender distribution at public events, to affect considerably more men than women. Information campaigns for various types of renewable energy also primarily attract male participants/visitors. When questioned, women often reply that although they are interested, other commitments take priority. We do not appear to have a successful method for reaching everyone with these issues, but work hard to obtain views on the measures resulting from the energy plan and climate work from both men and women in the municipality.

It is useful to consider the different parts of energy consumption separately, i.e. electricity, heating and transport. Of these three, transport is the easiest part to consider from the perspective of equality. Travel habit surveys provide answers at individual level, and there are surveys which show differences between the sexes in respect of travel habits and the distribution between public transport and individual car usage. The challenge facing the community's traffic and overall plans is to create a transport infrastructure which offers equal opportunities for men and women to find satisfactory transport solutions.

Most of the energy used by private households is linked to domestic heating systems and equipment. The challenge here is to provide information, which is equally understandable to men and women, on how energy can be saved, the opportunity for switching to a different energy source and the economic and environmental benefits in doing so.

References:

Gotländska miljömål [Environmental targets for Gotland] *(The County Council, 2004)*

100 % REN-ISLES, **A Renewable Energy Plan** *(The Gotland Energy Agency, financed by the Swedish Government Energy Authority and EU FP5 Altener, published in 2002)*

Regionalekonomiska konsekvenser av en full exploatering av förnybara energipotentialer på Gotland [Regional economic effects of a full exploitation of renewable energy potentials on Gotland] *(Michael Timmonen, University of Lund, on behalf of the Gotland Energy Agency)*

Bioenergins marknad och möjligheter på Gotland [The market and opportunities for bioenergy on Gotland] *(The Federation of Swedish Farmers' county association on Gotland 2003)*

Glossary

Agenda 21	Programme of environmental and development measures for the 21st Century (agenda for the 21st Century), adopted by 180 states at the Rio conference in 1992. The document sets out targets and guidelines for achieving sustainable development. It focuses on development which is sustainable not only from an ecological point of view, but also from a social and economic perspective, including the abolition of poverty. Particular emphasis is placed on the importance of involving all community groups in the work, particularly women and young people. In Sweden, all municipalities have started working on or adopted the concept of a local *Agenda 21*.
Bio-	First element (from the Greek bios meaning 'life'), life, living, refers to living organisms or life processes.
Biofuel	Fuels originating in the vegetable kingdom. Examples of biofuel include wood, forest chippings, bark, shavings, energy forest etc.
Bioenergy	Bioenergy is the energy produced from biofuels, a fuel consisting of biomass, i.e. materials of biological origin. Bioenergy is carbon dioxide-neutral, i.e. it does not contribute to global warming.
Biogas	The gas produced when organic material, such as manure, faeces, industrial sewage, sludge from water purification plants, household waste and plants, is rotted down by methane-producing bacteria under anaerobic (oxygen-free) conditions. Unlike natural gas, biogas is non-fossil. It is also known as digestion gas and marsh gas.
GRP	Gross regional product, is the total value of goods and services produced for final consumption at regional level (GNP, national level).
CO_2	Chemical name for carbon dioxide.
The four systems conditions	Fundamental principles for achieving ecological sustainability. By observing these principles more closely, we will move towards sustainability. They lead towards the objective without contradicting or overlapping each other, and is based on our knowledge of the natural sciences. The common basis for the eco-municipalities' strategic approach to environmental work.
E 85	"Ethanol" (Etamax B) is a fuel for passenger cars which contains 86% ethanol, 11.6% petrol, 2% MTBE (octane-boosting component) and 0.4% isobutanol. The petrol in E85 is added partly to make it easier to start a cold engine. For this reason, the proportion of petrol in E85 is increased in winter.
Output	Physical measurement which specifies the amount of work carried out during a specific period of time. The output is measured in watts (W). If the transferred energy is in the form of mechanical work, the unit Nm/s is also used (Newton metre/s = joule/s). An older unit is horsepower (hp), 1 hp = 75 kpm/s (kilopondmetre/second) = 735.5 W.
Eco-	First element (from the Greek. oikos meaning 'house') which describes systems, both in nature (ecology) and for the management of and valuation of scarce resources (economy).
Eco-municipality	Municipality which has decided to create sustainable local development through a combination of ecological sustainability and economic growth. The four systems conditions form a common basis for Sweden's eco-municipalities.
Eco-municipality Gotland	The eco-municipality is an initiative and commitment adopted by the Municipality of Gotland. It involves everyone living on Gotland in the challenge of, through broad collaboration, achieving an ecologically-sustainable community in combination with sustainable growth on Gotland by the year 2025.
Ecology	The science of the interplay between the species and their habitats, which describes the factors which form and affect the ecological systems.
Ecological sustainability	A state which has been achieved when the members of a community meet their needs in balance with the planet's ecosystem, without compromising the opportunities for future generations to meet their own needs.
Economy	The art of economising on scarce resources, and treasuring and managing resources.

Energy	There is no overall definition of energy, but it could be said that energy comes in three different forms: mechanical energy, kinetic energy and potential energy. The principle of energy is an empirical physical law which says that energy cannot be destroyed or regenerated, but can only be transformed from one type of energy into another. An energy form can, however, be consumed, which happens when it is transformed from one form into one or more other forms of energy. Energy is output distributed over time, i.e. energy = output (P) x time (t). The units for measuring energy are the wattsecond (Ws) or the joule (J).
EO1	(Heating oil 1), the lightest class of heating oil, with approximately the same properties as diesel, i.e. light fuel oil. A liquid fuel consisting of hydrocarbons and produced through the distillation of crude oil. As a commodity, heating oil comes in several different qualities, classed by its viscosity. EO1 has the lowest viscosity and is used, for example, in domestic boilers.
EO5	(Heating oil 5), belongs to the heavy heating oil class, heavy-bodied oil. The oil often contains high levels of sulphur which, when incinerated, is turned into sulphur dioxide, a contributory factor in environmental acidification. The highest permissible sulphur content has, therefore, been substantially reduced over the years. The use of this type of oil is falling continuously.
Fossil fuels	Fuels consisting of organic carbon and hydrogen compounds extracted from sediment or sedimentary rock. The economically most important fossil fuels are coal (brown), oil and natural gas. Fossil fuels are believed to originate from small aquatic animals and plants which have died in seas and lakes and then been subjected to high pressure and temperatures. Peat and sea coal are also counted as fossil fuels. Fossil fuels are still being generated, but at a very slow rate compared with modern industrialised society's consumption of these fuels. As a fuel source, they are, therefore, regarded as finite.
Success factor	Decisive stage on the path to achieving visions and goals.
Renewable energy	Energy sources which, unlike fossil ones, are renewed at a rapid rate and are infinite. These include solar power, wind and water. Biofuels and the use of timber are also included in this category. Renewable energy sources are often small-scale and leave few, or no, traces in nature.
G	Giga-, unit prefix designated G-, indicates a factor of 1 billion, 109 = 1 000 000 000. Example: GW (gigawatt).
Global warming	The term to describe the rise in the average temperatures of the Earth's atmosphere and the sea noted in the past few decades. In principle, the term "global warming" does not distinguish between the causes, but in current everyday speech, a human element is always implied. The UNFCCC does, however, use the concept of "climate change" for changes caused by humans, and "climatic fluctuations" for other changes.
Branches and tops	Waste from forest operations. Collected for energy extraction following felling.
HVDC	High Voltage Direct Current. A technology for transmitting electric power over long distances with less loss than when using conventional alternating current technology.
HVDC-Light	A further development of the HVDC technology, which offers reliable power control and fast reconnection of power in the event of a power cut. It is also environmentally-friendly, since it involves oil-free cables, no electromagnetic fields, compact rectifiers and underground or underwater power links.
Sustainable growth	Growth which is ecologically, socially and economically sustainable.
Sustainable development	A concept introduced on the global arena in connection with the UN report *Our common future* (1987) which was presented to the UN conference on the environment and development in Rio de Janeiro in 1992. The work on the UN report was lead by Gro Harlem Brundtland, and the report is, therefore, often referred to as the Brundtland Report. It defines sustainable development as a development where present-day needs are met without risk to the opportunity for development and needs of future generations. It aims to make sustainable development a general target for social development, as established in the programme of measures, *Agenda 21*.
Indicator	Measurement which indicates development over time, provided that it is followed up regularly.

Infrastructure	Technical provisions in the form of mains water, sewers, road networks, electrical networks, district heating, broadband and waste management systems.
Targets	Targets which are to be achieved over a period of 5 to 20 years through investment in success factors.
J	Designation of the energy unit Joule.
Joule	SI unit for all forms of energy, with the designation (J). 1 J (Joule) = 1 Nm (1 Newton metre).
k	Kilo-, unit prefix with designation k-, indicating a factor of 1,000, 103. Example: 1 kilowatt (kW) = 1,000 watt (W).
Climate	Average value for temperature and precipitation over a longer period of time, not individual years.
Climate-neutral	Production of goods and services without a negative impact on the climate, e.g. without emission of carbon dioxide and other greenhouse gases.
Climate impact	Increased concentrations of greenhouse gases in the atmosphere caused by emissions from heating and transport. Climate impact is one of the clearest examples of global environmental impact, which are characterised by the fact that any problems frequently arise far from the source of the emission.
Carbon dioxide-neutral	Operations which do not generate any net increase in the greenhouse gas carbon dioxide in the atmosphere, i.e. where the carbon dioxide produced during an activity equals the amount assimilated.
M	Mega-, unit prefix with designation M-, indicates a factor of 1 million, 106. Example: 1 MW = 1,000,000 watt (W).
m³f	Fixed measure, cubic metre wood volume (timber). Commercial measure within the forestry and sawmill sector. The measure refers to the fixed actual volume of log, chip, shavings or bark.
m³s	Stjälpt mått (loose volume), a cubic measurement for dry goods of varying size, e.g. forest chips (volume approximately 3 times fixed measure).
m³sk	Forest cubic metre is a unit used as a designation for the timber volume of a forest stand. The measure includes the whole log volume of the trees above normal stump height, which means that the top as well as the bark is included. Branches, stubs or roots are, however, not included.
Tropospheric ozone	Ozone (O^3) from ground level to a height of about 1 km is called tropospheric ozone. Tropospheric ozone is extremely toxic. At a chemical level, for example, the ozone attacks the unsaturated fatty acids in cell membranes. Extended exposure leads to significant irritation of the eyes and mucus membranes, as well as to other damage, particularly to the upper airways.
Environmental target work	The work which results in us achieving the national environmental quality targets which, on Gotland, are governed by the County Council's document, *Gotländska miljömål (Gotland's environmental targets)*.
Environmental sustainability	No negative impact on the environment.
Goal	A result which is to be achieved.
Zero emission zone	An area where waste from one production process becomes a resource for another, and where other waste is reduced through active environmental choices made by producers and consumers.
Key ratio	Indicator expressed as proportion, for comparability between groups of different sizes.
Petcoke	Residual product from the oil industry which is used as a fuel.
Plan	Indicates who is responsible for what, when sub-targets are to be achieved and the total timeframe, which resources are to be used, how and by whom results are to be measured and valued.
Policy	Joint values or approaches which govern work.
Programme	Collective document for overall targets, policies and strategies.
RME	Rapeseed oil methyl ester, fuel for diesel vehicles, biodiesel. Made from oils from plants, e.g. rapeseed, soya beans and sunflower seeds, or animals, which have been modified so that their chemical properties are similar to those of regular diesel oil.

Solar cell	A solar cell is a contraption made up of semi-conductors, often linked into larger units. When exposed to the sun's rays, they emit an electric current, unlike solar collectors which heat up a liquid.
Solar collector	A solar collector catches the sun's rays and turns them into heat. Water or some other liquid medium is circulated through the solar collector. The heated liquid can either be used directly as tapped hot water, or for heating a house.
Stand alone system	Unit or system situated a long distance away from the mains electric network and other infrastructure, such as satellites, lighthouses, mobile telephone masts and telecoms offices.
Strategy	Activities and processes selected with the aim of achieving set goals.
Target	Measure for development where a certain outcome is to be measured and reported annually.
System conditions	Description of the conditions necessary to the long-term sustainability of a system.
T	Tera, unit prefix with designation T-, indicating a factor of 10^{12}, i.e. 1 trillion.
TS	dry substance (ts), that which remains of an analysis sample or an organism after the water has been removed, normally through heating. The concept is frequently used in agriculture in connection with the energy/protein content of feed and crops.
Emission rights	Trading in emissions is an important economic control measure aimed at meeting the requirements for a reduction in greenhouse gas emissions laid down by the Kyoto Protocol. A central organisation, normally a government or one of its public authorities, determines a maximum permitted limit (a ceiling) for the amount of environmental toxins which may be emitted. Companies and businesses responsible for the emissions have at their disposal emission rights (allocations or rations) during a trading period lasting 4-5 years. The total number of emission rights is equivalent to the determined amount of emissions, and this means that the total amount of emissions is limited to the agreed ceiling. Companies which, during this period, generate less greenhouse gases than their ration may either save the rights for the following period or sell the emission rights to other companies which have used up their rations.
Vision	Future ideal image to aim for.
VOC	**V**olatile **O**rganic **C**ompound, VOCs. A group organic compounds which easily turn into gas at room temperature. These compounds contribute to air pollution and are a contributory factor in the formation of tropospheric ozone. The compounds may be hazardous to health, such as the carcinogenic benzene.
Heat pump	Installation which facilitates the use of heat energy from heat sources at low temperatures. Examples of free heat sources available in our surroundings include outdoor air, lake water and groundwater. Exhaust air from buildings, sewage water and industrial waste heat are other examples of possible heat sources.
Greenhouse effect	The phenomenon which stops long-wave radiation from exiting a planet's atmosphere due to greenhouse gases. On Earth, it is a contributory factor in keeping the planet's temperature at a habitable level. There are positive and negative greenhouse effects. The positive effects allow life to exist, while the negative greenhouse effect contributes to the rise in temperature of the Earth's climate. The concept of greenhouse effect is, in everyday speech, often used erroneously when discussing "global warming".
W	Designation for the output unit Watt.
watt	watt (after James Watt), SI unit with the designation (W) for the physical size effect within all areas of application. 1 W=1 J/s (joule per second).
Recycled energy	Energy from fuels which have previously been used for other purposes.

Conversion table for output and energy

Output measured in watt (W)	Energy is OUTPUT x TIME
1 kilowatt (kW) = 1 000 W	1 kilowatt hour (kWh) = 1 kW in 1 h
1 megawatt (MW) = 1 000 kW	1 megawatt hour (MWh) = 1,000 kWh
1 gigawatt (GW) = 1 000 MW	1 gigawatt hour (GWh) = 1,000 MWh
1 terrawatt (TW) = 1 000 GW	1 terawatt hour (TWh) = 1,000 GWh
Output is also expressed in: Newton metre/s (Nm/s) = Joule/s (J/s) 1 Nm/s = 1 W *Older unit:* Horsepower (hp) 1 hp = 735.5 W	*Energy is also expressed in:* Joule (J) = watt/s (W/s) 3,6 GJ = 1 MWh *Older unit:* Calorie (cal) or kilo-calorie (kcal) 1 kcal = 1.163 Wh

Comparison of the energy content of different fuels and energy sources

Energy source	Quantity	kWh	Note
Heating oil	1 m^3	9 960	
Ethanol	1 m^3	9 300	60 % lower energy content than petrol, 15–20 % greater fuel consumption
Biogas	1 m^3	6,4	
Forest chips, dry	1 m^3s	aprox. 900	11–15 m^3s equivalent to 1 m^3 heating oil
Timber, fixed measure	1 m^3f	aprox. 2 300	approximately 4.5 m^3f equivalent to 1 m^3 heating oil
Standing forest	1 m^3sk	2 000	approximately 5 m^3sk equivalent to 1 m^3 heating oil
Wood pellets	1 ton	4 800	2.1 tonnes equivalent to 1 m^3 heating oil
Grain	1 ton	aprox. 4 000	2.5 tonnes equivalent to 1 m^3 heating oil
		kWh/year	
Solar radiation	1 m^2	1 067	(output 150 W, average year on Gotland)
Solar collector	1 m^2	420	(standard domestic installation 10 m^2 = 4,200 kWh/year)
Solar cell	1 m^2	aprox. 200	
Wind generator	1 st	2 000 000 –6 000 000	Depending on size, installation output 1–3 MW
		kW	
Heat pump	1 kW	3–6	Output (heat factor, COP 3–6)

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Author: Municipality of Gotland,
Executive office, planning team, eco group
Front page photos: Göran Bylund, Bengt-Olof Grahn
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