



PHOTO: SESSE LINDLUNK IMAGE

Despite high energy consumption, Swedish carbon emissions are low.

ENERGY:

Generating power for a sustainable future

Cutting-edge technology, a wealth of natural assets and a long tradition of energy research – Sweden is in the front line as the world embarks on a shift to more sustainable energy systems.

The International Energy Agency (IEA) ranks Sweden highly on most counts in its report from 2008: low carbon dioxide emissions, a high proportion of renewable fuels and an efficient electrical power market (“Sweden is one of the true pioneers in liberalized electricity sectors”). Ever since the oil crisis in the early 1970s, Sweden has invested heavily in the search for alternative energy sources. Its phase out of oil has proceeded smoothly. In 1970, oil accounted for over 75 percent of Swedish energy supply; by 2006, the figure was just 32 percent, chiefly due to the declining use of residential heating oil.

In Sweden, 43 percent of the energy supply comes from renewable energy. This is more than in most EU countries. Many of the measures introduced in Sweden are a result of the *Renewable*

Energy Directive. Plus there are the requirements of the Kyoto Protocol concerning the reduction of carbon emissions and other greenhouse gases at global and national level.

Sweden outlined its present energy policy in 1997. The government wanted to promote “efficient and sustainable energy use and a cost-effective energy supply” that would “facilitate the transition to an ecologically sustainable society.” The Swedish National Energy Administration was set up for this and to monitor developments.

High power consumption – low emissions

Sweden consumes a great deal of electricity per capita (17,000 kWh per person per year). Only Iceland, Norway and Canada consume more. Yet Swedish

carbon emissions are small in relation to other countries. The average Swede releases 5.8 tons of carbon dioxide per year into the atmosphere, compared with the EU average of 8.6 tons and the US average of 19.7 tons.

The reason for this low emission rate is that about 90 percent of electricity in Sweden comes from nuclear power and hydroelectric power, neither of which generate carbon emissions. Cogeneration, or combined heat and power (CHP), plants account for a further 10 percent of the electricity output in Sweden, and these are mainly powered by biofuels.

Renewable electricity

In 2003, green electricity certificates were introduced in Sweden to encourage the use of renewable energy. To be certified green, the electricity has to

THE FUTURE OF ENERGY SUPPLY

Renewable energy will account for a higher share of both electricity and fuel in the future. And a combination of the two is likely to become increasingly popular – for example, battery-powered cars charged by wind-generated electricity.

WIND POWER

Wind power and bioenergy facilities are set to develop rapidly. Land-wise, Sweden has more forest than most other countries – 58 percent compared with the global average of 30 percent. About 90 percent of bioenergy in Sweden today comes from the forestry sector. In its report from 2006, the Commission on Oil Independence predicted bioenergy production in Sweden could rise from 108 TWh to 228 TWh up to the year 2050.

SOLAR POWER

A breakthrough for solar cell technology can be expected once solar cells become cheaper.

HYDROGEN

Energy from fuel cells is one technology to watch. A fuel cell is a battery that you top up instead of charging – the fuel is hydrogen and the exhaust it produces is water.

In seeking ways to manufacture hydrogen, Swedish researchers are trying to imitate photosynthesis in plants, since the process requires only sunlight and water, but it will be years before this line of research produces results.

WATER

Researchers from the Ångström Laboratory at Uppsala University are currently testing a new type of wave power in Lysekil, off the west coast of Sweden, using only buoys (floats) and a piston-driven generator. Project leader Professor Mats Leijon predicts wave energy will one day be able to contribute up to 2,000 TWh globally.

Read the article Wave power to the people here: http://www.sweden.se/templates/cs/Article___19300.aspx



PHOTO: SESSE LIND/INKIMAGE

Alternative fuels and hybrid cars are in the pipeline.

come from wind power, wave power, solar energy, geothermal energy, bio-fuels or small hydroelectric plants. Power consumers have to buy a certain number of green certificates – via their electricity bills – while power producers receive a certificate for every megawatt-hour (MWh) of renewable electricity they generate. The goal is to boost renewable electricity by 17 TWh (terawatt-hours) from 2002 to 2016. In addition, wind power has been further subsidized by means of a tax deduction scheme that will run until 2009.

Wind power is the fastest-growing renewable energy source in recent years. Installed capacity has trebled over the past decade. In 2007, the largest wind power park in northern Europe opened in the Öresund Sound, off the coast of southern Sweden. Altogether, 48 wind turbines are in place, generating a total of 110 MWh, which meets the electricity needs of 60,000 households.

Alternative fuels

Sweden puts a lot of effort into developing renewable, alternative fuels. Ethanol research began in the 1980s and Sweden is among the world leaders.

Most of the ethanol sold today is produced from grain, with varying consequences for the climate. From a lifecycle viewpoint – where climate impact is measured along the whole chain from production to use – ethanol extracted from sugarcane is favored. Swedish researchers focus on the production of

ethanol from cellulose, referred to as second-generation biofuels. In most cases, this is a more effective method than grain-based production. What's more, this type of ethanol does not affect food crops. Other biofuels of interest are different kinds of biogas that can be extracted from manure and waste, among other things.

The EU wants 7.75 percent of all fuel to come from renewable energy sources by 2010. By 2006, Sweden had reached 3.1 percent, mainly due to the increased use of ethanol. To speed up developments, a “pump law” was introduced in 2006 under which all gas stations selling more than 3,000 cubic meters of gas or diesel per year are required to supply at least one kind of renewable fuel.

Hybrid cars, i.e. vehicles that use electrical (battery) power and fuel, are up and coming. The combination of electricity and biofuels is a promising one. The next step is plug-in hybrids – cars with larger batteries charged from the power grid. In spring 2008, the Swedish Energy Agency, Volvo, Saab, Vattenfall and others embarked on an ambitious project to produce the next generation of plug-in hybrids. In July 2008, a Swedish-American joint venture for the development of a new type of plug-in hybrid was announced.

Conserving energy in industry

In 2005, Sweden introduced a special program designed to boost energy efficiency in industry. Under this program, the 180 or so power-intensive

LOW ENERGY DESIGN

The Interactive Institute in Stockholm has developed several prototypes that reflect human behavior, among them the Flower Lamp, which *Time* magazine considered to be one of the best inventions of 2006. For the lamp to open fully, power consumption in the home must be kept low. If consumption rises, the lamp closes its “petals” and the room darkens. More design concepts are presented at the Visual Voltage exhibition: <http://www.tii.se/visualvoltage>

REMOTE METER READING

All electrical power suppliers in Sweden must switch to remote meter reading by July 1, 2009. This means customers will be billed monthly for actual electricity use (as opposed to estimated consumption). Most companies have already made the switch. In all, five million electricity meters will be converted. The next step is to let consumers take their own readings, thereby giving them more control over their consumption.

WORLD-CLASS POWER MARKET

Since its deregulation in 1996, the Swedish power market has become a shining example by international standards, according to the International Energy Agency. For over a decade, customers have been able to freely choose their power supplier. Today, more than 100 Swedish companies sell electricity to consumers.

ELECTRICITY TRADING

Nord Pool in Oslo is where most of the power suppliers in the Nordic region buy electricity to sell to consumers. There is a spot market with prices by the hour as well as a futures market. Power prices are largely determined by water supply given the large proportion of hydroelectric power in Norway and Sweden. In dry years, water supply to hydroelectric plants dwindles, pushing prices up. Rainy years usually have the opposite effect.



Lillgrund opened in 2007 and is the largest wind power park in northern Europe.

industries taking part are granted tax relief in exchange for drawing up energy plans and taking steps to reduce energy use. To date, the program has resulted in energy savings of about 1 twh per year at a value of about SEK 500 million (about USD 62 million).

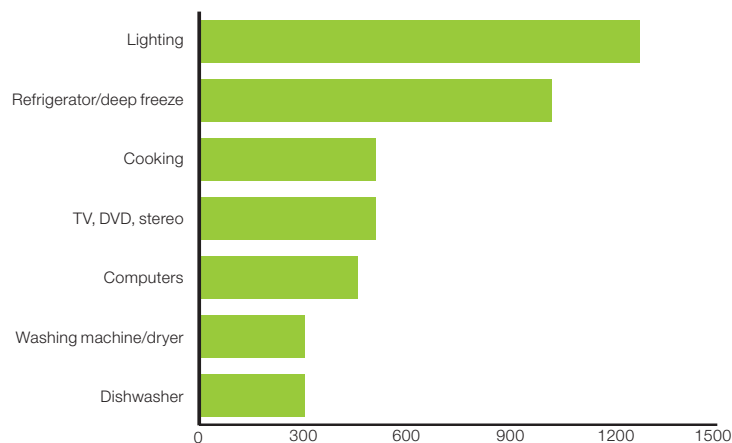
In the construction sector, the government wants a 20 percent reduction in energy use in building stock by the year 2020 (compared with 1995) and a 50 percent reduction per heated unit area by 2050. This has made energy-efficient housing a more interesting proposition. Passive houses are one example. These are built without conventional heating systems and are kept warm by the heat

given off by their occupants. Extra thick insulation and intelligent ventilation systems ensure low energy use.

Since January 1, 2008, a new law on energy declarations has been in force in Sweden. Based on an EU directive and applying to all owners of private homes, apartment blocks and other premises, its aim is to promote more efficient energy use.

The government is investing heavily in information and advice for households on how to save energy. Each municipality – there are 290 in Sweden – has an energy adviser people can turn to for tips. These include changing windows, using low-energy light bulbs, switching to different heating systems and so on. ■

Household power use (kWh)



Lighting and refrigerator/freezers are the highest energy consuming household appliances in Swedish homes.

STORING CARBON DIOXIDE

Phasing out fossil fuels in the short term is virtually impossible. One way to make the use of these fuels more environmentally acceptable is to separate carbon dioxide in the energy production process and store it underground. This is known as Carbon Capture and Storage (CCS).

Vattenfall became one of the first power companies in the world to implement CCS technology when it opened a pilot plant, Schwarze Pumpe, near Berlin in September 2008. Vattenfall owns several German coal-fired power stations, all with high carbon dioxide emissions. The company is now planning additional test facilities and will open its first commercial CCS plant in 2020. The European Commission has high hopes for CCS, too.

FACTS ABOUT CAPACITY AND ENERGY

CAPACITY = ENERGY PER UNIT OF TIME

(expressed in watts)
1 kW (kilowatt) = 1,000 W
1 MW (megawatt) = 1,000 kW
1 GW (gigawatt) = 1,000,000 kW

ENERGY = CAPACITY X TIME

(expressed in watt-hours)
1 Wh = 1 W for one hour
1 kWh = 1 kW for one hour (1 kilowatt-hour)
1 MWh = 1,000 kWh
1 GWh = 1,000,000 kWh
1 TWh = 1,000,000,000 kWh

Combating climate change internationally

The Kyoto Protocol calls for a reduction in greenhouse gas emissions to prevent “dangerous anthropogenic interference with the climate system.” Not all countries have ratified the treaty, though, among them the us. Under the terms of the agreement, signatories pledge to reduce their greenhouse gas emissions 5 percent (compared with 1990) between 2008 and 2012.

The most controversial measure concerns emissions trading. The European Emissions Trading Scheme, launched in 2005, establishes a ceiling for carbon emissions in EU member states. Each state is then required to divide up and distribute emission credits at national

level. In Sweden, the system primarily affects large companies in the industrial and energy sectors.

The Kyoto Protocol includes schemes called the Clean Development Mechanism and Joint Implementation that allow economies to meet their targets on greenhouse gas emissions by purchasing reductions elsewhere. Sweden is overseeing projects in China, Brazil, India and the Baltic that use Swedish technology to reduce carbon emissions. It is hoped that a new agreement will be finalized at the United Nations Climate Change Conference, Copenhagen, in November 2009. This would take effect once the Kyoto Protocol ends in 2012. ■

Useful links

- www.energimyndigheten.se – The Swedish Energy Agency, responsible for energy policy.
- www.elforsk.se – Research and development center for the Swedish energy industry.
- www.energimarknadsinspektionen.se – Energy Markets Inspectorate, regulator for the electricity, natural gas and district heating markets.
- www.svenskenergi.se – Swedenergy, a nonprofit organization representing companies involved in the production, distribution and trading of electricity in Sweden.
- www.naturvardsverket.se – The Swedish Environmental Protection Agency, responsible for Swedish environmental policy.
- www.vr.se – The Swedish Research Council.
- www.energikunskap.se – Fact bank on energy developed by the Swedish Energy Agency (in Swedish).
- www.energy.eu – Europe’s energy portal.
- www.iea.org – The International Energy Agency.
- www.ipcc.ch – The Intergovernmental Panel on Climate Change.
- www.managenergy.net – EC initiative aimed at local and regional energy management agencies.

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