International Energy Agency

Energy Policies of IEA Countries

Sweden

2013 Review

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Sweden

Sweden has made progress in recent years towards a more secure, sustainable energy future. The Scandinavian nation already has an almost carbon-free electricity supply and has phased out oil use in residential and power sectors. It is increasingly integrated within the Nordic and Baltic electricity markets, and its joint renewable electricity certificate market with Norway offers a unique model for other countries.

Now Sweden must take concrete steps to realise its vision of a fossil-fuel-independent vehicle fleet by 2030 and no net greenhouse-gas emissions by 2050. Although Sweden has decided to allow the replacement of its existing nuclear reactors, further emission reductions will come at a higher cost and require technology change. This means Sweden will need to carefully evaluate the most cost-effective pathways for its transition to a low-carbon economy.

Sweden has a high energy-intensity level, which requires greater energy efficiency in industry, buildings, heat and transport. A decarbonisation vision should be mapped out for each industry sector. Starting with transport, Sweden must specify how it will wean its vehicle fleet from fossil fuels by 2030.

Sweden's industry lead in smart grids is an asset. Sweden should scale up investment in clean energy technologies. As all Nordic countries decarbonise, cost-effective regional solutions can control consumers' costs. The large-scale deployment of renewable and energy technologies in a common Northern European energy market can drive decarbonisation without comprising competitiveness, security of supply and affordability.

This review analyses the energy-policy challenges currently facing Sweden, and provides studies and recommendations for each sector.

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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The European Commission also participates in the work of the IEA.

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1. EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

EXECUTIVE SUMMARY

Since the last in-depth review in 2008, Sweden has made further progress towards its long-term goal of an economy based on sustainable energy, and today is among the leading IEA member countries in terms of low-carbon intensity and high share of renewable energy in total energy supply, with strong growth coming from solid biofuels and onshore wind. This is the result of continuous political efforts: a stringent carbon dioxide and energy taxation, emissions trading and the promotion of renewable energies under the electricity certificate system.

In 2009, ambitious new targets were adopted under the „integrated climate and energy policy" framework. They support and even go beyond European Union and international obligations and require by 2020: *i)* the reduction of energy intensity by 20%; *ii)* a share of at least 50% renewable energy in gross final consumption and 10% in transport, and *iii) a* reduction of GHG emissions by 40%, two-thirds of which are to be implemented by domestic measures outside the EU Emissions Trading Scheme and the remainder by EU and international efforts.

For the longer term, Sweden put forward two ambitious priorities: *i)* a fossil fuel-independent vehicle fleet by 2030, and *ii)* zero net greenhouse gas (GHG) emissions by 2050.

The outlook for Sweden is good to further successfully progress on the envisaged transition towards a low-carbon economy; however, considerable challenges remain to be addressed, as such a transition is determined by a range of inherent uncertainties linked to the forecasting period of 20 to 30 years ahead.

The country is on track towards its 2020 targets, which pave the way for the long-term priorities. Reaching 20% more efficient energy use by 2020 will require stronger efforts beyond the energy-saving target of 9% for 2016. Sweden's export-oriented manufacturing and engineering base has been driving economic growth, but it also entails an energy-intensive economy. Further emissions reductions to 2030 and 2050 beyond the current levels are likely to come at higher cost, as they require substantial increase in energy efficiency in industry and buildings with emissions to be reduced in energy-intensive sectors.

In 2009, Sweden decided to annul the nuclear phase-out and to allow for the replacement of its nuclear reactors at the three existing sites at the end of their operational lifetime. Commendably, Sweden has opened the door to an additional option to shape the transition to a low-carbon economy. Nuclear power currently supplies about 41% of domestic electricity production. Greater certainty is however needed as to if, when and how nuclear capacity can be replaced by the industry on the horizon to 2030.

Sweden can reduce those uncertainties by developing comprehensive decarbonisation pathways to guide policy making and ensure long-term visibility for all market participants beyond 2020. These pathways allow to evaluate the likely implications and to test the robustness of different levels of renewable energy, nuclear, interconnections and energy efficiency. On the basis of such scenarios for the future, Sweden should build a shared vision among the government, industry and academia for the decarbonisation of the economy with, first, an action plan for transport for 2030 and, secondly, technology roadmaps for each industry sector. The Climate Roadmap 2050, which the government is preparing, is a good starting point.

Three elements will shape the success of the transition: cost-effective market-based measures, consumer benefits and technology innovation.

A competitive electricity retail market, with dynamic pricing and meter data management, using intelligent technologies, such as smart meters and smart grids, will allow consumers and businesses to benefit from efficiency across the energy system, facilitating demand-side responses and micro-generation. Such a retail market design can support energy efficiency and thus consumers in the transition.

As all Nordic countries have moved towards decarbonisation with high shares of renewable energy, Sweden can use cost-effective regional solutions to control the costs of this transition. Building on the already advanced Nordic market model, such benefits can be enhanced with a well interconnected energy system, regional deployment of renewable energies, a common Nordic retail market and the large-scale introduction of innovative energy technologies, including smart grids, electric vehicles and carbon capture and storage, to support decarbonisation without compromising economic competitiveness, security of supply and affordability.

MAJOR ACHIEVEMENTS

Since 2008, the Swedish government has implemented many of the recommendations contained in the IEA review, that is, to adopt a comprehensive energy and climate strategy, to clarify the future of nuclear, to foster renewable energies and to spur commercialisation of energy technologies.

Commendably, Sweden adopted an integrated climate and energy policy framework in 2009 with defined targets for 2020 and decarbonisation priorities for 2030 and 2050. This has helped guide both policies and markets. The country is on track to achieve or even exceed its 2020 targets.

Sweden's integration into the Nordic electricity market deepened over the last years. The country improved congestion management and capacity allocation by introducing market coupling on the interconnections and by splitting Sweden into four electricity price zones. With the integration of the Baltic States into Nord Pool, this market has expanded into a Northern European electricity market.

On the retail market, the country has rolled out the first generation of smart meters to almost all household consumers and introduced the choice of hourly metering of their electricity consumption. Sweden is regarded as a leader in smart grid technologies with large-scale demonstration, EU-wide and international technology co-operation. The government set up a Smart Grid Council to prepare a national action plan. The IEA applauds these achievements.

Commendably, Sweden clarified the conditions for the use of existing and future nuclear power capacity at its three existing sites. It allows for the replacement of a reactor once the old reactor is closed, if industry so decides. The government does not provide for any direct or indirect subsidies and relies on incumbent operators capacity to invest into the replacement. Sweden's utilities continuously support the modernisation of their nuclear fleet to ensure safe performance for 50 years or more.

Competition at wholesale level continues to be determined by the incumbent generators who hold cross-ownership in nuclear power plants. This situation has not changed since the last review. Sweden's decision in the 2009 energy policy framework to strongly promote renewable energy as the third pillar in the electricity mix can act as stimulus for potential new producers. It also supports security of supply in the medium to long term.

Sweden is strongly committed to reduce oil use in heating and transport sectors by strongly increasing the share of renewable energy, which reached an outstanding share of 9.8% in 2011 (calculated in accordance with the EU Renewable Energy Directive). The country is close to reach its 10% target for 2020, thanks to the promotion of efficient and environment-friendly vehicles, allowing for the flexible use of biofuels, through fiscal incentives, including motor vehicle tax breaks, and strong R&D activities. But, in the medium term, Sweden aims to have a vehicle fleet independent of fossil fuels by 2030.

The same trends hold true for the overall share of renewable energy. In 2011, 35% of total energy was supplied by renewable energy sources, well beyond the IEA average of 8%. This growth from 28% in 2006 was mainly the result of additions from solid biofuels and onshore wind power in recent years. In gross final energy consumption, Sweden reached a share of 48% of renewable energy (calculated in accordance with the EU Renewable Energy Directive). The IEA commends Sweden's stable framework to support renewable electricity production which enables these developments. The technology-neutral and market-based electricity certificate system provides investors with a long-term horizon until 2035. Since January 2012, it also provides for further cost-effectiveness in the joint market with Norway and, more importantly, it does so at moderate cost to consumers. Other countries can learn from this advanced co-operation and this first joint renewable market in the European Union.

Sweden has strengthened the demonstration and market deployment of energy technologies, such as smart grids and second-generation biofuels, fostered by a special demonstration funding, a soft loan programme and the new CleanTech Strategy, which are promoting innovative enterprises, innovation clusters and supporting technology incubators with the aim to facilitate the development and deployment of clean technologies. Commendably, the government's new Research and Innovation for a Sustainable Energy System Bill provides increased public funding for the period 2013-16 and guarantees continuity for private-sector investment.

SHAPING PROGRESS

VISION 2030 AND 2050

Sweden is well on track to meet its 2020 targets for the reduction of greenhouse gases (GHGs): average 2008-11 emissions are below 1990 levels and Sweden's target under the Kyoto Protocol and the EU burden-sharing target. As energy production is already almost carbon-free, further emissions reductions, moving towards zero net GHG emissions by 2050, will however come at a higher cost and will require stronger efforts across the entire economy, with technology innovation in the transport sector and energy efficiency increases in industry and buildings as well as deployment of clean energy technologies.

Nuclear energy accounts for around 41% of electricity generation in 2011. Considerable uncertainty remains regarding the replacement of existing reactors in the 2030 timeframe, given that nuclear investments are highly capital-intensive projects. Greater certainty will be needed as to the timetable of replacement needs, licensing and approval processes.

The IEA recommends Sweden to develop and implement a comprehensive 2030/2050 pathway analysis containing a number of supply and demand scenarios which account for different futures. This analysis should evaluate scenarios with and without new nuclear, varying levels of renewable energies, including offshore wind power, energy efficiency gains and interconnection levels. The analysis needs to take into account the cost to consumers, implications for supply security as well as demand-response requirements. This should account for the broader regional energy market context and be mindful of new technology developments that impact electricity demand, such as smart appliances, meters, electric vehicles, or heat pumps.

The government understands the 2030/2050 challenges and took first steps towards making them operational. It launched a public investigation into the 2030 priority for the vehicle fleet and assigned the Swedish Environmental Protection Agency to propose a Climate Roadmap 2050 which was presented in December 2012.

Providing long-term guidance to all market participants, a 2050 pathway analysis can help each sector to prepare detailed action plans for achieving long-term sustainability. The IEA encourages the Swedish government to reach a shared vision with industry and civil society on the decarbonisation priorities by means of more detailed 2050 technology roadmaps for all energy-intensive industries and, more urgently, to adopt an action plan for the transport sector for 2030 in order to guide policy making and provide a long-term framework.

EMPOWERING CONSUMERS AND SMART GRIDS

Sweden has also made further progress in reforming the electricity retail market to enhance the role of the consumer. The country has rolled out the first generation of smart meters to almost all household consumers and introduced the choice of hourly metering of their electricity consumption.

Emphasis on competition and consumer benefits should be equally important. Consumers will only make use of these opportunities in the retail market where electricity tariffs and meters provide for choice. To avoid that smart meters lock in consumers, access to meter data, data management and net metering will be important. The IEA recommends moving towards a dynamic pricing complemented with third-party access to metering data. This will create price signals for timely and innovative investment in energy efficiency, an efficient network, new demand-side services, intelligent grids and appliances. Future network planning has to be comprehensive and take into account generation, transmission, distribution, demand-side responses or distributed generation.

ENERGY EFFICIENCY DRIVING DECARBONISATION

Sweden remains an energy-intensive economy: 59% of all oil supplies are used by transport and 23% by industry. In the transport sector, oil accounts for 90% of total final consumption. Transport is the largest CO_2 emitter in the country (40%), followed by industry and agriculture. Swedish energy-intensive industries, in particular the iron and steel production, rely on coal. In 2010, coal consumption caused 20% of CO_2 emissions from fuel combustion in Sweden.

Commendably, the country has been making the polluters pay by means of a CO_2 tax and energy tax for decades. In 2009, Sweden revised its energy and CO_2 taxation to reduce exemptions and increase the participation of the non-ETS sectors, including agriculture and forestry. The IEA applauds this strengthened effort.

The government aims to achieve energy savings of 9% by 2016 from 2001-05 levels and to reduce the energy intensity by 20% below 2008 levels by 2020. Sweden is on track to achieve and exceed its interim energy-saving target with an estimated share of 15% by 2016, while achieving 20% by 2020 is still challenging. Energy efficiency will be the driver of the decarbonisation agenda for 2020, 2030 and 2050, across the whole economy. Sweden should therefore swiftly review energy efficiency policies in order to prioritise and scale up high-potential, cost-effective energy-saving measures. The focus has to be on cost-effective emissions reductions in the industry, buildings and transport sectors.

The Swedish energy efficiency model relies on the voluntary measures and commitment of local and regional authorities, such as the work of the 14 regional energy agencies, the local energy and climate advisors, and the co-operation with industry, services and academia in research, development and demonstration (RD&D). The IEA commends the government for its support to municipalities and county councils to develop energy efficiency strategies, for the funding of efforts by small and medium-sized enterprises (SMEs) and energy-intensive enterprises to reduce consumption through energy audits and the tax incentive Programme for Energy Efficiency in Energy Intensive Industry (PFE). In the buildings sector, the government strengthened the building code for new constructions, introduced energy performance certificates and supported the demonstration of low-energy and zero-energy buildings.

To date, the government has promoted efficient and environment-friendly cars and low blending using biofuels through tax exemptions. The demonstration and deployment of electric vehicles and of biogas-powered buses in Swedish cities continues. The congestion charge, introduced in Stockholm, will be applicable in Göteborg in 2013. Achieving the 2030 priority of a fossil fuel-independent vehicle fleet in Sweden is very ambitious. The IEA recommends the government to swiftly adopt an action plan in co-operation with industry and academia, so as to make the 2030 ambition operational. Stronger efforts will be needed to reduce emissions from heavy-duty vehicles (HDVs), which use growing amounts of diesel and emit nitrogen oxides and dust. HDVs face a toll charge but its vehicle tax is not subject to a carbon dioxide factor. Sweden should support efforts at EU level to strengthen mandatory fuel economy standards beyond Euro VI which is applicable as of 2013 and to phase in a mandatory infrastructure charge.

In industry, Sweden aims to promote the energy efficiency requirements of the new EU Energy Efficiency Directive 2012/27/EU. The government should prepare a comprehensive evaluation of the heat sector, including prices and efficiency, in order to explore all potential sources, their geographical distribution and energy efficiency gains along the heat value chain. The government and industry should consider how to reduce carbon emissions with the application of energy-efficient and clean energy technologies in industrial processes, including carbon capture and storage (CCS), where Sweden is active in research at regional levels. Co-operation on CCS will need to be stepped up for implementation in energy-intensive industries.

In the buildings sector, the IEA encourages the government to prepare and implement a national renovation strategy, placing the emphasis on the main efficiency leverage of existing and public buildings. Sweden should make use of renewable energy and new financing mechanisms to foster renovation.

CLEAN ENERGY TECHNOLOGIES

Sweden has strategically aligned energy-related RD&D policies with its energy and climate objectives. These are strongly geared towards market deployment and build on the country's comparative strength, including smart grids and biofuels. Innovation and business sector commitment are a key factor for the success of the Swedish energy RD&D policy. Since 2009, co-financing from industry has been increasing, especially in demonstration. This is the result of the strong involvement of the private sector and academia in the formulation of the strategic plans, by means of the Energy R&D Board and its technology platforms and stable public support. It is encouraging that the government recently proposed a further increase of RD&D funding for the period 2013-16 to achieve its ambitious energy and climate targets.

Since the last in-depth review, Sweden has made commendable progress in strengthening demonstration and commercialisation of R&D results, through the adoption of a CleanTech Strategy and the soft loan programme, both supporting innovative enterprises, innovation clusters and technology incubators. To strengthen the implementation of the CleanTech Strategy, Sweden should build on the results of both the RD&D programme and the Climate Roadmap 2050. The government should equally scale up financial mechanisms and instruments, for instance by creating a dedicated public mission bank, similar to the German KfW or the United Kingdom's Green Investment Bank, to enhance access to EU and international funds and leverage private-sector capital.

CONSOLIDATING ENERGY SECURITY

Oil supplies to Sweden are well diversified, both by country of origin and by import route and it consistently holds more oil stocks than required under the IEA stockholding obligation. This is commendable, given the fact that Sweden does not have indigenous oil production and is a net exporter of refined oil products.

All natural gas consumed in Sweden is imported via a single pipeline from Denmark. The government is aware of its dependence and prepared a risk assessment, a preventive action plan and an emergency plan in consultation with Denmark. These are important achievements. The diversification of natural gas supplies advances with the greater introduction of biogas into the system and with the first liquefied natural gas (LNG) terminal and more planned. LNG terminals would need to be connected to the grid so as to be used as full backup capacity. In order to ensure security of gas supply, Sweden should anticipate the projected decline of Danish natural gas production and monitor the development of new supplies to Denmark and assess the need for diversification.

Sweden's integrated climate and energy policy recognises a potential role for natural gas as transition fuel in industry and co-generation. In this context, the country is reforming the regulatory framework for natural gas. With Swedegas, Sweden has now an independent, ownership-unbundled and privately owned gas transmission system operator. Sweden should swiftly finalise the rules for its natural gas market to give market participants a long-term investment framework. Greater diversification and clear market rules stimulate more competitive gas prices and transparency.

To date, the Swedish electricity grid has the capacity to integrate growing volumes of non-intermittent biofuels. Long-term adequacy and security after 2030 to 2050 need to be monitored, given the uncertainty surrounding the replacement of existing nuclear reactors after 2030 and around the exploitable potential of wind power. Security of electricity supply has repercussions beyond Sweden's borders, as the country is integrated in the Northern European electricity market. When winter peak demand coincides with low hydro reservoirs and low nuclear plant availability, Sweden tends to be a net importer. Sweden's transmission grid operator, Svenska Kraftnät, continues to operate a strategic power reserve for winter times. The decision to phase out the reserve after 2020 is the right approach. Future projections indicate that Sweden can become a net exporter, even in winter times. The IEA encourages the government to identify market-based options within Nord Pool before 2020, in order to phase out the power reserve regulation, taking into account active demand responses from a smarter grid, intra-day markets and a common Nordic retail market.

FOSTERING REGIONAL SOLUTIONS

Sweden is right to develop regional renewables markets, such as the common certificate market with Norway. Other countries can learn this unique model to increase scale and cost-efficiency of renewables deployment and grid investment, for the benefit of consumers and businesses. The IEA encourages the government to expand co-operation on renewable energies across the Nordic and Baltic region, including offshore wind. Long-term projections for 2020-40 indicate that Sweden can become a net exporter of electricity. Sweden's hydro resources can balance growing regional renewable electricity flows in Central and Northern Europe. Conversely, Swedish consumers can benefit from renewable energies deployed in a cost-effective way and from electricity imports in terms of security. To facilitate trade flows of renewable electricity, the strengthening of the North-South connections in the Swedish electricity grid and its cross-border interconnections, as identified in the common Nordic Grid Master Plan, is essential. New price zones within Sweden should provide the price signals for investment to reinforce the transmission grid, and generating capacity, in areas where they are needed.

The IEA welcomes efforts to pursue a common Nordic electricity retail market and encourages Sweden to foster implementation of a common market model by 2015. Harmonised contracts, bills and settlement procedures with intelligent grids and active consumers, intra-day balancing and reserve markets within the Nordic market will entail new business opportunities and greater choice for consumers in a larger market.

Ambitious low-carbon policies in transport will be more effective if closely aligned with those of neighbouring countries and jointly pursued. Building on the existing co-operation on grid planning in the Nordic region, joint infrastructure planning, for example of smart grids and electric vehicles, can lead the way towards deploying clean technologies in the transport sector across the Nordic region.

KEY RECOMMENDATIONS

The government of Sweden should:

- ☐ *Urgently develop an action plan on how to cost-effectively achieve the 2030 priority of making the vehicle fleet independent of fossil fuels.*
- ☐ *Develop and implement long-term pathway analysis for the 2050 vision of zero net emissions of greenhouse gases to guide market participants and policy making. Building on this, create a shared vision for the decarbonisation of the Swedish economy together with industry and civil society on the basis of sectoral clean energy technology roadmaps.*

- *Further empower consumers to participate in the retail electricity market by removing all barriers to an efficient electricity grid, by introducing dynamic electricity pricing, third-party meter data and information management, net-metering for micro-generation, and by actively pursuing steps towards the creation of a larger, common Nordic retail market by 2015 on the basis of a common market model.*
- *Increase energy efficiency across the energy system, by mobilising demand-side services, fostering the use of renewable energy in buildings, promoting energy savings in industry and energy efficiency in the heat sector.*
- *Scale up investments in clean energy technologies, including smart grids, biofuels or carbon capture and storage, to achieve emissions reductions in industry processes and the transport sector, through research, development, demonstration & deployment (RDD&D) support, co-operation and joint planning at regional level to benefit from scale and synergies for their deployment.*

PART I
POLICY ANALYSIS

Figure 1. **Map of Sweden**

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

2. THE FRAMEWORK: ENERGY POLICY AND CLIMATE CHANGE

Key data (2011 provisional)

GENERAL ENERGY

TPES: 48.9 Mtoe (renewables 35.5%, nuclear 32.5%, oil 25.3%, coal 4.1%, natural gas 2.4%), +2.8% since 2000

TPES per capita: 5.2 toe (IEA average: 4.7 toe)

TPES per GDP at purchasing power parity (PPP): 0.15 toe per USD 1 000 GDP at PPP (IEA average: 0.15 toe per USD 1 000 GDP at PPP)

Electricity generation: 150.5 TWh (hydro 44.1%, nuclear 40.5%, biofuels and waste 8.5%, wind 4%, natural gas 1.2%, coal 0.8%, oil 0.5%, peat 0.4%), +3.6% since 2000

Inland energy production: 33.9 Mtoe, 69.3% of TPES

Total final consumption: 33.7 Mtoe (oil 32.5%, electricity 32.1%, renewables 18.7%, heat 12.9%, natural gas 1.9%, coal 1.7%), -4.4% since 2000

Consumption by sector: industry 39.3%, transport 24.1%, residential 22.5%, services and other 14.1%

CLIMATE CHANGE

Total GHG emissions excluding LULUCF (2010): 66.2 Mt CO_2-eq, -9% from 1990

Total GHG emissions including LULUCF (2010): 32.2 Mt CO_2-eq

2008-12 target: +4% from 1990 (EU burden-sharing target), -4% (national voluntary target)

CO_2 emissions from fuel combustion (2010): 47.6 Mt, -9.8% from 1990

Emissions by fuel: oil 68.9%, coal 16.9%, natural gas 6.5%, other 7.7%

Emissions by sector: transport 45.3%, combined heat and power generation 20.6%, industry 19.2%, services and other 5.1%, heat 2.6%, households 0.9%, electricity 0.5%

COUNTRY OVERVIEW

The Kingdom of Sweden is the fourth-largest country in the European Union with an area of 450 295 km² and has a population which passed the 9.5 million mark in 2012. Sweden has a low population density with 21 inhabitants per km², as the majority lives in Southern Sweden, Öresund Region, along the western coast to central Bohuslän, in the valley of Lake Mälaren and the capital city of Stockholm. Around 65% of Sweden's total land area is covered by forests and sparsely populated, with 15% of the territory being located north of the Arctic Circle.

The country borders Norway and Finland and has maritime borders with Denmark, Germany, Poland, Russia, Lithuania, Latvia and Estonia. It is connected to Denmark by a bridge-tunnel across the Öresund.

The Swedish economy has withstood most of the turbulences of the recent global financial and economic crisis, thanks to strong economic fundamentals with a sound fiscal position. In 2011, Sweden ranked fifth among European OECD countries in terms of GDP per capita (USD 41 242 per capita, PPP), after Luxembourg, Norway, Switzerland and Denmark. In the 2008/09 recession, Sweden experienced a 7.5% decrease of its output, but strongly recovered by the end of 2010, almost reaching pre-recession GDP levels. Sweden's economy rebounded thanks to its strong monetary policies, exports and the structural reforms undertaken in the aftermath of the banking crisis in the early 1990s.

Unlike many other OECD countries, in October 2012 Sweden was experiencing relatively favourable economic conditions, after the real GDP growth of 3.9% in 2011 and an estimated further 1.2% in 2012, low gross government debt levels and a 7.6% unemployment rate. Sweden's very positive external trade balance was supported by its export-oriented industry, which contributed around 50% to the GDP, and was expected to support the country's macroeconomic situation.

Sweden has leading engineering and manufacturing segments, such as motor vehicles, telecommunications, pharmaceuticals, industrial machines, precision equipments, chemical goods, home appliances, forestry, iron and steel. The main challenge is to keep enhancing resilience and sustainable long-term growth in light of the persistent economic downturn and the impact on the Swedish exports markets.

The Kingdom of Sweden is a parliamentary democracy with a constitutional monarchy under the King of Sweden and head of state, King Carl XVI Gustaf. The 2006 general election resulted in a majority government under the four-party centre-right alliance (the largest member being the Moderate Party, allied with the Centre Party, Liberal People's Party and the Christian Democrats). Following the 2010 election the government remained in power but had lost the overall majority. The current minority government under the leadership of Prime Minister Fredrik Reinfeldt is expected to stay in government until the September 2014 elections.

Sweden is a unitary state with 21 administrative counties. The development of energy policy rests with the central government, supported by several implementing national authorities and active local authorities. The county administrative boards, which represent the national government at the regional level, have an assignment from the government to formulate regional energy and climate strategies in collaboration with regional actors.

Since 1995, the Kingdom of Sweden has been a member state of the European Union. The EU framework sets legal requirements for the Swedish energy policy, in particular with regard to electricity and gas markets, energy efficiency, renewable energy, energy product taxation, state aid, environment and GHG emissions.

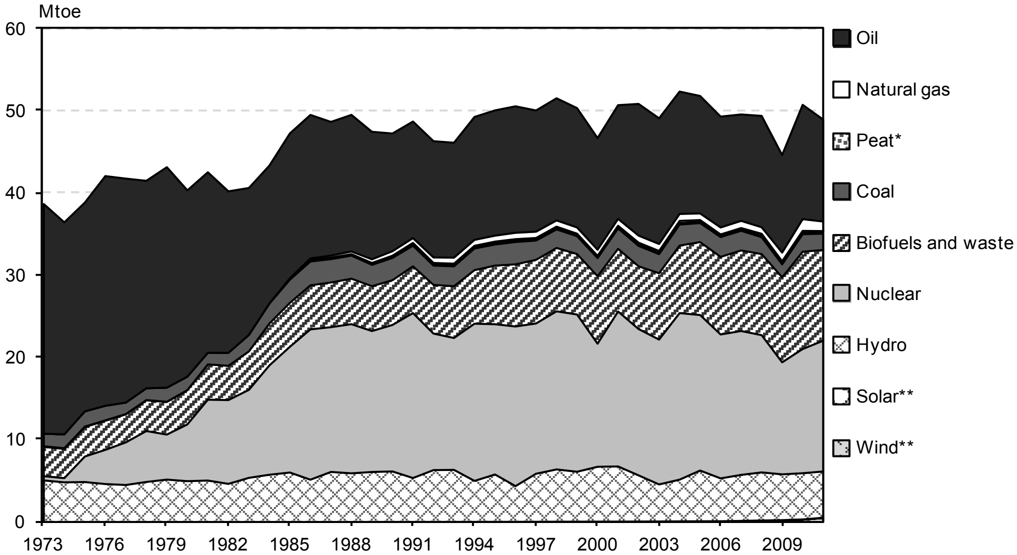
Sweden co-operates closely with its Nordic neighbours including in the Nordic Council of Ministers and with other neighbours around the Baltic Sea region, on issues, such as the electricity market and infrastructure, in order to strengthen trade links across the Northern and the European internal energy market.

SUPPLY AND DEMAND

SUPPLY

In 2011 Sweden's total primary energy supply (TPES) was 48.9 million tonnes of oil equivalent (Mtoe), a level which has remained fairly stable over the last three decades with a sharp drop in 2009 amid the global financial and economic crisis.

Figure 2. **Total primary energy supply, 1973-2011***

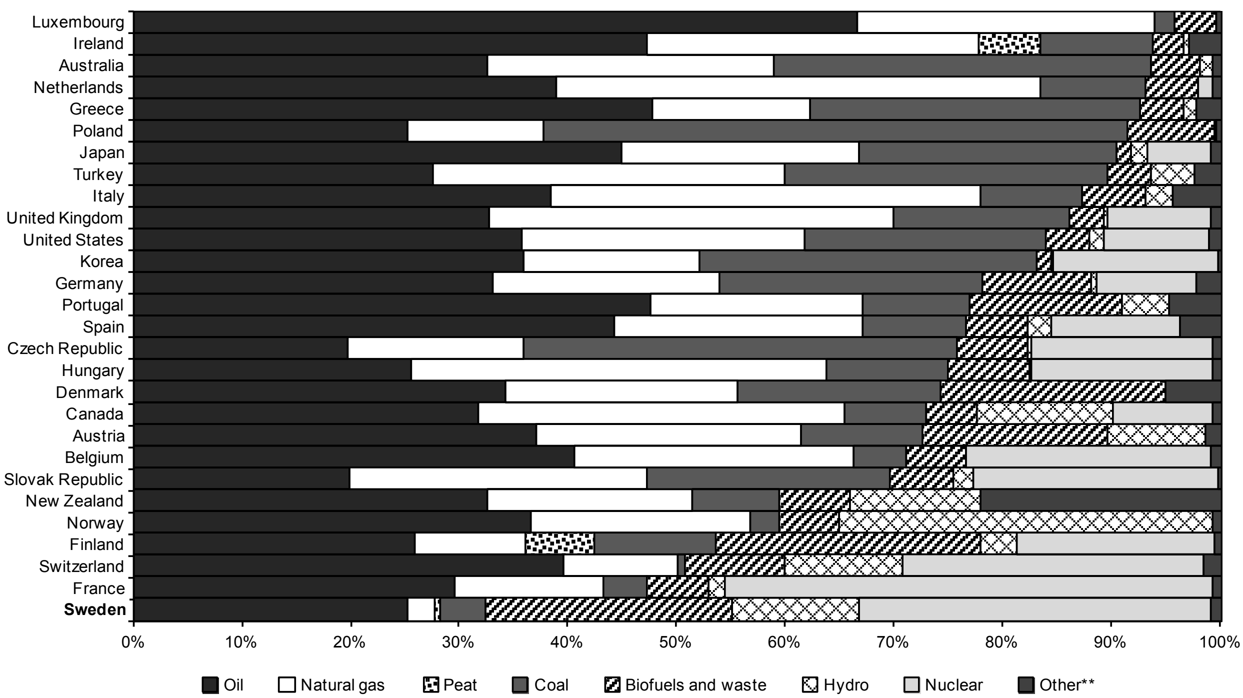


* Provisional for 2011.

** Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

Figure 3. **Breakdown of total primary energy supply in IEA member countries, 2011***



* Estimated with provisional data for Sweden.

** *Other* includes geothermal, solar, wind, and ambient heat production.

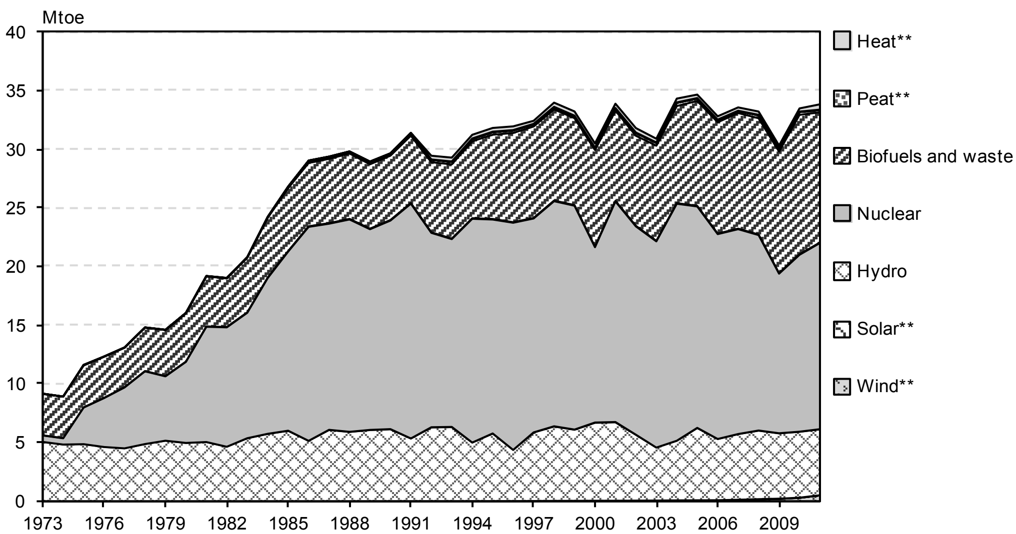
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

Fossil fuels, oil, coal and natural gas, represented 31.8% of TPES in 2011. Sweden is the IEA member country with the lowest share of fossil fuels in its energy mix (without nuclear). The average share in IEA member countries was 81% in 2011. Sweden's share of coal accounted for 4.1% and natural gas for 2.4%, compared to the IEA average of 20% and 25% respectively. Oil accounts for the lion share of the fossil fuels supplied to Sweden, amounting to 25.3% of TPES and 78.2% of all fossil fuels.

Nuclear makes a large contribution to the Swedish electricity mix, accounting for 15.9 Mtoe or 40.5% of its electricity generation in 2011. Sweden's share of nuclear in TPES was the second-highest among IEA member countries after France.

Rich natural resources and efficient, long-term policies rewarding renewable energy make Sweden rank third-highest among IEA member countries in terms of the share of renewable energy in TPES, reaching just over 35% in 2011. This is mainly due to both the second-highest share of biofuels and waste (22.7% of TPES) after Finland and the fourth-highest share of hydro (11.7% of TPES).

Figure 4. **Energy production by source, 1973-2011***



* Provisional for 2011.

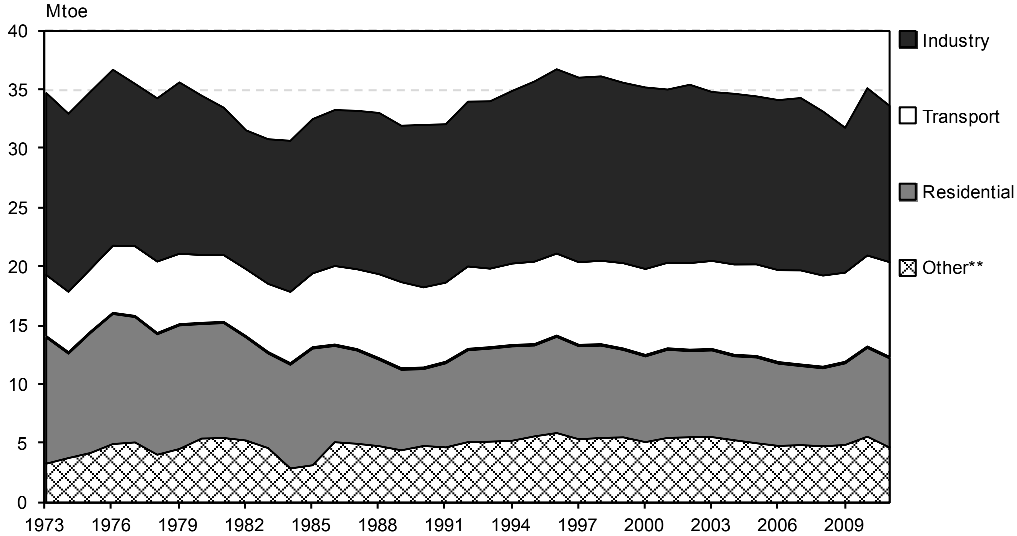
** Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

DEMAND

Around 15 Mtoe of TPES was used in transformation in 2011; therefore, total final energy consumption (TFC) was 33.7 Mtoe in 2011. This constitutes a 4.2% decline from 2010 and a 5.8% recovery from 2009 levels in the economic downturn. The industry sector consumed the largest share of energy, accounting for 13.3 Mtoe or 39.3% of the country's final consumption. It was followed by the transport (24.1%) and the residential sector (22.5%), while the commercial, public services and agriculture sectors amounted to 14.1% of total final consumption in Sweden in 2011 (more details in Chapter 3).

Figure 5. **Total final consumption by sector, 1973-2011***



* Provisional for 2011.

** *Other* includes commercial, public service, agricultural, fishing and other non-specified sectors.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

PROJECTIONS FOR 2020 AND 2030

According to the latest long-term projections of the Swedish Energy Agency, Sweden's total final consumption is to expected to grow before 2020, while remaining stable in the following decade up to 2030. Different sectors of the economy are forecast to exhibit different trends.

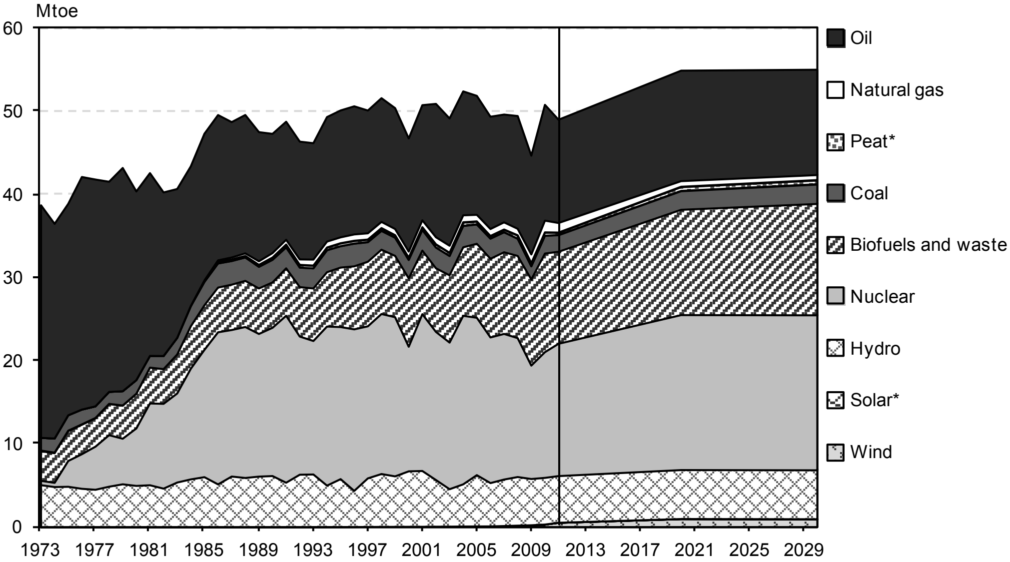
Under the reference scenario, total final consumption in Sweden will increase by 10.4% to 37.2 Mtoe in 2020, with most of the increase expected to come from the industry sector. Consumption growth will slow to 1.8% over the next years to 2030, reaching 37.9 Mtoe. The reference scenario assumes that new nuclear will replace existing reactors after 60 years of operation. Industry consumption is expected to increase by 28.5% up to 2030, as the economic recovery was faster than expected, thus fostering the Swedish industrial growth, but also electricity and coal use in the iron and steel, and pulp and paper industries. Industry consumption will grow by 24.2% by 2020, and a further 3.5% in the years to 2030.

This increase in energy consumption in the industry sector is expected however to be compensated by lower consumption in the commercial sector, in particular thanks to expected energy efficiency gains in buildings. Residential energy consumption will grow at a slower rate of 9.1% to 2030, while transport usage will remain relatively constant, growing by a mere 0.5% over the nineteen years.

The transport, commercial and residential sectors are expected to experience much slower growth in consumption compared to industry mainly due to an increase of renewable energy usage, including biodiesel (rapeseed-oil methyl ester or FAME), hydro-treated vegetable oils (HVO) and biogas. Sweden considers that it can reach its 2020 renewable energy target of 10% in transport already around 2015. In the residential sector, the increased use of heat pumps could largely replace existing electric heating. Energy use in the transport sector is projected to fall slightly to 2020, with a recovery in the ten years to 2030.

The Swedish Energy Agency's projections indicate that energy supply from biofuels and waste is to steadily increase from 22.7% in 2011 to around 25.3% of TPES in 2030. After 2030, most of the growth is expected to come from wind power which is to grow slowly between 2020 and 2030 but strongly between 2030 and 2040. According to the long-term forecast of the Swedish Energy Agency, electricity generation in Sweden is expected to total 175 terawatt-hours (TWh) with electricity exports of 24 TWh in 2020 and 23 TWh in 2030. This surplus would emerge with increased electricity generation, with additions coming from nuclear, combined heat and power (CHP) and wind power, and an only moderate increase in electricity use to reach 152 TWh.

Figure 6. **Total primary energy supply projections to 2030**



* Negligible.

Sources*: Energy Balances of OECD Countries*, IEA/OECD Paris, 2012; submission by the Swedish government to the IEA.

INSTITUTIONS

The development of Swedish energy policy rests with the central government, supported by several implementing national governmental authorities and active local authorities. The county's administrative boards, which represent the national government at the regional level, are tasked from the government to formulate regional energy and climate strategies in collaboration with regional actors.

The **Ministry of Enterprise, Energy and Communications (Näringsdepartementet)** is the lead ministry for energy policy with three ministers, the Minister for Information Technology and Energy being in charge of energy policy. The Division for Energy, with a staff of around 25 people, has an overall co-ordination and planning role.

The **Ministry of the Environment (Miljödepartementet)** is in charge of climate and environment policy. The Division for Climate leads global and EU climate change negotiations, environmental co-operation in the Nordic and Arctic regions, and the promotion of a green economy. The Division for Chemicals deals with environment and health issues related to products and their lifecycles as well as nuclear safety, radiation protection and management of radioactive waste. The Division for Environmental Analysis co-ordinates and governs the work on Sweden's environmental objectives and processes administrative matters under the Swedish Environmental Code.

The **Ministry of Health and Social Affairs** is responsible for the Planning and Building Act that governs the controls of construction work and environmental planning.

The **Ministry of Finance (Finansdepartementet)** is responsible for co-ordinating and negotiating the annual national state budget. The Tax and Customs Department has an overall responsibility for designing taxation instruments, including in the area of energy and environment policy.

Government agencies

The **Swedish Energy Agency (Statens Energimyndighet)** under the Ministry of Enterprise, Energy and Communications is the central governmental agency responsible for implementing the energy policy. It carries out the energy and environment computer-modelling projections and forecasts, provides for energy statistics and policy analysis, the administration of the electricity certificate system, the implementation of the sustainability criteria for biofuels, the promotion of wind power development, the administration of the project-based mechanisms under the Kyoto Protocol. It has the oversight over the implementation of energy efficiency measures and the energy policy programme for research, development and demonstration (RD&D) as well as the support to innovation, business development and commercialisation.

The **Swedish Energy Markets Inspectorate (Energimarknadsinspektionen),** created in 2008, under the Ministry of Enterprise, Energy and Communications, is the independent regulator and supervises the electricity, natural gas and district heating markets in Sweden. On consumer issues, the government and the regulator are supported by the **Swedish Consumer Agency (Konsumentverket)**.

Swedish National Grid (Svenska Kraftnät) is the transmission system operator. It owns and operates the national high-voltage electricity grid and is also responsible for the electricity system's short-term balance and security of electricity supply.

Since 2005, it has also operated the gas transmission system. The **Swedish Electricity Safety Board** under the Ministry of Enterprise, Energy and Communications oversees safety of electricity supply.

The **Swedish Environmental Protection Agency (Naturvårdsverket)** under the Ministry of the Environment has the main responsibility for implementing environmental policy, developing environmental scenario forecasts with the help of the Swedish Energy Agency and carrying out in-depth monitoring reviews (every four years) of the implementation of the 16 environmental objectives, and the generational goal, together with the All-Party Committee on Environmental Objectives.

The **Swedish Radiation Safety Authority (Strålsäkerhetsmyndigheten)** was created in 2008 under the supervision of the Ministry of the Environment as the regulatory authority for nuclear safety, radiation protection and nuclear non-proliferation.

The **National Board of Housing, Building and Planning (Boverket)** is the national agency for planning, management of land and water resources, urban development, building and housing. It promotes the efficient use of energy in buildings and the implementation of the building regulations.

In the area of research and development, the **Swedish Research Council (Forskningsrådet Formas)** promotes and supports basic research and need-driven research in the areas of environment, agricultural sciences and spatial planning.

Founded in 2001, under the authority of the Ministry of Enterprise, Energy and Communications, the **Swedish Governmental Agency for Innovation Systems (VINNOVA)** promotes sustainable growth by improving the conditions for innovations, as well as funding needs-driven research. VINNOVA acts as the national contact agency for the EU Framework Programme for Research and Development.

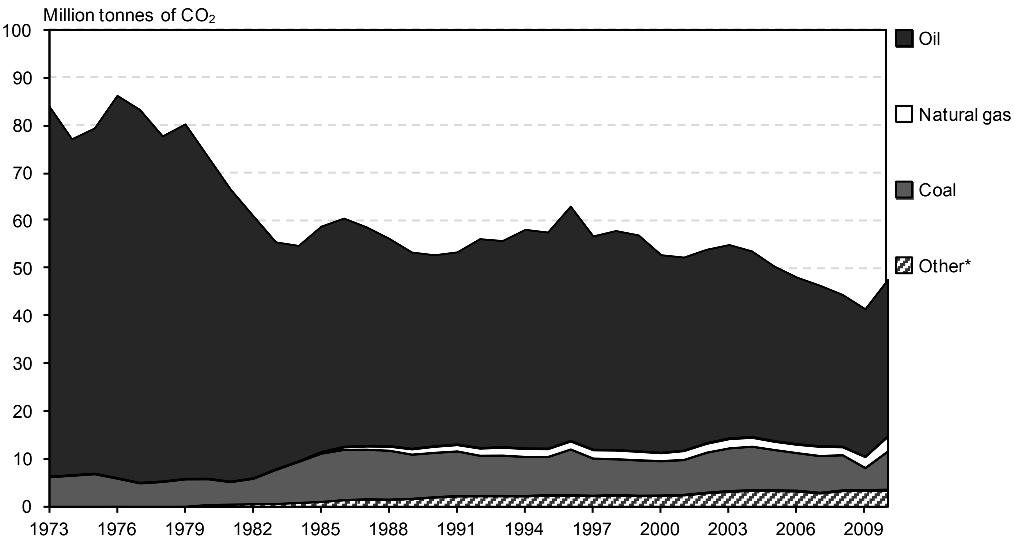
More information about key institutions in individual sectors of energy policy can be found in the sector chapters in Part II of this report.

CO_2 EMISSIONS FROM FUEL COMBUSTION

Since 1990, Sweden has decreased its emissions annually by 0.5% on average. CO_2 emissions from fuel combustion were 9.8% lower in 2010 than in 1990. In 2010, they represented 75% of all GHG emissions, amounting to 47.6 million tonnes (Mt). This is an increase of 14.9% from 2009 due to the swift economic recovery after the exceptional drop in economic activities during the financial and economic crisis.

Sweden lowered its carbon intensity by 40.5% in 2010 from the level in 1990. Compared to other IEA member countries, Sweden's economy has a very low carbon intensity. In 2010, it recorded 0.15 kg of CO_2 emissions per unit of GDP at PPP and ranked as the second-lowest among IEA members. This is mainly because Sweden has a high share of renewable energy sources and nuclear in TPES.

Figure 7. **CO_2 emissions by fuel, 1973-2010**



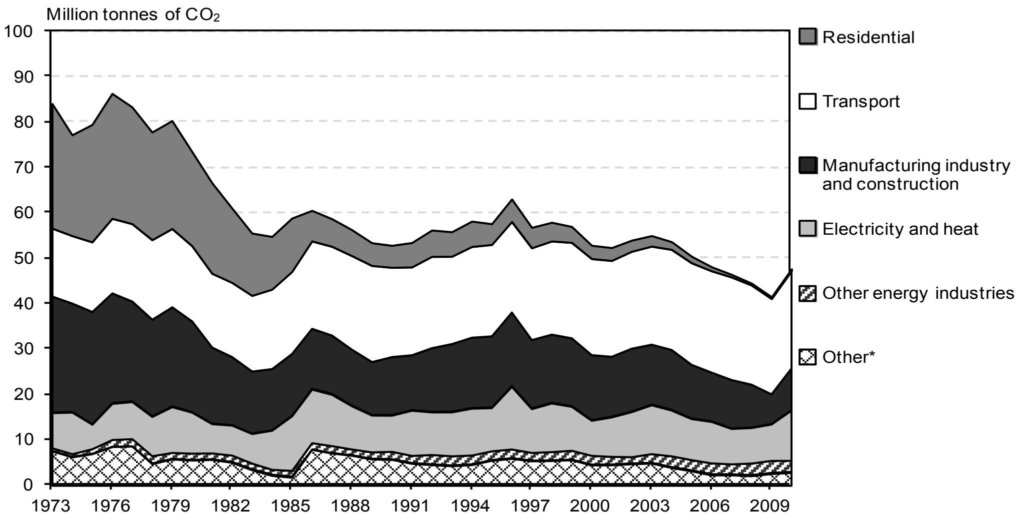
* *Other* includes peat, industrial waste and non-renewable municipal waste.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2012.

On a fuel basis, oil is by far the dominant source of CO_2 emissions, accounting for 68.9% of CO_2 emissions in 2010. Following oil, coal produced 16.9% of CO_2 emissions from fuel combustion. Both emissions from oil and coal, however, have steadily decreased by

18.3% and 13.8% respectively since 1990. Natural gas, peat and other wastes summed up the rest of 14.2% of CO_2 emissions, with emissions from all three sources more than doubling the 1990 levels.

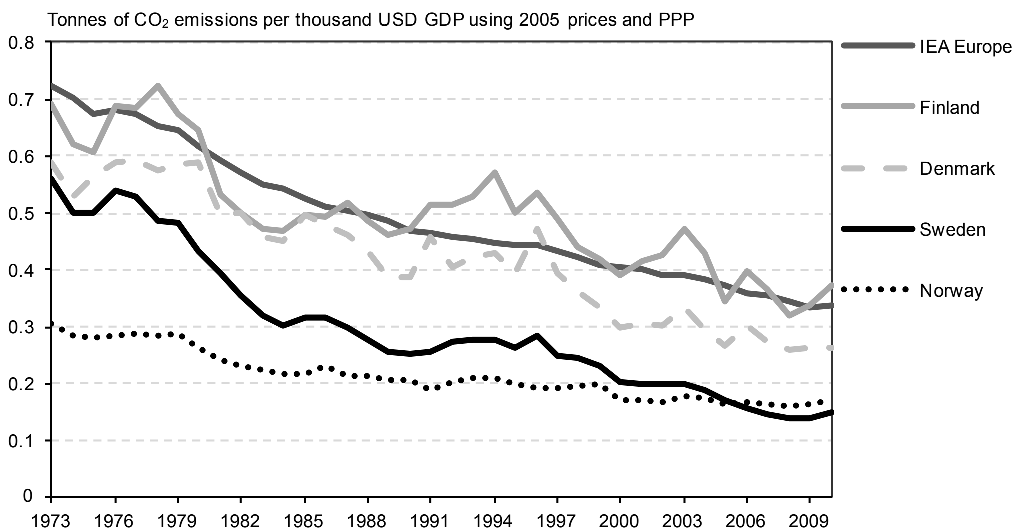
Figure 8. **CO_2 emissions by sector, 1973-2010**



* *Other* includes emissions from commercial and public services, agriculture/forestry and fishing.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2012.

Figure 9. **Energy-related CO_2 emissions per GDP in Sweden and in other selected IEA member countries, 1973-2010**



Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2012.

The transport sector was the largest emitter, accounting for 45.3% of the country's energy-related CO_2 emissions in 2010. CO_2 emissions in the electricity and heat generation sector, the second-largest emitter in Sweden, vary around 12 Mt or 20% of the total since 1990, depending on the weather and the availability of hydropower which accounts for up to 44% of electricity generation. In 2010 the sector emitted 11.3 Mt, amounting to 23.6% of total emissions. The manufacturing and industry sector, accounting for 19.2% of total CO_2 emissions in 2010, has gradually reduced its emissions from a peak of 16.2 Mt in 1996 to 9.2 Mt in 2010. Other sectors, residential, commercial and public services and agriculture play a relatively small role in terms of CO_2 emissions, mainly thanks to the extensive district heating system that is primarily based on biofuels.

KEY POLICIES

AN INTEGRATED CLIMATE AND ENERGY POLICY

Sweden's energy policy is guided by two government Bills (2008/09:162 and 163) which were approved by the Swedish Parliament in 2009. The bill on *En integrerad energi- och klimatpolitik* or **"integrated climate and energy policy"** sets out ambitious targets in support of and beyond the 20/20/20 objectives of the EU, in pursuit of a sustainable policy for the environment, competitiveness and long-term stability.

Short- to medium-term targets for 2020:

- 40% reduction in greenhouse gases (GHGs) or about 20 million tonnes of carbon dioxide equivalent (Mt CO_2-eq), compared to 1990, to be achieved outside the European Union Emissions Trading Scheme (EU-ETS) with two-thirds in Sweden and one-third by investments in other EU countries or the use of flexible mechanisms;
- at least 50% share of renewable energy in the gross final energy consumption;
- at least 10% share of renewable energy in the transport sector; and
- 20% more efficient use of energy compared to 2008.

The long-term priorities:

- by 2020, Sweden aims to phase out fossil fuels in heating;
- by 2030, Sweden should have a vehicle stock that is independent of fossil fuels;
- Sweden is committed to develop a third pillar in electricity supply, next to hydro and nuclear power, with increased co-generation, wind and other renewable power production to reduce vulnerability and increase security of electricity supply; and
- by 2050, the vision is that Sweden will have a sustainable and resource-efficient energy supply with zero net emissions of GHGs.

Sweden sees a role for natural gas as a transition fuel in industry and co-generation.

With a view to implement the priority of a fossil-fuel independent vehicle fleet by 2030, a committee has been created by the government to present concrete proposals on how Sweden can reach the 2030 decarbonisation goal.

The Swedish Environmental Agency, supported by the Swedish Energy Agency and other national authorities, presented a proposal for a Climate Roadmap in December 2012 (Box 1). The roadmap identifies scenarios for achieving the long-term 2050 priority and is to be adopted in the course of 2013.

Action plan for renewable energy

As part of the integrated climate and energy policy, Sweden set in motion an action plan for renewable energies. This included a higher ambition for the electricity certificate system with an increase of 25 TWh by 2020 compared to 2002, when the system started. Sweden also put forward a national planning framework for wind power of 30 TWh by 2020 (20 TWh onshore, 10 TWh offshore) to provide orientation to municipal spatial planning procedures.

Action plan for energy efficiency

Under the integrated climate and energy policy bill, Sweden adopted a comprehensive five-year energy efficiency programme for 2010-14 with a total of SEK 1 350 million (EUR 156.23 million) or SEK 270 million (EUR 31.25 million) per year. The activities under this programme aim to strengthen the regional and local climate and energy initiatives, to support green procurement by the public sector, to encourage small and medium-sized enterprises (SMEs) to manage and audit their energy consumption, and to procure energy-efficient technology. In addition, Sweden continues the Programme for Energy Efficiency in Energy-Intensive Industry (PFE). Overall funding from the State budget in the area of energy efficiency is around SEK 530 million (EUR 61.44 million) per year.

Nuclear replacement

Nuclear energy in Sweden has been controversial and the policy towards nuclear changed over time. As part of the 2009 agreement, Sweden has extended the transitional period during which nuclear power will be in use by allowing the construction of new reactors at existing sites within the limit of the existing ten reactors.

In 2010, the Swedish Parliament annulled the Nuclear Phase-Out Act and lifted the prohibition against the new construction in the Nuclear Activities Act. The replacement of old reactors will be possible under the conditions that the old one is permanently closed and that the new reactor is situated at the same site. The legislation entered into force on 1 January 2011. The nuclear liability legislation has also been adapted to provide for unlimited liability by operators. The government does not provide any direct or indirect subsidies for new nuclear power. Co-ownership of nuclear reactors has raised competition concerns. Efforts by the Swedish authorities to overcome these structural links between generators were made but did not succeed. As a result, the monitoring and supervision of nuclear power plants operations were strengthened.

Climate change adaptation

Sweden fully integrated the impacts of climate change adaptation into the climate and energy policy framework. The county administrative boards have been given the regional responsibility to co-ordinate activities in that area.

With the focus on improving the risk assessment, the Swedish Geotechnical Institute (SGI) has been developing a database on landslide risks and flooding; the National Land Survey set up an altitude database. The Swedish Planning and Building Act has been reviewed to include climate change adaptation into spatial planning. Co-ordinated transport infrastructure planning among the various transport agencies allows utilising opportunities for intermodal measures and handling of combined environmental effects of the transport system. As of 2009, infrastructure planning was placed under the Swedish Transport

Administration, which is responsible for overall long-term infrastructure planning for road, rail, sea and air travel, as well as for the planning, building, operation and maintenance of the state roads and railways.

Energy markets and consumers

The government considers energy markets with effective competition, efficient use of resources and efficient pricing as the fundamental basis for its integrated climate and energy policy. Sweden fosters the dynamic development of the Nordic Electricity Market as the cornerstone to the efficient and competitive exploitation of the common production resources in the region. The removal of any bottlenecks within the Nordic electricity grid and the European continent is continuously progressing. With the ambitious goal of achieving a common Nordic retail market by 2015, consumer issues have moved to the top priority of the Nordic co-operation. The Nordic Regulators (NordReg) recommended a new market model, “the supplier centric model”, for such an enlarged common Nordic retail market.

Sweden has undertaken reforms in the energy market in the process of transposing the Third Internal Energy Market Package, including important aspects of consumer protection, the powers and tasks of the regulatory authority and the definition of electricity and gas transmission activities. In June 2011, the government presented Bill 2010/11:153,[1] which was later endorsed by the Parliament, with measures to empower the consumer in the electricity market. The bill included a proposal for hourly metering for household consumers, for an investigation of the regulation for net metering to promote consumers’ micro-generation of renewable electricity and measures to facilitate the recharging of electric vehicles as well as the creation of a national smart grid council.

Climate taxation reform

In 2009, the Swedish Parliament approved the Bill 2009/10:41 on energy and climate taxation for the years 2010, 2011, 2013 and 2015, in line with the proposed revision of the EU Fuel Quality Directive, the recast of the Energy Taxation Directive 2003/96/EC and the new ETS period as of 2012/13 which now includes rail/air/sea transport, fishery, raw material use and waste incineration. The reform included an increased carbon dioxide factor in the vehicle tax and a strong rise in carbon dioxide taxes on the non-ETS sectors (agriculture, forestry and some industries). The reform reduced the number of exemptions to domestic industries, thereby enhancing the effectiveness of the energy and carbon dioxide taxes as an environmental signal and revenue base.

Research and innovation for a sustainable energy system

In October 2012 the government presented the Research and Innovation Bill (2012/13:30), proposing increased funding for research and innovation, including for energy research, demonstration and deployment (RD&D). The energy RD&D efforts in the period 2013-16 are laid out in the government Bill on Research and Innovation for a Sustainable Energy System (2012/13:21) of October 2012. The bill addresses the use of the additional resources, as described in the Research and Innovation Bill and proposed in the draft Budget Bill for 2013. The energy RD&D funding increases from EUR 100 million per year to about

1. “Strengthening the role of the consumer for a developed electricity market and sustainable energy system” [Stärkt konsumentroll för utvecklad elmarknad och uthålligt energisystem] (Govt. Bill 2010/11:153).

EUR 155 million per year by 2016. The bill confirms the key priorities of the Swedish strategic approach on research and innovation, ranging from basic research to demonstration, commercialisation and product development.

Box 1**. Climate Roadmap 2050**

On 11 December 2012, the Swedish Environmental Protection Agency in collaboration with the Swedish Energy Agency and other national authorities presented a proposal for a Climate Roadmap 2050 to the Swedish government.[2]

The roadmap points out how to achieve the 2050 vision of zero net GHG emissions in a cost-efficient way on the basis of different emission trajectories in different sectors. The roadmap foresees a reference scenario with all energy and climate policies in place to examine if and how Sweden reaches its 2020 targets and the developments beyond 2020. This scenario assumes that new nuclear will replace existing reactors. The analysis also includes scenarios with high efficiency in industry and transport and the application of CCS and biogenic CCS technologies.

The Climate Roadmap report concludes that the vision of Sweden without net emissions of greenhouse gases by 2050 can be achieved by:

- significant domestic emissions reductions as the most important long-term measure;
- contributions from an increased net uptake of carbon in forests and fields; and
- purchasing allowances on the international markets.

The report also proposes increased investment in research and innovation as a key element in a long-term roadmap. Reducing primary industry emissions to near zero is a big challenge and requires new technology, especially in the different industries, such as mining, iron and steel, cement, basic chemistry and the paper and pulp industry. In addition, the transport sector needs research and commercialisation of new technologies, in particular to obtain fossil-free and energy-efficient vehicles and renewable fuels. In parallel with the technical measures for vehicles and fuels, there need to be improved community planning and infrastructure investments.

The roadmap is to be adopted in the course of 2013.

CLIMATE CHANGE POLICIES

EU EMISSIONS TRADING SCHEME (EU-ETS)

As a member state of the EU, Sweden is covered under the regime of the EU-ETS cap-and-trade system which was set up in 2003 for the implementation of the Kyoto Protocol by Directive 2003/87/EC and started in 2005. Under this system, Sweden joins the overall efforts of the European Union to achieve the Union-wide target of reducing CO_2 emissions by 21% relative to 2005 over the period 2013-20. Each EU member state set out the total quantity of CO_2 emission allowances and the quantity allocated for each installation covered by the Emissions Trading Scheme in the first (2005-07) and the second (2008-12) trading periods in a national allocation plan (NAP).

2. www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6537-9.pdf

Process industries may receive part, or, if subject to carbon leakage, all of their allowances for free at the level of harmonised industry best practice benchmarks which were adopted by the European Commission for five years in a so-called "carbon leakage list" at the end of 2009 for the years 2013 and 2014. For the third trading period 2013-20, the national allocation plans will be progressively replaced, as harmonised allocation rules across the EU apply with auctioning as the main allocation principle. The EU-ETS was extended in scope to new sectors, as of 1 January 2012 to aviation,[3] and in 2013 to the production of petrochemicals, aluminium and ammonia, and the emissions of nitrous oxide in certain industries.

During the first trading period, 2005-07, as indicated in the NAP, Sweden allocated allowances under the ETS to electricity and district heating producers based on their historical emissions as well as to energy-intensive industries with an allocation based on the projected emissions.

For the second period 2008-12, Sweden allocated 19.8 million emission allowances on average per year. A reserve for new entrants was set for 13.1 Mt of CO_2 for the entire period. Operators exceeding the allocation have to purchase allowances from others, reduce their emissions or use credits from international carbon offsets. The use of flexible mechanisms by EU member states under the Kyoto Protocol is restricted by the European Commission to up to 10% of the total national allocation.

In the third trading period, 636 industry installations in Sweden have been allocated free emission allowances, with 22 new installations after 2012. The free allocation for 2013 is 30.2 million EU emission allowances (EUAs) and for 2020, 24 million EUAs.[4] No free allocation has been given to Swedish electricity producers which had been covered by the ETS since the start of the cap-and-trade mechanism. Seventeen airline operators who applied for allowances in Sweden in accordance with EU regulations have been allocated EUAs. In 2012, the aviation sector was allocated the equivalent of 97% of the sector's average emissions per year from 2004 to 2006. For the period 2012-20, the number of EUAs will be reduced from 97% to 95% of the average emissions in 2004-06.

DOMESTIC MEASURES OUTSIDE THE EU-ETS

Sweden is a Party to the Kyoto Protocol, and has adopted national GHG emissions reduction targets that are more ambitious than the ones set at the international level. For 1990-2012, Sweden's commitment under the Kyoto Protocol and the EU burden-sharing agreement (2002/358/EC) was to limit the increase in GHG emissions to no more than 4% above their 1990 level. However, the country decided to aim for an actual reduction of GHG emissions by 4% from 1990 levels for 2008-12.

The ambitious 2020 target to cut GHG emissions by 40% translates into a reduction of about 20 Mt CO_2-eq between 1990 and 2020 in the non EU-ETS sector. Sweden aims to achieve these reductions by two-thirds with domestic efforts outside the EU-ETS and one-third by international flexible mechanisms, including project-based mechanisms, like clean development mechanisms (CDM) and joint implementation (JI) projects. The non-ETS sectors represented 43% of CO_2 emissions in 2011. This included transport, housing, waste disposal, agriculture and forestry, aquaculture and some areas of industry.

3. In November 2012 the European Commission made a proposal to defer application of the scheme to flights operated to and from countries outside the ETS in 2012 so as to allow more time for a global agreement addressing aviation emissions to be reached.

4. The preliminary free allocation in EU-ETS phase 3, in line with the Commission Decision 2011/278/EU, was notified to the European Commission on 27 January 2012 by the Swedish Environmental Protection Agency (EPA). The final decision was taken in spring 2012 by the Swedish EPA, after a review by the European Commission.

Sweden intends to implement the reductions up to 2020 by the following means:

- emissions reductions between 1990 and 2007: 4 Mt CO_2-eq;
- forecast adopted national measures 2008-20: 5 Mt CO_2-eq;
- new environmental taxes and green investments: 2 Mt CO_2-eq;
- national implementation of joint EU decisions: 2 Mt CO_2-eq;
- other measures: 0.3 Mt CO_2-eq; and
- investments in other EU member states and flexible mechanisms such as CDM: 6.7 Mt CO_2-eq.

Average 2008-11 emissions were 12.6% lower than the 1990 level, well below the burden-sharing target of 4% for the period 2008-12. GHG emissions in 2010, the latest data available, amounted to 66.2 Mt CO_2-eq, which is 6.3 Mt CO_2-eq less than in 1990. Emissions per capita have decreased from 6.6 Mt CO_2-eq to around 5.5 Mt CO_2-eq from 2005 to 2010. In the sectors not covered by the EU-ETS, emissions were significantly lower than their target, by 13.5% of base-year emissions. Land use, land-use change and forestry (LULUCF) activities are expected to decrease net emissions by an annual amount of 3% of base-year level emissions.

Taking LULUCF into account, average emissions in the sectors not covered by the EU-ETS in Sweden were below their target level, by a gap of 16.4% of the 1990 level.[5] The use of renewable energy in transport in Sweden is estimated to reduce the emissions with 0.9 Mt CO_2-eq.[6] This reduction corresponds to approximately 1% of Sweden's total emissions. The cost for this reduction is estimated to SEK 3 per kg carbon dioxide.[7]

Projections indicate that Sweden is going to surpass its Kyoto commitment by a considerable margin.[8] According to the Environmental Protection Agency, the prognosis is that in 2020 total GHG emissions are expected to be about 17 % and in 2030 around 19 % below the 1990 levels.

Energy and carbon dioxide taxation

Electricity has been taxed in Sweden since the 1950s. In 1991, the carbon dioxide taxation was introduced in addition to the already existing energy tax on fossil fuels. Sweden has the world's highest CO_2 tax imposed on the non-trading (non EU-ETS) sectors and households/services. There are certain tax breaks to Sweden's domestic industries. High energy taxes on fuel and electricity as well as high CO_2 taxes on fossil fuels effectively steer demand through environmental signals, putting an implicit price on carbon, while at the same time providing state revenue (see overview in Table 2).

5. European Environment Agency, 2011.

6. Government office of Sweden, Sweden's First Progress Report under Article 22 of Directive 2009/28/EC, http://ec.europa.eu/energy/renewables/transparency_platform/template_progress_report_en.htm.

7. Swedish National Audit Office, Biodrivmedel för bättre klimat - Hur används skattebefrielsen? (RiR 2011:10), www.riksrevisionen.se/PageFiles/8575/Anpassad_11_10_Biodrivmedel_f%c3%b6r_b%c3%a4ttre_klimat.pdf.

8. Contribution by the Swedish government to the IEA. The preliminary calculation is made in accordance with Article 3.2 of Council Decision No 280/2004/EC on a Mechanism for Monitoring Community Greenhouse Gas Emissions and for implementing the Kyoto Protocol. The final calculation on the target fulfilment will be made in 2014.

In December 2009, energy and CO_2 taxation was reformed (Table 1) with a view to streamline tax levels towards the reduction of GHG emissions and the achievements of the 2020 targets for renewable energy and energy efficiency. On the basis of Government Bill 2009/10:41, Parliament decided to gradually limit CO_2 tax exemptions for energy-intensive industries and others between 2011 and 2015 outside the EU-ETS. It abolished the special CO_2 tax break to some industrial installations outside the EU-ETS and reformed energy taxes on heating fuels to strictly reflect the energy content.

Table 1. **Reform of energy and CO_2 taxes on fossil fuels in Sweden**

Area of use	**2010**	**2011 (decided by Parliament in December 2009)**
Households and services	100% energy tax – not based on energy content (EUR 0.001-0.008 per kWh) 100% CO_2 tax	100% energy tax – based on energy content (EUR 0.008 per kWh) 100% CO_2 tax
Industry outside the EU-ETS + agriculture	0% energy tax 21% CO_2 tax 0.8% rule – further tax reductions	30% energy tax = EUR 0.0025 per kWh 30% CO_2 tax (60% in 2015) 0.8% rule more strict (abolished in 2015)
Installations within the EU-ETS	Industry + heat production in CHP (combined heat and power plants): 0% energy tax 15% CO_2 tax Other heat plants: 100% energy tax; 94% CO_2 tax	Industry: 30% energy tax = EUR 0.0025 per kWh 0% CO_2 tax Heat production in CHP: 30% energy tax = EUR 0.0025 per kWh 7% CO_2 tax. Proposed to be 0% in 2013. Other heat plants: 100% energy tax; 94% CO_2 tax

Source: submission of the Swedish government to the IEA.

As set out in Table 1, following on from the 2009 taxation reform, industry outside the EU-ETS, including forestry, fisheries and agriculture, saw the introduction of a 30% energy tax and an increase in the CO_2 tax to 30% (60% as of 2015) from 2011 onwards.

Since 2011, industry within the EU-ETS faces a 30% energy tax but a 0% CO_2 tax. There are tax incentives for combined heat and power (CHP) while heat-only production faces higher taxes than electricity production, with the aim to increase the share of renewable energy in co-combustion.

Heat production in CHP (within the EU-ETS) saw the introduction of a 30% energy tax and 7% CO_2 tax, while other heat plants are taxed with a 100% energy tax and a 94% CO_2 tax. In the 2013 Budget Bill the government proposed to abolish the CO_2 tax for CHP heat production.

Sweden promotes efficient fuel use and the use of renewable energy sources in passenger cars with flexible fuel vehicles and efficient technologies, including electric vehicles and plug-in hybrids, and the use of biogas, ethanol, hydrogenated vegetable oils (HVO) and biodiesel through a number of tax incentives and blending. Sweden has no obligation to blend biofuels into petrol and diesel. Low blending depends on the excise duty. High blends, for example E85, ED95 and biodiesel (100% FAME) are subject to full tax exemption. In Sweden, the fulfilment of the sustainability requirements, as authorised by the Swedish Energy Agency, is a condition for obtaining tax exemptions. Under the EU Renewable Energy Directive 2009/28/EC, only biofuels that fulfil the sustainability criteria may be taken into account for the fulfilment of targets or be entitled to state aid.

Table 2. **General energy and CO_2 taxes in Sweden from 1 January 2011 (excluding VAT)**

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax öre/kWh
Fossil fuels for heating purposes					
Heating oil, SEK/m^3	797	3 017	-	3 814	38.3
Heavy fuel oil, SEK/m^3	797	3 017	108	3 922	37
Coal, SEK/tonne	605	2 625	150	3 380	44.7
Liquefied petroleum gas (LPG), SEK/tonne	1 024	3 174	-	4 198	32.8
Natural gas, SEK/1 000 m^3	880	2 259	-	3 139	28.5
Crude tall oil, SEK/m^3	3 814	-	-	3 814	38.9
Peat, SEK/tonne, 45% moisture content (0.3% sulphur)	-	-	50	50	1.8
Motor fuels					
Petrol, unleaded, environmental class 1, SEK/L	3.06	2.44	-	5.50	60.8
Diesel, environmental class 1, SEK/L	1.52	3.02	-	4.54	45.6
Natural gas and methane, SEK/m^3	-	1.58	-	1.58	14.4
Electricity use					
Electricity, northern Sweden, öre/kWh	18.7	-	-	18.7	18.7
Electricity, rest of Sweden, öre/kWh	28.3	-	-	28.3	28.3
Industry*					
Electricity use, industrial processes, öre/kWh	0.5	-	-	0.5	0.5

* Lower tax levels for industry within and outside the EU-ETS (see Table 1).

Source: Swedish Energy Agency, *Energy in Sweden 2011*.

In the 2013 Budget Bill the government presented a proposal to introduce from 2013 onwards an energy tax on biofuels used for low-blend purposes, at such a level that it is does not discourage the use of low-blends in the market. For 2014, the government is considering the introduction of a quota system aimed at 10% and 7% blending of biofuels in low-blended fossil fuels and diesel, as allowed by the EU Fuel Quality Directive. In the 2013 Budget Bill the government also presented stricter rules for motor vehicle tax exemptions where emission requirements also are related to the vehicle’s weight.

The Swedish taxation system supports the purchase of environment-friendly vehicles. An environment-friendly vehicle is defined as a vehicle equipped with technology for operation entirely or partially on electricity, alcohol or gas, or a fuel-efficient petrol or diesel car with CO_2 emissions below 120 g per km. The motor vehicle tax exemption during the first five years of the vehicles use for “environment-friendly cars” (< 120 g CO_2 per km) has been strengthened with the introduction of a new tax break for “super environment-friendly cars” (< 50 g CO_2 per km which targets plug-in hybrids or electric vehicles) for the period 2012-15.

The efficiency of new vehicles will be improved with new EU rules, in particular emission performance standards. From 2015 onwards, CO_2 limits for new passenger cars may not exceed 130 g CO_2 per km in line with (Regulation (EC) No 443/2009) and 95 g CO_2 per km by 2020 and for new vans of 147 g CO_2 per km in 2020 (Regulation (EU) 510/2011). Improvements in motor technology will reduce average emissions to 130 g CO_2 per km, while complementary measures will contribute a further emissions cut of up to 10 g CO_2 per km, thus reducing overall emissions to 120 g CO_2 per km. In 2012, the European Commission put forward proposals for interim targets of 130 g in 2015 for new cars and of 175 g in 2017 for new vans.

INTERNATIONAL MEASURES

Sweden increased the budget for purchasing emissions reductions from CDM/JI projects – a cost-effective way of reducing emissions. The 2009 integrated climate and energy bill stipulated that the focus should be on least-developed countries (LDC) and small island states (SIDS). The Swedish Energy Agency, through the administration of the CDM and JI purchase programme, has proactively been engaged in the development of CDM projects, both through bilateral projects and engagement in international carbon funds, governed by the multilateral banks, such as the World Bank, the Asian Development Bank, and the Nordic Environment Finance Corporation. The total budget up to 2014 is around SEK 1.8 billion.

By the end of 2011, the Swedish CDM/JI programme had a portfolio consisting of 46 CDM projects and two JI projects, the latest in Benin, Mauritius, India, Thailand, Vietnam, Tanzania, Nigeria, Uganda and Kenya. Complementing these bilateral projects, Sweden participates also in multilateral CDM and JI funds, including the World Bank Prototype Carbon Fund (PCF), the World Bank Umbrella Carbon Facility Tranche 2 (UCG T2), and the Carbon Partnership Facility (CPF).

Carbon capture and storage

Sweden is considering the potential for carbon capture and storage (CCS) at national level and within the Nordic and Baltic regions. With this aim, Sweden is actively participating in international technology research co-operation on CCS.

Sweden communicated transposition measures related to EU Directive 2009/31/EC of 23 April 2009 on the geological storage of carbon dioxide to the European Commission in 2011. The initial transposition created the legal framework for geological storage of CO_2 offshore, while limiting geological storage onshore to that associated with research and development (R&D) projects of less than 100 000 tonnes of injected CO_2. The reason for this distinction was to define a legal framework for interaction of CCS and extraction of geothermal energy from the relevant geological formations.

Swedish legislation is currently being amended to transpose all enabling measures in the EU directive, also for application onshore, through revision of laws related to environmental protection, Sweden's continental shelf and economic zone, and rights-of-way for pipelines. The amendments are due to come into effect by 4 January 2013. Member states are required under EU law to transpose all elements of the directive, irrespective of whether they have chosen to prohibit storage in their territory, unless storage is physically impossible.

A study analysing the national potential of geological CO_2 storage in the Swedish bedrock was undertaken and released in 2011 by the Centre for Geological Information and the Geological Survey of Sweden. The survey found that the majority of the bedrock, dominated by crystalline rocks, has low or no potential for storage of CO_2. There are two or possibly three alternatives for geological storage of CO_2 in the Baltic Sea, located within sedimentary bedrock basins in south-west Scania, in the south Baltic and in the southern Kattegat. In these areas, there are deep sandstone aquifers with sufficient porosity, permeability and thickness. The Cambrian sandstone in the south Baltic, extending into Lithuania, Latvia, Kaliningrad and Poland, is considered the most suitable candidate for CO_2 storage. The sandstone aquifers in southern Kattegat are considered to be less suitable, because of their low-storage volume.

The Swedish Energy Agency supports the project "CCS in the Baltic Sea Region", which is initiated by the Swedish industry in co-operation with the Finnish R&D Programme CCSP and still ongoing. The project focuses on the verification of the geological opportunities for CO_2 sequestration in the deep sandstone formations under the south-east Baltic Sea and studies the option of a common infrastructure for transport and storage of carbon dioxide in the Baltic Sea region, and analyses the environmental consequences, societal, legal and financial aspects. With a view to foster CCS research on storage, Sweden is carrying out a feasibility study for building a working test site in Sweden for CO_2 storage (project SwedSTORECO_2), supported by the Swedish Energy Agency, where CO_2 could be injected (up to 100 000 tonnes) into geological formations onshore. The feasibility study includes fluid flow modelling, cost assessment of drilling and injection operations, development of a monitoring strategy, identification of CO_2 sources, contacts with other CO_2 storage projects and an assessment of the total storage capacity of Sweden.

Within the framework of the Nordic Innovation, Chalmers University of Technology, the Swedish Environmental Research Institute (IVL) and the Geological Survey of Sweden (SGU) participated to the NORDICCS project with partners from the five Nordic countries. The project "Potential for carbon capture and storage (CCS) in the Nordic region" examined the potential for applying CCS in the Nordic countries with regional CCS solutions. In addition, Sweden participated to the project "CCS in the Nordic countries in a renewable/climate-neutral future (2050)", which evaluated the development of the energy system with more renewable energy in the Nordic region as well as the role of CCS in becoming climate-neutral by 2050.

Swedish companies, especially Vattenfall, have been active in advancing CCS technology, notably in Germany, with an EU pilot CCS project at Schwarze Pumpe lignite plant in Brandenburg. During 2009-11, Sweden participated to the CCS project in the Skagerrak/Kattegat region, partly funded by the EU, which assessed the prospects for CCS from industries and power plants located in the Skagerrak region, comprising the neighbouring areas of Denmark, Norway and Sweden. Energy-intensive industries consider CCS as important for their efforts to further limit their CO_2 emissions.

The forest industry, including the paper and pulp industry, has also potential for CCS technology, as it represents a relatively large share of the Swedish biogenic CO_2 emissions. Combining CCS with bioenergy would have the potential to achieve negative emissions, *i.e.* net removal of CO_2 from the atmosphere. This would require specific deployment incentives.

Research, development and demonstration (RD&D) efforts in the area of CCS are further described in Chapter 9.

ASSESSMENT

Since the 2008 in-depth review, Sweden has made significant and commendable progress towards achieving a more and more sustainable and resource-efficient energy supply, improving energy efficiency and supporting energy research, development and demonstration (RD&D) and innovation in collaboration with other countries across the European Union and the globe.

As a new comprehensive framework, Sweden adopted in 2009 an integrated climate and energy policy, in pursuit of a sustainable environment, competitiveness and long-term stability. This follows up on the IEA 2008 recommendation.

Under this framework, Sweden adopted ambitious 2020 targets which go beyond EU and international requirements. The country strives to reduce GHG emissions by 40% below 1990 levels outside the EU-ETS, to increase the share of renewable energy in gross final energy consumption to at least 50% and in the transport sector to 10%, and aims to reduce energy intensity by 20% below 2008 levels.

While Sweden's commitment under the Kyoto Protocol (and EU Burden-Sharing Agreement (2002/358/EC)) was to limit the increase of GHGs to no more than 4% during 1990-2012 above their 1990 levels, the country decided to reduce GHG emissions by 4% from 1990 levels during 2008-12.

For the longer term, Sweden also decided that *i)* by 2020, fossil fuels for heating should be phased out, *ii)* by 2030, the vehicle stock should be independent of fossil fuels, and *iii)* by 2050, a sustainable and resource-efficient energy supply should prevail with zero net emissions of GHGs in the atmosphere. Commendably, Sweden has made already significant progress in meeting these targets, and may well exceed them.

In 1990, renewable energy sources (RES) accounted for 33% of total final consumption of energy (TFC). By 2011, this share had increased to 48%. The heating and cooling sector (including industry) in Sweden has a high RES share of 65%, mainly thanks to district heating using solid biofuels and the prevalence of heat pumps. A similar picture emerges for the almost carbon-free electricity sector, where hydropower and nuclear energy account for the main share of production, and biofuels and onshore wind power are increasing rapidly in recent years. This growth is the result of the effective utilisation of the electricity certificate system.

This technology-neutral and market-based approach has allowed Sweden to increase further the RES share and at the same time to ensure that costs to consumers are kept moderate. Among IEA member countries, Sweden has the second-highest share of biofuels and waste in the TPES (22%). In transport, Sweden reached a RES share of 9.8% in 2011 and the government considers that it will meet the 2020 target of 10% already around 2015.

Emissions have gradually and steadily decreased for more than two decades, despite a steadily increased economic growth. Average 2008-11 emissions in Sweden were 12.6% lower than 1990 levels, well below the burden-sharing target of 4% for the period 2008-12. In 2010, emissions of GHGs amounted to 66.2 Mt CO_2-eq, which is 6.3 Mt CO_2-eq less than in the 1990s.

Projections indicate that Sweden is going to reach its Kyoto commitment by a considerable margin. This is the result of a high carbon dioxide and energy taxation. However, the taxation system uses a number of differentiated exemptions, which does not allow GHG emissions reductions to be achieved where they are the cheapest. In 2009, Parliament adopted a reform of the taxation system to gradually decrease and abolish the carbon tax exemptions for energy-intensive industries and other cases outside the EU-ETS. This is a step in the right direction.

Sweden has also taken important steps to clarify the framework for nuclear energy, allowing for the replacement of the nuclear reactors located at the three existing sites, by the end of their operational lifetime. The government will not provide any direct or indirect subsidies, as it follows a market-based approach with taxation, EU-ETS and technology-neutral support to renewable energies. Considerable uncertainty remains regarding the actual replacement of these reactors, which currently account for around 40% of electricity generation. The current economic climate and international competition for public support in low-carbon technologies make high capital investment projects challenging in Sweden and puts the Swedish industry at a disadvantage in comparison to other countries.

CO_2 emissions from the transport sector accounted for more than 45% of Sweden's total CO_2 emissions in 2010. Sweden has taken the lead in introducing more fuel-flexible passenger cars and increasing the share of biofuels. However, current policies are unlikely to lead to any significant decrease in GHG emissions by 2030 and could make the target of having a vehicle fleet independent of fossil fuels very challenging to achieve. In addition, clarification is required with regard to the definition of "fossil fuel independence".

For making these ambitions operational, the IEA recommends reviewing the costs and benefits and interplay of the different policy measures, in particular taxation, investment subsidies and the possible quota obligation for petrol and diesel. The government created a special committee for the 2030 priority. The IEA considers that an action plan is urgently needed to provide clarity to the market participants and a timeline for the implementation of such an ambitious medium-term priority.

Sweden has achieved considerable emissions reductions, in particular in the energy sector. Further emissions reductions in the 2050 horizon will be more costly and more difficult to achieve as they will require emissions reductions in industry, buildings and transport. This vision can only be achieved though cost-effective policies and measures across the whole economy. Its implementation will require substantial technological transformation of the industry and transport sectors, and investment in clean energy technologies, including electric vehicles, smart grids and carbon capture and storage.

Sweden is right to develop a Climate Roadmap for the 2050 vision. The IEA recommends the government to reach a common vision for the decarbonisation of the economy together with academia, industry and civil society on the basis of an overarching 2030/2050 pathway analysis and sectoral technology roadmaps. The Climate Roadmap which the government presented in December 2012 will provide a starting point for the discussion.

Energy-intensive industries consider CCS as an option to limit their CO_2 emissions; also the forest industry, including the paper and pulp industry, has potential, as it represents a relatively large share of the Swedish biogenic CO_2 emissions. With a view to gain more experience relevant for the implementation of CCS in Sweden, Swedish industry and academia are involved in several regional and international RD&D pilot projects on CCS within the Nordic and international research co-operation. The IEA encourages Sweden to scale up investment in clean energy technologies towards their deployment in order to achieve emissions reductions in the industry and transport sectors, including by co-operation at regional level. Building on the past experience of Nordic grid planning, co-operation and joint planning at regional level can provide benefits from scale and synergies for the large-scale deployment of clean energy technologies, including smart grids, electric vehicles, biofuels and CCS.

As set out in the 2009 integrated climate and energy policy, a progress review will be conducted in 2015. The review shall provide analysis on the energy balance, the cost, the impact of climate change and the progress towards the 2020 targets. The IEA encourages Sweden to review the cost-effectiveness of its climate and energy policy, including taxation, renewable support measures, emissions trading and their interplay towards the 2020 targets as well as the synergies of regional and international measures within the Nordic and EU market areas.

RECOMMENDATIONS

The government of Sweden should:

- ☐ *Urgently develop an action plan on how to cost-effectively achieve the 2030 priority of making the vehicle fleet independent of fossil fuels.*
- ☐ *Develop and implement a long-term pathway analysis for the 2050 vision of zero net emissions of GHGs to guide market participants and policy making. Building on this, create a shared vision for the decarbonisation of the Swedish economy together with industry and civil society on the basis of sectoral clean energy technology roadmaps.*
- ☐ *Scale up investments in clean energy technologies, including smart grids, biofuels or CCS, to achieve emissions reductions in industry processes and the transport sector, through RDD&D support, co-operation and joint planning at regional level to benefit from scale and synergies for their deployment.*
- ☐ *Periodically monitor the extent to which climate and energy policies are on track to achieve the Swedish vision of zero net GHG emissions by 2050 in a cost-effective way.*

3. ENERGY EFFICIENCY

Key data (2011 provisional)

Total final consumption: 33.7 Mtoe (oil 32.5%, electricity 32.1%, renewables 18.7%, heat 12.9%, natural gas 1.9%, coal 1.7%), -4.4% since 2000

Consumption by sector: industry 39.3%, transport 24.1%, residential 22.5%, services and other 14.1%

Energy supply per capita: 5.2 toe (IEA average in 2011: 4.7)

Energy intensity: 0.15 toe per 1 000 USD (IEA average in 2011: 0.15), -13% since 2000

TOTAL FINAL CONSUMPTION

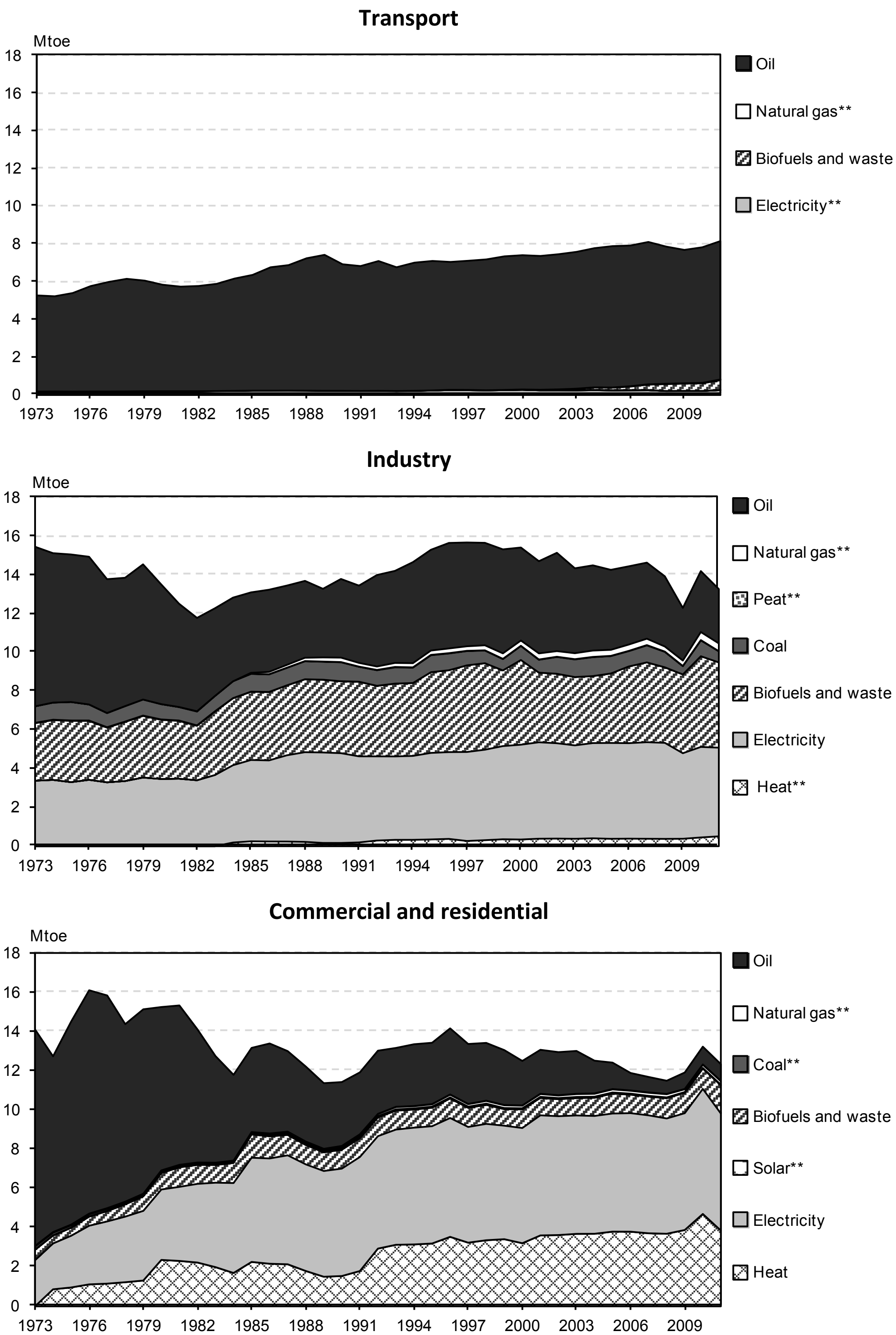
In the long-term trend, Sweden's total final consumption (TFC) of energy has remained remarkably stable since the early 1970s as a result of improved energy efficiency across the economy, and carbon dioxide and energy taxation. For example, consumption by industry has remained relatively constant, despite the fact that total industrial production has steadily increased. The residential sector has reduced TFC over the same period, while commercial and other services have exhibited a constant increase. However, TFC in transport has increased by 54% since 1973. In 2011, TFC was approximately 33.7 Mtoe, roughly the same as in 1990s, 1980s and in the 1970s. Industry accounted for 39.3%, followed by 24.1% for transport, 22.5% for the residential sector and 14.1% for other sectors (including commercial, public services, agriculture and fishing).

Electricity and oil are the main energy carriers. Electricity is the primary fuel for Swedish industry, followed by biofuels, waste and oil. Electricity and heat equally account for most of TFC in the residential sector, replacing oil use in this sector. In the transport sector, however, oil accounts for 90% of TFC, with a few contributions from other sources, such as 6.3% from biofuels and waste, 3.2% from electricity and 0.5% from natural gas.

Sweden's energy intensity,[9] adjusted for purchasing power parity (PPP), was 0.148 in 2011 (Figure 11). This places Sweden at the estimated IEA member country average of 0.15, but above the estimated IEA European member country average of 0.115. Energy intensity, adjusted for PPP, has continuously decreased by around 2% since the 1970s. These improvements can be attributed to energy efficiency gains and structural changes in the economy (services and light industry are growing faster than the energy-intensive sectors), and in the energy supply (electricity and heat replaced fuels, like oil). Electricity use has almost doubled over the period, and space heating is now dominated by district heating, electric heating and heat pumps. In addition, combined heat and power (CHP) is increasingly used.

9. The amount of primary energy used in a country per unit of GDP at 2005 prices.

Figure 10. **Total final consumption by sector and by source, 1973-2011***

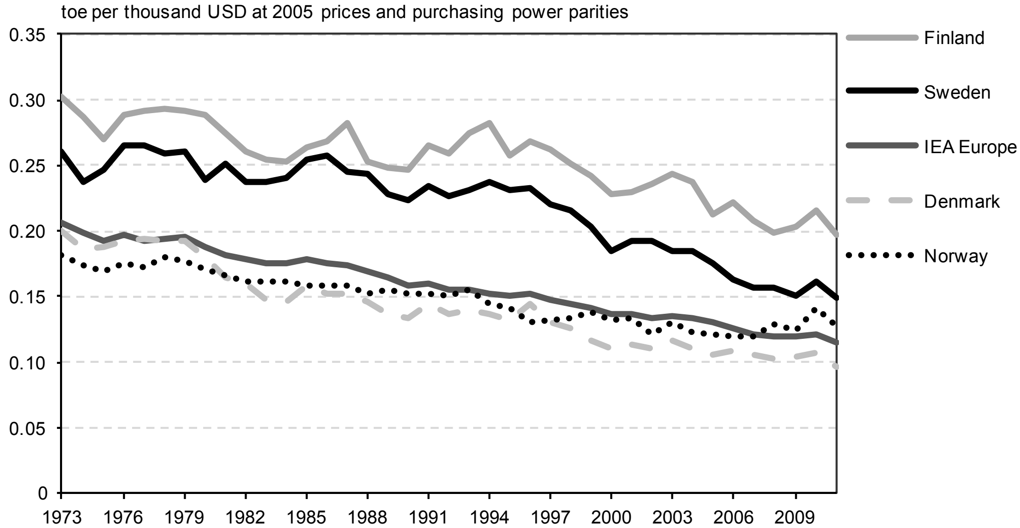


* Provisional for 2011.

** Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

Figure 11. **Energy intensity in Sweden and in other selected IEA member countries, 1973-2010**



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012; *National Accounts of OECD Countries*, OECD Paris, 2012.

INSTITUTIONS

The **Ministry of Enterprise, Energy and Communications** is headed by three ministers with the Minister for Information Technology and Energy being in charge of energy policy, including energy efficiency.

The **Ministry of Health and Social Affairs** is responsible for the Planning and Building Act, which is implemented by the **National Board of Housing, Building and Planning** through secondary legislation, including technical requirements for buildings (building code), such as energy use in buildings and minimum energy performance (MEP) requirements.

County administrative boards, which represent the national government at the regional level, have an assignment from the government to formulate regional energy and climate strategies in collaboration with regional actors. These strategies include energy efficiency policies.

Responsibility for the administration of the five-year programme for energy efficiency 2010-14 lies with the **Swedish Energy Agency**. The programme foresees the voluntary measures and financial support for which municipalities, county councils, county administrative boards, and businesses can apply. The Swedish Energy Agency also provides information and supports various actors. It oversees the implementation of EU requirements on energy services, labelling, and eco-design. The Swedish Energy Agency and the Swedish National Board of Housing, Building and Planning share the responsibility for implementing policies on energy efficiency in buildings.

The Swedish Energy Agency finances the liaison group **HyLok** which is composed of representatives from ten governmental agencies. The group aims to reduce tenants' energy end-use and enhance energy efficiency co-operation between property owners and tenants. The **Procurement Group for Business Premises (BELOK)** and the **Procurement Group for Residential Properties (BEBO)** support these efforts.

Fourteen **regional energy agencies** support municipalities, promote networks and initiate energy efficiency projects. Regional energy agencies work closely with the county administrative boards, the municipalities and companies in the region. The Swedish regional agencies are not governmental authorities; they were created in the framework of EU-funded activities. They carry out project activities on energy efficiency and renewable energy, funded by the various actors, including the EU and the Swedish Energy Agency.

With a view to co-ordinate the activities on energy efficiency, primarily across the national governmental agencies, but also across the national, regional and local levels, the **Energy Efficiency Council** (Energieffektiviseringsrådet) has been set up within the Swedish Energy Agency. The Council has members from the National Board of Housing, Building and Planning, the Energy Markets Inspectorate, the county administrative boards, the Board of Agriculture, the Environmental Protection Agency, the Association of Local Authorities and Regions, the Agency for Economic and Regional Growth, and the Transport Administration.

SECTORAL POLICIES AND MEASURES

As an EU member state, Sweden is guided by several EU regulations and directives in the area of energy efficiency. The Directive on Energy End-Use Efficiency and Energy Services 2006/32/EC (EU Energy Services Directive) sets out measures for energy efficiency of all sectors, including the public sector; and requires a national energy efficiency action plan; and aims at creating a market for energy services to deliver energy efficiency to end-users. Directive 2010/31/EU on the Energy Performance of Buildings (EPBD) requires EU member states to adopt minimum energy performance requirements (MEPs) for new and existing buildings, to ensure the certification of buildings energy performance, regular inspection of boilers and air-conditioning systems in buildings and that by 2021 all new buildings are "nearly zero-energy buildings".

The Energy Efficiency Directive 2012/27/EU requires each member state to set a national energy-savings target in line with the EU-wide targets; to establish a long-term strategy for renovating the building stock; to ensure that final energy consumers are provided with competitively priced individual meters; to assess the potential for high-efficiency co-generation and district heating and cooling. The directive obliges energy providers to achieve end-use energy savings equivalent to 1.5% of annual energy sales over the period 2014-20 and requires all large enterprises to undergo quadrennial energy audits. The Directive 2009/125/EC on Setting Eco-design Requirements for energy-related products (Eco-design Directive) promotes energy efficiency throughout the product's lifecycle and is the basis for future product-specific standards set by EU regulations. The Directive 2010/30/EU on Energy Consumption Labelling includes mandatory labelling requirements for commercial and industrial appliances and energy-related appliances. Regulation (EC) No 1222/2009 on tyre labelling complements these efforts for the transport sector.

EU policies aim to reduce CO_2 emissions across the EU from passenger cars (Regulation [EC] No 443/2009) with emission performance standards for passenger cars of 130 grams (g) CO_2 per km after 2015 and 95 g CO_2 per km by 2020 and for new vans of 147 g CO_2 per km in 2020 (Regulation [EU] 510/2011). Improvements in motor technology will reduce average emissions to 130 g CO_2 per km, while complementary measures will contribute a further emissions cut of up to 10 g CO_2 per km, thus reducing overall emissions to 120 g CO_2 per km. These complementary measures include efficiency improvements for car components with the highest impact on fuel consumption, such as tyres and air-conditioning systems, and a gradual reduction in the carbon content of road fuels, notably through greater use of biofuels. In 2012, the European Commission put forward proposals for interim targets of 130 g in 2015 for new cars and of 175 g in 2017 for new vans.

European regulations (EC 661/2009 and EC 1222/2009) require mandatory fitting of tyre-pressure monitoring systems (TPMS) by November 2012 for new passenger cars and by November 2014 for all newly registered passenger cars. In addition, the EU Fuel Quality Directive (2009/30/EC) requires the reduction of the lifecycle GHG intensity of the fuel by 6% per unit of energy by 2020. The efficiency and emission performance of new cars will be improved through EU regulations, including improved tyre efficiency (EC 661/2009) and tyre labelling on fuel efficiency, wet grip and external rolling noise (EC 1222/2009) for almost all tyres used on passenger cars, light-commercial vehicles and heavy-duty vehicles.

NATIONAL ENERGY EFFICIENCY ACTION PLAN AND TARGETS

Sweden is committed to reduce energy intensity by 20% between 2008 and 2020. Sweden's energy efficiency policy is guided by its National Energy Efficiency Action Plans (NEEAP), required under Article 14 of the EU Energy Services Directive (2006/32/EC). Its first NEEAP was submitted to the European Commission in March 2009, the second in June 2011, and the third one is scheduled for April 2014.

Under the EU Energy Services Directive, as set out in the NEEAP, Sweden aims to achieve an indicative energy savings target of 9% (or 33.2 TWh) by 2016, compared with average national TFC from 2001 to 2005. Sweden's 2011 NEEAP shows the country is likely to outperform this target by saving more than 53.8 TWh or 15% by 2016. Progress towards the 2020 energy intensity target will be assessed in the check-point 2015 as foreseen in the integrated climate and energy policy bill of 2009. Measures to accomplish these targets include energy taxation, emissions trading, strengthening local and regional actions, improving building code MEPs, information campaigns, support for technology procurement and market introduction, programmes for improving energy efficiency in energy-intensive industries and the introduction of support schemes for energy audit vouchers in small and medium-sized enterprises (SMEs).

Sweden has developed and implemented a comprehensive mix of measures to promote energy efficiency, including legislative and fiscal measures, setting price signals through energy and CO_2 taxes and the EU-ETS in order to steer demand. Sweden complements these measures with a range of financial support, information, training and dissemination tools to support voluntary energy efficiency measures.

The Swedish energy efficiency policy relies on local and regional initiatives, developed on the basis of regional energy and climate strategies and supported by work of the fourteen regional energy agencies and the Swedish Energy Agency. The agencies co-operate with the county administrative boards, the municipalities, municipal advisors and companies in the region to initiate projects on energy efficiency and renewable energy. Sweden is a role model for the creation of municipal energy and climate advisory services which are provided to households and small businesses.

Sweden leads by example and has already put in place elements which are now required under the new EU Energy Efficiency Directive 2012/27/EU. Under the five-year energy efficiency programme for 2010-14 public support is made available to local and regional initiatives by the public and private sector. In 2012, public funding for energy efficiency amounted to SEK 529 million (EUR 59 million). SEK 140 million went to energy and climate advisor programmes aimed at disseminating information, financing regional energy agency projects and implementing EU directives and EU projects. SEK 119 million went to sustainable energy use, for activities such as technology procurement, planning, evaluation and monitoring, training, testing energy-using products and financing international energy efficiency collaboration.

The Swedish Energy Agency provides public support to municipalities and county councils which adopt an energy efficiency target for 2020 and an energy efficiency strategy to reach the target with annual progress reports. In 2012, SEK 270 million were allocated to the action plan for energy efficiency, which includes public support for municipalities and county councils working strategically on energy efficiency, regional collaborative strategies, energy audit vouchers, green procurement and measures to promote energy declarations in buildings. Many SMEs made use of the support from the Swedish Energy Agency which provides for co-financing of 50% of energy audits of SMEs (maximum EUR 3 300). Under the Sustainable Municipality Programme, 38 municipalities share information with one another and receive technical assistance from the Swedish Energy Agency to implement sustainable planning strategies.

As required under the EU Energy Services Directive and EPBD, the public sector in Sweden leads energy efficiency efforts. By law, government agencies (180 public entities) are required to take energy efficiency improvement measures, *i.e.* in their buildings and when purchasing equipment, and to annually report progress to the Swedish Energy Agency. Energy savings are estimated to be around 230 GWh per year.

APPLIANCES, EQUIPMENT AND LIGHTING

Regarding the **appliances** sector, minimum energy performance requirements (MEPs) for numerous products covered under the Eco-design Directive (2005/32/EC) have entered into force, and the October 2009 Eco-design Directive recast (2009/125/EC) is being transposed. Sweden is also transposing the new Labelling Directive (2010/30/EU).

The government has introduced harmonised and strengthened MEPs for products and standardised labels, recording the energy efficiency of a product on an A to G scale (A+++ is awarded to the most energy-efficient products), in line with EU eco-design and labelling requirements. To support EU MEPs and labelling efforts, Sweden has implemented measures to improve consumer awareness, provide advice and conduct market surveillance. The Swedish Energy Agency has been appointed as the national market surveillance authority for the EU Eco-design and Energy Labelling Directives.

From 2012 to 2014, the Swedish Energy Agency participates in Ecopliant, an EU project which focuses on improved market surveillance of the Eco-design Directive and associated regulations. Ecopliant aims to improve surveillance across the EU market and to enhance information sharing with other national market surveillance authorities.

The Swedish Energy Agency also performs testing of products that are not yet regulated to study their energy performance and other aspects. The results of these tests are used to inform regulatory measures, support public procurement and provide consumer advice. As market surveillance authority partner, the Swedish Energy Agency also participates in the "ATLETE" project which was initiated by the European trade association for major appliances, the European Committee of Domestic Equipment Manufacturers, (CECED), and aims to demonstrate compliance or particular non-compliance discrepancy between eco-design/energy labelling requirements and the products on the market. The project is currently testing washing machines.

Inefficient incandescent bulbs are being phased out, in line with EU requirements. To improve **lighting efficiency**, the Swedish Energy Agency has allocated approximately SEK20 million to policies in this area, for information dissemination and awareness campaigns and for the creation of a laboratory to develop, test and standardise new lighting products. The laboratory will be available to parties from public and private sectors, as well as universities to explore lighting innovations, products and solutions.

Sweden fosters the implementation of **smart grids** to facilitate the achievement of ambitious national energy and climate targets, and to empower electricity consumers. The first generation of smart meters has already been installed in around 90% of Swedish households. In October 2012 the Parliament adopted a consumer-focused package of measures that are to be implemented in 2013, including voluntary hourly metering of electricity consumption for household customers, new methods for settlement, billing and data management and storage, and enabling households to generate their own renewable electricity and to charge an electric vehicle.[10] These measures will enable consumers to achieve greater efficiency in energy consumption.

TRANSPORT

The transport sector accounts for 24.1% of Sweden's TFC, with oil representing 59.1% of supplies. Sweden set out an ambitious target of achieving a vehicle stock that is independent of fossil fuels by 2030.

Private cars dominate transportation in Sweden. The total vehicle fleet is at 4.8 million cars with an annual growth rate of 4% or 192 000 cars. In 2011, over 4.3 million passenger cars were registered.

Table 3. **Modal split of passenger transport on land, 2010**

	Car	Bus	Train	Tram and metro
Share %	81.8	7.1	9.2	1.9

Source: *EU transport in Figures – Statistical Pocketbook 2011*.

Vehicle taxation and fuel efficiency

Since 2006, Sweden has a CO_2-based vehicle tax. Since 2011, light-duty vehicles, buses and motor caravans are covered by a CO_2 factor. Heavy-duty vehicles are not covered, they continue to be subject to the vehicle tax according to vehicle weight and exhaust levels. Heavy-duty vehicles and trailers have to pay an annual toll charge. As explained in Chapter 2, there are a number of motor vehicle tax breaks for so-called "environment-friendly" new passenger vehicles which, since 2009, are exempted from vehicle tax for the first five years.

Since 2012, a rebate of up to SEK 40 000 (EUR 4 600) has been granted to purchasers of vehicles that emit 50 g CO_2 per km or less ("super environment-friendly cars").

Sweden does not have mandatory blending requirements, but low blends are used depending on the excise duty. In the 2013 Budget Bill the government presented a proposal to introduce an energy tax on biofuels used for low-blend purposes from 2013 onwards. In 2014, the government considers the introduction of a quota system aimed at 10% and 7% blending of biofuels in low-blended fossil fuels and diesel, as allowed by the EU Fuel Quality Directive.

10. "Strengthening the role of the consumer for a developed electricity market and sustainable energy system" [Stärkt konsumentroll för utvecklad elmarknad och uthålligt energisystem] (Govt. Bill 2010/11:153).

New cars sold in Sweden are much more efficient today than a few years ago. In 2005, the average fuel consumption of new cars was around 8 litres per 100 km. In 2011, the corresponding consumption was 5.8 litres per 100 km.

The Swedish Energy Agency allocated for the years 2010-13 funds in the range of SEK 70 million for research and demonstration projects, technology procurement and methods, products and services to encourage more efficient modes of transport.

The government continuously promotes a clean public transport system. The demonstration and deployment of electric vehicles and buses running on biogas in Swedish cities progresses; the congestion charge, first introduced in Stockholm, will be applicable in Göteborg, the second-largest city, as of 2013.

Efforts to shift freight traffic from road to rail have also been made, but the potential expansion is limited. Other examples include support of affordable public transport in order to facilitate inter-modality towards energy-efficient transport modes, free parking for “environment-friendly” vehicles and higher parking charges for all others. Cycling has become increasingly important in many cities and large investments are being made in maintenance and creation of new bicycle infrastructure.

BUILDINGS

Sweden’s environmental quality objectives call for the reduction of energy use in the building sector by 20% in 2020 and 50% in 2050. The majority of the multi-storey buildings were built in the 1960s and 1970s. Approximately half of the non-residential building stock in Sweden is owned by the public sector. The construction rate of new buildings is low and the contribution of new construction to the energy efficiency target is limited.

In 2012, Sweden adopted a revised building code to require new residential, public and commercial buildings and buildings undergoing deep renovations to consume no more than 90 kWh per m^2 in the southern climate zone and 130 kWh per m^2 in the northern climate zone. Residential and commercial buildings when heated with electricity must not consume more than 55 kWh per m^2 in the southern climate zone and 95 kWh per m^2 in the northern climate zone.

Demonstration projects for low-energy and zero-energy buildings are under way. In 2010, Sweden launched the five-year financial support programme (LÅGAN) for the construction of buildings with very low energy use (at least 50% lower than current regulations). LÅGAN is a co-operative effort among the Swedish Energy Agency, the Swedish Construction Federation, the Region of Västra Götaland, Formas, the National Board of Housing, Building and Planning, private-sector clients, contractors and consultants. The total budget for LÅGAN is EUR 6.9 million, with the Swedish Energy Agency providing EUR 2.4 million and the other partners financing the balance.

Sweden promotes awareness of energy efficiency in the buildings sector, *e.g.* through the website www.energiaktiv.se, to educate the public on how to improve energy efficiency in buildings. In line with EBPD, an energy performance certificate (EPC) is required for large buildings with public functions or whenever a building is sold, rented or constructed.

The Swedish Energy Agency implemented (voluntary) policies, in particular through networks for the procurement of energy-efficient technology. Regional and municipal programmes are in place to improve energy efficiency in existing buildings.

INDUSTRY

Industry accounts for the largest share of TFC in Sweden. There are several policies in place to increase energy efficiency in industry. At the same time, energy-intensive industry accounts for 9% of GDP in Sweden with all export-oriented sectors contributing to 50% of GDP.

In January 2010, the government introduced an energy audit support scheme for SMEs. The scheme targets SMEs in the manufacturing and agricultural sectors, but all enterprises with an energy use over 500 MWh per year are eligible. More than 450 enterprises participated in this scheme that supports 50% of the costs of an energy audit (capped at SEK 30 000). The data from the audit are collected and verified by the Swedish Energy Agency.

The Programme for Energy Efficiency in Energy-Intensive Industry (PFE) continued after 2009. Companies under PFE are exempted from the EU minimum tax on electricity (in total SEK 145 million per year) and in return commit to an energy management system, energy audits and other measures to increase efficiency. Under the new EU environmental state aid rules, PFE is allowed to be continued for the companies that are already under the scheme also for the period 2009-14. In total, more than 100 energy-intensive companies representing 75% of industrial energy use achieved around 1.45 TWh in electricity savings with an investment of SEK 708 million over the previous five-year period.

National, regional and local networks have been created to enhance energy efficiency of SMEs, to develop methodology and energy-efficient technology as well as to promote the dissemination of best practices. There are national networks for energy-intensive SMEs, while regional and local networks cover all enterprises. These networks involve the regional energy offices and the local energy advisors. One example is the network Energy Efficiency in the Sawmill Industry, EESI, which started in 2010. A 20% decrease in energy use within the Swedish sawmill industry would mean a 1 200 GWh savings in heat-energy plus 300 GWh savings in electricity. For the sawmill industry, this means a total financial savings potential of SEK 390 million.

Within the area of energy services, the Swedish Energy Agency supports the development of energy performance contracting by analysing the market structure, required market conditions and business models.

Sweden currently assesses options to implement the requirements relating to energy efficiency in industry that are included in the EU Energy Efficiency Directive 2012/27/EU which was adopted in October 2012, such as the assessment of the potential for high-efficiency co-generation and district heating and cooling , and the obligation on energy providers to save energy.

ASSESSMENT

Sweden promotes energy efficiency with a comprehensive set of fiscal (energy and carbon dioxide taxation), financial (energy efficiency funding) and legislative as well as voluntary measures. These are supported at local, regional and national levels across all sectors. The strong local and regional commitment and the co-operation with industry, services and academia, in particular in industrial programmes and RD&D projects, have been success factors of the Swedish model which the IEA commends.

In many ways, Sweden's energy efficiency policy is exemplary. It is based on strong local and regional initiatives, for instance through the work of fourteen regional energy agencies, the energy and climate advisors, with local and regional energy and climate strategies and targets, energy audits of SMEs and households, and the best-practice sharing among networks of industries. Many of these elements have become new requirements in the EU Energy Efficiency Directive 2012/27/EU which was adopted in October 2012.

Since the last review, Sweden strengthened minimum energy performance requirements for buildings, appliances and lighting, promoted low-energy buildings, further supported RD&D activities in transport and industry (*e.g.* efficient-vehicle and industrial programmes). The IEA welcomes all these developments.

Co-ordination of the energy efficiency measures has been put in place with the creation of the Energy Efficiency Council under the umbrella of the Swedish Energy Agency. Sweden should continue these efforts to achieve a well co-ordinated energy efficiency policy. The work of the regional energy agencies and energy and climate advisors can further benefit from continuously sharing the best practices between the different regions and municipalities of Sweden.

The country aims to save 9% of total final consumption up to 2016 from 2001-05 levels and reduce its energy intensity by 20% up to 2020 from 2008 levels. Sweden is on track to achieve and is likely to exceed its interim energy savings target with 15% by 2016, but will need to do more to achieve the 20% reduction in energy intensity by 2020.

The country should evaluate the results and synergies of the different policies with a view to prioritise and scale up activities according to their potential for cost-effective and substantial energy savings, in particular in industry, buildings and the transport sectors. Energy efficiency policies will be an important element towards achieving a 40% reduction of GHGs by 2020 and zero net emissions in 2050.

Industry

Sweden kept industry consumption stable despite industrial production growth thanks to increasingly efficient processes. Industry, however, accounts for the highest share in TFC. The IEA commends Swedish policies for improved energy management in industry with audits in SMEs co-financed by the Swedish Energy Agency. To further foster their performance, the IEA recommends introducing the certification of energy managers and auditors to ensure high-quality, standardised and industry-specific information provided by qualified and trained individuals or companies.

Sweden is right to consider new policies to support private finance of energy efficiency upgrades through risk-sharing or loan guarantees, or through creating a market for energy performance contracting. However, large industry is shielded from price signals with some installations receiving free allowances under the EU-ETS in line with EU carbon leakage policies or tax exemptions. Therefore, it is important to encourage programmes that aim to further develop the best-practice sharing among industry, technology transformation, and innovation, including for the implementation of the new Energy Efficiency Directive 2012/27/EU. Technology roadmaps can provide an opportunity to create a shared vision for the technologies that are needed for further efficiency gains and emissions reductions.

Buildings, appliances and equipment

Since the last in-depth review, Sweden revised its building code, introduced energy performance certificates for buildings, supported the demonstration of low-energy and zero-energy buildings, promoted networks for the procurement of energy-efficient technologies and regional and municipal programmes to improve energy efficiency of existing buildings. The IEA commends these achievements.

Efforts in the public sector on existing buildings will be of key importance to achieve large-scale energy efficiency gains up to 2020. The government is right to focus on the public- sector role in energy efficiency management.

The government aims to task the Swedish Energy Agency with the preparation of a national renovation strategy together with the National Board of Housing, Building and Planning by the end of 2013 for adoption in spring 2014. In addition, it plans to evaluate by end 2015 the implementation of the current building codes and the nearly zero-energy building concepts. In the context of the national renovation strategy, Sweden should consider further financial mechanisms and policies to encourage building retrofits, including policy programmes promoting the use of renewable energies in public buildings.

Sweden should also set an ambitious timeline and a mandatory energy efficiency renovation rate as well as an action plan towards zero-energy buildings. Sweden should consistently collect data on the building stock and support cost-effective energy efficiency retrofits across its RD&D policy.

With regard to appliances and equipment, the IEA welcomes Sweden's Test Lab active role in conducting market surveillance and providing quality control. It will be essential to enhance the co-operation and information sharing with other European test labs and to take swift action against non-compliant products.

Sweden leads in the deployment of smart meters and the development of a smart grid. The country has almost completed the roll-out of the first generation of smart meters. The introduction of hourly metering for households as of October 2012 equips energy consumers with the possibility to use energy more efficiently and charge an electric vehicle. The government should ensure that the meters will provide consumer benefits and that no barriers are created for new entrants or supplier switching, and that potential service providers can have access to the data subject to guaranteed privacy.

Transport

The transport sector accounts for a large portion of Sweden's TFC (24%), with 59% of all oil supplies are used by transport and oil accounting for 90% of TFC, while electricity, gas, renewable sources remain at a marginal share. Transport is the largest CO_2 emitter in the country (40%). Against this background, Sweden's vision to have a vehicle fleet that does not depend on fossil fuels in 2030 is ambitious.

As in many IEA member countries, energy savings in the Swedish transport sector are driven by the need to reduce emissions and save high fuel taxes. Renewable energy, like ethanol and biodiesel, are playing an increasing role in blends in Sweden.

The IEA commends the good policies in place to stimulate energy-efficient vehicle driving and clean public transport. Sweden has an active eco-drive programme and several tax incentives in place to encourage the purchase of more efficient vehicles, such as low-emission and flexible-fuel cars. The EU cap for fleet average CO_2 emissions of 130 g per km from new passenger cars will apply in full in Sweden from 2015 onwards.

One area where Swedish industry has a competitive advantage is in the production of efficient heavy-duty vehicles (HDV). The government should continue to support ambitious policies within the EU to set mandatory fuel economy standards beyond Euro VI (which is applicable as of 2013) and to phase in a mandatory infrastructure charge.

Sweden has to urgently take action if it wants to achieve its 2030 priority. Current policies are unlikely to lead to significant GHG emissions reductions in transport, despite new cars becoming more efficient. The IEA considers it important that Sweden urgently develops a long-term policy for the role of renewable sources in the transport sector.

Regional and local programmes

The IEA commends the activities by the municipalities and county councils and the reinforced financial and technical support by the Swedish Energy Agency to develop energy efficiency strategies. The Sustainable Municipality Programme continuously supports leading municipalities with information and network platforms. The engagement with the financial sector in these programmes could further stimulate private-sector energy efficiency financing.

Finally, Sweden should continue its efforts and commitment to fully implement the IEA policy recommendations for improving energy efficiency (Box 2).

Box 2. **IEA 25 energy efficiency policy recommendations**

To support governments with their implementation of energy efficiency, the IEA recommended the adoption of specific energy efficiency policy measures to the G8 summits in 2006, 2007 and 2008. The consolidated set of recommendations to these summits covers 25 fields of action across seven priority areas: cross-sectoral activity, buildings, appliances, lighting, transport, industry and power utilities. The fields of action are outlined below.

1. The IEA recommends action on *energy efficiency* across sectors. In particular, the IEA calls for action on:

- data collection and indicators;
- strategies and action plans;
- competitive energy markets, with appropriate regulation;
- private investment in energy efficiency; and
- monitoring, enforcement and evaluation.

2. *Buildings* account for about 40% of energy used in most countries. To save a significant portion of this energy, the IEA recommends action on:

- mandatory buildings codes and minimum energy performance requirements;
- net-zero energy consumption in buildings;
- improved energy efficiency in existing buildings;
- building energy labels or certificates; and
- energy performance of building components and systems.

Box 2. **IEA 25 energy efficiency policy recommendations** (continued)

3. *Appliances and equipment* represent one of the fastest growing energy loads in most countries. The IEA recommends action on:

- mandatory minimum energy performance standards and labels;
- test standards and measurement protocols; and
- market transformation policies.

4. Saving energy by adopting efficient *lighting technology* is very cost-effective. The IEA recommends action on:

- phase-out of inefficient lighting products; and
- energy-efficient lighting systems.

5. To achieve significant savings in the *transport sector,* the IEA recommends action on:

- mandatory vehicle fuel-efficiency standards;
- measures to improve vehicle fuel efficiency;
- fuel-efficiency non-engine components; and
- transport system efficiency.

6. In order to improve energy efficiency in *industry*, action is needed on:

- energy management;
- high-efficiency industrial equipment and systems;
- energy efficiency services for small and medium-sized enterprises; and
- complementary policies to support industrial energy efficiency.

7. *Energy utilities* can play an important role in promoting energy efficiency. Action is needed to promote:

- utility end-use energy efficiency schemes.

Implementation of IEA energy efficiency recommendations can lead to huge cost-effective energy and CO_2 savings. The IEA estimates that, if implemented globally without delay, the proposed actions could save around 7.6 Gt CO_2 per year by 2030. In 2010 this corresponded to 17% of annual worldwide energy consumption. Taken together, these measures set out an ambitious road map for improving energy efficiency on a global scale.

RECOMMENDATIONS

The government of Sweden should:

- ☐ *Review energy efficiency policies with the view to prioritise and scale up high-potential, cost-effective energy-saving measures for the 2030 and 2050 objectives.*
- ☐ *Increase energy efficiency across the whole energy system, by mobilising demand-side services, fostering the use of renewable energy in buildings, promoting energy savings in industry and energy efficiency in the heat sector.*

- ☐ *Consider measures that encourage private finance and enable the market for energy performance contracting to further improve energy efficiency in the industry sector.*
- ☐ *Evaluate progress in renovation and consider future tightening of minimum energy performance requirements in building codes, with the goal of reaching zero-energy buildings. Publish clear guidelines for the enforcement of building energy codes that include a review of compliance at the design stage and after building construction.*
- ☐ *Collaborate with private financial institutions to develop frameworks that facilitate energy efficiency financing, particularly for deep building retrofits.*
- ☐ *Take leadership to promote ambitious binding fuel-economy standards for heavy-duty vehicles within the EU.*
- ☐ *Implement a programme to certify energy managers and auditors to ensure that high-quality, standardised and industry-specific information is provided by qualified and trained individuals and companies.*

PART II
SECTOR ANALYSIS

4. FOSSIL FUELS AND PEAT

Key data (2011 provisional)

OIL

Crude oil production: None

Share of oil: 25.3% of TPES and 0.5% of electricity generation

Crude oil imports: 19 Mtoe (Russia 51%, Norway 20%, Denmark 15.5%, United Kingdom 7.4%)

Inland consumption: 12.4 Mtoe (transport 59.1%, industry 22.6%, power and heat generation 2.6%, services and agriculture 5.7%, residential 1.2%, other 8.8%)

NATURAL GAS

Production: None

Share of gas: 2.4% of TPES and 1.2% of electricity generation

Natural gas imports: 1.3 bcm from Denmark 100%

Inland consumption: 1.2 Mtoe (power generation 46.4%, industry 35.8%, residential 6.6%, transport 3.7%, other 7.6%)

COAL

Production: None

Share of coal: 4.1% of TPES and 0.8% of electricity generation

Coal imports: 3.1 Mt (Australia 36%, United States 21%, Russia 21%)

Inland consumption: 2 Mtoe (industry 29.3%, power generation 22.6%, other transformation and energy sector 48.1%)

PEAT

Production: 560 000 tonnes

Share of peat: 0.5% of TPES and 0.4% in electricity generation

Net imports: 365 000 tonnes

OVERVIEW

Swedish energy and climate policy is committed to reducing the share of fossil fuels in the heating and transport sectors. Sweden aims to have a vehicle stock that is independent of fossil fuels by 2030 and plans to phase out the use of fossil fuels in heating by 2020. The government sees a potential for natural gas as a transition fuel, primarily in industry and co-generation, when covered under the EU-ETS.

Sweden has no indigenous production of oil, natural gas or coal and needs to import all fossil fuels it consumes. The country has indigenous peat which it sees as a complement to the use of biofuels, with a positive impact on prices and security of supply.

Over the past decade, the use of fossil fuels declined in Sweden. Oil use in the Swedish energy system has halved since the 1970s, driven by security of supply concerns after the oil crisis, and the subsequent turn towards nuclear energy, thus replacing fuel oil and gasoil used in heating and power generation. The largest decline in oil use has been in power generation. Thanks to carbon dioxide and sulphur taxation, coal and oil use in district heating and electricity production has declined significantly.

In the transport sector, Sweden has been active in increasing the share of renewable sources to 9.8% in 2011 (calculated under the EU Renewable Energy Directive 2009/28/EC), close to its target of 10% by 2020. However, oil supply is forecast to remain important in the transport sector, but its share is expected to fall with increasing use of electricity and biofuels.

OIL

OIL SUPPLY

Oil is the third-largest fuel in total primary energy supply (TPES) after renewables and nuclear energy. In 2011, total primary oil supply was 12.4 Mtoe, accounting for 25.3% of the country's TPES. The share of oil in TPES is lower than in most IEA member countries, the estimated IEA average being 36% in 2011. For over a few decades, both the amount and share of oil in TPES have been decreasing (from 27.9 Mtoe or 71.8% of TPES in 1973 to 12.4 Mtoe or 25.3% in 2011). For the past five years, oil supplies to Sweden have remained stable (around 13 Mtoe) with the exception of a sharp decline during the 2009 recession which was followed by a quick recovery in 2010.

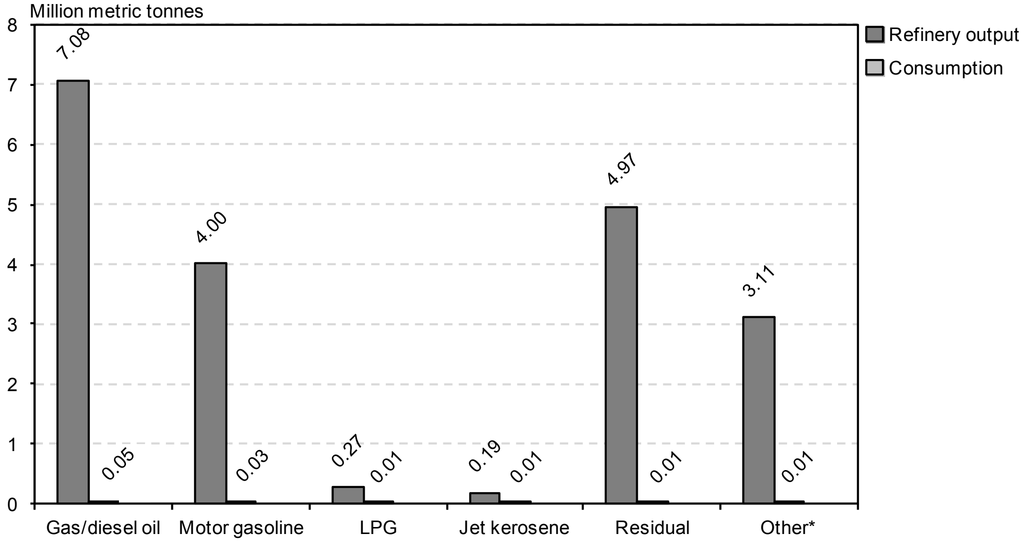
As Sweden has no indigenous oil production, it is 100% import-dependent. In 2011 Sweden imported nearly 19 Mtoe (18.8 Mt) of crude oil. More than half of crude oil imported to Sweden came from Russia and the rest was from the North Sea countries with 20% from Norway, 15.5% from Denmark and 7.4% from the United Kingdom. Russia is recently playing a growing role in Sweden's supplies, increasing its share from under 10% in the late 1990s to over 50% in 2011. Both Norway and the United Kingdom, the main crude oil suppliers to Sweden, decreased their exports.

As refining output exceeds domestic demand (13.5 Mtoe), Sweden is a net exporter of refined products. In 2011, refineries processed some 18.6 Mt of crude oil. Sweden exports gas/diesel oil, residual fuels and other oil products, by trading mainly with Denmark, Norway and the United Kingdom. In 2011, Sweden was a net importer of naphtha, ethane, jet kerosene and liquefied petroleum gas (LPG).

OIL DEMAND

Very little oil is used for electricity (0.5% of electricity generation) and heat production. Total oil use has declined at an annual average rate of 0.8% since 2000. In 2011, the total use of oil products in the residential and services sector amounted to 0.86 Mtoe, a reduction of 73.8% since 1990. Oil consumption in Sweden was at 12.4 Mtoe in 2011, when most of this was consumed in the transport (59.1%) and industry (22.6%) sectors (Figure 13).

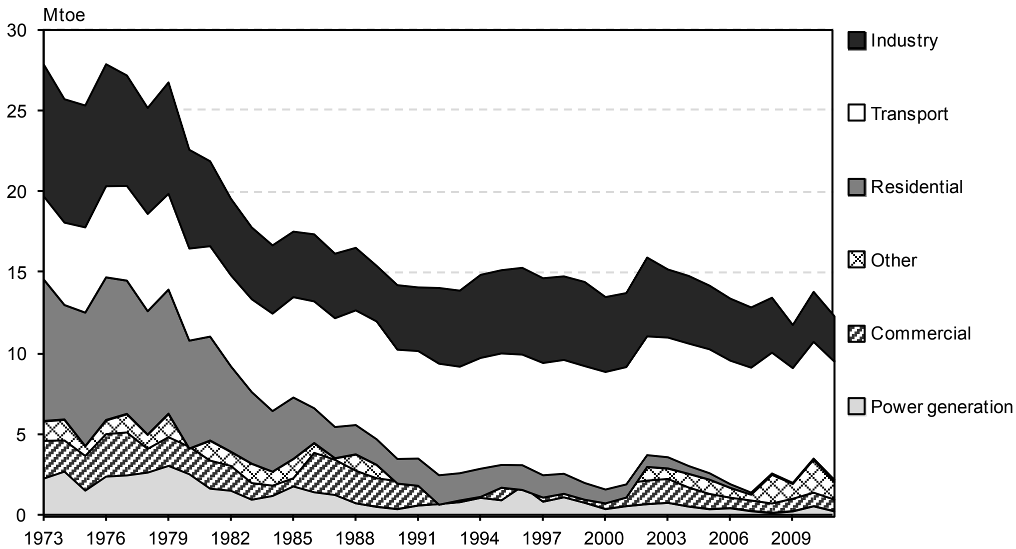
Figure 12. **Refinery output versus demand in Sweden, 2011**



* *Other* includes naphtha, bitumen, refinery gas, lubricants and other oil products.

Source: *IEA Monthly Oil Statistics*, 2012.

Figure 13. **Oil supply by sector*, 1973-2011****



* TPES by consuming sector. *Industry* includes non-energy use. *Other* includes other transformation and energy sector consumption. *Commercial* includes commercial, public services, agriculture/forestry, fishing and other final consumption.

** Provisional for 2011.

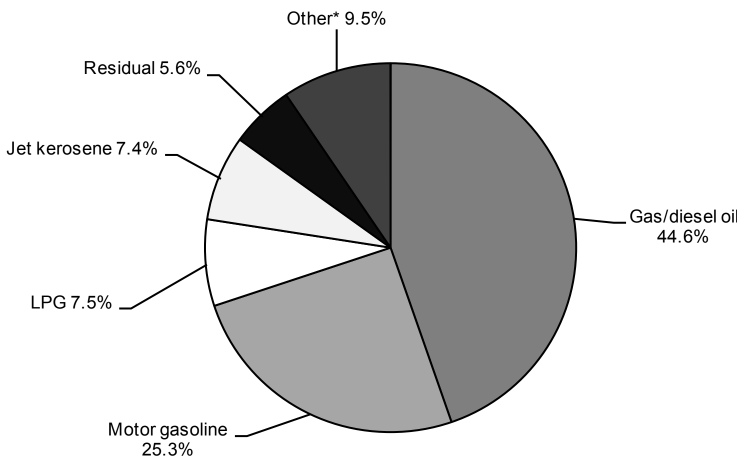
Source: *Oil Information*, IEA/OECD Paris, 2012.

The residential sector greatly decreased its oil demand by 83% from around 1 Mtoe in 2000 to under 0.2 Mtoe in 2011 over the past decade. While overall oil consumption has been on the decline, demand in the transport sector has increased since the 1970s, but remained constant over the past decade.

The mix of transport fuels has shifted substantially towards a greater share of diesel. The transition from gasoline to diesel in road transport can be largely attributed to EU regulations regarding CO_2 emissions for new cars (which favour diesel engines) and growth in the use of heavy duty vehicles. Total consumption for diesel grew at an annual average rate of 4.7% from 2000 to 2011, compared to a decline in demand for motor gasoline (-2.5% per year) over the same period.

According to the projections of the Swedish government, the share of oil in the transport sector is set to decline between 2010 and 2020. At the same time, the government expects that oil demand will become more concentrated on transport diesel.

Figure 14. **Oil consumption by product, 2011**



* *Other* includes aviation gasoline, biodiesels, biogasoline, ethane, lubricants and naphtha.

Source: *Oil Information*, IEA/OECD Paris, 2012.

OIL INFRASTRUCTURE

There are five refineries in Sweden with a total crude distillation capacity of roughly 435 thousand barrels per day (kb/d) at three sites. The largest of these, the refinery at Lysekil (Preem), has a crude capacity of 210 kb/d. Three refineries (Preem, St1 and Nynäs Refining) are located in Göteborg and together account for 45% of the country's total crude capacity. The fifth refinery (Nynäs Refining) is located south of Stockholm, at Nynäshamn. The Preem refinery at Lysekil underwent major upgrading over the past decade in order to produce greater volumes of sulphur-free gasoline and diesel oil. This has positioned Preem to be the biggest supplier of Mk1 diesel[11] in the Swedish market.

11. Sweden introduced environmental classifications in 1991 which divided diesel into three classes, Mk3, Mk2 and Mk1. Mk3 followed the European diesel standard, EN 590, while Mk2 and Mk1 held more stringent requirements on specific parameters. Mk2 was a fuel specification that some of the refineries could produce with minor upgrades, while Mk1, with a sulphur content of less than 5 ppm (parts per million), required large upgrades of all refineries. Within a few years Mk1 became the major diesel fuel used in Sweden and in 2010, some 97% to 99% of the diesel fuel sold is of Mk1 quality.

Figure 15. **Map of the Swedish oil infrastructure**

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Sweden has approximately 30 coastal and inland storage facilities with a combined total oil storage capacity of 15.2 mcm (Figure 15). Major depots are located in Göteborg, Lysekil, Gävle, Stockholm, Norrköping and Malmö, with a total storage capacity of nearly 65 million barrels (10.3 million cubic metres, mcm). These facilities play an important role in the domestic distribution of oil products from national refineries and import terminals. The remaining storage capacity (31 million barrels, mb) is spread over 22 storage sites located across the country.

There are three main ports for importing crude oil and the refinery feedstocks necessary to supply the country's refineries. The combined total capacity of these ports is roughly 450 kb/d, with the individual port capacities commensurate with the capacities of the refineries they serve. Imports of refined products flow primarily through six main ports, three of which are in the Stockholm area. The six ports have a total combined capacity to import over 190 kb/d of refined products.

Because of Sweden's small market and sparse population, the oil distribution infrastructure relies on road distribution rather than on pipelines. Currently, some 800 road tankers carry out secondary distribution to consumers and retail outlets.

OIL MARKET STRUCTURE

Three companies operate refineries in Sweden, with Preem AB operating the country's two largest refineries which together represent about 80% of the country's total distillation capacity. St1 operates the third-largest refinery, located in Göteborg, which was operated by Shell until the end of 2010. Nynäs Refining also operates two smaller refineries which are specialised in producing bitumen and lubricants.

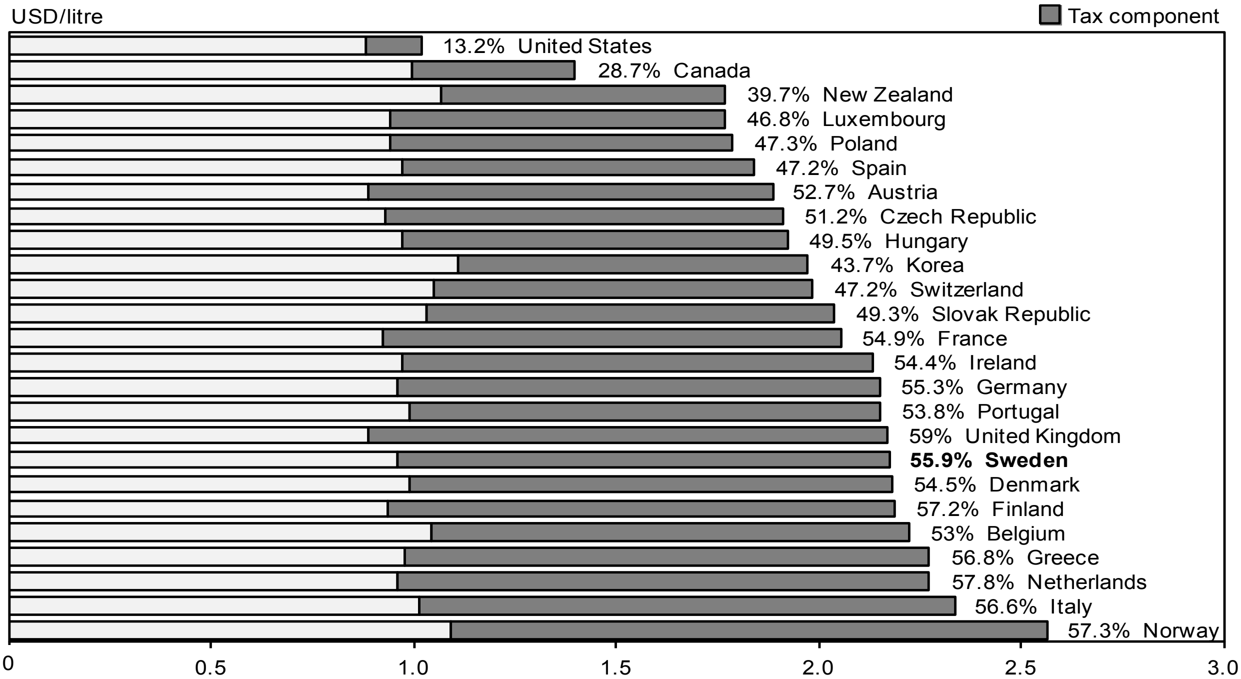
There are four companies in the Swedish oil market: Preem, Statoil, QK-Q8 and St1 (with retail stations branded Shell), which together accounted for roughly three-quarters of the market. Companies operating in the Swedish oil market are represented by SPBI, the Swedish Petroleum and Biofuels Institute.

OIL PRICES AND TAXES

Sweden operates a fully liberalised market for oil products. Wholesale and retail prices are mainly influenced by the relevant quotation prices and exchange rates, which are driven by global market fundamentals and expectations. The government's role in pricing is limited to determining the level of the excise tax and of the value-added tax (VAT). As in most IEA member countries, taxes on transport fuels are a major source of revenue for the State. High petrol and diesel prices are also a result of the energy and carbon dioxide taxes which have a strong environmental signal.

In 2012, Sweden's (unleaded) petrol prices were in the range of the IEA average (Figure 16); however, Sweden's diesel price was among the highest of IEA member countries, after Norway and the United Kingdom, as Sweden applies an energy tax on diesel which is differentiated according to classification (Figure 17). Since 1 January 2011, the tax on Mk1 is EUR 0.17 per litre, compared to EUR 0.20 and EUR 0.21 per litre for Mk2 and Mk3 respectively. Sweden's light fuel oil prices for households are the highest of the IEA member countries (Figure 19), with a tax component of 49%. This is mainly the result of the CO_2 tax which is levied at a constant rate for all three classifications, at EUR 0.33 per litre. At the same time, motor gasoline has an energy tax of EUR 0.34 per litre and a CO_2 tax of EUR 0.27 per litre.

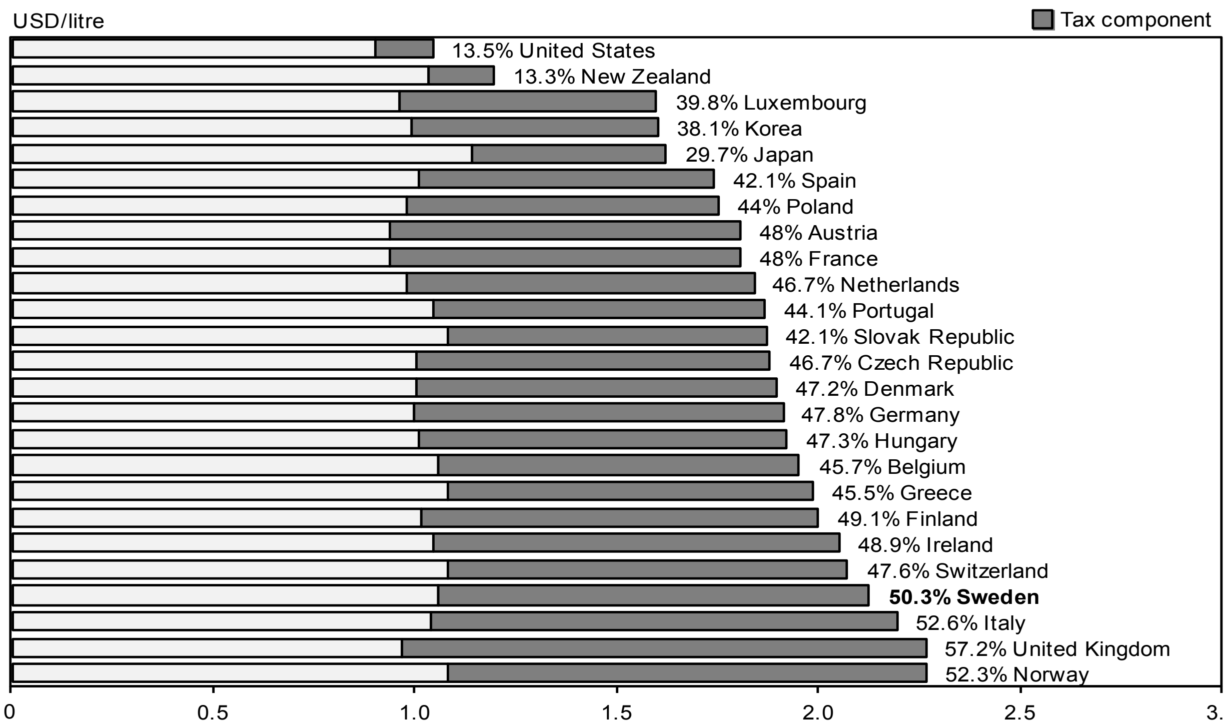
Figure 16. **Unleaded petrol prices and taxes in IEA countries, second quarter 2012**



Note: data not available for Australia, Japan and Turkey.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

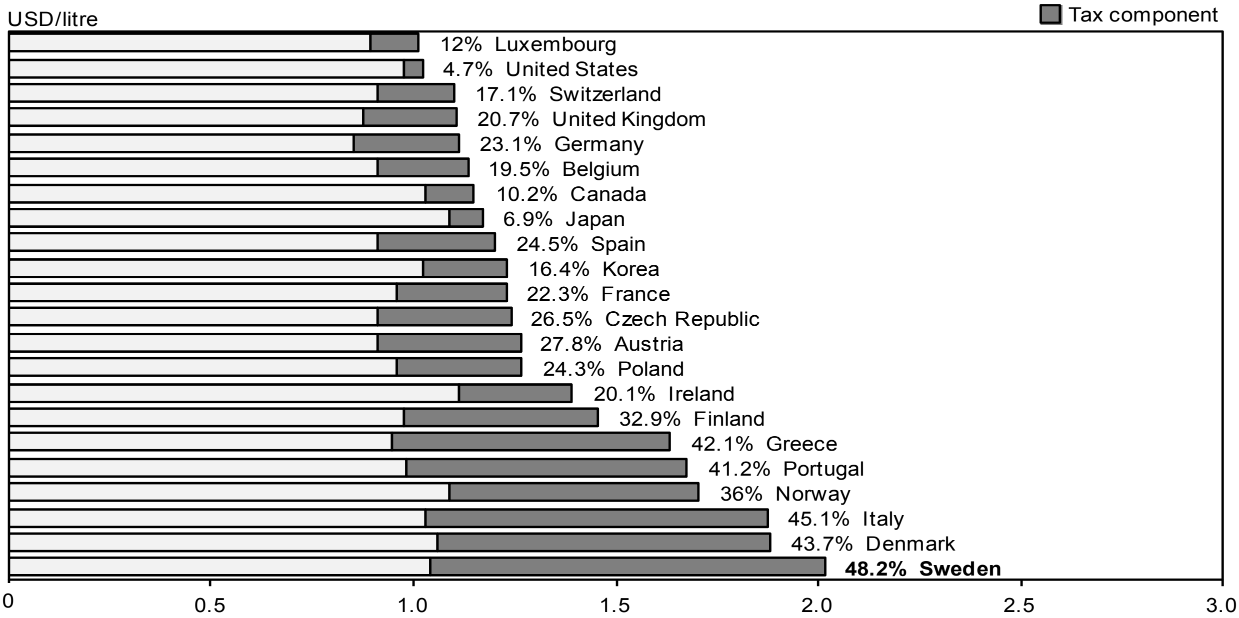
Figure 17. **Automotive diesel prices and taxes in IEA countries, second quarter 2012**



Note: data not available for Australia, Canada and Turkey.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

Figure 18. **Light fuel oil prices and taxes for households in IEA countries, second quarter 2012**



Note: data not available for Australia, Hungary, the Netherlands, New Zealand, the Slovak Republic and Turkey.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

SECURITY OF OIL SUPPLY

Sweden meets its stockholding requirements to both the IEA and the European Union by placing compulsory stockholding obligations (CSOs) on industry and major consumers. Compulsory stocks are commingled with commercial and operational stocks. Sweden has consistently met its minimum IEA stockholding obligation, with at the end of 2010 a total stock coverage of 118 days of 2010 net imports, 8 days of which were being held in other countries under bilateral agreements. Sweden has formal bilateral agreements with Denmark, Estonia, Finland, Ireland, the Netherlands and the United Kingdom.

CSOs are placed on deliveries to the domestic market of the main refined product categories (*i.e.* motor gasoline, kerosene, diesel and fuel oil). In addition to importers and domestic refiners, major consumers of these fuels (defined as consuming annually over 50 000 cubic metres), such as manufacturers and CHP plants, are subject to the stockholding requirement. A total of 29 companies had CSOs in the period from 1 July 2011 to 30 June 2012. Over 90% of the total CSO has been attributed to five companies, consisting of the four major oil companies and one major consumer from the mining industry. Roughly half of the remaining 24 companies with CSOs are combined heat and power (CHP) plants.

The Swedish Energy Agency (or its designated inspectors) is entitled to inspect the stocks held under the obligations, and can also examine the accounts and other documents relating to company stockholding operations. Any company failing to maintain compulsory stocks must pay the State a special storage penalty charge. This penalty charge corresponds to the estimated capital cost of the product for one month, plus a surcharge of 60% for failing to meet the requirement.

Sweden is currently adapting existing legislation with a view to transpose the EU Directive on Crude Oil and Petroleum Product Stockholding Obligations (Council Directive 2009/119/EC of 14 September 2009) into national law by 31 December 2012.

Among some of the changes envisioned is the intention to increase the limit of CSO covered by stocks held abroad from 20% to 30%. This would provide companies with greater flexibility in meeting the CSO, particularly in the case of motor gasoline and diesel. Allowing companies to cover a greater share of their CSO with stocks in other countries under bilateral agreements provides greater flexibility.

During a supply disruption and as a contribution to an IEA collective action, Swedish authorities would reduce the minimum obligation, thereby granting operators permission to draw stocks below the minimum level. The Swedish government can decide on these changes in the industry stockholding obligation, based on a draft government decision presented by the energy minister.

Following the government decision, the Swedish Energy Agency is to swiftly decide the maximum stockdraw of relevant stocks for each company as well as other specific conditions and immediately communicate the information to the oil companies. Each individual company would be left to take the commercial decisions on how to deal with the volumes of oil no longer bound by stockholding obligations.

NATURAL GAS

GAS SUPPLY

Natural gas plays a minor but increasing role in Sweden's TPES. In 2011, it accounted for 2.4% of Sweden's total primary energy supply (TPES) and 1.2% of electricity generation. Among the IEA member countries, this is the lowest share of gas in TPES and the third-lowest share in electricity generation.

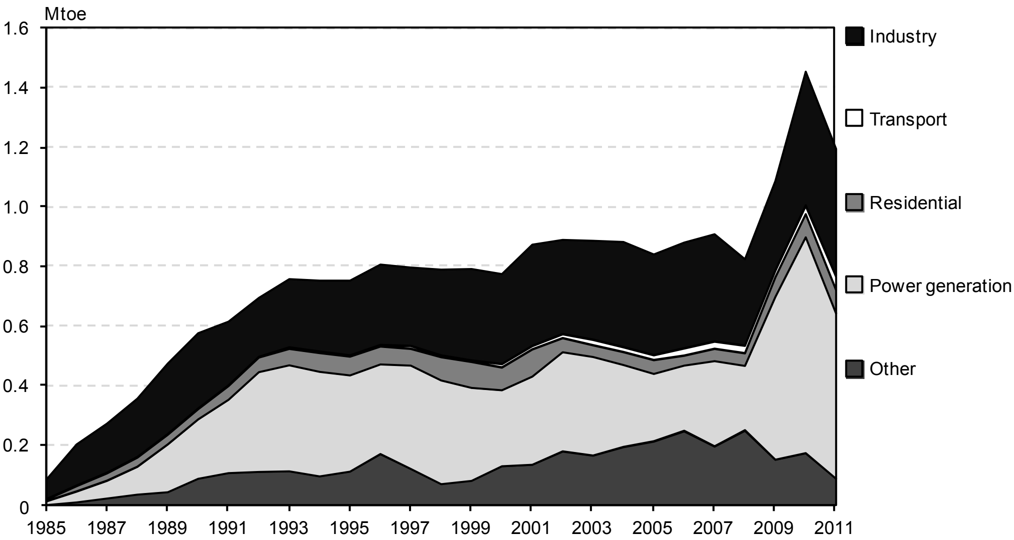
Since the introduction of natural gas in Sweden in the late 1980s, its share in TPES has been increasing steadily, faster than the share of biofuels, but below the growth rates of wind power. Its role in the supply of southern and western Sweden, through gas-fired combined heat and power plants and district heating, is much more substantial, accounting for around 20% of total energy use.

Sweden has no indigenous natural gas production. The potential of unconventional gas has been explored in the past years, but production economics remain low. Sweden imports all of its natural gas from Denmark's Tyra field through one pipeline (Dragör) connecting both countries. In 2011, imports stood at 1.3 billion cubic metres (bcm). Growing production of biogas emerged over the past years and is fed into the gas distribution network to a level of up to 1% to 2% of the gas distributed.

GAS DEMAND

Natural gas consumption in Sweden reached a record volume of 1.46 Mtoe in 2010, before falling slightly to 1.2 Mtoe in 2011. The increased gas consumption in 2010 was mainly due to the start of a large gas-fired CHP plant in 2009 and the cold weather during 2010. In 2011, the consumption was lower mainly because of warm weather. Gas demand in Sweden is driven by power generation in CHP plants and industry (Figure 19), mainly petrochemicals, which in 2011 accounted for 46.4% and 35.8% of the total, respectively. Around 60 large consumers, including nine co-generation plants (CHP and district heating), account for roughly 80% of total gas demand in the country. Households and other small consumers, in total around 34 000 located in the main cities of Göteborg and Malmö, account for only 2%.

Figure 19. **Natural gas supply by sector*, 1985-2011****



* TPES by consuming sector. *Other* includes other transformation and energy sector consumption. *Industry* includes non-energy use. Natural gas was not supplied until 1985 in Sweden.

** Provisional for 2011.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

LEGAL FRAMEWORK

The Swedish gas market is relatively small but developing since the introduction of natural gas in 1985 towards liberalisation in 2000 and its opening to competition in 2007.

As a member state of the EU, Sweden has to adapt its legislative framework, the Natural Gas Act, to transpose the EU Directive 2009/73/EC of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC (EU Gas Directive), while Regulation (EC) No 715/2009 of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005 and Regulation 994/2010/EC on security of gas supply apply directly. Sweden amended the Natural Gas Act in 2011 with complementary amendments made in 2012. The country has introduced ownership unbundling between the transmission and the trading of natural gas. The supply and distribution of natural gas are functionally unbundled.

The Swedish Energy Markets Inspectorate is the national regulatory authority (NRA) according to Article 39 of the EU Gas Directive which has to be responsible for approving and regulating tariffs and methodologies and ensuring third-party access to the gas transmission and distribution grid, and to storage and LNG facilities.

Sweden is currently preparing a proposal to the Parliament for early 2013 to introduce regulation providing for the ex-ante approval of tariffs by the Energy Markets Inspectorate.

In 2012, Sweden created a fully independent and privately owned transmission system operator (TSO) for its gas network. In 2009, E.ON Ruhrgas, Statoil, Dong Energy and Fortum sold their shares in Swedegas to the Dutch EQT Infrastructure Fund which now fully owns Swedegas. In late summer 2012, Sweden completed the certification of Swedegas as an ownership unbundled TSO. The country does not have a secondary market for transmission capacity, where unutilised capacity is made available for trading.

In the Swedish market model, capacity follows the customer and the supplier (or shipper) does not have to book capacity. The Swedish entry point is located in the Danish gas transmission grid, where shippers have access to capacity. The balancing regime is market-based owing to the considerable line-pack. The TSO has no flexibility contracts with suppliers or storage operators. Currently, the electricity TSO, Svenska Kraftnät, is responsible for the short-term daily balancing administration (nomination, matching and allocation of gas) and financial settlement, while Swedegas is responsible for the technical operation as well as the capacity allocation within the gas transmission system. This shared responsibility is likely to be changed in 2013.

In 2011, the Ministry of Enterprise, Energy and Communications envisaged the transfer of the present system-balancing authority from the electricity TSO Svenska Kraftnät to the new gas TSO Swedegas AB. At the end of 2012, a proposal is under preparation within the ministry which is to be presented to Parliament in early 2013.

The Swedish government does not finance or own any part of the gas networks. Any expansion of the gas transmission network, storages or LNG terminals has to be done on a commercial basis. The government takes the decision on the permit, subject to environmental and spatial planning provisions.

Within the regional framework, Sweden co-operates with European neighbours in Denmark, Germany, the Netherlands, Belgium, Luxemburg, France, Great Britain and Ireland to set in motion a common European gas market model by 2014, with primary focus on the common trading platform for capacity, with implicit auctions for the entire region.

GAS INFRASTRUCTURE

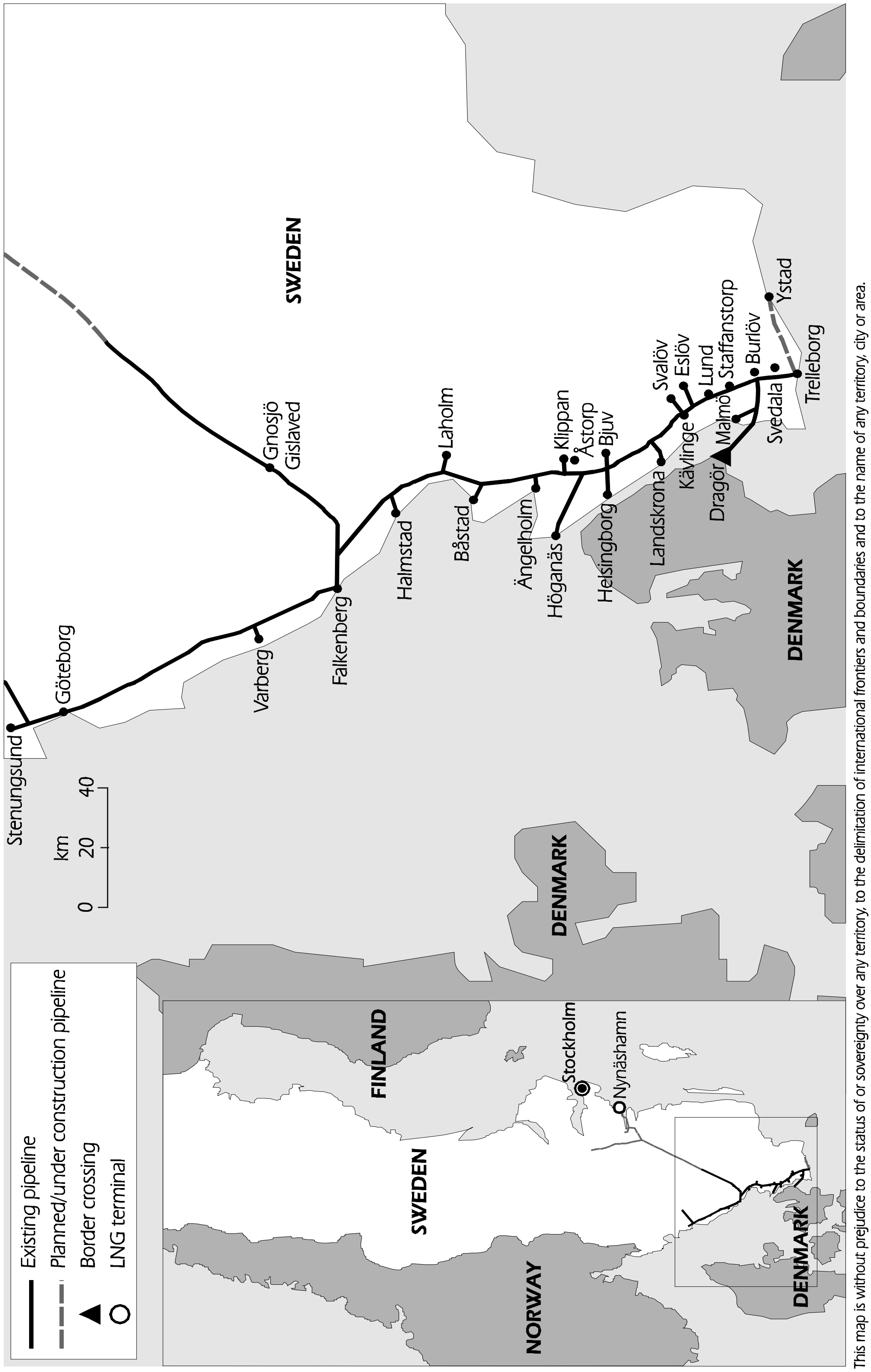
The Swedish transmission system for natural gas begins at Dragör in Denmark, crosses the Öresund via the Öresund pipeline to Klagshamn, south of Malmö, from where the trunk pipeline heads northward to Stenungsund (Figure 20). Branch pipes lead off from the trunk pipeline to various consumption areas. The Swedish natural gas network consists of approximately 620 km of transmission lines and roughly 27 200 km of distribution lines. The network also contains 39 metering and control (MC) stations.

All natural gas supplies enter the Swedish supply system via a single entry point from Denmark. As Sweden is at the end of the gas supply line from Denmark, there is no transit of natural gas through Sweden. The technical capacity of the Öresund trunk line is 9.10 mcm/d. An LNG receiving terminal was put into operation in mid-2011, at Nynäshamn, south of Stockholm in the East of Sweden. This terminal has a maximum capacity of 6 mcm/d, but is not connected to the gas transmission system in the south-west of Sweden and is not subject to the provisions of third-party access.

From the LNG terminal, gas is pumped into storage tanks on trucks at a temperature of minus 162 degrees Celsius and either transported directly to customers or to a pipeline link where it can be fed into an existing gas grid.

At present, there are no new gas cross-border interconnection projects planned. The Skanled gas pipeline project was suspended in 2009. However, two gasification plants for biofuel are planned and the government approved the expansion of the internal gas network at the branch line Småland (77 km from Gislaved to Jönköping) following application by E.ON. An LNG terminal is under construction in Lysekil on the Swedish west coast, adjacent to the existing Preem refinery, to be supplied with Norwegian gas. Another terminal is under planning in Göteborg, also on the west coast.

Figure 20. **Map of Sweden's high-pressure natural gas network, 2011**



Source: IEA.

There is only one small storage facility located in Sweden which is used for meeting peak demand. Located at Skallen, in southern Halland, it is a lined rock cavern with total working capacity of 9.20 mcm and a maximum withdrawal capacity, which varies from 0.60 to 0.90 mcm/d, depending on the pressure in the storage facility and the trunk pipeline. The withdrawal capacity corresponds to 10% to 20% of the gas requirement of the Swedish market under winter conditions.

The storage in Skallen is subject to regulated third-party access. There are no plans for additional storage capacity connected to the Swedish gas system. Sweden does not have any storage to provide for seasonal swings in natural gas demand. This is primarily provided for with the assistance of storage facilities in Denmark. There is a large flexibility in line-pack of about 25% of a winter's day consumption of the entire Swedish natural gas market.

GAS INDUSTRY STRUCTURE

The wholesale market has four actors who share the market as follows: E.ON Gashandel Sverige AB (market share of 41 %),[12] owned by E.ON AG, Dong Energy (22%) principally owned by the Danish State, Göteborg Energi AB (22%), owned by municipality of Gothenburg and Modity Energy Trading AB (15%), owned by Öresundskraft AB and Lunds Energi AB. In 2011, the volume of natural gas sold was approximately 15 TWh, mainly because of the new gas-fired CHP plants that came into operation in Sweden.

The retail gas market has five players, out of which three, E.ON Gashandel Sverige AB, Dong Energy AB and Göteborgs Energi AB, held just under 85% of the market in 2011.

In total, Sweden has five distribution system operators (DSOs) with the largest being E.ON Gas Sverige AB, next to Göteborgs Energi Gasnät AB, Kraftringen Nät AB, Varberg Energi AB, and Öresundskraft AB. Except for E.ON Gas Sverige AB, all DSOs are owned by municipalities.

GAS PRICES AND TAXES

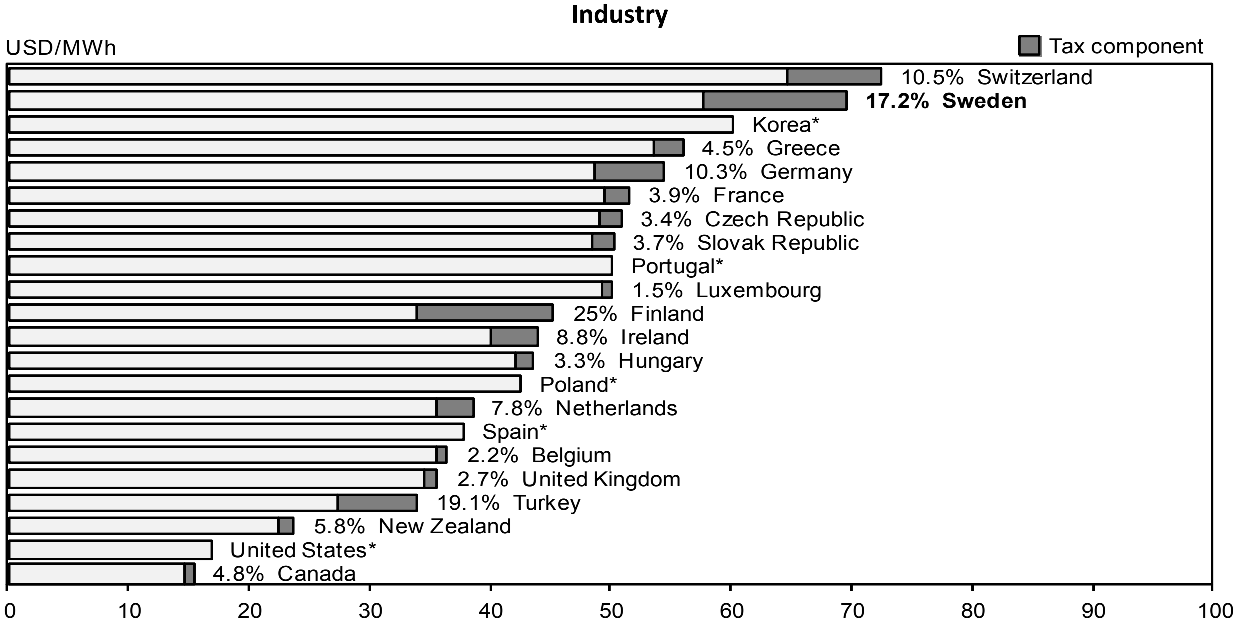
By international comparison, Sweden is the country with the highest gas prices for households (USD 164 per MWh) and ranges second-highest for industry customers (USD 70 per MWh), after Switzerland.

The high prices are driven by both the high network cost, the high tax component (44.3% for households) and gas supply prices accounting for a quarter of the final price (Figure 21).

In 2011, the gas supply price (24%) increased for households, mainly as the cost of natural gas increased in the range with international oil and gas prices. The network tariff accounted for 42% of the price, while energy tax and VAT together represented 34%. The total cost of natural gas for a household in 2011 amounted to SEK 1.10 per kWh for a household with gas heating, with a yearly consumption of 5 500 to 55 000 kWh per year. This is mostly because of the small size of the Swedish gas market and the limited access to other EU gas wholesale markets, plus a low diversification of the import portfolio (Sweden relies 100% on Danish gas imports and prices). Distribution companies tend to be small, and large consumers are few, implying that the fixed costs of the gas network are spread among fewer customers than in many other countries.

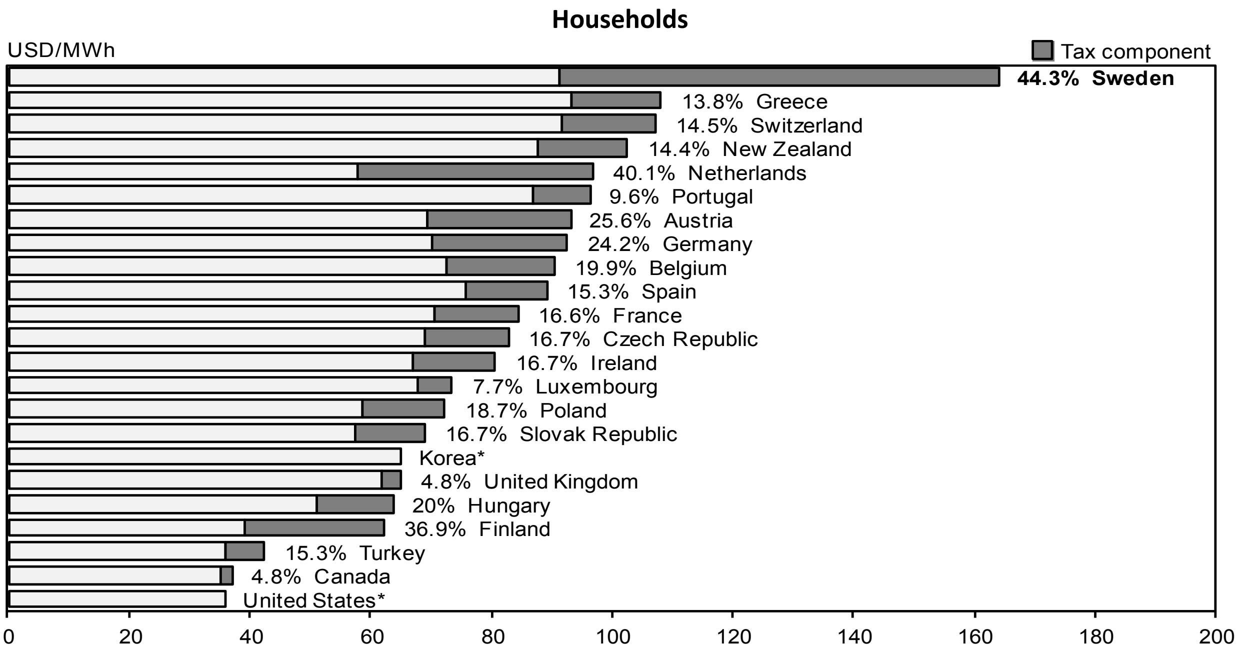
12. The E.ON Gashandel Sverige AB market share does not take into account that a part of this volume is sold to other companies in the E.ON Group, which in their turn have resold the natural gas to end-users.

Figure 21. **Natural gas prices in IEA member countries, 2011**



* Tax information not available for Korea, Portugal, Poland, Spain and the United States.

Note: data not available for Australia, Austria, Denmark, Italy, Japan and Norway.



* Tax information not available for Korea and United States.

Note: data not available for Australia, Denmark, Italy, Japan and Norway.

Source: *Energy Prices and Taxes,* IEA/OECD Paris, 2012.

In 2011, 281 households switched natural gas supplier, a 6% decrease over the previous year. The total number of switches continues to remain at a low level and is equivalent to almost 1% of the total number of domestic customers.

SECURITY OF GAS SUPPLY

Swedish emergency response policy for natural gas is based on the new EU Regulation No 994/2010, the Swedish Natural Gas Act and Natural Gas Ordinance which set statutory powers for balancing the domestic gas network in times of crisis and the standards under which supplies to protected customers are to be safeguarded.

The 2006 Natural Gas Ordinance establishes responsibilities under the Natural Gas Act, making the Swedish Energy Agency the competent authority for establishing and maintaining a national strategy for gas emergencies and for appointing Svenska Kraftnät (SvK) as the system-balancing authority. As explained above, this role is likely to be moved to the new gas TSO, Swedegas, in 2013. In 2011, Sweden informed the European Commission that the Swedish Energy Agency will remain the competent authority under Regulation (EU) 994/2010.

In line with EU Regulation No 994/2010 Sweden developed a national preventive action plan and an emergency plan, in consultation with Denmark, and presented them to the European Commission in December 2012. The plans build on the emergency provisions in place by system operators and the system-balancing authority, and include priority schedules for customer supply interruptions, as well as an evaluation of the potential and the possible timing of the ability of large consumers to switch away from gas.

Concerning the security of natural gas supply, during a gas disruption, the physical balance of the gas system would be maintained by restricting or discontinuing supplies to non-protected customers. System operators (TSOs, DSOs) are obliged to have in place crisis plans for dealing with emergency situations, including a strategy for reducing supplies to customers.

Peak day demand during the winter period can reach 8 mcm per day or more than 200% of the average demand during the year. During the summer period, the demand could be as low as 30% of the average demand. The difference is mainly a result of the large market share of CHP and district heating plants. These plants normally do not use natural gas during the warmer part of the year. Large CHP plants, district heating plants and some of the larger industries have the technical ability to use alternative fuels, *i.e*. oil. The system-balancing administrator has the power to order the proprietor of natural gas networks to restrict or discontinue the transmission or distribution of natural gas to customers.

EU Regulation 994/2010 and the Natural Gas Ordinance set the circumstances under which supplies to protected customers are to be safeguarded. These include: a partial disruption of supplies for up to 24 hours; supplies during the winter period (running from the beginning of December to the end of February); and during periods when temperatures are 4°C to 5°C less than the normal winter temperatures (1-in-20 winter).

In accordance with EU rules, Sweden defines protected customers as all households and small consumers connected to the gas distribution network. Approximately 34 000 customers fall under this definition and collectively they account for 2% of total natural gas consumption.

Means for responding in a crisis include utilising line-pack, maximising the input of biogas supplies into the network, and drawing on available gas volumes in storage. Sweden estimates that these measures could maintain supplies to the entire Swedish gas market during a total supply cut lasting less than 24 hours during high demand. The disconnection of large users of natural gas remains the most important measure for safeguarding natural gas supplies to protected customers in a gas crisis. In this case, supplies to protected customers could be maintained for one month in the case of high demand, and for several months in the case of low demand.

A total of some 60 large natural gas consumers can potentially be cut off from supplies very rapidly in an emergency, the equivalent of nearly 85% of total gas demand in Sweden. Large CHP units which constitute almost half of all gas demand in Sweden have the capacity to quickly switch from natural gas to gasoil. Large industries, representing another quarter of total gas demand, also have the capacity to switch to other fuels, primarily fuel oil. There are no requirements on gas users with fuel switching capability to keep specific stocks of alternative fuels. The new LNG terminal near Stockholm is not connected to the transmission grid and thus cannot provide for any backup of large industrial costumers.

Under the EU Regulation No 914/2009, member states have to ensure that their gas infrastructure is robust enough to make up for the disruption of the largest gas infrastructure (N-1), either by reinforcing their infrastructure or providing for demand-side management or a regional approach. Under this regulation, Sweden has derogation from this N-1 standard, as it has only one interconnection and a small gas market. The obligation to make interconnection points physically bidirectional is not considered to be of use for the connection to Denmark, as Sweden has no indigenous production.

Undoubtedly, the main challenge remains the diversification of gas supplies in the medium to long term, with declining production of the Danish Tyra field. In order to ensure continuous security of gas supply, Sweden should anticipate the projected decline of Danish natural gas production and monitor the development of new supplies to Denmark, regional gas market developments and the need for overall diversification.

COAL

COAL SUPPLY AND DEMAND

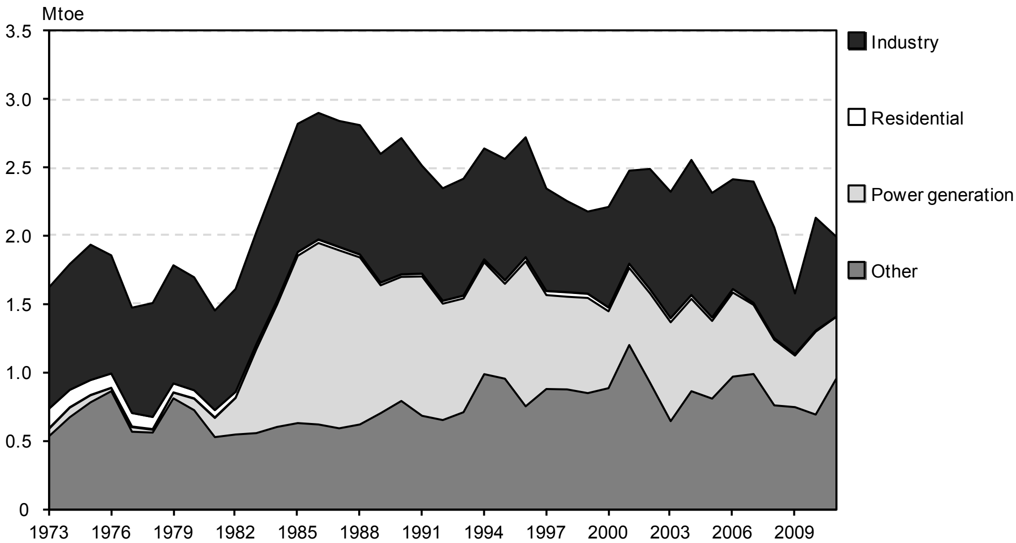
Out of the different coal types, Sweden almost exclusively consumes hard coal: in the form of coking coal, which is used to produce coke, coke-oven gas and blast-furnace gas, and steam or energy coal. Hard coal is primarily used in iron, steel and cement industries, and to some minor extent in CHP in the district heating sector. All primary coal supplied to Sweden was imported. Australia was the largest hard coal supplier, providing 36% of imports, followed by the United States (21%) and Russia (21%). Coke is produced in Sweden, from imported coking coal. The energy coal was imported mostly from Russia and Poland.

Compared to other IEA member countries, Sweden had the fifth-lowest share of coal in TPES after Switzerland, Luxembourg, Norway and France in 2010. Coal use in Sweden peaked in 1986, supplying 2.9 Mtoe or 6% of TPES; it has gradually decreased to around 2 Mtoe or 4.1% of TPES in 2011.

Coal use in the electricity sector (0.8% of electricity generation) is limited to a few CHP plants. The decline of coal use for district heating follows from the introduction of energy, carbon dioxide and sulphur taxes and to some extent from the investment support for biomass-based CHP. The use of coal in the Swedish district heating sector declined in the 1990s as it was being replaced by biofuels. Two of the major CHP plants located in Västerås and Stockholm still use coal as fuel, as CHP plants have a lower taxation compared to heat-only plants.

In 2011, around 29% of coal in Sweden was consumed by the industry sector, mostly by Sweden’s energy-intensive industries, mainly the large iron and steel industry, and cement, mining and pulp and paper industries. The country has ample iron ore resources, and converting them into steel requires coal (mostly in the form of coke) as a process input. Iron and steel producer SSAB in Luleå and Oxelösund is the main importer of metallurgical coal and the only producer of coke. Cementa is the dominating cement producer with foreign (German) ownership. LKAB mining (iron ore products) is 100 % government-owned.

Figure 22. **Coal supply by sector*, 1973-2011****



* TPES by consuming sector. *Other* includes other transformation and energy sector consumption. *Industry* includes non-energy use. *Residential* is negligible.

** Provisional for 2011.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

The EU-ETS system is putting a carbon price on coal use. To avoid negative impacts on the international competitiveness of Sweden's steel industry, the government has favoured steel plants in the National Allocation Plan (NAP 2008-12) of the EU-ETS. In the third trading period, industry in Sweden (outside heat or electricity production) will receive some free allocation of allowances, based on harmonised product benchmarks.

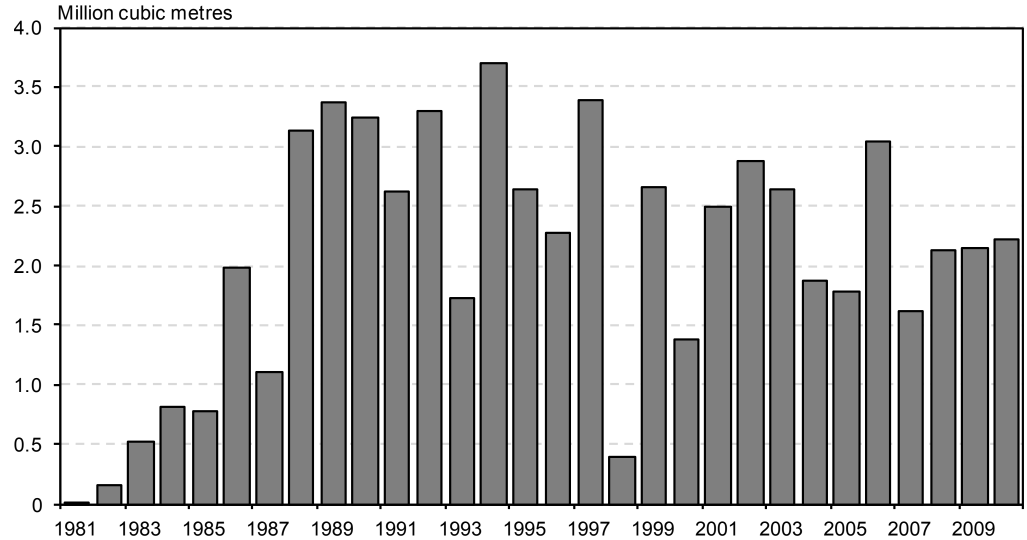
PEAT

DEMAND AND SUPPLY

In 2011, peat accounted for 0.5% of Sweden's TPES, a slight decline from 0.7% in 2010. Indigenous peat is harvested both for energy and horticultural use. The yearly differences in the harvested volumes are due to different weather conditions. In 2010, 2.2 mcm peat for energy use was harvested (Figure 23). The harvesting of peat for horticultural use in 2010 amounted to 1.25 mcm.

There are around 15 producers of peat for energy use across the country. Trade is usually regulated by means of contracts running over several years. There is also a spot market as a consequence of especially productive years.

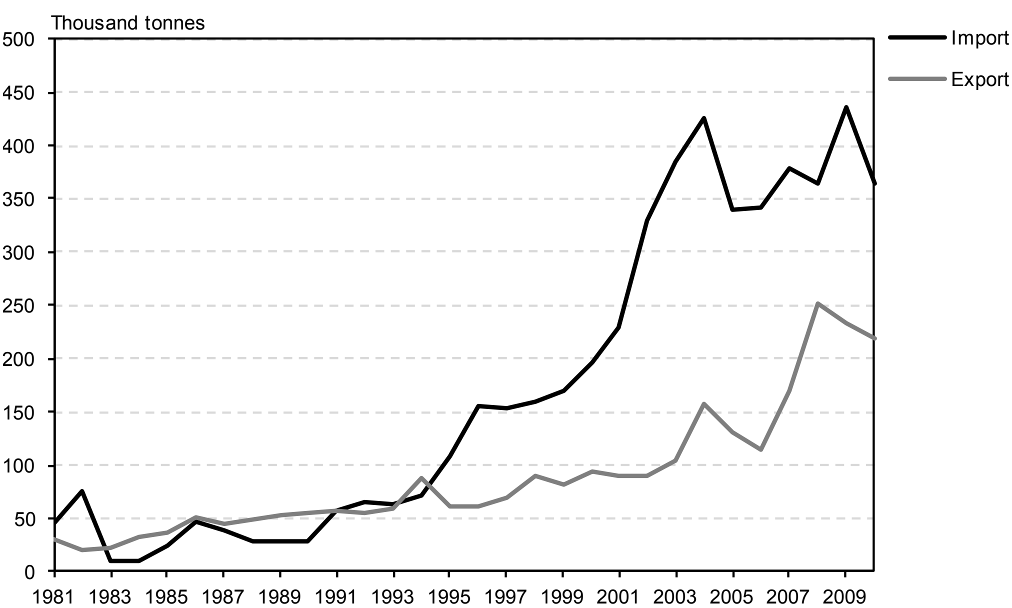
Figure 23. **Production of peat for energy use, 1981-2010**



Sources: SCB; SGU.

The leading supplier of peat in Sweden is Neova AB, holding 65 peat concessions and supplying 23 combustion installations, with approximately 250 employees. Neova AB is part of the Finnish Vapo Group, the world's leading supplier of peat with production in Finland, Sweden and Estonia. The Finnish State owns 50.1% of the shares in the parent company, Vapo Oy, and Suomen Energiavarat owns 49.9%.

Figure 24. **Imports and exports of peat, 1981-2010**



Sources: SCB, Utrikeshandel.

Peat imports vary greatly from year to year (Figure 24). In 2010, Sweden imported 32% of the energy peat it used. Total imports in 2010 amounted to 365 000 tonnes, a decline of 16% from 2009, with around 68% coming from Belarus and 21% from Finland. The export consists mainly of horticultural peat and amounted in 2010 to 218 000 tonnes, a decline by 6% from 2009, and went mainly to the Netherlands, Finland, Denmark, Belgium and Norway.

Total peat use for energy production in 2010 has remained constant since 2008 at 4.3 mcm or 330 000 tonnes. In 2010, the main energy peat use was for heat production in heat boilers, while only 25% was used for electricity generation in CHP plants. Around 30 of the larger heat plants and 22 CHP plants use peat as fuel. The vast majority of these apply co-generation with biofuels. A smaller amount was used for extraction of minerals and in the manufacturing industry.

PEAT SUPPORT POLICIES

Peat is an indigenous fuel resource available in Sweden, thus contributing to the security of supply of the country as well as to employment and economic activity in some Swedish regions.

Sweden considers that the use of peat under specific circumstances and in a lifecycle perspective can have a net positive effect on the climate. Peat is also considered to have qualities that improve the combustion process, when peat is co-fired with solid biomass, by reducing slag formation, sintering, build-up of deposits and corrosion in boilers.

The combustion of peat in approved CHP plants has been granted support under the Swedish electricity certificates system for promoting renewable energy and peat since 1 April 2004. Sweden exempts peat from carbon dioxide and energy taxation. However, a sulphur tax is charged on peat and the emissions from peat combustion are subject to EU-ETS system.

ASSESSMENT

OIL

Oil continues to be the most important fossil fuel in Sweden. In 2011, oil supply amounted to 12.4 Mtoe, accounting for 25.3% of TPES. The share remains below the IEA average. Sweden's policy to reduce oil use for space heating complemented by a stronger focus on refining and exporting oil products has been successful. Oil is hardly used for heating anymore and it has practically no role in electricity generation. The IEA encourages Sweden to continue this decarbonisation policy also in other sectors.

Transport is the largest oil user and, therefore, the largest CO_2 emitting sector. The government is addressing this issue with a suite of measures, indirectly with high taxes on petrol and diesel that contribute to steer consumer demand. Alternative fuels have gained ground considerably and the country's medium-term priority is to have a vehicle stock that is independent of fossil fuels by 2030. Electric vehicles are an alternative to oil-based transport. Sweden has a good starting point to increase the use for electric transport. It discusses legislative proposals on net-metering and many Swedish drivers are used to plugging in their vehicles at engine blocks in winter time, and thus would both be familiar with this process for charging electric vehicles and have installations for doing so. Sweden should be prepared to support electric transport over the next decade.

Sweden's oil supply security benefits from having well diversified sources of crude oil imports and a substantial domestic refining sector which makes the country a net exporter of oil products. The introduction of new biofuel grades, including possibly mandatory E10 blending, may require adjustments to the stockholding obligations.

Transport diesel is expected to make up an ever greater share of Swedish oil demand with an impact on both the environment and the oil supply security. This could create constraints for non-refiners to meet their compulsory stockholding obligation, given the low availability of storage capacity for motor gasoline in Sweden. An increase of the share of bilateral stockholding from 20% to 30% would provide operators (non-refiners) with useful flexibility for meeting stockholding requirements.

NATURAL GAS

In the 2009 energy and climate policy, Sweden acknowledges that natural gas can have a role in a transition period in industry and co-generation. With investment in a new gas-fired CHP in Öresund and a new LNG terminal, Sweden's gas market saw a small growth but natural gas plays still a marginal role accounting for 2.4% in TPES. An expansion of the national natural gas transmission network and new LNG terminals are planned. The IEA recommends Sweden to evaluate scenarios, within the broader pathways for 2030/2050, on the role of natural gas supplies and infrastructure in the key sectors, including industry and transport.

The government made progress in reforming the regulatory framework for the Swedish gas market with a view to the transposition of the Third Internal Energy Market Package and adjusted the security of gas supply policies, in co-operation with Denmark. Among these positive developments the IEA welcomes the work on a comprehensive risk assessment, a preventive action plan and an emergency plan on security of gas supply and the certification of Swedegas as ownership-unbundled TSO. Sweden is preparing legislation to introduce *ex ante* regulation of gas tariffs by the NRA and envisages the transfer of the balancing responsibility from Svenska Kraftnät to Swedegas in 2013. The IEA calls upon the government to swiftly finalise the implementation of the framework to provide certainty to operators and market participants in the Swedish natural gas market.

Price transparency and supplier switching remain insufficient to stimulate competitive gas prices to industry and household consumers. The competition and regulatory authorities should regularly assess progress, identify barriers and monitor price developments. The online price comparison tool of the Energy Markets Inspectorate, the so-called Elpriskollen, should be extended to monitor gas prices.

As Sweden depends 100% on imports via a single interconnection from Denmark and foreign gas storages, the IEA encourages Sweden to anticipate the projected decline of Danish natural gas production, to further pursue diversification of infrastructure and regional co-operation, in particular in co-operation with Denmark, with regard to securing the short-term (supply disruptions) and long-term availability of natural gas. Given the declining Danish gas production in the Tyra field and import constraints to the Danish market from Germany, Sweden should assess the needs for the diversification of gas supply, with new interconnectors, storages, LNG terminals as a matter of security of gas supply. In that context, the IEA welcomes the greater diversification with the introduction of increasing amounts of biogas in the grid and the opening of a new LNG terminal in Stockholm and the plans for new LNG terminals as well as the expansion of the internal natural gas transmission network.

However, the new LNG terminal in Stockholm remains unconnected to the grid and cannot be used as backup supply in an emergency. With a view to ensure security of supply during a potential emergency, Sweden has to assess the supply priorities and backup fuel options that major consumers of natural gas, notably for heat production and industry, would have in the case of a gas crisis. Sweden should also clarify the balancing responsibility on the gas network. The government plan to transfer this responsibility from Svenska Kraftnät to Swedegas is an important step.

COAL

The Swedish steel and iron industry as well as the cement, paper and pulp industries maintain growing coal consumption. Around 29.3% of the coal in Sweden was consumed by this sector, while coal use in the electricity sector is marginal (0.8% of total electricity generation). In 2010, coal produced 20% of all CO_2 emissions from fuel combustion in Sweden.

The 2050 Climate Roadmap, as presented in December 2012 by the Environmental Protection Agency, analyses emission trajectories for the different sectors. The Agency already identified the iron and steel as well as agriculture industries as particularly challenging sectors.

With a view to support Sweden's long-term vision of zero net emissions of GHG by 2050, the government and industry should consider how to reduce carbon emissions from the steel and iron and other energy-intensive industries with the application of new energy-efficient and clean energy technologies and processes, in particular carbon capture and storage including biogenic CCS, also through co-operation at the regional level.

PEAT

In 2011, peat provided 0.5% of TPES. Around 30 of the larger heat plants and 22 CHP plants in Sweden use peat as fuel. The vast majority uses peat as fuels in co-combustion with biofuels, as this increases plant efficiency. Peat use has been on the decline, as the use of biofuels and waste has increased over the years in the paper and pulp industry, in heat and electricity production and district heating.

Since peat is to a large extent a domestic energy source in Sweden, the government supports its use partly because of its contribution to security of supply but also for other reasons. The government exempts peat from both the energy and CO_2 taxes and favours peat use in co-combustion with CHP. Peat use in co-combustion in CHP is eligible for the renewable electricity certificates.

The contribution of peat to security of supply, however, is limited with a share of 0.6% in TPES. Any policy that could further increase demand, particularly for imported peat and through lower taxation, should be carefully considered. Although peat use falls within the EU-ETS, the government should rather consider increasing the share of biofuels and waste in co-combustion.

RECOMMENDATIONS

The government of Sweden should:

Oil

- *Improve long-term security of oil supply by carefully monitoring the impact of continued dieselisation on oil supply security and greenhouse gas emissions.*
- *Enhance efforts to reduce carbon emissions in the transport sector by expanding policies to support vehicle efficiency, low-carbon transport and modal shift.*

Natural gas

- *Evaluate the role of natural gas as a transition fuel in the co-generation, industry, transport sectors in the 2030/2050 pathway analysis, in line with long-term decarbonisation goals.*
- *Swiftly finalise the rules for the Swedish natural gas market to give market participants a stable investment framework. Expand the online price comparison tool, Elpriskollen, to natural gas pricing.*
- *Monitor the impact of Denmark's expected decline in gas production and import capacity expansions and continue close co-operation at the regional level to develop security of gas supply policies, aimed at ensuring the diversification of supply routes and sources and the assessment of backup supplies to Swedish gas customers.*

Coal and peat

- *Develop scenarios for the 2050 decarbonisation of Sweden's energy-intensive industries.*
- *Encourage the progressive increase in the amount of biofuels used in co-generation with peat-fired power plants.*

5. RENEWABLE ENERGY

Key data (2011 provisional)

Share of renewables: 35.5% of TPES and 56.7% of electricity generation (IEA averages: 8% and 19%)

Hydropower: 11.7% of TPES and 44.1% of electricity generation

Biofuels and waste: 22.7% of TPES and 8.5% of electricity generation

SUPPLY AND DEMAND

RENEWABLE ENERGY SUPPLY

In 2011, renewable energy sources provided 17.3 Mtoe or 35.5% of total primary energy supply (TPES) in Sweden. Sweden has the third-largest share of renewable energy sources in TPES among IEA member countries (Figure 26). Since 2000, this share has increased by 12%, mainly owing to the enhanced use of biofuels and waste, the largest renewable energy category in Sweden.[13] The availability of forest resources in Sweden is high and biofuel-fired electricity and heat benefit directly from the electricity certificate system and indirectly from the taxation of fossil fuels.

Biofuels and waste, which accounted for 22.7% of TPES in 2011, have grown annually at a rate of around 3.1% since 2000. This share in TPES is the second-largest among IEA member countries. The other main contributor to renewable energy source in Sweden is hydropower, amounting to 5.7 Mtoe or 11.7% of TPES in 2011.

The government expects most of the future additions in renewable energies to come from wind energy which saw a growth in recent years and contributed 1.1% to the country’s supply of energy in 2011. By comparison, Denmark, the IEA leading wind energy country, had a share of wind in TPES of 4.8% in 2011.

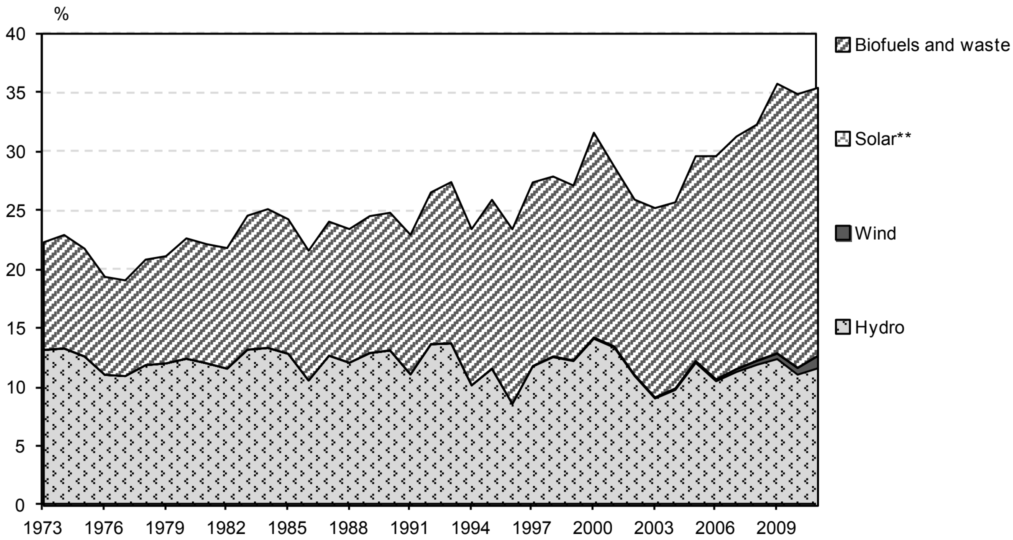
RENEWABLE ENERGY IN ELECTRICITY, HEAT AND TRANSPORT

In 2011, electricity generated from renewable energy sources amounted to 85.3 TWh, or 56.7% of total electricity generation. Among IEA member countries, Sweden is ranked fifth in terms of percentage of electricity generated from renewable energy sources (Figure 27).

Hydropower, with 66.4 TWh (44.1%) of total electricity generation in 2011, is by far the main contributor, accounting for nearly 80% of electricity generated from renewable energy sources. Electricity generated from hydropower varies in a considerable range, depending on weather conditions, from 78.6 TWh in 2000 to 53.5 TWh in 2003.

13. Biofuels and waste = solid and liquid biofuels, biogases, industrial waste and municipal waste.

Figure 25. **Renewable energy as a percentage of total primary energy supply, 1973-2011***



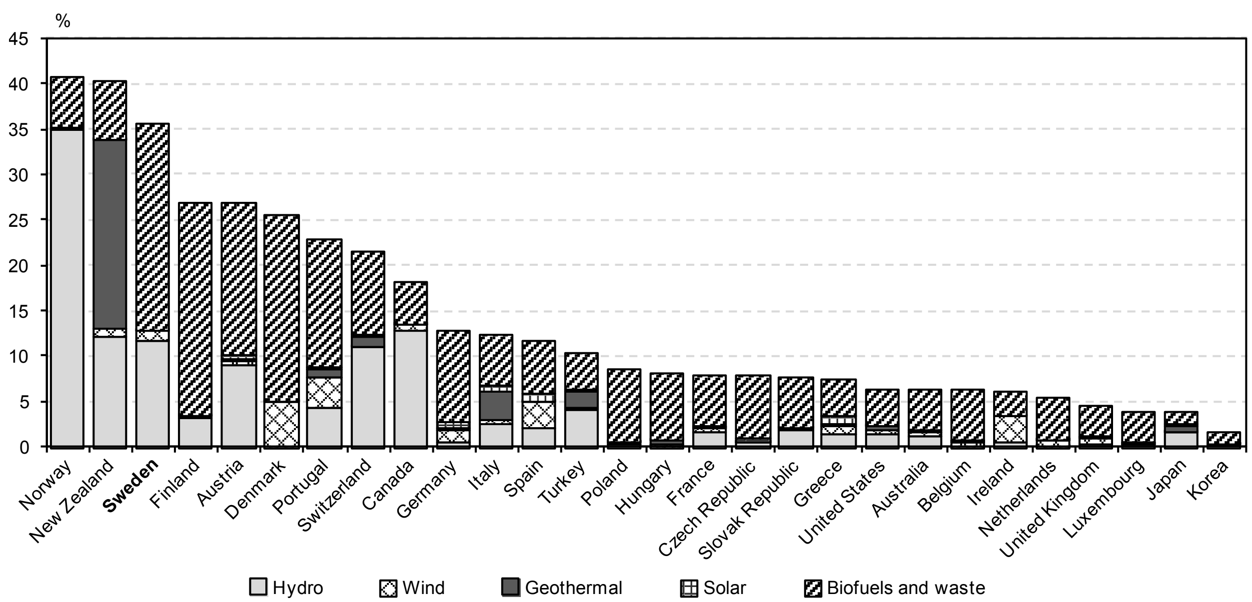
* Provisional for 2011.

** Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

In 2011, biofuels and waste provided 12.8 TWh or 8.5% of total electricity generation. Besides these two main renewable energy sources, Sweden increased electricity generation from wind which accounted for 4% of total electricity generation in 2011 (and 6.1% in 2012), growing from a share of only 0.3% in 2000.

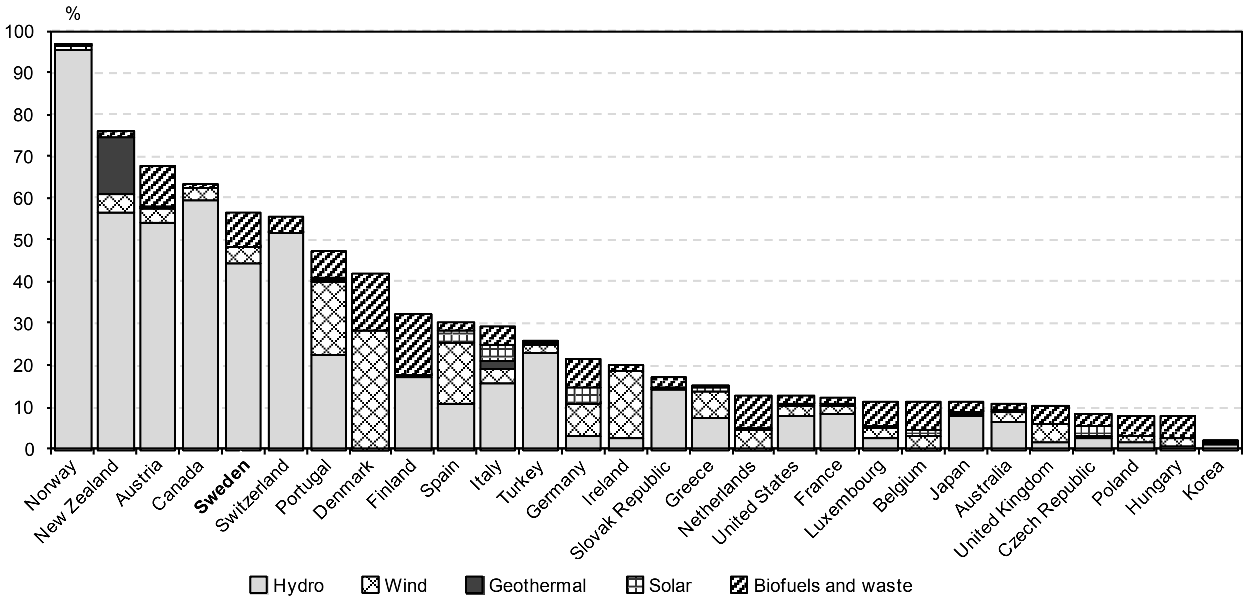
Figure 26. **Renewable energy as a percentage of total primary energy supply in IEA countries, 2011***



* Estimated with provisional data for Sweden.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

Figure 27. **Electricity generation from renewable energy as a percentage of all generation in IEA member countries, 2011***



* Estimated with provisional data for Sweden.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

Box 3. **Solid and liquid biofuels, waste and peat in Sweden**

The bulk of the biofuels, peat and waste used in the Swedish energy system is made up of:

- wood fuels, non densified (bark, sawdust, recycled wood, logging residues and energy forest) and densified (pellets, briquettes and powder);
- black liquors, tall oil and tall pitch oil (intermediate products and by-products in chemical pulp production);
- grain, energy grass and straw (biofuels from agriculture);
- peat;
- combustible waste from industries, households, etc.;
- ethanol 100% for industry (admixture in 95 octane petrol and main constituent of the vehicle fuels E85 and ED95);
- FAME (umbrella term for fatty-acid methyl esters, of which the vehicle fuel RME, rapeseed-oil methyl ester, is the most common); and
- biogas.

Source: *Energy in Sweden 2011*, Swedish Energy Agency.

Biofuels and waste accounted for around 64.2% of renewable energy supply. This is largely the result of increasing use of biofuels in electricity and heat production as well as in the pulp and paper industry. In 2011, total heat produced from renewable energy sources in combined heat and power (CHP) and heat-only plants was 73.6% of total heat produced in Sweden. The use of biofuels in the district heating sector has increased more than fivefold since 1990.

In the transport sector, the total use of renewable energy, including biogas, ethanol, biodiesel and renewable electricity, has seen significant growth to reach a share of 6.3% in 2011 in TPES. This is the result of taxation policies aimed at increasing the blending and the promotion of fuel-flexibility, including motor vehicle tax exemptions for "environment-friendly cars" and "super environment-friendly cars" that can be run on alternative motor fuels, tax incentives for the use of biofuels or carbon dioxide taxation.

INSTITUTIONS

The **Ministry of Enterprise, Energy and Communications (Näringsdepartementet)** is responsible for the overall co-ordination of Swedish energy policy, including renewable energies.

The **Ministry of the Environment (Miljödepartementet)** is responsible for climate change policies, developing environmental policies and measures as well as processing administrative matters under the Swedish Environmental Code. The **Swedish Environmental Protection Agency (Naturvårdsverket)** has a key role in implementing environmental policy, in monitoring the fulfilment of the national environmental objectives and developing long-term climate change and environmental scenarios.

In the area of renewable energy policy, the **Swedish Energy Agency (Statens Energimyndighet)** is among other areas responsible for energy policy analysis, energy statistics, forecasts and projections; ensures the administration of the electricity certificate-trading programme, including the approval of the allocation of certificates to plants and compliance issues; promotes wind power development, oversees the implementation of energy efficiency measures and the sustainability criteria for biofuels (which is the basis for tax exemption decision). In addition, the Agency oversees the implementation of the energy policy programme for RD&D, in particular the support to innovation, business development and commercialisation of new energy technologies.

The TSO **Svenska Kraftnät** is responsible for the registry within the electricity certificate system and the system of guarantees of origin. As the accounting authority, Svenska Kraftnät issues electricity certificates based on metered values of authorised plants and maintains the electronic register of electricity certificates, the so-called CESAR. Svenska Kraftnät also manages the technical allocation of guarantees of origin as a record in an account in CESAR.

The **Energy Markets Inspectorate** is the national regulatory authority for the electricity, gas and district heating sectors. It supervises the system of guarantees of origin.

Measures in the residential and building sectors are managed by the **National Board of Housing, Building and Planning** and the county administrative boards. The latter administer the investment subsidies to installations of solar PV.

POLICIES AND MEASURES

LEGAL FRAMEWORK AND TARGETS

Sweden transposed the EU Renewable Energy Directive 2009/28/EC through two main legal acts adopted by the Swedish Parliament in 2009, the government bill *Genomförande av direktiv om förnybar energi* (Implementation of the Directive on Renewable Energy) and the government bill *Hållbarhetskriterier för biodrivmedel och flytande biobränslen* (Sustainability criteria for biofuels and bioliquids).

Directive 2009/28/EC requires each EU member state to increase the share of renewable energy in its gross final consumption, in order to achieve a 20% renewable energy share at EU level by 2020. Under the directive, Sweden agreed to a binding overall target for a share of renewable energy in gross final energy consumption of 49% to be achieved by 2020. This is the highest target in the EU and can be explained by the fact that Sweden had had the highest share of renewable energy among EU member states, amounting to 40% of gross final consumption in 2005.

At national level, Sweden decided for an overall renewable target of at least 50%, and a 2020 target of 10% in the transport sector. Driven by the 50% national renewable energy sources (RES) target, Sweden set an objective of 25 TWh of renewable energy to be delivered under the electricity certificate system by 2020 compared to 2002. This is a technology-neutral support scheme for renewable electricity. Besides, with a view to facilitating wind power, Sweden has established a planning framework of 30 TWh by 2020, with 20 TWh onshore and 10 TWh offshore. This is not a production target but intended to guide the municipal spatial planning.

In the National Renewable Energy Action Plan (NREAP) of 2010, Sweden specified how it aims to achieve the overall 50% renewable energy target. The 2020 share of renewable energy sources in electricity generation (RES-E) is expected to be composed of 16.4 GW hydropower (generating capacity was at 16.2 GW in 2011), 2.9 GW biofuels, 4.4 GW wind onshore, 182 MW wind offshore (generating wind capacity in 2011 was at 2.9 GW) and 8 MW solar photovoltaics (PV). According to the 2011 projections of the Swedish Energy Agency, the share of RES-E is expected to reach at least 63% by 2020; the share of RES in the heating and cooling sector (RES-H&C) to be 62% by 2020 (with 90% provided by solid biofuels); and in the transport sector (RES-T) to reach 14% by 2020.

Article 22 of Directive 2009/28/EC requires member states to submit a report to the Commission on progress in the promotion and use of energy from renewable sources by 31 December 2011, and biannually thereafter. Sweden is well on track and ahead of projections; it should therefore be able to meet its 2020 renewable energy targets with some margin. Sweden estimates that the proportion of renewable energy in relation to the total final energy consumption is expected to reach 50.2% in 2020, providing for a surplus of approximately 1.2% in 2020 or approximately 5.6 TWh (486 thousand tonnes of oil equivalent, ktoe).

As set out in the first progress report of 2011,[14] Sweden is already well ahead of the indicative trajectory under the Directive, reaching a share of renewables of 47.8% in 2010 and 48% in 2011,[15] and is up well on track to achieve at least 50% by 2020. The share of renewables in the electricity sector was around 56% in 2010, for heating and cooling around 65% in 2010, and in the transport sector it reached a share of 9.8%[16] in 2011, coming close to the 10% target by 2020. For the period up to 2020, Sweden's renewable energy development forecast lies above the indicative trajectory under Directive

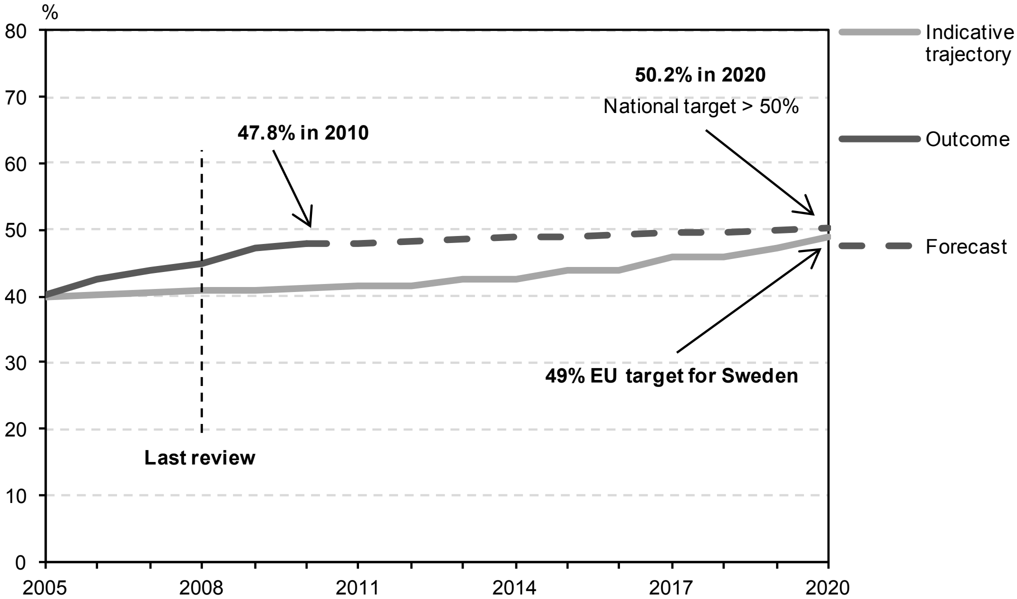
14. National Renewable Energy Action Plan, First Progress Report submitted to the European Commission in 2011. The report is published in English at: http://ec.europa.eu/energy/renewables/reports/doc/article_22_progress_reports_inenglish_language.zip.

15. Data submitted by the government of Sweden to the IEA, using the calculation methodology of Directive 2009/28/EC.

16. Data submitted by the government of Sweden to the IEA, using the calculation methodology of Directive 2009/28/EC. This includes biodiesel, bioethanol, bio-ETBE, hydrogen from renewables and renewable electricity. There is double-counting of biofuels made from wastes, residues, non-food cellulosic material and lignocellulosic material. Only biofuels produced in Sweden from the listed raw materials have been double-counted here (which includes biogas, hydrogenated vegetable oils, diesel, from crude tall oil and ethanol from residues from sulphite pulp production). The calculation of the share of renewable electricity in the transport sector includes road and non-road transport, such as rail, and biogas.

2009/28/EC, providing Sweden with a large potential surplus (Figure 28). The government is positive towards the use of the co-operation mechanisms, provided for under Directive 2009/28/EC, which include statistical transfers, joint support schemes and joint projects.[17] The common certificate market with Norway, in place since 1 January 2012, is the first example within the EU (Box 4).

Figure 28. **Target to 2020 for renewable energy sources**



Note: forecast by the Swedish Energy Agency, 2011.

Source: Progress report of Sweden under Article 22 of Directive 2009/28/EC, 2011.

The Swedish Energy Agency carried out an impact assessment on the further use of co-operation mechanisms and recommended that they should be implemented through the electricity certificate system, by broadening the scheme to include additional member states or through a partial co-ordination of the support scheme. Joint projects should be limited to offshore wind energy, in order to minimise the impact on the electricity certificate system.

ELECTRICITY

The electricity certificate system

In 2003, Sweden introduced the electricity certificate system (Electricity Certificates Act), on the basis of a quota obligation, as the primary policy instrument for promoting renewable electricity. This technology-neutral scheme is designed to encourage investments

17. Articles 6, 7 and 8 of Directive 2009/28/EC provide for three options as co-operation mechanisms between member states (and third countries) to support trade and cost-efficient progress towards the EU-wide target. Statistical transfers involve that one member state with a surplus of renewable energy can "sell" it statistically to another member state, whose renewable energy sources may be more expensive. Joint projects work on the basis that a new renewable energy project in one member state can be co-financed by another member state and the production shared statistically between the two. The projects can also involve third countries. Two or more member states can also agree to have joint support schemes to harmonise all or part of their support schemes by sharing out the production according to a rule such as where the financial support is coming from.

in cost-effective RES technologies. All renewable energy technologies are eligible for certificates, including solar, wind, geothermal, tidal and hydro power, and solid biofuels. From 2004, the system has also supported the use of peat in CHP plants.

Under the Swedish electricity certificate system, the demand for certificates is created by an obligation on electricity suppliers, certain electricity consumers and some industries to annually acquire renewable energy certificates in proportion to their electricity sales and consumption to prove that a certain proportion or quota of the electricity supplied by them was generated from renewable energy sources.

Exemptions from quota obligation are foreseen for smaller producers of renewable electricity who themselves use the electricity they produce. Electricity-intensive manufacturers are exempted from certificates obligations, entirely or partially, depending on the level of energy intensity, as they have the right to deductions for electricity used in the manufacturing process when calculating their renewable energy obligation.

All Swedish electricity generators using eligible RES-technologies receive a certificate for each MWh of electricity generated which can be traded, bilaterally or via brokers, in spot or forward contracts to provide revenue in addition to the sale of electricity on the electricity market.

In order to achieve the new target of 25 TWh electricity produced from renewable sources in 2020, the quota has to increase over time. The size of this quota obligation increases from year to year so as to increase the demand for certificates and renewable electricity.

With the decision in favour of a share of 50% renewable energy by 2020, the government also proposed a higher target for the electricity certificate system corresponding to a 25 TWh increase compared to 2002. On 1 July 2010, Parliament approved the government's proposal to amend the Electricity Certificates Act leading to increased quotas. At the same time, Sweden extended the system until the end of 2035. On 1 January 2012 Norway joined the scheme to form a common certificate market (Box 4).

Biofuels is the largest source covered under the system, while most of the growth in certificates recently came from new wind power installations, mainly onshore (offshore wind is also covered under the system but cannot compete with onshore wind).

Solar photovoltaic (PV) installations are included under the system, but their contribution was only marginal, as technology costs are much higher and requirements of hourly metering and reporting made it less economic for small installations.

In the seven years since 2004, there has been sustainable growth in the number of certificates issued, mainly from biofuel-based electricity production, followed by wind, hydro and peat. The certificates issued in 2011 were nearly double the number compared to 2004, adding up to almost 20 million by the end of 2011. Of those, more than half were represented by certificates for biofuel usage. However, the overwhelming trend over the same period has been strong growth in wind power certificates; wind power accounts for more than 50% of all certificates issued to new plants since 2004.

Figure 29 shows the increase in certificates trade and market liquidity since the system started in 2003 and the development of certificate prices as quoted by the broker SKM. There are regular peaks in the volumes of certificates traded, as forward contracts are delivered in March (in time for yearly cancellation on 1 April).

Box 4. **Joint Electricity Certificate Market: Sweden and Norway**

Sweden and Norway signed a legally binding treaty (29 June 2011) on a common market for electricity certificates which started on 1 January 2012 and will last until the year 2036. The Swedish Parliament approved the agreement on 30 November 2011 and the Norwegian Parliament, Stortinget, on 12 December 2011. On 20 December 2011, the EU's Renewables Directive was given force in law in the European Economic Area Agreement, which means that Norway has adopted the EU Renewable Energy Directive, which was a precondition for establishing the common market.

Each country has its national legislation governing the certificate systems, but certificates can be traded across the border in the joint market. The producer of electricity can obtain the electricity certificate regardless of whether the electricity is produced in Norway or in Sweden, and certificates from both countries can be used for compliance in both countries. The joint market is to lead to greater production of renewable electricity of 26 TWh between 2012 and 2020, the burden of which (quota) is split evenly between the countries. The size of the quota obligations is set by national legislations and is determined until 2036. Any major change in the national legislation should take place following common regular progress reviews, the first of which is to take place in 2015.

On the Norwegian side, Stattnet SF, the transmission system operator, is the authority to operate the accounting system NECS for the Norwegian electricity certificate market, similar to Svenska Kraftnät, operating CESAR. The market is mainly brokered, but Nasdaq OMX recently announced plans to open a trading platform for electricity certificates. The respective national certificate systems are administered by the Swedish Energy Agency and the Norwegian Water Resources and Energy Directorate (NVE).

It is expected that the common larger market is likely to improve market functioning, to provide for more stable certificate prices and the cost-effectiveness of renewables deployment. The joint market benefits from the pooling of Norwegian and Swedish resources in terms of market stability and diversification of the electricity mix. The continued development of the electricity grid is identified as a priority in the treaty. The high degree of regional integration within the common Nordic wholesale market Nord Pool has facilitated the creation and operation of such a joint mechanism.

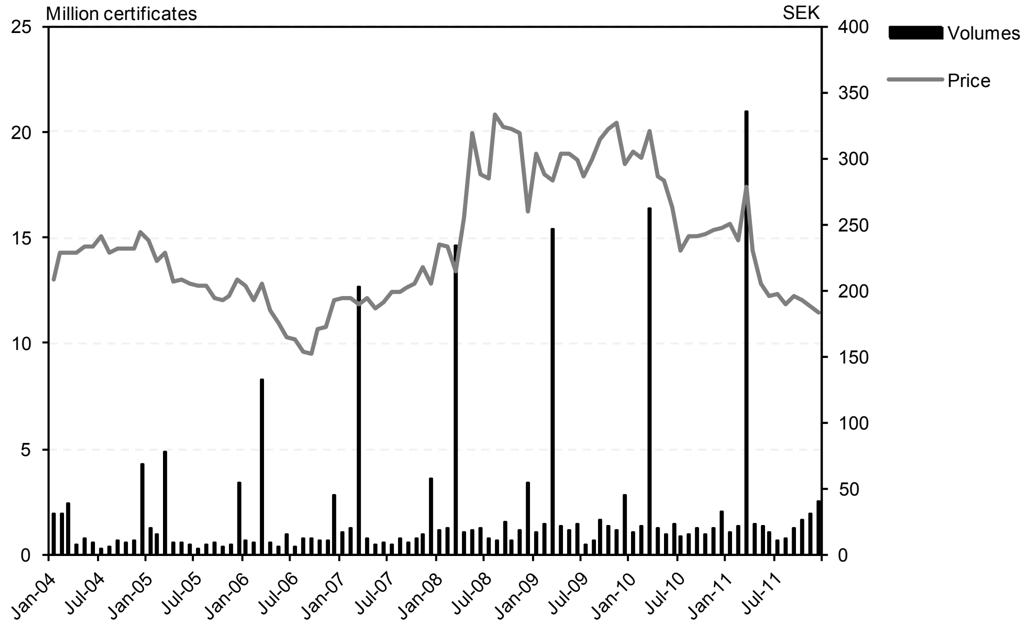
Details of the joint market and the respective national schemes are available at: www.energimyndigheten.se/en/Facts-and-figures1/Publications/.

The average spot price of electricity certificates fluctuated between 2003 and 2009 from SEK 150 per MWh to SEK 350 per MWh. Since 2010, the certificate price has decreased to approximately SEK 150 per MWh in 2011. The recent price trend is upwards again; in late 2012, it rose to around SEK 200 per MWh for March 2013 contracts.

Importantly, the electricity certificate system, supporting cost-efficient technologies, has limited the overall cost of renewable energy support to final consumers. The cost of suppliers' certificates is included in the price of electricity paid by consumers. In 2011, half of the overall cost of SEK 4 100 million (EUR 477 million) was paid by households.

Almost half of the cost of the electricity certificate system (45%) is paid by households, 29% by the service sector, 17% by the industry sector, and 9% by the transport, agriculture and district heating sectors. VAT and transaction costs further increase the price for consumers. Since the introduction in 2003, consumer costs varied over time with some peaks in 2009 with decreasing trends. In 2011, the average cost to consumers of this element of the total cost of electricity was Öre 4.40 per kWh (EUR 0.005 per kWh).

Figure 29. **Volume-weighted average monthly price of electricity certificates and number of certificates traded per month, January 2004 to December 2011**



Source: Svenska Kraftnät.

Table 4. **Estimated cost of certificates to electricity customers, 2003-10**

	2003	2004	2005	2006	2007	2008	2009	2010
Average spot price per certificate (EUR/MWh)	24.2	25.65	21.54	18.04	22.48	33.94	29.39	26.72
Quota (Number of certificates per kWh)	0.074	0.081	0.104	0.126	0.151	0.163	0.170	0.179
Electricity customers cost for certificates (EUR/kWh)	0.0018	0.0021	0.0022	0.0023	0.0034	0.0055	0.005	0.0048
Electricity suppliers transaction cost (EUR/kWh)	0.0002	0.0002	0.0002	0.0002	0.0003	0.0006	0.0005	0.0005
VAT, 25% (EUR/kWh)	0.0005	0.0006	0.0006	0.0006	0.0009	0.0015	0.0014	0.0013
Electricity customers estimated total cost (EUR/kWh)	0.0024	0.0028	0.0031	0.0031	0.0046	0.0076	0.0069	0.0066

Sources: SKM - Svensk Kraftmäkling; Swedish Energy Agency, 2012.

An unbanded certificate scheme tends to stimulate the deployment of least-cost production, which keeps cost to consumers moderate but may favour benefits to certain technologies. Sweden has amended the electricity certificate system to adjust it over time to avoid any overcompensation. As of 1 January 2012 the new Act for Electricity Certificates entered into force, providing for simplified rules, reduced cost to consumers by limiting the number of commercially viable older plants, including biofuel-fired CHP, under the scheme and rules for a common market for electricity certificates with other countries. Power plants are only entitled to earn certificates for a maximum of 15 years, and hydropower plants built before 2003 are not entitled at all. Plants which were commissioned before the certificate system was introduced are entitled to certificates only until end of 2012. Plants, which received a public investment grant after 15 February 1998, are entitled to certificates until end of 2014. The new rules provide for more stringent conditions for electricity produced in hydropower stations, limiting the eligibility to small hydro plants with an installed capacity of up to 1.5 MW.

Guarantees of origin

In December 2010 Sweden introduced a system of guarantees of origin for electricity (Guarantees of Origin for Electricity Act). This is a voluntary system that can be used for all types of electricity production. Producers of electricity receive a guarantee from the State for each MWh of electricity produced, which can then be sold on the open market.

In 2011 the Energy Markets Inspectorate (EI) put forward regulations making guarantees of origin a prerequisite for sales of electricity with a specific origin marking. The Energy Markets Inspectorate ensures that clear information to customers is provided about the origin of the electricity and the impact the electricity generation has on the environment.

Developing Sweden's wind power potential

The technology-neutral electricity certificate system is the main support instrument to promote wind power. Complementary policy measures include taxation and co-ordinated planning and communication to increase public awareness. The earlier investment subsidies for the market introduction of wind were phased out by end 2012.

To facilitate wind power, Sweden established a planning (not production) target for municipal spatial planning framework of 30 TWh in 2020, with 20 TWh from onshore and 10 TWh from offshore.

The electricity certificate system drives investments in onshore wind. Sweden also has a large potential for offshore wind. Six projects have received their permits: the total potential production from those projects is about 8 TWh per year. So far, construction has only started on one project, which is very close to shore. Otherwise, offshore wind cannot compete with onshore wind under the electricity certificate system. Offshore wind technology is still considered to be in the inception phase of its development, resulting in considerable upfront investment costs, which cannot be fully covered by the margins of the certificate system which stimulates the lowest cost technologies. A number of wind projects received support from the State Pilot Fund for the market introduction of wind power projects, such as Lillgrund, Uljabuouda, Storrun, Vindpark Vänern, Havsnäs and others.

In addition, electricity generated from wind energy is also eligible for tax privileges consisting in a reduction of the real estate tax, as defined in the Act on the Federal Real Estate Tax, and in a reduction of the energy tax, as authorised by the Energy Tax Act.

Grid connection has also been identified as a bottleneck for the further expansion of wind power. In Sweden, the regional authorities are the competent actors for granting permits for new wind farms under the Environmental Code, while the Energy Markets Inspectorate is in charge of the grid licence for the connections. The lead times for grid concessions and the examination of permit applications are sometimes four to five years and more, with the grid connection process being the limiting factor for the deployment of new wind farms. Also environmental concerns, public acceptance and the coexistence of military zones determine the development of new onshore or offshore wind farms.

Stronger co-ordination between the generation and network planning to avoid double regulation has been introduced with amendments to the Electricity Act in 2009. Matters relating to the grid licence which were examined under the Environmental Code do not need to be re-examined in the network concession under the Electricity Act. (This does not apply to hydro generation plants. Here, a network concession for the power line is a precondition for an application for the environmental permit.)

In Sweden, the nationwide wind survey carried out by Uppsala University on assignment from the Swedish Energy Agency provides the data for the spatial planning of regional authorities and for the government to determine the areas of national interest for energy production (the Agency revised the areas of national interest in 2011/12).

Several initiatives were set in motion to raise public awareness on the benefits of new renewable electricity production and enhance public consultation. The Swedish Energy Agency set up an internet platform (www.vindlov.se) for all permit issues that may arise in conjunction with the expansion of wind power. The Swedish Environmental Protection Agency produced guidance clarifying the possibilities of establishing wind power in the nature reserve zones (EU Natura 2000 areas),[18] in consultation with the Swedish Energy Agency, the Swedish National Board of Housing, Building and Planning, and the Swedish Agency for Marine and Water Management. In the decade 2000-10, financial support of SEK 84 million was provided to 212 municipalities and 13 county administrative boards that wanted to include wind power in their spatial planning for the handling of applications. The research programme "Vindval" supports the analysis of the environmental impacts and the dissemination of the information to project owners and courts for the permit applications.

HEAT

Sweden does not have a sectoral heat target but the electricity certificate system indirectly supports the heat production from renewable sources. Since the 1980s, there has been a transition towards the use of renewable fuels in the heat segment and CHP plants, following the introduction of the CO_2 tax in 1991, thus providing for the phase-out of coal and oil in the heating sector. Since 2003, the electricity certificate system supports electricity produced by biomass in approved biomass plants for CHP, industrial back-pressure and biogas.

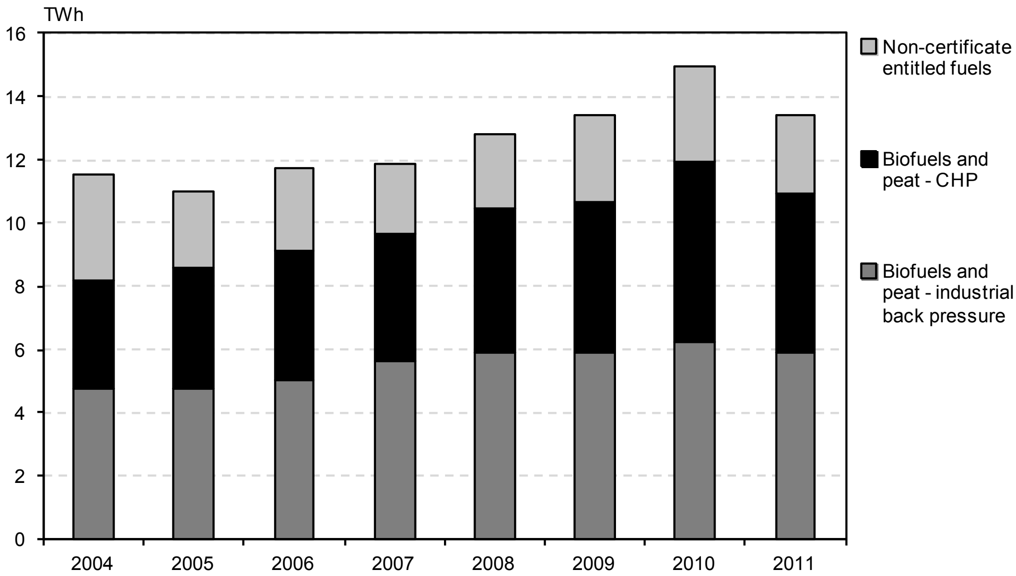
Figure 30 shows total CHP production and the shares of CHP receiving electricity certificates.

In 2011, district heat supply accounted for around 60 TWh, produced mostly from wood fuel and other biofuels (39.2%), waste (18.2%), mainly renewable organic waste, peat

18. Natura 2000 zones are qualified protected areas under the EU environmental legislation. Directive 2009/147/EC on the conservation of wild birds ("Birds Directive") requires the establishment of Special Protection Areas (SPAs) for birds. Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora ("Habitats Directive") requires Special Areas of Conservation (SACs) to be designated for species other than birds, and for habitats. Together, SPAs and SACs make up the Natura 2000 network of protected areas.

(3.8%) and waste heat (6.1%). Oil, natural gas and coal have minor shares. In 2011, approved biofuel-fired power plants used forest industry by-products (52.2%), forestry by-products (33.4%), other wood waste (7.3%), energy crops (0.7%), biogas (0.4%) with a marginal remainder with landfill gas. Peat, which is covered under the electricity certificate system when co-combusted with biofuels in CHP plants, but not a renewable source, accounted for 6%. Most of the waste is from renewable sources and its use increased over the past decade, in particular for district heating, as a result of the 2002 ban on combustible waste in landfills and of organic waste in 2005. In 2011, 41% of the total district heat was generated in CHP plants.

Figure 30. **Electricity production in approved biofuel-fired CHP plants, 2004-11**



Sources: Swedish Energy Agency.

Investment subsidies

Besides the certificate system, Sweden currently provides investment subsidies to solar PV and innovative biogas, which are still in the early phase of their development in Sweden. Investment subsidies are granted for innovative biogas projects, mostly for the production of biogas which could be fed into to the gas grid or used for transport. The government proposed to Parliament to prolong the support for solar PV and biogas until the end of 2016. The government has also assigned a public investigation to propose how a system for net metering for household's microgeneration (solar PV systems and wind generators for households) can be introduced.

Earlier support to wind power pilot projects was phased out in 2012, as the competitiveness of onshore wind improved and saw a strong increase through support by the certificate system. The investment aid programmes in support of solar heating and heat pumps have also been discontinued after 2011. Until 2009, the climate investment programmes (LIP and KLIMP) granted subsidies to municipalities for ecologically sustainable and environment-friendly CHP projects. Around 260 projects were supported in the district heating sector. Support continued under the programme "Sustainable Cities" until the end of 2012.

Table 5 provides an overview of the main investment subsidies in the reporting period.

Table 5. **Overview of the main investment subsidies**

Measure	Sector	Start	End	Budget SEK million
Investment aid (up to 45% of investment cost, capital grants or loans)	Solar PV connected to the grid	1 July 2009	Extended to 2016	2009-11: 222 2012: 60 2013-16: 210
Investment aid to production, distribution, and use	Biogas and other renewable gases	1 Nov 2009	Extended to 2016	2013-16: 280
Investment aid to urban development and planning	"Sustainable cities"	2009	2012	2009-10: 320 2011-12: 40
Investment aid R&DD and marketing (Pilot Fund)	Wind power	2003-07	2008-12	2003-09: 400 2008-12: 350 2013-16: 10 per year

Source: submission by the Swedish government to the IEA.

TRANSPORT

In the transport sector, Sweden promotes the use of flexible fuel vehicles and energy-efficient technologies, such as electric vehicles and plug-in hybrids, as well as the use of renewable energy sources, in particular biogas, ethanol, hydrogenated vegetable oils (HVO) and biodiesel (rapeseed-oil methyl ester or FAME). The Swedish Energy Agency approves biofuels that can be used in the transport sector in line with the national system of sustainability criteria for biofuels.

Sweden primarily promotes blending of petrol and diesel with liquid and gaseous biofuels (ethanol and biodiesel) in order to reach its renewable target in the transport sector. However, there is no mandatory obligation to blend a certain percentage. The contribution from high-blend bioethanol and biogas is also important. Biogas for transport is mostly produced from waste, coming from sewage treatment plants and co-digestion plants that use catering waste, food waste, slaughterhouse waste, manure, slurry and to a lesser extent energy crops.

Sweden has the approval of the European Commission to exempt biofuels from energy and carbon dioxide taxes until the end of 2013. From 1 January 2011, the level of tax exemption for a low-biofuel blend of ethanol in petrol is a maximum of 6.5% by volume, and for biodiesel in diesel, a maximum of 5% by volume. Low blending above these levels is subject to the same tax as petrol or diesel. However, high blends, *e.g.* 85% bioethanol or 100% biodiesel, are subject to full tax exemption. The tax loss due to the above tax exemption was SEK 2.54 billion in 2010 and SEK 2.83 billion in 2011. The tax loss could be reduced or avoided if mandatory blending was introduced, which is the case in many other EU countries.

In the 2013 Budget Bill the government presented a proposal to tax biofuels used for low-blend purposes from 2013 onwards. The government considers introducing an energy tax on biofuels which would be set at such a level that it is does not discourage the use of low-blend on the market. As of 2014, it also considers the introduction of a quota system aimed at 10% and 7% blending of biofuels in low-blended fossil fuels and diesel, as allowed by the EU Fuel Quality Directive.

The development and use of electric and electric-hybrid vehicles is supported by instruments for "environment-friendly cars" and "super environment-friendly cars" with an exemption from vehicle tax for the first five years 2010-14, and by research projects, such as FFI Strategic Vehicle Research and Innovation, Energy-Efficient Road Vehicles and the demonstration programme for electric vehicles. The government also supports the public procurement of electric vehicles. There is a small number of electric vehicles for road transport in Sweden. At the turn of the year 2010/11 there were around 200 electric vehicles, a small number of electric buses and around 130 electric lorries.

A government committee has been created with the responsibility to present concrete proposals on how to reach the transport long-term priority that Sweden should have a vehicle fleet that is independent of fossil fuel by 2030.

ASSESSMENT

Sweden has a track record in fostering the development of renewable energy sources as part of its overarching policy for sustainability, resource efficiency, security of supply and competitiveness. Thanks to its favourable resource base and long-term policies to reduce the use of fossil fuels and to increase renewables, Sweden is the EU leader in the share of renewable energies in gross final consumption; their share has steadily increased from 33% in 1990 to 48% in 2011 (calculated under the EU Renewable Energy Directive). The national target for 2020 is set for a share of at least 50% of renewable energy in gross final consumption.

Sweden favours a market-driven and technology-neutral design of renewable support, with a toolbox of carbon dioxide and energy taxation, international and EU-wide carbon mechanisms (EU-ETS) and the certificate system for renewable electricity. The system has broad political support in Sweden as it provides a transparent and stable framework for investors and reasonable costs for consumers.

In particular, the establishment of new wind power capacity and the outstanding availability and economic attractiveness of solid biofuels have contributed to this positive development in recent years. Both are competitive under the certificates system. Sweden is ahead of its indicative trajectory under the EU Renewable Energy Directive. With a share of 48% in gross final consumption and 9.8% in transport in 2011, Sweden is already today close to meeting the 2020 EU-targets. These developments are commendable.

Sweden's policies serve as an enabler for renewable energy development thanks to a stable support policy approach, low cost of capital, the stable fiscal policy and financing provided by municipalities, and use of biofuel-fired co-generation in the paper and pulp industry. Sweden has been a forerunner in cooperation with other countries under the EU Renewable Energy Directive and others can learn from that experience. The creation of a larger renewable market as a joint certificate market between Norway and Sweden on 1 January 2012 (until 2036), provides opportunities for future expansion. The agreement has provided long-term stability to investors regarding the duration of the system. The performance of the extended certificate market for Norway and Sweden should be followed and monitored.

Sweden is interested in making use of other opportunities in the EU Renewable Energy Directive to allow other countries to fund investments in Sweden in renewable energy generation or meet their targets via Swedish generation. Sweden is, together with the other four Nordic countries, exploring concepts and methodologies for use of the co-operation mechanisms "statistical transfer" and "joint projects" in order to be prepared for such arrangements, if – or when – an opportunity occurs. Offshore wind projects could provide for an opportunity for joint projects but Sweden needs to seek the approval from Norway on joint projects according to the electricity certificates treaty which may require stronger co-ordination.

The future outlook for renewable energy in Sweden is expected to depict a moderate growth in the coming years, even if no new initiatives are taken by the government. According to the IEA *Medium-Term Renewable Energy Market Report 2012*, Sweden's renewable energy is expected to grow in a baseline scenario by 9.1 TWh over the period 2011-17 or at a rate of +1.7% per annum, mainly led by onshore wind with additions from hydropower and biofuels.

Unbanded certificate systems entail the risk of providing windfall profits for certain technologies. Over time, Sweden has adjusted both the certificate system and the subsidies to avoid overcompensation and to keep pace with technology development and cost.

Solar PV and offshore wind, with some exceptions, are not considered to be viable within the electricity certificate system. Sweden uses investment grants for the deployment of biogas and solar PV. The support of microgeneration, including solar PV, under the certificate system remains limited; hence the government is considering a new approach through net metering. For the development of offshore wind, only joint projects with other countries are considered; additional offshore wind subsidies were phased out. Sweden has a targeted RD&D policy for the development of specific renewable technologies.

However, there are a number of factors that create challenges for the further expansion of renewable energy. Non-economic barriers, particularly for the construction of wind power and transmission projects, limit fast expansion, including permitting, public acceptance and the coexistence with other interests, such as with the military air force. Sweden introduced a number of measures to remove those barriers, *e.g.* for wind energy. Enhancing the efficiency of the environmental impact assessments by raising public awareness and building a societal consensus will be crucial for the construction of new energy infrastructure.

No binding EU or national targets for renewable energies are set for the period after 2020 in Sweden. The two long-term priorities for 2030 for transport and 2050 for the whole economy are now being assessed in the Climate Roadmap 2050 and a committee has been set up to make the transport priority operational. These long-term priorities should be the basis for Sweden to evaluate and plan for the continuous use of renewable energy also after 2020. The government foresees a progress review in 2015 of the climate and energy policy which could be an opportunity to consider a longer-term framework for renewable energy. The IEA recommends Sweden to provide greater clarity to all market participants on the contribution of renewable energy sources to these priorities.

RECOMMENDATIONS

The government of Sweden should:

- ☐ *Consider – in due time before 2020 – the desired volume of quota obligations in the certificates market in order to give investors certainty beyond 2020.*
- ☐ *Elaborate further the policy regarding the contribution of renewable energy in the transport sector in order to provide more clarity for market participants on how to achieve the 10% target in 2020 and a transport sector which is "independent" of fossil fuels by 2030.*

- ☐ *Provide longer-term certainty to renewable energy technologies that are currently benefiting from short-term secondary instruments, including biogas and solar PV.*
- ☐ *Explore opportunities in the EU Renewable Energy Directive to allow other countries to fund renewable energy investments in Sweden or to benefit from renewable energy generation through the use of the flexible co-operation mechanisms.*

6. NUCLEAR ENERGY

Key data (2012)

Number of plants in operation: 10 reactors at three sites

Installed capacity: 9.4 GW

Electricity generation (2011 provisional): 60.9 TWh (40.5% of total power generation)

OVERVIEW

Following on from the new integrated climate and energy policy of 2009,[19] Sweden aims to develop renewable energies in addition to the two traditional pillars of Swedish electricity supply, nuclear energy and hydropower, with a view to increase security of supply, reduce GHGs by 40% by 2020 and achieve zero net emissions by 2050.

In the context of this long-term vision, Sweden changed its policy for nuclear energy, providing for the continuation of nuclear power generation and for the construction of replacement reactors. New nuclear would be possible under two conditions: First, one of the older reactors would need to be permanently shut down and the replacement reactor must be built on an existing nuclear power plant (NPP) site; and secondly, the financing and development would have to come exclusively from industry, without direct or indirect government subsidies. The private sector would face higher nuclear liability requirements in addition to the cost of nuclear waste management and decommissioning.

In 2011, nuclear energy produced around 61 TWh, 40.5% of Sweden's electricity supply. Sweden has a total of 10 reactors in operation at three sites, Forsmark, Oskarshamn and Ringhals (Table 6). Two reactors were closed at Barsebäck (1 200 MW combined). Sweden imports uranium and enrichment services, even though it has significant, but high-cost uranium resources.

A modernisation and power uprating programme had added 1 050 MW of nuclear generating capacity by end 2008. Although not related to the political decision to close the two Barsebäck reactors, the uprating programme by 2008 had largely compensated for the closure of these two reactors (1 200 MW combined) that occurred as part of the nuclear phase-out policy of past governments. The modernisation programme, initiated in 2004, is expected to be completed in 2015.

Operating licences are valid as long as the reactors meet the safety criteria defined by the Swedish legal and regulatory framework, supervised by the Swedish Radiation Safety Authority (SSM). Most nuclear plants were constructed in the 1970s and early 1980s.

Sweden leads at global level the development of a permanent geological repository for spent fuel and research activities, developing safe and acceptable waste disposal practices.

19. On the basis of the 2009 political agreement, two government bills were adopted by the Parliament: 2008/09:162 and 2008/09:163 om en sammanhållen klimat- och energipolitik (on an integrated climate and energy policy).

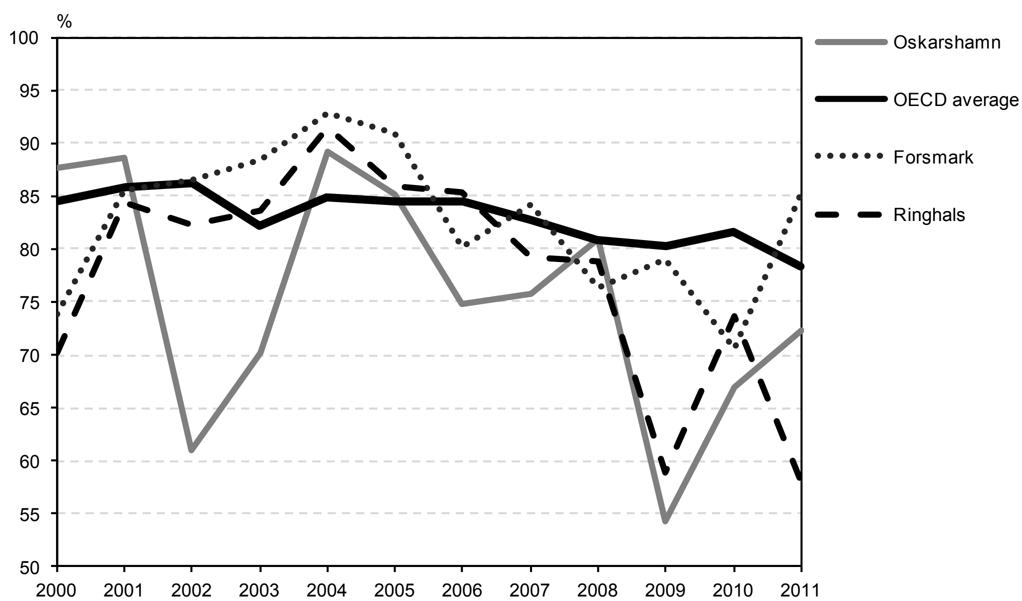
Table 6. **Nuclear power plants in operation in Sweden, 2011**

Name	Type	Net capacity (MWe)	First commercial operation	Electricity generation in 2011 (TWh net)	Lifetime electricity generation through 2011 (TWh net)
Forsmark 1	BWR	984	1980	6.8 (11.7%)	214.4
Forsmark 2	BWR	996	1981	8.2 (14.1%)	203
Forsmark 3	BWR	1 170	1985	8.7 (15%)	225.7
Oskarshamn 1	BWR	473	1972	3 (5.2%)	98.8
Oskarshamn 2	BWR	638	1975	4.2 (7.2%)	148.3
Oskarshamn 3	BWR	1 400	1985	8.3 (14.3%)	209
Ringhals 1	BWR	865	1976	6 (10.3%)	168.6
Ringhals 2	PWR	865	1975	1.7 (2.9%)	179.3
Ringhals 3	PWR	1 047	1981	7.1 (12.2%)	185.2
Ringhals 4	PWR	940	1983	4.1 (7.1%)	178
Total		**9 378**		**58.1 (100%)**	**1 810.3**

BWR: boiling water reactor; PWR: pressurised water reactor; WH: water heating.

Source: International Atomic Energy Agency (IAEA) Power Reactor Information System (PRIS) database.

Figure 31. **Energy Availability Factor (2000-11) for Swedish reactors compared to OECD average**



Note: station records for Forsmark, Oskarshamn and Ringals are an average of the Energy Availability Factor for all units at each station.

Source: International Atomic Energy Agency (IAEA), 2012.

Assuming an operational lifetime of 50 years for all reactors, the first closure would occur in 2022 and closures of the last two largest reactors in 2035.

Ownership of Sweden's three nuclear power plants is shared by three utilities: German E.ON, the Finnish Fortum (majority owned by the Finnish government) and the Swedish Vattenfall (100% owned by the Swedish government). The Forsmark plant is jointly owned by all three companies (Vattenfall 66%, Fortum 25.5% and E.ON 8.5%), the Oskarshamn plant is owned jointly by E.ON (54.5%) and Fortum (45.5%) and the Ringhals plant is 70% owned by Vattenfall and 30% by E.ON.

In May 2007, the Swedish Competition Authority recommended that the government consider ways of breaking up the co-ownership of the nuclear power plants in order to improve competition. However, negotiations with industry did not lead to any solution acceptable to all parties and the initiative was brought to an end. A code of conduct and an independent surveillance group to attend board meetings was set up by the Swedish government in 2010 to monitor the nuclear power companies.

INSTITUTIONS

Nuclear activities are regulated by the **Swedish Radiation Safety Authority (SSM)**, an organisation created in 2008 by the merger of the Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Authority. The SSM is a central administrative authority under the auspices of the Ministry of the Environment, independent within the legislation and statutes of the government. SSM proposes to the government for final decision the level of fees to the licensees to cover the cost of all regulatory activities, such as managing applications for new licences and safety reviews in accordance with the Swedish Radiation Safety Authority Ordinance. The government recently decided on fees for applications for new nuclear power plants. This has made it possible to employ additional staff to work on licence applications and safety reviews.

The SSM is the regulatory and emergency preparedness and response body. It supervises those conducting activities using radiation, taking responsibility for reducing the risks that accompany it by setting requirements and verifying compliance. SSM supervision spans the nuclear power industry, medical uses of radioactive materials and devices, the management and disposal of radioactive waste and research activities. The SSM also provides advice to the general public on protection from radiation exposure, including the potential harmful effects of natural radiation sources.

The SSM formulates regulations for nuclear activities, inspects facilities to ensure that those conducting the activities are following all rules and regulations (*i.e.* for nuclear safety, radiation protection and nuclear non-proliferation), and processes applications to establish or alter activities involving radiation. SSM finances research and is active in international development activities by carrying out projects that enhance radiation protection and nuclear safety in other countries.

A **fuel fabrication plant** in Västerås, operated by Westinghouse Electric Sweden AB and owned by Toshiba Power Systems, has a licensed conversion (UF_6 to UO_2) capacity of 600 tonnes of uranium dioxide per year (tUO_2/year) and produces about 400 tonnes of fuel for boiling water reactors (BWRs) and pressurised water reactors (PWRs) each year for domestic use and export.

Utilities operating the nuclear power plants are responsible for all the costs of managing and disposing of spent fuel and other forms of nuclear waste, including the decommissioning of reactors. The **Swedish Nuclear Fuel and Waste Management Company (SKB)** was established by utilities operating the reactors following the Waste Legislation Stipulation Act of 1977. SKB has since carried out a number of activities, including the establishment of an interim storage facility for spent fuel (Clab) and a final repository for low- and intermediate-level radioactive waste (SFR).

HISTORY OF NUCLEAR POLICY

Nuclear power has been an important but controversial component of baseload electricity generation in Sweden, as reflected by changing government policies.

In the mid-1960s, Sweden decided in favour of nuclear power as a source of electricity generation. The objective was to expand generating capacity beyond the hydro- and oil-fired power plants of the time, reducing reliance on oil imports and exposure to price volatility, thereby enhancing security of energy supply.

Following the Three Mile Island accident in the United States in 1980, Sweden adopted a nuclear phase-out policy (Phase-out Act), following a referendum, that essentially dictated the closure of all reactors by 2010. This led to the closure of the Barsebäck 1 and 2 reactors (with 600 MW each) in 1999 and 2005, after only 24 and 28 years of service, respectively. In 1997, Sweden revised its phase-out policy and decided that government decisions to close individual reactors should be based on age and condition of the reactor as well as on its role in the energy system, rather than being bound to a specific date and year.

In 2006, the Alliance Parties, a coalition of four centre-right parties, ended the nuclear phase-out policy, stating that, from an energy policy perspective, no additional reactor closures would be required before the end of a facility's operational lifetime, and allowing power uprates at existing reactors. However, the licensing of new reactors remained prohibited.

In 2009, the Alliance Parties repealed the Phase-out Act and adopted a number of principles aimed at allowing the construction of new reactors at the three existing sites, once an existing reactor is closed at the end of its operational lifetime (*i.e.* a new reactor cannot be brought into operation until the old one is permanently shut down). Any new build initiative would need to be undertaken by industry without any direct or indirect government subsidies and would have to compete with renewable energy sources that are actively being promoted and subsidised by the government as a third pillar of a low-carbon energy mix, next to hydro and nuclear. In 2010 Parliament also passed a proposal to increase third-party liabilities for nuclear power plant operators in the case of an accident, but this has not yet come into force. The new 2009 energy and climate policy, including the change of nuclear policy, was adopted by a narrow margin (174-172) in Parliament. The next general election is scheduled for 2014.

LEGAL FRAMEWORK

REGULATION

Nuclear activities are regulated and supervised by the Swedish Radiation Safety Authority (SSM) based on laws, governmental ordinances, annual government letters of appropriation and specific governmental decisions, including licensing.

The current nuclear policy, allowing for continued use of existing reactors and the construction of replacement reactors under certain conditions, came into force on 1 January 2011, with amendments to the Act on Nuclear Activities and the Environmental Code. In 2010, the government bill on nuclear liabilities introduced higher liability requirements for companies operating NPPs. Operators will need to provide financial guarantees of EUR 1 200 million (an increase of four times from current requirements) and will be subject to unlimited liability (*i.e.* the company's assets can be mobilised to cover accident costs and compensation if needed). These changes have not yet entered into force.

TAXATION

The government has levied taxes on nuclear power since the late 1990s. In 2000, the nuclear tax shifted from a production tax to a tax on installed capacity and was increased in 2006 and again in 2008. Regulated in the Act on Excise Duties on Thermal Capacity on Nuclear Power Reactors, the tax is based on the thermal production capacity of the nuclear reactor. The duty rate applicable is SEK 10 200 (about EUR 1 100) per MW of the permitted thermal capacity, amounting to about EUR 0.005 per kWh electric, or roughly EUR 350 million per year.

NUCLEAR SAFETY

Swedish NPPs have been continuously monitored, maintained and improved since the beginning of the nuclear power programme.

Despite political uncertainties about the future use of nuclear power, the licensees of the Swedish NPPs decided to make major investments in order to secure licensing to operate the ten existing reactors for 50 years or more. This modernisation, safety upgrading and power uprating, at a total cost of EUR 800 million, is expected to be completed in 2015. Implementation of the process has created some long outages and reduced power output, particularly in 2009.

During 2000 to 2009, Sweden reported a total of eight events to the International Atomic Energy Agency (IAEA). Of these events, there was one at the Forsmark 1 NPP in 2006 which was classified as International Nuclear Event Scale (INES) level 2 (an "incident"), and one transport event originating at the Studsvik nuclear facility in 2002 containing iridium-192 bound for the United States classified as INES level 3 (a "serious incident"). The other events were rated as either INES 1 ("anomalies") or under the scale. In annual reports for the years 2007 to 2009, the SSM and the former Swedish regulatory bodies SKI and SSI related that there were no events indicating a serious degradation of safety or radiation protection at Swedish NPPs. Over that period, a total of ten events were classified as level 1 on the INES scale.

From 2007 to 2010, worker radiation doses at the Swedish NPPs remained below the industry average and radiation doses to the public from emissions were well below regulatory limits.

Incident of note

On 25 July 2006, an external electrical accident triggered a short circuit of the switchgear at Forsmark 1. Two of the four backup diesel generators did not start up as expected, but the safety systems that automatically shut down and cooled the reactor functioned as designed to keep the incident under control. The categorisation as an INES level 2 incident means that it is to be taken seriously but is without consequences to people or to the surrounding environment. Following the incident, a precautionary and temporary shut-down of three other units (Forsmark 2 and Oskarshamn 1 and 2) was ordered by the regulator so as to conduct a thorough investigation.

Investigation of this event revealed several design weaknesses in the electrical system and highlighted the importance of developing good formal management systems as well as monitoring and following up on the functioning of the systems at the plants. Forsmark, Ringhals and Oskarshamn verified shortly after the incident that all units were operable. Analyses and modifications in some of the units ensured that they met all requirements. Among other things, the three licensees updated Safety Analysis Reports (SARs), issued new instructions, overhauled maintenance instructions and further developed the concepts of diversification, redundancy and common cause failure issues.

Before the accident at the Fukushima Dai-ichi NPP in 2011, the Swedish government requested in 2009 an international team of senior safety experts to conduct an Integrated Regulatory Review Service mission. Together with representatives of the SSM, the review was carried out from 6 to 17 February 2012 with the purpose of reviewing the effectiveness of the Swedish framework for safety with special attention to regulatory implications.

The conclusions of the review outline that the SSM operates as an independent regulator in an open and transparent manner with well-organised regulatory processes and that it responded promptly and communicated effectively following the Fukushima Dai-ichi accident. Furthermore, the NPP refurbishment (modernisation) programme required by the SSM had enhanced safety and shown that Sweden's regulatory framework for high-level waste disposal is comprehensive and technically sound.

Issues identified for attention included standardisation of SSM's internal guidance to staff on regulatory practices as well as the need to evaluate staffing and competence needs and to request appropriate resources from the government, as required. It also noted that the inspection programme in many technical areas needed to be strengthened.

WASTE DISPOSAL AND DECOMMISSIONING

As commercial nuclear power plants were built in the early 1970s, arrangements were made to transport spent nuclear fuel abroad for reprocessing. Contract commitments led to the reprocessing of 140 tonnes of spent nuclear fuel at Sellafield, in north-west England, resulting in 136 tonnes of reprocessed uranium and 833 kilograms of plutonium. The recovered plutonium remains in Sellafield.

During the late 1970s, attitudes changed and reprocessing was no longer considered an acceptable method of managing spent nuclear fuel. Prior to this an agreement to reprocess 672 tonnes of spent fuel in France was established, but only 55 tonnes was shipped before the contracts were cancelled.

The current policy of direct disposal without reprocessing was adopted in the late 1970s in Swedish legislation. Expenses for management of spent fuel and radioactive waste are to be covered by the revenues received by reactor owners from the sale of electricity produced; reactor owners are to safely dispose of the materials; the State has the ultimate responsibility (*i.e.* after a disposal facility has been closed; a requirement should be established to ensure that responsibility for and supervision of the facility can be maintained for a considerable time, likely by a government authority); and each country is responsible for the spent nuclear fuel and nuclear waste generated domestically (no materials will be imported from another country for disposal in Sweden).

Box 5. **Results of EU stress tests**

Following the severe accident at the Fukushima Dai-ichi nuclear power plant on 11 March 2011, the European Council requested that a comprehensive safety and risk assessment, including stress tests, of operating reactors and spent fuel storage facilities be performed. The stress tests focused on lessons learned from the accident in three main areas: natural initiating events (including earthquakes, tsunamis and extreme weather); the loss of safety systems (loss of electrical power, including a station blackout, and loss of the ultimate heat sink); and severe accident management (means to protect from and to manage the loss of core and spent fuel storage cooling functions and containment integrity). A key issue was the ability to maintain cooling without either off-site electricity supply or on-site backup power. The stress tests were carried out in a three-step process with, first, operators performing an assessment and making proposals for safety improvements; then national regulators conducting an independent review of the operators' assessments and issuing requirements, and last, a European-wide peer review of the national reports submitted by regulators.

All 15 EU countries with nuclear power plants, as well as Switzerland and Ukraine (a total of 140 nuclear reactors) conducted stress tests and were subjected to the peer review. Although the peer review concluded that all countries had taken significant steps to improve the safety of their plants, with varying degrees of implementation, recommendations were made in order to further strengthen safety at a number of operating reactors, including lengthening risk calculations of extreme event severity to 10 000 years, installing (or improving) on-site seismic instrumentation and filtered venting systems, storing equipment earmarked for severe accidents in secure, easily accessible locations and installing a backup emergency control room.

For Sweden, recommendations also included reducing risks and common cause failures in emergency diesel generators, enhancing the reliability of emergency electricity supply, planning for accidents involving multiple units, ensuring long-term performance of the filtered venting systems and implementing an early warning system. The peer review noted that Sweden had already improved nuclear safety systems through back-fitting, following the Three Mile Island accident, with further safety assessments and improvements planned.

National action plans with timetables for implementation will be prepared by national regulators, made available by the end of 2012 and peer-reviewed in early 2013 in order to verify that the recommendations on stress tests are consistently and transparently implemented. The European Commission intends to report on the implementation of the stress test recommendations in June 2014.

In addition, a review of the existing European legal framework for nuclear safety will result in revision of the current Nuclear Safety Directive in early 2013, including proposed amendments on safety requirements, the role and powers of nuclear regulatory authorities, transparency and monitoring. This will be followed by further proposals on nuclear insurance and liability and on maximum permitted levels of radioactive contamination in food.

Detailed results of the EU stress tests can be accessed at: http://ec.europa.eu/energy/nuclear/safety/doc/com_2012_0571_en.pdf.

The Swedish Nuclear Fuel and Waste Management Company (SKB) was established by utilities operating the reactors following the Waste Legislation Stipulation Act of 1977. SKB has developed, among other things, an interim storage facility for spent fuel (Clab) and a final repository for low- and intermediate-level waste. Sweden leads efforts at global scale in the development of a permanent geological repository for spent fuel.

Radioactive waste originates principally from the nuclear power industry, but also from medical uses, industry, research and consumer products. Past nuclear research activities have also generated some wastes that are either stored or have already been disposed of.

Licensees are required under the Radiation Protection Act to take all measures and precautions necessary to prevent or counteract injury to human health and the environment by radiation and to pay a nuclear waste fee per delivered kilowatt-hour of electricity generated. SKB makes annual cost estimates for all nuclear power utilities that are reviewed by regulatory authorities to calculate the fee, which in 2010/11 was SEK 0.01 per kWh, assuming that each reactor will generate electricity for 40 years. The fees are paid into the Nuclear Waste Fund.

The Nuclear Waste Fund has been used to develop the Central Interim Storage for Spent Nuclear Fuel (Clab), a waste transport system (including the ship Sigyn, containers and purpose-designed trucks), the Canister Laboratory, the Äspö Hard Rock Laboratory and the Bentonite Laboratory.

It also funds SKB's research and development costs, including those devoted to siting activities, and will cover costs associated with the encapsulation of spent fuel, the repositories for spent fuel and long-lived low- and intermediate-level waste, the decommissioning and dismantling of NPPs, the disposal facility for decommissioning waste, ongoing research and development work and the expenses for regulatory control and supervision after closure of the reactors.

In 1988, SKB also developed and put into operation the Forsmark facility (SFR), a final repository for short-lived low- and intermediate-level wastes from NPPs, health care, industry and research facilities. In the future it will also serve as a repository for wastes from decommissioned NPPs, most of which must be isolated for about 500 years. An extension to the SFR is currently being planned with the goal of being in operation by 2020.

As required in the Act on Nuclear Activities of 1984, SKB has produced nine RD&D programmes (the most recent in 2010) needed to manage and dispose of spent nuclear fuel and nuclear waste, and to decommission and dismantle NPPs. One of the main milestones of this programme was the filing of a licence application to build a disposal facility for spent nuclear fuel in March 2011. The licence application includes a spent nuclear fuel disposal facility in Forsmark and an encapsulation plant in Oskarshamn. With favourable licensing decisions by 2015, first deliveries to the final disposal of spent fuel are expected to be made in 2025.

In addition to the above-mentioned facilities, the Studsvik facility for treatment of low- and intermediate-level waste is operated by the publicly traded company Studsvik AB. Activities at this facility are mainly devoted to achieving volume reduction and stabilisation by melting and incinerating wastes before final disposal.

ASSESSMENT

Much progress has been made in nuclear energy policy since the last IEA review. The current government has helped clarify some aspects of the future role of nuclear power by enacting legislation that allows the construction of replacement reactors on existing sites, provided that certain conditions are met. Progress has also been made in drafting new regulations to govern the application process and set out the standards that new reactors must meet.

A modernisation and power uprating programme has been undertaken by the industry, improving the performance and safety of the existing reactors and preparing for the operation of these reactors for 50 years or more. With these significant investments, the industry will be able to continue to deliver significant amounts of carbon emission-free baseload electricity.

In July 2012, Vattenfall submitted an application to SSM for permission to build and operate one or two new reactors to replace capacity losses as older plants are retired from service. The company indicated that an investment decision had not been taken and that initiating the licensing process was necessary to provide information on a number of issues before any decision on replacement build can be made. Critically, the requirements that a replacement reactor must meet in order to obtain a licence need to be determined. Vattenfall estimates that it will take up to ten years to acquire all the information needed to take an investment decision.

Nuclear energy accounts for around 41% of electricity generation in 2011. Despite this opening of another possible option for the low-carbon transition, a significant financial investment from industry is needed if nuclear power is to remain a part of the energy mix beyond 2030. Greater certainty will be needed as to the timetable of replacement needs and approval processes.

In general terms, financing highly capital-intensive plants, such as nuclear, in the absence of a stable price on carbon but with public support to low-carbon technologies, is a significant challenge. This is especially the case when nuclear has to compete against renewable energy sources benefiting from the electricity certificate system and secondary policy instruments. Considerable uncertainty remains regarding the replacement of existing reactors in the 2030 time frame. The government does not provide for any direct or indirect subsidies. The global economic context and the general trend towards public support of low-carbon investment across the IEA member countries, make highly capital-intensive projects, such as nuclear, challenging, in a liberalised market framework. Very few examples of successful outcomes using such an approach exist and it is the reason why countries such as the United Kingdom have opted for introducing some price certainties for investors in NPP construction, while keeping a market-based financing. The approach adopted in Sweden sets nuclear investors at significant disadvantage.

The recently enacted legislation that allows the construction of replacement reactors specifies that any new reactor must be built on an existing site. Since the owners of the current NPPs own the properties on which the plants are built, the new legislation means that the current owners will have a central role in determining if and when replacement reactors will be built, potentially restricting new entrants from participating in the electricity generation market.

SKB continues to make good progress in the development of a spent fuel repository and meeting other goals in terms of establishing a repository for low- and intermediate-level waste, establishing an interim storage facility for spent fuel and associated research activities. SKB is owned, operated and funded by the utilities operating the reactors. Under these arrangements, any new entrants in nuclear power generation will have to either negotiate an arrangement to dispose of spent fuel with SKB or develop an alternative disposal facility. This could also limit the access of new entrants to this portion of the electricity generating market.

Ultimately, the success of the ongoing operation, modernisation, safety upgrade work and licensing of potential new replacement reactors depends upon continued development of skilled human resources in the utilities, the regulatory agency and the government. Efforts to attract qualified young people to the nuclear sector must continue if the generation of electricity at nuclear power plants is to continue.

RECOMMENDATIONS

The government of Sweden should:

- ☐ *Develop post-2030 scenarios for nuclear generating capacity in the future mix of electricity generation sources in consideration of security of supply of baseload electricity. In doing so, recognise the significant hurdles that new nuclear investment will face in a liberalised market.*
- ☐ *In a timely fashion, finalise the development of the necessary regulatory framework for the licensing of new replacement reactors and of designs not previously licensed in Sweden, and produce estimated process timelines to provide a clear picture of the approval process to investors.*
- ☐ *Consider ways to facilitate the entry of new market entrants in the construction and operation of new nuclear generating capacity, given the control that the current owners of reactors have over site access and waste disposal facilities.*
- ☐ *Continuously monitor and, when required, take the necessary steps to encourage the development of the human resource expertise required in the nuclear industry, in particular in the regulatory agency, the Swedish Radiation Safety Authority.*

7. ELECTRICITY

Key data (2011 provisional)

Installed capacity: 36.5 GW

Total gross electricity generation: 150.5 TWh, 3.6% increase from 2000

Electricity generation mix: hydro 44.1%, nuclear 40.5%, biofuels and waste 8.5%, wind 4%, natural gas 1.2%, coal 0.8%, oil 0.5%, peat 0.4%

Peak demand: 26 GW

Inland consumption: 10.8 Mtoe (industry 42.3%, residential 34.3%, services and other 21%, transport 2.4%)

ELECTRICITY SUPPLY AND DEMAND

SUPPLY

Sweden's electricity supply is almost carbon-free, as it is dominated by hydro and nuclear energy. Compared to the other IEA member countries, Sweden has the second-lowest share of fossil fuels in the electricity mix, after Switzerland (Figure 33). In 2011, total electricity generation amounted to 150.5 TWh, which is an increase of 1.3% from 148.5 TWh in 2010.

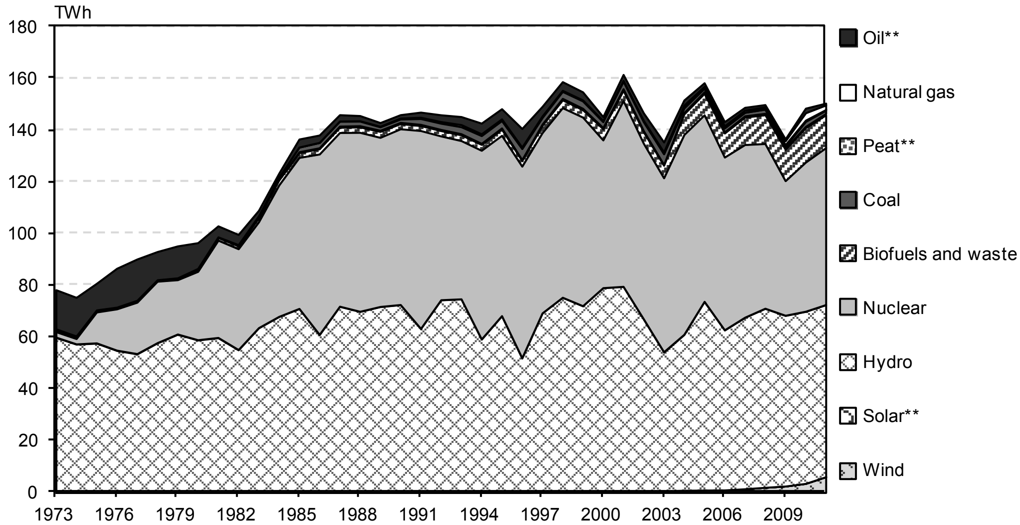
Hydropower is the largest generation source, amounting to 66.4 TWh or 44.1% of total electricity generation. Its supply has been stable at around 65 TWh over the past five years, but varied over the last decade between a low of 53 TWh in 2003 and a high of 79 TWh in 2001, depending on the weather conditions.

Nuclear power is the second-largest source, providing 60.9 TWh or 40.5% of total electricity generation. Its share has been gradually declining from the record high of 77.5 TWh or 51.1% of total electricity generation in 2004. Thermal power production based on gas and oil is primarily used to provide reserve capacity.

The share of hydro and nuclear power supply has shrunk from around 95% in the early 2000s to slightly under 85% in 2011, mainly a result of the nuclear modernisation programme and the growth of electricity generation from solid biofuels, waste and wind, supported by the electricity certificate system.

As outlined in Chapter 5, electricity from solid biofuels and waste accounted for 12.8 TWh or 8.5% of the country's total electricity generation in 2011. Growth in wind power generation has been significant since 2009, accounting for 6.1 TWh or 4% of electricity supply in 2011, an increase from 3.5 TWh in 2010 and 1.4 TWh in 2007.

Figure 32. **Electricity generation by source, 1973-2011***

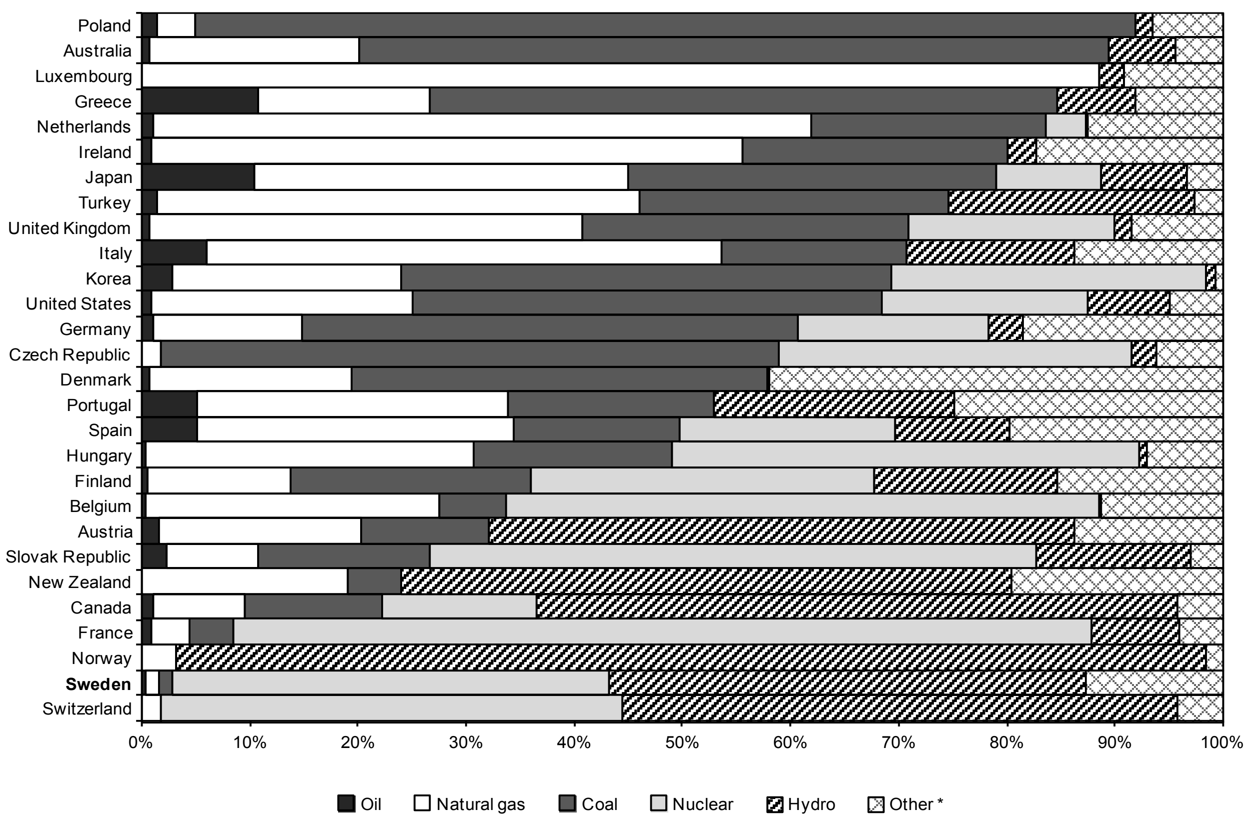


* Provisional for 2011.

** Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

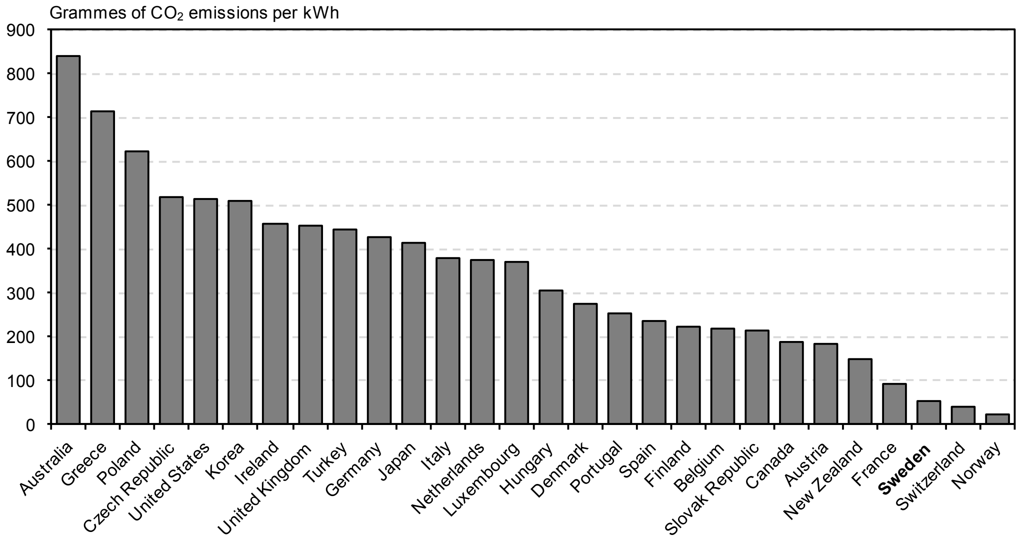
Figure 33. **Electricity generation by source in IEA countries, 2011**



* *Other* includes geothermal, solar, wind, and ambient heat production.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

Figure 34. **CO_2 intensity of electricity generation in IEA countries, 2010**



Note: electricity generated from CHP plants is included.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2012.

GENERATING CAPACITY

At the end of 2011, total installed generating capacity in Sweden was around 36.5 GW (Table 7). Hydropower capacity amounted to 16.2 GW or 46% of total capacity. Nuclear capacity amounted to 9.4 GW (26%) and other thermal power, mainly CHP, accounted for 8 GW (23%) in 2011.

Swedish total installed capacity increased by 8.1% over the past decade. The major part of the total net capacity growth came from wind power, with a 39% increase only between 2009 and 2010, coming almost exclusively from Swedish onshore wind.

DEMAND

During the 1970s and 1980s, electricity use in Sweden rose on average by 5% per year. Since the 1990s, the electricity consumption pattern has been relatively stable, as seen in Figure 35, with the exception of volatility in the past three years, including the economic crisis in 2009. Over the last decade, electricity consumption of all sectors has remained almost the same, though it slightly decreased in the industry sector, while it increased in the commercial and service sectors.

In 2011, final electricity consumption amounted to 10.8 Mtoe, a decrease of 3.9% compared to 2010. Swedish electricity consumption is strongly influenced by the large share of energy-intensive industries and the high number of electricity-heated houses. In 2011, 42.3% of the country’s electricity consumption came from the industry sector; the residential sector and commercial service sector accounted for most of the rest, 34.3% and 21% respectively. The remaining 2.4% was consumed in the transport sector where the share of electricity remains low.

Sweden had the third-highest electricity consumption per capita among IEA member countries in 2010, following Norway and Finland. Residential and industrial consumption in combination with relatively cold winters makes the consumption vary significantly between summer and winter. In 2011, the maximum load in Sweden occurred on 23 February 2011 between 8:00 and 9:00 with 25.82 GW. This compares with the highest peak demand which Sweden recorded thus far, reaching 27 GW, on 5 February 2001.

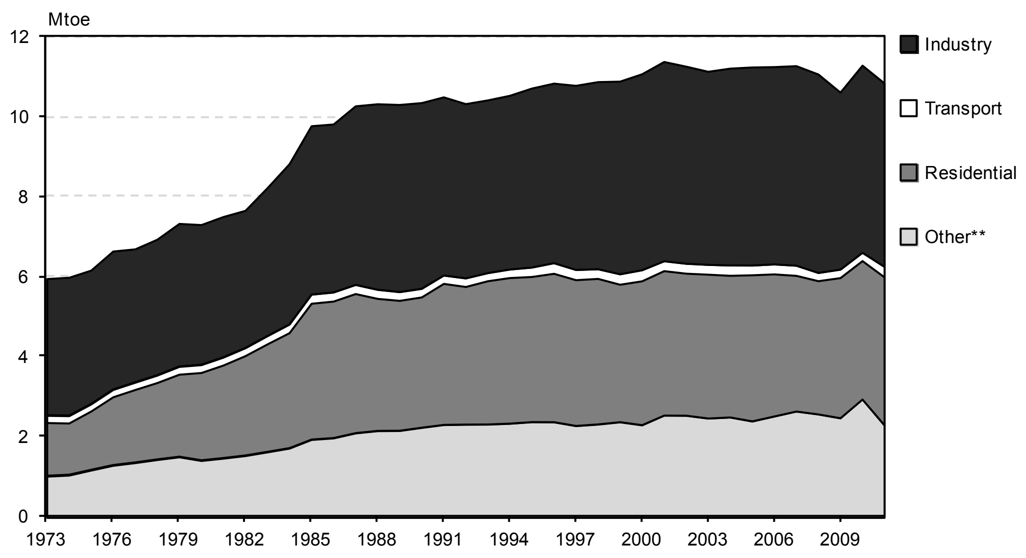
Table 7. **Installed generating capacity in Swedish bidding zones by fuel type, 2011**

Fuel type	Bidding zones				
	SE1	**SE2**	**SE3**	**SE4**	**SE Total**
Hydro	5 255	8 015	2 587	341	16 197
Nuclear	0	0	9 363	0	9 363
Wind	198	487	1 294	920	2 899
Thermal, of which:	283	522	4 378	2 805	7 988
CHP, district heating	160	260	2 244	887	3 551
CHP, industrial	122	260	522	335	1 240
Condensing power	0	0	618	1 005	1 623
Gas turbines, etc.	0	0	993	577	1 570
Total	**5 736**	**9 023**	**17 621**	**4 066**	**36 447**

Note: the four bidding zones have been created on the Nord Pool spot market in 2011.They are created when and where there are limitations on electricity transmission within the Swedish grid and consist of Luleå bidding area (SE1), Sundsvall bidding area (SE2), Stockholm bidding area (SE3) and Malmö bidding area (SE4). They are formed by taking into account the generating capacity and demand in each area. In 2011, SE3 and SE4 are areas of generation shortage, while SE1-SE2 are areas of generation surplus.

Source: Svenska Kraftnät, "Perspectivplan 2025", 2012.

Figure 35. **Electricity consumption by sector, 1973-2011***

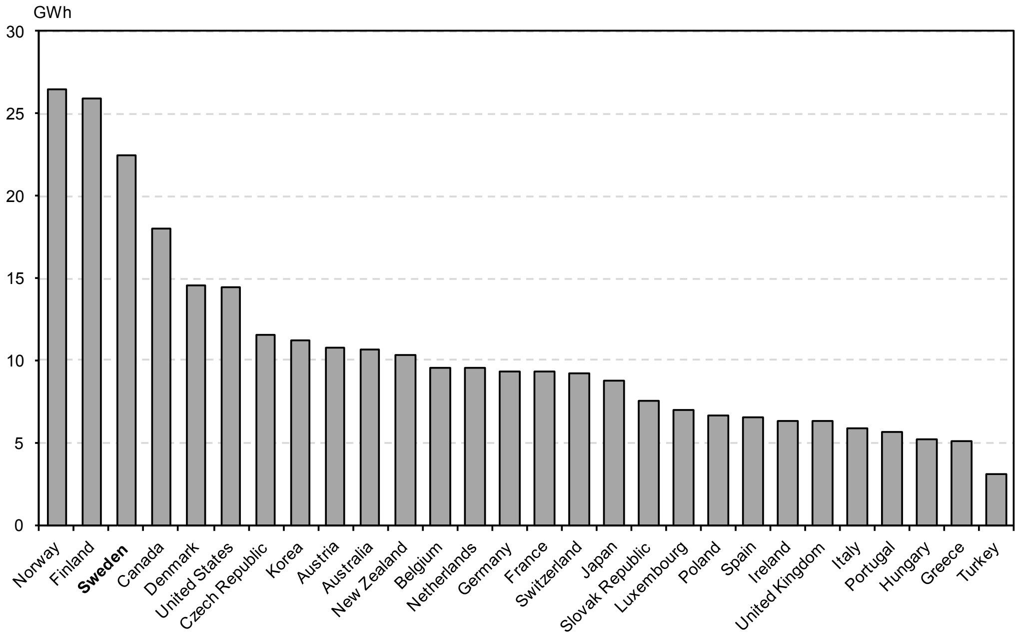


* Provisional for 2011.

** *Other* includes commercial, public service, agricultural, fishing and other non-specified sectors.

Source: *Energy Balances of OECD Countries,* IEA/OECD Paris, 2012.

Figure 36. **Electricity consumption per capita in IEA member countries, 2010**



Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2012.

IMPORT AND EXPORTS

Sweden is located in the centre of the Nordic region with interconnections to its neighbours in Denmark (west and east), Finland, Norway, Germany and Poland (Table 8). During rainy years and in summer, cheap hydropower flows south from Norway through Sweden to the continent. During dry years and in winter, expensive thermal power flows north.

Table 8. **Net transfer capacities between Sweden and its neighbours, winter 2011/12**

Country	To Sweden, MW	From Sweden, MW
Denmark (west)	740	680
Denmark (east)	1 700	1 300
Finland	1 650	2 050
Norway	3 595	3 895
Poland	0	600
Germany	600	610

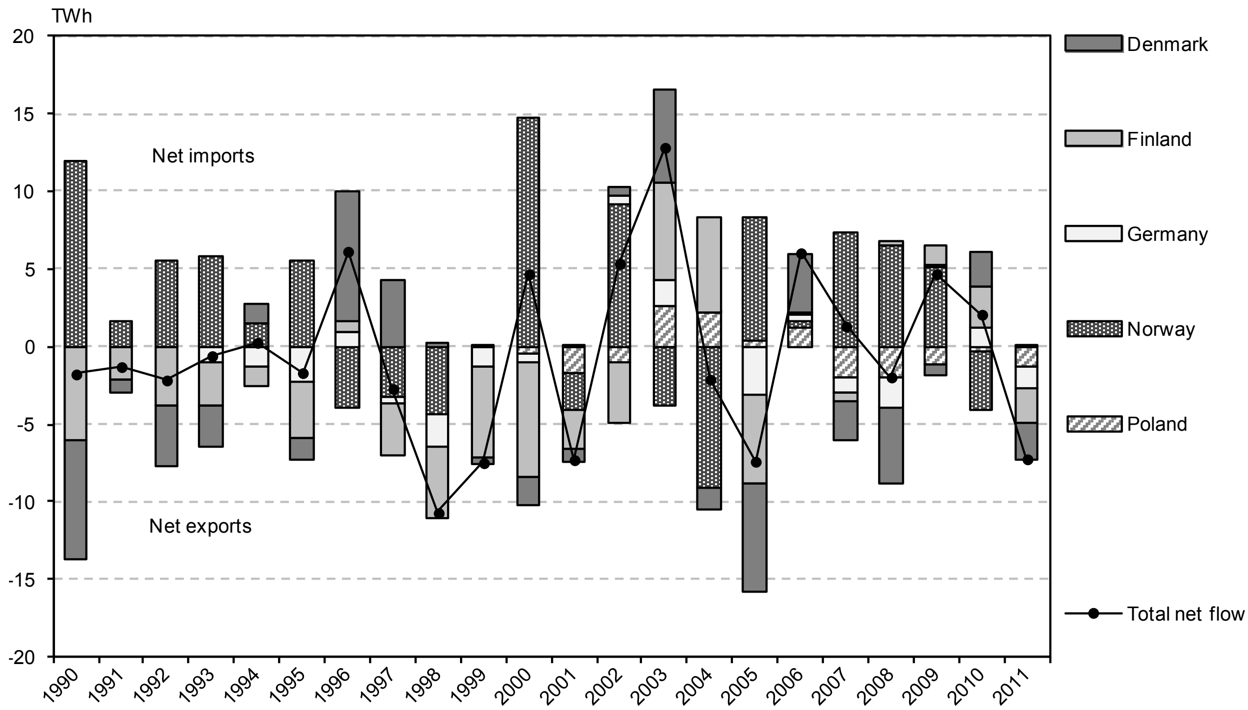
Note: indicative values for net transfer capacity (NTC). NTC = total transfer capacity – transmission reliability margin.

Source: European Network of Transmission System Operators for Electricity (ENTSO-E), NTC matrix, 2011.

Sweden has shifted from being a net importer to a net exporter over the years, depending on seasonal consumption patterns in the Nordic and Central European markets and on the availability of nuclear and hydro power in Sweden. Electricity imports and exports strongly vary depending on the year and the countries. The winter peak demand has resulted in stronger imports in recent years. In 2010, Sweden was a net importer of electricity with 14.9 TWh imported mainly from Denmark (31%, CHP), Finland (31%), Norway (19%) and Germany (15%). In 2010, Sweden exported 12.9 TWh, more than half to Norway (52%), Denmark (19%), Finland (15%) and Germany (8%).

However, thanks to high water reservoirs and better availability of nuclear power in 2011, Sweden was a net exporter of electricity with 12.5 TWh imported mainly from Norway (48.3%), Finland (24.3%), Denmark (20.3%) and Germany (4.8%). In 2011, Sweden exported 19.7 TWh, mainly to Norway (30.4%), Finland (26.2%), Denmark (25.3%) and Germany (10.5%). The long-term projections of the Swedish Energy Agency consider that Sweden will become a net exporter in the decades to come, also for the winter peak.

Figure 37. **Net electricity imports to and exports from Sweden, by country, 1990 to 2011**



Source: *Electricity information*, IEA/OECD Paris, 2012.

INDUSTRY STRUCTURE

GENERATION

In Sweden, electricity generation assets are owned by four large companies: Vattenfall AB, E.ON Sverige AB, Fortum Power and Heat AB, Statkraft Sverige AB. The State owns through Vattenfall approximately 40% of the country's total power generating capacity, non-Swedish owners account for 40%, Swedish municipalities for around 12% and others for roughly 8%.

The three largest electricity generators, Vattenfall, Fortum and E.ON Sverige together accounted for 80% of domestic electricity generation in 2011, a slight decrease from 86% in 2008. The decrease of their market share is to some extent the result of new generation by new market players, in wind (*e.g.* Norwegian Statkraft) and biofuels.

In 2010, Vattenfall alone accounted for 42% of the electricity generated in Sweden, while E.ON Sverige and Fortum, 60% owned by the Finnish State, generated 19% and 18% of domestic electricity supplies, respectively.

In the context of the common Nordic electricity market, the market share of the four largest electricity generators in the Nordic region, however, remained stable and stood at 50% in 2010. Vattenfall accounts for 18% of the electricity generated in the Nordic market. As the Nordic area is divided into different bidding areas and several different price areas (depending on bottlenecks in the transmission grids), the actual market share for the four largest electricity generators can differ from hour to hour in relation to the price areas.

Table 9. **Largest utilities and their assets in Sweden (in MW)**

Company	Hydro power	Nuclear power	Wind power	Other thermal power	Total
Vattenfall AB	7 941	4 682	261	668	13 552
E.ON Sverige AB	1 788	2 668	18	2 078	6 552
Fortum Power and Heat AB	3 135	1 690	0	994	5 819
Statkraft Sverige AB	1 261	0	0	0	1 261
Total	**14 125**	**9 040**	**279**	**3 740**	**27 185**

Source: SEA, 2011.

DISTRIBUTION, RETAIL AND SUPPLY

In 2011, there were five distribution system operators of the regional distribution networks and around 170 local distribution system operators active, which are functionally unbundled. Since market liberalisation and deregulation in 1996, following mergers and acquisitions, the number of electricity suppliers in Sweden has fallen from over 3 000 to 120 in 2011. In 2010, the three largest electricity suppliers that dominate the wholesale market had a market share of more than 50% in the retail market with each serving more than 800 000 customers: Vattenfall (22%), E.ON (19%) and Fortum (12%). The smallest supply companies have less than 1 000 customers.

COMPETITION

Given the joint- and cross-ownership of generation assets, as explained in Chapter 6 and highlighted in Table 9, competition issues are a continuous concern of the Swedish authorities. In several investigations the Swedish Competition Authority highlighted the risk of collusion due to structural ties between producers. As outlined in Chapter 6, this particularly concerns nuclear generation. Investigations were not conclusive, but a code of conduct and an independent surveillance group were set up by the government in 2010 to monitor the nuclear power companies. This group of independent observers attends board meetings.

As of 1 January 2011, following the amendment of the Competition Act, the Swedish Competition Authority has the power to examine and intervene against distortions of competition which might occur when a State, municipality or county council carries out sales activities on competitive markets.

The growth of renewable energy generation, *e.g.* biofuel-fired CHP and wind power, can reduce the dependence on existing hydro and nuclear assets and lead to more diversified and competitive electricity generation. Such competitive pressure has been rather low so far.

In 2012, the Energy Markets Inspectorate carried out an investigation into the impact of four bidding areas on competition. The study showed that the division leads to higher market concentration for isolated areas, but allows for greater flexibility and better competition when the bidding areas are linked to those of neighbouring countries.[20]

INSTITUTIONS

The **Energy Markets Inspectorate** is Sweden's national regulatory authority, which is acting as an agency under the Ministry of Enterprise, Energy and Communications since 2008, has satisfactory independence and powers to supervise electricity and natural gas as well as district heating markets with a staff of 95 and a budget of EUR 11 million. The Swedish Parliament and government decide on its assignments.

The state-owned **Svenska Kraftnät** owns, operates and develops the Swedish high-voltage network as transmission system operator and is responsible for maintaining the power balance and operational security of the Swedish electricity system.

Several authorities co-operate on the monitoring of transparency and competition of the wholesale electricity markets. The Energy Markets Inspectorate monitors market developments in Sweden, including wholesale market transparency (under the REMIT Regulation EU 1227/2011), while the **Swedish Competition Authority** is responsible for ensuring fair competition under the Competition Act and the EU Treaty, and that no market actor is abusing a dominant position in the market. The **Swedish Financial Supervisory Authority** oversees the financial market in Sweden. Within Nord Pool Spot and Nasdaq OMX, trading is monitored by the Norwegian regulatory authorities, the Norwegian Water Resources and Energy Directorate, and the Financial Supervisory Authority of Norway. Recently, the price and market supervision of physical and financial trading at Nord Pool Spot were separated.

In spring 2011, the so-called **"insight Council"** was set up within **Nord Pool Spot** to monitor bidding activities. It is composed of representatives from the regulatory authorities in Sweden, Finland, Norway, Denmark and Estonia, and also from Nord Pool Spot management.

With regard to the retail market, the Energy Markets Inspectorate monitors the market on consumer issues and prices, while the **Swedish Consumer Agency** advises on contractual terms and conditions for the industry. In December 2011, the **Swedish Consumer Energy Markets Bureau** was created under the umbrella of the Energy Markets Inspectorate, as the joint contact point for electricity and gas consumers.

The regulator co-operates with other regulatory authorities in the Nordic region within **Nordic Energy Regulators (NordREG)** and at EU level within the Agency for the Co-operation of Energy Regulators and Council of European Energy Regulators (CEER) on the creation of legal structures for the internal electricity market through Framework Guidelines and Network Codes, according to the Third Internal Energy Market Package.

20. Energy Markets Inspectorate: Bidding areas in Sweden EI R2012:06.

LEGAL FRAMEWORK AND MARKET DESIGN

With early deregulation in 1996 and the creation of the common Nordic electricity market, the Swedish electricity system is considered as a role model for market liberalisation and regional integration.

The legal basis for the Swedish electricity sector is provided in the Electricity Act of 1997. As a member state of the European Union, Sweden is obliged to transpose the EU Electricity Directive 2009/72/EC of 13 July 2009 concerning common rules for the internal market in electricity, and repealing Directive 2003/54/EC, into national law in 2011 and 2012, while Regulation (EC) No 714/2009 of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity applies directly.

The Swedish electricity market is fully liberalised with customers being free to choose their own supplier. Electricity transmission and supply activities are separated through ownership unbundling, while most distribution network assets are owned by the suppliers. As of January 2010, distribution network operators are functionally unbundled.

There is no price regulation of electricity supply; but grid access tariffs for electricity transmission and distribution have been regulated *ex ante* since 1 January 2012. Distribution networks are regulated at a return rate, weighted average capital cost (WACC) of 5.2%, with a regulatory period of four years and a revenue cap including quality norms. Transmission maintains a regulatory period of one year. The transmission tariff structure is based on a point of connection (not distance-related) tariff system, where the user is charged for the injection or out-takes of electricity at a connection point in the transmission grid. The transmission tariff consists of two parts, a power charge and an energy charge.

WHOLESALE MARKET

More than in the national context, the Swedish electricity system has to be considered as part of the regional Nordic electricity market, which comprises Denmark, Finland and Norway, and recently also the Baltic States, and through market coupling the Central-West European markets. Virtually all power generated in Sweden is sold at and around 94% of national electricity consumption is purchased via Nord Pool Spot.

The Swedish, Norwegian, Finnish and East Danish power systems form one common synchronised zone at a frequency of 50 Hertz (within ENTSO-E Europe there are five synchronous zones). Sweden forms a common bidding zone with at least one other power spot area. In 2011, the Nordic area had one common electricity price during 26% of the time, an increase from 18% in 2010, depending on the hydrological balance, the availability of nuclear power and demand for electricity in the Nordic countries.

Box 6. **Overview of Nord Pool: integrating the Nordic and the Baltic markets**

A Northern European power market has been created over the past years through Nord Pool Spot AS as the marketplace for physical power contracts, with a spot market (Elspot) and an intra-day market (Elbas). The Nordic market is interconnected with Russia, Germany, the Netherlands, Estonia and Poland and is becoming increasingly integrated with other regional European markets, the United Kingdom, Belgium and the Netherlands, through new interconnections and market coupling – a development which will gradually lead to a Northern European and single European market for electricity.

Box 6. **Overview of Nord Pool: integrating the Nordic and the Baltic markets** (continued)

Nord Pool has increased its share in electricity trade every year. In 2010, physical spot market trading amounted to 307 TWh, or 74% of total consumption in the four Nordic countries. In 2011, total traded volume fell slightly to 297 TWh, owing to the fall of electricity consumption in the Nordic countries. The remaining 24% was traded on termed bilateral contracts. The market share of Nord Pool Spot AS is more than 50% in all the Nordic countries. In 2011, 370 actors from 20 countries were active on Nord Pool Spot's markets in the Nordic and Baltic regions, with 324 on Elspot and 95 on Elbas (in January 2011) and the United Kingdom market N2EX.

Nord Pool Spot AS is jointly owned by the Nordic transmission system operators, Statnett SF (28.2%), Svenska Kraftnät (28.2%), Fingrid Oyj (18.8%), Energinet.dk (18.8%) and the Baltic transmission system operators Elering (2%) and Litgrid (2%). The Latvian operator AST has an agreement in place to acquire 2% of Nord Pool Spot once the Latvian market is opened for trading.

On the spot market (Elspot), physical power contracts are traded hour by hour for delivery on the following day. The Elspot market comprises Denmark, Finland, Norway, Sweden, Estonia and, since 18 June 2012, Lithuania. Prices are determined on the basis of the balance between bids and offers from all market participants and implicit auctions are used to allocate cross-border capacity. The spot market price provides the basis for the TSOs when balancing the flow of power between the Nordic countries.

Elbas is the physical intra-day balancing market for trading in the Nordic countries, Estonia and Germany. If transmission capacity is available, neighbouring countries can trade on the Elbas market. It is the only cross-border intra-day market in the world, with a total volume of 2.2 TWh in 2009.

TSOs publish their daily power transmission capacity on Elbas and contracts are hourly and traded continuously around the clock up to 30 minutes before delivery to adjust power production or consumption plans. The balancing market is used by power producers, energy-intensive industry, portfolio managers and traders. In January 2011 the Nordic system operators and regulators started work on a common Nordic balance settlement. In 2011 Elbas was licensed to APX-ENDEX as the intra-day market in Belgium and the Netherlands.

There is financial trading on the Nordic power market on Nasdaq OMX with exchange of power derivatives and CO_2 allowances. Derivatives contracts can be made for up to six years with the Elspot system price used as reference price. Turnover on Nord Pool is dominated by the financial market, with financial trading reaching 2 108 TWh, an increase by 73% in comparison to 2009; 341 actors were active on the Nasdaq OMX in December 2010. Svenska Kraftnät and Statnett FT sold their financial operations to Nasdaq OMX in April 2010; Nasdaq OMX is now the sole owner of the financial market place. In 2010 N2EX market in the United Kingdom was launched by Nord Pool Spot and NASDAQ OMX Commodities.

On 9 November 2010, the Central-West Europe (CWE, covering Germany, France and the Benelux countries) price market coupling and the CWE-Nordic region Interim Tight Volume Coupling (ITVC) were launched, in a joint effort of 17 TSOs and power exchanges. This created a day-ahead market area with 1 800 TWh of annual power production, the largest of its kind in the world, and will lead to prices converging in the two areas.

Box 6. **Overview of Nord Pool: integrating the Nordic and the Baltic markets** (continued)

Currently, the two market areas are connected by cables between Germany and Denmark, and Germany and Sweden. The NorNed cable between Norway and the Netherlands will be integrated into this system of implicit auctions of cross-border capacity.

Following the deregulation in Estonia and Lithuania in 2012, the Nordic and Baltic markets have been integrated. In March 2012 Estonian, Latvian and Lithuanian electricity TSOs Elering, Augstsprieguma Tīkls and Litgrid signed a Memorandum of Understanding on the purchase of the shares of the Nord Pool Spot. The Nord Pool Spot Lithuanian bidding area was put in place. Agreement on Power Exchange Operation in the Republic of Lithuania between Litgrid and Nord Pool Spot was signed. In Latvia, the certification procedure of AST as an independent system operator was to be completed in 2012 and AST was to acquire 2% of the shares of Nord Pool Spot. A project with Nord Pool Spot has been initiated towards launching a Latvian bidding area.

In addition to power trade, Nordic TSOs also co-operate on security of electricity supply within the Nordic Contingency Planning and Crisis Management Forum (NordBER), which includes cross-border contingency planning and crisis management; risk and vulnerability assessment; a mutual contingency plan; resource planning and sharing of information; communication and experience exchange; as well as a training programme.

More information on NordPool is available at: www.nordpoolspot.com/.

RETAIL MARKET

Unlike the wholesale market, the electricity retail market is a national one. At the start of the deregulation in 1996, around 78% of households had switched supplier or renegotiated their contract. In 2011, out of the total 5.2 million domestic customers (4.4 million households), more than 1.6 million, or 37%, were active, either by renegotiating their contract or by switching electricity supplier. That means that the majority of Swedish domestic customers did not switch suppliers and mostly stayed with open-ended contracts.[21] However, there is a trend away from open-ended towards shorter (one to three years) fixed contracts (42% of customers), which avoid price spikes but allow for medium-term price savings. Retail tariffs for domestic customers in Sweden are largely single tariffs; there are only a few time-related or dynamic tariffs. In May 2012, the regulator presented a proposal for reducing the proportion of customers with open-ended contracts.

In 2011, the Electricity Act was amended to introduce consumer protection measures, including information requirements for electricity suppliers' and network owners' contracts with individual consumers, a definition of vulnerable customers (persons who permanently lack the ability to pay for the electricity or natural gas transferred and delivered to them for purposes that fall outside business operations).

Since 1 July 2009, distribution system operators (DSOs) are obliged to read electricity meters of household customers (with fuse of 16 to 63 amperes) every month. In Sweden, the first generation of smart meters, enabling remote readings, are already installed in around 90% of Swedish households. Industrial and commercial consumers (fuse above 63 amperes) have their consumption read on an hourly basis.

21. For more information, see the 29 May 2012 report by the Energy Market Inspectorate on the customer mobilisation at: http://ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202012/Systemet_med_anvisad_elhandlare_EIR_2012_07.pdf.

Smart meters and smart grids

In October 2012, the Parliament adopted new measures to strengthen consumers' role in the electricity market and their flexibility to adapt consumption to peak and off-peak hours. The new measures that are to be implemented in 2013 include voluntary hourly metering of households' electricity consumption, new methods for settlement, billing and data management, and enabling households to generate their own renewable electricity and to charge an electric vehicle.[22] It is expected that existing smart meters can be upgraded to enable hourly reading and more active demand-response services in the future.

Sweden has taken technology leadership in the development of smart grid solutions, with leading power technology industry and a number of research programmes and large-scale demonstration projects (Chapter 9). Smart grid demos are running in Stockholm (prosumer), Malmö and Gotland (wind power balancing), including e-vehicle demos, smart cities and co-operation between Norway (Trontheim) and Sweden on chargers. Sweden's Uppsala University with Royal Institute of Technology were chosen to lead smart grids in the EU Knowledge and Innovation Community (KIC) InnoEnergy. The government established a national smart grid council and a knowledge platform, supported with SEK 10 million (EUR 1.16 million) per year during 2012-14, with the aim to increase the knowledge of smart electricity networks among stakeholders and society at large, to strengthen the interaction between different actors and to develop a national action plan.[23]

FOSTERING INTEGRATION IN THE NORDIC MARKET

The common Nordic and Baltic electricity market is a comprehensive regional electricity market based on close co-operation among neighbouring markets at the level of ministers, regulatory authorities, transmission system operators and industry. As set out in the priorities of the Nordic Council of Ministers, there is strong political will to foster integration at both the wholesale and retail levels through investment in new transmission capacity and the creation of a common Nordic retail market by 2015.

Harmonisation of rules related to operations, congestion management, capacity allocation and balancing progresses and allows business and consumers to benefit from a larger market and to minimise the costs of balancing the system.

The Nordic TSOs, through co-operation in the European Network of Transmission System Operators for Electricity (ENTSO-E, formerly in Nordel), have been forerunners in joint grid planning, based on the Nordic Grid Master Plan, a Nordic cost-benefit analysis and cost allocation. The 2012 Nordic Grid Development Plan was prepared as requested by the Nordic Council of Ministers of 25 October 2010, in a joint planning by Statnett, Svenska Kraftnät, Energinet.dk and Fingrid, and the Icelandic TSO Landsnet. Despite this effective regional planning, investments have been slower than expected. Nordic regulators analysed the regulatory barriers to investments. The results align with findings at European level: the permitting process, including resistance against overland transmission lines, cost-sharing issues, criteria for investments to be deemed beneficial. The planned investment budgets of the Nordic TSOs have increased, and important investments are in the pipeline. The allocation of congestion revenues on the cross-border interconnections should ensure the financing of the most needed infrastructure.

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22. "Strengthening the role of the consumer for a developed electricity market and sustainable energy system" [Stärkt konsumentroll för utvecklad elmarknad och uthålligt energisystem] (Govt. Bill 2010/11:1539).

23. http://ei.se/Documents/Publikationer/Rapporter%20och%20PM/Rapporter%202011/Adapting_electricity_networks_to_a_sustainable_energy_system_EIR_2011_03.pdf

Nordic regulators are actively co-operating at EU level to establish a single price linking procedure and cross-border intra-day market between the Nordic countries, Germany, the Netherlands, Belgium, Luxembourg, France and Great Britain and develop an internal European electricity market. A common Nordic market for balance power has been created. Balance regulation is handled jointly by all Nordic TSOs, as if the Nordic synchronised area were one single control area. In 2009, common principles for balance settlement were introduced which are currently being expanded to a common balance settlement which is a prerequisite for a common Nordic end-consumer market.

The organisation of the Nordic Energy Regulators (NordREG) intensified its efforts to harmonise the Nordic electricity retail markets and recommended a revised market model for a common Nordic retail market, switching from the present model with a dual point of contact, where the customers very often need to contact both the DSO and the electricity supplier, towards a “supplier-centric market model” with mandatory combined billing.

TRANSMISSION AND DISTRIBUTION

TRANSMISSION NETWORK

In 2011, the Swedish electricity network consisted of a total of 538 000 km of conductors, of which 320 000 km were underground cables and 218 000 km were overhead lines. The transmission network has over 140 connection points and around 25 grid customers, mainly large electricity generating facilities and regional networks.

Sweden is connected to Finland, Germany and Poland with direct current (DC) lines. The capacity allocation on all DC links is done through implicit auctions via Nord Pool Spot or the European Market Coupling Company (EMCC).

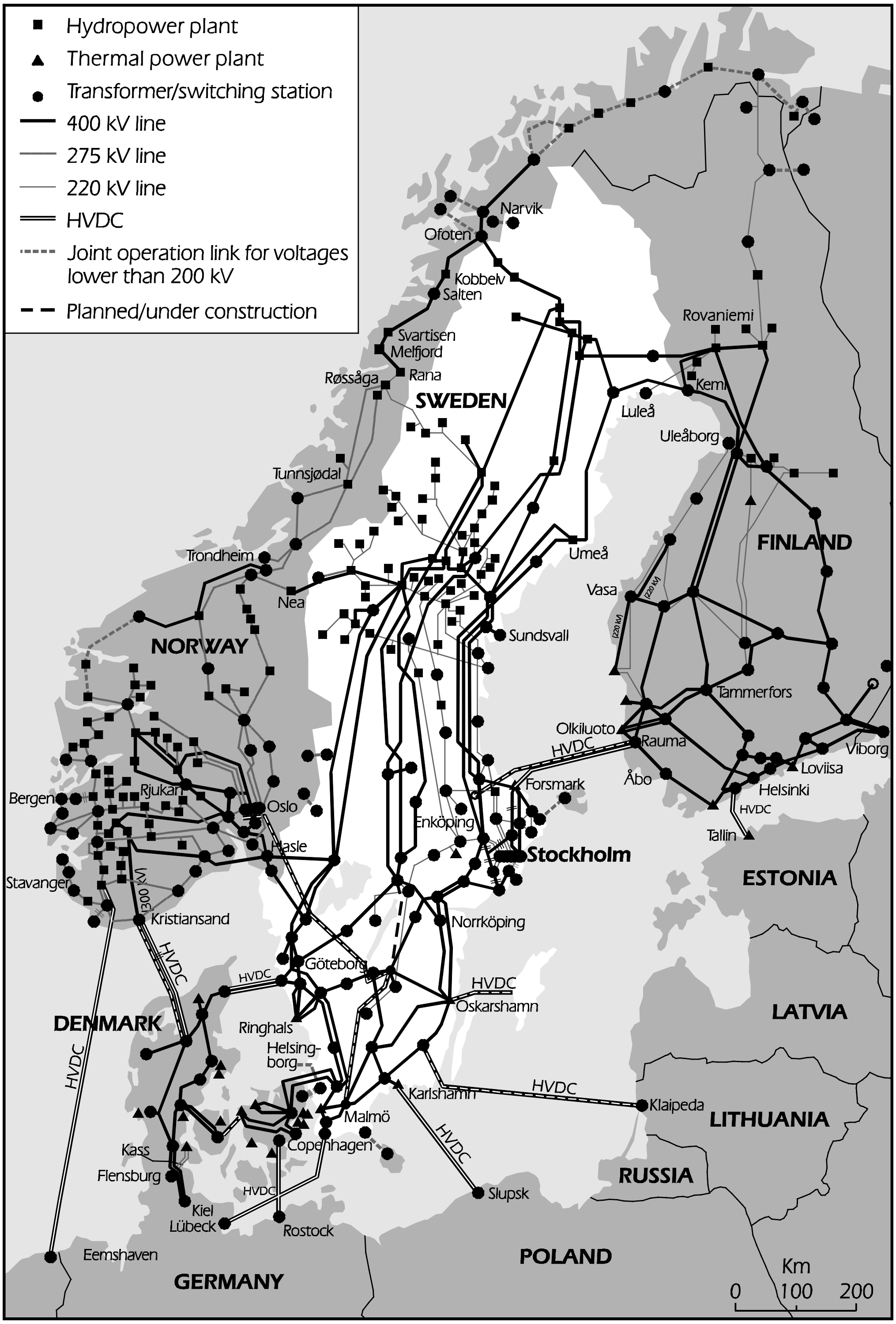
The BalticCable is a 600 MW submarine high-voltage direct current (HVDC) link between Trelleborg in Sweden and Lübeck in Germany, which was built in 1991 and is owned and operated by Baltic Cable AB. The HVDC 250 km submarine line, SwePol Link, connects the Stärnö peninsula near Karlshamn in Sweden, with Bruskowo Wielkie, near Słupsk in Poland. The SwePol link started operation in 2000 as built by SwePol Link AB, a company jointly owned by Svenska Kraftnät (51%), Vattenfall (16%), and PSE-Operator (33%), the Polish TSO. In August 2012, SwePol Link AB sold all assets to Svenska Kraftnät and SwePol Link AB’s subsidiary in Poland, SwePol Link Poland, sold its share to PSE-Operator S.A. Since December 2011, the new 800 MW Fenno-Skan-2 link has been put in operation to strengthen the existing DC link between Finnböle (Sweden) and Rauma (Finland). The link consists of around 200 km undersea cable and around 100 km overhead line, and is run by Svenska Kraftnät and Fingrid Oyj.

REGULATION

The TSO Svenska Kraftnät manages and operates the electricity lines and associated installations for the transmission of high-voltage electricity (220 kV and 400 kV, 15 000 km) in Sweden, including the cross-border connections owned by the Swedish State.[24]

24. The transfer of the ownership to the Swedish State (Svenska Kraftnät) has been accomplished on the interconnections Sweden-Poland and Sweden-Germany.

Figure 38. **Map of the Swedish electricity transmission grid, 2011**



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Svenska Kraftnät is the balance-responsible authority, and has to maintain the balance of the electricity system in real time, on the basis of consumption and generation forecasts which are submitted by market actors to the TSO.

Based on the separation of the supply and transmission activities, Svenska Kraftnät was certified as an ownership unbundled TSO in Sweden in 2012. Svenska Kraftnät and the state-owned generator Vattenfall AB are governed by two different ministries. Svenska Kraftnät falls within the area of competence of the Swedish Ministry of Enterprise, Energy and Communications, while Vattenfall AB falls under the Ministry of Finance.

Svenska Kraftnät co-operates closely with other TSOs across the Nordic area and in the EU within ENTSO-E.

CONGESTION MANAGEMENT

The internal Swedish network has congested areas in the North-South direction, between the zones of generation in the north and consumption areas in the south. In the Nordic market area, congestion is managed on the basis of counter-trading or market splitting through the creation of price areas. Such price areas are determined by the TSOs on the basis of the congestion at the price determined by Nord Pool. They are created when and where there are limitations on electricity transmission within the Swedish grid. The bidding areas are Luleå bidding area (SE1), Sundsvall bidding area (SE2), Stockholm bidding area (SE3) and Malmö bidding area (SE4) with SE3 and SE4 having a generation shortage, and SE1-SE2 a generation surplus.

Since the last review in 2008, Sweden moved towards market-based congestion management and capacity allocation within its network and on the interconnections to neighbouring systems.[25]

In the past, Sweden managed congestions within the national grid by either counter-trading or by moving the congestion to the border. Following complaints by Danish market participants, in April 2010, analysis by the European Commission DG Competition found that the reduction of interconnector capacity discriminated against foreign customers in the EU internal market. As a result, Sweden aligned its congestion management with the market-splitting mechanism of the Nordic market area and suggested as binding commitment to the European Commission the division of Sweden in four separate bidding areas (SE1 to SE4, see Figure 39) as of 1 November 2011: Luleå bidding area (SE1), Sundsvall bidding area (SE2), Stockholm bidding area (SE3) and Malmö bidding area (SE4).

The price differences within Sweden are expected to send investment signals to the market on where new power plants are needed and on where the transmission capacity should be increased. Svenska Kraftnät reports the interconnector capacity in quarterly monitoring reports to the European Commission.[26]

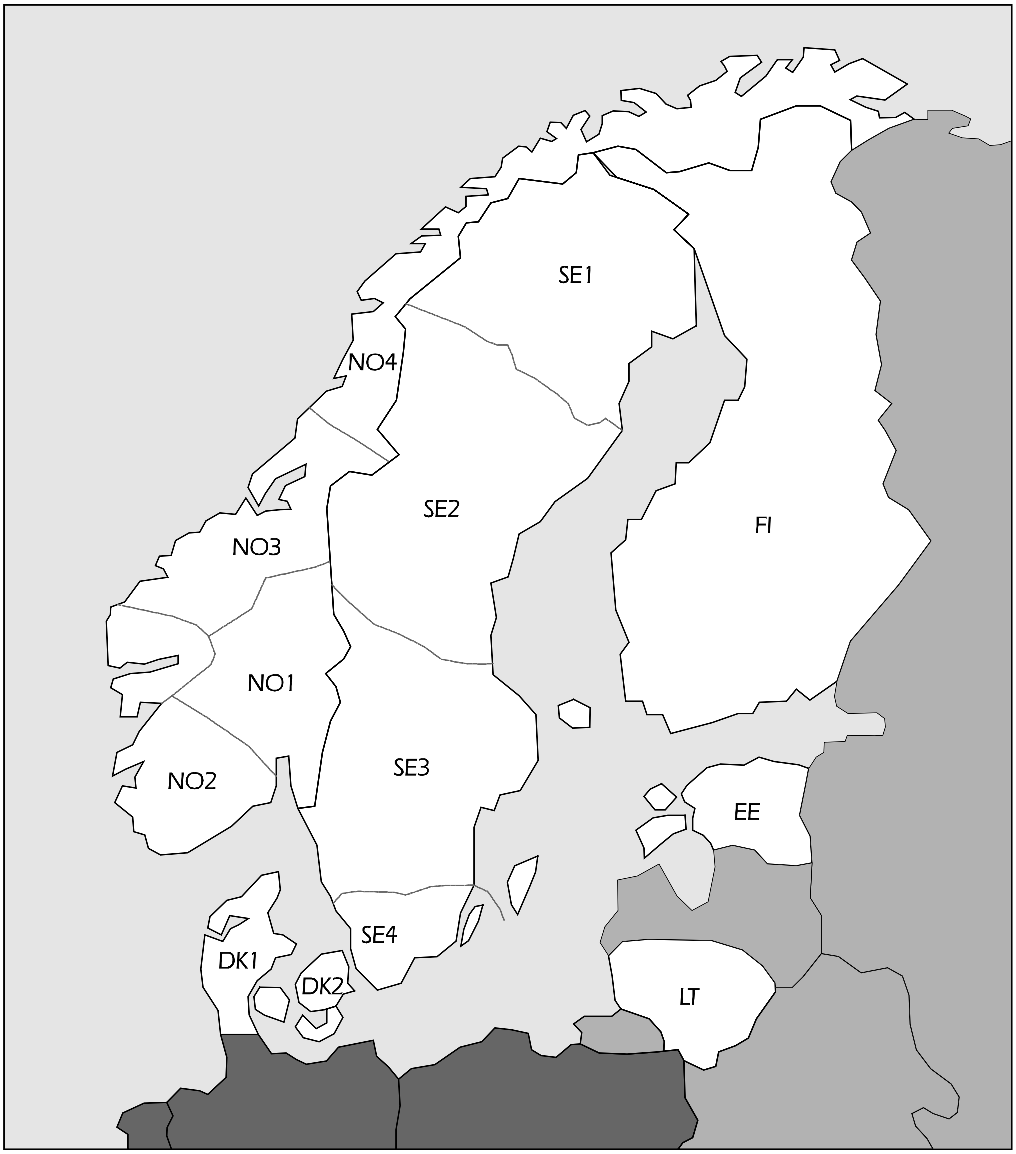
In 2011, counter-trading cost amounted to SEK 132 million and revenues from cross-border congestion which were accumulated by Svenska Kraftnät totalled SEK 313 million. Svenska Kraftnät, together with the other TSOs in the Nordic area, following approval by the regulators, decided to use these revenues to strengthen cross-border connections.

25. Sweden has still one open infringement procedure under the Second Energy Package concerning the lack of congestion management and a transparency provision concerning access to the network for cross-border exchanges in electricity.

26. The reports are available on the website of Svenska Kraftnät, www.svk.se.

Sweden has to apply market-based allocation of interconnection capacity, following concerns raised by the European Commission in 2009 about the capacity allocation on the DC interconnections BalticCable and SwePol Link. All capacity for interconnectors within the Nordic area (*i.e.* between Sweden, Norway, Finland and Denmark) is now handled through implicit auction. The two HVDC links between Sweden and Germany and Poland have been market-coupled: Baltic Cable from 2 May 2010 and SwePol Link from 15 December 2010. For the Baltic Cable, connecting Sweden and Germany, the capacity of the cable is included in the market coupling (implicit allocation) between Germany and the Nordic markets. For the SwePol Link, connecting Sweden and Poland, only day-ahead implicit allocations apply.

Figure 39. **Map of the Nord Pool bidding zones and the new four bidding zones in Sweden**



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Svenska Kraftnät, 2012.

TRANSMISSION NETWORK INVESTMENT

In order to foster trade and integrate increasing amounts of renewable energy and to further strengthen the integration within the Nordic and Central-West electricity markets, Sweden plans to reinforce its national electricity grid and the interconnections with neighbouring countries.

In October 2012, Svenska Kraftnät presented for public consultation its long-term network investment "**Perspectivplan 2025**" with investments of SEK 50 to 60 billion (EUR 6 to 7 billion), providing electricity market participants with an opportunity to express their views on the network planning, before it is finalised by spring 2013.

The "Perspectivplan 2025" envisages network upgrades within Sweden, from northern Norrland, central Sweden, Småland and Blekinge to secure long-term electricity supply with power increases from uprated nuclear power plants. In addition, Svenska Kraftnät foresees national reinforcements to allow for the connection of offshore wind farms and benefits from an interconnector from Sweden to the European continent, possibly to Germany.

Box 7. **Major planned interconnections until 2025**

NordBalt is a project (EUR 552 million) for the construction of a DC electricity interconnection (300 kV, 700 MW) between Klaipėda (Lithuania) and Nybro (Sweden), by transmission system operators Svenska Kraftnät and Litgrid, to promote trade in electricity and the security of electricity supply in both regions. European Union financial support to the project is in the range of EUR 175 million in total, with EUR 131 million for the construction of the link, and the remainder for the reinforcement of the Latvian electricity transmission system. The interconnection is planned to be in operation by the end of 2015.

The **South-West Link** is Svenska Kraftnät's largest network investment, required to enable the integration of higher amounts of renewable energy. The link consists of a new alternating current (AC) link between Barkeryd and Hallsberg, and a direct current link between Norway and Skåne with a nodal point in Barkeryd. The project will reinforce the AC network, increase operational reliability, and deal with limitations in transmission capacity to southern Sweden and between Norway and Sweden, thus limiting the price differences within the Swedish bidding areas. The north and south branches are estimated to be completed at the end of 2014 or beginning of 2015. The west branch is expected to be ready at the earliest by 2018. The three branches of the South-West Link will in total be 700 km to 800 km.

The connection between **Sweden and Gotland** will be reinforced in two phases: The Gotland 1 300 kV HVDC line will provide for 500 MW and be constructed in 2015-20. Gotland 2 will be added later to further upgrade the connection with another 300 kV HVDC line of 500 MW.

The analysis of the Swedish and Nordic power systems has shown that there are benefits from an additional **interconnector from Sweden to the European continent**. A more detailed study is planned for a new HVDC line to Germany for the time horizon 2018-25. Further connections to Finland and Norway in the higher North of Sweden are in the planning stage.

According to the Plan, investments worth SEK 29 billion (EUR 3.6 billion) are envisaged for projects on market integration. The TSO estimates a total of SEK 27 billion (EUR 3.1 billion) for maintenance and security of supply and plans to invest around SEK 17 billion

(EUR 2 billion) for the connection of new generating capacity. For the medium term (2012-16), the priorities are strengthening of internal connections within Sweden and the construction of the 300 kV HVDC interconnection to Lithuania (Nordbalt). In the longer term after 2017 to 2022, the reinforcement of the south-west connection (South-West Link) between Sweden and Norway with two parallel connections is scheduled. Svenska Kraftnät currently is extending the national electricity grid with several projects, including Ekhyddan-Barkeryd, Forsmark-Stackbo, Forsmark-Råsten, Lindbacka-Östansjö, Råsten-Östfora, Stackbo-Hamra, Stenkullen-Lindome, Stockholms Ström and Storfinnforsen.

Sweden is seeking to connect and build offshore wind parks. Two large offshore wind parks are planned in the S4 Malmö zone, including the connection of the 700 MW Södra Midsjöbanken wind park in the horizon 2020-25 and the 1 000 MW Blekinge offshore wind park for 2018-22. An internal upgrade of the sub-station at **Storfinnforsen** was completed, where four 400 kV lines are connected, plus a hydroelectric power station of E.ON. In order to meet current operational reliability requirements, an entirely new sub-station has been constructed, on the site of the old one. The new sub-station was put into operation in November 2011. This will allow the future integration of important wind power farms that are planned in the area.

PERMIT GRANTING PROCEDURES

In Sweden, the permit granting procedure for the development of the transmission grid consists of two parts: the network concession to build and operate a network, which is handled by the Energy Markets Inspectorate, and the environmental permit under the Environmental Code and the Planning and Building Act. This permit is decided by the regional authorities, the county administrative board and the municipalities with regard to protected areas (EU Natura 2000 zones), and the county administrative board or the environmental courts with regard to tunnelling or extensive ground works.

The permitting procedure generally takes four to five years, but in some cases it may take up to ten years. There are no binding maximum periods for authorities to take a decision. Over the past years, the government introduced measures to facilitate a faster permit granting procedure.

At the level of the network concession, Sweden has limited the instances of appeals to one instance.

Following amendments to the Electricity Act in 2009, matters relating to the construction or use of an electric power line, where a case concerning the permit has been brought before the court under the Environmental Code, does not need to be tried again in a permit case under the Electricity Act. (This rule does not apply to hydro generation plants, for which a network concession for the power line is required in order to be able to submit an application for an environmental judgement of the hydro plant.)

As of January 2009, the government may also provide for an exemption from the requirement for grid licence for certain types of lines or in the case of lines in certain areas. This concerns cases where two or more production sites, which form a functional unit, may be connected to internal networks. The Energy Markets Inspectorate has set out around ten binding statements for internal networks linking production sites.

Investments are approved by Parliament once the grid licence is granted by the Energy Markets Inspectorate.

DISTRIBUTION NETWORK

Electricity distribution network companies own and operate the regional networks (40 kV to 130 kV) as well as the local networks at 40 kV or below. The regional grids have a cable length of 33 000 km, while the local networks consist of 479 000 km.

Regional networks are operated by five DSOs, among them three large distribution operators: Vattenfall Eldistribution, Fortum Distribution and E.ON Elnät Sverige with more than 800 000 customers each.

In 2011, there were 171 distribution companies, operating local networks. These companies are co-operative associations, privately owned companies and municipalities. Sweden's electricity production, distribution and supply are carried out within the same corporate group with functional unbundling of activities.

The Electricity Act of 1997 guarantees the right to be connected to the grid. In the past, distribution networks were regulated *ex post*, with the DSOs setting their connection tariffs. Since 1 January 2012, the Energy Markets Inspectorate has started regulating the electricity distribution networks in Sweden in an *ex ante* approach for a regulatory period of four years (2012-15). The distribution operators are planning investments in the range of SEK 18 billion in the grid for the period 2012-15.

PRICES AND TAXES

WHOLESALE PRICE

Virtually all electricity generated in Sweden is traded on Nord Pool markets. Price trends are a function of transmission capacity, precipitation (and reservoir levels), availability of nuclear, and wind as well as temperature shifts in the Nordic and Baltic markets. The Nordic system price showed large fluctuations in the past years. During the first six months of 2011, the system price reached more than SEK 0.70 per kWh.

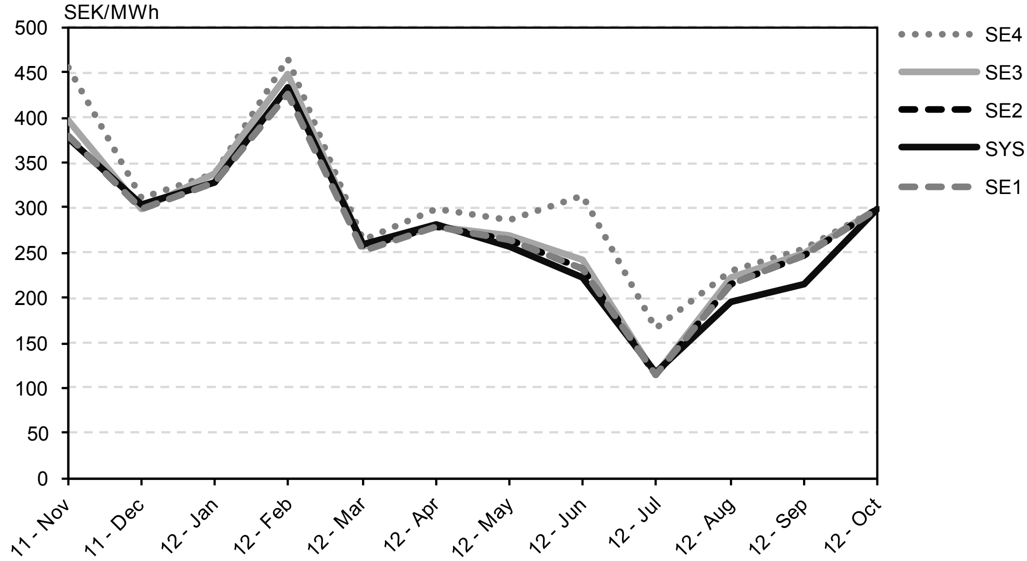
In 2010, Sweden recorded the highest annual average spot price of SEK 0.5448 per kWh, with the highest ever 24-hour-average price of SEK 5 000 per MWh (EUR 582), reaching an hourly price of almost SEK 14 000 per MWh (EUR 1 630). Network congestion, low water levels in the reservoirs and nuclear power plants being out of commission were the main drivers of these price spikes in 2010.

Following the introduction of the bidding areas as of 1 November 2011, an initial increase in prices in Sweden was recorded. This was mainly due to low temperatures, reduced transmission capacity between Sweden and Finland and the temporary shut-down of nuclear power reactors at Ringhals.

Towards the end of 2011, prices fell, thanks to high water levels in reservoirs, and should continue to fall with new investment in internal networks and interconnections becoming completed. In 2011, the average spot price in Sweden was around SEK 0.42 per kWh.[27] Investigation by the Energy Markets Inspectorate into the impact of the price zones found relatively modest price differences, overall better price signals and better use of grids.

27. Source: Nord Pool.

Figure 40. **Average monthly wholesale system price and Sweden bidding prices at Nord Pool Elspot, November 2011 to October 2012**

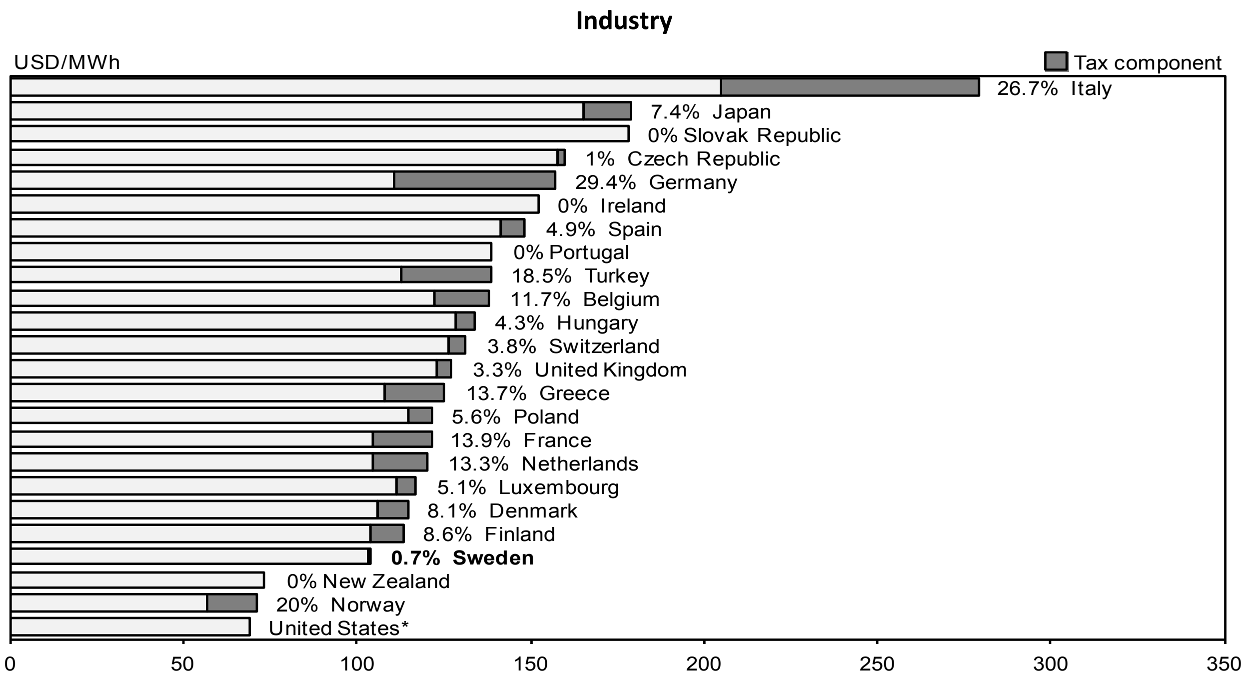


Source: Nord Pool.

RETAIL PRICES

Electricity retail prices are set by the suppliers, as there are no regulated electricity prices in Sweden. Given the low share of fossil fuels in the electricity mix, the retail prices mainly reflect the wholesale market prices in the Nord Pool Spot vary strongly.

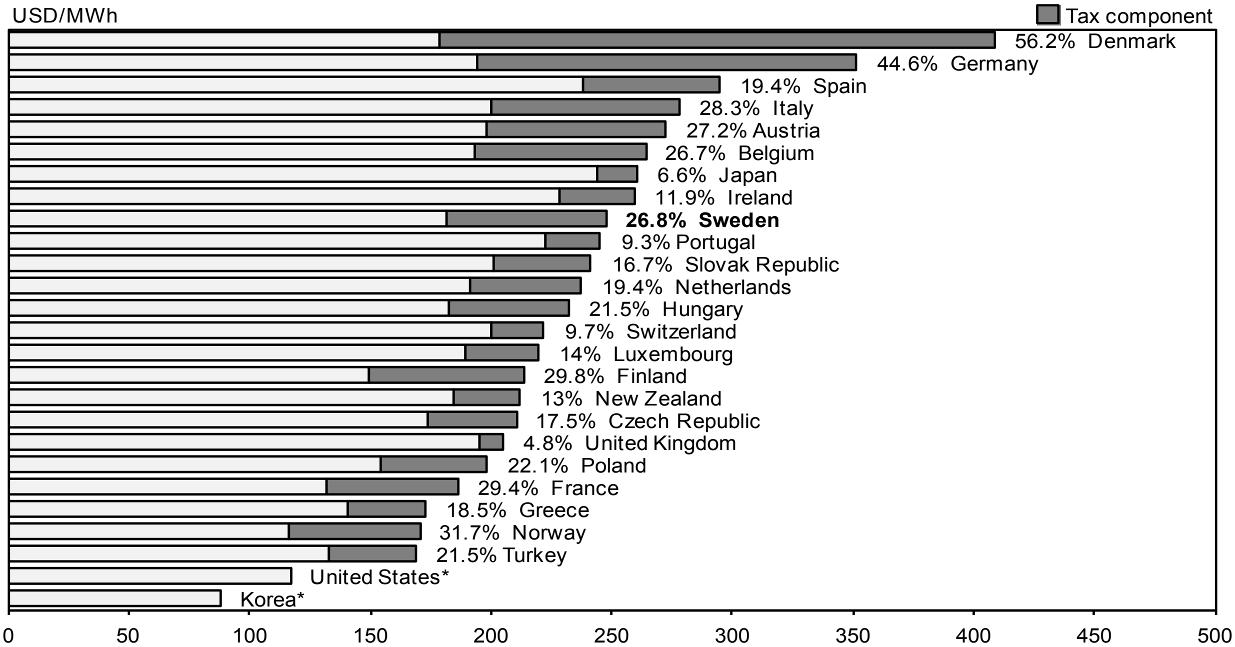
Figure 41. **Electricity prices in IEA member countries, 2011**



* Tax information not available for the United States.

Note: data not available for Australia, Austria, Canada and Korea.

Households



* Tax information not available for Korea and the United States.

Note: data not available for Australia and Canada.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

Retail prices for electricity have been increasing over the past years. In 2011, for a household customer in an electrically heated detached house, the electricity bill consisted of supply costs of 49%, network cost of 15%, while energy taxes and VAT accounted for 36%. The total electricity cost for a household in 2011 amounted to SEK 1.37 per kWh, or SEK 27 400 (EUR 3 200) for the year.

The independent price comparison tool, the Elpriskollen[28] set up by the regulator, collects information from the companies about the retail electricity prices across Sweden.

By international comparison, the Swedish industry currently pays below-average prices, while prices for household customers are above average (Figure 41). Within the Nordic market, in 2010, Swedish price levels were below Danish levels, but above Norwegian prices.

SECURITY OF SUPPLY

Electricity consumption has almost doubled since the 1970s and supply capacity has kept pace. In the short to medium term, Sweden has sufficient installed capacity to meet demand; the electricity supply in the longer term (2020-50) will depend on the replacement of the nuclear fleet, the potential for more wind energy and biofuels and electricity demand from electric vehicles.

In recent years, lower availability of hydro reservoirs and of nuclear capacities because of the maintenance presented a recurrent challenge to Sweden's electricity grid and supply

28. www.elpriskollen.se

security. Since deregulation in 1996, the capacity margin between supply (and imports) and demand fell by 20% from 1996 to 2000. Against this background, the government introduced in 2003 the Power Reserve Act as a temporary measure to be in place only until 2011. In 2011 the government decided to keep the power reserve in place for the coming years, but include a gradual phase-out by 2020 towards a market-based mechanism.

On 17 December 2009 the Swedish peak load reserves were activated on Elspot because of insufficient production volumes. During winter 2009/10, the power reserve was activated during 30 days, while in 2010/11 it was activated for 8 days without any Elspot activations. The highest level of consumption occurred on 23 February 2011 between 8:00 and 9:00 and reached 25 820 MW. This is close to the historic peak demand of 27 000 MW which was recorded on 5 February 2001. During winter 2011/12, the reserve was activated during three to four days owing to network problems and resulted in a cost of EUR 10.2 million for the 1 760 MW contracted. In winter 2012/2013, the power reserve was activated, too.

Box 8. **The Swedish power reserve**

Under the Act on the peak load reserve Svenska Kraftnät has a responsibility to ensure that a peak load reserve of up to 2 000 MW is available during the winter period. The Ordinance (2010:2004) states the amount to be procured every winter. The type and number of facilities to be included in the peak load reserve depend on the contracts and varies from year to year. For the time horizon to 2020, the peak load power reserve should not exceed the following capacities:

- 2011-13: 1 750 MW with a 25% demand reduction;
- 2013-15: 1 500 MW with a 50% demand reduction;
- 2015-17: 1 000 MW with a 75% demand reduction; and
- 2017-19: 750 MW with a 100% demand reduction.

Every year, Swedish TSO Svenska Kraftnät can procure reserves for the winter periods between 16 November to 15 March through auctions and commercial bids on the Nordic day-ahead market, Nord Pool Elspot. The owners of the reduction bids may choose to offer their resources to Elspot. If they are not traded on Elspot, owners are required to enter bids on the balancing power market. Activation of the production bids can occur when the supply and demand curves on Elspot do not meet. The bids are activated only after all the commercial bids are activated and then to the price of the highest commercial bidder plus 0.1 euro per MWh (the minimum price step for bids on Nord Pool Spot). As a lower price limit for the activation of the peak load reserve, there is a minimum price specified.

Svenska Kraftnät can activate resources after the closing of Elspot. This is the most common way of activating the peak load reserve. The price is the minimum price specified in the contract between the resource owner and Svenska Kraftnät.

Svenska Kraftnät recently changed the management of the demand reduction of the power reserve as a result of new legislation. The procurement of consumption reductions will only cover bidding on the balancing market and the management of the consumption reduction resources shall also permit plant owners to make their own bids for the resource to the Elspot market. If the resource is not activated on the spot market, it will remain at the disposal of the balancing power market. As resources are made available as bids on the spot market, they participate in the price formation.

According to the forecasts of the Swedish Energy Agency, the electricity generation was to increase to 158 TWh in 2012. Up to 2030, generation is expected to reach 175 TWh for a consumption of 152 TWh, giving rise to exports from Sweden in the range of 23TWh in 2030.[29] With a view to the longer term, the government adopted a policy to diversify electricity generation towards the introduction of more renewable energies, in order to reduce the dependence on nuclear and hydro generation. The latest forecasts point to the fact that Sweden can even be a net exporter during the winter time, which would further lower the need for the strategic power reserve.

The Swedish transmission grid has a high level of security of supply. The system operator, Svenska Kraftnät, had never resorted to any manual disconnection of consumption. In 2011, thousands of customers suffered long electricity outages caused by the storm Berta, which affected southern Sweden. As outlined before under the transmission network investment sub-section, several projects are under way to reinforce the Swedish internal electricity grid and the cross-border interconnections, thus contributing to the security of supply of the Swedish power system.

The Energy Markets Inspectorate monitors the quality of supply at transmission and distribution levels on the basis of network operators' reports of short and long outages. This evaluation also serves as a basis for the cost approval under *ex ante* regulation. Network operators are encouraged to increase security of supply by replacing overhead lines by underground cables. The losses in the Swedish transmission system amounted to 2.4 TWh in 2010 (2.2% of the energy extracted from the transmission system) and 2.7 TWh in 2009 (2.6%). Energy not supplied accounted for 5 MWh in both 2009 and 2010. In 2010, losses in the distribution network amounted to 4.3 TWh with average outages of 93 minutes.

In accordance with the Electricity Act, consumers whose supplies had been interrupted for more than 12 hours owing to the failure of the network operator, have the right to automatic compensation. The Electricity Act stipulates the right of the consumer to claim damages from the network operator.

The Swedish Energy Agency developed a new systematic method for planning the disconnection of electricity for short-term electricity shortages, the so-called Styrel method. The Swedish Energy Agency is responsible for the co-ordination of Styrel. The Electricity Act has been adjusted and a separate regulation for Styrel was adopted. Started in 2004, Styrel carried out work to identify and prioritise electricity users that are important for society to function, such as hospitals, emergency services and electronic communications, including electricity users such as those responsible for water and waste water systems. The first national planning session was conducted in 2011. During 2011 all 290 municipalities, 20 county administration boards and 170 power distribution companies in Sweden have been identified and planned for prioritising.

At regional level, NordBER, the Nordic Contingency Planning and Crisis Management Forum, continues its work with a new agreement by all Nordic TSOs and power emergency authorities in 2010. The co-operation includes cross-border contingency planning and crisis management; risk and vulnerability assessment; a mutual contingency plan; resource planning and sharing of information, communication and experience exchanges as well as a mutual training and exercise programme. Cross-border support during a real crisis is foreseen, but has so far been limited.

29. Swedish Energy Agency, Langsiktsprognos 2011.

ASSESSMENT

Since the last review, Sweden's integration within the Northern European energy market area has significantly increased thanks to network upgrades and new interconnections and the introduction of market coupling and market splitting to the Swedish electricity grid. The IEA commends these achievements, which are contributing to the creation of a large Northern European electricity market and thus internal European electricity market. In order to reduce internal bottlenecks in the grid, Sweden introduced four bidding zones within Sweden. This is commendable and should lead to a better utilisation of the electricity grid and provide important signals as to where investment in new generation and networks will be needed. Following the introduction of bidding zones, the government should now carefully monitor the price signals provided and congestion revenues need to be allocated in the upgrade of the internal electricity grid and foster the development of a smart grid.

At the retail level, efforts in establishing a Nordic retail market have been further intensified and a common market model, the "supplier-centric model", has been developed by the Nordic regulators. To achieve a common retail market, further harmonisation across the Nordic area will be essential. A necessary condition to the establishment of a common Nordic retail market is that important infrastructure investments and common balancing agreements come forward. The ministers of the Nordic Council set an ambitious deadline for achieving a common Nordic retail market by 2015. The IEA encourages Sweden to strongly contribute to the creation of such a regional model, as it entails new business opportunities, competition, more cost-effective solutions and greater choice for consumers.

The government and the regulator are active in promoting consumer choice on the retail market both within the Swedish and the Nordic markets. With the already installed smart meters and the availability of hourly metering to customers as of 1 October 2012, consumers will have new opportunities. If utilities started to offer supply contracts with dynamic electricity pricing, this would encourage consumers to make use of such opportunities and to better control their energy use (and expenditure) and have greater incentives to optimise demand.

Extra effort should be put into supplying the still inactive customers with better communication and information provisions and greater choice. The government should ensure that the meters do not create barriers for new entrants and supplier switching and that potential service providers can access the information subject to the customers agreement and guaranteed privacy. The IEA encourages the government to establish a metering market with guaranteed third-party access to the meter data.

Since the last review, the electricity industry structure and competition has not significantly changed. A small decrease of 6 percentage points in the market power of the three main electricity generators can be observed. The three largest electricity suppliers continue to co-own nuclear generation assets. Increasing new generation, in particular from wind and biofuels should however provide a more competitive picture over time. The IEA recommends the government to further pursue its policies to reduce dependence on nuclear and hydropower. Sweden should continuously monitor competition and price transparency both on the Swedish and in the Nordic wholesale electricity market by strengthening co-operation of the various bodies in charge of competition and market oversight. In this context, Sweden should monitor the impact of the price zones on grid and generation investment and consider the costs and benefits of future shift towards nodal pricing, within the Nordic market area, also with a view to increase competition.

Sweden's electricity supply is dominated by nuclear and hydro and growing renewable sources, like biofuels and wind. It is essentially carbon-free. Huge hydropower capacity, including storage, is providing flexibility to the Nordic, Baltic and EU markets. Sweden is a leader in the low-carbon pathways in the electricity sector. This low-carbon track record is commendable, but it implies that any further emissions reduction will come at higher cost. Regional solutions, such as an extended renewable and reserve capacity market, are thus favourable to Swedish stand-alone solutions.

Electricity consumption has almost doubled since the 1970s and supply capacity has kept pace. While in the short term Sweden has sufficient installed capacity to meet demand, it is useful to keep an eye on changes in the electricity supply in the medium to long term (2020-50) that could pose a risk to demand/supply balances and grid capacity. Such developments could include low reservoirs of hydropower, cold winter periods, maintenance or modernisation of the nuclear fleet, greater proportion of intermittent wind energy, more demand for electricity from electric vehicles, etc. During 1996 and 2000, the capacity margin between supply (and imports) and demand decreased by 20%, giving rise to the creation of a power reserve.

Given uncertainties over whether new nuclear capacity will come forward on market terms or to what level combined with no new large scale hydro plants being planned, this will likely mean greater future emphasis on new capacity from renewables like wind, biofuels, solar and CHP, waste and energy efficiency. It is likely that current quotas under the electricity certificate system will be achieved ahead of time; further investment may slow significantly unless greater clarity of desired capacity is given beyond 2020.

Sweden has a high level of security of supply. However, congestion, the low availability of hydro reservoirs and nuclear energy owing to the maintenance programme put pressure on the TSO to keep the system in balance. The strategic power reserve, in place since 2003, has been activated in recent winters. The TSO has improved the management of the power reserve. The IEA encourages Sweden to identify market-based options, in particular at regional level, with a view to gradually phase out the power reserve regulation, giving due consideration to more active demand responses following from a smarter grid.

Investments in the internal transmission grid and new interconnections will be critical for the country's security of supply, in particular under certain scenarios (*e.g*. no new nuclear capacity) and the further market integration of the Nordic, Baltic and wider European Union at wholesale and retail levels. Sweden introduced revenue-cap *ex-ante* regulation of the transmission and distribution networks. Sweden should increase efforts, including at regional level, to tackle the identified obstacles to network investment, such as permit granting delays and cost allocation. The Nordic model of a regional grid planning is a basis for further co-operation. Establishing clear time limits for permit granting decisions provides certainty for grid operators and generators. Greater co-operation among regional authorities should be enhanced in the environmental impact assessments and permit-granting procedures. The financing challenge cannot be underestimated. The allocation of significant congestion rents to these new investments will need to be made. The government, the TSO and industry should improve working together to plan grid development according to likely generation investments, especially in wind power. The analysis should focus more on the system costs of generation in combination with grid costs and demand response as well as smart grids in order to identify the socially optimal options. In 2012, Svenska Kraftnät published a network plan "Perspectivplan 2025" for consultation which is a first step in this direction.

The conversion from a mainly top-down energy system with large-scale nuclear and relatively flexible hydropower, to a more intermittent and small-scale two-way system with active consumers in a European market, requires a smarter grid and a more resilient network in which the distribution and transmission grid can intensively interact with each other and market parties. The IEA applauds the Swedish industry leadership on smart grids. Greater emphasis on consumer benefits and competition should be an equally important aspect. The government set up a Smart Grid Council and envisages a national action plan for smart grids which determines the success of the retail markets.

RECOMMENDATIONS

The government of Sweden should:

- ☐ *Further empower consumers to participate in the retail electricity market by fostering an efficient electricity grid, by introducing dynamic electricity pricing, third-party meter data and information management, net-metering for microgeneration, and by actively pursuing steps towards the creation of a larger, common Nordic retail market by 2015 on the basis of a common market model.*
- ☐ *Monitor the results of the bidding zones in Sweden and the impact on an efficient grid, generation investment and the need for a power reserve. With a view to strengthen market monitoring, pursue stronger co-ordination across several agencies.*
- ☐ *Remove all barriers to an efficiently planned and upgraded electricity grid including cross-border interconnections. Consider binding time limits for the permit decisions and encourage stronger co-ordination among regional authorities, also at Nordic area level, to facilitate grid investment needed for connection of renewable energies.*
- ☐ *Undertake an analysis of potential transmission network impacts of longer-term developments towards 2030/2050, involving all market participants, with due consideration to the developments in the European Union electricity supply market, demand-side responses and smart grids, and renewable capacities in the North Sea and Baltic Sea regions.*

8. DISTRICT HEATING

Key data (2011)

Total supply of energy: 60 TWh

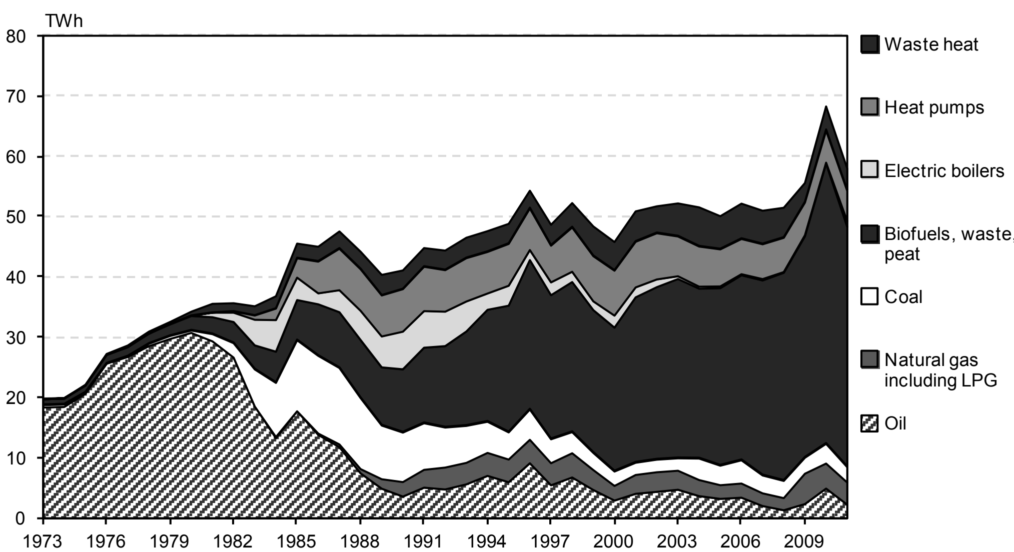
Total final domestic use: 48.1 TWh (residential 60.5%, public administration 13.6%, industry 9.2%, other 16.6%)

SUPPLY AND DEMAND

SUPPLY

District heating[30] emerged in Sweden in the 1950s. Since the 1970s, there has been a major transition towards the use of renewable fuels leading to considerable emissions reductions. In 2011, district heat supply accounted for around 60 TWh, produced mostly from wood fuel and other biofuels (39.2%), waste (18.2%), mainly renewable organic waste, peat (3.8%) and waste heat (6.1%). Oil, natural gas and coal have minor shares.

Figure 42. **Energy input for district heating, 1970-2011**



Note: the sharp increase in district heat production in 2010 is primarily due to an extremely cold winter.

Source: submission by the Swedish government to the IEA.

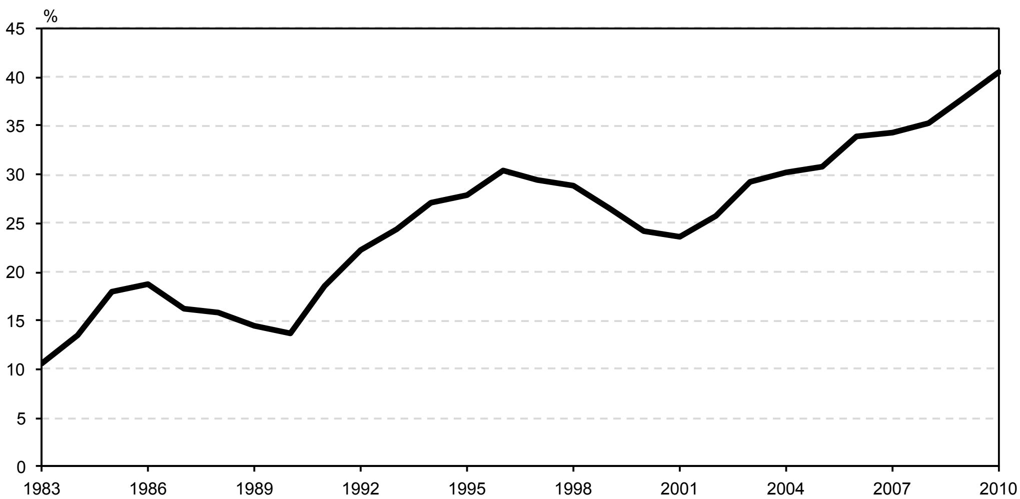
30. District cooling has been introduced in the 1990s and is mainly used for air conditioning in offices, shops and industrial processes. In 2010, 31 companies provided district cooling on a commercial basis with supplies of 871 GWh. District cooling is not the focus of this chapter.

The supply of waste has increased over the past decade, and in some Swedish cities, heat from waste incineration forms the basis of district heating. The increase in waste incineration is a result of the 2002 ban on combustible waste in landfills and a similar ban regarding organic waste in 2005. The decrease in electric boilers, and to some extent heat pumps, led to a reduction in electricity use in the district heating sector. However, this does not apply to district heating in industry which is sourced from electricity, biofuels and peat.

Figure 42 shows the energy supplied to district heating between 1970 and 2011. Thanks to improved technology and network utilisation as well as an increased proportion of ready heat, distribution and conversion losses in the district heating system have decreased considerably over the years. The losses came down from 19% in the 1980s to a current level of around 11% in the 2000s.

The increase in CHP production over the years is a notable change in the development of the district heating market. The growth of the CHP share is primarily fuelled by the electricity certificate system as well as substantially lower rates of CO_2 taxation in relation to heat-only boilers. In 2011, CHP amounted to 41% of the total district heating generated (Figure 43).

Figure 43. **Share of CHP in district heating, 1983-2011**



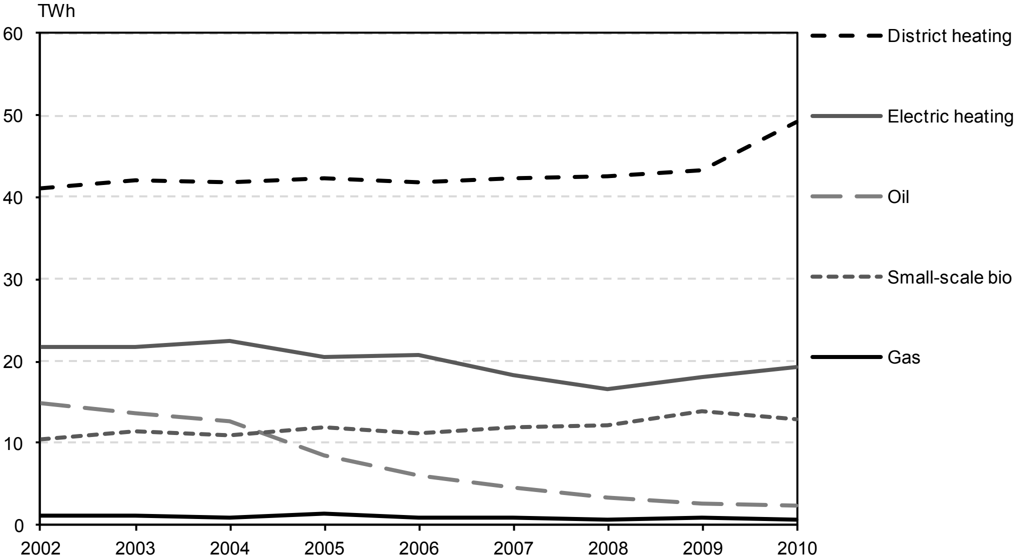
Source: submission by the Swedish government to the IEA.

DEMAND

District heating is the leading heating method for multi-dwelling buildings and non-residential premises, accounting for 93% and 83% of the market shares respectively in 2010. In the market for detached and semi-detached houses, district heating has a share of 16%.

Figure 44 shows the dominance of district heating in relation to other heating alternatives. Heat pumps are not included in the figure and contribute with approximately 14 TWh in 2009.

Figure 44. **Total energy use for heating and hot water, 2002-10**



Source: submission by the Swedish government to the IEA.

INDUSTRY STRUCTURE

In total, there are 200 district heating companies active in the market. The Swedish district heating network accounts for 20 000 km.

Municipal district heating companies currently provide 63% of the delivery of district heating in Sweden, while private and state-owned district heating companies account for 37%. There are only eight municipalities where district heating operations are under municipal administration and where, in accordance with the Swedish Local Government Act, these operations must be run at cost price. However, of the total supply of district heating, these eight municipalities account for just 0.3 TWh out of 60 TWh in 2011.

In a survey of 150 companies, 42 stated that they had profit maximisation as a business principle, while 16 stated the cost pricing principle. The remaining companies included municipal and political interests and objectives in their strategy.

LEGAL FRAMEWORK

Until the mid-1990s, district heating companies were mainly run by municipalities and district heating was regulated at cost price. The electricity market reform in 1996 required, however, district heating to be operated on a commercial and competitive basis. The reform initiated a change where many municipality-owned companies passed into private ownership. Between 1990 and 2004, around 70 municipal energy companies with district heating operations were sold to private companies but since then privatisation has halted.

The distribution of district heating can be considered a natural monopoly. District heat production can be considered either a natural monopoly, for instance in smaller areas, where large production plants supply all customers, or a competitive segment giving consumers the choice of different heat sources. There are lock-in effects as consumers who have invested in connection fees to the network are reluctant to change their heating system and are unable to recover their investment, when changing for example to a (ground source) heat pump. In around 40% of the municipalities it would prove profitable to change heating system from district heating.[31]

Since 2008, the district heating market in Sweden has been governed by the District Heating Act. The Energy Markets Inspectorate is the supervisory authority in charge of enforcing the provisions of the District Heating Act. District heating companies have, for example, an obligation to negotiate certain contractual terms with individual district heating customers. If the parties are not able to come to an agreement themselves, they may apply to the District Heating Board for mediation. The board can mediate between district heating companies and other actors wishing to gain access to the distribution networks. However there has been no case of mediation thus far.

In order to increase transparency in the district heating market a number of regulations have been put in place. Companies have been required to submit separate accounts for their various activities in order to avoid cross-subsidisation. This measure was, however, not considered enough for the desired transparency. On 1 October 2009, new regulations by the Energy Markets Inspectorate entered into force, defining the companies' obligations to provide accurate price information. In 2009, district heating companies also began reporting operational and business details to the Inspectorate.

DISTRICT HEATING MARKET REFORM

Current regulations governing district heating operations mean that only owners of a district heating network have the right to access the network. As a consequence, the possibility of introducing third-party access (TPA) has been investigated. The TPA investigation (SOU 2011:44) proposed to open up the district heating networks for access to competing producers and suppliers. Where competition arises, a distinction between the various operations of distribution, production and supply would then be made. A central idea behind legislated third-party access is to help open up the district heating market to more waste heat from industry. The TPA investigation however found that it was unclear how district heating prices would be affected if the legislative proposal was adopted. The cost of realising these objectives in relation to the energy and environmental goals has not been investigated.

In March 2012 the Swedish government rejected the proposed TPA legislation and instead proposed four measures to strengthen the position of consumer and industrial waste heat suppliers in the district heating market given the difficulty of achieving effective competition in this market.

- the introduction of a price-change test to protect customers from unreasonable price hikes;
- the regulated access for residual heat suppliers and other heat producers;
- the accounting for residual heat potential in the design of new district heating production; and
- the equal treatment of customers in the same customer group.

31. Fastigheten Nils Holgerssons underbara resa genom Sverige - En avgiftsstudie för 2011 (2011).

These regulations should protect consumers from unfair rate hikes and lead to greater efficiency and in the long run benefit customers.

The new rules have not yet entered into force, as legislation is being prepared by the Energy Markets Inspectorate and the Swedish Energy Agency.

PRICES AND TAXES

There are significant differences in the price of district heating. The price in the most expensive municipality is more than twice the price in the cheapest. These price differences are due to factors such as ownership structures in the district heating companies, profitability requirements, fuel allocation as well as geographical conditions for district heating installations. A given customer’s choice of options on the heating market depends largely, then, on where the customer lives. The lowest price for district heating can be found in Luleå (85, SEK 1 per m²) while the most expensive in the municipality of Falkenberg (189, SEK 2 per m²) for multi-dwelling buildings. Between 2006 and 2011 around 34 district heating companies have increased their prices by more than 30%.[32]

SUPPORT POLICIES

Between 2006 and 2010 investment grants for conversion from oil or direct electric heating to district heating, ground source heat pumps or small-scale biofuel installations could be obtained. The grants for conversions from direct electric heating totalled around SEK 455 million for the whole period, of which 75% was allocated to district heating conversions. Around SEK 450 million was paid to conversions from oil heating (2006/07), and around 20% went to district heating installations.

ASSESSMENT

Since the last review, the Swedish government carried out several reviews of the district heating sector in order to introduce a regulatory reform in the coming years.

The Swedish district heating sector was deregulated, largely privatised and opened to competition in 1996 (with the exception of some municipalities which are forced to use cost pricing). The 2008 District Heating Act introduced negotiated pricing, information and reporting obligations, with the Energy Markets Inspectorate acting as supervisory authority and a District Heating Board charged with mediating prices and access to the distribution network. However, the sector fails to deliver the adequate choice for the consumer and competition on the heat production side. Between 2006 and 2011, district heating prices increased by 30%, while switching district heat suppliers remains very limited in practice, as the customers’ choice depends on where they live.

In that context, the IEA welcomes the proposal by the Swedish government of March 2012 to reform the sector in order to develop the district heating market for the benefit of the consumers, new suppliers and producers.

The IEA urges the Swedish government to actively pursue this reform to create opportunities for investment in energy-efficient district heating networks through the

32. Fastigheten Nils Holgerssons underbara resa genom Sverige - En avgiftsstudie för 2011 (2011).

adoption of a heat evaluation in order to explore all potential sources, their geographical distribution and energy efficiency gains in production and distribution for the use of new heat sources and for greater consumer choice and protection against unfair price hikes and lock-in effects.

In that respect, the IEA invites the government to adopt an adequate regulatory framework so as to encourage the entrance of new heat suppliers, to strengthen the price-setting model with possible *ex ante* approval or with ceilings for the margins allowed for similar price areas and classes of consumers.

In the future, on the basis of continuous price monitoring, Sweden should reassess costs and benefits of third-party access to the network, the separation of production and distribution and the switching of suppliers.

RECOMMENDATIONS

The government of Sweden should:

- ☐ *Prepare a comprehensive heat evaluation in order to explore all potential sources, their geographical distribution and energy efficiency gains in production and distribution.*
- ☐ *Enhance competition of heat production and consumer protection in the district heating market by accelerating the adoption and implementation of the regulatory framework reform.*

PART III
ENERGY TECHNOLOGY

9. ENERGY TECHNOLOGY RESEARCH, DEVELOPMENT, DEMONSTRATION & DEPLOYMENT

Key data (2011 estimates)

Government energy RD&D spending: SEK 1.6 billion

Share in GDP: 0.63 per 1 000 units of GDP (IEA median: 0.39)

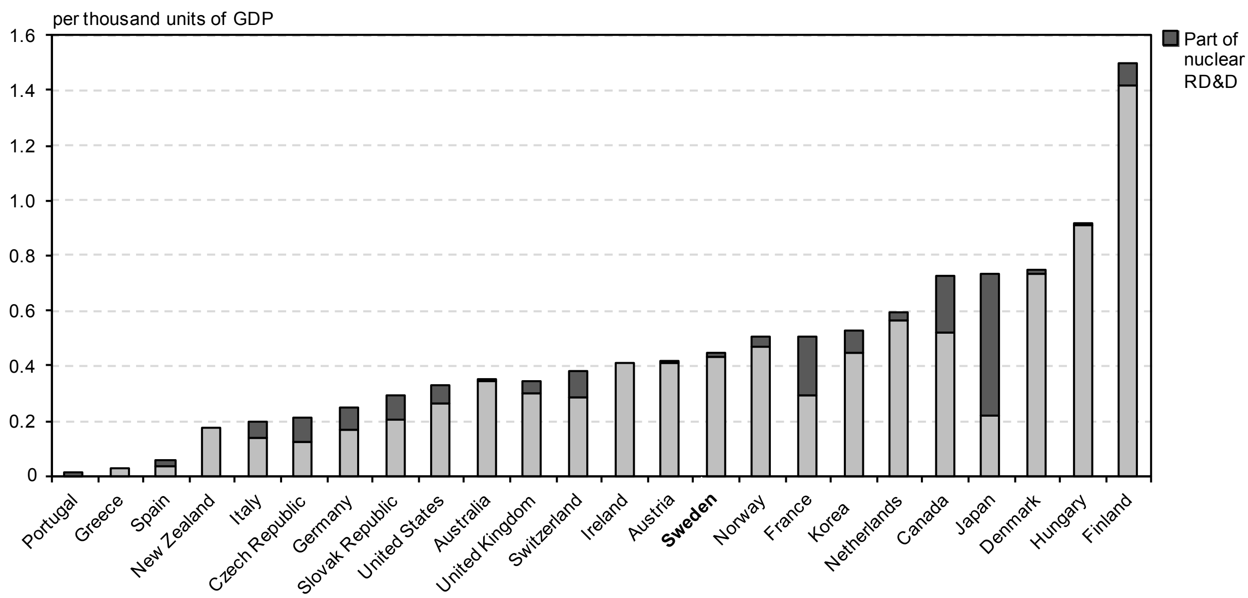
Share in GDP (2010): 0.47 per 1 000 units of GDP (IEA median: 0.32)

RD&D per capita: 26.3 per capita (IEA median: 12.8 per capita)

OVERVIEW

Over the past decade Sweden has steadily increased its energy RD&D spending. In total, between 1975 and 2011, Sweden spent SEK 23.64 billion (EUR 2.8 billion) with a strong increase during 2009-11 coming from demonstration funds (Figure 47). The country has emerged as a leader in innovation and research for several clean energy technologies, such as second-generation biofuels, smart grids and carbon capture and storage (CCS).

Figure 45. **Government spending on energy RD&D as a ratio of GDP in IEA member countries, 2010**



Note: data for Belgium, Luxembourg, Poland, and Turkey are not available.

Sources: *OECD Economic Outlook*, OECD Paris, 2011; submission by the Swedish government to the IEA.

Energy RD&D spending per unit of GDP in Sweden is above the IEA average, providing USD 0.47 per 1 000 units of GDP, which was above the IEA median of USD 0.32 in 2010. In 2011, this ratio increased to USD 0.63 (or SEK 170.1). Among IEA member countries, Finland, Hungary and Denmark were the top-three leaders on energy research, development and demonstration (RD&D) spending in 2010.

INSTITUTIONAL FRAMEWORK

As an authority under the Ministry of Enterprise, Energy and Communications, the **Swedish Energy Agency** has the overall responsibility for implementation of energy RDD&D policy, the national Energy Research Programme, including market development and commercialisation. The Agency funds a number of research activities with support provided to universities, institutes and the industry.

The Swedish Energy Agency is responsible for the strategic planning and prioritisation. Within the six priority areas of the Swedish energy R&D strategy, the **Energy R&D Board of the Swedish Energy Agency** is the decision-making body for the Energy Research Programme. Its members are appointed by the government and represent different areas of experience and competence, ranging from universities, industry and the public policy sphere. Sectoral advisory boards and technology development platforms have been established for each of the six thematic areas, bringing together experts from industry, public authorities and other stakeholders, to support the Swedish Energy Agency in developing strategic research plans for each thematic area.

Specific energy-related research activities are also carried out by other agencies in co-operation with the Swedish Energy Agency, or as part of their respective areas of responsibility.

The Ministry of Enterprise, Energy and Communication supports research and development (R&D) also through another authority, **the Swedish Governmental Agency for Innovation Systems (VINNOVA).** Its mission is to promote innovativeness, supporting sustainable growth for the benefit of the economy and society by financing R&D and developing effective innovation systems, without specific sector focus. VINNOVA is the national contact agency for the EU Framework Programme for R&D.

General energy research is carried out jointly by the **Swedish Research Council** (evaluating scientific quality) and the Swedish Energy Agency (evaluating relevance). The **Ministry of Education and Research** closely supports the Strategic Research Area under EU co-operation.

As an authority under the Ministry of the Environment, the **Swedish Research Council Formas** promotes and supports research in the areas of environment, agricultural sciences and spatial planning. Through its department of co-ordination and international affairs, Formas co-operates closely with the EU, the IEA and the Nordic Energy Research network as well as with other international organisations in the field of energy. The principal decision-making body for the research council is the **Scientific Council** which meets five times a year.

Basic research on nuclear fission and fusion is financed by the **Ministry of Education and Research** through the **Swedish Research Council**.

POLICIES AND PROGRAMMES

Sweden's policy on energy RD&D aims at building the scientific and technological basis for the transition to a sustainable energy system and at supporting the development and commercialisation of new energy technologies and services that have the potential for reducing both CO_2 emissions and dependence on fossil fuels. Innovation and business sector co-financing are vital components of the Swedish energy RD&D policy.

ENERGY RESEARCH BILL

The basis for the Swedish energy RD&D programme is the government Energy Research Bill which the Parliament adopts for a four-year cycle. The Bill provides direction on visions, goals and priorities for thematic areas.

The 2006 Bill on Energy Research and Development towards Future Energy Systems (Prop. 2005/06:127) sets out the energy research policy in the public sector in Sweden. It determines the policy for RD&D, which is updated every four years by the government and approved by the Parliament.

In 2010, the government conducted an evaluation of the energy RD&D programme. The results were reported to Parliament through the written communication from the government Evaluation of Energy Research and Innovation (2009/10:168). The communication also gives some guidelines for continued work.

On 11 October 2012 the government presented to the Swedish Parliament the new Research and Innovation Bill (2012/13:30), proposing increased funding for research and innovation, including for energy RD&D.

The energy RD&D efforts in the period 2013-16 are laid out in more detail in the Government Bill on Research and Innovation for a Sustainable Energy System (2012/13:21) which was presented to Parliament on 19 October 2012. The government addresses the use of the additional resources also described in the Research and Innovation Bill in more detail, and proposed in the government's Budget Bill for 2013. The energy RD&D funding increases from EUR 100 million per year to about EUR 155 million per year by 2016. The Bill confirms the key priorities of the Swedish comprehensive and strategic approach on research and innovation, ranging from basic research to demonstration, commercialisation and product development.

ENERGY RESEARCH PROGRAMME

The priorities of the RD&D portfolios in the public sector and research-intensive universities are need-driven and focus on the energy and environmental goals and areas, where Swedish industry leads technology development. While large research units of multinational companies and public RD&D portfolios are separated, the effective collaboration and long-term stable support are crucial success factors.

On the basis of the Energy Research Bill of 2006, the national Energy Research Programme has been implemented by the Swedish Energy Agency and evolved over the years. The Energy RD&D programme focuses on the needs of the users, disseminating R&D results, deploying technologies and services, building up scientific and technological knowledge and competence, and further increasing the collaboration with different stakeholders, both at national and international levels.

The national Energy Research Programme focused on six priority research areas according to the Energy Research Bill 2006:

- energy system studies;
- building as an energy system;

- transport sector;
- energy-intensive industry;
- biomass in energy systems; and
- power system.

In 2011, about 50 programmes were active under the six thematic areas, in addition to a large number of individual projects.

According to the 2012 Government Bill on Research and Innovation for a Sustainable Energy System, there will be five priority areas from 2013:

- fossil independent vehicle fleet;
- power system for renewable electricity;
- energy efficiency in the built environment;
- increased use of bioenergy; and
- energy efficiency in industry.

FUNDING MECHANISMS

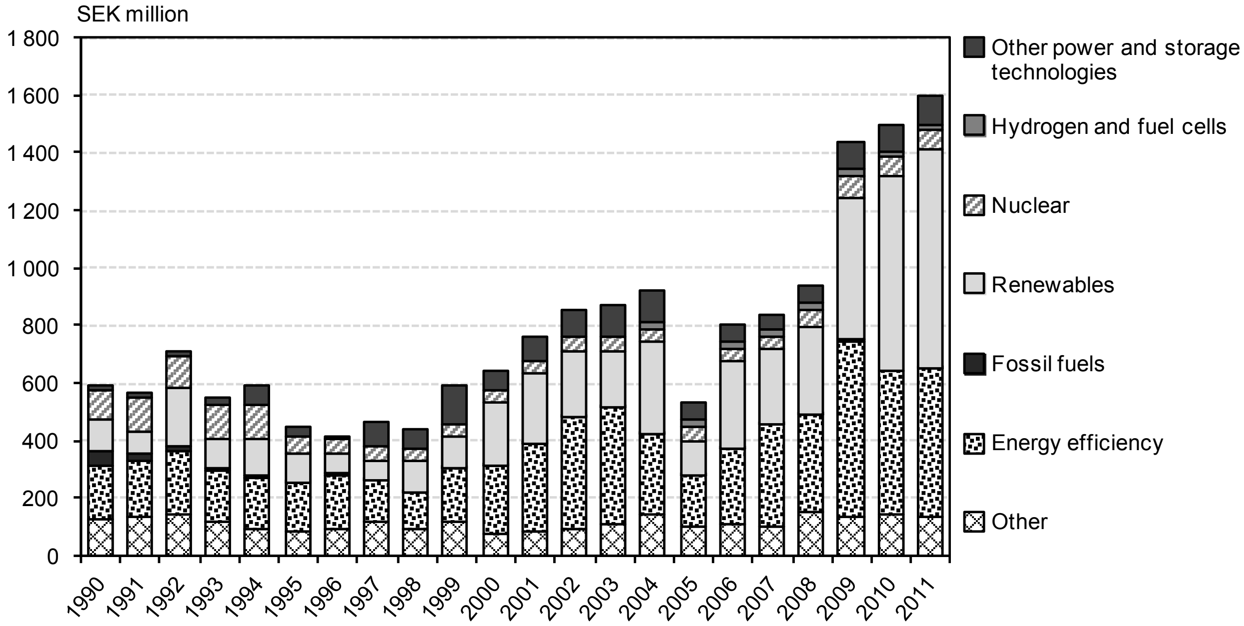
Activities under the Energy Research Programme are funded by both the Swedish Energy Agency and the industry (co-financing). In 2011, the Agency provided grants (SEK 443 million) to large demonstration facilities, universities (SEK 418 million) business (SEK 327 million), and industry and associated institutes (SEK 179 million). To international energy R&D Sweden contributed SEK 44 million (EU, IEA, Nordic Energy Research, others).

Energy efficiency and renewable energy projects account for more than 70% of energy R&D funding. In 2011, renewable energy projects received the largest part of government RD&D funding, overtaking energy efficiency. Funding to renewable energy projects has been steadily increasing, in particular for biomass. As for energy efficiency, the transport sector takes the largest share. Other than these two sectors, funding on nuclear energy has been declining since the late 1990s to below 4% in 2011. Nuclear energy is not part of the Swedish Energy Agency portfolio. Research on nuclear energy is supported on scientific grounds, and not with the aim to promote the development or deployment of nuclear energy.

In 2011, public energy RD&D funding amounted to around SEK 1.4 billion (EUR 144 million). If funding from other agencies, Vinnova, the Swedish Research Council and the Swedish Research Council Formas is included, the total public funding was about SEK 1.6 billion for 2011. In addition, in 2008 the government decided to allocate an *ad hoc* budget for large demonstration facilities for the period 2009 to 2011: five projects were selected which demonstrate for commercialisation technologies for the production and use of second-generation biofuels. The demonstration budget was further increased in 2011 and 2012.

Since 2009, contributions from industry have been increasing, overtaking amounts provided by government funding. In public RD&D, basic research on energy efficiency, renewables, transport and nuclear energy accounts for significant amounts of funding. Private funding significantly contributes to pilot and demonstration projects. The private sector is committed to energy research, development and demonstration and is involved in the formulation of the strategic plans, through the Energy R&D Board and its six technology platforms.

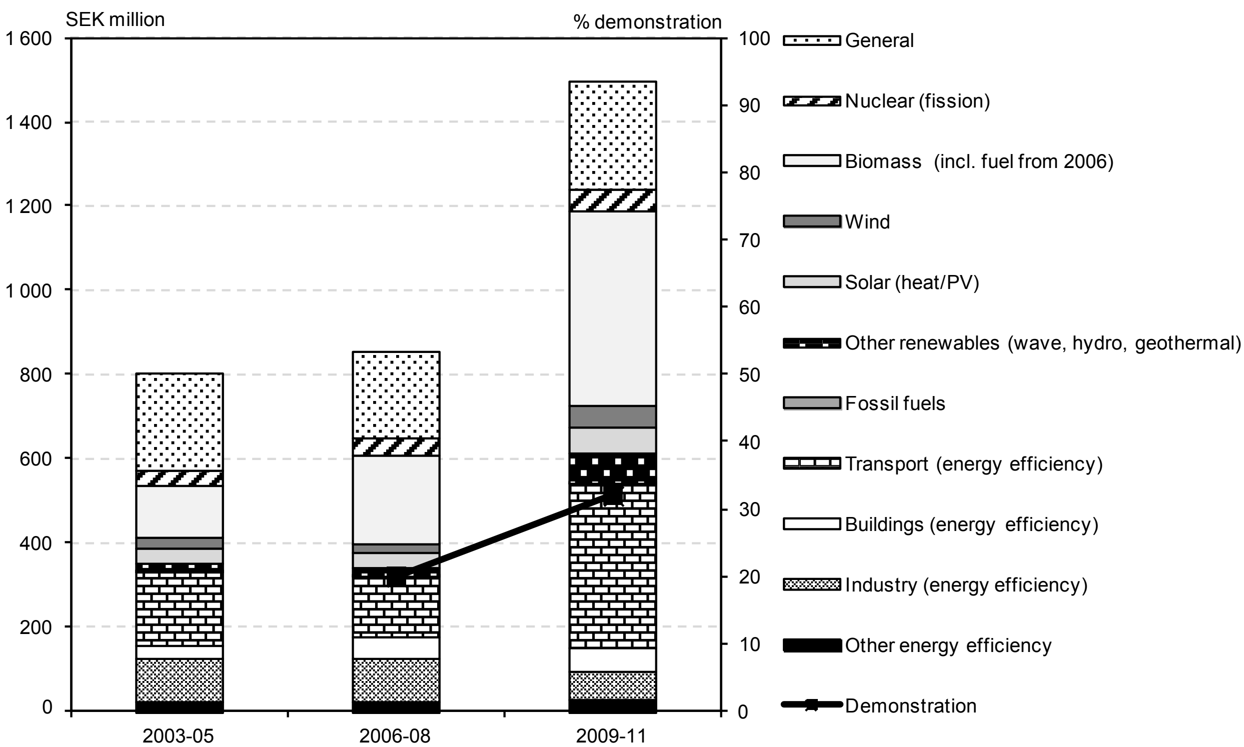
Figure 46. **Government RD&D spending on energy, 1990-2011***



* Provisional for 2011.

Sources: *OECD Economic Outlook*, OECD Paris, 2012; submission by the Swedish government to the IEA.

Figure 47. **Average annual government energy RD&D budget, 2003-11**



Source: submission by the Swedish government to the IEA.

Table 10. **Financing of energy RD&D, 2009-11**

	2009		2010		2011	
	SEK million	%	SEK million	%	SEK million	%
Swedish Energy Agency	1 239	42%	1 332	39%	1 411	37%
Industry and industrial organisations	1 712	58%	2 063	61%	2 404	63%
Total	**2 951**	**100%**	**3 395**	**100%**	**3 815**	**100%**

Source: submission by the Swedish government to the IEA.

Power system and smart grids

Swedish energy research activities promote the development of the power system to become ecologically and economically sustainable. Sweden follows an energy system approach with a long-term research component, a demonstration angle and a university support programmes. Within the power system, R&D activities focus on five areas: smart grids, wind, hydro, solar and ocean energy.

The annual public R&D funding for smart grids totals EUR 4 million for RD&D activities, including research programmes ELEKTRA, for Electrical Power Engineering and SweGRIDS, for smart grids and energy storage, and the European innovation centre, EIT KIC InnoEnergy Sweden, for smart grids and electricity storage. There are three large-scale demonstration projects, such as Smart Grid Hyllie in Malmö, the Stockholm Royal Seaport and Smart Grid Gotland (Box 9).

Box 9. **Smart grids in Sweden**

Sweden is a leader in promoting research, development and demonstration of smart grid applications with financial support from the Swedish Energy Agency.

Within the **Swedish Centre of Excellence in Electrical Power Engineering (EKC2)** four research programmes are organised with regard to smart grid solutions. They include maintenance management, controllable power systems, information technology applications to power system operation, control and high-performance electrical machine drives.

The **SweGRIDS programme** fosters basic research in the areas of smart grids, information and communication technologies (ICT), energy storage and material under the KIC InnoEnergy Sweden in co-operation with KTH and Uppsala University.

The **ELEKTRA programme** aims to strengthen the long-term competitiveness of the Swedish industry, primarily the power and manufacturing industry. The programme covers both traditional power technical issues, such as electric power materials and electric motor loads as well as the application of new knowledge from other areas, such as information technology, automatic control, and signal theory. Research activities within ELEKTRA are composed of four work streams: electromagnetic systems, power electronic systems, electric power systems and power electric components.

To enhance the development of smart grid technology, several RD&D projects are ongoing in Sweden. Among key activities in the smart grid roll-out in Sweden, three pioneering projects are noteworthy: Smart Grid Hyllie, Stockholm Royal Seaport and Smart Grid Gotland, for being cutting edge in the smart grid field and aiming to become international role models for sustainable power systems.

Box 9. **Smart grids in Sweden** (continued)

Malmö's largest development area, **Hyllie,** will be used as an international reference project for future sustainable solutions with the application of smart technologies where a number of technologies and solutions will be applied first. The project will show the way to Malmö's future as a sustainable city based on recycling, self-sufficiency, energy conservation and the use of renewable energy. The design of a sustainable energy supply will look beyond the boundaries of Hyllie and consider all types of energy needed at the consumer side, including industrial processes, electricity supply, heating and cooling of buildings, infrastructure services (water supply, lighting, etc.), energy for mobility.

Smart Grid Gotland includes planning, building and development of a large-scale smart grid by upgrading the existing grid on the island. Gotland has a grid with a high proportion of renewable energy (primarily wind power), connecting rural and urban areas on the island. It has been connected to the mainland via an HVDC link since 1954. The smart grid project will combine new advanced equipment with new methods to incorporate renewable energy into the distribution network and create a more flexible production and distribution system. Smart grid functions to be implemented and tested include the use of existing advanced metering infrastructure, advanced grid automation and energy storage technology. New market models and services will be developed to involve active customer participation and pave the way for new market players.

Stockholm Royal Seaport is a large-scale smart grid project where a former brownfield industrial site is being transformed into a state-of-the art waterfront area with a high-tech smart grid component for the new urban district includes development of 10 000 new apartments and 30 000 new work spaces. Smart grid functions to be implemented and tested from 2012 onwards include, for instance, smart meters and advanced metering infrastructure, demand response, grid automation, distributed storage and integrations of small-scale renewables. The demonstration project will increase knowledge about optimisation, control, maintenance, market concepts and regulation of future smart grids in urban areas, and the project will implement a smart grid supporting and demonstrating climate mitigation in city areas.

In the area of wind power, the Vindforsk programme focuses on wind resourcing and cost-effective construction. The Swedish Wind Power Technology Centre (SWPTC) carries out research on power and control systems, turbine design and wind load, mechanical power transmission and system optimisation, maintenance and reliability issues. The Vindval programme supports the analysis of the environmental impacts, while the Vindpilotprojekt develops cost reductions for large-scale wind power deployment, thus fostering technology development and market introduction.

Solar energy activities range from basic research (on thin-film photovoltaic, CIGS), molecular photovoltaic, polymer photovoltaic), to R&D support to innovation centre CIGS Ångström Solar Centre and the demonstration and commercialisation of molecular photovoltaic, the aim being to support export-oriented Swedish start-up companies in the area of solar R&D. In the area of hydro and ocean energy, Sweden has set up an Ocean Energy Centre with the Lysekekil pilot plant, the Minesto Tidal pilot project as well as a sea-based tidal energy demonstration project with 10 MW. The Swedish Hydropower Centre (SVC) is a centre for education and research within hydropower and tailing dams. SVC creates high-quality, long-term sustainable education and research environments at selected universities. SVC is organised in two competence areas: Hydraulic Engineering and Hydro Turbines and Generators.

Solid and liquid biofuels

Sweden developed a unique and specialised biofuels research expertise. It covers research along the whole fuel chain, from supply to the use of bioenergy. Given Sweden's increased use of biofuels, abundant natural resources in Sweden, the developed forest industry, district heating system and industrial structure, the country has a strong competitive advantage in the segment.

On the supply side, R&D activities focus on developing environmental aspects, more efficient systems to produce, extract and deliver solid and liquid biofuels from forestry and agriculture, including fast-growing tree crops, and on ensuring fuel quality and enhancing processing and refining as well as transportation.

On the demand side, research focuses on increasing the efficiency in combined heat and power (CHP) plants and the tolerance for using a broader range of fuel qualities, on biomass gasification for CHP applications, small-scale CHP and microgeneration, carbon capture and storage (CCS) and bio-CCS, biorefinery and industrial use of solid biofuels and resource efficiency aspects.

Energy efficiency

In the area of buildings, the Swedish Energy Agency initiated a programme for energy-efficient building construction and facilities management (CERBOF), providing a forum for the construction sector and research organisations to investigate how energy can be used most efficiently in the buildings sector. The Swedish Energy Agency supports the demonstration programme Passive Houses and Low Energy Buildings (LÅGAN).

The Swedish Energy Agency allocated SEK 60 million to research for improved energy efficiency under the Research Programme on Energy Efficiency in the area of lighting for the period 2008-15. Increasing energy efficiency in the Swedish industry has been a focus area, notably the reduction of CO_2 emission from steel production (EUULCOS – ultra low carbon dioxide steelmaking, LKAB) and improvements to the efficiency of the blast furnace process and the pulp production.

Transport and vehicles

RD&D priorities in the transport sector focus on three main activity streams with a view to foster*: i)* emissions reductions and energy efficiency in vehicles and drive trains*, ii)* the development of renewable fuels from lignocelluloses or waste with potentially high system efficiency and *iii)* energy efficiency in the transport sector.

The Swedish Energy Agency co-finances two competence centres conducting applied research on engine development and catalysis and on hybrid vehicles. In addition, it funds strategic vehicle research under the Strategic Vehicle Research and Innovation Initiative (FFI) and the electric vehicle demonstration programme.

With regard to biofuels in transport, the R&D programme supports projects for the gasification of biomass, ethanol processes, energy efficiency in transport and the activities of the Swedish Knowledge Centre for Renewable Transportation Fuels. There are several pilot, demonstration and deployment projects for the production of methanol and dimethyl ether (DME), biomethane from forest waste, from municipal and industrial waste and for the production of HVO by using tall oil from the pulp industry.

Carbon capture and storage

Chalmers University of Technology has a long-standing experience in experimentally based research and is involved in a high number of EU-wide pilot-scale test units for carbon capture in the form of oxyfuel combustion (*e.g*. Germany, 30 MW pilot project, Vattenfall) and chemical looping combustion (CLC) of gaseous, liquid and solid fuels for carbon capture. Sweden extensively co-operates with the EU Seventh Framework Programme (FP7), demonstration and Nordic Energy Research on CCS (see section on International Collaboration).

Research efforts in Sweden focus on CCS in industry and the storage site testing. The project “Assessing the Potential of Implementing CO_2 Capture in an Integrated Steel Mill” was developed by IEAGHG in collaboration with the Swedish company Swerea MEFOS AB. It was initiated in January 2010, with co-funding from the Swedish Energy Agency, SSAB, LKAB and the member companies of Swerea MEFOS. The primary goal of this project is to specify a conceptual reference integrated steel mill producing hot rolled coil, and evaluate the cost and performance of the plant with and without CO_2 capture.

MUSTANG is a four-year large-scale integrating project funded by the EU FP7 that spans from 2009 to 2013, under the co-ordination of the Uppsala University, Sweden. The MUSTANG consortium comprises 19 institutions. It aims at developing guidelines, methods and tools for the characterisation of deep saline aquifers for long-term storage of CO_2, based on a solid scientific understanding of the underlying critical processes.

Numerical models will be developed for analysing CO_2 injection and storage and then applied at a number of test sites representing different geological settings and geographical locations in Europe. One of the potential test sites is located in south-western Scania in Sweden.

PROGRAMME EVALUATION

In 2009, the government commissioned an evaluation of the Energy Research Programme which was subsequently carried out by a private consulting firm. It focused on the processes, strategies and priorities of the Swedish Energy Agency and the Energy Research Programme, and less on an evaluation of the results. The outcome was presented and discussed in a hearing, and subsequently communicated to Parliament.[33]

Overall, the government found that the Swedish Energy Agency had responded to the guidelines and instructions of the Energy Research Bill of 2006, and that the activities corresponded to its objectives.

33. SKR: 2009/10:168 Utvärdering av insatserna för forskning och innovation inom energiområdet. A comprehensive study that formed the basis for the 2006 Bill on Research and New Technology for the Energy System of the Future had provided an in-depth evaluation. See Andersson/Ejermo: Effort and Performance of R&D in Sweden, 2005, at: www.iked.org/pdf/Effort%20and%20Performance%20of%20R&D%20in%20Sweden.pdf.

Some signals on further development were given. The Swedish Energy Agency should:

- make increased efforts on communicating the results;
- continue the efforts to guarantee the quality of the funded activities;
- analyse new ways to increase commercialisation;
- ensure that the consensus sought in strategy- and priority-setting does not counteract new initiatives and efforts; and
- increase efforts to collaborate with other national, regional and local agencies and organisations.

In 2012, the Swedish Energy Agency submitted a report on the energy RD&D programme and suggested priorities for the future. This report was an important input to the Research and Innovation for a Sustainable Energy System Bill (2012/13:21).

PUBLIC-PRIVATE PARTNERSHIPS

The Swedish Energy Agency has the task of formulating quantitative and qualitative visions, goals and targets for the thematic areas, and for any subdivisions of these, in consultation with industry, researchers and society. This places the strategic processes closer to the stakeholders and makes for more flexible and well-informed priority setting. While the government has no direct influence on private research, it involves the private sector closely in the formulation of the public energy RD&D policy. The involvement of the private sector occurs most directly through the Energy R&D Board and its six technology platforms, the competence centres, the work of VINNOVA and in the framework of the new CleanTech Strategy.

There are eight competence centres conducting interdisciplinary applied research in areas relevant to industry's long-term goals. The centres are co-financed by the Swedish Energy Agency and various industry alliances and universities, providing each for one-third of the budget. These eight centres are:

- Combustion Engine Research Centre (CERC);
- High-Temperature Corrosion Centre (HTC);
- Catalysis Competence Centre (KCK);
- Swedish Centre of Excellence in Electrical Power Engineering (EKC2);
- Competence Centre for Gas Exchange (CCGEx);
- Swedish Hybrid Vehicle Centre (SHC);
- Swedish Gasification Centre (SFC); and
- Competence Centre for Combustion Processes (KCFP).

The Swedish **CleanTech Strategy** was created by the government to encourage innovation specifically among Swedish companies that foster eco-innovation and sustainable development in their products, services and processes ("cleantech"). It is an association of businesses fostering innovation in clean technologies, making recommendations to policy makers and participating in public debates.

The government's Innovation Agency, **VINNOVA,** lends support to RD&D projects, to entrepreneurs and the development of start-up companies. VINNOVA helps to optimise knowledge and technology transfer. Its annual budget is around SEK 2 billion.

DEMONSTRATION OF ENERGY TECHNOLOGIES

Demonstration of new energy technologies underpinning R&D is vital to public acceptance and environmental sustainability.

In 2008, the Swedish Energy Agency launched a call for large demonstration facilities and granted for the period 2009-10 SEK 1101 million (EUR 128 million) to five projects aiming at commercialising second generation biofuels and energy technology solutions.

- Chemrec AB demonstrates the extraction of biofuels from black liquor at a facility in Domsjö, Örnsköldsvik.
- Göteborg Energi AB develops the transformation of low-quality forestry materials to high-quality biofuels, such as biomethane.
- In Mörrum, Södra Cell AB runs a full-scale demonstration of the LignoBoost concept.
- Volvo Car Corporation runs a special demonstration project for demonstrating an electrically powered urban vehicle that can cover 90 % of the daily transport needs of a commuter. The project will conclude with 50 vehicles being demonstrated in actual traffic.
- The Seabased demonstration of ocean energy is supported by a project which runs a full-scale wave power plant for large-scale electricity production with an output of 10 MW.

DEPLOYMENT

INSTITUTIONS

The Swedish Energy Agency (Statens Energimyndighet) is tasked with the promotion of commercialisation in the energy field by providing support to the introduction of new energy-related products and services in the market. The Department for Market Development works to support businesses acting in the renewable energy and energy efficiency fields, during the seed, start-up and early growth stages. In the area of innovation clusters, the Swedish Energy Agency is supported by a number of other private and state bodies. The Swedish Governmental Agency for Innovation Systems (VINNOVA), under the Ministry of Enterprise, Energy and Communications, is the national contact agency for the EU Framework Programme for R&D.

There are several state-owned venture capital funds in Sweden, including Industrifonden, created by the government in 1979, which invests in Swedish SMEs with international growth potential in the information technologies and telecom, communication technology, electronics, life science and industry, and energy and environmental technology sectors. Created in 2009, Fouriertransform fosters strategic investments on commercial terms in the Swedish automotive sector to support the international competitiveness of the Swedish automotive cluster.

Innovationsbron administers the national incubator programme and promotes the commercialisation of R&D results by grants, soft loans and early/seed equity investments for projects in the very early stages of development across all sectors. Innovationsbron was formed by Teknikbrostiftelserna, Industrifonden and the government in 2005 with the support of VINNOVA. Innovationsbron is owned by the State and Industrifonden.

In support of the CleanTech Strategy, the Ministry of Enterprise, Energy and Communications commissioned to set up a national initiative, Cleantech In Sweden, to facilitate the early commercialisation of cleantech innovations. It is owned by Innovationsbron and financed by VINNOVA, Swedish Agency for Economic and Regional Growth (Tillväxtverket), Region Skåne and Västra Götalandsregionen.

In addition, there are a number of regional structures that support business development and commercialisation in Sweden's regions. The Swedish Agency for Economic and Regional Growth (Tillväxtverket) has been tasked by the government to support business concepts and business start-ups in all sectors. Almi Företagspartner promotes the development of competitive SMEs and innovation across Sweden. It is owned by the State and is the parent company (holding 51%) of a group of 17 subsidiaries. Other owners are county councils, regional authorities and municipal co-operative bodies. Almi's lending activity is self-financed, but the management and day-to-day operations are financed by annual grants from the owners. Inlandsinnovation is a state-owned venture capital actor, established in 2011 to offer loans, loan guarantees and direct equity investment in northern Sweden. Since 1961, Norrlandsfonden Foundation provides financing for SMEs in the five northernmost counties of Sweden. It originates from the state-owned minerals group LKAB.

Regional universities are strongly committed to deploying R&D results and promoting the commercialisation of advanced research and entrepreneurial activities. There are 15 regional University Holding companies which are fully owned by regional universities.

POLICIES AND PROGRAMMES

Business development, commercialisation and deployment of new energy technology are a key factor to realise the Swedish government's ambitions within the climate and energy politics.[34]

Support to business development and commercialisation in the area of energy in Sweden is regulated under the 2008 Innovation Ordinance (Förordning 2008:761). The objective of the regulation is to promote energy research in order to create conditions for efficient energy markets, a secure energy supply and protection of the environment, health and climate, in line with the Research, Development and Innovation (RD&I) Framework of October 2007, the EU framework for state aid for research, development and innovation.[35]

There are new areas of support for businesses in the seed/start-up stage, including:

- intellectual property rights (IPR) costs for SMEs;
- technical feasibility studies;
- young innovative enterprises;
- process and organisational innovation in services;

34. Swedish Energy Agency for Growth Policy Analysis, The performance and challenges of the Swedish National Innovation System, 2011.

35. http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2006:323:0001:0026:en:PDF

- innovation advisory and support services;
- loan of highly qualified personnel; and
- innovation clusters.

FUNDING MECHANISMS

Since 2006 the Swedish Energy Agency offers soft conditional loans and business development support to businesses in the pre-commercial stage. The businesses and their related growth projects are first pre-screened and then audited in a legal, technical and business aspect. The audit is similar to the standard due diligence process made by venture capital investors.

In response to the financial crisis and venture capital moving out of early stage investment financing, the Swedish Energy Agency introduced in 2010 a new financing instrument, a soft loan instrument with 50% co-financing, based on the existing 2008 Innovation Regulation “Support for young innovative enterprises”. The instrument facilitates commercialisation and growth of companies which have been supported by the Swedish Energy Agency, but also from individual innovators and spin-offs from existing companies.

The Swedish Energy Agency aims to achieve the right setting for the technologies, products and services that contribute to increased energy efficiency and/or to an increased proportion of renewable energy in order to reach and develop on a commercial market, and thereby contribute to the development of the Swedish energy-related industry and energy system nationally and globally. The Agency promotes project management in growth areas, facilitates growth in project financing and a higher rate of commercialisation of research and innovation, within the Swedish trade and industry, and to commercialise technologies that contribute to a sustainable energy system. Experienced business professionals and legal advisors participate in business development activities, which are primarily aimed at three different target groups, entrepreneurs/businesses, investors and other actors within the innovation system. The due diligence activities and market exposure, provided by the Agency, create businesses that are attractive for investors and facilitate commercialisation of their innovations.

The soft loans from the Swedish Energy Agency provide liquidity in growth projects and leverage to private investments. The information and knowledge dissemination actions contribute to an increased interest in private equity investments within the energy sector and facilitate the participation of other innovation-supporting actors to also assist in the development of the businesses, and further deployment of new energy technologies.

EVALUATION

An official evaluation of the programme has not taken place yet, but parameters of the programme indicated an annual growth in new patents, high shares of equity investments and export market turnovers (Table 11).

Table 11. **Effects of business development and commercialisation activities, 2009-11***

Parameters	**2009**	**2010**	**2011**
Collective turnover, million SEK	32.9	57.9	73.7
Turnover, export markets, million SEK	0.004	19	20.4
Number of employees, 1 December	109	195	134
Private equity raised each year, million SEK	41.2	183	99.32
Customers each year	415	244	595
Partnerships each year	41	65	64
New products each year	15	65	13
New patents each year	9	24	24
New loans approved each year	12	10	8
Total loans per year, million SEK	**61.34**	**34.75**	**40.02**

* The figures include only active projects each year, which means that all figures from ended projects are removed from the table.

Source: submission by the Swedish government to the IEA.

THE CLEANTECH STRATEGY

On 1 September 2011, the Swedish government launched the **CleanTech Strategy** together with an action plan for 2011-14 with a total budget of SEK 100 million per year (EUR 11.7 million). The strategy aims to improve the conditions for growth and development of Swedish cleantech companies with the aim to promote Swedish exports and thus contribute to sustainable growth with strong research and innovation coming from the clean tech sector. The scope of the CleanTech Strategy is not limited to energy technologies but does also cover waste management, water treatment and air quality. Neither is the focus only on "new technologies" but also on services.

Sweden considers that it has a competitive advantage in the cleantech energy sector. Compared to many other countries, Sweden stands out in that political policy measures have stimulated market growth and the export of innovative technologies. Taxes, different support measures, subsidies, refund systems and other political measures have steered the development in a positive direction. Co-operation between municipalities, research institutions and the business sector led Sweden to the R&D forefront in many areas.

The evaluation of the Energy Research Programme underlined that greater efforts are needed on the commercialisation of the research results. When it comes to commercialising R&D results, Sweden like many other countries, suffers from a general lack of capital in the early pre-revenue stages of the development of businesses. Many venture capital actors that used to invest in early-stage businesses have moved their focus to the later phases, which mean larger investments in fewer businesses. This also means that there are fewer possibilities for the remaining investor community for risk diversification through syndication. This gap in capital availability is called "The valley of death", because many innovations never reach the other end.

It is not unusual that new technologies within the cleantech energy area need large-scale demonstration in a realistic production setting to convince potential customers. This demonstration will, in certain cases, require the construction of large demonstration plants. These demonstration plants are costly, and private financing is very difficult to obtain given the normally notable technical project risks, such as outlined above.

Cleantech energy innovations require careful analysis from a business potential point of view. The investor community often lacks the expertise to analyse the business models, public support schemes' reliability, energy price forecasts and the potential market impact of an innovation in this sector.

The CleanTech Strategy focuses on facilitating better conditions for Swedish clean technologies for their development and deployment. Since the adoption of the Strategy, the government has initiated approximately 20 assignments to various government bodies. The objective of the assignments is to reduce the barriers for clean technology companies in the challenging phases all over the value chain: from research, development to commercialisation to internationalisation.

So far the government has assigned the Swedish Innovation Agency (VINNOVA) with the implementation of the R&D activities, Innovationsbron with the administration of the incubator programme and the Swedish Energy Agency to establish a "meeting place" for entrepreneurs and investors.

The Swedish Trade Council and the Swedish Energy Agency are tasked to promote small companies' exports, and the relation with strategic trade partners, such as the United States, Brazil and Turkey. The government has also appointed a high representative to work to support the bilateral co-operation with China, India and Russia in the area. The Swedish Energy Agency and the Swedish Innovation Agency are responsible for developing the capacity and implementation of innovative procurement nationwide. VINNOVA is also in charge of improving the infrastructure for testing and verification of the technologies. The Swedish Agency for Economic and Regional Growth is supporting business competence in small and medium-sized enterprises, information about EU funding programmes and is in charge of developing a website with gathered information about government activities in the field.

INTERNATIONAL COLLABORATION

International collaboration on energy research policy and energy policy is of key importance for an R&D-oriented country like Sweden.

The Swedish Energy Agency is the primary organisation that represents Sweden in the IEA Standing Committees, such as the Committee on Energy Research and Technology (CERT) and the Standing Group on Long-Term Co-operation (SLT). Sweden ranks seventh among IEA member countries in terms of participation in the IEA multilateral technology initiatives, or in Implementing Agreements (24 out of 40), in areas in line with the overall energy priorities:

- **cross-cutting**: energy technology research database, energy technology systems modelling;
- **end-use buildings**: buildings and community systems, efficient electrical end-use equipment, heat pumps;
- **end-use electricity**: demand-side management, high-temperature superconductors, smart grids;
- **end-use industry**: combustion, industrial technologies and systems;

- **end-use transport**: advanced fuel cells, advanced motor fuels, hybrid and electric vehicles;
- **fossil fuels**: greenhouse gas reduction;
- **fusion**: fusion materials; and
- **renewables**: bioenergy, geothermal, hydrogen photovoltaics, solar heating and cooling, solar chemical, wind.

On 31 March 2011 the Swedish government signed the Implementing Agreement for a Co-operative Programme on Smart Grids (ISGAN) ("ISGAN IA"). A national co-ordination platform has been initiated, where representatives of industry, academia, and government agencies gather around issues related to the ISGAN IA and smart grids.

Sweden is also a partner in international energy initiatives such as the Clean Energy Ministerial, International Renewable Energy Agency (IRENA), and the Global Carbon Capture and Storage Institute (GCCSI).

Sweden (through Chalmers University, the Royal Institute of Technology, Lund University and others, industry, etc.) participates in many of the European Union's Seventh RD&D Framework Programme activities, the European Research Area (ERA), and the EU's Strategic Energy Technology Plan (SET Plan), and in work on industrial initiatives on wind, bioenergy, smart grids and smart cities.

Under the Nordic Energy Research Programme "Sustainable Energy Systems 2050", the thematic focus during 2011-14, Sweden closely co-operates with its neighbours on ten projects within renewables, market and grids and low-carbon transport.

The collaboration under the top-level research initiative (TRI), launched by the Nordic Council of Ministers in Finland in 2007, focuses on large-scale wind power, and sustainable biofuels, energy efficiency, nanotechnology and CCS. Sweden supports the Top-level Research Initiative (TRI), currently the largest joint Nordic research and innovation initiative, with the aim to make a Nordic contribution towards solving the global climate crisis, including CCS technology.

Sweden has bilateral agreements dedicated to energy and research with several key partner countries, including Brazil, India, China, and the United States, and one agreement with the State of California. In the area of clean technologies, the Swedish Energy Agency focuses its international collaborative efforts on those countries, where energy-related bilateral agreements are in place, such as the United Arab Emirates, India, China, the United States and Russia, and partly on the markets with the greatest potential for Swedish clean energy technology exports, such as western Europe and Japan.

ASSESSMENT

ENERGY TECHNOLOGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

The Swedish public energy research, development and demonstration (RD&D) landscape is well organised, strongly targeted on market deployment, with full engagement by all actors, and takes advantage of Sweden's comparative strength.

The current RD&D policy framework has been developed and implemented on the basis of the 2006 Bill on Energy Research and Development towards Future Energy Systems.

The Swedish Energy Agency is the main body for identifying specific energy RD&D policy priorities and implementing the national Energy Research Programme and other RD&D activities. Some energy-related activities are carried out by other agencies, either in co-operation with the Swedish Energy Agency or as part of their respective areas of responsibility.

Sweden's RD&D policy is largely consistent with its energy policy. The national Energy Research Programme has been evolving over the past years to better meet policy needs. In addition, it contributes to strengthening the competitiveness of Sweden's industries. The programme has six priority areas: energy-system studies, buildings as an energy system, transport, energy-intensive industry, biomass in energy systems and the power system.

For each of the above six priority areas, advisory boards and technology platforms comprised of experts from industry, academia and other areas were formed to support the Swedish Energy Agency in identifying policy needs and developing strategic research plans along the entire knowledge value chain. In 2011, about 50 programmes were implemented in these six areas. In general, targets for RD&D activities are set on the basis of market needs over the next ten to fifteen years. They take into account comparative advantages and the strengths of Sweden's technologies.

It is commendable that the government has been significantly increasing the energy RD&D budget since the last in-depth policy review, particularly for transport (a challenging sector for all IEA member countries). However, Sweden's overall performance in terms of energy RD&D expenditure as a percentage of GDP has been close to the IEA average. It is encouraging that the government recently proposed a further increase of RD&D funding from 2013 and onwards to achieve its ambitious energy and climate targets.

The IEA welcomes the private sector's active involvement in public energy RD&D. The Energy Research Programme is funded both by the Energy Agency and by industries. While contributions from industry are roughly equivalent to funds provided by the government, private funding is overtaking public financing for large-scale demonstration projects.

Every four years, the government evaluates energy RD&D activities to ensure that objectives will be met in an effective and efficient manner. In 2009, the government conducted an evaluation of the Energy Research Programme with a focus on the processes, strategies and priorities of the Energy Agency and the Energy Research Programme. The key recommendation to have a stronger focus on commercialisation has been taken up and demonstration activities increased over the past two years.

The number of young people with strong interest in technologies and engineering has been decreasing in recent years. Thus, there is a risk that the current education system will not provide enough engineers. Considering the increasing needs for new low-carbon technologies, the government, in co-operation with academia and industries, should strengthen engineering education in the energy technology sectors.

Sweden is actively involved in international collaboration, such as the EU Seventh Framework Programme for Research and Technological Development (FP7), the IEA activities and its Implementing Agreements, the Nordic Energy Research Programme, the Clean Energy Ministerial, IRENA, the Global Carbon Capture and Storage Institute (GCCSI) and bilateral agreements with a number of strategically selected countries.

ENERGY TECHNOLOGY DEPLOYMENT

Sweden has developed a strong RD&D strategy and capacity, which has enabled the emergence of new technologies and innovations. Moving from idea and innovation to early deployment of technologies remains a challenge in most markets, including in Sweden. The energy sector presents a particular challenge given the large upfront capital requirements for many technology innovations, high technology risk, longer-term business models, among other particularities.

Co-financing innovation and business sector commitment are vital components of the Swedish energy RD&D policy. The private sector is engaged in energy RD&D and is involved in the formulation of the strategic plans, through the Energy R&D Board and its six technology platforms, and as a significant financing partner in the special large-scale demonstrations projects for which the State provides co-financing.

Since 2009, contributions from industry have been increasing, overtaking funding provided by the governmen. In public RD&D, research on energy efficiency, renewables, transport and nuclear energy accounts for significant amounts of funding. Private funding significantly contributes to pilot and demonstration projects.

Since the last review, Sweden has made progress in supporting clean energy technology commercialisation, through the development of its CleanTech Strategy and the introduction of new programmes, such as the young innovative enterprises, innovation advisory and support services, innovation clusters, soft loan programme, to name a few. These are positive developments in helping to develop a framework and support to bring innovative technologies to the market, but additional actions can be taken.

Sweden's RD&D strategy clearly articulates its areas of priority, with a particular emphasis on smart grids and bioenergy, in addition to research into key sectoral areas (transport, power, buildings and industry). The selected focus on bioenergy and smart grids builds on two of Sweden's areas of comparative market advantage: resource availability, and opportunity for potential growth in a decarbonised economy. The government has assigned to a number of actors the responsibility for the evaluation and foresees an independent evaluation by the Swedish Growth Analysis. This is commendable. However, Sweden's CleanTech Strategy could benefit from strong alignment with the RDD&D policy to build on the good results from the demonstration and deployment projects.

Enhanced linkage between the RD&D strategy and the CleanTech Strategy would help leverage the public funds already invested. In addition, as investors look to long-term market potential for new emerging technologies, government technology deployment policies should also be transparent, predictable and sufficiently long-term to ensure investor confidence. Sweden has set out a long-term vision that supports clean energy technology deployment, and the continued development of clear policies that support the implementation of this vision is important.

The introduction of the technology incubators, innovation hubs, the soft loan programme, inducement prices are very positive developments in meeting Sweden's objectives of overcoming the technology pre-commercialisation gap. These programmes could be further scaled up and complemented with additional financial tools that aim to leverage a larger share of private-sector capital. This would not only provide alternative support options, but also help government funds go further.

Given that the clean energy technology sector is a relatively complex and new market, further actions to encourage "traditional" private financial actors to engage in these new markets could be taken. These could include, for example, measures to address gaps in investor knowledge in the cleantech sector.

Sweden has several state-owned venture capital funds, but has no public mission bank. The country could benefit from stronger engagement with international financial investors and financial intermediaries to access European and other international funds such as the European Local Energy Assistance (ELENA) or the European Energy Efficiency Fund (EEEF). The IEA encourages the government to consider establishing a dedicated bank for clean technologies.

Building on the strong track record in international co-operation, in particular Nordic Research collaboration on issues such as smart grids or CCS, the IEA encourages the government to further develop the innovation and cleantech work also within the excellent structures of the Nordic Research framework with a view to achieve scale, cost-efficiencies and synergies across the Nordic countries. Ideally, regional co-operation on RD&D should link up to results of the 2050 pathway analysis.

RECOMMENDATIONS

The government of Sweden should:

Energy technology research, development and demonstration

- ☐ *Continue the development of the Energy Research Programme by assessing challenges and adjusting portfolios as national energy policy priorities change.*
- ☐ *Maintain sufficient funding for RD&D, including more access to EU funds, to ensure that energy technology innovation will better contribute to energy policy.*
- ☐ *Further strengthen engagement of industries, in particular SMEs, in RD&D activities to accelerate deployment of new, low-carbon technologies.*
- ☐ *Increase efforts in education to meet future demands for researchers and engineers.*

Energy technology deployment

- ☐ *Ensure strong alignment of the CleanTech Strategy with Swedish RDD&D policy to build upon the good results and strengthen co-ordination for the implementation.*
- ☐ *Enhance linkages and prioritisation between the CleanTech Strategy, the government RD&D strategy, and national technology deployment policies.*
- ☐ *Scale up co-operation and planning at regional levels to support clean technologies towards commercialisation, including e-vehicles, smart grids and carbon capture and storage, to achieve emissions reductions of the industry processes and the transport sector and create scale and synergies.*
- ☐ *Evaluate and consider additional mechanisms and programmes to further leverage private-sector capital in supporting technology commercialisation.*
- ☐ *Consider the creation of a dedicated public mission bank to foster the inflow of international private and public investment to Sweden.*

PART IV
ANNEXES

ANNEX A: ORGANISATION OF THE REVIEW

REVIEW CRITERIA

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex C.

REVIEW TEAM AND PREPERATION OF THE REPORT

The in-depth review team visited Sweden from 28 May to 1 June 2012. The team met with government officials, energy suppliers, interest groups and various other organisations. This report was drafted on the basis of these meetings, the team's preliminary assessment of Sweden's energy policy, the government response to the IEA energy policy questionnaire and other information. The members of the team were:

IEA member countries

Mr. Hergen HAYE, the United Kingdom (team leader)

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Organisations visited

During its visit in Sweden, the review team met with the following organisations:

Association of Swedish Regional Energy Agencies

Association of the Swedish Home-owners

Association of Independent Electricity Retailers

Association of Swedish Engineering Industries

City of Stockholm

Innovationsbron AB

Energikontoret Örebro

Ministry of Enterprise, Energy and Communications

Ministry of the Environment

Ministry of Finance

Ministry of Transport

Royal Technology Institute (KTH)

SEB Venture Capital

Swedish Competition Authority

Swedish Consumer Association

Swedish Construction Federation

Swedish Confederation of Enterprises

Swedish District Heating Association

Swedish Energy Agency

Swedish Energy Markets Inspectorate

Swedish Forest Agency

Swedish Gas Association Energigas Sverige

Svenska Kraftnät

Svensk Kraftmäkling AB

SwedEnergy

Swedish National Board of Housing, Building and Planning

Swedish Society for Nature Conservation

Swedish Radiation Safety Authority

Swedish Property Federation

Swedish Wind Power Association

SWECO Energy Markets

Teknikföretagen

Testlab at the Swedish Energy Agency

ANNEX B:
ENERGY BALANCES
AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	2000	2009	2010	2011P	2020	2030
TOTAL PRODUCTION		**9.3**	**30.5**	**30.3**	**33.5**	**33.8**	**39.0**	**39.6**
Coal		0.0	-	-	-	-	-	-
Peat		-	0.2	0.2	0.2	0.2	0.4	0.4
Oil		-	-	-	-	-	-	-
Natural Gas		-	-	-	-	-	-	-
Biofuels & Waste[1]		3.5	8.3	10.4	11.9	11.1	12.7	13.5
Nuclear		0.6	14.9	13.6	15.1	15.9	18.6	18.6
Hydro		5.1	6.8	5.7	5.7	5.7	6.0	6.0
Wind		-	0.0	0.2	0.3	0.5	1.0	0.9
Geothermal		-	-	-	-	-	-	-
Solar/Other[2]		-	0.4	0.3	0.3	0.5	0.3	0.2
TOTAL NET IMPORTS[3]		**29.1**	**17.3**	**14.9**	**17.1**	**16.0**	**14.2**	**13.7**
Coal	Exports	0.0	0.0	0.2	0.0	0.0	-	-
	Imports	1.7	2.4	1.4	2.5	2.1	2.2	2.3
	Net Imports	1.7	2.3	1.2	2.4	2.1	2.2	2.3
Oil	Exports	1.4	11.0	12.1	12.8	11.7	-	-
	Imports	30.0	26.7	27.0	28.3	27.5	16.3	15.8
	Int'l Marine and Aviation Bunkers	-1.2	-2.0	-2.8	-2.6	-2.5	-3.0	-3.1
	Net Imports	27.4	13.7	12.1	12.9	13.3	13.3	12.6
Natural Gas	Exports	-	-	-	-	-	-	-
	Imports	-	0.8	1.1	1.5	1.2	0.7	0.7
	Net Imports	-	0.8	1.1	1.5	1.2	0.7	0.7
Electricity	Exports	0.4	1.2	0.8	1.1	1.7	2.1	2.0
	Imports	0.5	1.6	1.2	1.3	1.1	-	-
	Net Imports	0.1	0.4	0.4	0.2	-0.6	-2.1	-2.0
TOTAL STOCK CHANGES		**0.5**	**-0.2**	**0.1**	**0.7**	**-1.0**	**-**	**-**
TOTAL SUPPLY (TPES)[4]		**38.8**	**47.6**	**45.4**	**51.3**	**48.9**	**53.1**	**53.3**
Coal		1.6	2.2	1.6	2.1	2.0	2.2	2.3
Peat		-	0.2	0.3	0.4	0.3	0.4	0.4
Oil		27.9	13.6	11.9	13.9	12.4	13.3	12.6
Natural Gas		-	0.8	1.1	1.5	1.2	0.7	0.7
Biofuels & Waste[1]		3.5	8.3	10.4	11.9	11.1	12.7	13.5
Nuclear		0.6	14.9	13.6	15.1	15.9	18.6	18.6
Hydro		5.1	6.8	5.7	5.7	5.7	6.0	6.0
Wind		-	0.0	0.2	0.3	0.5	1.0	0.9
Geothermal		-	-	-	-	-	-	-
Solar/Other[2]		-	0.4	0.3	0.3	0.5	0.3	0.2
Electricity Trade[5]		0.1	0.4	0.4	0.2	-0.6	-2.1	-2.0
Shares (%)								
Coal		*4.2*	*4.7*	*3.5*	*4.2*	*4.1*	*4.2*	*4.4*
Peat		*-*	*0.5*	*0.8*	*0.7*	*0.5*	*0.8*	*0.8*
Oil		*71.8*	*28.5*	*26.1*	*27.1*	*25.3*	*24.9*	*23.7*
Natural Gas		*-*	*1.6*	*2.4*	*2.8*	*2.4*	*1.4*	*1.2*
Biofuels & Waste		*9.1*	*17.4*	*22.9*	*23.2*	*22.7*	*24.0*	*25.3*
Nuclear		*1.4*	*31.4*	*29.9*	*29.4*	*32.5*	*35.0*	*34.8*
Hydro		*13.3*	*14.2*	*12.5*	*11.1*	*11.7*	*11.3*	*11.2*
Wind		*-*	*0.1*	*0.5*	*0.6*	*1.1*	*1.8*	*1.8*
Geothermal		*-*	*-*	*-*	*-*	*-*	*-*	*-*
Solar/Other		*-*	*0.8*	*0.6*	*0.5*	*0.9*	*0.5*	*0.4*
Electricity Trade		*0.2*	*0.8*	*0.9*	*0.3*	*-1.3*	*-3.9*	*-3.7*

0 is negligible, - is nil, .. is not available

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**2000**	**2009**	**2010**	**2011P**	**2020**	**2030**
TFC	**34.8**	**35.3**	**31.9**	**35.2**	**33.7**	**37.2**	**37.9**
Coal	1.0	0.8	0.5	0.8	0.6	1.7	1.8
Peat	-	0.0	0.0	0.0	0.0	0.0	0.0
Oil	24.4	14.2	10.6	11.2	11.0	12.0	12.0
Natural Gas	-	0.4	0.5	0.6	0.7	0.5	0.5
Biofuels & Waste[1]	3.5	5.3	5.5	6.1	6.3	6.9	7.4
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	0.0	0.0	0.0	0.0	-	-
Electricity	6.0	11.1	10.6	11.3	10.8	11.4	11.5
Heat	-	3.5	4.3	5.1	4.4	4.6	4.7
Shares (%)							
Coal	*3.0*	*2.2*	*1.4*	*2.4*	*1.7*	*4.7*	*4.8*
Peat	-	-	-	-	-	-	-
Oil	*70.0*	*40.2*	*33.3*	*31.9*	*32.5*	*32.3*	*31.6*
Natural Gas	-	*1.3*	*1.4*	*1.8*	*1.9*	*1.3*	*1.4*
Biofuels & Waste	*9.9*	*15.0*	*17.1*	*17.3*	*18.7*	*18.6*	*19.5*
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	-	-	-	-	-	-
Electricity	*17.1*	*31.4*	*33.3*	*32.0*	*32.1*	*30.7*	*30.4*
Heat	-	*10.1*	*13.4*	*14.6*	*12.9*	*12.4*	*12.4*
TOTAL INDUSTRY[6]	**15.4**	**15.4**	**12.3**	**14.2**	**13.3**	**16.5**	**17.1**
Coal	0.9	0.7	0.4	0.8	0.6	1.7	1.8
Peat	-	0.0	0.0	0.0	0.0	0.0	0.0
Oil	8.2	4.8	2.7	3.1	2.8	3.8	3.8
Natural Gas	-	0.3	0.3	0.4	0.4	0.3	0.3
Biofuels & Waste[1]	2.9	4.3	4.0	4.6	4.4	5.1	5.4
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	-	-	-	-	-	-
Electricity	3.4	4.9	4.4	4.7	4.6	5.2	5.3
Heat	-	0.3	0.4	0.4	0.5	0.4	0.4
Shares (%)							
Coal	*5.8*	*4.8*	*3.6*	*5.8*	*4.4*	*10.6*	*10.6*
Peat	-	-	*0.1*	*0.1*	-	-	*0.1*
Oil	*53.2*	*31.1*	*22.0*	*22.1*	*21.1*	*23.0*	*22.4*
Natural Gas	-	*2.0*	*2.4*	*3.2*	*3.2*	*1.6*	*1.6*
Biofuels & Waste	*19.0*	*28.1*	*32.7*	*32.7*	*32.9*	*30.7*	*31.8*
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	-	-	-	-	-	-
Electricity	*22.0*	*31.8*	*36.0*	*33.0*	*34.6*	*31.6*	*31.1*
Heat	-	*2.2*	*3.1*	*3.2*	*3.8*	*2.4*	*2.3*
TRANSPORT[4]	**5.3**	**7.4**	**7.7**	**7.8**	**8.1**	**8.0**	**8.2**
OTHER[7]	**14.1**	**12.5**	**11.9**	**13.2**	**12.3**	**12.7**	**12.7**
Coal	0.1	0.0	0.0	0.0	-	-	-
Peat	-	-	-	-	-	-	-
Oil	11.1	2.3	0.8	0.9	0.9	1.1	1.0
Natural Gas	-	0.1	0.1	0.2	0.2	0.2	0.2
Biofuels & Waste[1]	0.5	1.0	1.0	1.0	1.5	1.3	1.4
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	0.0	0.0	0.0	0.0	-	-
Electricity	2.4	5.9	6.0	6.4	6.0	6.0	5.9
Heat	-	3.2	3.9	4.7	3.9	4.2	4.3
Shares (%)							
Coal	*1.0*	*0.2*	*0.1*	*0.1*	-	-	-
Peat	-	-	-	-	-	-	-
Oil	*78.5*	*18.2*	*7.1*	*6.9*	*6.9*	*8.4*	*7.7*
Natural Gas	-	*1.0*	*1.2*	*1.2*	*1.5*	*1.3*	*1.3*
Biofuels & Waste	*3.7*	*7.6*	*8.8*	*7.9*	*11.8*	*10.6*	*10.8*
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	-	*0.1*	*0.1*	-	-	-
Electricity	*16.8*	*47.2*	*50.2*	*48.4*	*48.6*	*46.7*	*46.2*
Heat	-	*25.6*	*32.6*	*35.5*	*31.2*	*33.0*	*33.9*

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**2000**	**2009**	**2010**	**2011P**	**2020**	**2030**
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**8.2**	**26.2**	**26.0**	**29.1**	**28.5**	**32.2**	**32.3**
OUTPUT (Mtoe)	**6.7**	**12.5**	**11.7**	**12.8**	**12.9**	**14.8**	**14.8**
(TWh gross)	78.1	145.2	136.6	148.5	150.5	172.0	171.9
Output Shares (%)							
Coal	*0.6*	*1.7*	*0.7*	*1.3*	*0.8*	*0.8*	*0.9*
Peat	-	-	*0.5*	*0.5*	*0.4*	*0.7*	*0.2*
Oil	*19.4*	*1.1*	*0.5*	*1.2*	*0.5*	*0.1*	-
Natural Gas	-	*0.3*	*1.1*	*1.9*	*1.2*	*0.3*	-
Biofuels & Waste	*0.5*	*3.0*	*8.9*	*9.0*	*8.5*	*8.9*	*9.9*
Nuclear	*2.7*	*39.5*	*38.2*	*38.9*	*40.5*	*42.2*	*42.2*
Hydro	*76.7*	*54.1*	*48.2*	*44.7*	*44.1*	*40.5*	*40.5*
Wind	-	*0.3*	*1.8*	*2.4*	*4.0*	*6.5*	*6.4*
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	-	-	-	-	-	-
TOTAL LOSSES	**3.4**	**13.8**	**13.8**	**15.4**	**15.1**	**16.9**	**16.1**
of which:							
Electricity and Heat Generation[9]	1.5	10.7	10.2	11.4	11.2	12.9	12.0
Other Transformation	1.0	0.8	1.0	1.3	1.2	1.8	1.8
Own Use and Losses[10]	1.0	2.4	2.6	2.7	2.6	2.2	2.3
Statistical Differences	**0.6**	**-1.5**	**-0.2**	**0.7**	**0.1**	**-1.0**	**-0.7**
INDICATORS	**1973**	**2000**	**2009**	**2010**	**2011P**	**2020**	**2030**
GDP (billion 2005 USD)	187.78	324.51	376.91	400.03	415.83	503.88	623.75
Population (millions)	8.14	8.87	9.30	9.38	9.48	10.20	10.66
TPES/GDP[11]	0.21	0.15	0.12	0.13	0.12	0.11	0.09
Energy Production/TPES	0.24	0.64	0.67	0.65	0.69	0.73	0.74
Per Capita TPES[12]	4.77	5.36	4.88	5.47	5.15	5.21	5.00
Oil Supply/GDP[11]	0.15	0.04	0.03	0.04	0.03	0.03	0.02
TFC/GDP[11]	0.19	0.11	0.09	0.09	0.08	0.07	0.06
Per Capita TFC[12]	4.28	3.98	3.43	3.76	3.56	3.65	3.56
Energy-related CO_2 Emissions (Mt CO_2)[13]	84.0	52.8	41.4	47.6	..	..	..
CO_2 Emissions from Bunkers (Mt CO_2)	3.9	6.3	8.8	8.2	..	..	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-09**	**09-10**	**10-11**	**11-20**	**20-30**
TPES	1.2	0.1	-0.5	12.9	-4.7	0.9	0.0
Coal	3.1	-2.0	-3.7	35.1	-6.5	1.3	0.4
Peat	-	-0.1	4.5	2.0	-27.4	6.2	-
Oil	-3.9	-0.5	-1.5	17.2	-10.8	0.8	-0.5
Natural Gas	-	3.0	3.8	33.8	-17.8	-5.3	-1.0
Biofuels & Waste	2.6	4.1	2.6	14.6	-6.7	1.5	0.6
Nuclear	22.7	-1.7	-1.0	10.8	5.3	1.8	-
Hydro	1.1	0.8	-1.9	0.8	0.0	0.5	-
Wind	-	44.2	20.8	40.7	73.8	7.1	-0.3
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	61.5	-2.8	-	61.2	-5.9	-1.4
TFC	-0.5	0.9	-1.1	10.5	-4.2	1.1	0.2
Electricity Consumption	3.3	0.7	-0.5	6.4	-3.9	0.6	0.1
Energy Production	7.1	0.3	-0.1	10.4	1.0	1.6	0.2
Net Oil Imports	-3.8	-0.4	-1.4	6.5	3.0	-0.0	-0.5
GDP	2.0	2.1	1.7	6.1	4.0	2.2	2.2
Growth in the TPES/GDP Ratio	-0.9	-2.0	-2.2	6.7	-7.8	-1.3	-2.1
Growth in the TFC/GDP Ratio	-2.4	-1.1	-2.7	3.5	-8.0	-1.0	-1.9

Please note: Rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprises solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
2. Other includes ambient heat used in heat pumps.
3. In addition to coal, oil, natural gas and electricity, total net imports also include peat.
4. Excludes international marine bunkers and international aviation bunkers.
5. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
6. Industry includes non-energy use.
7. Other includes residential, commercial, public services, agriculture, forestry, fishing and other non-specified.
8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and 100% for hydro, wind and photovoltaic.
10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
11. Toe per thousand US dollars at 2005 prices and exchange rates.
12. Toe per person.
13. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach from the Revised 1996 IPCC Guidelines. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2010 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

ANNEX C: INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

*Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

ANNEX D: GLOSSARY, LIST OF ABBREVIATIONS AND CURRENCY CONVERSION

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for many of the abbreviations used.

AC alternating current

b/d barrels per day
bcm billion cubic metres

CCGT combined-cycle gas turbine
CDM clean development mechanism (under the Kyoto Protocol)
CHP combined production of heat and power
CH_4 methane
CO_2 carbon dioxide
CTI Commission for Technology and Innovation

DC direct current
DSO distribution system operator

EI Energy Markets Inspectorate (the regulator)
EPA Environmental Protection Agency
EPC Energy performance certificate
EU European Union
EU-ETS EU Emissions Trading Scheme

FAME fatty-acid methyl ester

GDP gross domestic product
GHG greenhouse gas
GW gigawatt, or 1 watt × 10^9
GWh gigawatt-hour, or 1 gigawatt × 1 hour

HVDC high-voltage direct current
HVO hydrogenated vegetable oils

ktoe	thousand tonnes of oil equivalent
kW	kilowatt, or 1 watt × 10^3
kWh	kilowatt-hour, or 1 kilowatt × 1 hour
LNG	liquefied natural gas
LPG	liquefied petroleum gas
mcm	million cubic metres
MEPS	minimum energy performance standard
Mt	million tonnes
Mt CO_2-eq	million tonnes of CO_2 equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt, or 1 watt x 10^6
MWh	megawatt-hour, or 1 megawatt x 1 hour
NPP	nuclear power plant
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, *i.e.* PPP estimates the differences in price levels between countries
PV	photovoltaics
RD&D	research, development and demonstration
RES	renewable energy sources
SEK	Swedish Krona (see below for exchange rate)
SSM	Swedish Radiaton Safety Authority
TFC	total final consumption of energy
TJ	terajoule
toe	tonne of oil equivalent, defined as 10^7 kcal
TPA	third-party access
TPES	total primary energy supply
TSO	transmission system operator
TW	terawatt, or 1 watt × 10^{12}
TWh	terawatt-hour, or 1 terawatt × 1 hour
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax
W	watt

ANNEX E: SWEDISH KRONA TO EURO EXCHANGE RATE

Year	EUR (SEK 1 000)
2005	107.7
2006	108.0
2007	108.1
2008	104.1
2009	94.2
2010	104.8
2011	110.7

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