Greenhouse gas abatement opportunities in Sweden

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In addition to traditional client work, McKinsey also has a long tradition of working pro bono with important societal issues. Since 2006 McKinsey has worked on mapping greenhouse gas abatement opportunities, both globally and for individual countries such as the United States, Germany and Australia.

Foreword

In Sweden, ambitious goals are being discussed for reducing emissions of greenhouse gases: a reduction of up to 40 percent by 2020, compared to 1990. The European Union has a commitment of reducing its emissions by at least 20 percent, but has announced that it will raise this ambition to 30 percent if a sufficiently broad international agreement is reached.

The overall ambition of significantly reducing emissions of greenhouse gases in Sweden has solid backing in political and industrial circles. However, there has been no clear fact base available for discussing which measures are most effective in reducing emissions, which goals are realistic for Sweden and for different industries, and what the consequences of different targets may be for Sweden.

In order to create such a fact base, the Confederation of Swedish Enterprise has given McKinsey & Company the task of conducting this study. More than 40 different companies and organisations from all sectors of the economy have taken part in an in-depth analysis of more than 200 different measures for greenhouse gas abatement in Sweden. All results have been discussed and verified with leading experts in different industries to ensure the realism of the assumptions. The study is based on the same methodology used in other studies conducted both globally and in other countries such as Germany, the United States and Australia.

The analysis deliberately does not offer recommendations to regulators or suggest implementation mechanisms, means of control or political decisions. Instead, the aim is to create an objective fact base for the continued debate on how emissions of greenhouse gases in Sweden can be reduced.

We would like to thank participating companies, organisations and independent experts for their constructive collaboration in recent months. Broad support and anchoring have been necessary to make this study possible. We also wish to thank Professor Erland Källén, Senior Economist Klas Eklund and Ph.D. Phil Björn Carlén for their support as independent reference group in the work.

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Executive summary

Opportunities and costs for greenhouse gas abatement in Sweden

In order to limit global warming in the long term to no more than 2 degrees, the UN's panel for climate change (IPCC) assesses that greenhouse gas emissions must be reduced to approximately 1 tonne per person per year by the end of the century. As emissions in Sweden today equal 7.4 tonnes per person, this will be quite a challenge.

Greenhouse gases are absorbed slowly from the atmosphere once emitted. To achieve balance between what is released and what is absorbed, the IPCC assesses that emissions by the end of the century should be no more than 1 tonne per person per year globally.

In order to make the long-term goal realistic, the EU has committed to reducing its greenhouse gas emissions to half of the 1990 level by 2050. By 2020 the EU has set a target of reducing emissions by 20 percent.[1] Furthermore, it is possible that this ambition will be raised to a 30 percent reduction depending on how countries outside the EU act.

One of the mechanisms that the EU has put in place for reducing emissions is the EU-ETS (European Union Emission Trading Scheme). This is a system for trading the right to emit carbon dioxide, the largest contributor to increasing greenhouse gas emissions. In this system the EU sets an international cap for carbon dioxide emissions from the sectors included in the trading system, primarily energy-intensive industry and the energy sector. In the trading sector, so-called "emission rights" can be purchased and sold, catalysing the implementation of abatement measures where they are most cost-effective. Today, approximately one third of Sweden's emissions of greenhouse gases are part of the EU-ETS. There are ongoing discussions on whether to include a greater share of emissions in the trading system, primarily the transport sector. In the remainder of this report, trading and non-trading industries are treated separately.

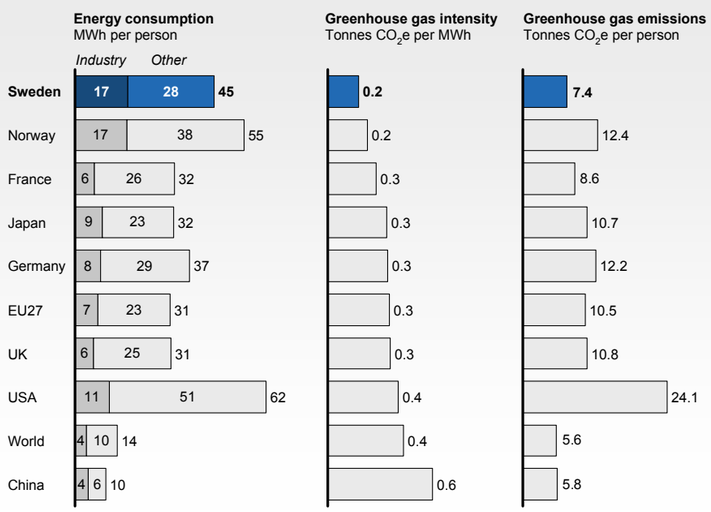
1 Corresponding to 14 percent reduction compared to 2005.

In the EU's 2020 target, industries that are part of the trading system are to reduce their total emissions by 21 percent compared to 2005 levels. For industries outside of the EU-ETS, that goal is 10 percent. The latter goal is further differentiated among the EU member states. It is proposed that Sweden should reduce emissions in the non-trading industries by 17 percent by 2020, compared to 2005 levels.

Sweden has low greenhouse gas emissions compared to other industrialised countries – primarily due to very low greenhouse gas emissions in the energy sector. The majority of Sweden's total emissions of 67.0 million tonnes comes from transportation and industry.

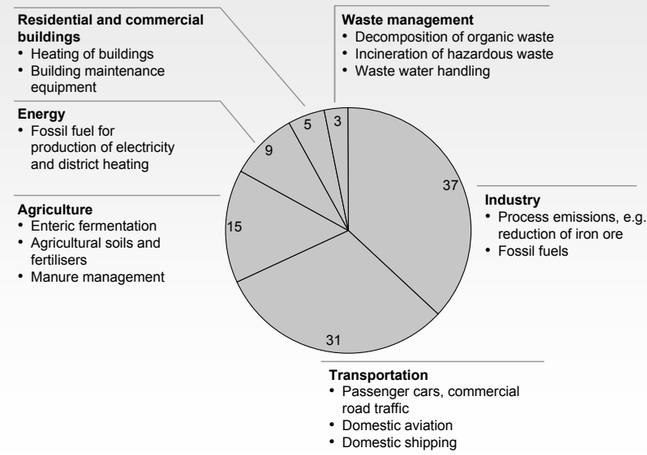
Compared to other countries, Sweden has low emissions from power production – about 97 percent of power comes from hydro, nuclear and biomass-based production. As a consequence, we have lower emissions of greenhouse gases per person than most industrialised countries, despite relatively high energy consumption per person given the significant portion of energy-intensive industry.

Sweden's greenhouse gas intensity



Emissions of greenhouse gases in Sweden – 2005

Percentage; 100% = 67.0 million tonnes CO_2e



In 2005 Sweden emitted 67.0 million tonnes of carbon dioxide equivalent, representing 0.2 percent of the world's total emissions. Emissions are dominated by carbon dioxide, which is responsible for 79 percent of the total climate impact. In addition, nitrous oxide (N_2O) contributes 11 percent, methane contributes 8 percent and other greenhouse gases account for the remaining 2 percent. Greenhouse gases have different global warming potentials (GWP), and in order to compare them with each other, their emissions are converted into the unit of carbon dioxide equivalent (CO_2e).

Of the total emissions in Sweden in 2005, the industry and transportation sectors accounted for 25.0 and 20.5 million tonnes CO_2e respectively, or 68 percent of Sweden's total emissions. The third largest emitter is agriculture, with 10.0 million tonnes CO_2e, chiefly methane and nitrous oxide. Energy production releases 5.9 million tonnes CO_2e. Waste management, as well as housing and other buildings account for the remaining 5.6 million tonnes CO_2e.

Greenhouse gas emissions have two main sources. The primary source is the burning of fossil fuels, for instance in the transportation and industry sectors. Combustion of fossil fuels generated 47.6 million tonnes of CO_2e emissions in Sweden in 2005. The second source is "process emissions", i.e., greenhouse gases emitted as a direct consequence of chemical and biological processes (for example, enteric fermentation or reduction of iron ore). These emissions accounted for 19.4 million tonnes of CO_2e in 2005.

Additional emissions of greenhouse gasses

Burning of non-fossil fuels also gives rise to greenhouse gas emissions, but the carbon dioxide that is released is assumed to be reabsorbed by growing biomass. Therefore, carbon dioxide emissions from the burning of non-fossil fuels are not included in Sweden's official reporting of greenhouse gas emissions. In 2005 carbon dioxide emissions from non-fossil fuels amounted to approximately 20 million tonnes of CO_2e. Emissions arising from the production process of biofuels are reported by the respective producing countries. For example, Sweden imports large quantities of ethanol from Brazil. In 2005 Swedish imports corresponded to about 9 percent of Brazil's total ethanol export, but the emissions that this production generated were allocated to Brazil.

In the reference scenario, emissions are expected to fall by 3 percent to 65.6 million tonnes of CO_2e by 2020 and then remain stable until 2030.

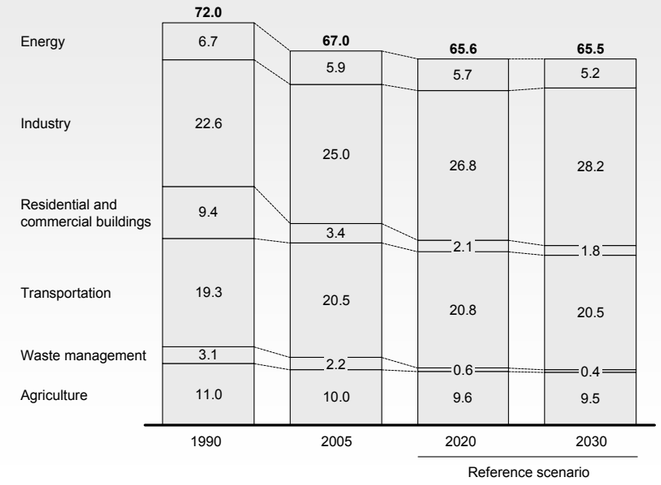
In order to assess the effect of future measures, a reference scenario[2] has been constructed which shows how the emissions will develop until 2020 and 2030, assuming that no special measures are taken beyond regulations already decided on. Emissions in the reference scenario grow through increased production and consumption, corresponding to 2.2 percent annual GNP growth. This increase in emissions in the reference scenario is balanced by the replacement of older, less effective installations with new equipment when they reach the end of their service life. Other factors are the fulfilment of the EU's goal of 10 percent biofuel introduction and successive upgrades of, for example, production facilities in industry. In order to compare the effectiveness of different measures across sectors, existing means of control such as taxes and EU-ETS are not included in the cost calculations.

In the reference scenario the total emissions in Sweden are reduced by 0.1 percent annually to 65.6 million tonnes of CO_2e by 2020 and then marginally thereafter until 2030. Until 2020, industrial emission growth is more than compensated for by rapidly declining emissions from landfills and heating of buildings. Emissions do not continue to decline after 2020 as the potential for emission reductions in these sectors is then nearly exhausted.

2 Check Point 2008 predicts that emissions in 2020 will be 70.8 million tonnes of CO_2e without new means of control. This was revised to 69.2 million tonnes CO_2e in SOU (Swedish Government Official Reports) 2008:24. The major reasons why the reference scenario in this report is lower than the prognosis in Check Point 2008 is the assumption of faster phase-out of oil-fired boilers in the residential sector and a greater rate of improvement in vehicles.

Greenhouse gas emissions in Sweden in 2020 and 2030 in the reference scenario

Million tonnes of CO_2e



Through measures costing up to SEK 500 per tonne of CO_2e, the total greenhouse gas emissions in Sweden 2020 can be reduced by 10 percent compared to 2005 levels.

Besides the emission reductions in the reference scenario, additional measures can be taken. In this study the focus is on measures that do not require any significant change in behaviour or standard of living.

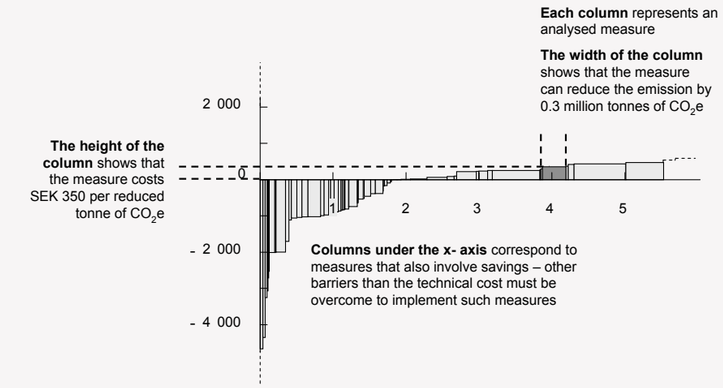
For each measure a reduction potential (measured in millions of tonnes of CO_2e reduction per annum) and a reduction cost (measured in SEK per tonne of CO_2e reduction) has been quantified. In order to undertake a full socioeconomic assessment of the measures, other factors, in addition to technical cost, must be evaluated. However, for comparing different measures with each other and determining which are the most cost-effective for society, cost per tonne reduced is the most relevant parameter.

In the trading sector, abatement costs are a good indication of which measures will be implemented in Sweden. Measures that cost more than the market price of carbon dioxide are unlikely to be implemented as it is more cost-effective to purchase emission permits from other countries. SEK 500 is in the high range of anticipated carbon dioxide market prices, which is why this report differentiates between measures exceeding this cost and those that are below it. SEK 500 is also used as a threshold in the non-trading sector to facilitate comparison between the two sectors.

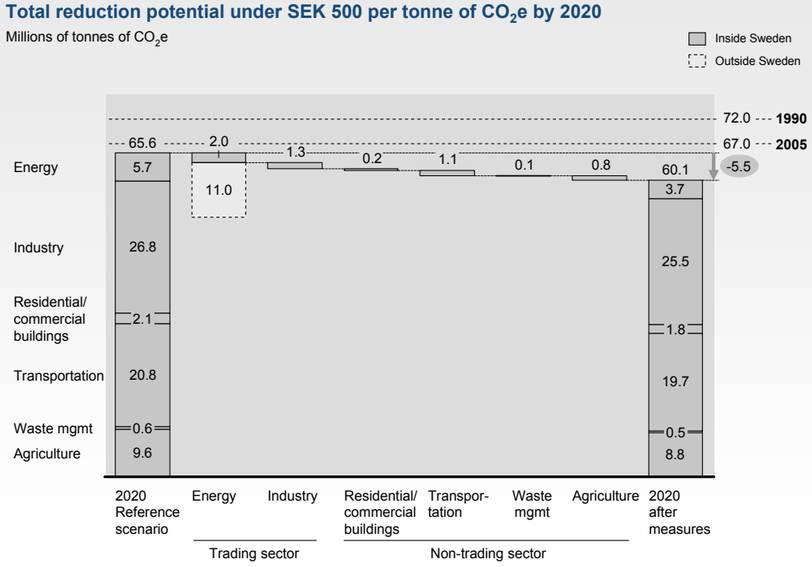
If all measures costing up to SEK 500 per tonne of CO_2e reduction were implemented, greenhouse gas emissions could be reduced to 60.1 million tonnes of CO_2e by 2020. This is 6.9 million tonnes lower than 2005 (10 percent). Compared to the reference scenario for 2020, the reduction is 5.5 million tonnes.

More than half of the potential is dependent on permitting, such as environmental certification. This applies to everything from expanding wind power capacity to process changes and fuel shifts in industrial production.

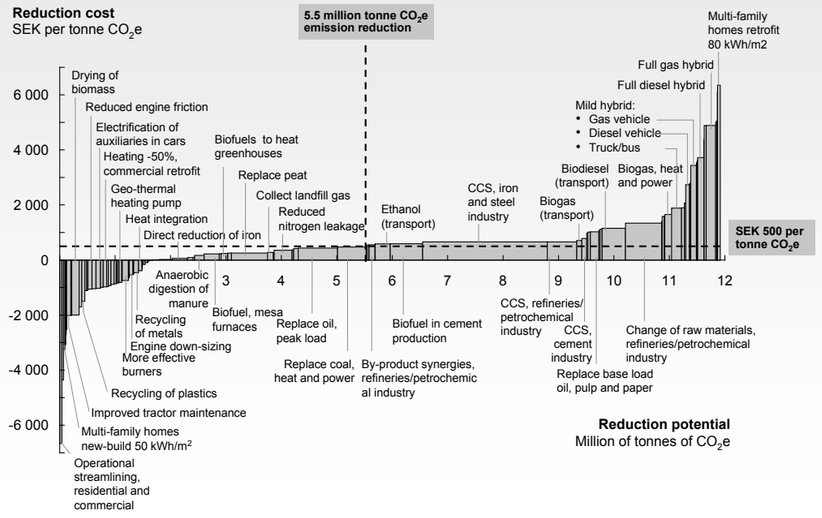
How to Read the Diagram



Total reduction potential under SEK 500 per tonne of CO_2e by 2020



Measures in Sweden beyond the Reference scenario 2020



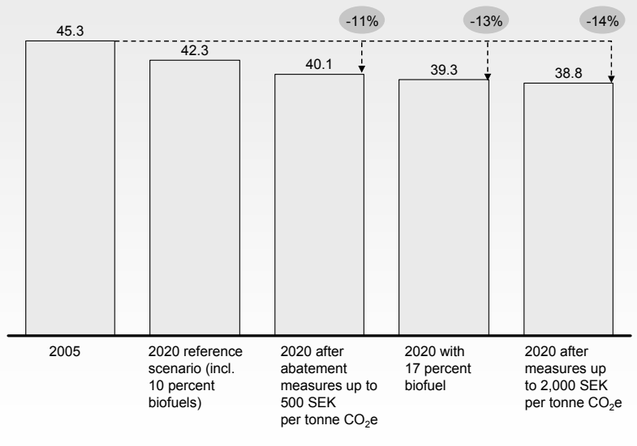
Compared to a 2005 baseline, by employing measures costing up to 500 SEK per tonne of CO_2e, Sweden will be able to reduce its emissions by 11% in the non-trading sector (residential and commercial buildings, transport, waste management and agriculture) by the year 2020.

Already in the reference scenario, emissions in the non-trading sector are reduced by 3.0 million tonnes of CO_2e by 2020. Measures beyond those in the reference scenario contribute an additional reduction of 2.2 million tonnes of CO_2e. This results in emissions of 40.1 million tonnes of CO_2e, or 11% below the 2005 level.

Within the non-trading sector, the main abatement levers costing up to 500 SEK per tonne of CO_2e are more efficient vehicles (1.1 million tonnes), reduced nitrogen leakage in agriculture (0.5 million tonnes) and more energy-efficient buildings (0.2 million tonnes). An increase in the share of biofuels to 17% (compared with the EU's objective of 10% as included in the reference scenario) would reduce emissions in the non-trading sector by an additional 2 percentage points. From a purely technical perspective, the Swedish vehicle fleet would be able to use a much higher proportion of biofuels by 2020, yet the supply of such fuels is expected to be limited.

Abatement potential 2020, non-traded sector

Million tonnes CO_2e



Other measures, costing up to 2,000 SEK per tonne of CO_2e, would be able to reduce emissions 1 percentage point more in the non-trading sector. As evidenced in the diagram summarising all analysed measures, the costs of additional technical measures rise steeply if greater abatements are desired.

Technical solutions alone are not enough to achieve the EU's suggested objective of a 17% emissions reduction in the non-trading sector by 2020. Behavioural changes are needed in order to further reduce emissions. For instance, if total driving distances were reduced by 10%, emissions could be reduced by approximately 1 million tonnes of CO_2e (2% of emissions in the non-trading sector). Other examples with potential to reduce emissions include lower speed limits and reduced consumption of beef and milk[3].

By implementing measures costing up to 500 SEK per tonne of CO_2e, the trading sector (carbon dioxide from the power generation industry and other heavy industry) will be able to reduce its emissions by 8% by the year 2020, compared to a 2005 baseline.

In the trading sector, measures costing up to 500 SEK per tonne of CO_2e will be able to reduce emissions to 20.0 million tonnes of CO_2e by 2020. This is 8% below the volume of emissions generated in 2005, or 3.3 million tonnes of CO_2e less than in the reference scenario. Most of the potential is found in the replacement of fossil fuels in power generation and district heating (1.8 million tonnes), process changes and increased efficiencies in industry (0.7 million tonnes) and the replacement of fossil fuels used in industrial processes (0.4 million tonnes).

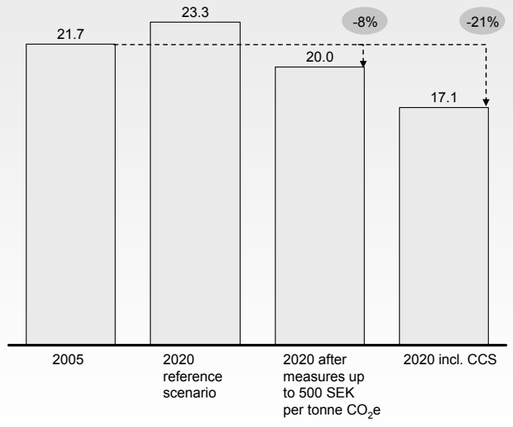
Within the trading sector, a high proportion of remaining emissions are process emissions generated as an inevitable consequence of various manufacturing processes (e.g. reduction of iron). After the above measures are implemented, 45% of industrial emissions will consist of process emissions, as compared to 35% today.

The only way to reduce process emissions without reducing industrial output is by capturing and storing carbon dioxide (CCS). This is still only a developing technology and it is not expected to become widely commercially available until 2020. However, by investing heavily in this technology now, a handful of plants in the cement, steel and refinery industries could be equipped with CCS technology prior to 2020.

3 Only the consumption of beef and milk produced in Sweden affects Sweden's emissions.

Abatement potential 2020, traded sector

Million tonnes CO_2e



This could reduce Sweden's emissions by 2.9 million tonnes of CO_2e, corresponding to an additional 13% reduction compared emissions from the trading sector in 2005. The abatement cost associated with CCS technology in 2020 is anticipated to be in the range of 600-1000 SEK per tonne of CO_2e. Favourable technological development might be able to cut the cost to under 500 SEK per tonne of CO_2e reduction in the long term.

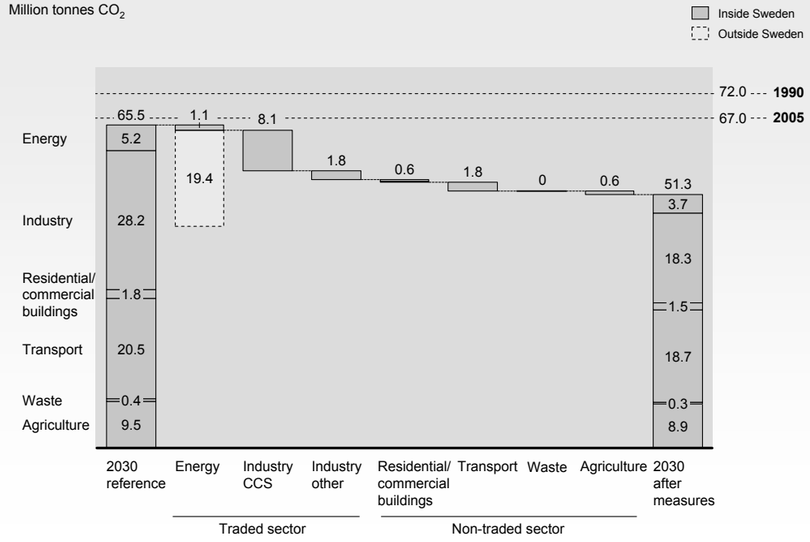
There are abatement opportunities in the trading sector that cost over 500 SEK per tonne of CO_2e. However, it is unlikely that such measures will be implemented, since it will probably be possible to purchase emissions credits at a lower cost.

By 2030, Sweden's total emissions can be reduced to 51.3 million tonnes of CO_2e, i.e. 23% below 2005 emissions, by employing measures costing up to 500 SEK per tonne of CO_2e.

By 2030, measures costing up to 500 SEK per tonne of CO_2e reduction may reduce emissions further, despite continued industrial growth. More industrial facilities will be replaced or upgraded. More buildings will be retrofitted to reduce their energy consumption, while fuel-efficient vehicles will achieve greater market penetration.

Total abatement potential under 500 SEK per tonne CO_2e 2030

Million tonnes CO_2



Moreover, it is anticipated that CCS will be available on a wider scale by 2030, and that the cost of CCS will fall to the range of 300-600 SEK per tonne of CO_2e reduction. However, biofuels are expected to continue to cost more than 500 SEK per tonne of CO_2e.

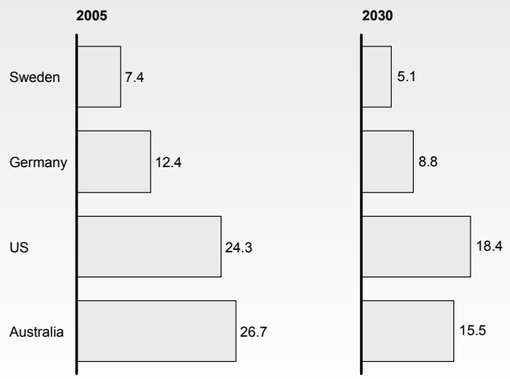
By 2030, CCS employed at industrial facilities may contribute a total abatement of 8.1 million tonnes of CO_2. Other measures totalling 6.1 million tonnes of CO_2 reduction potential, as compared to the 2030 reference scenario, include increased market penetration of fuel-efficient vehicles, as well as additional industrial efficiency improvements and equipment upgrades. In aggregate, the measures result in an additional 8.8 million tonnes of greenhouse gas emissions reductions compared to what can be achieved by 2020 at a cost of 500 SEK per tonne of CO_2e.

For Sweden, the implementation of all measures costing up to 500 SEK per tonne would result in per capita greenhouse gas emissions of 5.1 tonnes in the year 2030. The relative abatement potential identified in Sweden from 2005 to 2030 is greater than what most other countries can achieve at the same cost[4], despite our favourable initial position . In other words, Sweden has the opportunity to continue to be at the forefront of the industrialised world in terms of carbon efficiency in 2030. The annual cost of these measures is anticipated at 0.2-0.3% of Sweden's anticipated GDP[5] in 2030.

4 Based on corresponding national studies performed in Germany, USA and Australia.
5 Not directly comparable to the EU commission's appraisal of the costs Sweden would incur in attaining the goals set forth in the climate package discussed, mainly because the commission also considers effects on energy costs beyond what has been forecasted.

Emission of greenhouse gases 2030 after abatement measures up to 500 SEK per tonne CO_2e

Tonnes CO_2e per person



Efficiencies and the continued expansion of renewable energy sources have an insignificant effect on Swedish emissions; however, electricity freed up in this way could be used to promote “green” industrial growth in Sweden, or to export “clean power.”

In many countries, electricity saving measures such as more efficient home appliances and lighting also lead to lower emissions for the country in question. In Sweden however, such measures have only a marginal effect on national emissions, since power generation in Sweden is already carbon-efficient. However, electricity freed through such efficiencies could be used to promote “green” industrial growth within Sweden, and thus to reduce emissions in other countries. In addition, the electricity market is not limited to Sweden, meaning that such electricity could also be exported and used to replace electricity generated from gas or coal in other countries, thus reducing their emissions.

Realising residential and industrial energy efficiencies has the potential to reduce Sweden’s consumption of electricity and district heating despite increases in population and living standards.

Efficiency measures in Sweden costing up to 500 SEK per tonne of CO_2e reduction will be able to free 16 TWh of electricity beyond what is assumed in the reference scenario[6]. This corresponds to a reduction of emissions outside Sweden of approximately 6 million tonnes of CO_2e, or 9% of Sweden’s 2005 emissions. In addition, there are opportunities for Sweden to expand its sources of renewable energy, primarily wind, by up to 13 TWh beyond what is assumed in the reference scenario. This corresponds to an additional reduction potential outside Sweden of approximately 5 million tonnes of CO_2e, or 7% of Sweden’s 2005 emissions.

In order to achieve our long-term objectives, further reductions are necessary. This will require strategic focus and investments in new technology in order to contribute to accelerated reductions prior to 2030. Such an effort would also create attractive growth opportunities for Swedish companies.

As emissions are lowered, it will become increasingly difficult to squeeze additional reduction potential from measures based on proven technology. In order to achieve the long-term reduction objectives for 2050 and 2100, measures costing up to 500 SEK per tonne of CO_2e reduction are not sufficient. Strategic focus and investment in new technologies by Swedish society is required.

The two sectors that contribute the most to Sweden’s emissions are industry and transport. CCS has already been mentioned as a technology needed to reduce industrial process emissions. Within the transport sector, there are two technologies with great potential. First, the development of what are referred to as second-generation biofuels – more efficient manufacturing technologies that are able to produce biofuels from several types of feedstock – is going to play an instrumental role in whether we are able to increase the share of biofuels used in the Swedish vehicle fleet. Secondly, electric cars are a technology with great potential, given Sweden’s favourable supply of carbon efficient electricity.

The technologies mentioned above have only a limited potential to reduce emissions over the next 10-15 years, yet they may play a more significant role in the long-term reduction of emissions. If resources are invested now, the pace of reduction until 2030 could be accelerated. The development of new greenhouse gas-efficient technologies also represents an opportunity for Swedish companies, and can thus contribute positively to economic growth and employment.

6 Production is assumed to increase by 13 TWh through a combination of already established incentive system for renewables, planned CHP plants and increased output from existing hydro and nuclear assets.

Main sources

The sources listed below are not an exhaustive list of reference documents but rather a compilation of the organizations whose publications the report has been using. In addition to publications and statistics from these organizations, environmental reports from the largest companies in each sector have been consulted. The content has been discussed and aligned through a series of workshops with reference groups, with participants from more than 40 Swedish companies.

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