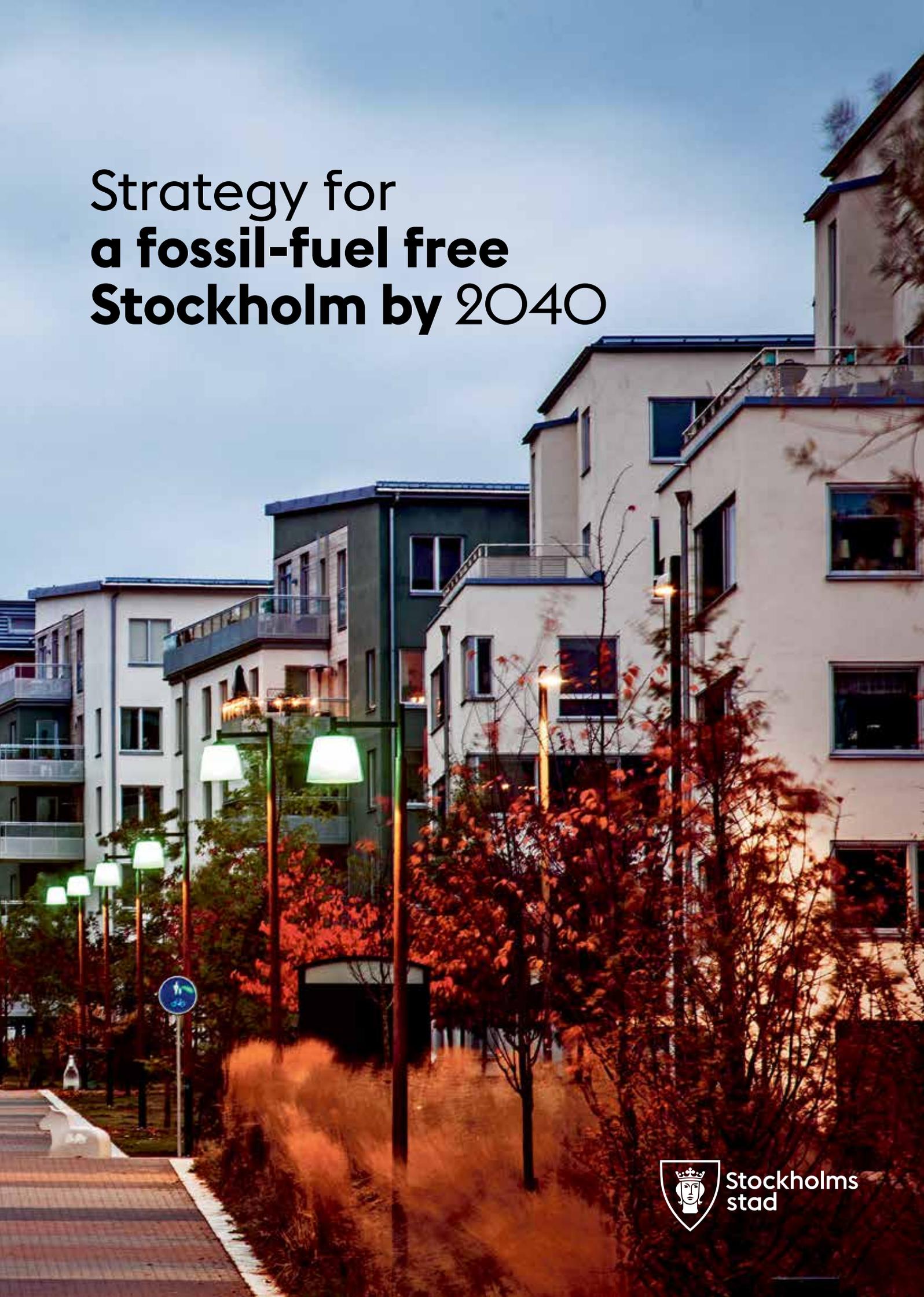


Strategy for a fossil-fuel free Stockholm by 2040



Stockholms
stad



Strategy for a fossil-fuel free Stockholm by 2040 has been produced in two stages. Gustaf Landahl (City Executive Office/Environment and Health Administration) led the work of producing reports on which the strategy is based, and was assisted in this work by Emma Hedberg (Environment and Health Administration), Charlotta Hedvik (Environment and Health Administration), Linda Holmström (City Executive Office) and Jonas Tolf (Environment and Health Administration). Linda Holmström and Björn Hugosson were responsible for the final wording of the strategy.

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Strategy for a fossil-fuel free Stockholm by 2040

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Contents

Foreword	5
Summary	7
Fossil-fuel free by 2040 – municipal measures	8
Introduction	13
Background	15
A climate-smart Stockholm by 2040	15
Guidelines to achieve the goals	15
Limitations	15
Stockholm's fossil fuel use and climate impact	17
System limits	18
Reduction targets to 2020	18
Sustainable energy use	21
Heating and cooling	21
Electricity and town gas	25
Steps towards fossil-fuel freedom by 2040	27
Transport	29
Road traffic	29
Aviation	32
Shipping	32
Plant and construction machinery	33
Steps towards fossil-fuel freedom by 2040	34
Resource-efficient natural cycles	37
Steps towards fossil-fuel freedom by 2040	38
Compensation for remaining emissions	41
A fossil-fuel free municipal organisation by 2030	43
Implementation and follow-up	45



Foreword

Tranquil nature close to the intensity of the city is the defining characteristic of Stockholm. Here smart solutions make it simple for all residents to lead eco-friendly lives. Without compromising the prospects of future generations, the city can grow and expand based on people's needs and respect for the natural limits of our planet.

This vision of a climate-smart Stockholm forms the basis for Strategy for a fossil-fuel free Stockholm 2040, a strategy that describes how the city needs to work to meet and manage the challenge of climate change, one of the most pressing issues of our time.

The accelerating pace of climate change is jeopardising our future and that of our children. The relentless accumulation of greenhouse gases in the atmosphere must be stopped and rising global temperatures halted. Stockholm can and must be a leader in efforts to reduce human impact on the global climate by making a successful transition from a society built on fossil fuels to one based on renewables.

This essential shift also creates opportunities. Demands for renewable energy, improved energy efficiency and other green solutions are driving the development of a rapidly growing sector. An energy transition in Stockholm is creating new jobs and opening up opportunities to develop new technology and new companies.

Stockholm and all who live and work in it need to take a large share of responsibility for the climate; the city's authorities must make many future-oriented decisions and residents must make informed choices in their day-to-day lives. The current strategy merely lays down a minimum level for these endeavours; the potential for more rapid progress will be constantly reassessed.

The City of Stockholm cannot achieve success alone. A consumption perspective that takes account of all emissions must be a key factor for future consideration. Collaboration with residents, industry and commerce, academics and the regional forums and international contexts in which the city participates is essential to achieve the goals we have set.

This strategy provides us with the tools we need to become a fossil-fuel free city. It is the foundation on which a sustainable Stockholm will be built.

Stockholm, December 2016

Karin Wanngård
Mayor of Stockholm

Katarina Luhr
Vice Mayor of Environment



Summary

Stockholm is to be fossil-fuel free by 2040. The City Council has set up a milestone target for emissions of no more than 2.3 tonnes of CO₂e (carbon dioxide equivalents) per resident by 2020. Since 1990 total emissions of greenhouse gases have fallen by almost a third. But to achieve the goal of a fossil-fuel free Stockholm by 2040 we need to increase the pace of our work to reduce emissions. There is considerable uncertainty about how the situation will develop between now and 2040. Eliminating fossil fuels requires smart technical solutions and reduced demands for energy. It is possible to do this using today's technology but, if the deadline is to be met, numerous strategic decisions must be taken at the earliest possible stage.

A climate-smart Stockholm means incorporating the climate goal into all municipal operations and assigning a clear responsibility to certain municipal committees and the boards of certain municipal companies to coordinate and promote action. Freedom from fossil fuels also requires close collaboration with residents, businesses and other public sector bodies at a time when the population is rising rapidly. Regional development, particularly in terms of physical planning and access to public transport, plays a key role in the city's endeavours to achieve its goal.

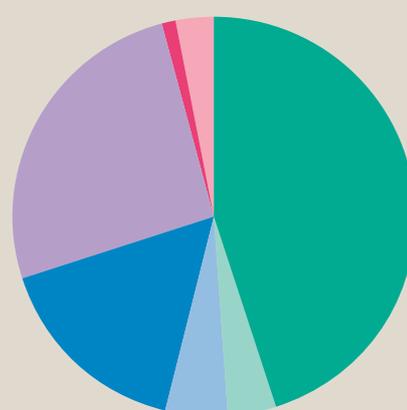
The strategy lays down a framework for what the City can do, in the short and long term, to make its own operations fossil-fuel free; it also identifies the most important challenges for the city, where the need for documentation on which to base decisions is greatest. As an organisation, the City of Stockholm is responsible for approximately 10 percent of greenhouse gas emissions and should set an example by already becoming fossil-fuel free by 2030.

Many of the measures that need to be taken by 2040 are outside the purview of the city. For this reason, the long-term strategy includes a number of investigative assignments, the aim of which is ultimately to influence Swedish and European legislation.

Fossil fuels currently account for approximately 30 percent of total energy use. This equates to emissions of 2.7 tonnes of CO₂e per person (2014). Although the goal is a fossil-fuel free Stockholm, estimates predict a residual fossil energy use by 2040 that corresponds to 0.4 tonnes of CO₂e per person.

The toughest challenge is that facing the transport sector; it is here that the need for action is most urgent. In 2040 residual fossil fuel is most likely to be found in the aviation and shipping industries, sectors governed by international agreements and

Measures up to 2020



- Measures in district heating
- Energy efficiency improvements in municipal properties
- Energy requirements for new construction
- Solar power
- Reductions in road traffic
- Reduced use of fossil fuels in transport sector
- Transport procurement with climate requirements
- Increased biogas production

regulations over which the City of Stockholm has limited powers. In the energy sector, too, fossil-based plastics are likely to continue to be present in waste that is incinerated in heating plants. To compensate for these residues, carbon sinks can be developed to reduce the city's climate impact by absorbing atmospheric carbon dioxide.

In the shorter term the strategy proposes measures to achieve the climate-related goals of the Stockholm Environment Programme 2016–2019 by 2020. The measures proposed are those over which the municipal authorities and companies have the greatest power to act, those that will lead to the greatest reduction and those where the consequences of implementation are deemed to be acceptable. The measures correspond to a reduction of 533,000 tonnes of CO₂e between 2013 and 2019.

Fossil-fuel free by 2040 – municipal measures

The measures below summarise what needs to be done to achieve the goal of a fossil-fuel free Stockholm. Responsibility within the municipal organisation is allocated and specified in the strategy. The strategy lays down a minimum level to achieve the long-term goal. Success is predicated on structural change and it is essential that the City of Stockholm continuously reassesses the potential for more rapid progress and more extensive climate mitigation measures.



Sustainable energy use

Steps towards fossil-fuel freedom by 2040

- The City makes sure Fortum Värme upholds its decision to phase out coal. The ambition is that by 2020 coal will no longer be used. A plan for phasing out coal in CHP 6 is to be presented by 2017 at the latest.
Tasked to: City Executive Board, Group board and Fortum Värme.
- The City collaborates with energy companies, hospitals, etc. to gradually replace fossil oils with renewable fuels to meet peak load demands. Progress to be reported in 2017.
Tasked to: Group board.
- The City supports Fortum Värme's work to increase connections to the Open District Heating network and to investigate the potential for even more users. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Development Committee, together with Group board and Fortum Värme.
- The City investigates the potential for increasing the amount of renewable electricity produced in Stockholm. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Group board, Fortum Värme and Environment & Public Health Committee.
- The City lobbies for legislation and regulations that support the use of fossil-free energy.
Tasked to: City Executive Board.
- The City aims to produce enough of its own solar energy based electricity to meet 10 percent of the municipal organisation's electricity consumption.
Tasked to: Real Estate Committee and the boards of Svenska bostäder, Stockholmshem, Familjebostäder, Micasa and SISAB.



Sustainable energy use

Measures to meet the 2020 milestone target

The milestone target of emissions of max. 2.3 tonnes of CO₂e by 2020 requires a reduction in energy use in buildings that corresponds to 285,000 tonnes. This will be achieved through the following measures, with results monitored each year within the framework for the Environment Programme.

- ✓ The City effectuates a district heating system that reduces overall emissions by at least 240,000 tonnes of CO₂e by 2020.
Tasked to: Group board and Fortum Värme.
- ✓ The City takes action to improve energy efficiency in its municipal operations by 10 percent compared with the reference year 2015. This will reduce emissions by at least 20,000 tonnes of CO₂e by 2020.
Tasked to: This target applies to all municipal operations, but most particularly to the Real Estate and Service Committees and the boards of Svenska bostäder, Stockholmshem, Familjebostäder, Micasa and SISAB.
- ✓ The City acts to impose an energy consumption ceiling of 55 kWh/m² Atemp in new-builds on municipally allocated land, with the ambition of achieving a level of 45 kWh/m² Atemp. This will reduce emissions by at least 25,000 tonnes.
Tasked to: Development Committee.
- ✓ The City produces a model for the layout and form factor of buildings with the aim of facilitating compliance with energy requirements.
Tasked to: City Planning Committee.
- ✓ The City increases its own solar energy production by 2020 at a rate sufficient to meet the goal for 2040.
Tasked to: Real Estate Committee and the boards of Svenska bostäder, Stockholmshem, Familjebostäder, Micasa and SISAB.



Eco-efficient transport

Steps towards fossil-fuel freedom by 2040

- The City presents an action plan for a fossil-free road transport sector and investigates the feasibility of prohibiting the sale of fossil fuels by 2040, with a sub-target for 2030. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: City Executive Board with support from Environment & Public Health Committee and Traffic Committee.
- The City lobbies for legislation and regulations that support a fossil-free transport sector.
Tasked to: City Executive Board.
- The City investigates measures to promote fossil-fuel free shipping. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Board of directors of the Ports of Stockholm.
- The City presents an action plan for the use of fossil-free fuel in construction machinery and plant. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Development Committee, Traffic Committee and Environment & Public Health Committee.
- The City works to introduce local Environmental Zones from which vehicles running on fossil fuels will be banned by 2040 at the latest.
Tasked to: City Executive Board.



Eco-efficient transport

Measures to meet the 2020 milestone target

Measures to meet the 2020 milestone target
The milestone target of emissions of max. 2.3 tonnes of CO₂e by 2020 requires a reduction in energy use in the transport sector that corresponds to 228,000 tonnes. The strategy calculates that this can be achieved through the following measures, with results monitored each year within the framework for the Environment Programme.

- ✓ The City acts to reduce road traffic sufficiently for CO₂e emissions to fall by at least 80,000 tonnes.
Tasked to: Traffic Committee and City Planning Committee.
- ✓ The City acts to reduce the use of fossil fuels for road traffic sufficiently to eliminate at least 140,000 tonnes of emissions.
Tasked to: Environment & Public Health Committee, together with City Executive Board and Traffic Committee.
- ✓ The City acts to reduce emissions by at least 8,000 tonnes by making transport within the municipal organisation more climate efficient.
Tasked to: Service Committee.



Resource-efficient natural cycles

Steps towards fossil-fuel freedom by 2040

- The City investigates the potential for reducing the amount of fossil plastic in incinerated waste. Chemicals, health and other environmental impacts must be considered in addition to climate impact. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Group board, together with Stockholm Vatten & Avfall and Fortum Värme.
- The City produces a report that describes how to secure an increase in the production of biogas that is sufficient to meet needs to replace fossil natural gas. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Environment & Public Health Committee, together with Group board and the board of Stockholm Vatten & Avfall.



Resource-efficient natural cycles

Measures to meet the 2020 milestone target

- The milestone target of emissions of max. 2.3 tonnes of CO₂e by 2020 requires a reduction of at least 20,000 tonnes. The strategy calculates that this can be achieved by implementing the following measure, with results monitored each year within the framework for the Environment Programme.
- ✓ The City acts to increase biogas production to a level sufficient to correspond to an overall reduction of 20,000 tonnes of CO₂e.
Tasked to: Board of Stockholm Vatten & Avfall.

Compensation

It may prove difficult to replace all fossil fuels within the aviation and shipping sectors with renewables, and there may also be some fossil plastic in waste that is incinerated. However, the City can achieve net climate neutrality by compensating for these emissions.

- The City investigates the potential for creating carbon sinks within the municipal boundaries to compensate for any residual fossil fuel emissions in 2040. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Group board and Fortum Värme.

A fossil-fuel free municipal organisation by 2030

- The City presents an action plan for a fossil-fuel free municipal organisation by 2030. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: City Executive Board, together with the Environment & Public Health and Service Committees.







Introduction

Climate change is one of the greatest global challenges facing us today. At the Climate Summit in Paris in December 2015 the world's nations agreed to a legally binding undertaking that constitutes a joint plan of action to reduce emissions of climate gases. The deal specifies that the global temperature rise must be kept well below 2 degrees, while pursuing efforts to limit the increase to just 1.5 degrees. Action is required at both global and local level to significantly reduce emissions and slash demand for energy.

In its national environmental quality objective “Reduced Climate Impact”, the Swedish parliament recognises that atmospheric concentrations of greenhouse gases must be stabilised at a level that is not hazardous to the climate system. In connection with the Paris summit the Swedish government launched its Fossil Free Sweden initiative, which aims to make Sweden the world's first fossil-free welfare nation. The All-Party Committee on Environmental Objectives used its report, “Framework for Climate Politics” (SOU 2016:21), to propose that Sweden takes measures to totally eliminate its net atmospheric emissions of greenhouse gases by 2045 at the latest. The proposal requires average emissions to fall to just under 0.9 tonnes per capita, based on a projected population of 12.2 million.

The world must act in concert to meet the targets set by the Paris Agreement. Cities are one of the keys to success; dense urban environments create good opportunities for systems to heat and cool buildings efficiently, and can offer attractive alternatives to private transport.

The City of Stockholm has set the goal of becoming fossil-fuel free by 2040, with the milestone target of a maximum of 2.3 tonnes of CO₂e per resident by 2020 – albeit with the ambition to reduce emissions even sooner. Stockholm is well placed to lead the way in terms of work to stop climate change and to prove that it is possible to combine well-developed welfare and growth with minimal climate impact.

This climate strategy lays down a long-term road map for Stockholm's route to a fossil-fuel free future by 2040 and describes the challenges the city faces to attain this goal. The strategy constitutes a minimum level for the city's ambitious goals, however. It is imperative to continually test the opportunities to accelerate the pace and expand the scope of climate mitigation measures.●



Background

A climate-smart Stockholm by 2040

The City Council has resolved that the city authorities will base work to achieve Vision 2040 of “a Stockholm for everyone” on four objectives. A climate-smart Stockholm is one of these objectives, and climate awareness applies to all of the municipal authority’s activities.

In connection with its approval of the budget for 2015 the City Council declared that Stockholm should be fossil-fuel free by 2040 and that a milestone target was to reduce emissions of carbon dioxide equivalents to a maximum of 2.3 tonnes per resident by 2020. The City Executive Board was tasked, together with the Environment & Public Health Committee, with producing a strategy for the 2020 milestone target and a road map leading to fossil-fuel freedom by 2040. The results of these assignments are presented in this, the City Executive Board’s overarching strategy for a fossil-fuel free Stockholm by 2040.

Guidelines to achieve the goals

The milestone target of 2.3 tonnes forms part of the Stockholm Environment Programme 2016–2019. This strategy serves as a guideline both for the 2020 milestone and the 2040 goal of a fossil-fuel free city. The strategy is based on current fossil fuel use and examines, sector by sector, the trends, forecasts and potential for achieving the 2020 target and the goal for 2040.

The strategy is divided into three of the Environment Programme’s target areas: sustainable energy use, environmentally friendly transport and resource-efficient recycling. It identifies the measures that need to be taken and allocates responsibility for implementing them.

The strategy presents calculations of the emissions reductions required to achieve the climate targets. Some slight reduction may be ascribed to previously adopted measures that are already being implemented. It is important to make sure that planned and approved measures lead to the desired climate effect. Through their inclusion in the strategy they become part of the city’s integrated system for steering and follow-up. Measures laid down in the strategy are those over which the municipal authorities and companies have the greatest power to act, those that will lead to the greatest reduction and those where the consequences of implementation are otherwise deemed to be acceptable.

Measures designed to achieve the 2020 milestone target are more action-oriented; those for a fossil-fuel free Stockholm by 2040 are more strategic in character. Many challenges have been identified that are of strategic importance for the 2040 goal. As the majority of these are wholly or partly outside municipal control, a broad-based approach will be essential to pave the way to success. Accordingly, the strategy states where a strategically important basis for decision needs to be produced and when decisions need to be taken.

Funds have been set aside for climate-related measures in the municipal budgets up to and including 2018. The strategy, with its all-encompassing analysis of Stockholm’s challenges and opportunities, provides guidance about which areas to prioritise when allocating funds and indicates needs for budget priorities in the longer term.

Limitations

One important limitation of the strategy is that it deals only with energy use within the geographical boundaries of the city. The precise system limit is described in later chapters. The total climate effect for which Stockholm is responsible is significantly larger when seen from the consumption perspective: i.e. emissions relating to the production of goods and transport/travel outside Stockholm. The City of Stockholm seeks to reduce consumption-based emissions through information and mandatory impositions, but these activities fall outside the scope of this strategy.

It is also important to consider the regional perspective. The goal of a fossil-fuel free Stockholm must not be achieved by relocating emissions in other municipalities. On the contrary, Stockholm’s actions should inspire others and mobilise a coordinated response of similar measures elsewhere in the region. The City of Stockholm also contributes to regional planning to phase out fossil fuels.

Stockholm’s ambition is to be totally fossil-fuel free by 2040 at the latest, precluding the use of fossil fuels within the city’s geographical boundaries. However, the municipal authorities recognise that it may prove difficult to totally eliminate fossil fuels in the aviation and international shipping industries, and that some fossil-based plastics will still be incinerated in heating plants in 2040. Nevertheless, climate neutrality or zero net emissions can be achieved by compensating for these residual effects, for example by investing in carbon sinks. Climate neutrality permits the use of fossil fuels provided that CO₂ emissions are offset by measures that in some way bind the carbon or carbon dioxide. ●



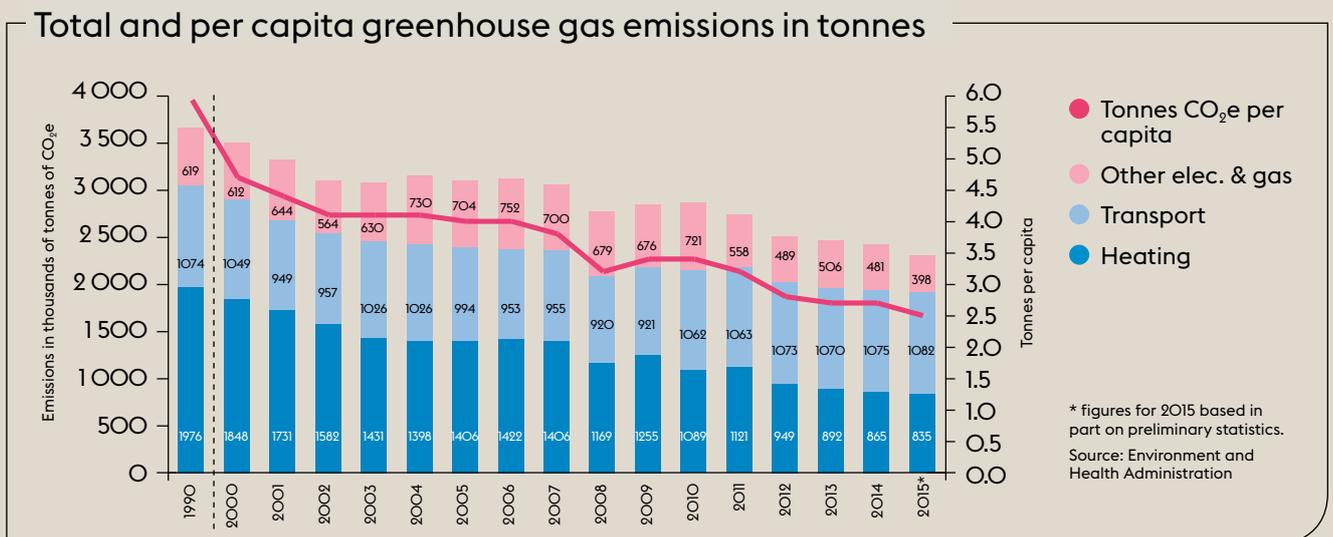
Stockholm's fossil fuel use and climate impact

Fossil fuels account for approximately 30 percent of all the energy used in Stockholm and consist primarily of the following:

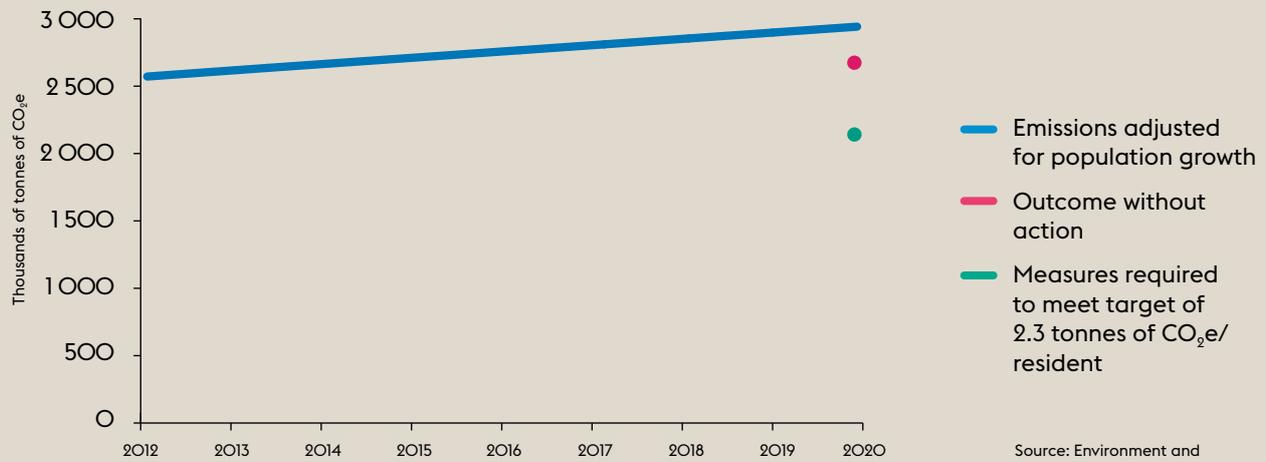
- Coal in the Värtan combined heat and power plant (CHP 6) that produces district heating and electricity.
- Oil for boilers in buildings, for heating plants that produce district heating, and for industry and shipping.
- Natural gas for boilers in buildings, stoves and gas-powered vehicles.
- Petrol for road vehicles.
- Diesel for road vehicles, construction machinery, plant and shipping.
- Kerosene for aviation fuel.
- Fossil-based plastics for waste incineration in CHP plants producing district heating and electricity.

Total emissions for 2014 amounted to 2,421,000 tonnes of CO₂e. Energy use in buildings accounted for 865,000 tonnes, the use of gas and electricity for 481,000 tonnes, and transport for 1,075,000 tonnes of CO₂e. The City of Stockholm's organisation is responsible for approximately 10 percent of total emissions.

Since the City of Stockholm began monitoring levels in 1990, overall emissions and per capita emissions have both fallen. In the period up to 2014 they fell by a third in real terms, while per capita emissions were halved from 5.4 to 2.7 tonnes of CO₂e. Progress has been greatest in heating buildings; despite a steep rise in population with a more than 30 percent increase in the number of Stockholm residents since 1990, emissions from heating have fallen by more than 50 percent.



Actual emissions of CO₂e in 2012, forecast of emissions in 2020 adjusted for population increase, and required reduction in emissions by 2020



System limits

The climate goal and strategy include all energy use and associated emissions of greenhouse gases within the geographical boundaries of the City of Stockholm as a consequence of:

- Heating and cooling properties and premises.
- Road transport within the city boundaries, regardless of who is responsible for the transport.
- Rail traffic and shipping within the city boundaries and air traffic from Bromma Airport up to an altitude of 915 metres (3,000 feet).
- All other uses of gas and electricity in private households and business premises.

The goal does not include greenhouse gas emissions from:

- Journeys made by Stockholm residents outside the city boundaries.
- The production of foodstuffs or other goods or services consumed in Stockholm but produced outside the city boundaries.
- Freons in refrigerants, construction waste and medical nitrous oxide.
- Short-lived climate pollutants (SLCPs), with the exception of methane and nitrous oxide generated by fuel combustion.

Emissions are estimated using the City of Stockholm’s current calculation method, i.e. the consumption method with an LCA supplement. This calculates emissions for the entire life cycle of the fuel, including those generated during the production and distribution of biofuels. According to the system limits, calculations of electricity use are based on the Nordic electricity mix (83 g CO₂e/kWh 2012). Most estimates and forecasts on which the strategy is based use 2012 as the reference year.

The City of Stockholm as a municipal organisation is referred to in the strategy as the City, while Stockholm describes the geographical area covered by the city.

Reduction targets to 2020

The 2020 milestone target is related to the number of inhabitants and uses 2012 as its reference year. To identify the total need for reduction, the 2020 target of 2.3 tonnes of CO₂e emissions per resident must be adjusted to reflect not only the anticipated increase in population, but also the construction of new homes and other factors.

The City’s own forecasts indicate that the population of Stockholm will rise to 1 million by 2020. To calculate the total need for emissions reductions by this date, current emissions levels have been adjusted to take account of the rise in population.

A direct reduction in emissions is anticipated as a result of the following factors:

- Lamps and electrical utensils are becoming more energy-efficient, so electricity use is not expected to increase, despite the rise in population.
- Stockholm’s population is expected to increase at a faster rate than the construction of residential and other premises, which will necessitate a more efficient use of living and working space.
- Certain energy-efficiency improvements are expected in the existing building stock.

These factors are expected to lead to a reduction of approximately 130,000 tonnes of CO₂e.

However, to achieve the goal of no more than 2.3 tonnes of CO₂e per resident, it is estimated that the total reduction in CO₂e emissions from the 2012 level needs to be slightly more than 533,000 tonnes. ●





Sustainable energy use

This chapter deals with energy use in residential premises and trade and industry, divided up into heating/cooling, electricity and gas. The sector as a whole accounts for approximately 56 percent of total emissions in Stockholm.

Heating and cooling

Fossil-fuel dependence in the sector

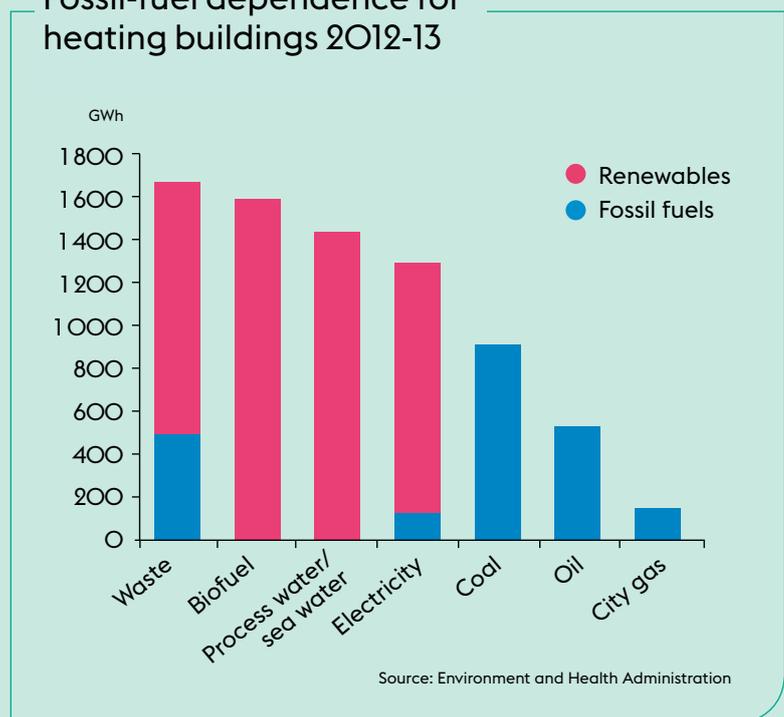
In 2014 a total of 7,600 GWh of energy were used to heat properties and premises in Stockholm, and 700 GWh of energy were used for cooling. As the diagram (right) shows, the four main sources for this energy are waste, biofuels, process water/sea water and electricity.

The main fossil fuels used for heating in Stockholm are, in descending order, coal, oil and plastics that are incinerated in combined heat and power (CHP) plants. In 2012 fossil fuels used for heating and cooling delivered approximately 2,200 GWh of energy, generating emissions of some 700,000 tonnes of CO₂e or just over 0.8 tonnes of CO₂e per resident.

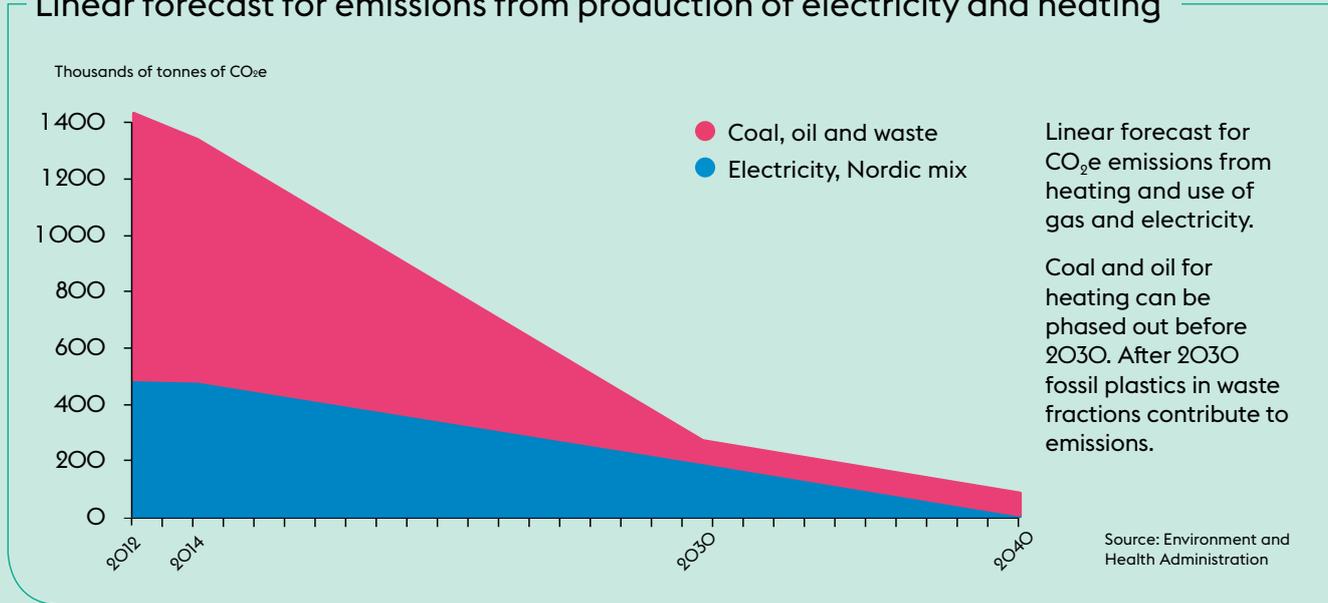
Today approximately 80 percent of buildings in Stockholm are heated by district heating. This is produced by Fortum Värme (jointly owned by Fortum and the City of Stockholm) in several CHP plants and supplemented, to some degree, with heat recovered from various industrial and commercial operations (Open District Heating).

Currently the CHPs use biofuels, coal, waste, electricity and heat from sea water and wastewater, as well as small quantities of fossil oil. Waste is classed as a fossil fuel because it currently comprises almost 30 percent plastic from fossil sources. Fortum Värme is taking measures to reduce the use of fossil fuels in the district-heating system. This work is of crucial importance to the City's climate goal.

Fossil-fuel dependence for heating buildings 2012-13



Linear forecast for emissions from production of electricity and heating



The use of fossil oil for heating individual properties is limited in extent in Stockholm. There are some 500–600 oil-fired boilers in large premises (including some of the City’s own premises) and around 700 in private homes; this represents roughly 1.5 percent of the total building stock. Small amounts of oil are also used to meet peak demand for district heating in very cold weather. In addition, oil is a source of reserve power in hospitals, etc., which are required by law to have back-up generators. Fossil heating oils are used because of their good storage characteristics.

In 2012 end-users in Stockholm took delivery of 40,600 m³ of fuel oil (EO1). During combustion this generates emissions of approximately 110,000 tonnes of CO₂e. It is estimated that a total of approximately 25,500 m³ of oil (corresponding to almost 70,000 tonnes of CO₂e emissions) are used each year in Stockholm for heating and hot water in homes with individual heating systems. The remaining 15,100 m³ (corresponding to just over 40,000 tonnes of CO₂e emissions) are used in other premises and in industrial processes.

Private homes are mainly heated with electricity or electric heat pumps. Direct electric heating, ground-source heat pumps and air-to-air heat pumps each have a third of this market (approximately 15,000 homes respectively). The City’s use of direct electric heating is restricted to certain pre-schools and temporary school buildings.

The district-heating network incorporates other heating solutions, such as gas and biofuel-fired

boilers and/or geothermal solutions with heat pumps.

Buildings that need to be cooled

Demand for cooling in Stockholm was approximately 700 GWh in 2014, with 420 GWh of this total distributed via the district cooling network. Cooling is needed both for comfort cooling (mostly in offices and commercial premises) and process cooling (for example in computer halls, in the food processing industry and to produce ice for ice rinks). Today cooling is produced in district cooling plants or by electric chillers. Electricity consumption can be reduced by replacing electrically generated solutions with district cooling.

District cooling works by distributing cold water through a network of pipes in the same way as district heating. As district cooling involves removing energy from a property, it is only the electricity that has been used for the production and distribution of cooling that is counted as supplied energy. Process cooling can be necessary in buildings that house a great deal of energy-intensive equipment. The cooling systems make use of “free cooling”, either in the form of naturally cool sea water or cooler outdoor air.

Suitable temperatures can often be achieved by replacing active cooling systems that consume energy with passive cooling techniques, such as screens that block out the sun’s heat. Integrating passive cooling solutions into the design of a building minimises the need for comfort cooling.

Calculated values for total energy needs in buildings 1995–2040 in TWh/year

Source: Environment and Health Administration. Data up to 2012 supplied by Statistics Sweden and Fortum.



Trends and forecast

In absolute figures energy consumption in buildings has remained largely constant since 1990. Improved energy efficiency in existing properties has led to savings equal to the increase in energy required to meet needs in new builds. Since 1995 energy efficiency in existing residential premises in Stockholm's total property stock has improved by an average of 0.64 percent p.a. (heating, property electricity and domestic electricity).

Between 2012 and 2015 the City's own property companies and the Real Estate Committee have intensified efforts to improve energy efficiency (heating and property electricity) in their property stock by approximately 2.75 percent p.a. It is estimated that energy efficiency has been improved by around 11 percent during this period.

Since 1990 the expansion of district heating has caused oil consumption to plummet; the reduction is almost 90 percent since 1970. Electricity consumption has remained unchanged during the same period.

District heating's contribution to heating needs has increased steadily. Today's deliveries are double those of the early 1990s, mostly as a result of connecting existing properties to the network. The total climate impact from heating has been dramatically reduced by decommissioning small oil-fired boilers, improving energy efficiency in properties and continuously reducing district heating's dependence on fossil-fuels.

Demand for district cooling has risen by a couple of percent each year since 2005. Around 700 GWh of energy is used for comfort cooling each year, but climate change with rising temperatures and an increased risk of heatwaves may well push demand higher.

It is anticipated that average energy efficiency improvements related to heating and hot water in existing buildings will continue at the same rate, reducing total energy needs by some 18 percent or 1,280 GWh by 2040. Planned new construction during the same period will increase energy needs by 1,800 GWh. An additional 520 GWh will therefore be needed between 2013 and 2040, equivalent to a 7 percent increase on today's 7,600 GWh. Supported by measures designed to make new construction much more energy efficient, energy use per square metre in Stockholm will be almost halved.

However, the transition to district heating that is less dependent on fossil fuels is made even more urgent because demand for energy (including comfort cooling) is expected to rise somewhat by 2040, as the construction of new properties outpaces both improvements in energy efficiency and the densification of living-space.

The impact of new construction

The City has set a target of 140,000 new homes between 2010 and 2030, with 40,000 being built by 2020. These calculations presuppose the same pace of construction in subsequent years, which would mean a total of 240,000 new

homes by 2040, plus all the new pre-schools, schools, hospitals, sports halls, shops, etc. that will be needed.

Even assuming that the City can impose demands on 80 percent of the total floor area of new builds (i.e. 4 million square metres of residential premises and 1,500 square metres of other premises), the additional energy needed will emit an estimated 32,000 tonnes of CO₂e per year.

It is not expected that the full potential for reductions will be achieved, as certain projects are not covered by the City's energy demands. In consequence, the actual reduction is calculated to be 25,000 tonnes of CO₂e p.a. based on the energy demands in the City of Stockholm's Environment Programme.

Fossil-fuel free by 2040 – challenges and opportunities

The City's ability to achieve its short- and long-term climate goals depends to a great extent on how district heating is produced.

The most effective way to reduce the use of fossil fuels for the production of district heating is to gradually replace them with renewable energy. Fortum Värme has declared its commitment to produce district heating that by 2030 will be climate- and resource-neutral and based 100 percent on renewable or recycled fuels. Fortum Värme plans to decommission CHP 6 Värtan, a coal-fired combined heating and power plant, by 2030 at the latest, although it has ambitions to do so by a much earlier date.

The new biofuel-fired CHP 8 plant came online in 2016, so greenhouse gas emissions will decrease as annual operating times for CHP 6 are reduced. The City aims to phase out the use of coal by 2020.

The remaining fossil fuels that need to be phased out are coal at the Värtan CHP facility and fossil plastics in the waste mix incinerated at the Högdalen CHP plant. In addition, there is a small amount of fossil oil used to meet peak load demand.

To mitigate climate impact, fossil plastic fractions in waste fuels must be reduced and more fossil plastics must be recycled or reused. Other viable measures to cut greenhouse gas emissions include improving heat recovery systems, interlinking district heating systems in the region, and expanding energy storage facilities and low-temperature systems.

It has not been considered necessary to propose any special measures for phasing out oil use in individual heating systems. In all probability, this process will take place naturally as old boilers are gradually replaced by solutions based on biofuel, district heating and heat pumps.

Measures are required, however, to phase out fossil oils in premises such as hospitals, where back-up generators are mandatory. Although there is not yet any long-term plan to phase out fossil oils in these back-up generators, guaranteed access to high-quality, storable energy in the form of renewable HVO-type fuels would seem to be a good alternative.

Increased demand for biofuel may result in supply shortages. In addition to undermining ambitions to convert to renewables, this would also push up prices, making coal and natural gas more favourable alternatives from a purely financial point of view.

Municipal initiatives to reduce energy consumption in the property sector are regulated in part by national legislation, so the City is limited in terms of the demands it can impose. Another factor to consider is a possible lack of liquidity among property owners to finance extensive energy efficiency improvements. Taken as a whole, these factors could result in a lower than expected fall in the demand for energy.

Electricity and town gas

This section deals with the supply, production and use of electricity and gas for purposes other than heating and transport. For residential properties this is mostly electricity for private domestic purposes and for lifts, laundry rooms, lighting in shared areas, etc. For other properties, it is chiefly electricity for lifts, escalators, office equipment, etc.

Gas is used for domestic stoves, restaurant kitchens, industrial processes and crematoriums.

Electricity

Fossil-fuel dependence in the sector

In 2014 a total of 6,409 GWh of electricity was consumed, excluding heating and transport: this corresponds to approximately 469,000 tonnes of CO₂e.

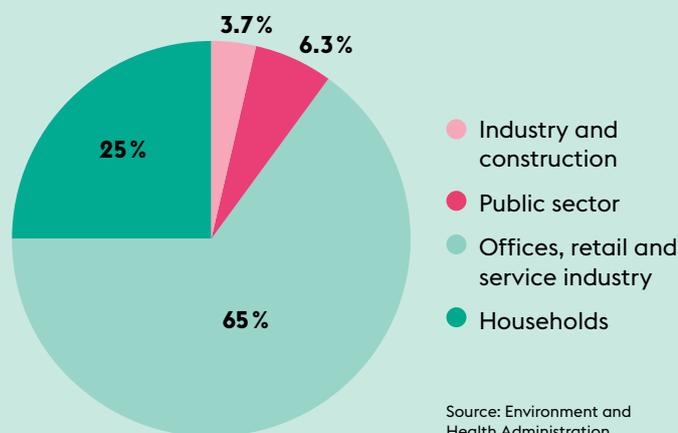
Trends and forecast

Total electricity consumption has remained largely unchanged in Stockholm over recent decades. Per capita reductions of 20 percent in total electricity use and 15 percent in domestic electricity have been achieved mainly because many industrial activities have moved out of Stockholm, but also as a result of significant energy efficiency improvements in lighting and household equipment. In contrast, electricity use has risen in offices and the service sector.

The City's system limits for climate calculations use an average emissions factor for electricity based on the Nordic production mix over five years. Electricity production in the Nordic countries is increasingly based on renewable energy, but some fossil fuels are still used, albeit mostly outside Sweden. However, as Stockholm is part of the interconnected Nordic and Northern European power system, there is little prospect of the City being able to convert the Nordic electricity mix to a fossil-fuel free mix.

Many proposals for phasing out fossil energy in buildings involve conversion to electricity as an energy carrier, for example by replacing boilers in private homes with heat pumps. Ultimately,

Electricity use in Stockholm 2014



of course, this requires a robust and reliable electricity grid, and a project has been initiated in Stockholm to strengthen the electricity network.

An increase in electricity consumption as a result of a transition from fossil fuels can be offset by measures to reduce energy consumption in other sectors and by investments in renewable electricity, cogeneration and solar power.

Swedish households' electricity consumption remains below the EU average, but trends suggest that consumption in Stockholm is rising. White goods and home electronics are becoming more energy-efficient, but the number of items of equipment in use is also increasing. And, while the densification of cities and suburbs may lead to an increase in electricity consumption per square metre, it may also result in a per capita reduction, as a room with several people requires no more light than a room with just one.

Electricity consumption in premises and offices is rising. This may be because, despite improvements in energy efficiency, premises and offices are using electricity for more purposes. Also, a more efficient utilisation of space translates into an increase in electricity consumption per unit of area.

Fossil-fuel free by 2040 – challenges and opportunities

Several uncertainties surround future electricity production. One decisive factor is how electricity prices relate to operating costs in existing premises versus the cost of new investments. With today's relatively low electricity prices, old nuclear power plants are no longer profitable, so four of Sweden's reactors will be decommissioned in the near future. Several investments in wind farms have been

mothballed for the same reason. Among Sweden’s consumers, however, interest is increasing in producing their own electricity from solar panels. The production of solar power is expected to increase as the regulations for this become more favourable.

The Nordic electricity mix is moving towards fossil-free alternatives, but this is dependent on how production develops in the other Nordic countries: higher energy prices benefit renewable alternatives. A realistic assumption is that by 2040 Nordic electricity will have a production mix that includes 1–2 percent of fossil fuels. By 2050 there will probably be no fossil fuels in the Nordic electricity production.

Stockholm has opportunities to produce its own power from solar energy and by using the district heating network for cogeneration. Some buildings have the potential to produce solar power that could, theoretically, meet around 10 percent of the overall needs of the City’s organisation of approximately 700 GWh per year. To safeguard the viability of renewable alternatives, the rules surrounding energy production need to be adjusted, in particular tax credits for micro-generated renewable electricity, but also the Energy Tax Act and rules for transferring energy between buildings.

The biggest opportunity for renewable electricity production in Stockholm is bioenergy in combined heat and power plants. CHP 8 came online in 2016 and its total electricity production during a normal year is approximately 750 GWh.

City gas

Fossil-fuel dependence in the sector

Construction of the city gas grid in Stockholm began in the mid-1800s. Today the gas in the grid is fossil natural gas mixed with air; this impacts less on the climate than the naphtha-based gas previously used. Replacing all the fossil gas in the grid with biogas would reduce CO₂e emissions by approximately 12,000 tonnes p.a.

In 2014 a total of 72 GWh of city gas was supplied: 49 GWh of this total reached end-users, while 23 GWh was lost to leaks in the system.

Trends and forecast

Demand for city gas has fallen by 17 percent over the past four years. During the same period the grid has suffered some leaks.

Demand for city gas is expected to remain more or less stable at today’s level. The trend is for less city gas to be used for domestic stoves, while demand from restaurants is increasing. Overall gas usage, including that used for transport, is expected to rise. Total gas deliveries in Stockholm County, including gas for transport and heating, are shown below.

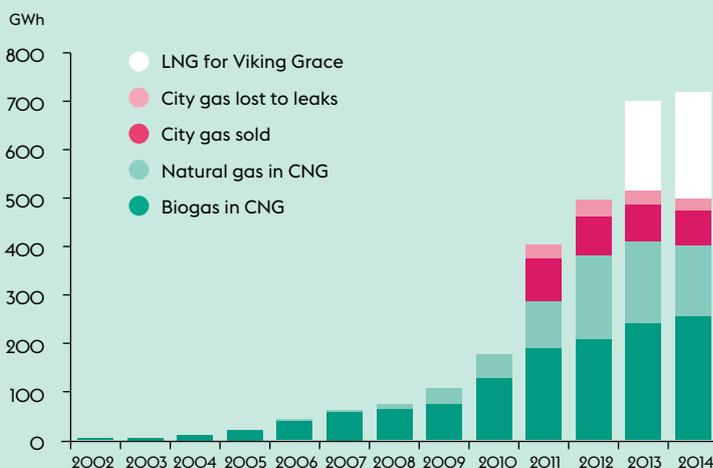
Fossil-fuel free city gas – challenges and opportunities

Secure supplies of city gas free from fossil fuels presuppose that the City acts to ensure biogas production rises to meet demand.

The City has set a target for 2020 of collecting at least 70 percent of food waste in Stockholm to use in the production of biogas that can be used to replace natural gas in the city gas grid or as vehicle fuel. The City has the capacity to increase biogas production in Stockholm Vatten & Avfall’s waste management facilities. A dedicated food-waste sorting facility in Högdalen is scheduled to be operational by 2020, producing biogas that will help reduce the amount of CO₂e entering the atmosphere by around 20,000 tonnes a year. More sites in Stockholm are also earmarked for biogas production.

Biogas has many applications: as fuel for vehicles (CNG), CHP plants and industrial processes. Despite increases in biogas production, competition for biogas is expected to remain strong, while access to natural gas continues to be good. ●

Supplies of gas to Stockholm County



Supplies of gas to Stockholm County in GWh. Supplies of biogas have been constantly rising. Biogas availability doubled in 2003 and again in 2004. Over the past three years, however, the increase has been more moderate.

Source: Environment and Health Administration



Steps towards fossil-fuel freedom by 2040

- The City makes sure Fortum Värme upholds its decision to phase out coal. The ambition is that by 2020 coal will no longer be used. A plan for phasing out coal in CHP 6 is to be presented by 2017 at the latest.
Tasked to: City Executive Board, Group board and Fortum Värme.
- The City collaborates with energy companies, hospitals, etc. to gradually replace fossil oils with renewable fuels to meet peak load demands. Progress to be reported in 2017.
Tasked to: Group board.
- The City supports Fortum Värme's work to increase connections to the Open District Heating network and to investigate the potential for even more users. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Development Committee, together with Group board and Fortum Värme.
- The City investigates the potential for increasing the amount of renewable electricity produced in Stockholm. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Group board, Fortum Värme and Environment & Public Health Committee.
- The City lobbies for legislation and regulations that support the use of fossil-free energy.
Tasked to: City Executive Board.
- The City aims to produce enough of its own solar energy based electricity to meet 10 percent of the municipal organisation's electricity consumption.
Tasked to: Real Estate Committee and the boards of Svenska bostäder, Stockholmshem, Familjebostäder, Micasa and SISAB.



Measures to meet the 2020 milestone target

The milestone target of emissions of max. 2.3 tonnes of CO₂e by 2020 requires a reduction in energy use in buildings that corresponds to 285,000 tonnes. This will be achieved through the following measures, with results monitored each year within the framework for the Environment Programme.

- ✓ The City effectuates a district heating system that reduces overall emissions by at least 240,000 tonnes of CO₂e by 2020.
Tasked to: Group board and Fortum Värme.
- ✓ The City takes action to improve energy efficiency in its municipal operations by 10 percent compared with the reference year 2015. This will reduce emissions by at least 20,000 tonnes of CO₂e by 2020.
Tasked to: This target applies to all municipal operations, but most particularly to the Real Estate and Service Committees and the boards of Svenska bostäder, Stockholmshem, Familjebostäder, Micasa and SISAB.
- ✓ The City acts to impose an energy consumption ceiling of 55 kWh/m² Atemp in new-builds on municipally allocated land, with the ambition of achieving a level of 45 kWh/m² Atemp. This will reduce emissions by at least 25,000 tonnes.
Tasked to: Development Committee.
- ✓ The City produces a model for the layout and form factor of buildings with the aim of facilitating compliance with energy requirements.
Tasked to: City Planning Committee.
- ✓ The City increases its own solar energy production by 2020 at a rate sufficient to meet the goal for 2040.
Tasked to: Real Estate Committee and the boards of Svenska bostäder, Stockholmshem, Familjebostäder, Micasa and SISAB.



Transport

The transport sector accounted for 44 percent of climate emissions in Stockholm in 2014. CO₂e emissions rose from 1,073,000 tonnes in 2012 to 1,075,000 tonnes in 2014 and constitute the greatest challenge on the path to a fossil-fuel free Stockholm. Strong measures are required to support the transition to renewable vehicle fuels, reduced energy needs and a city that combines good access with reductions in traffic volumes.

This chapter is divided into four sections: road traffic, aviation, shipping and plant and construction machinery.

Road traffic

Road traffic emitted 841,000 tonnes of CO₂e in 2014. To overcome the sector's heavy dependence on fossil fuel, vehicles must be replaced and investments must be made in new infrastructure. Although the City has limited powers in this respect, prospects for facilitating the transition are good. Stockholm is already well served by public transport and proposals for new underground lines and the City Line for commuter traffic have already been approved.

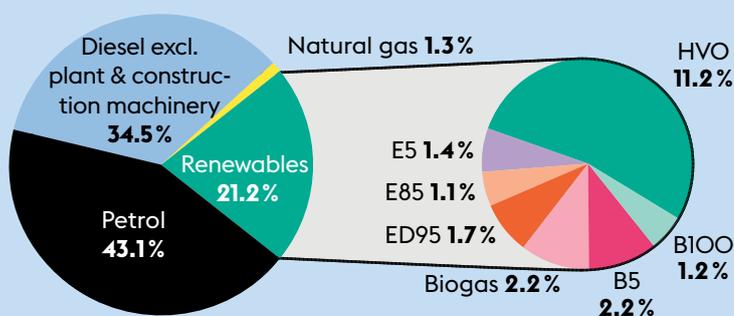
Urban density is high in Stockholm. This leads to reduced needs for road traffic as residents can cycle or walk to their destination. Reduced road traffic is one of the sub-targets in the City of Stockholm's Environment Programme 2016–2019. Road mileage (i.e. the distance travelled by road) per resident in Stockholm is significantly less than in the rest of Sweden. Enabling as many people as possible who want to live in Stockholm to do so, would make an important contribution towards reducing road traffic nationwide. The construction of 140,000 new homes by 2030, as planned by the City, will encourage Stockholmers to choose other forms of transport rather than cars. An expanding population does, however, necessitate more goods traffic. Also, major construction work leads to extensive transport needs during construction and in connection with future infrastructure solutions. More residents mean greater demand for goods and more waste to be removed. It will be a tough challenge to mitigate the negative consequences of goods traffic and ensure that goods vehicles use renewable fuels or electricity.

Renewable fuels accounted for 21 percent (650 GWh) of the total of 3,100 GWh of fuel used by road traffic in 2014. Petrol stood for 43 percent (1,300 GWh) of the fuel share, and diesel for 35 percent (1,100 GWh). Natural gas accounted for just over 1 percent (40 GWh).

Renewables were mostly hydrogenated vegetable oils (HVO), biogas, ED95 (ethanol for diesel buses and lorries), E85 for flexible-fuel vehicles and a low blend of 5 percent ethanol in regular petrol (E5).

In recent years HVO in diesel has emerged as an interesting alternative to fossil diesel in regular diesel vehicles. The proportion of electric vehicles has risen but remains low.

Fuel for road traffic in Stockholm County



In 2014 road traffic used fuel equivalent to 3,100 GWh. Renewables accounted for 21 percent (650 GWh) of this total.

Source: Environment and Health Administration

Trends and forecast

Road traffic accounts for around 80 percent of climate emissions from transport in Stockholm. The remaining 20 percent is emitted by shipping, aviation and plant and machinery. Although private cars top the statistics for road traffic, goods vehicles are also responsible for a significant share of emissions. Heavy goods vehicles (HGVs) represent just 4 percent of road mileage but around 20 percent of road traffic emissions.

After declining for some years, road mileage rose by 5 percent between 2012 and 2014. However, more energy-efficient vehicles and renewable fuels mean that recent years' traffic increases are not reflected in higher emissions. Green vehicles and renewable fuels are winning greater shares of the

market, but they are doing so from a low level.

Light goods traffic is expected to increase, while private car usage declines. This has already been the trend for some years. Estimates suggest that the road traffic mix in 2040 will be 74 percent private cars, 20 percent light goods vehicles, 4 percent HGVs and 2 percent buses.

The Swedish Transport Administration expects mileage for goods traffic on Swedish roads to rise by 53 percent between 2006 and 2030. More residents in an expanding Stockholm mean greater flows of high-value goods such as food, clothes, furnishings, equipment and documents.

It is assumed that vehicles will continue to become more energy efficient, with an improvement of some 17 percent in the energy efficiency of Sweden's private vehicle fleet between 2014 and 2020. Today a clear majority of new vehicles sold have diesel engines. Some of these will still be on the road in 2040; this is certainly true of virtually all diesel vehicles purchased after 2020. There are, however, signs of a trend towards hybrid vehicles.

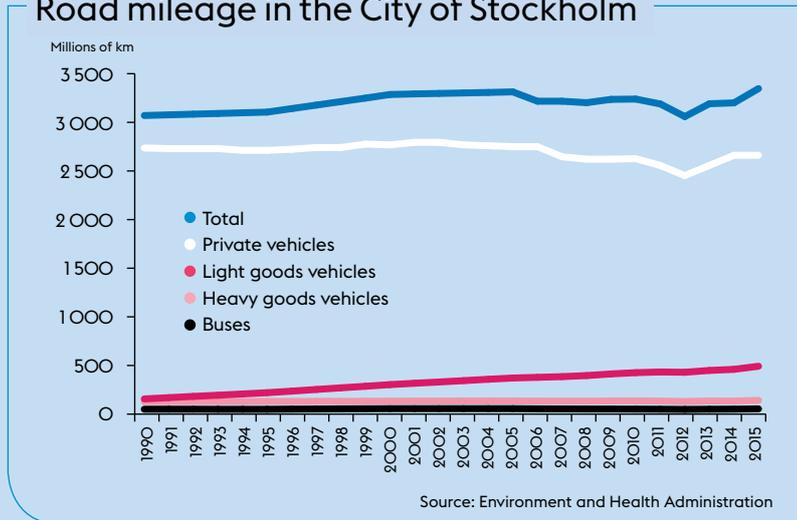
The diagram on the opposite page shows developments up to 2014 and forecasted energy needs for road traffic in Stockholm, provided that there is no increase in total road mileage.

A fossil-fuel free road transport sector – challenges and opportunities

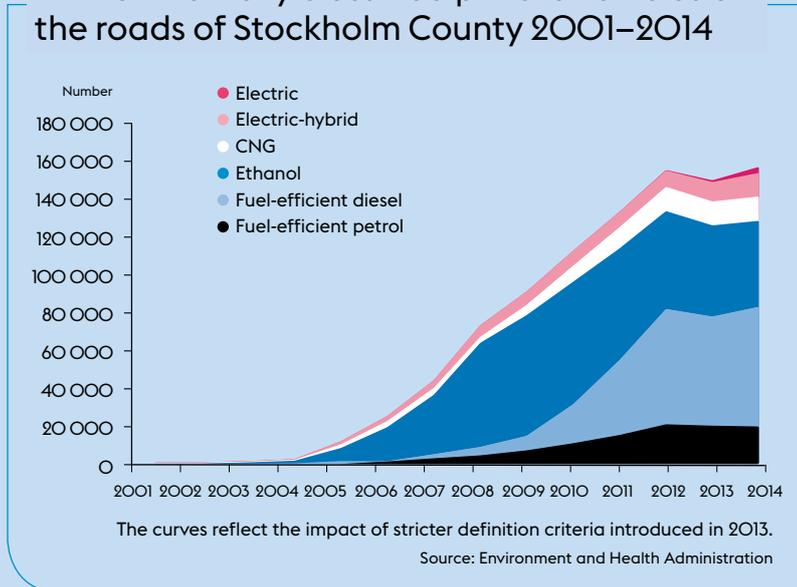
A private car has a lifespan of around 20 years. To ensure a fossil-fuel free fleet by 2040, vehicles sold from 2020 onwards must be prepared for this transition. It is important to choose the right path without delay by sending clear signals to the market before 2020 about how the change to fossil-fuel free road transport will be made. If vehicle fossil fuels are to be totally phased out by 2040, it is essential that the transition, first and foremost to electric vehicles and plug-in hybrids (PHEVs), is made at an appropriate rate. The City cannot, therefore, afford any delay in formulating and following up long-term targets for charging infrastructure for electric vehicles.

As Stockholm grows, so does the need for transportation. The surface available for road traffic is limited, so road space needs to be used more effectively. Total road mileage, especially for private cars, must be reduced, while a transition to public transport, cycles and pedestrian solutions will improve access for goods deliveries. Improving and prioritising public transport can reduce travel times and make more road space free for increases

Road mileage in the City of Stockholm



Environmentally classified private vehicles on the roads of Stockholm County 2001–2014



in goods traffic as a consequence of new construction work and to meet the needs of an expanding population.

Progress in the transport sector depends largely on the long-term conditions and incentives to change investment patterns in infrastructure and vehicles. To achieve the goals that have been set, the state must take its share of responsibility; amendments to legislation and changes to other instruments at national level have a great impact and can influence progress in a positive or negative way. For this reason, change is most urgent in the following areas.

- Measures to promote the transition to renewable fuels and improve the energy efficiency of vehicles. For example, differentiated taxes for new vehicles, a price premium model for the production of biofuels and quota obligations for biofuels. A long-term regulatory framework is needed to stimulate investment in increased production.
- Measures that can impact directly on road mileage. For example, a review of taxation rules for company cars, taxes on fuel or CO₂ emissions, congestion charging, kilometre taxes, adjustment or abolition of tax deductions for travel expenses, etc. New instruments are needed to reduce mileage for goods traffic. For example, pre-booked loading bays and digitised parking enforcement to reduce search times and improve parking availability.
- State financing for public transport and investments in the electricity infrastructure.
- New regulations to promote sustainable travel alternatives. For example, digitised monitoring of everything from bus lanes to environmental zones and parking spaces, facilities for reserving on-street parking for green vehicles or car share vehicles, etc.
- A national strategy is needed for different goods transport modes, with rules adjusted to ensure competition on equal terms. There should be an obligation to report HGV fuel consumption rates and carbon dioxide emissions for combined driving.

The City exercises considerable powers over physical planning. A dense, cohesive, mixed-use urban infrastructure creates the right conditions for a transport-efficient environment and high-capacity passenger rail systems. The City is responsible for expanding an attractive network of cycle and pedestrian paths and for maximising the potential for efficient bus services.

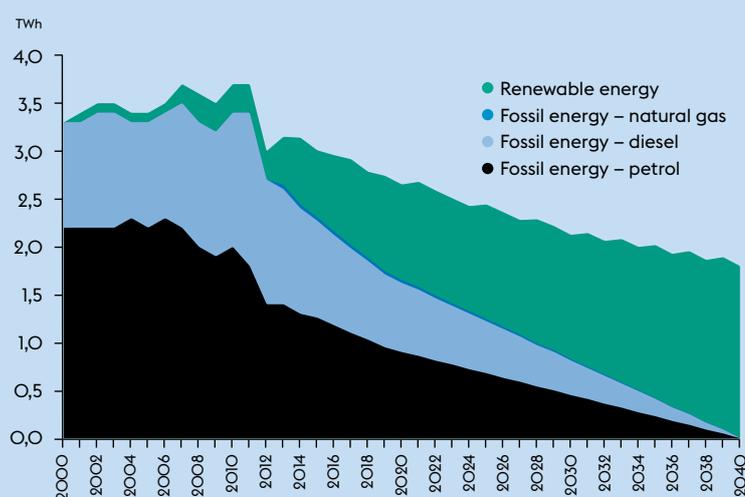
As the City's ability to achieve its goal hinges on transport-efficient regional physical planning decisions that stimulate the transition to a fossil-fuel free transport sector and support the evolution of a cohesive public transport system in the region, there is a clear need for collaboration and a broad regional consensus.

Also, through its procurement of transport and other services, the City is in a strong position to accelerate progress towards a fossil-fuel free vehicle fleet by setting criteria for environmental performance and encouraging consolidation of goods. Demands on the use of renewable fuels for plant and construction equipment and on adapting buildings for sustainable mobility solutions can be made in connection with land allocation decisions.

Phasing out fossil fuels in favour of renewables may intensify competition for fuels. Supplies of biofuels are limited and increased demand may cause prices to rise sharply. It is important for the City to follow developments and to help promote technical innovation relating to alternative fuels.

Good access to attractive, high-capacity public transport solutions helps reduce road traffic, but the expansion of public transport is expensive and planning and implementation can be protracted.

Road traffic in Stockholm County – energy consumption



Forecasted energy needs and target for phasing out fossil fuels and transition to renewable energy, in TWh. This simplified representation shows the proportional phasing-out of fossil energy in two stages, first to meet the Environment Programme's targets by 2019 and then up to 2040. Calculations of total energy needs are based on road mileage in 2012 and the Swedish Transport Administration's forecasts for energy-efficiency improvements in the vehicle fleet up to 2040.

Source: Environment and Health Administration

Aviation

Air traffic in Stockholm, based on the City's methods for calculating landing and take-off (LTO) cycles up to altitudes of 915 metres (3,000 feet), accounts for only a small share (21,000 tonnes in 2014) of total greenhouse gas emissions.

Jet fuel is a fossil fuel and, while the air industry itself has set targets to reduce the use of fossil fuels on domestic flights, the influence that municipal authorities can exert in this sector is limited.

Most services to and from Bromma Airport are domestic flights. Swedavia's agreement with the City of Stockholm expires in 2038, so it is uncertain how long the aviation industry will contribute to emissions within the geographical boundaries of Stockholm.

Trends and forecast

A government report, presented in April 2016 by the state coordinator investigating the balance between Stockholm's air transport capacity and the city's housing needs, states that Bromma Airport has no future after 2038 and should be closed.

The aviation industry has set itself a global target to improve energy efficiency by at least 2 percent a year. Blending more biofuel into aviation fuel and improving energy efficiency could theoretically halve emissions at Bromma between today and 2040.

Work is under way to make domestic flights totally fossil-fuel free. There is still no definite deadline for this, but it is expected that the next few years will see relatively good progress in terms of price and availability.

Planes that consume around 25 percent less fuel will take to Sweden's skies early in 2018. This will see a corresponding reduction in emissions, but air traffic in general will still not be totally fossil-fuel free by 2040.

Shipping

The maritime sector accounts for 4 percent of total emissions and 10 percent of transport sector emissions. In 2012 shipping within the city's geographical limits emitted a total of approximately 92,000 tonnes of CO₂e.

Trends and forecast

Most vessels that dock in Stockholm are powered by oil or diesel. In the future vessels with cargoes for Stockholm are expected to dock at ports outside the city's geographical boundaries, while the number of cruise ship calls is expected to rise.

Stockholm's ports are working to promote the use of onshore power supplies rather than on-board generators. Some local commuter ferries run on electricity and recharge their batteries at the landing stages. The port authorities have begun installing power outlets, and subsidies for conversions to facilitate connection are available for vessels that regularly call at Stockholm. There is potential to develop this scheme and also to introduce differentiated docking fees that encourage the use of renewable fuels and onshore power supplies.

Stockholm's ports (Stadsgården, Frihamnen and Värtahamnen) are central ports for goods and passengers to and from Finland and the Baltic states, and for cruise ships. Cruise traffic, in particular, is expected to increase. It is expected that freight will be mainly ro-ro traffic and fuel supplies for the CHP plants in Värtan, Hässelby/Lövsta and Hammarby. The plan is for most other goods to be shipped to ports outside the city boundaries by 2040.

Biofuels, bio-oils and liquefied natural gas (LNG) are slowly being introduced in the shipping industry as possible replacements for fossil oils. Since 2013 one cruise ferry (Viking Grace) has been running on LNG and more may be expected to do so as demands to

reduce sulphur content in bunker fuels become stricter. For shipping to become fossil-fuel free, LNG must ultimately be replaced by biogas or hydrogen gas. However, developments in this direction are highly unpredictable, chiefly due to concerns about the availability of bio-oils and biogas.

There is much uncertainty about the feasibility of a fossil-fuel free maritime sector in Stockholm by 2040. The municipal authorities have little opportunity to influence a sector governed by international conventions. While it should be possible for local and regional shipping to become fossil-fuel free, it is reasonable to assume that, without a strong international commitment to change, many other vessels will continue to use fossil fuels in 2040 and beyond. The conclusion is that fossil fuels will still constitute approximately 93 percent of marine fuels in 2040.

Loudden oil terminal and Berg's oil port in the Municipality of Nacka will be closed and all operations with both fossil- and non-fossil-based oil products will be transferred to Södertälje, Västerås and Gävle. This will have no direct impact on the use of fossil fuels in Stockholm, but it will necessitate an increase in the transportation of fuel to Stockholm.

There is potential for increasing local transport by boat to relieve pressure on the road network. Examples include large, heavy consignments of gravel, aggregates and construction materials. On the European continent many such consignments are transported by barge. Waterborne public transport can also be increased, but local ferries and boats serving the archipelago need to use renewable fuels or some other technology if the climate target is to be met.

Plant and construction machinery

Plant and construction machinery comes in many shapes and sizes and, because of its versatility, it is frequently moved from place to place. The estimated total energy consumption of plant and machinery in Stockholm in 2014 was some 270 GWh, with diesel accounting for around 95 percent of the fossil fuels used. This corresponds to 5 percent of total greenhouse gas emissions in Stockholm.

The City imposes environmental criteria when procuring contracted services but these do not yet prescribe the use of renewable fuels. While renewables are not generally used in this type of machinery, more and more manufacturers are authorising the use of HVO.

Trends and forecast

Plant is a broad concept that covers machinery for all types of work, so it has proved difficult to lay down general guidelines to govern the sector.

In Sweden as a whole, usage is expected to remain relatively unchanged up to 2040, but demand in Stockholm is certain to escalate to meet the increase in construction and infrastructure projects.

It should be possible to reduce greenhouse gas emissions from plant and construction machinery in the same way as for vehicles, so it is expected that emissions from this segment will be totally fossil free by 2040.

Fossil-fuel free plant by 2040 – challenges and opportunities

The City procures many contracted services (waste management, road maintenance, etc.) and thus has considerable power to stimulate technological progress and fast-track change in the industries concerned by demanding that these services are fossil-fuel free. ●



Steps towards fossil-fuel freedom by 2040

- The City presents an action plan for a fossil-free road transport sector and investigates the feasibility of prohibiting the sale of fossil fuels by 2040, with a sub-target for 2030. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: City Executive Board with support from Environment & Public Health Committee and Traffic Committee.
- The City lobbies for legislation and regulations that support a fossil-free transport sector.
Tasked to: City Executive Board.
- The City investigates measures to promote fossil-fuel free shipping. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Board of directors of the Ports of Stockholm.
- The City presents an action plan for the use of fossil-free fuel in construction machinery and plant. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Development Committee, Traffic Committee and Environment & Public Health Committee.
- The City works to introduce local Environmental Zones from which vehicles running on fossil fuels will be banned by 2040 at the latest.
Tasked to: City Executive Board.



Measures to meet the 2020 milestone target

The milestone target of emissions of max. 2.3 tonnes of CO₂e by 2020 requires a reduction in energy use in the transport sector that corresponds to 228,000 tonnes. The strategy calculates that this can be achieved through the following measures, with results monitored each year within the framework for the Environment Programme.

- ✓ The City acts to reduce road traffic sufficiently for CO₂e emissions to fall by at least 80,000 tonnes.
Tasked to: Traffic Committee and City Planning Committee.
- ✓ The City acts to reduce the use of fossil fuels for road traffic sufficiently to eliminate at least 140,000 tonnes of emissions.
Tasked to: Environment & Public Health Committee, together with City Executive Board and Traffic Committee.
- ✓ The City acts to reduce emissions by at least 8,000 tonnes by making transport within the municipal organisation more climate efficient.
Tasked to: Service Committee.





Resource-efficient natural cycles

A resource-efficient natural cycle requires greater restraint in the use of finite resources and a focus on eliminating waste. More and more of what we produce and consume must build on the principle of the circular economy. A resource-efficient natural cycle provides a good foundation for fossil-fuel freedom by using waste to produce heat and electricity. Fossil plastics currently make up a large fraction of the waste that is incinerated.

Freedom from fossil-fuel – challenges and opportunities

Waste and recycled energy sources are already being used as fuels and their share of the mix is expected to increase. To mitigate climate impact the fossil plastic fraction in waste fuels needs to be reduced; this can be done by cutting back on the use of and increasing the recycling and re-use of fossil plastics. However, there is a limit to the number of times that plastic fibres can be recycled to make new plastic. For the sake of resource efficiency, plastic that cannot be re-used should be used as fuel rather than landfill or similar, even though this is at odds with the goal of freedom from fossil fuels.

Biogas is produced locally and can be upgraded to vehicle fuel quality. Biogas production contributes to the circular economy as nutrients left over after the digestion process can be used in agriculture. The City has invested in a new grid for vehicle gas (CNG) that is a blend of biogas and natural gas. Demand for biogas has outstripped supply and natural gas has been used to meet needs.

There is great potential for using thermal gasification to produce biogas from forest residues and carbohydrate-rich agricultural waste. Biogas can also be produced by digesting sewage sludge and household waste, either separately or together. This is one way to make good use of the waste products generated by Stockholm's residents.

By 2020 at the latest the City aims to collect at least 70 percent of Stockholm's food waste for conversion into biogas. This gas can be used to replace natural gas in the city's gas grid and provide fuel for vehicles. Replacing fossil fuels in vehicles with biogas will reduce CO₂e emissions by around 20,000 tonnes. The City currently has the capacity to increase biogas production in the facilities operated by Stockholm Vatten & Avfall. ●



Steps towards fossil-fuel freedom by 2040

- The City investigates the potential for reducing the amount of fossil plastic in incinerated waste. Chemicals, health and other environmental impacts must be considered in addition to climate impact. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Group board, together with Stockholm Vatten & Avfall and Fortum Värme.
- The City produces a report that describes how to secure an increase in the production of biogas that is sufficient to meet needs to replace fossil natural gas. A report with proposals for action is to be presented for decision before the end of 2017.
Tasked to: Environment & Public Health Committee, together with Group board and the board of Stockholm Vatten & Avfall.



Measures to meet the 2020 milestone target

The milestone target of emissions of max. 2.3 tonnes of CO₂e by 2020 requires a reduction of at least 20,000 tonnes. The strategy calculates that this can be achieved by implementing the following measure, with results monitored each year within the framework for the Environment Programme.

- ✓ The City acts to increase biogas production to a level sufficient to correspond to an overall reduction of 20,000 tonnes of CO₂e.
Tasked to: Board of Stockholm Vatten & Avfall.





Compensation for remaining emissions

Calculations suggest that some fossil energy will still be used in 2040, primarily in shipping and aviation, where the City's powers to implement change are limited, but also in the form of fossil-based plastics in waste incineration facilities. Measures to compensate for the climate impact of these remaining emissions include carbon sinks that absorb carbon dioxide from the atmosphere. The oceans and vegetation are the planet's greatest carbon sinks, but it is possible to create the corresponding effect, for example by removing carbon dioxide from the flue gases of CHP plants and depositing it permanently in the ground or the sea in a process known as carbon capture and storage (CCS).

Another method involves the use of a hydrothermal carbonisation process to transform organic material into biochar that can subsequently be used as a soil conditioner. The City of Stockholm is working together with a prize-winning pilot facility for biochar. In addition to the positive climate effects, biochar improves soil fertility and reduces nutrient leach and the risk of eutrophication.



Steps towards fossil-fuel freedom by 2040

- The City investigates the potential for creating carbon sinks within the municipal boundaries to compensate for any residual fossil fuel emissions in 2040. A report with proposals for action is to be presented for decision before the end of 2017.

Tasked to: Group board and Fortum Värme



A fossil-fuel free municipal organisation by 2030

As an organisation, the City of Stockholm accounts for around 10 percent of total emissions in Stockholm. In accordance with the Environment Programme, the City is currently actively involved in phasing out fossil fuels from the energy it uses. The electricity it purchases that is produced from fossil-fuel free sources meets eco-labelling criteria, and its road fleet includes an ever-increasing number of electric vehicles.

The City of Stockholm is well placed to continue to serve as a good example and a forerunner in efforts to achieve freedom from fossil fuels by 2030, before Stockholm as a whole meets this ambition. Alongside the implementation of the Environment Programme, work will focus on the following measure.



Steps towards fossil-fuel freedom by 2040

→ The City presents an action plan for a fossil-fuel free municipal organisation by 2030. A report with proposals for action is to be presented for decision before the end of 2017.

Tasked to: City Executive Board, together with the Environment & Public Health and Service Committees



Implementation and follow-up

The strategy sets the target for the minimum reduction in emissions. Each of the committees and the board of each company involved is responsible for ratifying, implementing and following up measures that will lead to the required reduction in emissions. This includes responsibility for analysing which measures are most cost-effective for the City. The Environment Programme's emissions ceiling of 2.3 tonnes of CO₂e by 2020 applies to all committees and company boards. As a consequence of the adoption of this strategy, various named committees and company boards are made responsible for the implementation of a number of prioritised measures. Municipal committees are urged to make use of the funds specially earmarked for climate investments in the City's budgets up to and including 2018. The strategy provides guidance about areas prioritised for the allocation of these funds and indicates the need for budget priorities over the longer term. It is also recommended that the City seeks state investment funds to achieve its climate goal.

The measures proposed by the strategy are in line with the Stockholm Environment Programme and are therefore implemented in the City's integrated management system (IMS). This places responsibility for implementation and follow-up with the respective committee and the business plan of the boards concerned.

Follow-up takes place in connection with tertial reports and activity reports in the same way as other activities and budget issues are monitored. When necessary, the City Executive Board may call upon committees and boards and urge them to take the necessary action to achieve the required reductions in emissions.

The instrument that governs the City's overall environmental work is the Environment Programme 2016–2019. As part of the process of revising the Environment Programme for the subsequent period, a revised target should be set for reductions in greenhouse gas emissions. By continuously analysing and calculating climate emissions in Stockholm in order to create milestone targets, it is possible to map an emissions trajectory that serves as a framework for the climate measures that are needed to achieve freedom from fossil fuel. In view of the complexity of such long-term forecasting, it is unlikely that this trajectory will show a linear development. Individual measures and events in the wider world can have a big impact during specific periods. It is important that the City focuses on the long-term goal and continually renews its analyses of the potential for reductions in different sectors.

Provided that the City's Environment Programme is revised every four years and that an even pace is maintained in terms of reductions in emissions, targets for the years ahead should follow the trajectory below, allocated per resident.

Environment Programme period	CO ₂ e/capita at end of period
2016–2019	2.3
2020–2023	1.8
2024–2027	1.4
2028–2031	1.0
2032–2035	0.7
2036–2039	0.4

Success factors in climate work

The climate challenge is complex and cannot be defined in terms of a traditional environmental issue. Successful climate work reinforces Stockholm's competitive status and is linked to extensive welfare and new job opportunities in "a city for everyone". Success in rendering its own organisation fossil-fuel free by 2030 will establish the City of Stockholm as a forerunner that paves the way forward for others to follow.

Work to address climate issues places special demands on regulation and follow-up, as it extends over a long period of time and involves many sectors and stakeholders, both internal and external. The City Executive Board has overall responsibility for strategic climate work in Stockholm and plays a key role in supporting and encouraging the implementation and follow-up of the City's climate goals. It is proposed that the City Executive Board reviews this strategy in connection with its revisions of the Environment Programme. The special focus on climate investments up to and including 2018 improves the opportunities for the investing committees to take measures.

The City needs to work with external players to achieve its fossil-fuel free goal. The Stockholm Climate Pact is a good example of long-term cooperation with trade and industry. In addition, residents are being informed through communication initiatives such as the "Climate-smart Stockholmers" project that provides tools to help residents reduce their climate impact.

It is considered feasible to achieve freedom from fossil fuel with the aid of today's technology, provided that this is supplemented by successive investments in further technological development and a resource-efficient and energy-efficient infrastructure. Initiatives that lead to innovations and

technical developments within the climate area also strengthen local trade and industry.

Achieving the goal of a fossil-fuel free Stockholm depends to a great extent on regional development, particularly in terms of public transport and regional physical planning that promote the transition to fossil-free alternatives. It is essential that the City of Stockholm remains well informed about overall climate impact beyond the system limits that have been defined.

The City has identified a number of areas, most particularly the transport sector and the production of renewable energy, where current national and international regulatory frameworks obstruct efforts to implement the measures and create the incentives that are necessary to reduce climate impact. The regulations need to be amended in order to benefit climate work, while also giving positive synergies in the form of other aspects of sustainable urban development, such as improved air quality and access.

Climate issues are a global challenge. The most notable contribution the City of Stockholm can make towards achieving the goals of the Paris Agreement is to act as a good example to others. Stockholm's high ambitions in terms of climate and environment were recognised when the city received the very first European Green Capital Award in 2010. Within the framework of international climate work the City prioritises measures taken through, for example, C40, CNCA (Carbon Neutral Cities Alliance) and the Global Covenant of Mayors for Climate & Energy. Within these forums the City can act as an engine for change to create the conditions for a fossil-fuel free society. International undertakings also present the City of Stockholm with an opportunity to acquire valuable experience through collaboration with other cities that are successfully seeking ways to meet the world's climate goals.●



