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The Stockholm Royal Seaport Road Map

The Journey Has Begun

Developed according to the CCI framework

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1. Executive Summary

Stockholm has a long history of integrating environmental aspects into urban management in a structured and goal-oriented way, and as the climate threat has risen on the political agenda, ambitious targets have been defined. In 2009, Stockholm City Council decided that the Stockholm Royal Seaport (SRS) should become the next environmentally profiled city district and a model for sustainable urban planning in order to consolidate Stockholm's position as a leading city in the area of climate work.

One of the main objectives is to limit the GHG emissions from the SRS. As part of this work, the City entered into a collaboration with CCI (Clinton Climate Initiative, 2011) and adopted the initiative's framework for climate positive urban districts. The expected outcome of this collaboration is that the SRS will become a climate positive urban district.

This report summarises and analyses the City's efforts and progress so far, both in terms of calculated reductions in GHG emissions and with respect to the valuable lessons learnt from the process.

The baseline has been established using a similar city district in Stockholm, Hammarby Sjöstad, and emission factors from 2010 as the reference. The baseline for the SRS would be 50 000 tonnes CO_{2e}/year.

The Road Map describes the steps that must be taken to create a climate positive urban district and outlines the measures that must be implemented in order to reduce the baseline emissions. There are three basic kinds of road-mapping measures, energy efficiency, fuel substitution, and behavioural change measures.

The measures that have been quantified in the SRS road map are

1. Requirements that have been applied on the development since 2010 (SRS standards)
2. A progressive scenario, where there are potential improvements to be made (Progressive)
3. Credits – where the development in the SRS has clearly influenced other projects

The total reduction of GHG emissions for the SRS-standard scenario is about 30 000 tonnes CO_{2e}/year (-60 %) and for the Progressive scenario 40 000 tonnes CO_{2e}/year (-80 %).

Even though the ambitions in SRS are high, the net emissions will not be below zero (in other words, will not be climate positive) unless effects outside the area can be included. Under the CCI framework, it is possible to earn climate positive credits. A total of 30 000 tonnes CO_{2e}/year has been accounted for in the Road Map. In conclusion, the SRS can reach a Climate Positive status in either scenario.

	Baseline tonnes CO_{2e}/year	**SRS** tonnes CO_{2e}/year	**Progressive** tonnes CO_{2e}/year
SRS Total	49,991	20,295	10,870
Credits		-29,870	-29,870
Road map including credits		-9,575	-18,872

The methodology of developing a road map has been a useful tool for identifying the activities and measures that will have the greatest impact on emissions, thereby providing a tool for prioritisation.

2. Introduction

Stockholm has a long history of integrating environmental aspects into urban management in a structured and goal-oriented way, and as the climate threat has risen on the political agenda, ambitious targets have been defined. These are some of the reasons why Stockholm was appointed the first European Green Capital in 2010.

Since 1990, greenhouse gas (GHG) emissions have been reduced by 1,000,000 tonnes, mainly due to the transition away from individual heating systems and using fossil fuels as the main energy carrier in the district heating for the City's residential areas. Between 1990 and 2012, GHG emissions were reduced by 30% in total or 47% per capita taking the population growth into consideration.

Targets at the national level mainly focus on transport, energy efficiency in buildings and production of renewable energy according to the EU directive. Translated into national targets, this means that Sweden aims to:

- reduce CO_2 emissions by 40% by 2020 (using 1990 as the baseline)
- increase energy efficiency by 20% by 2020 (using 2008 as the baseline)
- increase the energy efficiency in the property portfolio by 50% by 2050 (using 1996 as the baseline)
- ensure that at least 50% of Swedish energy production comes from renewable sources by 2020

A recently proposed but not yet decided national target is to reach zero net emissions by 2045, i.e. 85% reduction compared to 1990 and 15% increased net uptake of carbon.

The Swedish Policy Framework provides a good foundation for the climate policies described in Stockholm's vision 2030, the Stockholm Environmental Programme 2012–2015 and various action plans.

Stockholm is growing. By 2050, Stockholm's population is expected to reach 1.2 million, an increase of 40% compared with 2012. According to the City's target, an additional 140,000 homes will need to be built by 2030. If no measures are taken, the City expects its energy need to continue growing at the same rate, meaning that 15% more energy will need to be produced. Given Stockholm's ambitious climate goal of becoming fossil fuel free[1] by 2040, this is a major undertaking.

As part of its vision of a fossil-free Stockholm by 2040, the City developed a road map to investigate how this goal can be achieved. The road map describes how fossil fuels can be replaced by other sources of energy and how the overall need for fuel can be reduced through energy-efficiency measures.

The road map states that by taking radical measures, it will be possible for Stockholm to become fossil fuel free by 2040. It describes how to reduce GHG emissions from 3.8 to 0.4 tonnes/capita per

[1] All energy used in Stockholm is free of fossil energy carriers

year. The remaining emissions are derived from plastics combusted in combined heat and power plants (CHP), supplements for life-cycle assessments and direct emissions from aviation and shipping.

Measures are mainly focused on the energy system (shift to fossil fuel-free district heating and increased energy efficiency in buildings) and the transport system (for example ,increase the capacity of the public transport system, improved bus services and measures to facilitate walking and biking to replace the use of private vehicles).

In 2009, Stockholm City Council decided that the Stockholm Royal Seaport should become the next environmentally profiled city district and a model for sustainable urban planning in order to consolidate Stockholm's position as a leading city in the area of climate work. The Stockholm Royal Seaport (referred to below as the "SRS") is being developed to be a state-of-the-art project, a showcase where the City – together with private and public developers and utilities – can demonstrate how to plan and build a sustainable city district. One of its ambitious goals is to become fossil fuel free by 2030.

In 2009, a memorandum of understanding was signed between the City of Stockholm and the Clinton Climate Initiative (CCI), with the City committing to establish the SRS as a model city for climate positive development and to support in the development of standards.

To guide the sustainability management of the project, a steering document, The Overarching Environmental Programme, was developed, comprising themes ranging from renewable energy to sustainable lifestyles and climate adaptation. One of the main objectives is to limit the GHG emissions from the SRS. As part of this work, the City has entered into a collaboration with CCI and adopted the initiative's framework for climate positive urban districts (Clinton Climate Initiative, 2011). The expected outcome of this collaboration is that the SRS will become a climate positive urban district. The ambition is to become climate positive as soon as possible and at the latest when the area is fully developed in 2030.

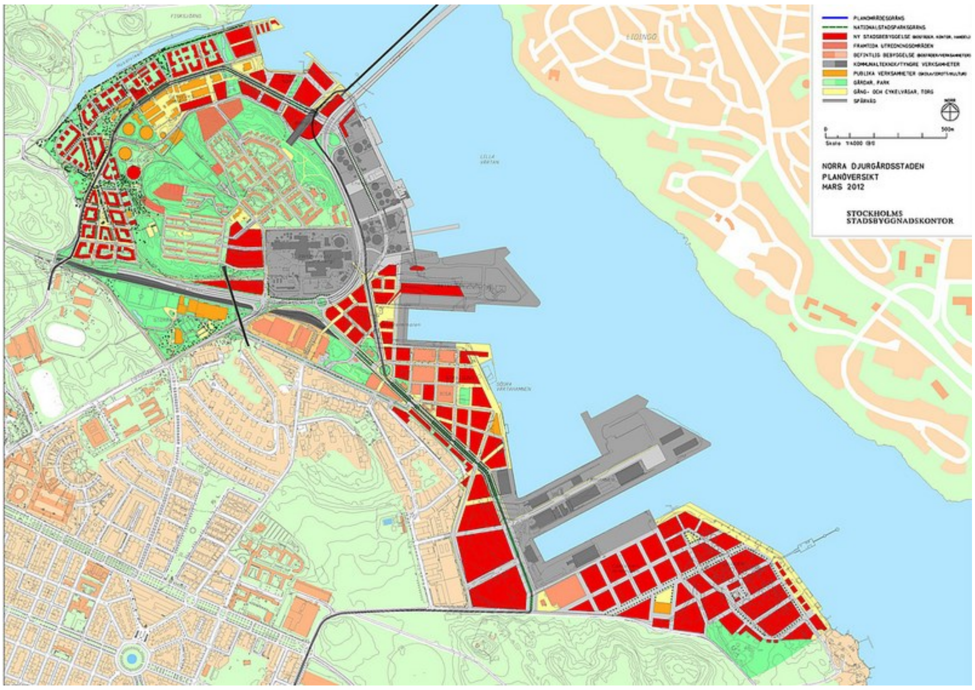


Figure 1. The Stockholm Royal Seaport covers 236 hectares in a former industrial area located three kilometres from the city centre

2.1. The Aim and Contents of this Report

This report summarises and analyses the City's efforts and progress so far, both in terms of calculated reductions in GHG emissions and with respect to the valuable lessons learnt from the process. The following issues will be described:

- **CCI's framework, the climate positive process, the SRS system boundaries and basic data** – general background information on the CCI's process, what a climate positive urban district entails, how the urban district's system boundaries are formulated, as well as a comparison with the City of Stockholm's own reporting system.
- **Accounting for GHG emissions, data and calculations used** – a brief overview of the data used and how calculations are performed.
- **The SRS's baseline for emissions** – a description of the baseline, "business as usual" based on 2010.
- **The SRS's road map and credits** – a description of the measures and how they are implemented in two scenarios: one conservative (calculating the measures in the existing agreements) and one progressive (if the requirements were stricter).
- **Analysis of emissions, emission reductions and credits** – a description of the results of the two scenarios.
- **Analysis of the process as a whole** – what are the benefits of using the methodology and how can the work progress?
- **Future work** – the road map is just the beginning of the journey: what steps need to be taken to become climate positive?

3. SRS Road Map

3.1 The Rationale of a Road Map

As the capital of Sweden and the nation's engine for growth, Stockholm has taken the lead in demonstrating that it is possible to phase out fossil fuels and reduce emission levels while still sustaining growth and meeting the challenge of an increasing population. The City has developed its own road map to becoming a fossil fuel-free city by 2040, and the conclusion reached is that Stockholm is, indeed, facing a major challenge that should not be underestimated, but also that achieving this goal is fully feasible. Success, however, will be predicated on resolve and hard work.

In the same manner, the SRS Road Map is a hands-on description and a plan for how to achieve the long-term goal of becoming fossil fuel free by 2030. The road map methodology has been a useful tool for prioritisation and to show the impacts of the various proposed measures. The vision and goal for the SRS force and encourage all stakeholders to think innovatively, and the experiences, methods and techniques developed in the SRS are expected to be used as cases for demonstrating how to redirect energy use in the City.

As a partner in the CCI collaboration, the SRS has developed its road map using the CCI framework and the tools developed within the partnership.

3.2 The Climate Positive Framework

The CCI framework is an open framework that allows participating projects to adopt existing local, regional or national accounting standards, only adding, subtracting or modifying if needed. Accordingly, the City of Stockholm's accounting methods can be and have been used in the development of the road map for the SRS (City of Stockholm, 2012).

The CCI framework focuses on measures such as efficient use of energy, a high degree of renewables, local on-site renewable energy generation and influencing neighbouring urban districts and the community/city as a whole towards reducing carbon emissions (Clinton Climate Initiative, 2011). In practice, the road map was developed by defining the baseline and thereafter identifying and calculating strategies (measures within the project and credits) to reach the target – climate positive. The baseline provides an inventory of emissions in terms of both magnitude and location at a specified time. The strategies were developed to describe how to reduce emissions in practical terms, either through energy-efficiency measures, by substituting fossil fuels with renewables or through the CCI's specific system of credits, where measures implemented within the SRS could contribute to reducing GHG emissions in neighbouring districts or even the City of Stockholm as a whole, either directly or by influence.

3.3 The Definition of a Climate Positive Urban District

The definition of "climate positive" used in this report is that the baseline emissions are to be lower than the calculated emission reductions in the road map, including possible credits.

3.4 System Boundaries and Local Preconditions

The system boundaries delimit which GHG emissions are accounted for and which are not. The CCI framework includes three primary emission categories: emissions from energy, transport and waste (Clinton Climate Initiative, 2011).

The emission categories themselves do not clearly define which emissions are accounted for and which are not. Therefore, system boundaries need to be defined. The system boundaries used for this road map are in line with both the City's method of calculating emissions and the CCI framework (terminology may differ):

- **A geographical boundary** limiting emissions to activities taking place within the SRS's geographical boundary. The geographical boundary has two exceptions: the life cycle analysis (LCA) emissions from fuels and energy carriers, and certain emissions from industrial processes outside the geographical boundary, such as the treatment of waste, biogas production and wastewater treatment (see Table 1).
- **An activity boundary** limiting emissions by only including emissions from the three main emission categories (energy, transport and waste) and excluding all other activities.
- **A temporal boundary** limiting emissions to only include operational emissions starting in 2030, when the entire SRS will be completed.
- **An LCA-based boundary** including emissions from fuel production and energy carriers.

This description of Stockholm's methods of reporting compared with the CCI system boundaries is summarised in Table 1:

Table 1. Comparison between the system boundaries for the City of Stockholm and the CCI framework

	The City of Stockholm	**SRS according to the CCI framework**
Target(s)	City: 1.5 tonnes of carbon dioxide equivalents (CO_2e)/capita (cap) 2015. Fossil fuel free by 2030	Climate positive < 0 tonnes of GHG emissions **once the entire area is operational** Fossil fuel free by 2030
Unit of measure	Tonnes of CO_2e/cap (residents only) 22,800 persons in total	Tonnes of CO_2e /cap (residents and workers) 57,800 persons in total
Boundary principle	Direct and indirect emissions stemming from activities directly related to the SRS's geographical area	Same as Stockholm
Construction phase	Emissions <u>not</u> included due to temporal aspects	Same as Stockholm
Data use	Life cycle-based data regarding fuels and energy carriers. Emissions and emission reductions from **the collection, transport and treatment** of waste	Same as Stockholm
Energy	Emissions from heating, cooling and electricity. Emission reductions from local energy production	Same as Stockholm

	The City of Stockholm	SRS according to the CCI framework
Transport	100% of emissions from transportation stemming from activities directly related to the SRS's geographical area: Private trips (residents) Commuting trips (residents) Commuting trips (workers) Business trips (workers) Goods and services Through traffic **Not included:** Long-distance travel	40% of <ins>**all**</ins> trips starting/ending within the SRS Private trips (residents) Commuting trips (residents and workers) Business trips (residents and workers) Goods and services **Not included**: Long-distance travel Through traffic from the harbour and the island of Lidingö
Waste	Emissions and emission reductions from the collection, transport and treatment of waste. Emissions from the incineration of waste **Not included:** recycling and landfill	Same as Stockholm
Emissions excluded due to geography	Emissions from societal functions such as: hospitals, libraries, sports centres, public buildings, etc., located outside the geographical area	Same as Stockholm
Consumption	Emissions <ins>not</ins> included due to geography	Same as Stockholm

Most of the system boundaries are the same or very similar. However, there are a few important exceptions.

- <ins>The number of capita:</ins> the City uses the number of residents, whereas the CCI includes **both** residents and workers in its cap.
- <ins>The accounting method for transport:</ins> the City calculates all private and commuting trips from the home and includes all through traffic on the motorways crossing the municipality, whereas the CCI takes into account 40% of the emissions from all trips starting or ending in the SRS.
- <ins>Additions:</ins> the City adds its general functions benefitting all residents and used by other municipalities.

3.5 Basic Data and Assumptions

Most of the calculations in the road map are based on the SRS's completion in 2030, including the future number of residents and workers. Therefore, the following basic data has been used throughout the report:

Table 2. The SRS development

	Assumptions for the development (on completion in 2030)
Number of apartments	12,000
Number of residents	22,800 (based on 1.9 residents per apartment)
Number of workers	35,000
Residential space	1,372,080 m^2
Office space	854,796 m^2
Commercial space	100,818 m^2
Public amenity space	11,400 m^2

Source: City of Stockholm plans as of 8 February 2012 (Christina Salmhofer, 2013)

Three different types of emission data are used in the road map:

1. SRS-specific data: Whenever possible, local data specific to the SRS has been used, such as calculated use of heating per square metre and year for offices in the SRS.
2. City-specific data: If local data is not available, data for the City of Stockholm has been used. This type of data may include the composition of the vehicle fleet (% gasoline cars, % biogas cars, etc.) or the emission factor from the Stockholm district heating mix (g CO_2e/kWh of district heating).
3. Swedish statistical data: If data specific to the SRS or Stockholm is not available, data from Sweden or, in the case of electricity emissions, from the Nordic energy mix has been used.

3.6 The Anchoring Process

As the SRS project is a regular Stockholm City development project, it is essential that all project planning and reporting is approved by the relevant City administrative departments. The road map has been developed based on external experts' assumptions and scenarios in each sector, compiled by the City's Development Administration. The scenarios have been reviewed by the Environmental, Traffic and Waste Administrations. The measures and strategies that refer to SRS standards have been developed in expert groups with participants from all relevant City administrations. Although this process takes time, achieving a broad consensus is important to ensuring that the measures are realistic and the vision is implemented.

4. The Baseline of Emissions

The baseline describes the performance of the development at the point of departure and based on the assumption that no development takes place. The purpose of the baseline is to identify, in a transparent way, the main sources of emissions and the magnitude of these sources.

The baseline has been established using a similar city district in Stockholm, Hammarby Sjöstad, and emission factors from 2010 as the reference. In the baseline, data concerning calculated energy use, waste and transport has been collected and extrapolated to represent the whole of the SRS. This is, of course, a significant overestimation since the baseline is a worst-case scenario. More details on the baseline are found in Appendix B.

Hammarby Sjöstad was Stockholm's first environmentally profiled area with, at that point, high ambitions with respect to energy efficiency, sustainable transport and the reuse and recovery of materials and energy from the waste stream. The area is currently being finalised and the lessons learnt are being used in the planning and development of the SRS. Over the years, the standards of Hammarby Sjöstad have become the standard for the rest of the City. Accordingly, the final stages of this development have been used as the baseline for the road map.

4.1 Baseline Emission Profile

4.1.1 Baseline Emissions – Energy

Preconditions – the Swedish Energy Sector

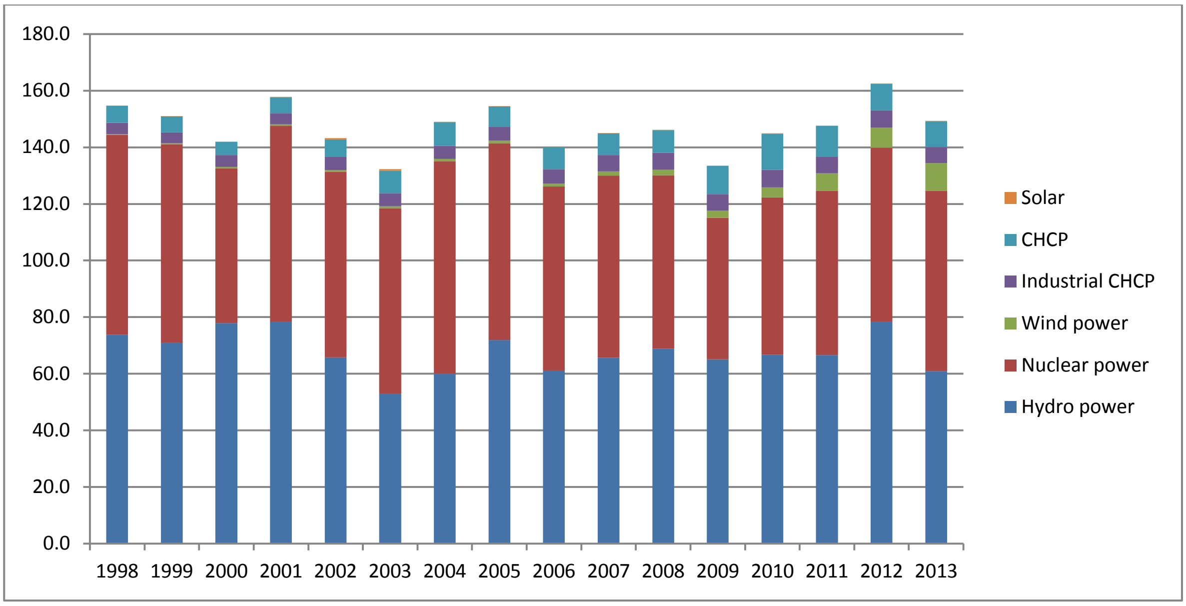
Electricity

About 70% of electricity is generated by hydro or nuclear power. The first national hydropower station for electricity production was taken into operation in 1882. In the 1940s and 1950s, about 100 large-scale hydropower plants were built in northern Sweden. Today, hydropower generation covers roughly 45-50% of the country's electricity needs. The use of nuclear power started in 1963, when the first rector was built and supplied the southern areas of Stockholm with electricity and heating. The first commercial large-scale reactor was built in 1970, and ten commercial reactors are presently in use.[2]

The need for renewable energy sources became evident during the 1970s energy crisis. Nevertheless, the use of wind energy only picked up in the 1980s after the first commercial turbine was taken into operation in 1982. After a relatively slow start, the development of renewable energy, such as wind, solar and wave power, is now increasing. Figure 1 shows the production capacity by energy carrier: in 2012, 43% of Swedish electricity was generated by hydropower, 25% by nuclear power, 15% by CHP and 12% by wind power.[3]

[2] History of hydropower and nuclear power generation, Eon and Vattenfall
[3] History of wind power, Eon

Figure 1. Swedish electricity production by carrier



Source: Energy in Sweden 2014, Swedish Energy Agency

The combination of energy carriers in Sweden provides an electricity mix with a relatively low emission factor. However, the Nordic countries and northern Germany have a connected electricity grid and a common energy market. Although the electricity generated in Sweden is a mix of about 65% renewable energy sources (hydropower, wind power and CHP plants) and 20% nuclear power, resulting in relatively low emission factors, the common grid that covers Sweden, Norway, Denmark and northern Germany motivates the use of the Nordic electricity mix rather than the Swedish electricity mix for the purpose of calculations.

Heating

The City started building a district heating network at the end of the 1940s and the first customers were connected in 1953. In 1957, the first CHP plant (CHPP) was built, with a publicly owned utility as the provider. Over the past decades, the benefits of the district heating system have motivated the extension of the grid to single-housing areas, replacing individual oil combusted heating systems. Today, a grid of seven CHPPs operated on 30% waste[4] and a network of some 1,300 kilometres supply heat to approximately 80% of Stockholm's buildings. A new bio-fuelled CHP system will be taken into operation in 2016 and the district heating system in Stockholm will, according to the utility, be carbon neutral by 2030 at the latest. In 2012, the ownership of the energy utility was transformed into a public-private partnership.[5]

Cooling

In the past, the need for cooling has been met by individual cooling systems. As the need for cooling increased, development of a district cooling system started in 1990s to provide primarily commercial buildings in the inner city with a reliable source of cooling. Some 10,000 customers (mainly commercial) are connected to the district cooling system.[6]

[4] The content of fossil fuels, including plastic in the waste fraction, is reflected in the emission data.
[5] Fortum Annual Report 2014
[6] Fortum Annual Report 2013

Biogas production

The production of biogas started in the 1960s, when sludge digesters were introduced at wastewater treatment plants (WWTP). In the 1980s, the potential to recover biogas from landfills and organic waste, primarily from the food industry, was explored and privately operated biogas plants were introduced. In 2014, the City of Stockholm approved an investment in infrastructure that will enable biogas production to be doubled. Biogas is mainly used as a replacement for fossil fuels in the industry and transport sector, but if there is a surplus it may be used to replace natural gas in the City's gas network.

Consumer perspective

Household energy use has changed over time. The combined energy consumption of households and the service sector nearly tripled between 1970 and 2000[7]. However, energy use has stabilised over the last 15 years, and the average for Sweden is 3.8 MWh per capita per year, which is lower than the average for the EU (4.8 MWh per capita per year). The average electricity use for Stockholm is approximately 3 MWh per capita per year.

Energy Emissions – Baseline

Energy is divided into three sub-categories: (1a) energy used in buildings, (1b) energy used in the maintenance and operation of infrastructure, and (1c) locally generated energy.

1a Emissions from energy used in buildings

The National Building Code restricts the energy performance of a building, defining the maximum average use of energy per square metre to obtain building permission. In 2010, when the Overall Environmental Programme for the SRS was established, the required energy performance in the Stockholm region was 110 kWh/m^2 for residential buildings, including heating, hot water and operational electricity for the building. Household electricity use is not included in this figure. In 2011, the requirement was lowered to 90 kWh/m^2 and since 2016 further decreased to 80 kWh/m^2. Securing its position as a frontrunner, Stockholm has introduced even stricter requirements for energy use in new buildings: 80 kWh/m^2 until 2012 and now 55 kWh/m^2 per year, which is approximately 40% lower than the current National Building Code.

A recently passed law limits the City's right to use binding requirements outside the National Building Code. However, civil agreements between the City and the developers can still be applied, and this will be the aim for the entire development.

As of 2008/2009, it is mandatory to declare a building's energy performance in a Declaration of Performance. Comparing the calculated energy performance of a building with the actual measured performance shows that energy use is, on average, 15-20% higher than the calculated performance. There are different explanations for this discrepancy; the difficulty of predicting user behaviour (mainly hot water use), the lack of a common basis for calculations and the lack of control during the planning and construction of a building are some assumed reasons. These three areas will be addressed in the SRS development, both at the requirement level and during the ambitious follow-up process.

[7] Energy in Sweden 2013, Swedish Energy Agency

For the baseline, the assumption is 102.5 kWh/m^2 per year, which is the reported average energy performance of buildings constructed in Hammarby Sjöstad in 2010[8]. This is assumed to be a good indication of the actual energy performance in newly constructed buildings.

The energy use in housing and commercial buildings differs. For example, offices and retail premises use cooling, which is very rare in housing. Accordingly, the buildings in the area have been subdivided into categories: residential, office, commercial and public amenity buildings, each with their own specific energy needs. All four building types use heating and electricity, whereas offices and commercial buildings also use cooling. Electricity is categorised as a) operational electricity, b) household electricity, and c) electricity for commercial use (Person et al., 2014). For further details, see Appendix B.

1b Emissions from energy used in infrastructure

The energy used in infrastructure is electricity used to power non-building specific infrastructure, such as traffic lights, streetlights, water and wastewater management.

The emissions originating from energy used in urban infrastructure, such as traffic lights, streetlights, water and wastewater management, are estimated using the average for Stockholm and applying this to the SRS. The City and its utilities use eco-labelled electricity purchased on an annual basis for all operations.

Emissions from water management, meaning the purification and distribution of potable water and collection and treatment of wastewater, are based on the Stockholm Water Company's Annual Report (Stockholm average). This is calculated based on an estimated water use of 150 l/person per day for residential purposes and 45 l/person per day for commercial purposes. Losses due to leakage are estimated at 24% in the water network and influx into the wastewater network is estimated at 35% (Rydberg & Hellstedt, 2012). For further details, see Appendix B.

1c Emissions from locally generated energy

The energy produced within the boundaries of the city district, meaning energy from photovoltaic (PV) cells and solar panels on buildings, local geothermal systems and so forth, is used to replace purchased energy from the grid.

The locally generated energy in the baseline is biogas. In the baseline, it is assumed that none of the buildings use waste disposers or local geothermal energy to replace district heating.

The biogas generated from the SRS, which originates from sludge treatment in the WWTP, is used to replace petrol and is therefore seen as a reduction in emissions that otherwise would have been generated in the traffic system. The data is based on the Stockholm Water Company's Annual Report (Stockholm average). The assumed amount of produced biogas energy in the baseline is 80 kWh/person per year for residents and 26 kWh/person per year for workers (Rydberg & Hellstedt, 2012).

At the WWTP, heat is recovered from wastewater and reversed into the district heating system.

[8] Declaration of Performance – Swedish Energy Agency

Table 3. Baseline – Summary of energy emissions

	Tonnes CO_2e	Tonnes CO_2e/cap
Emissions from buildings – heating	17,764	0.307
Emissions from buildings – cooling	293	0.005
Emissions from buildings – electricity	10,833	0.187
Emissions from infrastructure – electricity	38	0.001
Reduction of emissions – biogas	-658	-0.011
Total baseline energy emissions	**28,270**	**0.489**

4.1.2 Baseline Emissions – Transport

Preconditions – the Stockholm Transport Sector

Public transport

Stockholm is a city located on the water. Public transport by boats has been part of everyday life in the City since the early 1800s. In the late 1800s, trams were introduced and their use escalated quickly, reflecting the need for good transport solutions. The trams were initially operated by horse power, but when the City was electrified in the early 1900s, the trams were also electrified. With the advent of the combustion engine, taxis and buses were introduced. Stockholm's first inner city bus line was established in 1923 and the first underground line began operating in 1952.

Today, Stockholm has an efficient and well-developed public transport system, and public transport is used by 80% of all rush-hour commuters and for 60% of work-related trips. The public transport system consists of buses, trams, boats and an underground system, and covers the entire City. In total, 100% of the buses and 100% of the trams and underground trains in the City run on renewable energy.[9] Starting in 2014, the inner city buses will gradually be converted into energy-efficient hybrid buses. Only 5.3% of transport-related greenhouse gases are generated in the public transport system.

The importance of providing energy- and environmentally efficient transport systems was recognised on a national level in the 1970s. The Swedish government passed a law in 1978 stipulating that every region must have an authority that manages the provision of public transport. Responsibilities include not only provision and investments, but also the sustainability of the system.

One challenge for the public transport system is that the number of passengers is weather dependent and varies over the year. During winter and with harsh weather conditions the use of the public transport increases significantly. The system must be designed for the maximum capacity on a cold winter day, while the number of passengers decreases substantially in the summer.

Private vehicles

Something that has attracted considerable international attention is the City's congestion tax on travel in and out of the inner city, which has reduced motorised traffic in the city centre by 10-12%

[9] The Stockholm Public Transport Company's Annual Report 2013

since its introduction. Other benefits of the tax include shortened travel time by 30-40% and improved air quality by 10-14%.[10]

Bicycles

Stockholm has invested heavily in improving the conditions for bicycle traffic. Hundreds of kilometres of bicycle lanes have been built over the last few years. The number of people commuting to and from work by bike in the City has increased by about 75% over the past ten years. As for the public transport system, the number of cyclists varies significantly over the year; the number of cyclists peaks in May and September, and although more people ride their bikes in the winter than in the past, the number of cyclists in February is only 15-20% of the peak months.

Emissions

Transportation is divided into three categories: (2a) residents' and workers' travels, (2b) goods and services, and (2c) operation and maintenance of municipal infrastructure.

2a) Emissions from Residents' and Workers' Travels

The CCI framework suggests that 40% of all trips – commuting, work-related and leisure trips – starting and ending in the SRS should be included in the road map. The road map therefore includes residents' private and commuting trips, but excludes their business trips. On the other hand, it includes workers' commuting and business trips, but excludes their private trips.

Two methods have been used to source transportation data: the most recent study on travel behaviour for Stockholm (Ericsson & Fried, 2006) and a comprehensive analysis of transport behaviour in the Stockholm Royal Seaport (Glitterstam, et al.).

2b) Goods and Services

The main mode of supplying the area with goods and services is and will be by motorised transport, meaning light, heavy and trailer trucks. The assumption is that the SRS will require the same amount of transportation for goods and services as the rest of the City.

2c) Operation and Maintenance of Municipal Infrastructure

The operation and maintenance of the urban infrastructure is, to a large extent, carried out by motorised machinery. Activities include road maintenance, sanding and snow ploughing. The data is based on the City's overall data (Fahlberg et al., 2007).

Transport Emissions – Baseline

It is difficult to define emissions associated with transportation since a large amount of transportation occurs off-site, beyond the geographical boundary of the development. To simplify the calculations, the framework suggests that a percentage of the total emissions associated with vehicular trips that start or end in the district be included. The framework suggests that 40% of transportation emissions from trips that start or end on-site be included in the calculation. This method differs from the Stockholm method of allocating transport-related emissions, wherein

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[10] Analysis of Stockholm's traffic – with focus on the effects of congestion taxes 2005-2008

emissions are allocated only to the residents. However, the results, i.e. the number of generated trips of these two methodologies do not differ significantly and the CCI methodology has therefore been applied in this road map.

The emissions in the baseline have been calculated based on the findings of a comprehensive study that analyses how a reversed traffic hierarchy could be implemented in the SRS and the effects of such measures. The assumed modal split for the baseline is in line with Hammarby Sjöstad (see table XX), and the assumption of the number of motorised trips generated by households and commercial space are based on the figures generally used in traffic planning. The figures used for the number of trips in the baseline are 2.2 trips per household per day (365 travel days per year); the estimated number of trips for commercial and retail are 75 and 100/1,000 m^2 per day, respectively (226 travel days per year) (Glitterstam, 2014).

It is assumed that the residents travel 365 days per year and that the workers travel 226 (Glitterstam, 2014). The average trip lengths measured in person-kilometres (PKM) and the mode of transport used for each type of trip in the baseline are summarised in Appendix B.

A significant amount of goods enters the SRS by light, heavy and trailer trucks. The PKM/year and emissions are based on the assumption that the SRS will require the same amount of transportation for goods and services as the rest of the City.

In the baseline, diesel fuel is used to power vehicles carrying out road and infrastructure maintenance, such as road works, sanding and snow ploughing. The amount of diesel fuel is assumed to be the same as for the rest of Stockholm (Fahlberg et al., 2007).

Table 4. Baseline – Summary of transport emissions

	Tonnes CO_2e	Tonnes CO_2e/cap
Emissions from personal transport	22,255	
Emissions from goods and services	1,223	
Emissions from maintenance of road infrastructure	2,571	
Total baseline emissions	**26,049**	**0.451**

4.1.3 Baseline Emissions – Water and Waste

Preconditions

The following section addresses both liquid and solid waste.

A more organised waste management system was introduced in Stockholm in the mid-1800s as a result of a cholera epidemic in 1854. Latrine buckets were collected and taken into the archipelago. In 1908, some 38,000 tonnes of excreta from the City of Stockholm were handled by Stockholm's waste management organisation. Toilets had been introduced in the late 1800s, but were not allowed to be connected to the tap water network. This rule was changed in 1909, and toilets became more common, moving the excreta from land to water. In 1932, the first WWTP was put into operation. Since then, the centralised collection system and wastewater treatment have developed into a sophisticated system with 100% coverage, removing 99% of the phosphorus and organic compounds and about 70% of the nitrogen from all wastewater. Biogas has been produced at the WWTP since the 1990s.

The organised management of solid waste was introduced in the late 1800s, collecting waste at the household level and depositing it at landfills. Waste incineration was introduced as early as 1901, although a significant amount of waste was dumped in Lake Mälaren. It took almost 70 years before waste incineration plants became part the central heating system. It was recognised early on that the waste contained valuable resources. The Lövsta waste treatment plant began sorting waste in 2010, collecting glass, paper, metals and clothing from the waste stream and selling them separately. Organised waste separation at source was only introduced in the mid-1970s and, since then, a well-managed waste management system has been introduced. Municipalities are responsible for the collection of all household waste that is outside the producer's responsibility. Producers are responsible for all waste subject to statutory producer responsibility, such as waste paper, packaging, electrical and electronic waste, tyres, batteries and pharmaceuticals. To increase resource efficiency, a waste hierarchy is applied, which prioritises minimisation of waste and reuse over material and energy recovery. Landfill disposal is only permitted in exceptional cases. In Stockholm, the majority of household waste is recycled: 25% material recycling, 73% thermal recycling and 1.5% biological treatment. Less than 0.5% is taken to landfill sites. .[11]

Water and Waste Emissions – Baseline

Water and liquid waste

Emissions from water are based on the production distribution of potable water and the collection and treatment of wastewater. The baseline calculations are based on statistics from the Stockholm Water Company (average figures for Stockholm). The average domestic water use is 150 l/person per day and the average for commercial properties is 45 l/person per day. The estimated leakage from the water distribution network is 24% and the influx into the wastewater network is 35%. The total energy consumption for supplying water and treating wastewater for the SRS is 1,636,784 kWh/year, originating from renewable sources (Rydberg & Hellstedt, 2012).

Solid waste

The emissions from waste are divided into categories based on the different waste streams, such as mixed solid waste, gardening waste, glass and paper. For the baseline, general statistics for the Swedish waste system are used (Sundqvist & Palm, 2010).

The measurement for waste is generated on the basis of weight per year [tonnes of waste per year] and the corresponding emission factors vary depending on the collected materials and treatment method. There are three basic treatment options: material recycling, incineration and landfill.

Depending on the treatment method, the emission factor varies significantly. Since an accounting perspective is used, it is even possible to arrive at negative emissions from waste when two different treatment methods are possible. For example, extracting aluminium from bauxite (aluminium ore) is

[11] Renhållning och sophämtning i Stockholm http://sv.wikipedia.org/wiki/Sophämtning_i_Stockholm

a very energy-intensive process, while reusing recycled aluminium requires significantly less energy. Recycling aluminium will therefore reduce emissions compared with using virgin material.

It is important to note that since the waste generated in Stockholm is mainly used in City's district heating plants, there is a risk that the waste emissions will be reported twice unless it is clearly indicated what is included. Accordingly, the emissions already accounted for in the emissions from district heating have been deducted from the waste emissions in the summary below.

Table 6. Baseline – Summary of water, wastewater and solid waste emissions

Waste emissions	Tonnes CO_2e/year	Tonnes CO_2e/cap
Emission from water and liquid waste	26	
Emissions from solid waste	7,150	
Emission reductions from the recovery of materials	-8,709	
Emissions already accounted for in the district heating mix	-2,769	
Total waste emissions	**-4,302**	**-0.074**

Source: (Johansson et al., 2012b)

4.2 Summary of Baseline Emissions

The baseline emissions are summarised in Table 14:

Table 7. Baseline – Summary of emissions

Emission category	Tonnes CO_2e/year	Tonnes CO_2e/cap
Energy in buildings and infrastructure – total	28,270	0.489
Transport – total	26,049	0.451
Waste – total	-4,328	-0.075
Total emissions	**49,991**	**0.865**

Discussion:

Energy

More than 80% of the emissions in the SRS are related to buildings and infrastructure. Some of the required changes, such as a change of fuel in the district heating system, are out of the hands of the project. The project is therefore focusing on energy-efficiency measures and increased local energy production. At the same time, ambitions at the national and regional level play a significant role in the road map. The planned transition to renewables in the energy sector is crucial to achieving a climate positive city district.

In addition to energy efficiency, future planning will need to address a number of other issues, including how to avoid sub-optimisation in local energy production. For instance, if only climate effects would be taken into consideration the promotion of geo-thermal energy for heating purposes would be a priority. However, when considering resource efficiency in a wider perspective, the district heating system is without a doubt important to further develop.

One option is to create a decentralised district heating system for a section of the development that optimises the different need of energy over the year using large-scale geothermal storage underneath the development.

The regional versus local generation of electricity is also an issue for discussion. The emission factor for solar PVs is considerably higher (at the point of writing the report) than the emission factor for wind power generated regionally. There are however two main reasons to promote solar PVs, firstly that it is a measure to create awareness of both energy generation and use. Secondly by using solar PVs widely it creates opportunities for the market to produce PV-panels that are more sustainable.

Transport

Although transport-related emissions account for only about 25% of the total, they represent a major challenge since these emissions have no geographical boundaries and involve a higher degree of fossil fuel dependency. It would be difficult – or even impossible – for an isolated city district to implement special requirements or benefits related to transport, such as environmental zones or a fee reduction for electric vehicles. The project will instead focus on using various tools, such as restrictions on parking and incentives to use public transport. Consolidation of goods and the clear prioritisation of efficient modes of transport in traffic planning are other measures that will be incorporated. The road map also highlights the need for regional and national intervention to reach targets at the city district level.

Water and waste

Although the current water and waste management systems are already highly efficient, there are certain efficiency measures that could be implemented, such as reducing leakages in the water and wastewater network, increasing the recycling of nutrients from wastewater and improving the collection of organic waste for energy production.

However, the main challenge is to reduce the total amount of generated waste. The collected bulk waste is to a very large extent useable goods and materials. An improved collection and handling system for this fraction can contribute to a significant reduction of generated waste.

5. The Climate Positive Road Map – Strategies

The Climate Positive Road Map according to the CCI framework describes the steps that must be taken to create a climate positive urban district. The road map also outlines the measures that must be implemented in order to reduce the baseline emissions. There are three basic kinds of road-mapping measures:

- **Energy-efficiency measures** encompass all actions that result in smaller amounts of fuel or energy carriers being used compared with the baseline.
- **Fossil-fuel substitution measures** encompass all actions where fossil fuels or energy carriers are substituted with renewables or a mix with a higher degree of renewables. Certain fossil-fuel substitution measures are beyond the scope of the project's targets and vision, while others are decided by the project.
- **Behavioural change actions** lead to less GHG-intensive behaviour, such as replacing cars with public transport or turning off the stand-by function on electrical appliances.

The measures that have been quantified in the SRS road map are

1. Requirements that have been applied on the development since 2010 (SRS standards)
2. A progressive scenario, where there are potential improvements to be made (Progressive)
3. Credits – where the development in the SRS has clearly influenced other projects

See Appendix C page 46 for further details.

5.1 Road-Mapping Measures – Energy

The development of measures for the SRS is based on:

1. energy efficiency, meaning the construction of energy-efficient building envelopes
2. choice of locally adapted energy systems

In the section below, the four types of measures are described, starting with the non-project-related measures.

5.2.1 National and Regional Efforts Affecting the SRS

The emissions from district heating are also likely to change, but not as significantly after 2016, once the new bio-fuelled CHP system has been put into operation. The changes after that are still unknown.

Substitution of energy carries in the national and regional energy systems

The emissions from fuel and energy carriers are likely to change over time, especially if the planned expansion of renewable energy production in the Swedish and Nordic electricity grid is realised (Fahlberg et al., 2011). This means that the emissions from the SRS will also change over time. The speed and timeframe for this transformation is determined at the national level. Nevertheless, the SRS will benefit. The estimated changes according to planned developments up to 2016 are used in the calculation.

The conservative estimate is based on the energy companies' own plans up to 2016.

- Nordic electricity mix 79.5 g (2010) => 50.0 g CO_2e/kWh (2018)
- District heating (DH) 114.5 g (2010) => 102.0 g CO_2e/kWh (2018)

- District cooling (DC) 14.2 g (2010) => 13.4 g % CO_2e/kWh (2018)

It has been difficult to obtain reliable figures for the period after 2016 therefor the road map does not include a progressive estimate

Total reductions	**- 5,500 tonnes CO_2e**

5.2.2 Energy Efficiency

Energy efficient buildings

The concept is to ensure that the energy requirements of all new buildings in the SRS are as close as possible to the passive-house standard. Agreements have been signed with developers and a thorough monitoring process is in place to ensure that the targets are met. The City initiates a close dialogue early on in the development process and supports the developers throughout the planning and implementation stages. A capacity development programme has been set up and an energy expert evaluates all plans and measures and gives advice throughout the process.

SRS standard: Current requirement for developers: at 55 kWh/m^2/year (= 25 for hot water, 22 for heating and 8 for operational electricity), which is equivalent to a 40% reduction compared with the National Building Code.

The progressive scenario is based on a slightly more ambitious, yet achievable level of 45 kWh/m^2/year (= 20 for hot water, 18 for heating and 7 for operational electricity), which is equivalent to a 50% reduction compared with the National Building Code.

The long-term ambition is to achieve plus-energy buildings near the end of the project, based on a near-zero energy requirement in the buildings and local production of renewable energy. This scenario, however, is not included in the current road map. A competition for a plus-energy building was held in 2014 and, based on the experiences from this competition; a more progressive set of requirements will be developed.

Total reductions – SRS standards	**- 7,800 tonnes CO_2e/year**
Total reductions – Progressive	**- 9,800 tonnes CO_2e/year**

Energy efficient infrastructure

The planned efficiency measure in the infrastructure relates to water distribution and wastewater collection. According to the Stockholm Water Company (SVAB), the estimated loss from water network leakages is 24% and the estimated influx of groundwater into the sewers is 20%.

The SRS-standard includes a new network with measuring points in critical areas that will monitor the energy efficiency of the network.

The progressive scenario includes installing leak detectors in the network, leaks can be reduced and up to a third of the energy can be saved. Although a major energy saving would be achieved, the emission savings would be limited due to the use of eco-labelled electricity

Total reductions – SRS standards	**- 8 tonnes CO_2e/year**
Total reductions – Progressive	**+/- 0tonnes CO_2e/year**

5.2.3 Fuel Substituting Through Local Energy Generation

Local generation of geothermal energy

The use of locally generated GT heating and cooling is becoming a more attractive option for developers. The possibility to be independent and utilise a cost-saving renewable energy source is appealing. However, due to sub-surface infrastructure throughout the area and the fact that access to Lilla Värtan's water is restricted to Fortum's district cooling system, it is not an option for the entire development. The SRS-standard assumption is:

- 10% of residential buildings
- 50% of commercial and public buildings

will use GT heating and cooling.

The generated heating/cooling effect is 1:3. Since the energy used for running the heat-exchangers will be part of the building electricity, it is assumed that the used electricity is 100% eco-labelled.

A progressive scenario has not been included. The overall environmental benefits and not only climate effects have been taken into consideration in this decision.

Total reductions – SRS standards	**- 3,000 tonnes CO_2e/year**

Local generation of solar energy

Although Sweden is located quite far north, the use of solar energy generation on buildings is becoming cost effective. The challenge is to incorporate the technology into the design of the building and to develop business plans for long-term management and replacement over time.

For the road map, the SRS standard requirement is used:

- 2 kWh/ m^2 built floor area solar PVs, or
- 6 kWh/m^2 built floor area solar heating

will be installed on the buildings. The generated energy will be used to substitute purchased energy from the grid. The changes for the progressive scenario are only a result of changing energy carriers. There is no progressive scenario in terms of added installed effect, but the decreasing fossil influx in the overall grids contributes to comparatively higher emissions.

Total reductions – SRS standards	**+ 100-200 tonnes CO_2e/year**

Biogas

Increased collection of organic waste for biogas production is a goal for Stockholm. The target for the City is for 70% of all organic waste to be collected and used in biogas production. At present, some 5-10% of all food waste is collected. The City is trying out various systems to enable households to improve their waste collection. The biogas produced in Stockholm is used to substitute petrol

- The In the SRS, a system is being implemented for collecting organic waste through waste grinders connected to the sewers. The waste is processed at the existing biogas plant at the WWTP. Estimated average biogas generation per person:

- Sludge only: 80 kWh/person per year
- Sludge + organic waste: 120 kWh/person per year

- In the progressive scenario ground organic waste is collect separately and the expected exchange of energy increases by an estimated 25% as the organic compound is not used in the processes of the WWTP.

Total reductions – SRS standards	**- 1,000 tonnes CO_2e/year**
Total reductions – Progressive	**- 1,200 tonnes CO_2e/year**

5.2.4 Behavioural Change

Subscription to eco-labelled electricity

Eco-labelling of electricity has been introduced as a tool to increase the generation of renewable energy in Sweden. By subscribing to eco-labelled electricity, wind and/or hydropower, eco-labelled electricity is allocated to the user. There are three main areas where the use of eco-labelled electricity is being discussed:

- the operation of buildings
- electricity used in households
- electricity used in commercial activities

By subscribing to eco-labelled electricity, the emission factor is reduced. For example, wind power accounts for one-fifth of the Nordic electricity mix. The subscription does not necessarily increase the amount of renewable energy generated, but contributes to reducing the exchange of energy over national boarders, by selling “renewable energy” and replacing it with purchased “fossil coal energy”.[12]

- In the SRS standard the assumption is that 50% of building electricity, 25% of household electricity and 50% of commercial electricity is eco-labelled.
- In the progressive scenario the assumption is that 100% of building electricity, 75% of household electricity and 100% of commercial electricity is eco-labelled

Total reductions – SRS standard	**- 2,000 tonnes CO_2e/year**
Total reductions – Progressive	**- 4,400 tonnes CO_2e/year**

[12] Carbon dioxide signals for Swedish internal electricity consumption, Evin Jamal, KTH 2013.

5.2.4 Summary of effects of energy measures

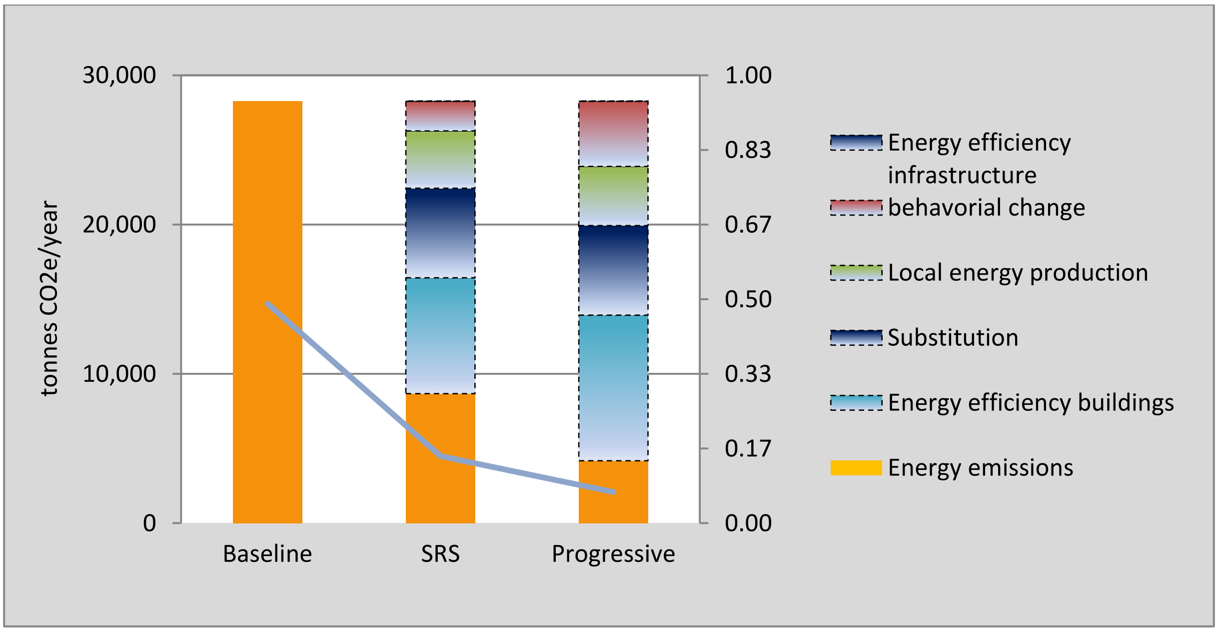
Table 8. Total road map measures (energy) – Summary of energy savings and emission reductions

	SRS standards		Progressive	
	tonnes CO_2e	tonnes CO_2e/cap	tonnes CO_2e	tonnes CO_2e/cap
Baseline	28,270	0.489	28,270	0.489
National/regional efforts	-5,996		-5,996	
Energy efficiency – buildings	-7,758		-9,752	
Energy efficiency – infrastructure	-9		-9	
Geothermal	-2,952		-2,952	
Solar energy	+102		+222	
Biogas production	-987		-1,234	
Behavioural change	-1,985		-4,360	
Total	**8,685**	**0.150**	**4,189**	**0.072**

With the present level of requirements, GHG emissions will be reduced by about 65%. The slightly more ambitious targets will reduce GHG by an additional 15%.

The figure below summarises the reduction of emissions due to energy measures.

Figure 2. Summary of energy emission reductions



5.2.5 Discussion

The effects of the measures are directly linked to the emission factor for the various forms of energy. The “cleaner” the energy, the smaller the effects of the measures from a GHG perspective. The Swedish energy systems are based on a large share of renewable and nuclear energy and therefore have a lower share of fossil fuels. The changes in the systems are beyond the scope of the project, but the City’s overall efforts to be fossil fuel free by 2040 and the national targets for the energy sector strongly support the road map. The issue of energy use still needs to be addressed.

The road map shows that the best effects can be achieved through changes in robust, large-scale infrastructure. Measures such as changing energy carriers in the supply system or constructing buildings in an energy-efficient manner and installing energy-efficient equipment in buildings and infrastructure will have the best effects. The effects of such measures are also much more likely to last over time than measures requiring individual choices and decisions that could be hampered by weighing the cost against the environmental benefit.

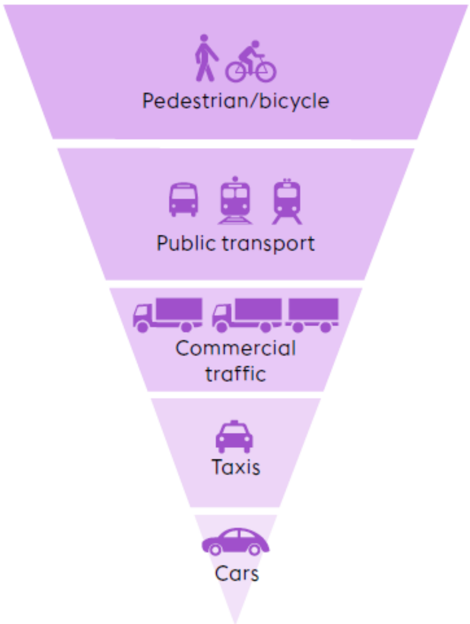
The SRS road map does not contain many awareness-related behavioural change measures, mainly because Swedish research has shown that displaying energy use could actually be counterproductive. In a study made by one of the public housing companies, Stockholmshem, the consumption of hot water increased; when residents realised the low cost of hot water. On the other hand, energy and water use are lower per capita in single-family houses, probably due to the residents’ awareness of their use and the related costs. The assumption is that the behavioural aspect probably accounts for a relatively small share of the total effect and is difficult to calculate, and a choice has been made not to incorporate it.

The road map highlights the challenge facing Stockholm, which is to increase energy efficiency per capita. Based on the results of the road map, the use of thermal energy in combination with solar heating needs to be further investigated. However, the requirements should not lead to sub-optimisation, and other aspects, such as cost and operational robustness, need to be factored in.

The large scale generation of electricity is extremely efficient in terms of climate effects, and local electricity generation will therefore contribute to increased climate emissions. However, the symbolic value of displaying local energy production, the potential to increase the efficiency of PVs and support the market are important factors.

Another aspect that has to be taken into consideration is that a city district that has a lifespan of one to 200 years needs to be flexible, and decisions must be made with a long-term perspective in mind. Today’s energy prices and the energy carriers in the systems may change over time, which could affect the long-term outcome.

5.2 Road-Mapping Measures – Transport



The overall guiding principle for the SRS is the so-called reversed traffic hierarchy (se figure xxx), where pedestrians and cyclists are to be prioritised. This prioritisation should be reflected in the use of street space, planning of properties and the accessibility of various modes of transport.

The transport system is complex. Available research on effects focuses on isolated measures, such as the effects of availability of parking and improved access to public transport. Throughout the road map process, it has become clear that the best thing we can do at this time is to describe the various measures, and make a qualified estimate of their effects.

5.2.1 National Efforts Affecting the Project

Changes in the car fleet

The commitment of both the national government and the regional authorities is necessary to achieve the goals in the transport sector. On a national level, restrictions and incentives that contribute to the development of the car fleet as well as the infrastructure for and use of renewable fuels must be established. By creating local, environmental zones, the City could enhance the effects of these measures. Although the measures are out of the City's control, these aspects are fundamental pieces of the puzzle.

Emissions from personal vehicles are linked to the future development of the vehicle fleet. The rate at which people change to cars that run on renewable fuels is dependent on legislation and national policies. Over the years, the change has been slow, but positive.

With respect to heavy traffic, the Swedish government investigated the possibility to achieve fossil fuel independence for road traffic.[13] According to this study, it is likely that heavy traffic will operate on electricity earlier than private vehicles.

The conservative assumption is that the current trajectory of the share of the personal vehicle fleet running on renewable fuels will continue => 10% of the total PKM will be shifted from fossil fuels to renewables (biogas, ethanol and electricity). Heavy traffic: 80% operates on electricity. Nordic electricity mix been used in the calculations.

The progressive assumption is that national policies will be put in place to aid a significant greening of the personal vehicle fleet. It is assumed that more than 95% of the total PKM will be shifted from

[13] Fossil fuel free transport system – National investigation (Fossilfrihet på väg), SOU 2013:84

fossil fuels to renewables (biogas, electricity, ethanol and hybrids). Heavy traffic: 80% operates on electricity. 50% on the Nordic electricity mix and 50% on an environmentally labelled electricity mix.

Fuel efficiency in vehicles

The dependency on fossil fuels in the transport sector is an issue that has been discussed for many years and, as fuels have become increasingly expensive, the automotive industry has developed more efficient combustion engines.

Emissions from vehicles are linked to the development of the vehicle fleet. The assumption is that the historical development of fuel efficiency will continue => 30% more energy-efficient vehicles

Total reductions – Conservative	**- 9,600 tonnes CO_2e/year**
Total reductions – Progressive	**- 15,100 tonnes CO_2e/year**

5.2.2 Transport Efficiency

Implementation of traffic hierarchy

The planning of the SRS transport system is based on a reversed traffic hierarchy, where pedestrians, cyclists and public transport are to be prioritised in the planning of the City. Cars will be allowed, but access to parking will be limited.

The conservative approach has been implemented in the first areas. Pedestrians and cyclists have been given ample space, public transport – namely, buses – shares space with other traffic, and parking spaces, although limited in number, are available in the basements of the properties.

The assumed effect of the measures is a modal split somewhere between Hammarby Sjöstad and the inner city.

The progressive approach is to implement the traffic hierarchy to the full extent. Pedestrians and cyclists have access to all streets and passages, with a network that allows for high-speed commuting as well as safe streets for children. Public transport – a tram – forms the backbone of the development, with its own space and few intersections in order to limit disturbances, which allows for timely, fast and frequent service. Car pools with cars running on renewable fuels are easily available throughout the area and parking for private cars is available in detached garages.

The assumed effect of the measures is a modal split similar to the inner city, but with a lower rate of car use.

Total reductions – SRS standards (see Appendix C for details)	**- 2,700 tonnes CO_2e/year**
Total reductions – Progressive	**- 2,500 tonnes CO_2e/year**

Improved logistics

A goods consolidation centre will be implemented in or in the vicinity of the SRS. A conservative estimate is that the supply of goods and services through this consolidation centre will reduce emissions from trailer and heavy trucks by 50% and from light trucks by 30%.

Total reductions – SRS standards	**- 59 tonnes CO_2e/year**
Total reductions – Progressive	**- 39 tonnes CO_2e/year**

Improved energy efficiency in the infrastructure

To optimise the energy use for operation and maintenance of streets public open space. The challenge is that it is specially designed machinery that is used and standards have to be changed over time To substitute fuels in maintenance machinery, from fossil fuels to electricity and biogas,

Total reductions SRS & Progressive Standards	**-800 tonnes CO_2e/year**

5.2.3 Behavioural Change

Mobility management

To influence the individual's choice of transport towards a more sustainable option. Provide support to promote sustainable choices with ICT solutions. Companies are encouraged to provide personal MM plans to their employees. A travel planner combining all modes of transport is to be made available to workers and residents. Real-time information in public places, car pools, sharing systems and so forth.

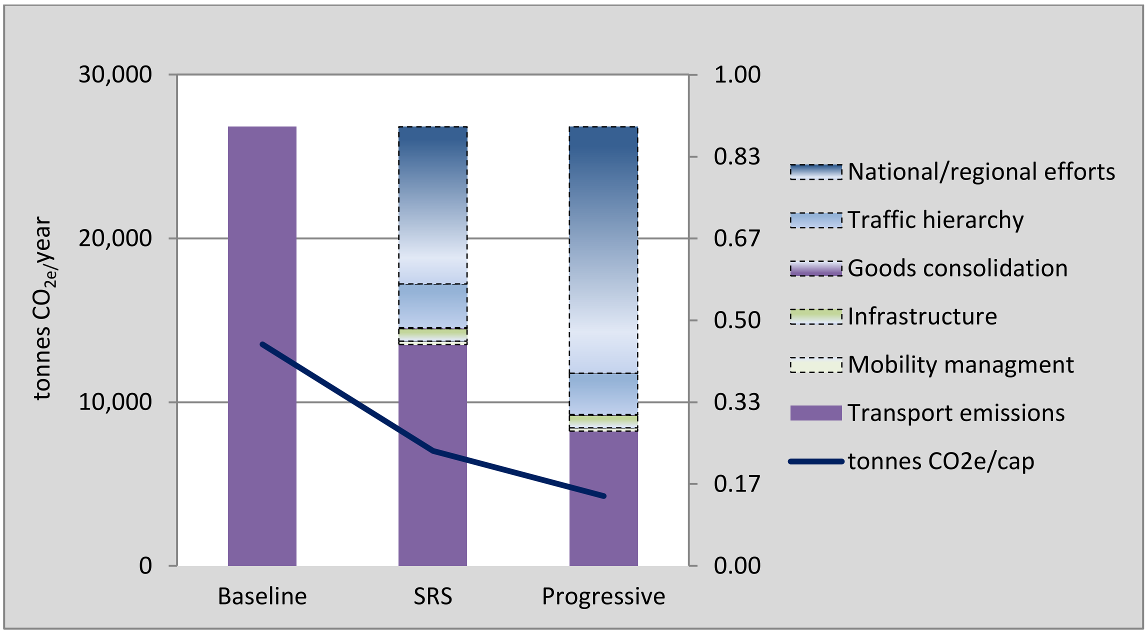
Total reductions – SRS standards	**-200 tonnes CO_2e/year**

5.2.4 Summary of Effects of Transport Measures

Table 3. Summary of energy savings and emission reductions within the SRS boundary (40% of all traffic)

	Baseline	**SRS standards**		**Progressive**	
		CO_2e/year	CO_2e/cap	CO_2e/year	CO_2e/cap
Baseline	26,049	26,049	0.451	26,049	0.451
National/regional efforts		-9,596		-15,052	
Traffic hierarchy		-2,667		-2,522	
Goods consolidation		-59		-39	
Infrastructure		-771		-771	
Mobility management		-203		-203	
Total	**26,049**	**13,525**	**0.234**	**8,235**	**0.142**

The figure below summarises the reduction of emissions due to transport measures. Figure 4. Summary of energy emission reductions due to transport measures



5.2.5 Discussion

How to effectively assess and estimate the effects of transport measures has proven to be complex and nearly impossible. The effect of each separate measure can be estimated, but when one or more measures are combined, the effects are not cumulative. Another difficulty is that transport is not confined to geographical boundaries, and measures outside the boundary affect the travel pattern in the area – positively and negatively. Individual choice – the last unpredictable factor – is something that changes over time, and although efforts are made to assess trends, there are too many societal factors that affect travel behaviour that are impossible to predict. Weather conditions are just one example of a factor that affects travel patterns.

The challenge in the transport sector is the dependency on fossil fuels. The national goals for a fossil fuel-free society are important factors for reaching the goal. According to national forecasts, the transport sector and public transport systems are expected to run on renewables by 2030. For the private vehicle fleet, the change is going to take longer. Irrespective of what is being done to minimise the transport need, some vehicles will continue to run on fossil fuels. The transformation of the vehicle fleet is a national – or perhaps even global – undertaking. It is not enough to implement policies, regulations and incentives in the city district; these must be citywide, if not nationwide. However, the SRS is an affluent area and changes in the vehicle fleet are likely to happen faster in this area, given that national and city regulations support and encourage ownership of environmentally friendly vehicles.

The other major challenge pertains to vehicles for operation and maintenance of the infrastructure. The development of this machinery is subject to procurement policies and, since the Swedish Transport Administration is a major player, this segment could also see a more rapid development to replace fossil fuels with renewables.

5.3 Road-Mapping Measures – Waste

The road-mapping measures for waste are more complex than those for energy and transportation since they do not involve a single action, but rather a number of actions focusing on different aspects of waste, such as waste minimisation, collection, treatment and recycling.

The waste hierarchy is used to prioritise measures related to waste. The order of priority means that one should preferably prevent waste or alternatively reuse it, thirdly remanufacture it and so on. The option that provides the best results for the environment as a whole should be selected. In some cases, it may be necessary to deviate from the hierarchy in terms of specific waste streams when this is justified on the grounds of technical feasibility, economic viability or environmental protection.

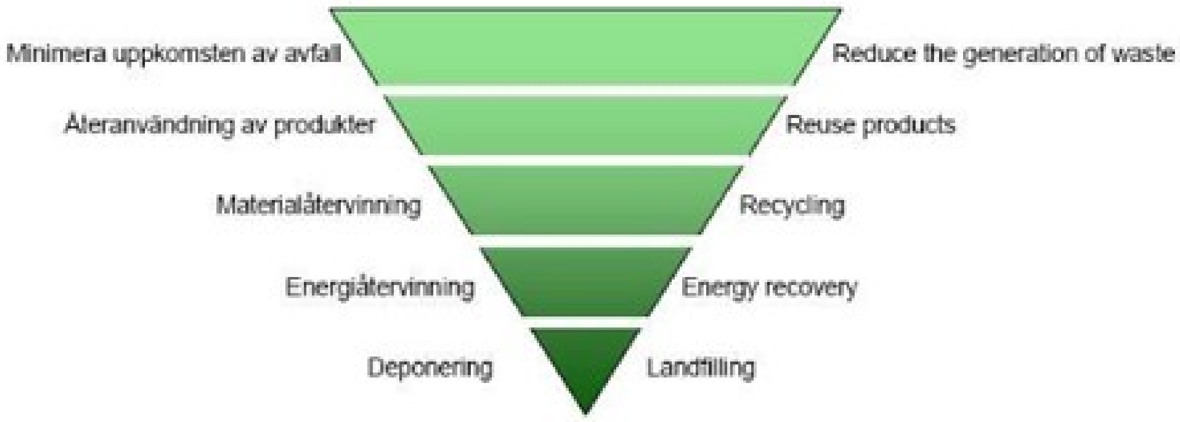


Figure XXX: Waste hierarchy

5.3.1 Waste Management

The waste management system in Stockholm is highly efficient. Household waste and eight to ten other fractions are normally collected at the property. The challenge in Sweden is to reduce the total amount of generated waste.

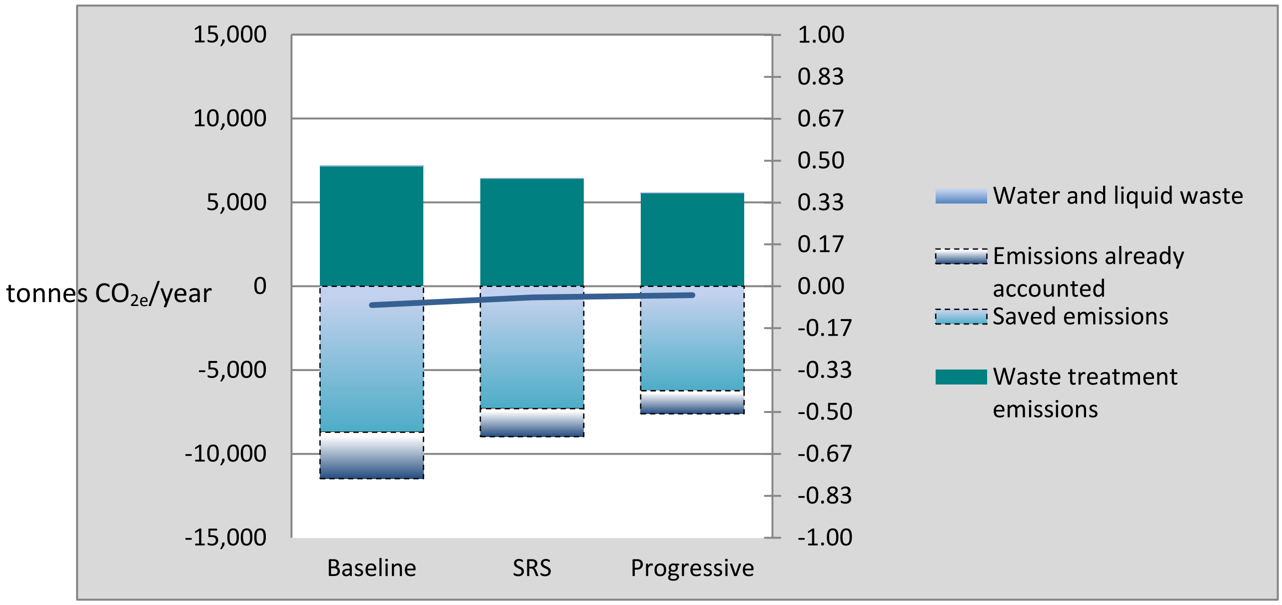
The conservative approach focuses on installing systems that contribute to a 10% reduction in waste, increasing material recovery by 5% and collecting more food waste. This is achieved by having an automated waste collection system combined with a recycling room in every building. Waste grinders collect the organic household waste sent to the sewer system. It is also assumed that gardening waste is recycled locally and that a local reuse centre is established.

The progressive approach focuses on further increasing recycling rates and improving the collection of organic waste.

Total reductions – SRS standards	**-2,600 tonnes CO_2e/year**
Total reductions – Progressive	**- 2,100 tonnes CO_2e/year**

5.3.2 Summary of climate emissions reductions – waste emissions

Figure 5. Summary of waste emission reductions due to waste measures



5.3.4 Discussion

The total emissions from waste are already negative in the baseline, using the CCI's accounting methods (only accounting for waste management and recycling, not the whole lifecycle). However, applying the same method, this could be interpreted to mean that waste generation should be encouraged since the level of net negative emissions decreases when the amount of waste is reduced, which in itself is counterproductive. Reducing the amount of waste is always beneficial from a sustainability perspective.

The challenge for the future is to minimise waste. For example, in Stockholm, 20-25% of purchased food goes to waste. Even if the organic waste is collected and biogas is produced, this is not sustainable. Waste generation is also an indicator of consumption patterns.

5.1 Credits

The credit system has been introduced to emphasise any measures that would affect urban developments outside the project area. In the case of the SRS, one of the aims of the project is to influence the rest of the City's developments. Some of the identified credits that could be accounted for according to CCI are described below.

See Appendix D page 62 for further details.

5.4.1 Credits Accounted for in the Road Map

Learning from the SRS development process, the City has begun to implement more stringent energy requirements for new developments. This means that 7,000 apartments, or roughly 700,000 square metres of developed area per year, will be developed with lower energy use than the requirements in the National Building Code. The "gap" between the City's requirements and the requirements of the National Building Code can be accounted for as a credit.

The SRS also has a huge influence on the surrounding municipalities with respect to both the sharing of knowledge between municipalities and the knowledge and experience gained by the developers through their involvement in the SRS. When it comes to calculating magnitude, the application is slightly delayed compared with Stockholm, and a timespan of five years has been used in the calculations.

Total credits – within Stockholm municipality	**-19,300 tonnes CO_2e/year**
Total credits – in surrounding municipalities	**-10,500 tonnes CO_2e/year**

5.4.2 Credits Not Accounted for in the Road Map

Training and capacity building: So far, some 40 developers, each bringing architects and consultants, have gone through an extensive training programme. This will in the long run benefit the construction industry in the long run.

Stockholm Royal Seaport Innovation: The aim of the SRSI is to disseminate knowledge and results originating in the SRS to the rest of Stockholm. The SRSI holds a mini trade fair to connect developers and their design consultants with suppliers of various green-tech solutions. The fair is open to all developers in Stockholm.

Construction Consolidation Centre: The SRS has developed a Construction Consolidation Centre to reduce construction traffic into and out of the area. The CCC also provides services that reduce waste, damages and losses during the construction phase. The concept will be replicated in two other major urban development projects in Stockholm.

Research and development results passed on: The SRS is conducting some 20 research and development projects on various topics through national funding. The results from these projects will be widely spread and applied throughout Sweden through articles and reports.

Innovative ways of developing projects: Innovation competitions, innovation procurement and negotiated procurement are new ways of introducing new ideas into the development, which are receiving local as well as national attention.

SRS as a lighthouse project – inspiration for others: Every year, professionals, civil servants and politicians visit the SRS project to learn from the experiences gained during planning and implementation. Most of these visitors come to learn and draw inspiration for their own work.

5.4.1 Discussion

Even though the ambitions in SRS are high, the net emissions will not be below zero (in other words, will not be climate positive) unless effects outside the area can be included. Under the CCI framework, development partners are permitted to earn climate positive credits. Since the SRS has been designated as a lighthouse project – primarily aimed at influencing the City as a whole, but also all of the stakeholders involved, as well as influencing urban development at the global level – the project will contribute to many potential credits. The list of credits is not comprehensive.

However, the need to make changes that contribute to direct effects is more important than credits. The ambition of the SRS project is to develop a city district that is as energy efficient and as close to carbon neutral as possible, on its own merits. This is more difficult than trying to identify and calculate credits, and limits the risk of greenwashing, something that urban developments in affluent areas are often accused of.

The SRS Road Map therefore includes the one credit that is easiest to calculate: the impact on energy efficiency in the future development of the City. However, the list of potential credits is far longer. The SRS project's ambition is to contribute to actual changes by demonstrating how to limit emissions to an absolute minimum, rather than aiming to be climate positive.

5.2 Summary of Road Map Emissions

The table below summarises the Stockholm Royal Seaport road map.

	Baseline tonnes CO_{2e}/year	SRS tonnes CO_{2e}/year	Progressive tonnes CO_{2e}/year
Energy	28,270	9,326	4,821
Transport	26,049	13,525	8,235
Waste	-4,328	-2,556	-2,057
Total road map	**49,991**	**20,295**	**10,870**
Credits		-29,870	-29,870
Road map including credits		**-9,575**	**-18,872**

Summary of climate emission reductions – Total emissions

Figure 6. Summary of emission reductions due to measures – without using credits

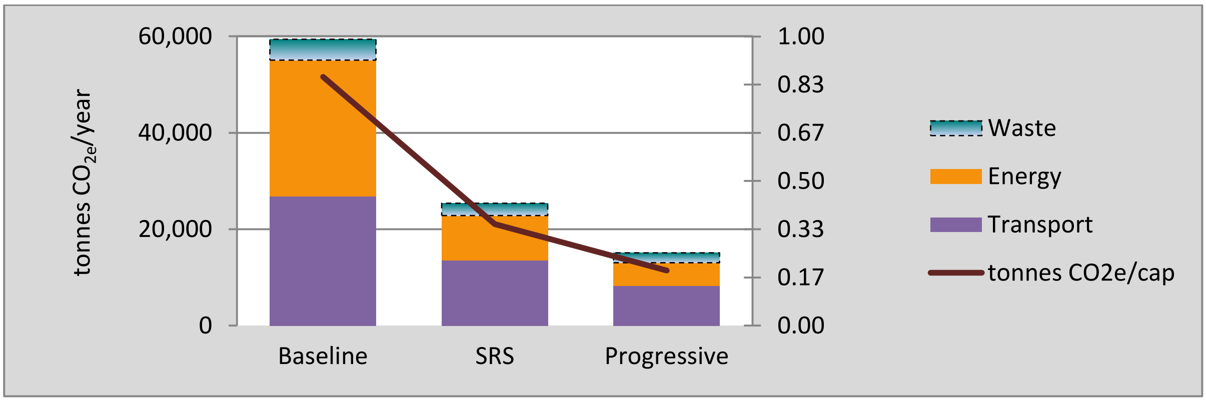
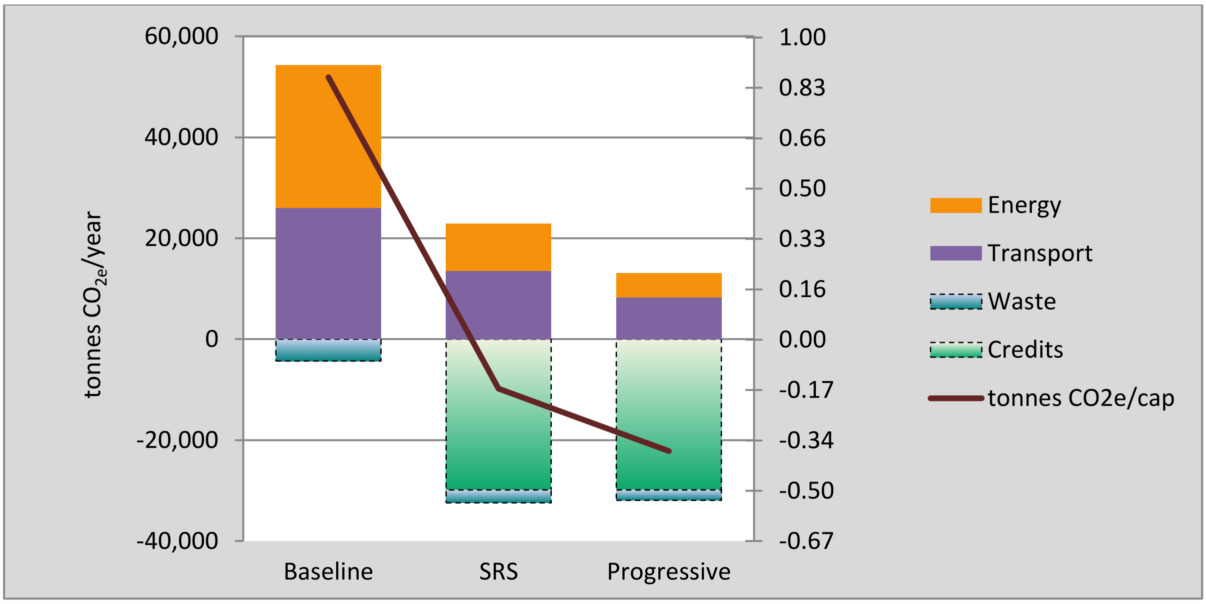


Figure 7. Summary of emission reductions due to measures – using credits



5.5.1 Discussion

The most significant impact will be achieved as a result of the high use of energy in properties and the fact that Stockholm's energy systems are large-scale and robust. As soon as personal choice comes into play, the possibility to predict individual choices becomes more difficult and less robust – as is the case with traffic. However, when combined with tariffs, good infrastructure that enables sustainable choices can also be effective. The waste management and public transport systems are examples of this.

However, the transportation sector presents a challenge. The growth of the City, the limited space available and the future need for an efficient supply to the City have contributed to a broad political understanding and support for making the necessary changes to the traffic system. This will be beneficial to the SRS, since new concepts will be tested with broad political support.

The method is simple to use if data is available. Even in Sweden, where data is collected and generally made public, it is difficult to obtain the specific, personal data sometimes needed to make such precise calculations. The main difficulty has been to calculate the effects of the traffic system. There seems to be little data and few methods available that take biking and walking into consideration as a mode of transport. The figures for the effects of this type of traffic are rough estimations.

There are a number of emissions that are not included in the CCI's methodology. The total impact of these emissions, should they be included, is significant. Although they are not included in the CCI's methodology at present, establishing road-mapping measures that would limit these types of emissions could be a viable approach. Some emissions are also excluded due the methodology's focus on the urban district rather than the City as a whole.

Other emissions, such as embedded emissions, are not included due to the temporal boundary. A recent study of the Swedish building sector concluded that embedded emissions are equivalent to approximately 50 years of operation in a regular Swedish building. With the SRS preconditions on energy efficient buildings, this would be equivalent to some 100 years of operation, a significant and very important aspect that needs to be taken into consideration in the road map process.

Swedish consumption patterns contribute to some 60-80% of GHG emissions, depending on location and family conditions. The question of how to approach this issue and how to incorporate consumption into a climate positive framework must be given some thought.

The goal of becoming a climate positive city district by 2030 has forced the City to work hard from the start to identify measures that will reduce emissions and to incorporate these measures into the development process. It has also challenged the City, developers and other stakeholders involved to look at the development process from a different perspective. Instead of the "traditional" approach of minimising energy use and emissions, the focus has been on asking, "What would it take to create a climate positive transportation system in the SRS?" This has also contributed to new collaborations between stakeholders that traditionally have not interacted and to a broader approach.

6. Measurement and Verification Plan

The conservative estimates of the measures in the road map represent requirements that have already been imposed on the developers. To monitor the results, the project has developed a comprehensive measurement and verification plan. All developers will report their results and achievements in a database at seven different stages of the development process. During the design and construction stages, the results will be calculated. These results, focusing on such areas as energy efficiency, waste management and general resource use, will be verified twice during the process. The results will be made public and be distributed to the decision-makers, as well as all of the developers. An annual report will be made available on the Internet.

The verification of the road map measures will be derived from this database, and it will be possible to monitor the progress on an annual basis.

Verification will be performed on an annual basis.

7. Conclusions and Recommendations

7.1. Conclusions

This process has been very interesting; it is an excellent way of working in an integrated manner. The methodology of developing a road map has been a useful tool for identifying the activities and measures that will have the greatest impact on emissions, thereby providing a tool for prioritisation.

Although we are confident that we have adopted a proactive and ambitious approach, it is incredibly difficult to become carbon neutral. Having the ambition to be climate positive represents an even greater challenge.

Cities and municipalities are in an excellent position to influence development on a broader level. This has already been proven in Hammarby Sjöstad, and in the case of the Stockholm Royal Seaport, the ambition level is even higher. By being transparent and making the process public, we believe that stakeholders can be encouraged to work together to achieve these goals.

An environmentally profiled city district such as the SRS is likely to have several impacts that are difficult to identify and even more difficult to quantify. The “Credits” section in this report contains extensive information on knowledge and technology transfer that will not only benefit Stockholm and Sweden, but hopefully also provide inspiration globally.

The CCI process has contributed to improving the City’s on-going efforts to improve GHG calculation methods. For example, to only include emissions that are originating from a specific urban district and calculate the effects of direct measures gives a better understanding of scenarios. Compared with other cities with ambitious GHG targets, the City is now able to present highly transparent calculations and assumptions based on local urban district-specific data, which will only grow more accurate over time as data from the first residents is collected.

7.2. Challenges

The experiences gained from Hammarby Sjöstad and other initiatives to monitor progress have proven that it is difficult to reach the calculated energy performances. In the SRS project, the ambition is to have a comprehensive monitoring process in place from the very earliest stages of the building design process, along with a close dialogue with developers throughout all phases. This approach appears to be effective and sufficient to reach the goals. The verification after two years in use is now being reported for the first phase and, although there are variations, on average the energy used is lower than the calculated level.

Transport has proven to be extremely difficult to project. The behavioural aspects and the complexity of transport systems make it extremely difficult to assess the effects of the measures. Transport is not confined to specific geographical boundaries, and most incentives and restrictions are managed on a national level, which means that the outcome of the transport measures will depend on the ambitions of the national government.

Other aspects, such as embedded energy and consumption, are contributing significantly to the CO_2 footprint of the city district. These aspects need to be integrated into the long-term calculation.

7.3.Recommendations

The process of developing the CCI roadmap has been inspiring and a good learning curve to understand the effects of the different requirements we have on our developers and ourselves. The networking also enables sharing of good examples, of methods and tools that can be altered to suit your own preconditions.

Based on the experiences of the process our recommendations to improve the framework are

- The framework should include emissions from the entire life cycle, such as embedded energy, and not only operational energy.
- Methods to calculate and assess the emissions from consumption would be beneficial.

The lessons that we would like to share with other potential participants are

- Start from existing preconditions and develop the strategies from there
- Identify “low-hanging fruits”
- Include cost-benefit analyses at the start, and assess the long-term investment
- Public-private cooperation/partnerships based on robust business models if the state/municipality/city cannot provide essential systems
- Political will is essential – changes need strong political support
- Communicate your success story
- Integrate your processes, involve stakeholders for a mutual learning process
- Governance is essential: “carrot and stick” approach through dialogue – resources are needed
- Extended your public participation process – involve the future users
- Utilise holistic planning, sett ambitious goals and involve stakeholders
- If the City owns the land, set ambitious requirements for the development

- Facilitate partnerships, secure political support
- Initiate innovative procurement, competition to create new ideas
- Extended citizen participation processes
- Create feedback processes to learn from and share good practice and implement in future development areas

Appendix A – Basic Data

Basic data

The SRS development

	Assumptions for the development (at completion 2030)
Number of apartments	12 000
Number of residents	22 800 (based on 1,9 residents per apartment)
Number of workers	35 000
Residential space	1 372 080 m^2
Office space	854 796 m^2
Commercial space	100 818 m^2
Public amenity space	11 400 m^2

Source: City of Stockholm plans as of 2012-02-08 (Christina Salmhofer, 2013)

Calculation of Capita

	Assumptions for the development (at completion 2030)
Number of residents	22 800
Number of workers	35 000
No of capita	**57 800**

Source: City of Stockholm plans as of 2012-02-08 (Christina Salmhofer, 2013)

Appendix B – Baseline

<u>Baseline – Energy</u>

Table B1: Baseline – Annual Energy use/m^2 and type

		Baseline	SRS standards	Progressive estimate
Residential	Heating	52,50	27,00	18,00
	Hot water	35,00	20,00	20,00
	Cooling	0,00	0,00	0,00
	Building electricity	15,00	8,00	8,00
	Household electricity	30,00	30,00	30,00
Commercial	Heating	35,00	18,00	15,00
	Hot water	2,00	2,00	2,00
	Cooling	20,00	10,00	10,00
	Building electricity	25,00	25,00	18,00
	Commercial electricity	50,00	50,00	50,00
Retail	Heating	25,00	18,00	15,00
	Hot water	2,00	2,00	2,00
	Cooling	35,00	15,00	10,00
	Building electricity	20,00	20,00	18,00
	Commercial electricity	80,00	80,00	80,00
Public amenities	Heating	55,00	35,00	25,00
	Hot water	10,00	5,00	5,00
	Cooling	0,00	5,00	5,00
	Building electricity	15,00	10,00	10,00
	Household electricity	35,00	35,00	35,00

Source: (Johansson et al., 2013)

Table B2: Baseline – Emission factors 2010

Energy type	CO_2/kWh	Energy type	CO_2/kWh
District heating	114,50	Solar heating	50,86
District cooling	14,21	Biogas	25,40
Electricity	79,50	Petrol	272,35
SolarPv	30,00		

Source: (Johansson et al., 2013 and City of Stockholm)

Table B3: Baseline - Energy use in buildings, by type

Type of building	Heating + hot water	Cooling	% connected to district heating/cooling	Building electricity	Household electricity	Commercial electricity
	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2
Domestic	87,5		100%	15	30	
Commercial	37,0	20	100%	25		50
Retail	27	35	100%	20		80
Public	65		100%	15		35

Source: (Johansson et al., 2013 and Boverkets databas för energideklarationer ??)

Table B4: Baseline – Energy use and emissions from energy used in buildings, totals

Area of Emissions	Energy use [MWh/year]	Emissions [ton CO_2e/year]	Emissions [ton CO_2e/cap]
Heating totals	155 148	17 764	0,307
Cooling totals	20 625	293	0,005
Electricity totals	136 505	10 807	0,188
Totals	**312 360**	**28 902**	**0,500**

Table B5: Baseline - Energy use and emissions from electricity used for maintaining SRS infrastructure

Infrastructure emissions	Baseline Energy use [MWh/year]	Emissions [ton CO_2e/year]	Emissions [ton CO_2e/cap]
Electricity (street & traffic lights etc.)	756	11	0,000
Water management	1 750	26	0,000
Totals	**2 506**	**38**	**0,001**

Source: (Johansson et al., 2013)

Table B6: Baseline – Energy generation and emissions from locally generated energy

	Generated energy [MWh/year]	Emissions [ton CO_2e/year]	Emissions [ton CO_2e/cap]
Biogas generated from sewage	2 664	68	
Amount of replaced fossil fuels (petrol)	2 664	726	
Totals	**0**	**-658**	**-0,011**

Source: (Johansson et al., 2013)

Table B7: Baseline – Summary Energy emissions

	ton CO_2e	ton CO_2e/cap
Emissions from buildings - heating	17 764	0,307
Emissions from buildings - cooling	293	0,005
Emissions from buildings - electricity	10 807	0,188
Emissions from infrastr. - electricity	38	0,001
Reduction of emissions - biogas	-658	-0,011
Total Baseline emissions	**28 270**	**0,489**

Table B8: Baseline – Transportation

Baseline – traffic generation by car

Type of development	Generation factor	No of trips	Travelled days	Total no of trips per year
Residential	2,2 trips per apartment and day	26 400	365	9 636 000
Commercial	75 trips per 1000 sqm and day	64 050	226	14 475 300
Retail	100 trips per 1000 sqm and day	10 080	226	2 278 080
Total No of trips by car		100 530		26 389 380

Source: (Glitterstam et al., 2014)

Table B9: Baseline – Modal split – assumption based on Stockholm average

Mode of transport	No of trip	Average distance of trips	Travelled distance km/year	40% acc. to CCI framework
Car	26 389 380	10,3	99 250 800	136 334 154
Public transport	48 112 475	18,5	267 793 050	742 696 533
Walking and biking	29 661 935	18,5	42 144 480	177 184

Source: (Glitterstam et al., 2014)

Table B10: Baseline – Emission factors and vehicle fleet composition

Modes of transport		Emission factor g CO_2e/PKM	Vehicle Fleet Share of %	Emissions tonnes CO_2e
Cars	Biogas	15,93	1,6	34,75
	Diesel (5% RME)	166,04	21,4	4 844,16
	Electric	11,56	0,004	0,06
	Ethanol E85	76,78	11,6	1 214,18
	Petrol E5	170,81	63,7	14 833,71
	Hybrid Electric/Gasoline	136,65	1,6	298,07
Public transport	Bus	4,13	32,0	980,36
	Subway/tram	0,05	26,0	9,56
	Commuter train	0,13	42,0	40,55
Total emission personal transport				**22 255,49**

Source: (Johansson et al., 2012b)

Table B11: Baseline - Emissions from goods and services

Modes of transport	Distance travelled km/year	Emission factor g CO_2e/VKM	Vehicle Fleet Share of %	Emissions tonnes CO_2e
Light trucks	2 799 168	299,93	45,0	377,80
Heavy trucks	2 153 206	691,72	35,0	521,30
Trailer trucks	1 345 754	1 202,41	20,0	323,63
Total emission personal transport				**1 222,72**

Source: (Johansson et al., 2012b)

Table B12: Baseline - Emissions from the maintenance of road infrastructure

Emissions from the maintenance of the infrastructure	Baseline energy use MWh/year	Emissions ton CO_2e/year
Diesel fuel used for road maintenance	9 204	2 571

Source: (Johansson et al., 2012b)

Table B13: Baseline – Summary Transport emissions

	ton CO_2e	ton CO_2e/cap
Emissions from personal transort	22 255	
Emissions from goods & services	1 223	
Emissions from Maintenance if road infrastructure	2 571	
Total Baseline emissions	**26 049**	**0,451**

Table B14: Baseline – Waste

Baseline - Amounts of generated waste, emission factors and direct and saved emissions

	Residents	Workers	SRS total	Emission factors		Emissions	Saved emissions
				Generation	Recycling		
Waste fractions	Ton/year	Ton/year	Ton/year	g CO_2e/ton	g CO_2e/ton	ton CO_2e/year	ton CO_2e/year
Mixed MSW	5 711	3 290	9 001	0,38	-0,43	3 421	-3 871
Bulk waste	3 801	0	3 801	0,01	-0,41	38	-1 558
Gardening waste	146	0	146	0,04	-0,14	6	-20
Packaging		0	0	0,19	-0,23	0	0
Glass	595	259	854	0,24	-0,42	205	-359
Paper packaging	160	1 092	1 252	0,24	-0,42	300	-526
Newspapers	1 076	1 712	2 788	0,24	-0,42	669	-1 171
Metal packaging	27	100	128	0,17	-0,78	22	-100
Plastic packaging	57	877	934	2,51	-0,99	2 345	-925
Electronics	278	112	390	0,31	-0,36	121	-140
Other	59	0	59	0,40	-0,67	24	-40
Total	**11 911**	**7 442**	**19 353**			**7 150**	**-8 709**
Emissions included in district heating			**-2,58**			**-2 769**	

Table B15: Baseline - Summary of waste emissions

	ton CO_2e/year
Waste treatment	7 150
Saved emissions from recyling	-8 709
Emissions already accounted for	-2 769
Net emission - ton CO2e/year	-4 328
Per capita emission - ton CO2e/cap, year	-0,075

Appendix C – Roadmap

Road-Mapping Measures - Energy

Measure E1 - Substitution of energy carries in the national and regional energy systems

The challenge	Supplying the area with energy produced from renewables.
The concept	The speed and timeframe for transforming the energy supply are to be determined at the national level. Nevertheless, the SRS will benefit. The estimated changes according to planned developments up to 2016 are used in the calculation.
Conservative	• Nordic electricity mix 79.5 g (2010) => 50.0 (2018) CO_2e/kWh • District heating (DH) 114.5 g (2010) => 102.0 (2018) CO_2e/kWh • District cooling (DC) 14.2 g (2010) => 13.4 (2018) CO_2e/kWh
Progressive	The energy mix will change over time, but it has been difficult to obtain reliable figures for the period after 2016.
Impact	The replacement of energy carriers has excellent potential since the impact is felt throughout the system. In the SRS, the changes planned by the energy utilities will contribute to a significant reduction in emissions.
Responsibilities	The energy utilities are responsible for planning and implementing the transformation of the energy systems.
Benefits	The substitution of energy carriers is a national undertaking aimed at achieving the national climate goals, but is also a significant component of the SRS Road Map.
Robustness	Changes in the supply system are efficient and reliable.
Activity plan	The project does not influence developments in the energy grids.
Financing	The investments are included in the energy cost.
Potential	Investments in large-scale clean energy sources are extremely efficient.
Milestones	Shifting energy carriers in the district heating system from fossil fuels to renewables starts in 2016 and will be completed by 2030.

Estimated emission reductions

	Baseline ton CO_2e/	**Conserv.** ton CO_2e/year	**Savings** ton CO_2e/year
District Heating	17 764	15 825	1 457
District Cooling	293	276	17
Electricity Mix - Nordic	10 845	6 805	4 027
Total Emission Reduction			**5 501**

Measure E2 - Energy efficient buildings

The challenge	80% of the climate emissions in the baseline are related to energy used in housing, where heating and electricity are the two outstanding contributors. Improved energy efficiency in the building envelope and the building installations are important aspects to consider as the building lifecycle is expected to be a

	hundred years or more. There is potential to improve the energy efficiency of the homes and commercial spaces that will be built in the SRS. For example, plus-energy buildings tested on a small scale, but the challenge is to streamline the concept and help developers to acquire the knowledge needed for implementation on a large scale.
The concept	The concept is to ensure that the energy requirements of all new buildings in the SRS are as close as possible to the passive-house standard. Agreements have been signed with developers and a thorough monitoring process is in place to ensure that the targets are met. The City initiates a close dialogue early on in the development process and supports the developers throughout the planning and implementation stages. A capacity development programme has been set up and an energy expert evaluates all plans and measures and gives advice throughout the process.
SRS standard	Current requirement for developers: at 55 kWh/m^2/annum (= 25 for hot water, 22 for heating and 8 for operational electricity), which is equivalent to a 40% reduction compared with the National Building Code.
Progressive	The progressive scenario is based on a slightly more ambitious, yet achievable level of 45 kWh/m^2/annum (= 20 for hot water, 18 for heating and 7 for operational electricity), which is equivalent to a 50% reduction compared with the National Building Code. The long-term ambition is to achieve plus-energy buildings near the end of the project, based on a near-zero energy requirement in the buildings and local production of renewable energy. This scenario, however, is not included in the current road map. A competition for a plus-energy building was held in 2014 and, based on the experiences from this competition, a more progressive set of requirements will be developed.
Responsibilities	The City of Stockholm Development Administration is responsible for developing targets and requirements, as well as monitoring compliance. The developers are responsible for the implementation of the concept.
Impact	Heating is the most utilised form of energy in buildings. Although district heating is based on renewables, the emission factor is relatively high. Accordingly, the impact of energy-efficient buildings is by far the most important measure to implement. The reduced need for heating in the conservative scenario (SRS-standards) alone would cut emissions by 20-25%.
Robustness of the concept	The development agreements stipulate the requirements for developers. So far, the developers have done their utmost to comply with the requirements. However, the impact can only be verified once the buildings have been in use for more than two years.
Activity plan and timeframes	The agreements for the first phase (4,000 apartments) of the development contain energy targets. These buildings will be constructed over the next five years. Agreements for additional phases (approximately 3,000 apartments) will be signed in 2015 and 2016. A competition for a plus-energy building was held in 2014 and, based on the experiences from this competition, targets may change.
Costs and financing	The extra costs for this measure are related to additional insulation and more efficient energy systems. So far, there are no isolated figures available for the cost of the measure. However, the developers are incorporating the costs into the overall project budget and this is reflected in the offer for the land. The developers leasing the land have included the cost in their long-term financial management plan.

	Ultimately, the homeowners and tenants will carry the costs.
Potential to replicate	The target level of 55 kWh/m^2 has already been adopted as the energy requirement for all new developments in Stockholm. There are also indications that large, nationwide companies are incorporating the knowledge they HAVE gained in this project into their general production. Experiences from Hammarby Sjöstad also show that once a concept has been developed, implemented and evaluated, it becomes mainstream.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result. The first two phases of the development have been completed and data is now being delivered. The results are in line with the requirements.

Estimated emission reductions

	Baseline		SRS Standards		Progressive	
	Used energy MWh	Emissions ton CO_2e	Used energy MWh	Emissions ton CO_2e	Used energy MWh	Emissions ton CO_2e
District Heating	155 148	15 825	84 056	8 574	68 726	7 010
District Cooling	20 625	276	18 665	250	9 613	129
Electrical Mix - Nordic	136 505	6 805	126 844	6 324	120 658	6 015
Totals		22 906		15 148		13 154
Total Emission Reduction				**-7 758**		**-9 752**

Measure E3 - Energy efficient infrastructure

The challenge	Energy is mainly used in the City's infrastructure for street lights, traffic and water management. The City manages this infrastructure and, over the years, has been successful in reducing costs and energy use. The City as a whole subscribes to eco-labelled energy. For the past five to ten years, the City has been implementing a programme to replace all lights in the City with energy-efficient – and thus cost-effective – streetlights and traffic signals. The potential to reduce emissions from traffic infrastructure is therefore, in comparison, limited. The treatment of both potable water and wastewater is highly centralised and efficient. The treatment plants also generate energy (heating and biogas). The water and sewer network in the City is old; some parts are more than 100 years old. Leaks – which waste potable water and increase the volume of water to be treated at the WWTP – offer the greatest potential for emission savings.
The concept	The planned efficiency measure in the infrastructure relates to water distribution and wastewater collection. According to the Stockholm Water Company (SVAAB), the estimated loss from water network leakages is 24% and the estimated influx of groundwater into the sewers is 20%.
SRS standard	A new network with measuring points in critical areas will monitor the efficiency of the network.
Progressive	By installing leak detectors in the network, leaks can be reduced and up to a third of the energy can be saved. Although a major energy saving would be achieved, the emission savings would be limited due to the use of eco-labelled electricity.
The impact	Reduced energy use for water treatment and distribution, as well as wastewater

	collection and treatment.
Responsibilities	The City of Stockholm Development Administration is responsible for defining targets and constructing the system. The Stockholm Water Company is responsible for management of the system.
Robustness of the concept	The City's utility is constantly developing methods and routines to improve leak detection.
Activity plan and timeframes	There are no particular activities incorporated into the on-going development other than monitoring of distributed water and collected wastewater. In the future, the networks might be equipped with a leak detector system to capture information at an early stage.
Costs and financing	The Stockholm Water Company is financing the implementation. Developers pay a connection fee.
Potential to replicate	If successful, it will be replicated in all new developments in Stockholm. There is also potential to use the same approach for major refurbishments of the networks.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

	Baseline		**SRS Standards**		**Progressive**	
	Used energy MWh	Emissions ton CO_2e	Used energy MWh	Emissions ton CO_2e	Used energy MWh	Emissions ton CO_2e
Water & wastewater mngm	1 750	26	1 166	18		
Total Emission Reduction				**8**		

Measure E4 – Substitution of energy carriers from local sources

E4.1 - Local generation of geothermal energy

The challenge	The use of locally generated GT heating and cooling is becoming a more attractive option for developers. The possibility to be independent and utilise a cost-saving renewable energy source is appealing. However, due to sub-surface infrastructure throughout the area and the fact that access to Lilla Värtan's water is restricted to Fortum's district cooling system, it is not an option for the entire development. At the moment, there is no requirement stipulating GT systems, as it is not possible to implement everywhere.
The concept SRS standard	For the road map, the assumption is that: • 10% of residential buildings • 50% of commercial and public buildings will utilise GT heating and cooling. The generated heating/cooling effect is 1:3. Since the energy used for running the heat-exchangers will be part of the building electricity, it is assumed that the used electricity is 100% eco-labelled. The reason why there is no progressive scenario is that the City has to take other aspects, such as resource efficiency, into consideration in the decision process.

	The use of thermal energy is therefore not promoted over the use of district heating. A progressive scenario has not been included. The overall environmental benefits and not only climate effects have been taken into consideration in this decision.
Impact	For every kWh of district heating that is replaced with geothermal heating, GHG emissions are reduced by 90%.
Responsibilities	Private and public developers are responsible for the selection and implementation of the energy system.
Benefits	In the short term, the reduced operational costs will be included in the overall financial plan, which will benefit the developer. The long-term operational costs for a building will be reduced, which will benefit the owner of the property.
Robustness of the concept	The developers decide on the energy system, and the current energy prices are an important factor. At the moment, the pay-off period for a GT system is about eight to ten years. There is an ongoing discussion about the benefits of GT versus DH, in terms of both primary energy sources and how to secure provision of heating for all residents. If the majority of the developers in an area choose GT, the incentive for the utility to invest in a DH grid is low. The need for extra heating during extreme winters is also an issue for discussion.
Activity plan and timeframes	In the first 20 phases of the development, the assumptions with respect to the ratio of properties connected to district systems and generation of local GT energy appear to be appropriate.
Costs and financing	The developers carry the costs of the investment, which are then included in the overall investment and financial management plan.
Potential to replicate	The technology is widely used in Stockholm. Limitations arise when sub-surface infrastructure restricts sinking of boreholes. Using GT combined with solar heating to regenerate heat during the summer will also minimise the risk of peak loads. The cost of the system is highly competitive compared with district heating.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

	Baseline			**SRS Standards**		
	Used energy MWh	Emission factor	Emissions ton CO_2e	Used energy MWh	Emission factor	Emissions ton CO_2e
District Heating - res	120 057	102,0	12 246	108 051	102,0	11 021
District Heating – other	35 091	102,0	3 579	17 545	102,0	1 790
District Cooling -other	20 625	13,4	276	10 312	13,4	138
Geo-thermal - residential				12 006	5,0	60
Geo-thermal - other				27 858	5,0	140
Totals			16 101			13 149
Total Emission Reduction						**-2 952**

E4.2- Local generation of solar energy

The challenge	Although Sweden is located quite far north, the use of solar energy generation on buildings is becoming cost effective. The challenge is to incorporate the technology into the design of the building and to develop business plans for long-term management and replacement over time.
The concept SRS standard	For the road map, the assumption is that: • 2 kWh/ m^2 built floor area solar PVs, or • 6 kWh/m^2 built floor area solar heating will be installed on the buildings. The generated energy will be used to substitute purchased energy from the grid. The changes for the progressive scenario are only a result of changing energy carriers.
Impact	The geothermal heating system is highly efficient, providing 3 kWh of heat per kWh of electricity. For every kWh of district heating that is replaced with geothermal heating, GHG emissions are reduced by 90%.
Responsibilities	The City of Stockholm Development Administration is responsible for the development of targets and requirements, as well as monitoring compliance. Private and public developers are responsible for investing in and maintaining the solar energy systems.
Benefits	In the short term, the reduced operational costs will be included in the overall financial plan, which will benefit the developer. The long-term operational costs for a building will be reduced, which will benefit the owners of the property.
Robustness of the concept	The initial investment is guaranteed through requirements in the development agreements between the City and the developers. The long-term reinvestment is guaranteed if the prices on solar PVs are reduced.
Activity plan and timeframes	For the first 20 phases of the development, it appears that the developers have chosen solar PVs.
Costs and financing	The developers carry the costs and take investment costs into account when designing the energy systems. The required amount of energy can be used within the property, thereby substituting purchased energy.
Potential to replicate	The inclusion of solar PVs as a design concept on roofs and facades is becoming more common as the price of solar PVs is reduced.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

	Sqm	**Potential**	**Emission factors**			**Emissions**	
		MWh	PV/heating	2018	Progressive	SRS	Progressive
Electricity	2 339 094	3 437	30,00	50,00	15,09	- 69	51
Heating	620 715	3 724	50,86	5,03	5,03	171	171
Total						**102**	**222**

E4.3 –Biogas generation

The challenge	Increased collection of organic waste for biogas production is a goal for Stockholm. The target for the City is for 70% of all organic waste to be collected and used in biogas production. At present, some 5-10% of all food waste is collected. The City is trying out various systems to enable households to improve their waste collection.
The concept SRS standard	In the SRS, a system is being implemented for collecting organic waste through waste grinders connected to the sewers. The waste is processed at the existing biogas plant at the WWTP. The biogas produced in Stockholm is used to substitute petrol. Estimated average biogas generation per person: • **Sludge** only: 80 kWh/person per year • Sludge + organic waste: 120 kWh/person per year The estimated emission factors are Biogas = 25,40g CO2e/kWh Diesel = 272,35g CO2e/kWh
Progressive	In the progressive scenario ground organic waste is collected separately. By not discharging the organic waste into the sewer, the expected exchange of energy increases by an estimated 25% as the organic compound is not used in the processes of the WWTP.
Impact	The use of biogas to substitute petrol or diesel reduces GHG emissions by 90%. The demand is greater than the supply, and all biogas produced will be utilised.
Responsibilities	The City of Stockholm Development Administration is responsible for the development of targets and requirements, as well as monitoring compliance. Public and private developers are responsible for installing waste disposal units in the kitchen. The Stockholm Water Company manages the biogas plant.
Robustness of the concept	The infrastructure for the production of biogas is readily available and the challenge is to collect organic waste in a way that is easy for the homeowners. The installation is part of the development agreement between the City and the developers. To ensure replacement, the process must be understood and user friendly.
Activity plan and timeframes	Waste disposal units connected to the sewer have been installed from the beginning of the development. The separate collection of organic waste will be tried out on a pilot basis in the first section of the development.
Costs and financing	Developers carry the cost for installations for waste disposal units in the buildings. Users benefit from the reduced cost for waste management. The biogas is produced is an existing system with a market for the product. The societal benefit is increasing biogas production to substitute petrol.
Potential to replicate	The technology has excellent potential to be used in Stockholm since waste disposal units can be installed anywhere. The infrastructure to manage the waste exists and the benefits are immediate.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

	Baseline		SRS standards		Progressive	
	Energy MWh	**Emissions ton CO_2e**	**Energy MWh**	**Emissions ton CO_2e**	**Energy MWh**	**Emissions ton CO_2e**

Produced biogas	2 664	67,67	3 996	101	4 995	126,2
Replaced petrol	2 664	725,55	3 996	1 088	4 995	1 360
Total Emission Reduction		**-658**		**-987**		**-1 234**

Measure E5 – Behavioural change, subscription to eco-labelled electricity

The challenge	Eco-labelling of electricity has been introduced as a tool to increase the generation of renewable energy in Sweden. The challenge is to increase people's awareness and understanding of the importance of participating in this type of consumer-driven activity. In the commercial sector, the use of eco-labelled electricity is much more common since it is part of many companies' environmental management systems (EMS).
The concept	By subscribing to eco-labelled electricity, wind and/or hydropower, eco-labelled electricity is allocated to the user. There are three main areas where the use of eco-labelled electricity is being discussed: • the operation of buildings • electricity used in households • electricity used in commercial activities The estimates are (conservative/progressive). By subscribing to eco-labelled electricity, the emission factor is reduced. For example, wind power accounts for one-third of the Nordic electricity mix. The subscription does not necessarily increase the amount of renewable energy generated, but contributes to reducing the exchange of energy over national boarders, by selling "renewable energy" and replacing it with purchased "fossil coal energy".[14]
SRS standard	50% of building electricity, 25% of household electricity and 50% of commercial electricity is eco-labelled. Emission factors: Nordic electricity mix = 50,00 g CO_2e/kWh Environmentally labelled electricity mix = 15,09 g CO_2e/kWh
Progressive	100% of building electricity, 75% of household electricity and 100% of commercial electricity is eco-labelled
Responsibilities	The City of Stockholm Development Administration is responsible for the development of targets and requirements, as well as monitoring compliance. Developers, residents and commercial actors subscribe individually.
Impact	The short-term, global impact will be minimal, but as the market for renewable energy grows, the willingness to invest in new renewable energy plants will increase.
Robustness of the concept	The choice to subscribe to eco-labelled electricity is made by individual companies, housing associations and residents. The cost is slightly higher, so the subscription requires understanding and commitment.
Activity plan and timeframes	Requirements on developers to provide information to initiate the subscription. Information to all new residents moving in.
Costs and financing	The extra cost is carried by the residents and companies.
Potential to	Can be replicated anywhere, since it does not require an investment in

[14] Carbon dioxide signals for Swedish internal electricity consumption, Evin Jamal, KTH 2013.

replicate	infrastructure.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

	Energy use	Baseline		SRS Standards		Progressive	
	MWh	share	ton CO_2e	share	ton CO_2e	share	ton CO_2e
Operational electricity	50 805	3%	2 487	50%	1 653	100%	767
Household electricity	44 138	3%	2 161	25%	1 822	25%	1 051
Commercial electricity	41 162	25%	2 152	50%	1 340	100%	621
			6 799		4 815		2 439
Total Emission Reduction					**-1 985**		**-4 360**

Road-Mapping Measures – Transport

General preconditions

Emission factors g CO_2/PKM and vehicle fleet composition %

Modes of transport		**Emission factor g CO_2e/PKM**	**Baseline Share of %**	**Conservative Share of %**	**Progressive Share of %**
Cars	Biogas	15,93	1,6	4,3	9,0
	Diesel (5% RME)	166,04	21,4	18,7	5,0
	Electric	11,56	0,004	2,8	15,0
	Ethanol E85	76,78	11,6	14,1	5,0
	Petrol E5	170,81	63,7	55,8	3,0
	Hybrid Electric/Ethanol	61,42	0,0	0,0	12,0
	Hybrid Electric/Gasoline	136,65	1,6	4,3	4,0
	Plug in hybrid Ethanol	61,42	0,0	0,0	10,0
	Plug in hybrid Gasoline	136,65	0,0	0,0	37,0

Source: (Johansson et al., 2012b)

Modes of transport		**Emission factor g CO_2e/kWh**	**Baseline Share of %**	**Conservative Share of %**	**Progressive Share of %**
Buses	Biogas	81,06	100	20	20
	Electric (Nordic)	50,00		80	
	Electric (Env label)	15,09			80
Trucks	Diesel (5% RME)	166,04	100		
	Biogas	81,06		20	20
	Electric (Nordic)	50,00		80	
	Electric (Env label)	15,09			80

Source: (SOU 2013:84)

Measure T1 - Substitution of energy carries in the national and regional energy systems

T1.1 - Changes in the car fleet

The challenge	The dependency on fossil fuels in the transport sector is an issue that has been discussed for many years and, as fuels have become increasingly expensive, the automotive industry has developed more efficient combustion engines.
The concept	Emissions from personal vehicles are linked to the future development of the vehicle fleet. The rate at which people change to cars that run on renewable fuels is dependent on legislation and national policies. Over the years, the change has been slow, but positive. With respect to heavy traffic, the Swedish government investigated the possibility to achieve fossil fuel independence for road traffic.[15] According to this study, it is likely that heavy traffic will operate on electricity earlier than private vehicles.
Conservative	The conservative assumption is that the current trajectory of the share of the personal vehicle fleet running on renewable fuels will continue => 10% of the total PKM will be shifted from fossil fuels to renewables (biogas, ethanol and electricity). Heavy traffic: 80% operates on electricity. Nordic electricity mix been used in the calculations.
Progressive	The progressive assumption is that national policies will be put in place to aid a significant greening of the personal vehicle fleet. It is assumed that more than 95% of the total PKM will be shifted from fossil fuels to renewables (biogas, electricity, ethanol and hybrids). Heavy traffic: 80% operates on electricity. 50% on the Nordic electricity mix and 50% on an environmentally labelled electricity mix.
Responsibility	The national government and authorities are responsible for laws and regulations. The City is responsible for implementing environmental zones. The Stockholm Public Transport Company is responsible for the choice of fuels for the public transport vehicle fleet.
Impact	Reduced emissions from vehicles.
Robustness of the concept	Stockholm plans to be a fossil fuel-free city by 2040. This commitment will require polices and legislation that support the transformation of the vehicle fleet.
Activity plan and timeframes	N/A
Costs and financing	The owners carry the cost of changing vehicles. The conservative estimate is based on historical patterns and will not entail any additional cost. The progressive estimate will entail higher costs, possibly reduced through subsidies from the national and local government.
Potential to replicate	Stockholm is committed to becoming fossil fuel free by 2040. This is a first step toward testing the feasibility of this goal and determining what regulations are required.

[15] Fossil free transport system – National investigation (Fossilfrihet på väg), SOU 2013:84

T1.2 – Fuel Efficiency in Vehicles

The challenge	The dependency on fossil fuels in the transport sector is an issue that has been discussed for many years and, as fuels have become increasingly expensive, the automotive industry has developed more efficient combustion engines.
The concept	Emissions from vehicles are linked to the development of the vehicle fleet. The assumption is that the historical development of fuel efficiency will continue => 30% more energy-efficient vehicles
Responsibilities	National government, vehicle manufacturers.
Impact	Reduced energy use and emissions from vehicles.
Robustness of the concept	Fuel efficiency is primarily a marketing issue for vehicle manufacturers and has been the driving force in the past. National and global awareness of climate change is likely to contribute to the development.
Activity plan and timeframes	N/A
Cots and financing	The owners carry the cost of changing vehicles.
Potential to replicate	Global development, but the rate of increased efficiency depends on the rate at which vehicles are replaced.

Estimated emission reductions (T1.1 + T1.2)

	Baseline ton CO_2e/year	**Conservative ton CO_2e/year**	**savings**	**Progressive ton CO_2e/cap**	**savings**
Cars	21 224	13 750		8 586	
Public transport	1 030	721		512	
Goods and services	1 223	181		98	
Maintenance equipment	2 571	1 800		1 800	
Total	**26 048**	**16 452**	**- 9 596**	**10 996**	**- 15 052**
Per cap	**0,450**	**0,284**		**0,190**	

T2 – Implementation of Traffic Hierarchy

The challenge	The transport sector is complex and it is difficult to make predictions in a controlled way. The transport system consists of thousands of individuals that make decisions based on their own convenience at any given moment. Among other factors, transport behaviours are dependent on distance to destination, time accuracy, flexibility and convenience. In addition, Stockholm's population is expected to grow by about 40% in the next 15 years, but the available space for transport will be more or less the same. The challenge is to utilise the road network as efficiently as possible.
The concept	The planning of the SRS transport system is based on a reversed traffic hierarchy, where pedestrians, cyclists and public transport are to be prioritised in the planning of the City. Cars will be allowed, but access to parking will be limited.
SRS standards	The conservative approach has been implemented in the first areas. Pedestrians and cyclists have been given ample space, public transport –

	namely, buses – shares space with other traffic, and parking spaces, although limited in number, are available in the basements of the properties. The assumed effect of the measures is a modal split somewhere between Hammarby Sjöstad and the inner city. Modal Split: Cars 17%, Public transport 49%, Bikers/pedestrians 34%
Progressive	The progressive approach is to implement the traffic hierarchy to the full extent. Pedestrians and cyclists have access to all streets and passages, with a network that allows for high-speed commuting as well as safe streets for children. Public transport – a tram – forms the backbone of the development, with its own space and few intersections in order to limit disturbances, which allows for timely, fast and frequent service. Car pools with cars running on renewable fuels are easily available throughout the area and parking for private cars is available in detached garages. The assumed effect of the measures is a modal split similar to the inner city, but with a lower rate of car use. Modal split: Cars 15%, Public transport 45%, Bikers/pedestrians 40%
Responsibilities	The City of Stockholm Development Administration is responsible for the development of targets and requirements, as well as monitoring compliance. The City of Stockholm Traffic Administration is in charge of designing and implementing the traffic hierarchy, from the early planning of the structure to the final design and furnishing of the streets. The Stockholm Public Transport Company services the area with high-quality and frequent public transport. Developers are responsible for providing high-quality biking infrastructure on the properties.
Benefits	A more energy-efficient transport system and reduced emissions.
Robustness of the concept	The decision to implement the traffic hierarchy has been politically sanctioned by all political parties, as it is a policy to secure Stockholm's growth. The detailed implementation of the policy is more difficult to implement since other factors must be considered, such as harbour activities and use of space for other purposes. The first and second phases of the SRS are planned from a traffic-hierarchy point of view, but since planning started ten years prior to the decision on environmental profiling, the principles have not been fully achieved.
Activity plan and timeframes	2012-2014: Decide how to incorporate the traffic hierarchy into the planning and design of the transport system. 2015-2020: Evaluate the results of the first phase of the development.
Costs and financing	The cost of implementing the measure in the public open space (POS) has not been calculated separately. The financing of the measure is part of the City's budget. The cost of implementing the measure in the properties is part of the developers' financial management plan.
Potential to replicate	The SRS is being used as a pilot and any good examples will be replicated throughout the City.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

Effect	**Conservative ton CO_2e/year**	**savings**	**Progressive ton CO_2e/cap**	**savings**

Use of cars	11 130		6 133	
Use of public transport	673		443	
Total	**11 803**	**- 2 667**	**6 576**	**-2 522**
Per cap	**0,204**		**0,114**	

T3 – Improved Logistics

The challenge	Supplying the City with goods and services is a transport-related activity that needs to be much more efficient. The challenge is that little is known about the logistics in various sectors and the potential to improve efficiency. Some efforts are being made in the inner city of Stockholm to gain more knowledge and to cooperate with retail and commercial stakeholders in developing business models that will last over time.
The concept	A goods consolidation centre will be implemented in or in the vicinity of the SRS. A conservative estimate is that the supply of goods and services through this consolidation centre will reduce emissions from trailer and heavy trucks by 50% and from light trucks by 30%.
Responsibilities	The City of Stockholm Development Administration is responsible for the development of targets and requirements, as well as monitoring compliance.
Benefits	Reduced traffic movement as well as a possibility to use energy efficient vehicles for last mile deliveries.
Robustness of the concept	The planning of the city district will be based on the assumption that the area will be supplied through nodes where goods will be consolidated and distributed. By setting up the infrastructure and developing a business model, the concept is expected to be robust.
Activity plan and timeframes	Ongoing: Consolidation centre for building materials. 2014-2016: Investigations and development of concept. 2016-2020: Pilot project to optimise size and business model. 2020 ->: Full-scale consolidation centre.
Financing	A business model will be developed to cover costs.
Potential to replicate	The SRS will be used as a pilot and any good examples will be replicated throughout the City.
Milestones	The monitoring process ensures that data will be collected and compiled to verify the result.

Estimated emission reductions

	% of total transport	**Reduction due to consolidation**	Conservative savings ton CO_2e/year	Progressive savings ton CO_2e/cap
Reduced use of heavy trucks	20 %	-50 %	- 13	- 9
Reduced use of light trucks	35 %	-30 %	- 46	- 30
Total savings			**- 59**	**- 39**

Source: (Assumption based on SU)

T4 – Improved Energy Efficiency in Infrastructure Maintenance Vehicles

The challenge	**To optimise the energy use for operation and maintenance of streets public open space. The challenge is that it is specially designed machinery that is used and standards have to be changed over time.**
The concept	To substitute fuels in maintenance machinery, from fossil fuels to electricity and biogas,
Responsible	Stockholm City, The Development Administration and Traffic department
Benefits	
Robustness	Very robust as the City together with other national and regional actors are joining hands in setting standards.
Activity plan and timeframes	On-going
Financing	The City of Stockholm
Potential to replicate	Good examples will be replicated throughout the city.

Estimated emission reductions

	Baseline CO_2e/year	SRS Standards CO_2e/year	Progressive CO_2e/year
Mobility managment	2 571	- 771	- 771

Source: (Johansson et al., 2012b and SOU 2013:84)

T5 – Mobility Management

The challenge	**To influence the individual's choice of transport towards a more sustainable option.**
The concept	Provide support to promote sustainable choices with ICT solutions. Companies are encouraged to provide personal MM plans to their employees. A travel planner combining all modes of transport is to be made available to workers and residents. Real-time information in public places, car pools, sharing systems and so forth.
Responsible	The City of Stockholm Development Administration is responsible for the development of targets and requirements, as well as monitoring compliance. Public and private developers are responsible for providing the owners and tenants with MM services.
Benefits	A larger number of people living and working in the area are using resource-efficient modes of transport.
Robustness	MM measures largely focus on personal choices. In addition to the built-in infrastructure, property owners and businesses need to continuously inform and encourage individuals to make sustainable choices.
Activity plan and timeframes	2015: Mobility Index, a tool that includes a range of possible measures to encourage developers to include MM in the concept for living and working in the area, will be part of the development agreement.
Financing	A business model will be developed to cover costs.
Potential to	The SRS will be used as a pilot and any good examples will be replicated

replicate	throughout the City.
Milestones	The monitoring process ensures that data from each phase of the development will be delivered and compiled to verify the result.

Estimated emission reductions

	SRS Standards $CO_2e/year$	Progressive $CO_2e/year$
Mobility managment	-203	-203

Source: (Johansson et al., 2012b and SOU 2013:84)

Road-Mapping Measures - Waste

General - Amounts of generated waste, emission factors and direct and saved emissions

	Residents	Workers	SRS total	Emission factors Generation	Emission factors Recycling	Emissions	Saved emissions
Waste fractions	Ton/year	Ton/year	Ton/year	g CO_2e/ton	g CO_2e/ton	ton $CO_2e/year$	ton $CO_2e/year$
Mixed MSW	5 711	3 290	6 039 939	0,38	-0,43	3 421	-3 871
Bulk waste	3 801	0	14 420 083	0,01	-0,41	38	-1 558
Gardening waste	146	0	97 912	0,04	-0,14	6	-20
Packaging		0	0	0,19	-0,23	0	0
Glass	595	259	0	0,24	-0,42	205	-359
Paper packaging	160	1 092	2 938 757	0,24	-0,42	300	-526
Newspapers	1 076	1 712	8 056 337	0,24	-0,42	669	-1 171
Metal packaging	27	100	0	0,17	-0,78	22	-100
Plastic packaging	57	877	6 865 481	2,51	-0,99	2 345	-925
Electronics	278	112	0	0,31	-0,36	121	-140
Other	59	0	0	0,40	-0,67	24	-40
Total	**11 911**	**7 442**	**38 418 511**			**7 150**	**-8 709**
Emissions included in district heating						**-2 769**	

Measure W1 - **Implementing the waste hierarchy**

The challenge	**The** waste management system in Stockholm is highly efficient. Household waste and eight to ten other fractions are normally collected at the property. The challenge in Sweden is to reduce the total amount of generated waste.
The concept	
Conservative	The conservative approach focuses on installing systems that contribute to a 10% reduction in waste, increasing material recovery by 5% and collecting more food waste. This is achieved by having an automated waste collection system combined with a recycling room in every building. Waste grinders collect the organic household waste sent to the sewer system. It is also assumed that gardening waste is recycled locally and that a local reuse centre

	is established.
Progressive	The progressive approach focuses on further increasing recycling rates and improving the collection of organic waste.
Responsibilities	The City requires developers to connect to the automated waste system and design the waste collection stations on the property so that they can easily be accessed and used for the rest of the fractions, which minimises the number of collections. Responsibility for waste management is shared by various players: SVAAB manages household waste, the packaging industry manages recycled packaging and private companies are appointed to manage commercial waste.
Benefits	Impact
Robustness	The waste management system has been in place since the 1970s and different actors players are well aware of their roles. The behavioural aspect of waste sorting is the main challenge.
Activity plan and timeframes	Information campaigns carried out on a continuous basis. An automated waste system was introduced from the first stage.
Costs and financing	The investment in the property is part of the developer's financial management plan. The residents carry the operational costs for waste collection.
Potential to replicate	The Stockholm Water & Waste company are the drivers of the change, good ideas will therefore be carried through to the rest of the city.
Milestones	

Estimated emission reductions

	Baseline CO_2e/year	**SRS Standards CO_2e/year**	**Progressive CO_2e/year**
Waste treatment	7 150	6 415	5 555
Saved emissions from recycling	-8 709	-7 301	-6 2340
Emissions already accounted for	-2 769	-1 670	-1 373
Total	**-4 328**	**-2 556**	**-2 058**

(Johansson et al., 2012b)

Appendix D – Credits

Credits C1 - Energy-efficiency requirement

The concept	Learning from the SRS development process, the City has begun to implement more stringent energy requirements for new developments. This means that 7,000 apartments, or roughly 700,000 square metres of developed area per year, will be developed with lower energy use than the requirements in the National Building Code. The “gap” between the City’s requirements and the requirements of the National Building Code can be accounted for as a credit. The SRS also has a huge influence on the surrounding municipalities with respect to both the sharing of knowledge between municipalities and the knowledge and experience gained by the developers through their involvement in the SRS. When it comes to calculating magnitude, the application is slightly delayed compared with Stockholm, and a timespan of five years has been used in the calculations. Over time, the gap between the City’s requirements and the National Building Code will decrease.
Responsibilities	The City, developers, etc.
Impacts	The SRS has helped to set the standard when it comes to imposing requirements and constructing low-energy buildings that can be replicated on a large scale – contributing to a lower need for energy in new buildings.
Robustness	Political support. Lower costs for property owners and residents.
Cost and financing	Developing knowledge is costly – once the knowledge becomes mainstream, it is no longer questioned.
Potential to replicate	The knowledge is highly replicable.

Estimated emission reductions

<u>Stockholm municipality</u>

Assumption: 7 000 apartment per year
improvement with 20% on a 5-year period

	5 - year periods			
	2010-2015	2015-2020	2020-2025	2025-2030
	kWh/m2, year	kWh/m2, year	kWh/m2, year	kWh/m2, year
BBR	90,00	72,00	57,60	46,08
City of Stockholm	70,00	56,00	44,80	35,84
Savings	20,00	14,00	11,20	8,96

	Area built	**Accumulated**	**Energy savings**	**Emission reductions**
Year	m2/year	m2	MWh	ton CO2e
2010 - 2015	700 000	3 500 000	70 000	7 140
2016 - 2020	700 000	7 000 000	49 000	4 998

2021 - 2025	700 000	10 500 000	39 200	3 998
2026 - 2030	700 000	14 000 000	31 360	3 199
Total savings			**-189 560**	**-19 335**
Ton CO2e/cap				**-0,335**

Surrounding municipalities

Assumption: 7 000 apartment per year
Impact 5 years behind

	5 - year periods			
	2010-2015	2015-2020	2020-2025	2025-2030
	kWh/m2, year	kWh/m2, year	kWh/m2, year	kWh/m2, year
BBR	90,00	72,00	57,60	46,08
City of Stockholm	80,00	64,00	51,20	40,96
Savings	10,00	8,00	6,40	5,12

	Area built	**Accumulated**	**Energy savings**	**Emission reductions**
Year	m2/year	m2	MWh	ton CO2e
2010 - 2015	700 000	3 500 000	35 000	3 570
2016 - 2020	700 000	7 000 000	28 000	2 856
2021 - 2025	700 000	10 500 000	22 400	2 285
2026 - 2030	700 000	14 000 000	17 920	1 828
Total savings			**-189 560**	**-10 536**
Ton CO2e/cap				**-0,182**