SIEMENS

Helsinki's 2030 Climate Technologies

City Performance Tool – March 2016

Global Center of Competence Cities

Helsinki is on course to meet its target to reduce its greenhouse gas emissions by 30 percent by 2020 having already achieved 23 percent reductions since 1990. The city is now preparing to meet its next important target of carbon neutrality by 2050 relying predominantly on the supply of cleaner electricity and heating in the future. As a way of modelling the city's progress towards this long term goal, this report looks to 2030 as an observation year to identify the most cost effective technologies that can be driven by the municipality.

Executive Summary

Helsinki is on course to meet its target to reduce its greenhouse gas emissions by 30 percent by 2020 having already achieved 23 percent reductions since 1990. The city is now preparing to meet its next important target of carbon neutrality by 2050 relying predominantly on the supply of cleaner electricity and heating in the future. As a way of modelling the city's progress towards this long term goal, this report looks to 2030 as an observation year to identify the most cost effective technologies that can be driven by the municipality.

In this study we modelled two scenarios for Helsinki's emission development in 2015-2030: the Business As Usual[1] (BAU) scenario and the City Performance Tool (CyPT) scenario, which features additional technologies that will bring greenhouse gas savings.

This report has found:

1. Helsinki is benefiting from major investments to clean up its electricity and heating mix from its local energy company HELEN. However, because of rapid population growth, these gains will be mainly levelled out due to an increase in total household floor area by 34% in the city by the year 2030. The city therefore needs to find further investments if it is to meet its targets.

2. Due to Helsinki's cold climate, the residential buildings' share of total greenhouse gas emissions currently stands at 1 megaton, accounting for almost 42% of total emissions. This is considerably higher in relative terms to other European cities. Although targeting these emissions is straight forward, financing retrofitting initiatives can be difficult particularly because of Finland's very low energy prices, which have consistently been amongst the lowest in Europe.

3. The CyPT scenario features ten technologies from the transport, buildings and energy sectors. The technologies were selected in a workshop with city stakeholders. Compared to the BAU scenario, these technologies can deliver a further 23 percent (550 kiloton) of CO_2eq reduction over the next 15 years at a total investment cost of €2.8 billion. In this CyPT scenario, compared to the year 1990 the emissions would be reduced by nearly 50 percent, whereas in the BAU scenario the emissions would be reduced by only 34 percent.

4. In the CyPT scenario for the buildings sector, we identified a number of technologies delivering over 13 percent of citywide emission savings compared to the BAU scenario. The total investment for these technologies stands at €1.9 billion, but in return over €2.2 billion of energy savings will be delivered in the 15 year period. Although this is long pay-back period for investors, the city could look at setting up a warehousing loan facility to increase the total loan value for retrofits and attract larger investors.

5. Although transport emissions account for only 24 percent of emissions in Helsinki's BAU scenario, a share that will not change over the next 15 years, two technologies provide considerable savings as they target the largest emission sources. City tolling, which targets over half of the transport related emissions delivers 2.5 percent of citywide savings. Onshore power for vessels provides 1.9 percent CO_2eq reductions and cuts more than one third of the city's NO_x transportation emissions compared to 2030 business as usual levels.

6. There are clear winners in both the buildings, transport and energy sectors and Helsinki should look at funding and financing initiatives that bundle technologies from all the sectors. Cross sector funding such as Green City Bonds may exploit Helsinki's entrepreneurial culture and invite CO_2eq saving projects to compete for funds as was recently proved in Gothenburg. Furthermore, revenues from city tolling may help to prop up investments in other sectors.

1. In BAU scenario the electricity consumption per capita stays constant until 2030 (Helsingin parhaat energiatehokkuuskäytannot, 2011). Total district heating consumption is reduced by 0,5 TWh by 2030 (Pöyry, 2015). Fuel shares in local district heating and national electricity are based on Helsinki's 30 % emission reduction study's (2013) BAU scenario.

Introducing the City Performance Tool (CyPT)

European cities stand at the forefront of sustainable development in the world. Global rankings regularly highlight their performance in terms of connectivity, mobility, and reduction of greenhouse gas emissions. Cities like Helsinki are constantly striving to test the cost efficiency of their current infrastructure solutions and explore new, more effective technologies that will help them meet their environmental targets.

To help cities make informed infrastructure investment decisions, Siemens has developed the City Performance Tool (CyPT) that identifies which technologies from the transport, building and energy sectors best fit a city's baseline in order to mitigate greenhouse gas (referred to in this report as carbon dioxide equivalents, CO_2eq) emissions, improve air quality and add new jobs in the local economy.

The CyPT model compares the performance of over 70 technologies, with only 60 percent being Siemens technologies. This provides an opportunity for Siemens to compare its portfolio with more popular mitigation solutions such as wall insulation and triple glazing.

In Helsinki, ten technologies were selected by an expert panel and that were later used in the modelling (pp. 20-21). Apart from these ten technologies, some further technologies from the CyPT portfolio were used for comparing the performance in terms of CO_2 savings and cost efficiency.

The CyPT model takes over 350 inputs from Helsinki's transport, energy and buildings sectors, which include the energy mix of electricity generation, transport modalities and typical energy, travel and building space demand. We refer to this as a city's energy DNA, which we split into transport and buildings energy demand. How high the energy demand is and how it is split between the transport and buildings sector depends on how people use transport and building space and how the city generates its electricity and heating.

As soon as the energy profile is calculated we estimate the CO_2eq emissions and NO_x levels. The model measures the impact of technologies on the CO_2eq, and NO_x baselines of the city with CO_2eq accounting performed at scopes 1 and 2 levels for the building and transport sectors (Figure 1). This means that we have taken into consideration both direct emissions that are occurring within the city boundaries such as from exhaust fumes but also indirect emissions from the consumption of purchased electricity and heat. Scope 3 emissions that look at the energy required to feed the electricity and heating generation in the city have been excluded.

The model also tests the performance of each technology on two economic indicators. Firstly, the total capital investment needed to deliver the technologies. Second, the total number of gross jobs that could be created in the local economy. These include installation, operation and maintenance jobs, which are calculated as full time equivalent jobs of 1760 hours per year. Manufacturing jobs are not accounted because some of these technologies may be produced outside the city's functional area, with no local benefits to the economy.

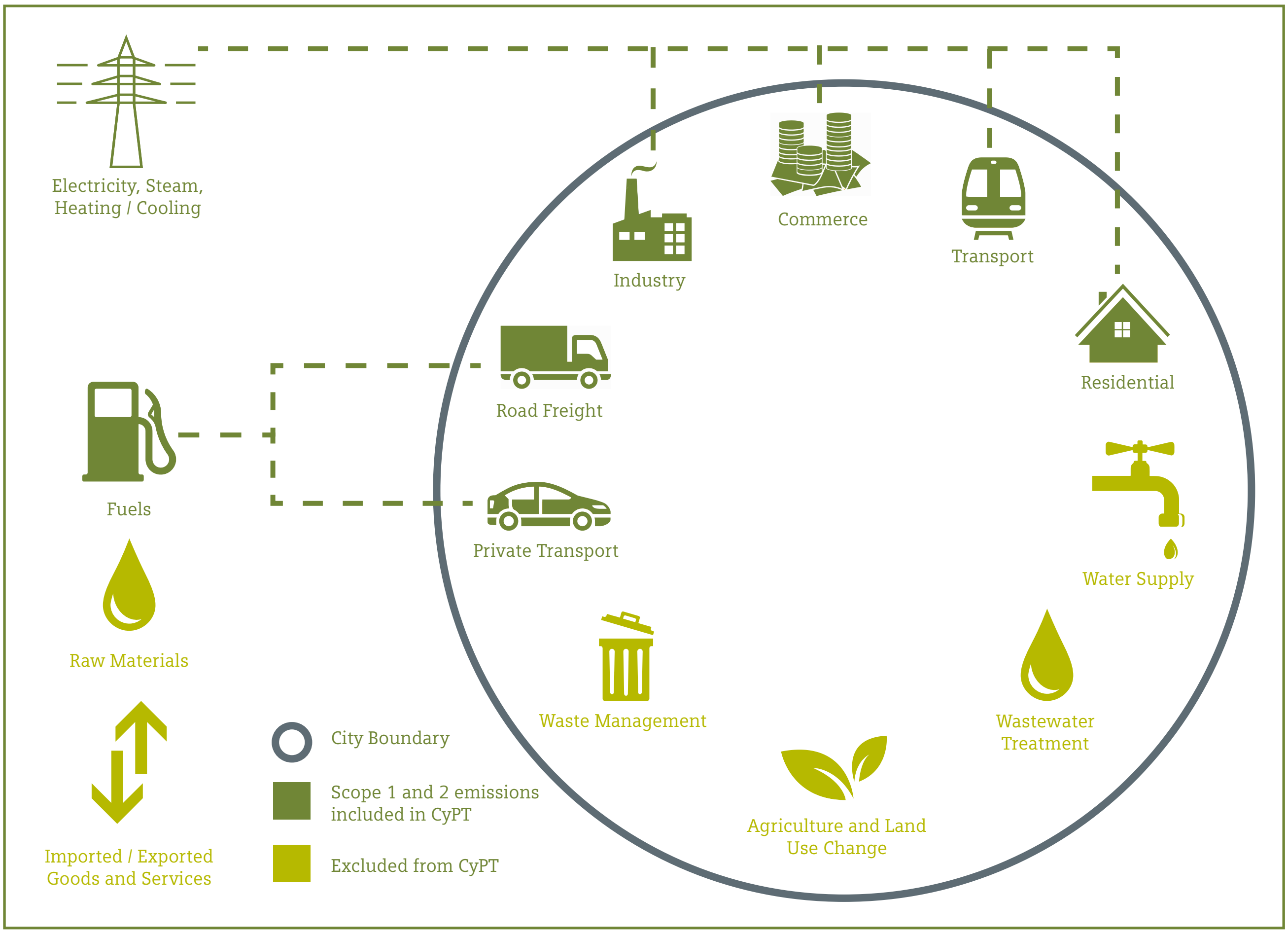


Figure 1: Scope 1 & 2 emissions captured in this study. Icons are for indicative purposes only

Starting with the city's population, energy performance, and emissions baseline, the model estimates the future impacts of technologies along the following three emission savings drivers:

1. Cleaner underlying energy mix: Shifting the energy generation mix from non-renewable to renewable energies (e.g. photo voltaics) and / or improving the efficiency of the current, fossil fuel, sources (e.g. Combined Cycle Gas Turbines).

2. Improved energy efficiency in buildings and transport: Replacing existing technologies with more energy efficient technologies. For example replacing traditional street lighting with LED and / or demand oriented street lighting.

3. Modal shift in transportation: Modelling changes in the modal split of the city. For example by creating a new metro line, a city potentially moves passengers away from high-emitting cars and into the subway.

The CyPT model has so far been used in cities such as Copenhagen, Vienna, London, Minneapolis and Nanjing with each city identifying infrastructure solutions that best fit the city's energy demand and production characteristics.

Number of data points by sector

Transport – 39%

- Annual passenger km
- Freight ton kms
- Length of road network
- Length highway network
- Bus, BRT, Street Car, Metro, Commuter / Regional Rail, Taxis, Bicycles, Cars etc.

General – 2%

- Population
- Geographic size
- Emissions target

Energy – 15%

- Electricity mix
- Heating mix
- Emissions factors for fuels

Buildings – 44%

- Square metres by building type
- Electricity demand
- Heating demand
- Cooling demand
- End use for electricity, heating and cooling
- Building envelope

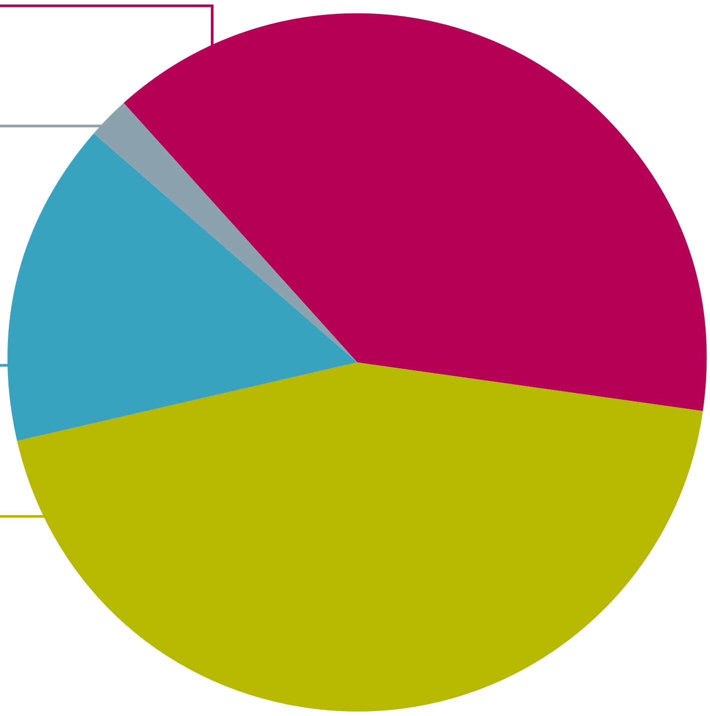
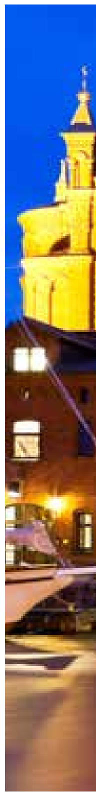


Figure 2: Number of data points by sector used in the CyPT.



Helsinki's Climate Plan

The City of Helsinki has set specific targets for reducing its greenhouse gas emissions over the next 35 years. The capital aims to reduce greenhouse gas emissions by 30 percent by 2020 (since 1990) and to become carbon neutral by 2050. The energy company HELEN has a target of being carbon neutral by 2050 and a target of 20 percent greenhouse gas emission reduction by 2020 since 1990. The City of Helsinki also has a target of increasing the energy efficiency by 20 percent per capita (2005 – 2020) in the city area. The Helsinki Region Transport has a target of reducing the greenhouse gas emissions and air pollutants of bus transport by 90 percent by 2025 (since 2015).

By 2050 the city has set a vision to transform its buildings into energy efficient and energy producing buildings by increasingly implementing smart solutions such as building automation which can halve buildings' heating costs. In regards to transportation, Helsinki plans to lower personal transport use and encourage more people to use public transport and non-motorized modes such as cycling. The vision also envisages that the majority of vehicles will run on electricity which will have a positive impact on air quality and citizens' health.

Helsinki has already taken action to achieve the reduction target on schedule and sees 2030 as a key milestone year to check on its progress. The progress that the city has already made is most concretely illustrated by how Helsinki has managed to decouple its energy consumption and related CO_2eq emissions during the last decade: consumption and emissions growth are not tied together any more.

Results from the 30% emission reduction study

A major study looking at the city's progress was published in 2014 by Gaia Consulting and the Finnish Environment Institute. It identified 18 additional measures that the city could pursue in terms of cost efficiency to meet its targets that went beyond the cleaner energy transition delivered by the electricity and district heating companies. This is important because the city is relying on *HELEN*, the major energy company to deliver the largest share of reductions by 2050. The 18 short term measures proposed by Gaia Consulting could deliver nearly 98.4 kt of CO_2eq with the greatest potential (outside of the cleaner energy transformation) being traffic and logistics followed by building energy efficiency (Figure 3).

In addition to these 18 measures, it was estimated, that shifting from coal use to renewable energies could reduce emissions of district heating by about 500 kiloton by 2020.

The *Gaia Consulting* study also suggested that all measures were cost effective based on the total socio-economic benefits that they delivered as is shown in figure 3. With the exception of increasing public transport modalities and low emission trials, all other measures are negative in terms of cost per ton of reduced greenhouse gas emissions (€/CO_2eq) (i.e a net benefit).

This CyPT study goes a step further to model the impacts of actual technologies with direct costs to the investor rather than wider socio-economic costs to society. Although this will make the cost profile of technologies higher by excluding monetized wider social benefits such as reduced congestion, it deals with the direct investment challenge that cities ultimately face. While benefits for mitigation and other co-benefits would fall to households and companies, the cost of their implementation would fall to the city. In other words, the city would need a way to fund the initiatives.

Another major difference between the studies are the observation years. In the Gaia Consulting study, reductions are measured for a period of 10 years between 2010-2020. In this study, reductions are measured for 15 years between 2015-2030. This will generate two major differences in the results. Firstly, this study will not account greenhouse gas reductions between 2010-2015. Secondly, because of prolonged population growth to 2030, some of the major investments undertaken by HELEN will be levelled out by the sheer increase in building floor space in the city.

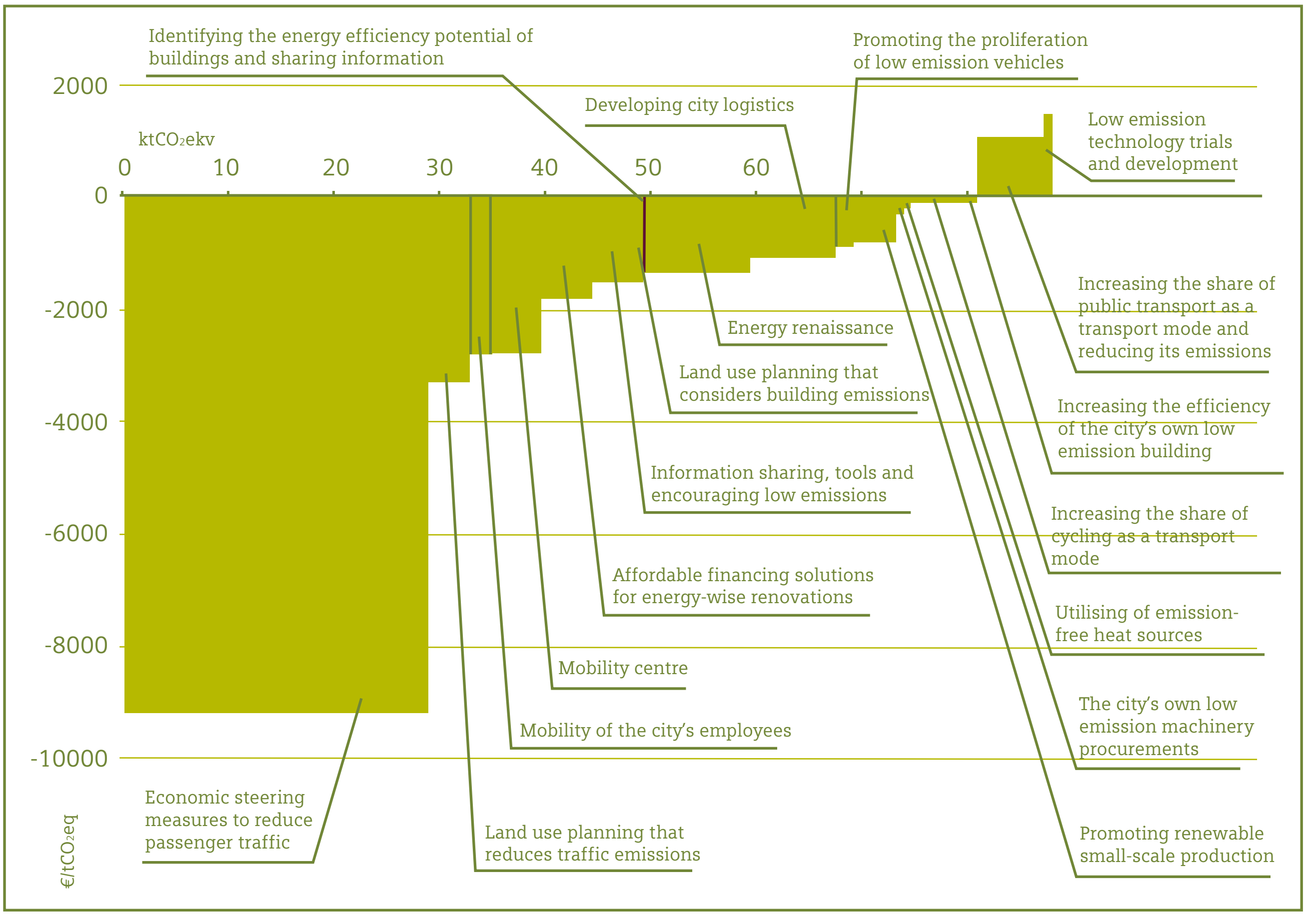


Figure 3: 30 % emission reduction study / Gaia and FEI 2015.

Helsinki's emissions

The greenhouse gas reduction target will be one of the guiding principles for the future development of Helsinki and the entire region, as the region is already home to more than 23 percent of the country's entire population, which is expected to grow even further in the run up to 2050. Helsinki has 620 715 inhabitants, being similar in size to other capitals of Northern Europe, such as Copenhagen or Oslo. The city is sparsely inhabited with 2,914 inhabitants per square kilometre, similar again to Copenhagen and Oslo, which have densities of 2,630 and 3,200. This figure falls significantly to 350 inhabitants per square kilometre for the Greater Helsinki Area (which includes Espoo, Vantaa, Kauniainen and nine other municipalities), as over 40 percent of this area consists of green areas.

The Helsinki Metropolitan area is one of the most dynamic metropolises in Europe. It expects to have a population of two million inhabitants in 50 years, implying a significant increase compared to the present one and half million. In Helsinki, the population increase is estimated to be over 200 000 people by 2050. According to our calculations, this increase in population is driving forward building space demand with residential floor space set to increase by 34 percent in the next 15 years[2]. This could put immense pressure on energy demand and subsequently on greenhouse gas emissions.

One of the key factors influencing Helsinki's emissions despite the population growth is the energy mix of the city to which existing and new buildings are connected. Heating energy in Helsinki benefits from the primary energy savings of a combined heat, power and cooling system provided by the city-owned energy company HELEN. More than 90 percent of the buildings are in the district heating network. This system is currently almost exclusively powered from fossil fuels, which cause major emissions with the heating of buildings, but HELEN is investing very heavily in cleaning this mix up having already decided in 2015 to switch off one coal powered plant.

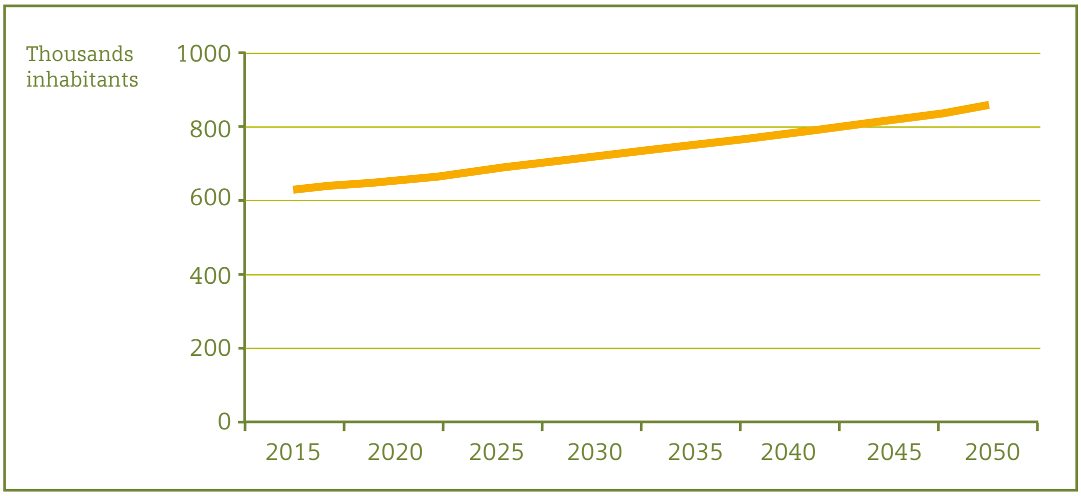


Figure 4: Population growth in Helsinki (Helsinki Masterplan 2050) (Helsinki City Planning Department, 2015)

2. We assumed the same energy demand intensity (kWh / m²) in 2015 as in 2030

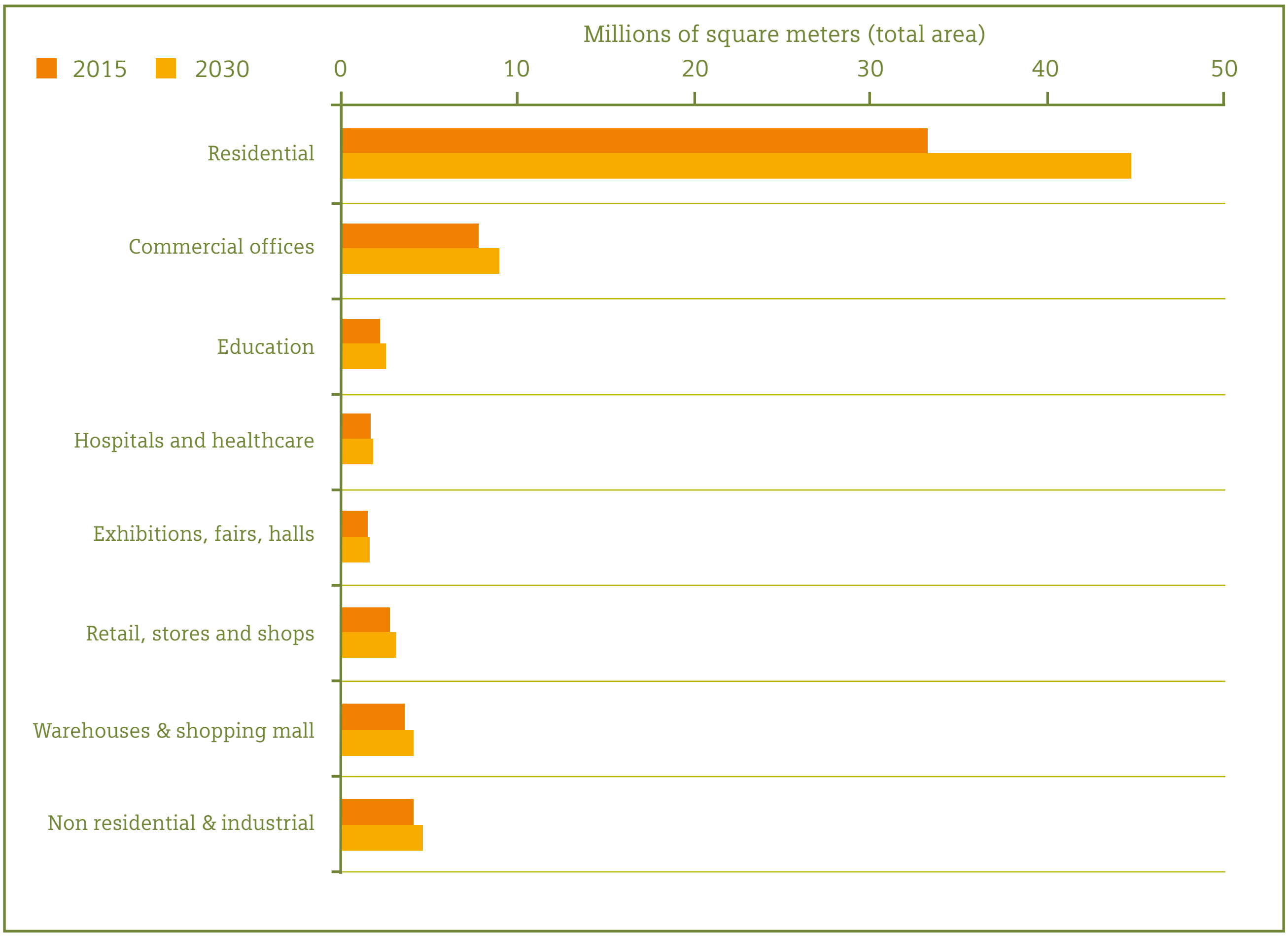


Figure 5: Increase in floor space (total area) between 2015 and 2030 by type (Facta building registry and City Planning Department, 2015)

The electricity mix of Finland relies heavily on nuclear power, as it already represents 26.3 percent of the electricity and according to national projections, this will increase to 41.5 percent in 2030. The breakdown of renewable energies is 15.9 percent for power generation from hydro, 12.7 percent from biomass, 0.8 percent from wind power and one percent from waste.

Over the last five years Finland has imported on average 17.8 percent of the electricity. In 2030 this figure will decrease to 3.2 percent[5].

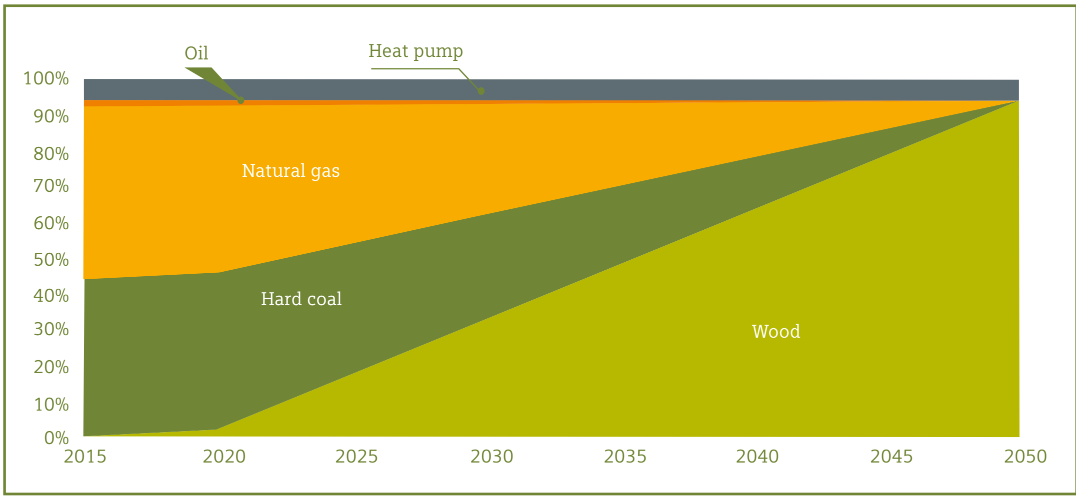


Figure 6: Changes in Helsinki's heating mix. Gaia / FEI, 2013 [3,4]

3. In December 2015 the city council decided to shut down the Hanasaari coal power plant by 2024. Hanasaari accounts for 2/3 of the coal usage of Helsinki. 4. According to the current governmental programme the use of coal is going to be banned by 2030 and use of oil (shows more in the transport sector) is going halved by 2030. There is going to be a new national energy and climate strategy in the following year and if it is implemented as planned, it will affect Helsinki. 5. The emissions of imported electricity are not accounted for in this report.

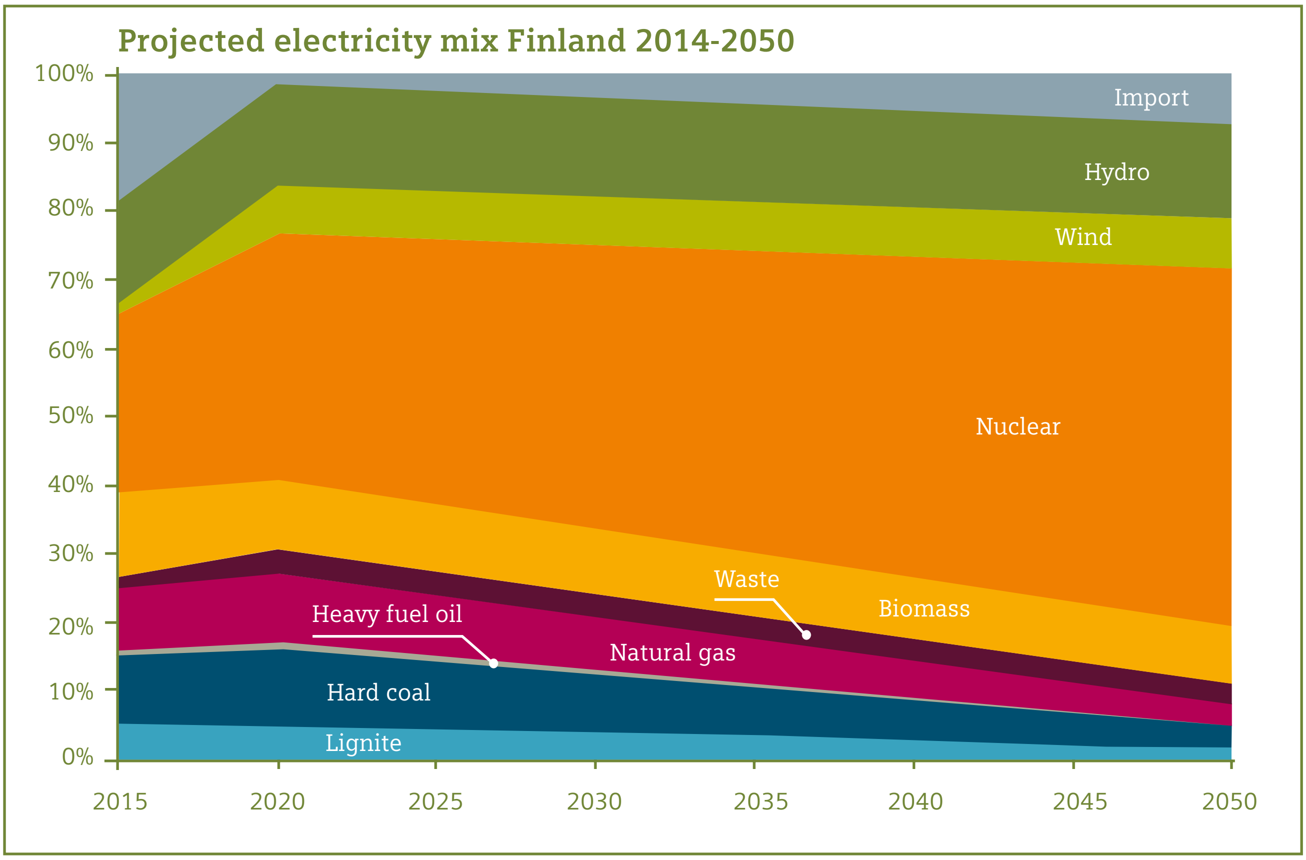


Figure 7: Changes in Finland's Electricity Mix. The electricity mix in 2030 is a linear interpolation between 2020 and 2050. (Statistics Finland, 2015, Gaia / FEI, 2013)

When looking at the emission factors for Helsinki in the run up to 2030 and to 2050, one observes the huge improvements in the decarbonisation of the heating mix due to HELEN investments. From 2015 to 2030, the factor is reduced by over 30% for district heating and by over 22% for the electricity bi-product. In electricity it is estimated that national mix will be 22 % cleaner by 2030.

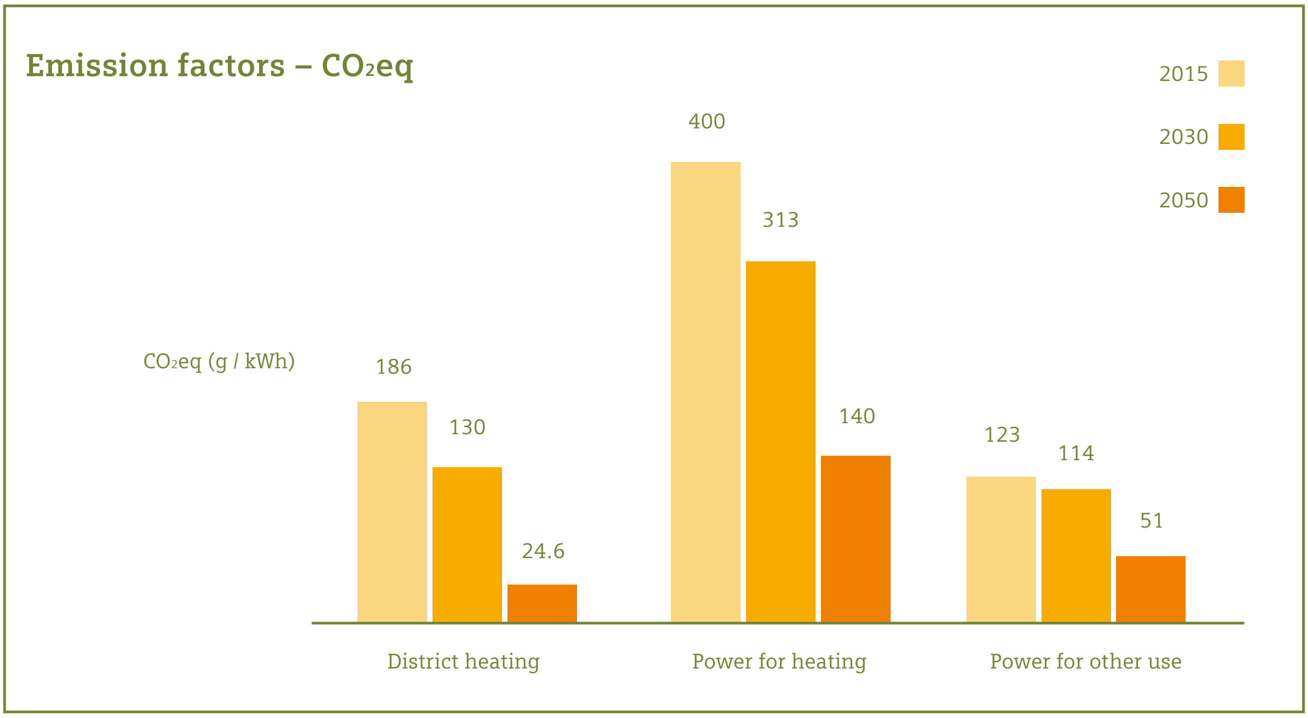


Figure 8: CO_2eq emission factors for heating, power for heating and electricity in Helsinki for 2015, and projected figures for 2030 and 2050 in accordance with Helsinki's local heating and electricity mix in figure 6 and 7, respectively

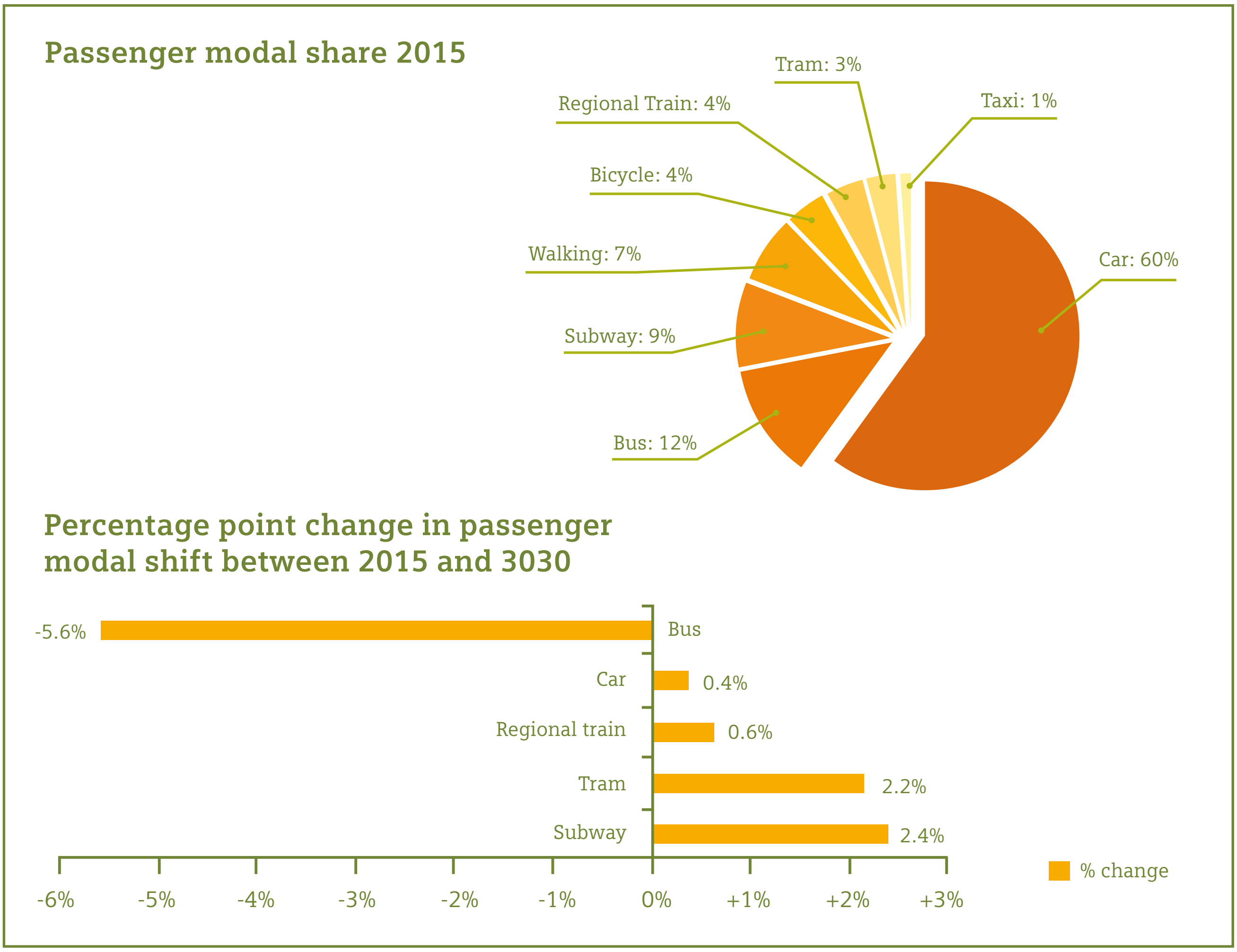


Figure 9: Modal shares in Helsinki and projected changes based on annual passenger kilometres (Helsinki Region Transport, 2015, Helsinki City Planning Department, 2015 and Helsinki Environment Centre, 2015)

Transport

Helsinki's population increase will have an impact on the total transport demand in the city. The modal split of transportation in 2015 relies mostly on cars and buses. Cars represent 60 percent of person kilometres while buses account for 12 percent of journeys.

Altogether, public transport (regional trains, subway, tram and bus) account for 27.9 percent of the passenger kilometres travelled in Helsinki. Cycling and walking respectively account for 4 percent and 7 percent of the modal split, or 11 percent altogether. The personal transportation demand for Helsinki is 4,298 million passenger kilometres per year, while the freight transportation demand is 1,365 thousands of ton kilometres per year. Looking to the future, Helsinki is planning to move more people into metro and rail thus removing vehicular traffic from the roads. Our model was also based in a near 6 percent drop of bus modal share within the next 15 years with more passengers moving to rail systems.

BAU scenario for 2030

Helsinki's demand for space and transport and its consumption of electricity and heating as described above is driving its greenhouse gas emissions in 2015. Figure 10 splits the city's greenhouse gas emissions in its constituent buildings and transport parts in 2015. From the city's total annual emissions of 2.5 megaton CO_2eq, 1.9 megaton originates from the buildings sector and 600 kiloton from the transport sector.

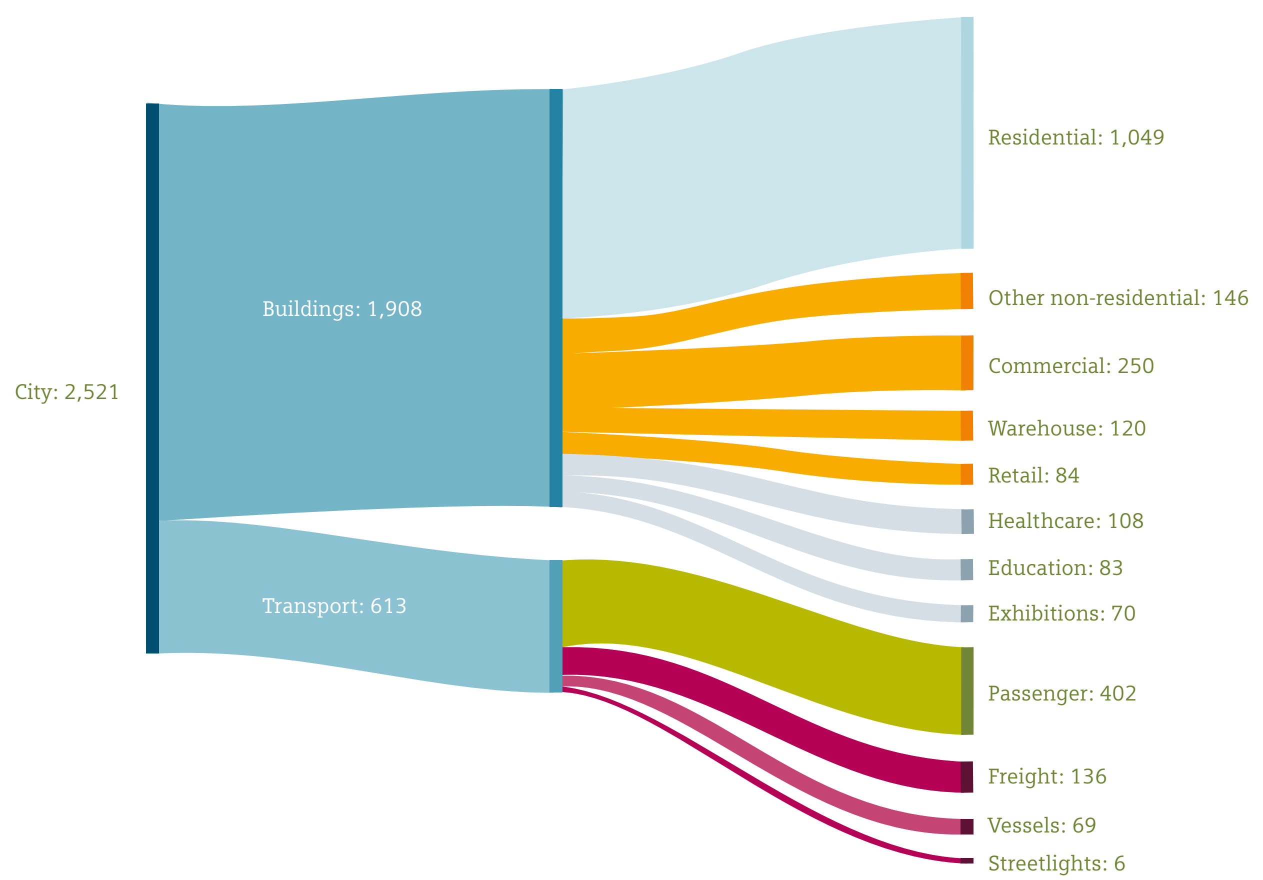


Figure 10: Helsinki's greenhouse gas emissions in 2015 (Kilotons CO_2eq in year 2015.)

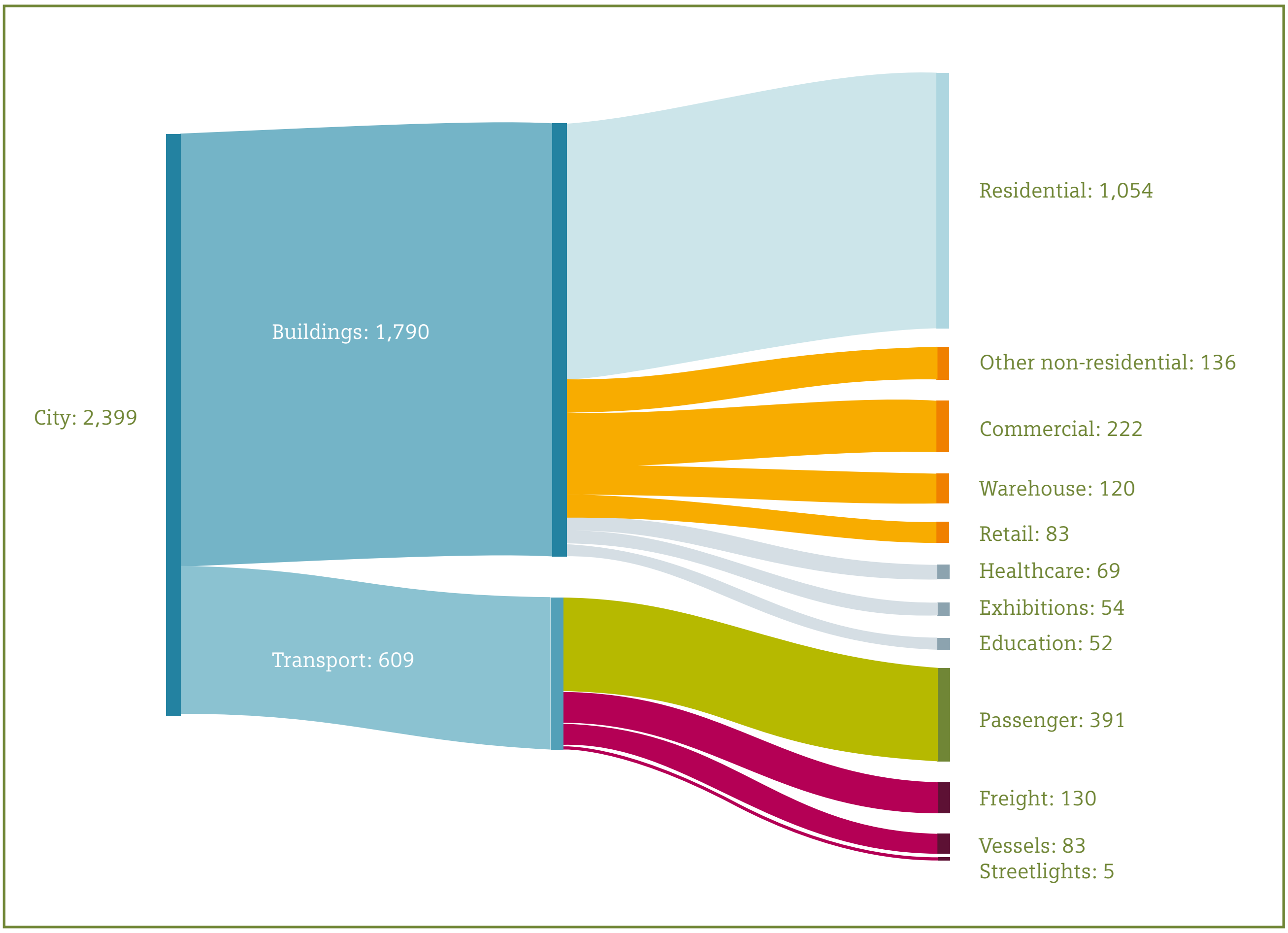


Figure 11: Helsinki's greenhouse gas emissions in 2030 in the BAU scenario (Kilotons CO_2eq in year 2030.)

At just over 1 megaton CO2eq, nearly half of the building related greenhouse gas emissions originate from Helsinki's residential stock with commercial buildings accounting for just a quarter of that. Similarly, in the transport sector, cars are the cause of over half of transport related emissions. Having two such distinct and well defined emission sources can help the city concentrate its mitigation strategy. It can also help the city narrow down the technology choices by selecting those that target the residential building sector and car use directly.

In the BAU scenario, comparing these emissions to the 2030 levels (figure 11) without the implementation of any CyPT technologies, one observes nearly 100 kiloton of annual savings in the buildings sector because of the cleaner electricity and heating mixes.

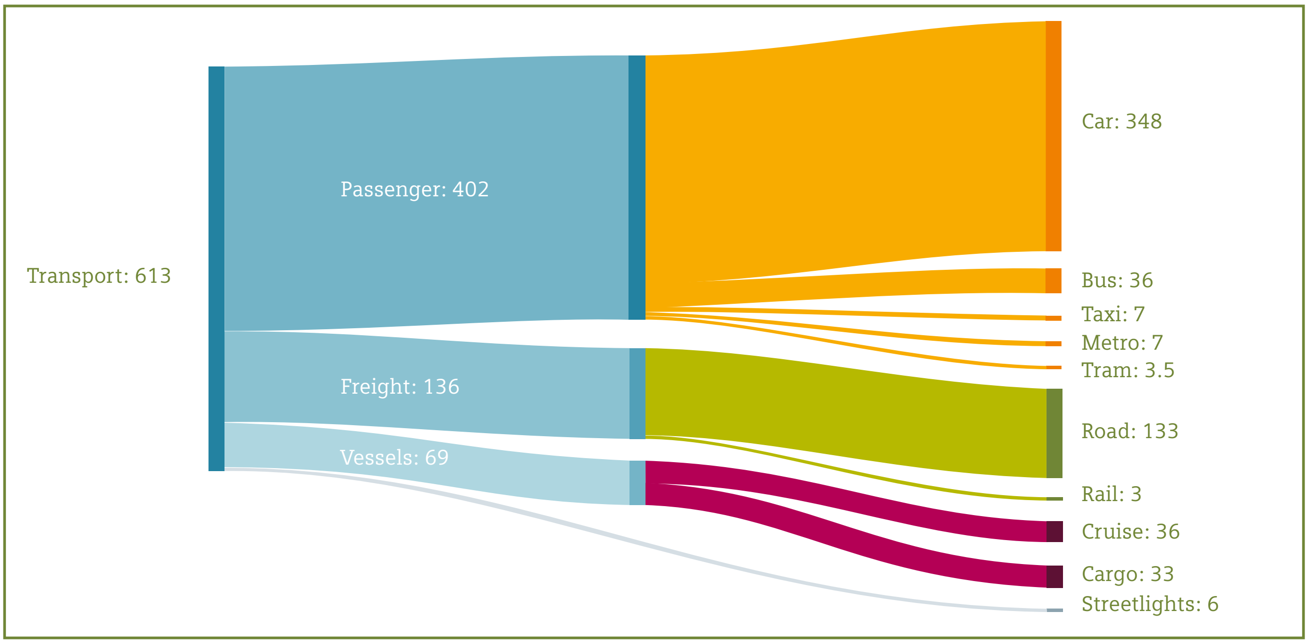


Figure 12: Helsinki's greenhouse gas emissions in the transport sector in 2015, (Kilotons CO_2eq in 2015.)

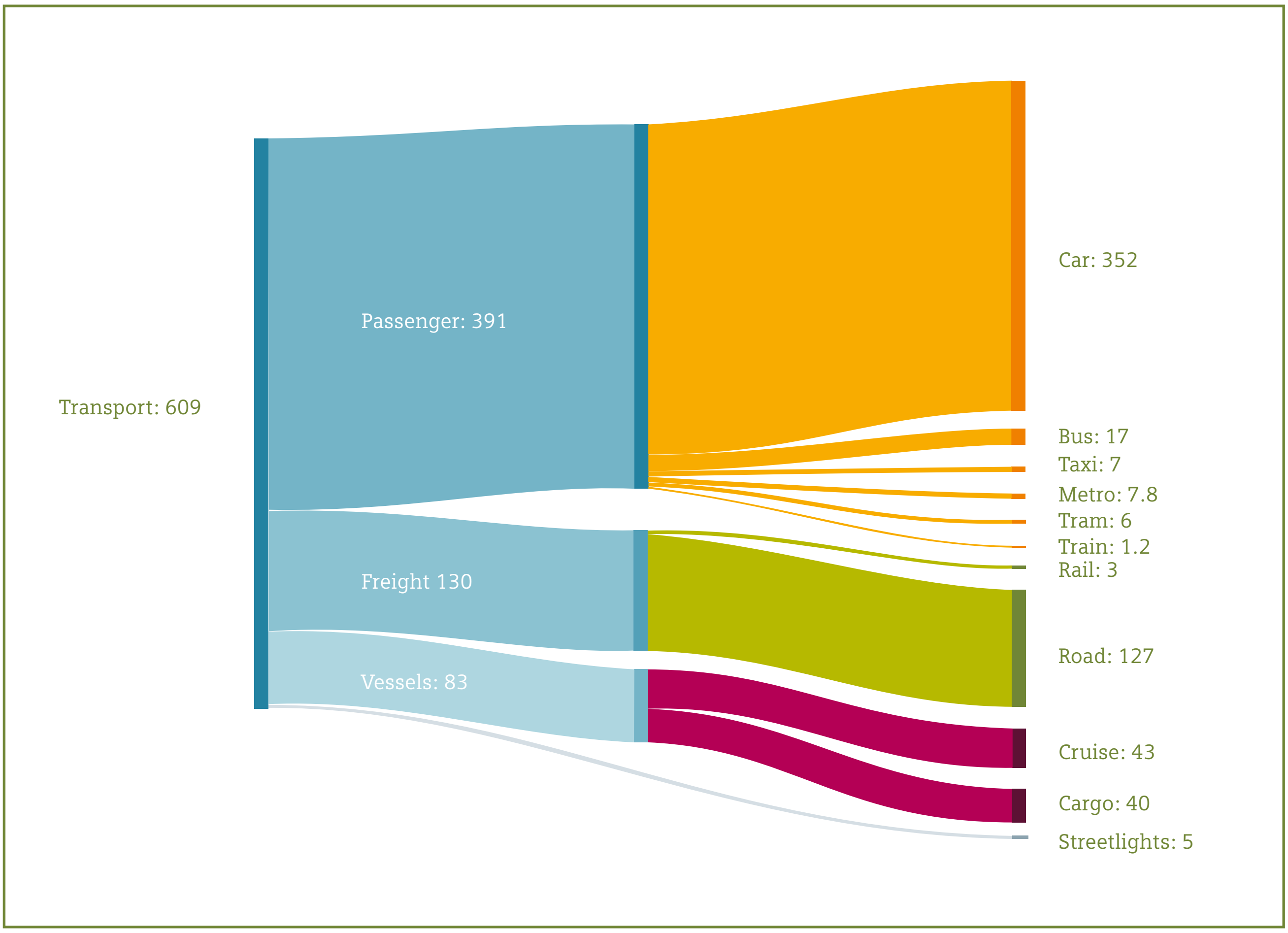


Figure 13: Helsinki's greenhouse gas emissions in the transport sector in 2030 in the BAU scenario, (Megatons CO_2eq in 2015.)

Technology Choices

Once Helsinki's baseline was calculated, which gave Siemens a clearer idea of the city's energy and the development in the BAU scenario until 2030, a workshop was held in the city that brought together some of the key municipal stakeholders. This included participants from the transport, energy and public works departments. The aim of the workshop was to determine the most relevant technologies for Helsinki in policy terms potential research themes that Siemens could focus on for this report.

The workshop was structured in an hour long exercise where the participants were split into four teams and given the following pieces of information:

1. Helsinki's CO_2eq emissions baseline, split between buildings and transport

2. The effective implementation rate of technologies in the model – that is the implementation that we are modelling minus the current deployment of that technology in the city

3. A series of 40 cards each describing an individual technology and their environmental benefits generated in Helsinki in the run up to 2030

Participants were asked to pick their top 10 technologies – with at least two from each of the transport, buildings and energy sectors that would deliver the maximum greenhouse gas savings and that would be feasible to implement in policy terms in the next 15 years.

A number of technologies were chosen unanimously across all groups, which are shown in green in figure 14. These included building performance optimization, heat recovery and building automation in the buildings sector. City tolling and photo voltaics installations were chosen unanimously in the transport and energy sectors. Participants were driven to these choices because of the relatively large saving for building technologies and because of the anticipated introduction of a congestion charging scheme in the city. Participants also asked us to model the impact of three further technologies with potentially high returns indicated in blue an the figure 15.

Person	Representing
Alpo Tani	City Planning Department
Jari Rantsi	City Planning Department
Tuula Pipinen	City Planning Department
Jari Viinanen	Environment Centre
Outi Väkevä	Environment Centre
Petteri Huuska	Environment Centre
Sonja-Maria Ignatius	Environment Centre
Ari Karjalainen	Executive Office
Päivi Piispa	Executive Office
Veera Mustonen	Forum Virium
Rauno Tolonen	HELEN
Alexandra Zischow	Helsinki City Transport
Susan Lyytikäinen	Helsinki Region Environmental Services HSY
Tapani Touru	Helsinki Region Transport
Jouni Tuomisto	National Institute of Health and Welfare
Katri Kuusinen	Public Works Department
Eetu Helminen	Siemens
Florian Ansgar Jaeger	Siemens
Lars Maura	Siemens
Markku Suvanto	Siemens
Savvas Verdis	Siemens
Trond-Olav Dahl	Siemens
Tanja Lahti	Urban Facts

Figure 14

Technology	Implementation rates by 2030	Unit
Residential – Home Automation	45%	Share of total residential stock fitted
Non-Residential – Building Performance Optimization (BPO)	75%	Share of total commercial stock fitted
Non-Residential – Heat recovery	52.5%	Share of total commercial stock fitted
Non-Residential – Room Automation, BACS A	30%	Share of total commercial stock fitted
Non-Residential – Building Remote Monitoring (BRM)	45%	Share of total commercial stock fitted
Car & Motorcycle – City tolling	20%	Reduction in road traffic
Photo voltaic	5%	Share of electricity mix in 2030
Metro – Reduced headway	180 sec (from 360 sec)	Peak-time headway [sec]
E-Highways	70%	Share of highway equipped
Harbours – Onshore Power Supply	70%	Share of vessels with on shore power supply

Figure 15: Short listed technologies in the workshop. In green are technologies picked by all the groups. In blue were other notable technologies discussed during the day. These ten technologies were incorporated in the CyPT scenario. For a full list of technology descriptions, please look at Appendix III

Results

The ten selected technologies chosen in the Helsinki workshop can deliver an additional 23 percent of annual greenhouse gas emissions savings in the run up to 2030 when compared to the BAU scenario. These are independent initiatives from the greening of the heating and electricity that will be delivered by HELEN and the National Grid.

Figure 16 shows the emission reduction progress of Helsinki since 1990. In blue is a business as usual projection that shows reductions based predominantly on the cleaner energy mix in the city. In red is the reduction progress of the 10 selected CyPT technologies (CyPT scenario) assuming an investment period from 2015-2030 with the technologies still operating until 2050. In yellow are the 2020 and 2050 targets set by the city. Overall in the CyPT scenario, the city can achieve nearly 50% emission reductions in 2030 compared to 1990 levels.

The economic benefits of the ten technologies in the CyPT scenario are considerable with more than 23,000 FTE jobs created in Helsinki during the next 15 years. These include installation, operation and maintenance jobs in the period 2015-2030 with the largest benefits coming from the photo voltaic installations adding over 6,000 jobs.

Technology Lever	Jobs (FTE)
PV	6,202
Non-Residential – Room Automation, BACS A	5,720
Non-Residential – Heat recovery	4,981
Non-Residential – Building Remote Monitoring (BRM)	2,853
Non-Residential – Building Performance Optimization (BPO)	1,288
Metro – Reduced headway	1,111
Residential – Home Automation	383
E-Highways	302
Harbors – Onshore Power Supply	233
Car & Motorcycle – City tolling	49
Total	23,122

Full-Time Equivalent jobs created by the respective technology lever to Helsinki's local economy.

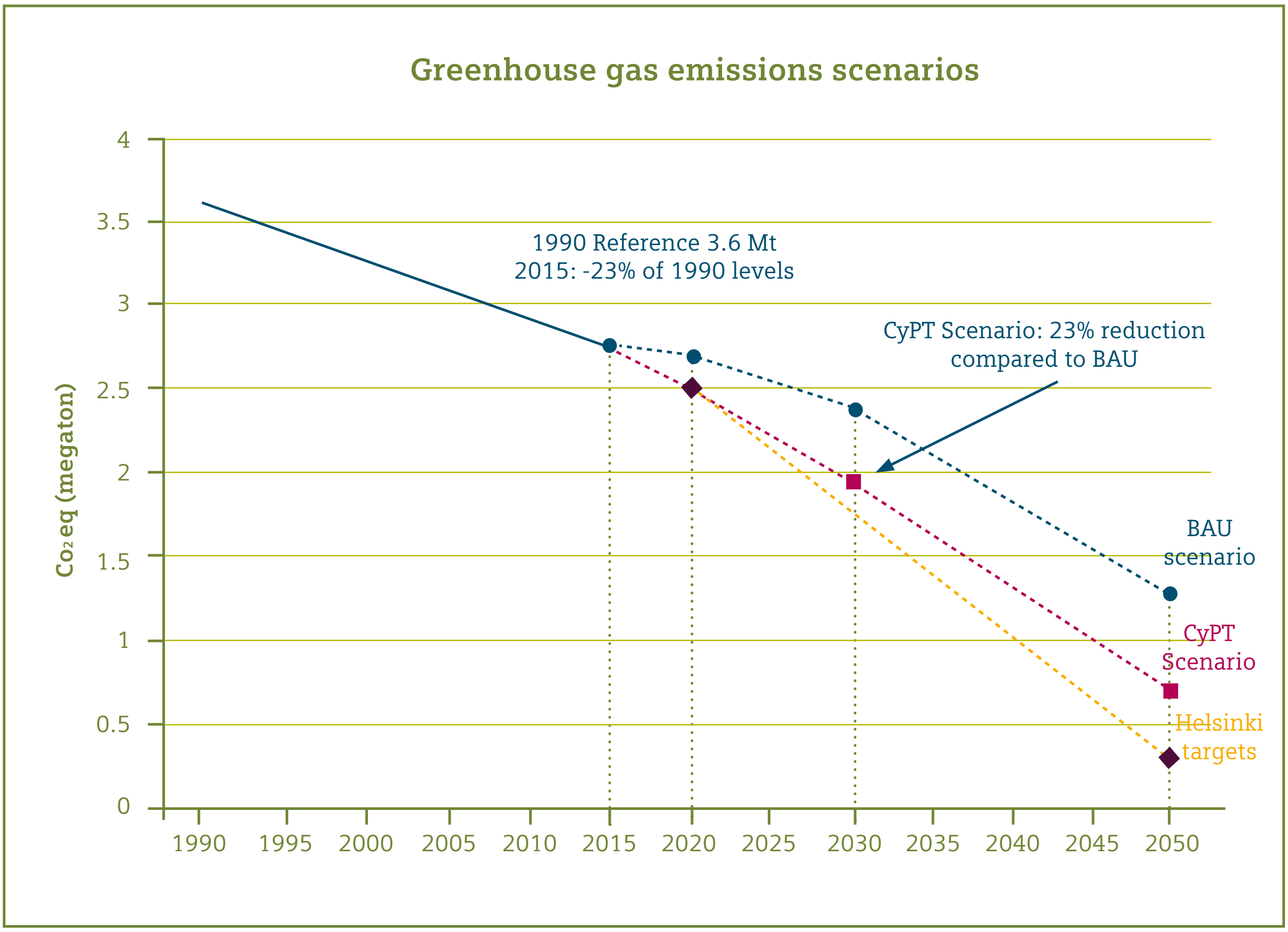


Figure 16: Comparing the BAU scenario, CyPT scenario and CyPT technologies and target emission levels, Observation years 2015, 2020, 2030 and 2050 are highlighted with dots.

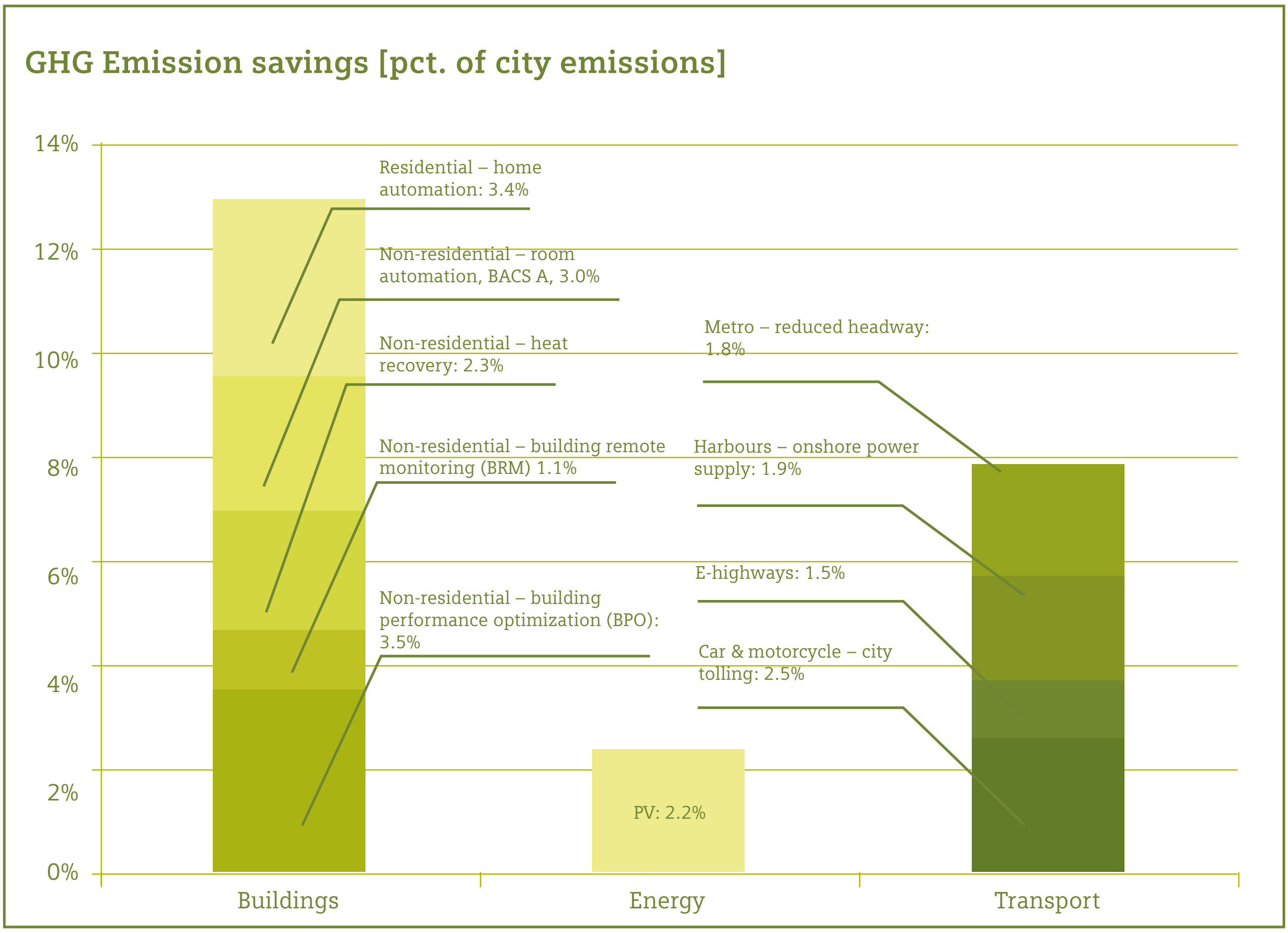


Figure 17: Greenhouse gas emissions savings from the selected 10 technologies

The CyPT scenario can achieve 23% reduction in greenhouse gas emissions compared to the BAU scenario

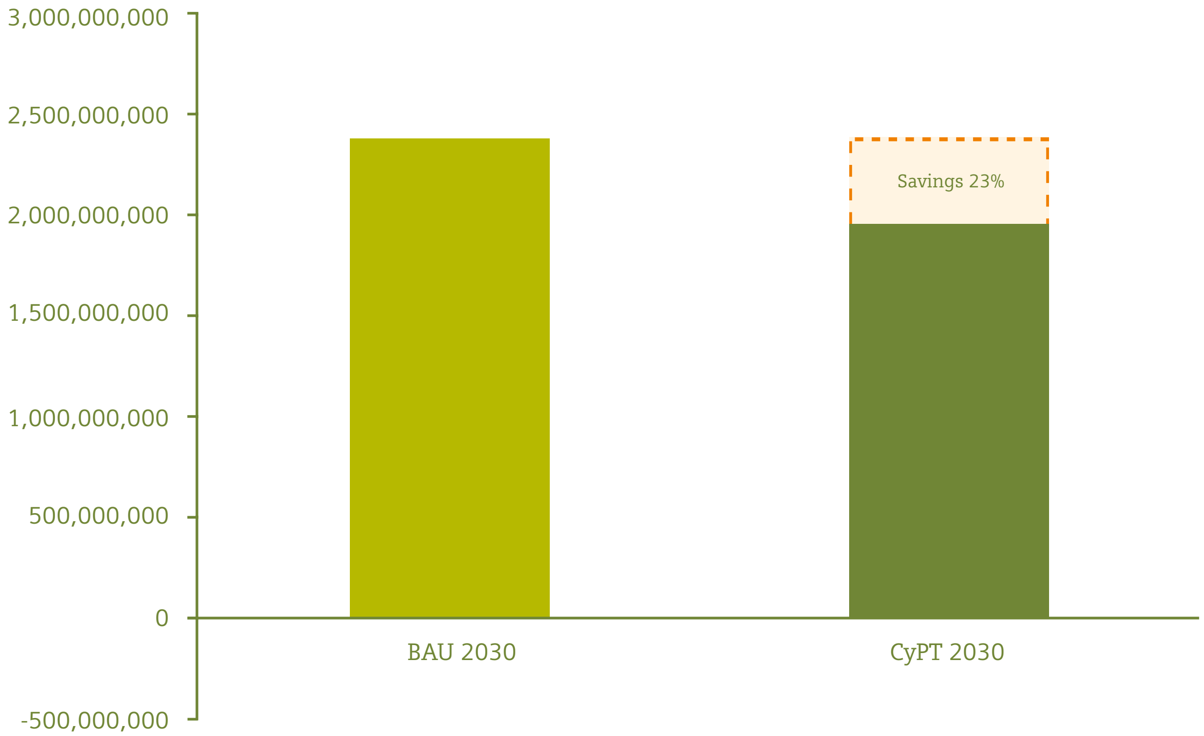


Figure 18: CO_2eq savings from selected 10 technologies in CyPT scenario compared to BAU scenario in 2030

Building Technologies

The five building technologies selected in the workshop will deliver roughly 8 percent of annual greenhouse gas emissions savings by the year 2030 when compared to the business as usual emissions in 2030. Annual implementation for these technologies was set to between 2 and 5 percent of the total city stock to provide a realistic delivery strategy. At a total investment of €1.9 billion, predominantly driven from building automation technologies, these solutions are technically viable and can be delivered in the space of the next 15 years. Financing their installation however may prove difficult because of the low energy prices in Finland.

Technology	Annual rate of implementation	Implementation by 2030	Unit
Residential – Home Automation	3%	45%	Share of total residential stock fitted
Non-Residential – Building Performance Optimization (BPO)	5%	75%	Share of total commercial stock fitted
Non-Residential – Heat recovery	3.5%	52.5%	Share of total commercial stock fitted
Non-Residential – Room Automation, BACS A	2%	30%	Share of total commercial stock fitted
Non-Residential – Building Remote Monitoring (BRM)	3%	45%	Share of total commercial stock fitted

Figure 19: Implementation rates for building technologies

In this study we modelled energy savings based on an average household price for electricity of 20c / kWh and 8.6c / kWh for heating. Commercial price equivalents were 14 c / kWh and 7 c / kWh, respectively. Figure 20 shows that approximate total savings accruing over 15 years would be in the region of €2.2 billion.

Although this is higher than the €1.9 billion needed to fund the technologies, it is important to note that ten years as a pay-back period for these technologies is way above the average 3-5 year repayment period behind most energy performance contracting in commercial buildings, which may prove challenging for the city. There are a number of strategies that the city can take to work around this problem. One involves bundling the building technologies together with energy and transport solutions that may have better returns for investors. The second involves creating a warehouse facility for smaller retrofitting activities so that their loans become large enough to interest institutional investors. Both are highlighted in the examples in box 1 on page 28 from Gothenburg and the WHEEL programme in the US.

	Heat	Electricity	Total
Annual Energy Savings [kWh]	1,300,000,000	1,000,000,000	2,300,000,000
Aggregate energy savings until 2030 [kWh]	10,000,000,000	7,500,000,000	17,500,000,000
Price per kWh [EUR] – Households	0.086	0.20	N / A
Price per kWh [EUR] – Businesses	0.070	0.14	N / A
Monetary savings [EUR]– Households	650,000,000	1,150,000,000	1,800,000,000
Monetary savings [EUR] – Businesses	150,000,000	250,000,000	400,000,000
Monetary savings [EUR] – Total	800,000,000	1,400,000,000	2,200,000,000

Figure 20: Monetary savings from building technologies

Box 1

Driving down the costs of capital for energy efficiency retrofits in the United States

Energy efficiency is often cited as one of the least expensive measures for GHG emission reductions. However barriers including sufficient scale, geographic diversity and performance data have limited it from accessing capital.

WHEEL (Warehouse for Energy Efficiency Loans) is a facility in the US, that commits a financial institution to purchase and "store" (warehouse) loans that meet certain agreed upon criteria until the aggregated value of the loans is sufficient to be securitized (meets the size and other criteria of larger institutional investors). It builds on the success of a large number of state and locally-sponsored energy efficiency programs that have been running for a number of years; building-up volume and performance data.

By aggregating state and local energy efficiency programs, WHEEL drives down the cost of capital and thereby incentivizes additional activity; and provides an appropriate vehicle for institutional investors with a desire to invest in energy efficiency.

A "socialized" credit enhancement facility is built from state contributions of public, utility benefits charge, or other monies to help support from a credit perspective the specific policy objectives of a participating state (e.g. interest rates offered to households, or inclusion of certain income levels).

WHEEL is supported by several policy framework-related provisions including state and local programs that develop a sufficient pipeline that can be aggregated, the Federal government's allowance for American Recovery and Reinvestment Act (ARRA) funds which are used in the socialized credit enhancement facility.

The consortium closed the first asset-backed securitization of energy efficiency loans to market in 2015. Subsequent securitizations will continue as the facility fills, and depending on program growth the facility could be resized, and the frequency of securitizations increased, accordingly.

WHEEL involves a range of stakeholders, from philanthropic organizations that provided seed funding (e.g. Rockefeller Foundation and Ford Foundation), NGOs that were instrumental in its development (e.g. Energy Programs Consortium, National Association of State Energy Offices – NASEO), state and local programs (e.g. Pennsylvania's Keystone Help), Federal agencies such as the Department of Energy that facilitates use of Federal

funds and financial institutions such as AFC First, Citi and Renewable Funding).

A number of lessons were learned in the development of WHEEL. These include the multiple components and stakeholders required to deliver the scale of aggregation needed. Whilst capital markets are not a panacea they do offer a path to larger quantities and more efficient capital, a key ingredient for program growth. As such it was critical to ensure that state and local programs, and their aggregation, meet the needs of the capital markets in terms of size, diversity (across several dimensions of risk), and required data / information. The time required to establish and launch WHEEL was considerable. Establishing new asset classes in the capital markets takes time, but now that it is established, a platform exists to rapidly grow energy efficiency programs and provide larger amounts and more efficient sources of capital.

(Source: Citi, C40 & Siemens, Climate Financing: A new perspective for Cities, 2016).

Box 1 continued

The Gothenburg Green City Bond Programme

Green City Bonds are traditional municipal bonds issued by cities in order to generate up front capital for investment. Their key difference is that they are labelled as green with a commitment to deliver environmental benefits within the maturity period of the bond.

In 2013, the city of Gothenburg raised its first green city bond at a value of €200m. Within only a couple of days the bond was oversubscribed due to the high credit rating of the municipality. Rather than the city telling capital markets where the money would be spent, it launched an innovative competition model for organisations to submit green projects that they wanted to fund in diverse sectors such as renewable energy, waste management and mobility. This was also open to departments within the municipality itself. Each submission had to be accompanied with an estimate of greenhouse gas emissions savings that the project would deliver. As soon as all submissions were received a selection committee composed of the Environment and Energy departments as well as the City Council selected the most impactful projects on a cost to savings ratio. The winners were a water purification plant, a biogas heat and the replacement of municipal cars with e-cars.

Total cost: €75 million
Benefits: capacity increase by 40%, socioeconomic gains in terms of lower disease outbreaks which saves up to 290,000 days in productivity loss between 2014 – 2018

Water plant and purification filter

Output: 800-1,000 GWh

Biogas heat and electricity plant

100 electric vehicles

Electric car city fleet

Gothenburg 2013 Green City Bond Programme

Issuance

Markets ▶ €200 million City Bond ▶

Lending

- Renewable energy sector (solar, wind, wave and hydro)
- Energy efficiency
- Waste management
- Waste management (efficiency)
- BioFuel (from forestry waste)
- Smart grids
- Sustainable housing (ex. infrastructure and construction)
- K2020 public transport development program
- Environmental (max. 20%)
- Development of new nature conservation areas
- Water clearing facilities

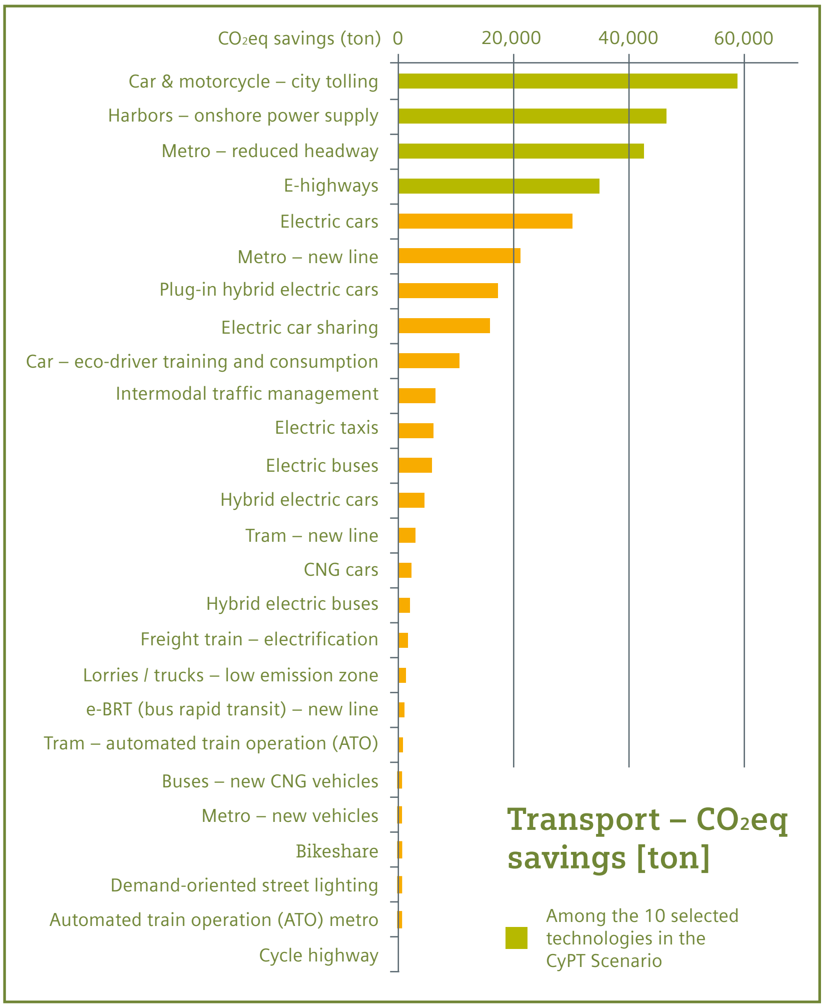
Selection committee: Environmental Department Treasury department, City Council

Reporting

Annual investor letter with a list of projects financed. However, no standardised monitoring and verification process.

Transport technologies

From the selected four transport technologies in the workshop, city tolling and onshore power provide the largest CO_2eq reductions with more than 4 percent of combined annual savings for the city by the year 2030. A full list of technologies is listed in figure 21.



In general the most effective technologies are those that target the largest emission sources, notably cars that represent nearly 60 percent of transport related emissions. City tolling, which was modelled to reduce congestion by 20 percent and metro reduced headways of 3 minutes (compared with present 4 minutes) can have the double the outcome of reducing the number of vehicles in the city and putting more people on public transport.

Interestingly city tolling remains one of the most cost effective ways of dealing with emissions in the city because it acts as a direct tax to polluters. A recent IPCC report compared different policy tools and found that city tolling was the best revenue generator as a regulatory tool at the disposal of cities. This is indicated as Cordon Pricing and Zoning Charge in figure 22.

Figure 21: Possible savings from various technologies in Helsinki until 2030. The technologies used in CyPT scenario are marked with (Green). The other technologies are for comparison only.

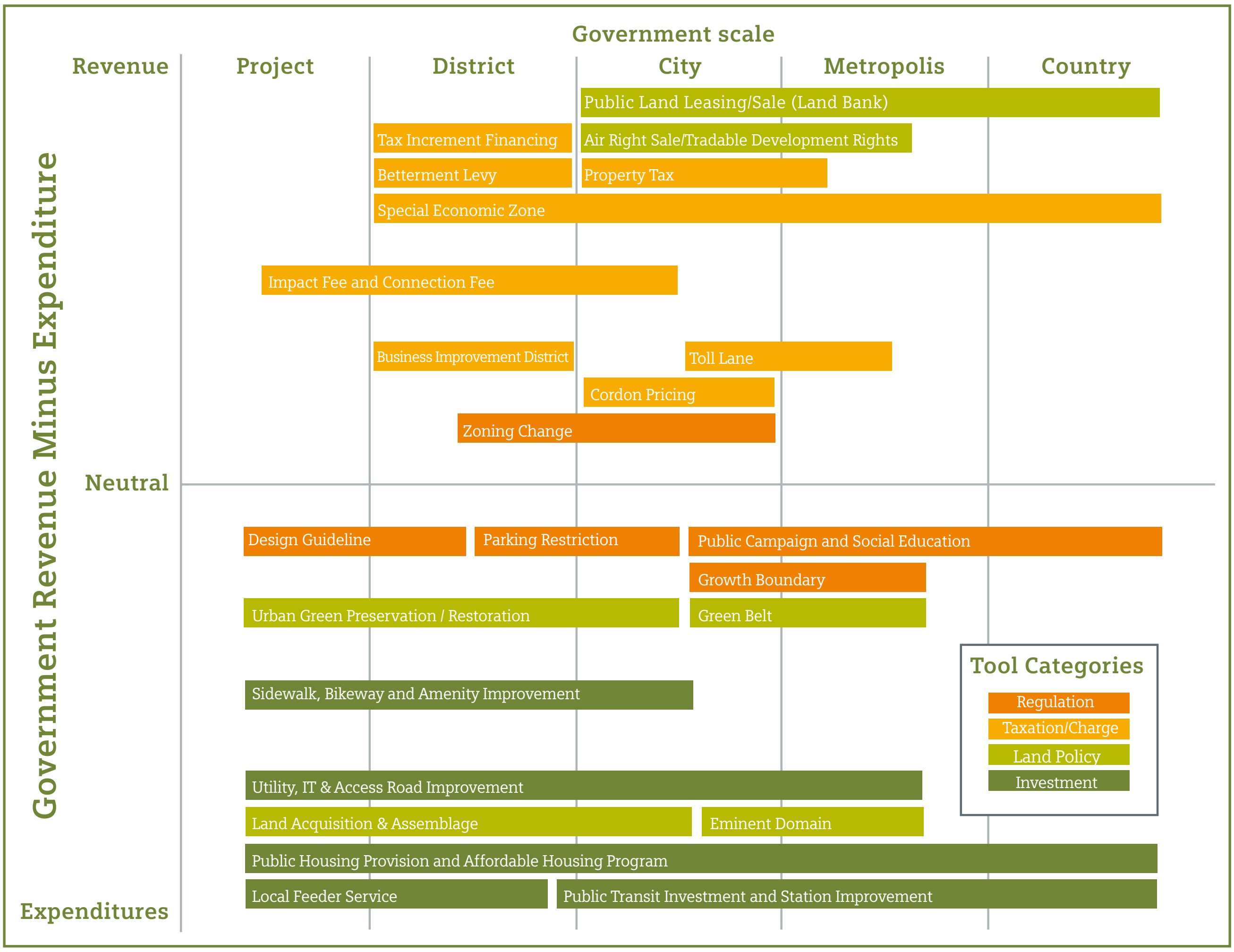


Figure 22: Revenue profile of city programmes (Source IPCC, 2011)

London's experience from or city tolling is an interesting one in terms of revenue generation. Since its inception in 2001, it has consistently been one of the main sources of revenue in the city as box 2 to the right suggests.

Helsinki could learn from London's attempts to extend the geographic area of the charge and increase the charge itself to bring more revenue to the city. It could improve London's experience by potentially reducing the costs to run the system and by re-allocating some of the proceeds to other city investment priorities. This will of course depend on the existing public transport provision in areas where car trips originate.

Looking at Helsinki's other top performing transport technologies, onshore power supply that allows docked vessels in the ports of Helsinki to run on local electricity rather than diesel deliver of 40 Kiloton of annual greenhouse gas emissions savings by 2030. Other significant technologies include reducing the headway between peak hour metros which can exponentially increase capacity in the system without replacing the existing rolling stock.

Transport solutions also play an important role in reducing background NO_x levels in the city with onshore power supply for vessels reducing levels by 35 percent in 2030 compared to the BAU scenario. The challenge with this technology is that infrastructure investments must be made both at the port site but also by the vessel owners. A coordinated effort by other international port authorities that receive the vessels from the same shipping companies can accelerate their deployment.

Improving on London's Congestion Charging

The congestion charge in London is a daily levy imposed on drivers entering central London between 07:00 and 18:00 from Monday to Friday, excluding public holidays. Set at £5 at its inception in 2003, the charge has gradually increased over time, and as of June 2014 stands at £11.50 if paid in advance or on the day, or £10.50 for drivers that have registered for CC Auto Pay.

The scheme makes use of purpose-built automatic number plate recognition (ANPR) cameras to record vehicles entering and exiting the zone. The cameras read car number plates and cross-reference them against a register of cars. Cameras can record number plates with a 90% accuracy rate through the technology. Drivers are able pay the charge in advance or on the day of travel. If they forget they can pay up until midnight the following day, but will incur a surcharge.

Box 2

Groups exempt from paying the congestion charge and those eligible for discounts include people with disabilities, residents living within the congestion zone, emergency services and breakdown recovery vehicles, taxis, and drivers of alternative fuel vehicles.

The congestion charge zone covers a large portion of central London. In 2007 the congestion charging zone was enlarged via the Western Extension, but this was revoked in 2011, returning the charging zone to its original size.

Behind ticket and fare sales, congestion charge is the second biggest revenue generator for Transport for London bringing nearly €300m of annual revenue. Revenue is generally earmarked to be spent on new bus investments in the city.

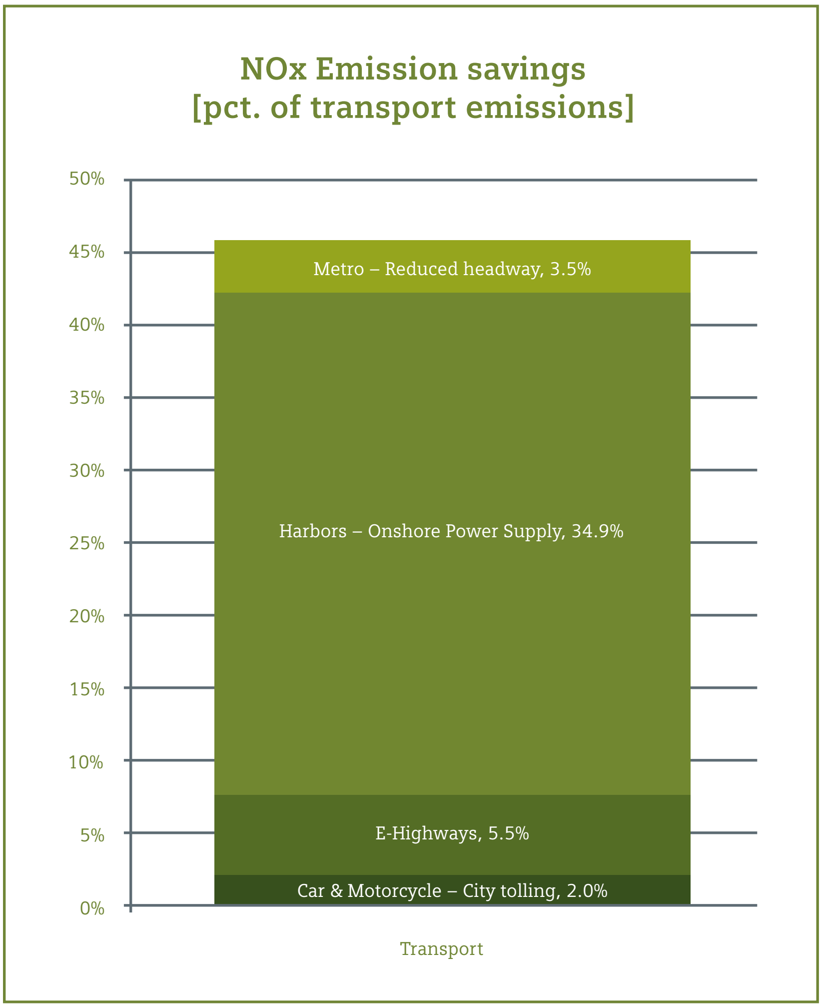


Figure 23: NO_x savings from selected transport technologies

Energy technologies

In this model we assumed relatively conservative shares for both wind and photo voltaic (PV) installations in Finland in line with projections provided by the city. For wind, we modelled our results based on 10 percent of the electricity share and for photo voltaics – based on 5 percent.

Due to the local climatic conditions, photo voltaics is by far more effective in providing high power output compared to wind energy with over 50 Kiloton of annual greenhouse gas emissions savings[6].

Helsinki's local energy company, HELEN, has realized the potential and has started major investments in the field. One of its more recent investments includes solar panels on top of the city's substation in Suvilahti. The plant has an output of 340 kWh and an estimated annual production of 275 MWh, enough to power 140 one-bed apartments. The project cost €600,000 and was predominantly funded by the company's innovative Environmental Penny Fund, whereby the company sets aside over €3 per month for each one of its customers. This money is then invested in new renewable energy for the city. To recoup its upfront investment HELEN auctioned each of the 1,200 panels on the site to customers who would be deducted the energy produced from the panel in their monthly bill.

Helsinki could look to more incumbents to enter the solar space. A recent startup in the US called Solar City maybe a model that could be replicated in the city.

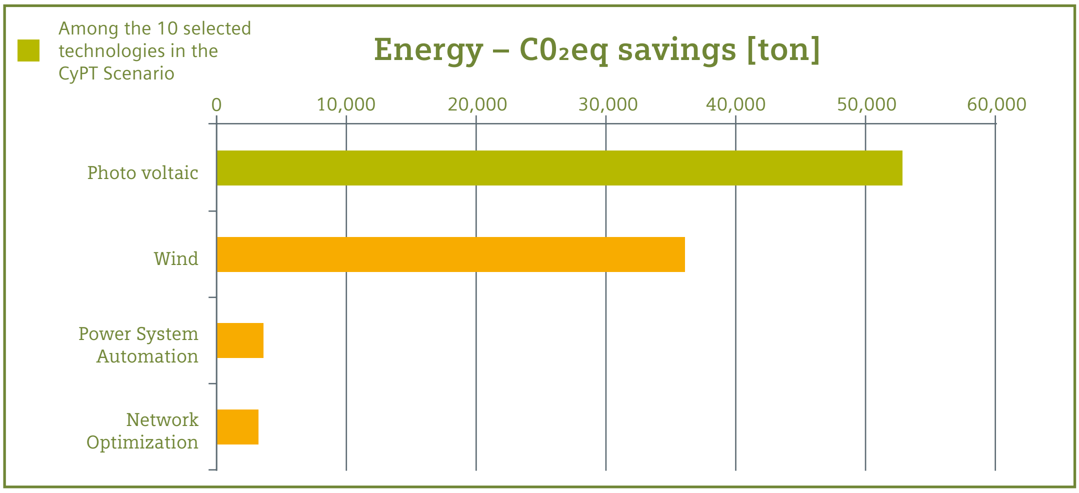


Figure 24: CO_2eq savings from energy related technologies

6. The wind share of electricity in 2030 is 6.6% (Figure 7). Therefore a 10% implementation rate yields only 3.4 percentage point effective additional implementation. Currently photo voltaics is 0%, therefore the full 5% implementation is effective.

Solar City

SolarCity is a publicly listed company in the US that pays and installs for the deployment of solar panels in homes and businesses. With recent aerial solar intensity mapping advances, the company can approach those areas and buildings with the highest potential output. Customers only pay a monthly fee for the service as long as they allow installation and access rights to their roof. Depending on local energy prices, the solar contract may often be lower than their existing monthly bill. By 2014, then company had an output of more than 2 gigawatts of deployed power.

Solar City delivers its service through two models called the Solar Lease and Solar PPA. In the former the monthly rate is predetermined and tied to a production output. In Solar PPA, the actual amount paid relates to actual demand. These options have allowed the company to both diversify its customer base but also reduce its risk profile with a steady minimum income reported to investors.

Box 3

Conclusion

This report has identified some of the highest impact mitigation technologies for Helsinki. A selection of just ten technologies chosen in a workshop between city stakeholders and Siemens can deliver 23% annual emission reductions by the year 2030 compared to a business as usual scenario. Figure 25 summarizes these solutions across all sectors both in terms of their overall greenhouse gas emissions savings as well as their cost effectiveness (i.e the greenhouse gas emissions savings per € of investment).

By far, the highest impact solutions are residential building automation technologies that target the very high residential emissions, and photo voltaic panels. Interestingly in both these cases, their cost effectiveness is comparatively low as shown in the yellow bars in the diagram above. In contrast, city tolling and onshore power supply provide much better mitigation returns on the investment.

This report has presented a number of ways that the city can deal with some of these investment challenges through a series of international case studies. The first involves sector specific initiatives such as a warehousing facility for residential retrofitting loans to bundle the small investments together in order to attract larger investors. In the energy sector, photo voltaics expansion could be accelerated using HELEN's crowd funded solution for solar panels or by providing an array of solar tariffs as tested by Solar City in the US.

Perhaps the greatest opportunities lie in the city being able to cross subsidize investments between sectors so that revenue generators such as city tolling could provide loan facilities to more difficult to fund energy and building projects. Alternatively, setting up a culture of competing mitigation projects vying for investment from a Green City bond may allow city authorities to mix and match projects across sectors.

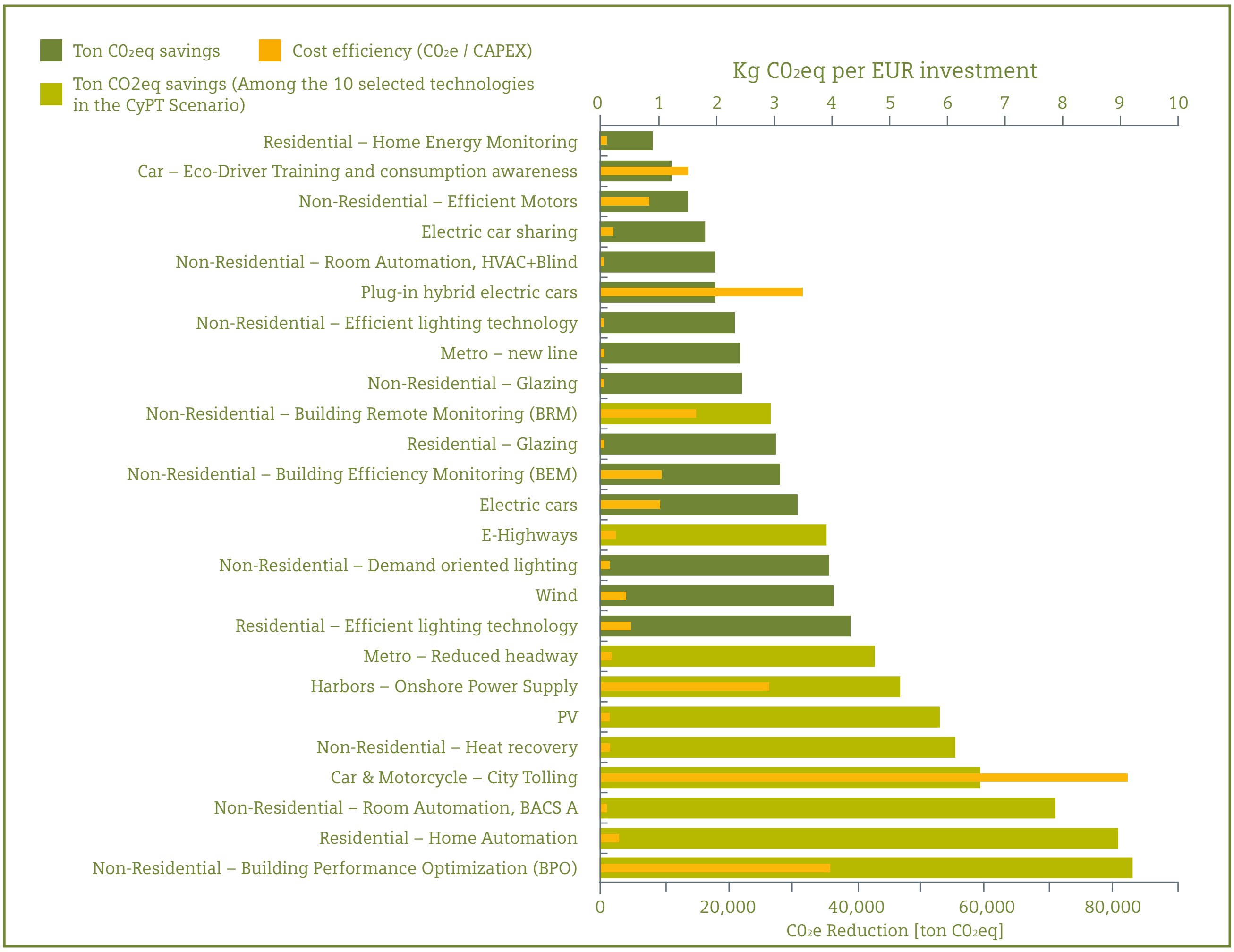


Figure 25: Overall CO_2eq mitigation performance and cost effectiveness of top performing technologies. The technologies included in the CyPT scenario (year 2030) are marked with light green.

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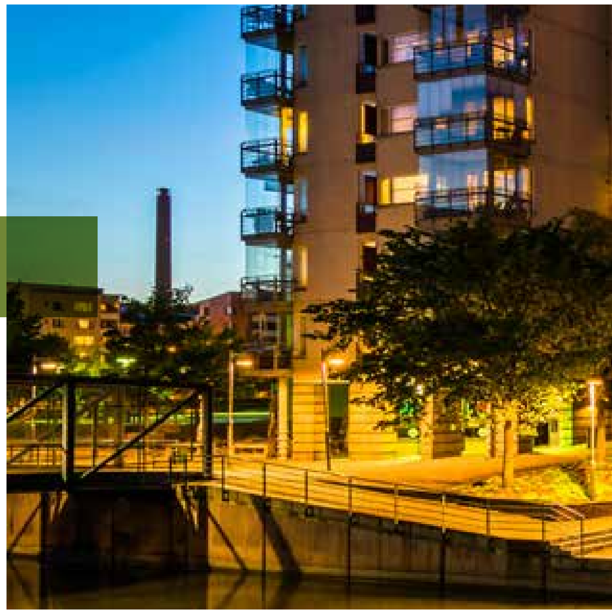

Exact sources and data used can be found at www.hri.fi

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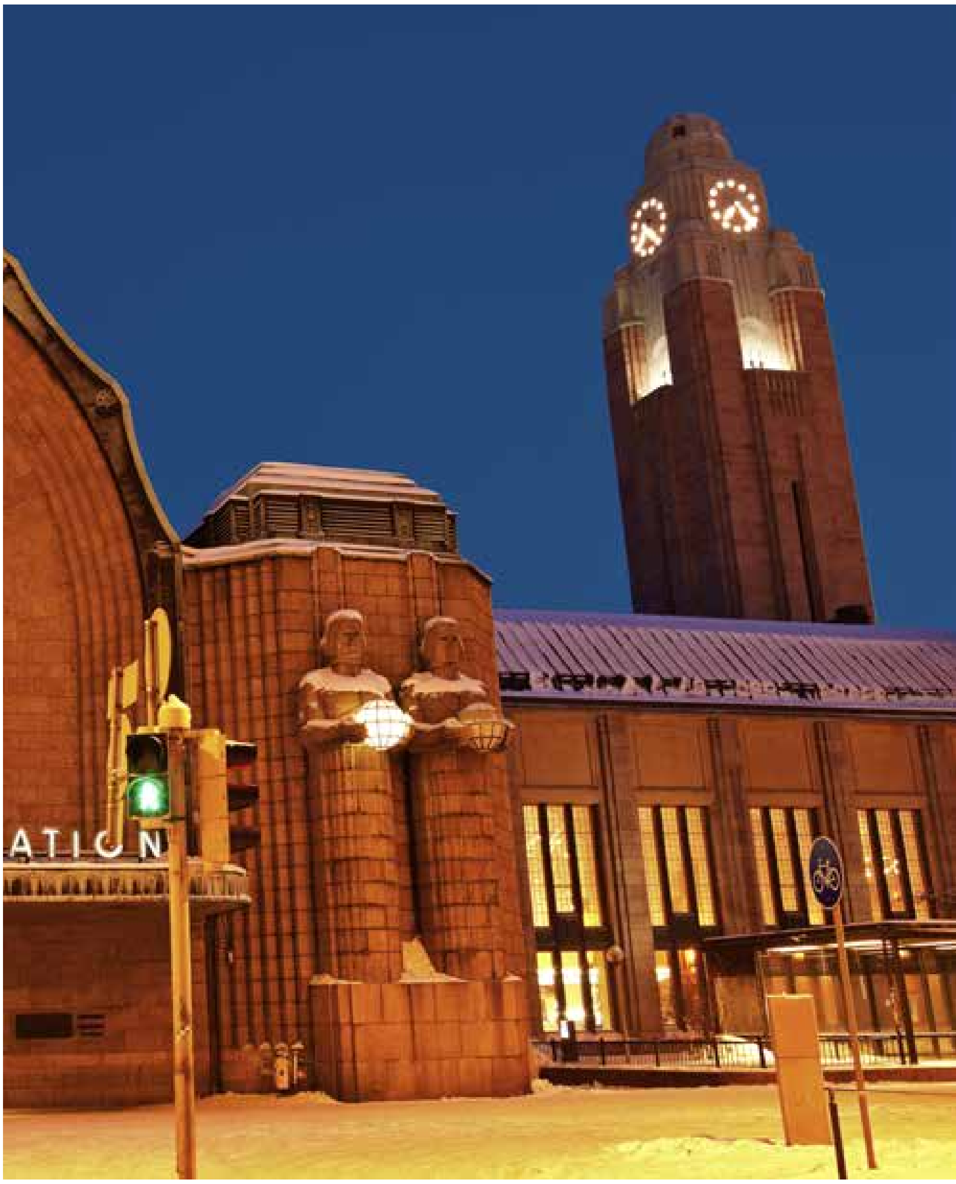
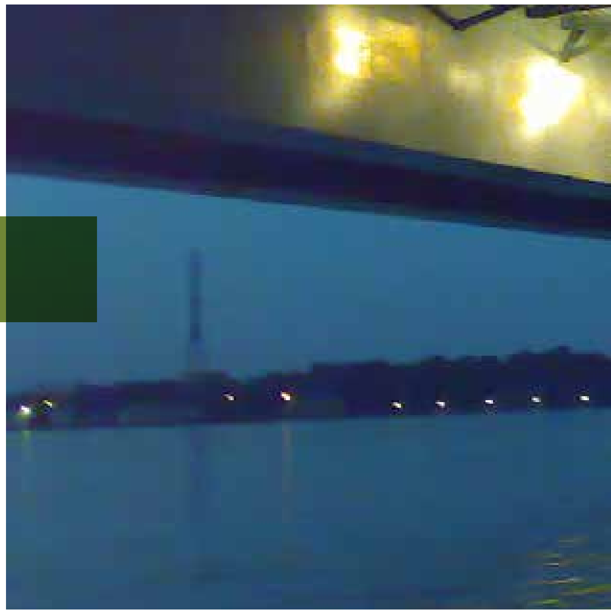


Appendix I



Implementation Rates used in the study.

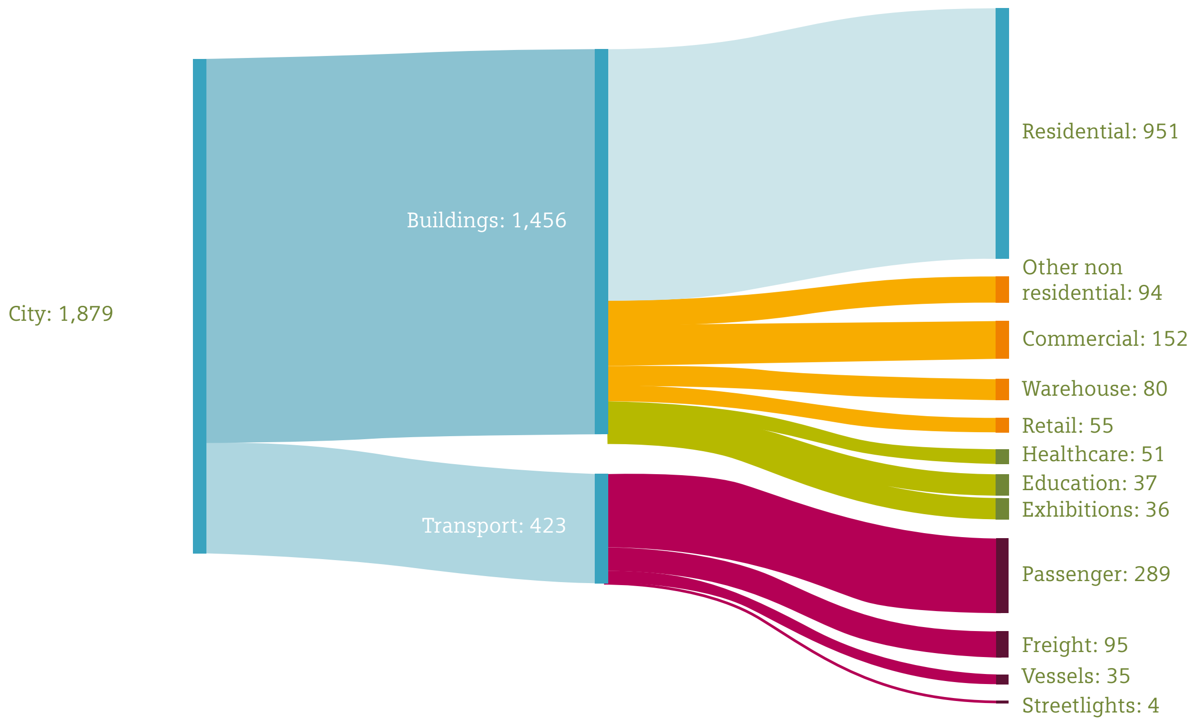
Technology – Transportation	Implementation rate	Unit
Automated train operation (ATO) Metro	100%	Share of lines equipped
Hybrid electric buses	70%	Share of fleet replaced
Electric buses	70%	Share of fleet replaced
Automated train operation (ATO) Regional Train	70%	Share of lines equipped
Metro - new line	1	Number of new lines
E-Highways	70%	Share of highway equipped
CNG cars	10%	Share of car fleet replaced
Electric cars	10%	Share of car fleet replaced
Hybrid electric cars	10%	Share of car fleet replaced
Plug-in hybrid electric cars	10%	Share of car fleet replaced
Electric taxis	100%	Share of taxi fleet replaced
Demand-oriented street lighting	70%	Share of street lights replaced
Electric car sharing	2	Cars per 1000 inhabitants
Inter modal traffic management	70%	Users as share of travellers
Bike share	3	Bikes per 1000 inhabitants
Metro – New vehicles	100%	Share of fleet replaced
Tram – New line	5	Number of new lines
e-BRT (Bus Rapid Transit) - New line	3	Number of new lines
Car – Eco-Driver Training and consumption awareness	30%	Share of driving license holders trained
Metro – Reduced headway	180	Peak-time headway [sec]
Street Car – New vehicles	100%	Share of fleet replaced
Buses – New CNG vehicles	70%	Share of fleet replaced
BRT (Bus Rapid Transit) – Electrification	100%	Share of lines equipped
Tram – Automated train operation (ATO)	100%	Share of lines equipped
Metro – Regenerative braking	100%	Share of lines equipped
Tram – Regenerative braking	100%	Share of lines equipped
Cycle highway	10	Km of new cycling highway per 100.000 Inhabitants
Freight tram –Line upgrade	10%	Share of tram network equipped
Freight Train – Electrification	100%	Share of electrified railway equipped
Lorries / Trucks – Low emission zone	6	Minimum euro class standard to enter low emission zone

Technology – Transportation	Implementation rate	Unit
Car & Motorcycle – City tolling	20%	Reduction in road traffic
Public Transport – E-ticketing	70%	Users as share of travellers
Harbours – Onshore Power Supply	70%	Share of vessels with on shore power supply

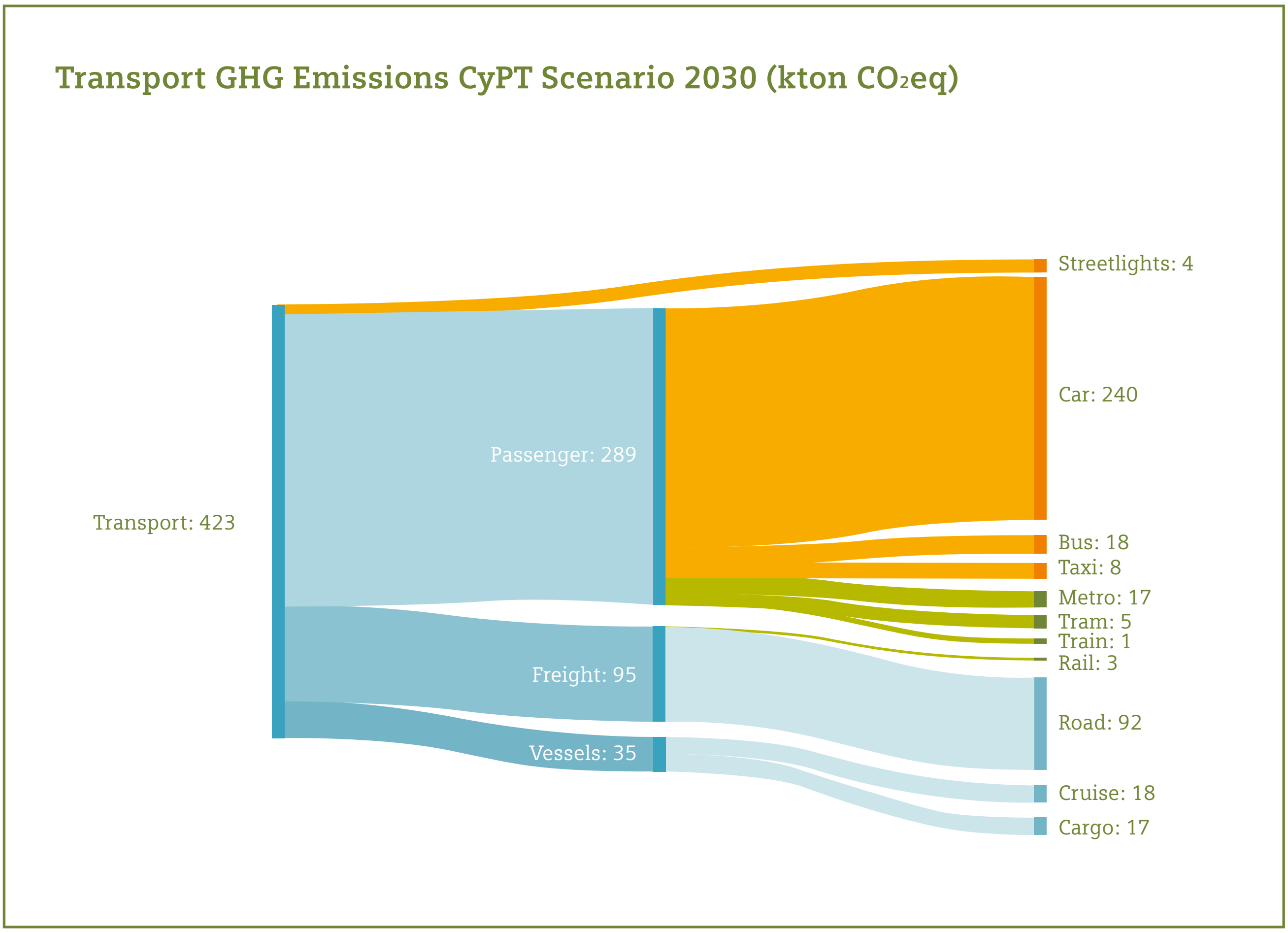
Appendix II

Breakdown of CO2 eq. emission in 2030 for the CyPT Scenario with implementation of 10 technologies according to Figure 15.

City GHG Emissions CyPT Scenario 2030 (kton CO_2eq)



Helsinki's greenhouse gas emissions in 2030 predicted in the CyPT Scenario (kiloton CO_2eq. in 2030).



Helsinki's greenhouse gas emissions from transport sector in 2030 predicted in the CyPT Scenario (kiloton CO_2eq. in 2030).

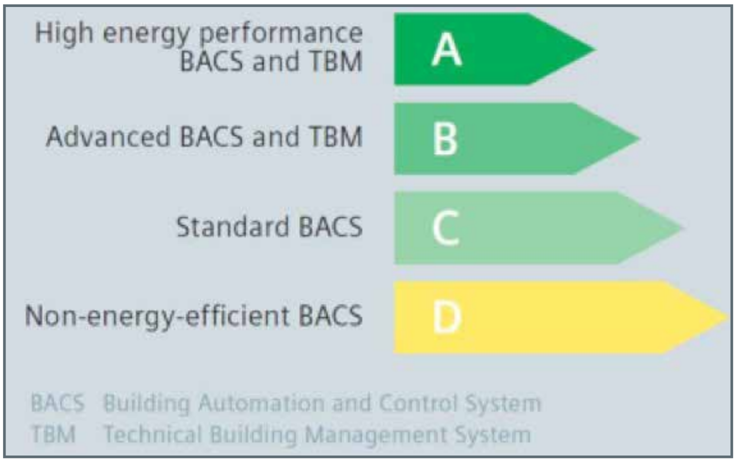
Appendix III

Appendix III provides a description of some of the technologies used in the model

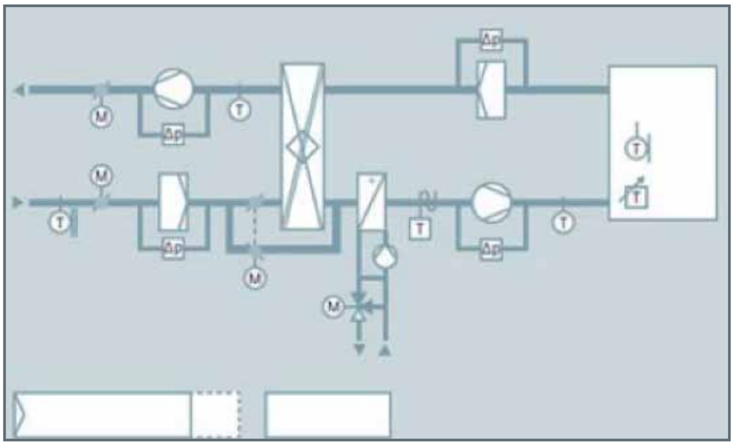
Home Automation allows the automatic regulation of different space temperatures throughout the home via heating and / or cooling depending on occupancy periods, user adjustable setpoints and outdoor conditions. The solution is usually carried out by a central control system, connected to wired (or wireless) sensors and actuators and can also include lighting, shading and security features (alarms, information), plus remote connectivity. Reduction of CO_2eq, PM_{10}, NO_x related due to energy savings.

Room Automation BACS A allows thermal and electrical energy usage to be kept to a minimum. Building Automation and Control System (BACS) are building technologies that can be installed in existing or new buildings. An Energy Class A building corresponds to a high energy performance BACS and Technical Building Management Systems (TBM). Class A BACS systems include:

- Networked room automation with automatic demand control
- Scheduled maintenance
- Energy monitoring
- Sustainable energy optimization



Heat Recovery is an energy recovery system can reduce energy consumption in a building by pre-conditioning the outside air with 'free' energy extracted from the space. By comparing outside and indoor temperatures, you can also maximize 'free cooling' during summer and pre-heating by mixing some of the warm extract air from the room with the outside air (via a bypass or heat exchanger) during winter. Reduction of CO_2eq, PM_{10}, NO_x related due to energy savings. There has to be temperature difference between outside temperature and requested room temperature. Its work vise versa for cooling.



Building Performance Optimization (BPO) is a range of services designed to increase the energy efficiency of an existing building by implementing proven building control strategies otherwise known as Facility Improvement Measures (or FIMs). BPO can improve thermal and electrical energy efficiency in a building in many ways; typically via improved HVAC technology, by adapting the building to suit usage profiles or providing information and analytics for operational personnel.

Building Remote Monitoring allows individual building performance to be measured and compared against benchmark values for similar building types or sizes. Energy experts are able to remotely analyze building energy usage, to detect problems and make proposals for improvements. Impact on emissions reduction: Offering monitoring services and performance reports creating awareness and transparency and enable continuous improvement and reduction of overall energy consumption. Reduction of CO_2eq, PM_{10}, NO_x related due to energy savings.

Metro Reduced Headway increases the capacity of over-utilized metro lines by modelling the introduction of additional trains and a signaling automation system, inducing a modal shift from motorized modes of transport to the metro lines. Impact on emissions reduction: Modal shift to a low-emissions mode of transport. Impact depends on current modal split and electricity mix.

City tolling simulates the establishment of a tolling zone in the city. Charges are obtained at a level, where the target reduction in city-internal car and motorcycle use is reached. Impact on emissions reduction: Modal shift to emitting lower emissions mode of transport. Impact depends on current modal share and electricity mix.


YLE-2
YLE-1

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