Low-carbon Gothenburg 2.0. Technological potentials and lifestyle changes. Mistra Urban Futures Reports 2014:02

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Low-carbon Gothenburg 2.0

Technological potentials and lifestyle changes

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MISTRA URBAN FUTURES

Mistra Urban Futures is an international centre for promoting sustainable urban futures, with its base in Gothenburg, Sweden. We believe that the coproduction of knowledge is a winning concept for achieving sustainable urban futures and creating FAIR, GREEN, and DENSE cities. It is funded by the Mistra Foundation for Strategic Development, the Swedish International Development Agency (SIDA), and seven consortium members.

Foreword

The report *'Klimatomställning Göteborg. Tekniska möjligheter och livsstilsförändringar' (Low-carbon Gothenburg. Technological potentials and lifestyle changes*), which was published in September 2013, generated much interest among both experts and the public as a whole. The English summary (Low-carbon Gothenburg) also generated interest at international level. This led the Swedish Environmental Protection Agency (through Eva Ahlner) to fund an English version of the report.

Rather than simply translating the original report, we decided to develop the analysis further, partly because we ourselves had identified a number of potential improvements and partly to take account of the many useful comments we had received in response to the report. For this reason, we entitled the report *Low-carbon Gothenburg 2.0* (the report is also available in Swedish with the title: *Klimatomställning Göteborg 2.0. Tekniska möjligheter och livsstilsförändringar*).

Jörgen Larsson (Chalmers) and Lisa Bolin (SP Technical Research Institute of Sweden) are the main authors of the report and are responsible for the majority of the work associated with it. The further analysis was, however, carried out in close consultation with Pernilla Hellström, Inger-Lise Svensson, Kristofer Palmestål at the City of Gothenburg, Berit Mattsson at Region Västra Götaland and Robin Sinclair at Chalmers.

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Summary

When it comes to climate change, Gothenburg aims to be one of the world's most progressive cities and to reach sustainable emission levels by 2050. As a step in this direction there is a target that by 2035 the consumption based emissions for the residents of Gothenburg shall be less that 3.5 tonnes of greenhouse gas emissions per person.

This type of goal requires an approach where not only local emissions are targeted, but also the emissions to which our patterns of consumption give rise beyond geographical borders. The purpose of this report is to raise awareness of the options available for achieving this. The key question in this study is what technological and lifestyle changes that could enable emission levels of less than two tonnes per annum by 2050. Another important part of the analysis is how these radical reductions might affect people's wellbeing.

In order to be able to answer the above questions and to incorporate greenhouse gas emissions from all areas, a wide range of different types of data has been combined: statistics, reports as well as our own and other people's research. A bottom-up method was used in which greenhouse gas emissions was calculated on the basis of average data on how much Gothenburg residents drive their cars, how much electricity they use etc. All the figures for emissions refer to carbon dioxide equivalents (CO_2e), which means that the calculations include not only carbon dioxide but also other greenhouse gases, e.g. methane and nitrous oxide. Analyses were carried out for a high-income family with two cars living in a detached house, a low-income family without a car living in a rented apartment and for the average Gothenburg resident. The starting-point was an analysis of greenhouse gas emissions in 2010.

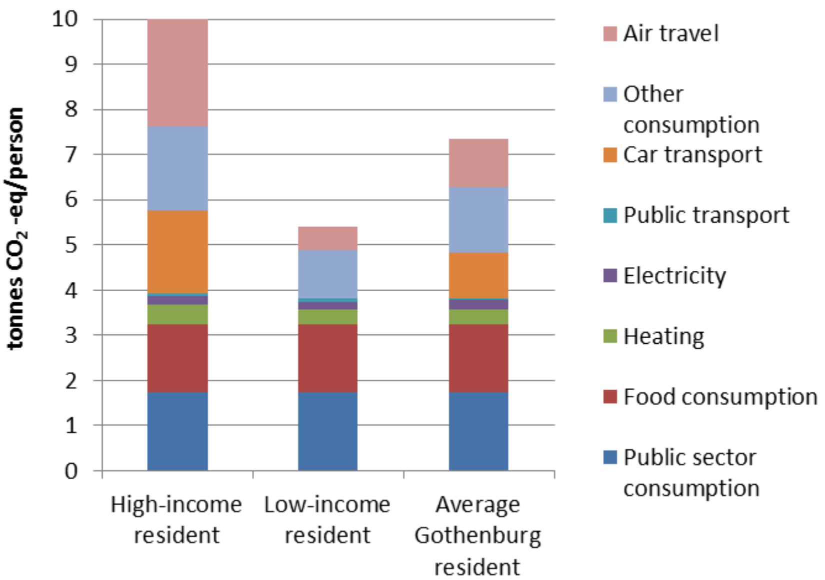

Figure. Emissions from the different typical households in 2010 sub-divided into different domains.

Using our methodology, in 2010 the average Gothenburg resident gave rise to emissions of approximately 7.4 tonnes of carbon dioxide equivalents. This is probably an under-estimate. The Swedish Environmental Protection Agency came up with a figure of approximately 10 tonnes using a method which is more suitable for estimating total emissions per capita at national level. We, on the other hand, chose a method which is better suited analysing potential measures for reducing future emissions.

At the base of the above stacks are emissions of 1.7 tonnes from public consumption (hospitals, schools, healthcare, administration, defence etc.). Swedes' average food consumption generates emissions of approximately 1.5 tonnes a year, of which just over half comes from the consumption of meat. Overall, the high-income family's emissions are almost twice as high as those of the low-income family. The main reason for the difference in emissions between the households is the extent to which they travel by car and by plane.

Three different future scenarios

Three different scenarios have been analysed in order get a picture of the possibilities to reach emission targets. These are built on a range of different assumptions.

The scenario *Business as usual (BAU)* aims to illustrate how the situation could be in 2050 if climate policy, technological advances and trends in consumption continue in the same way as they have done in recent decades. The scenario assumes continued improvements in efficiency in, among other things, cars (a total of 20%) and air travel (40%) up to 2050 but also an increase in electricity consumption (+25%), dwelling size (+58%), meat consumption (+50%) and air travel (+350%).

The scenario *Current climate policy scenario (CCP)* assumes that the objectives of current climate policy have been achieved, i.e. significant reductions in emissions from energy systems (-65%) and totally fossil-independent road transport by 2050.

The scenario *Low-carbon transition (LC)* includes enough changes in order to achieve emissions lower than two tonnes per person by 2050. In addition to the changes in CCP the following is assumed: a 50% reduction in residential energy consumption, a 50% reduction in the consumption of beef and pork, air travel at year 2000 levels, a greater proportion of service-based consumption and a 25% reduction in working hours.

These assumptions result in very large differences in emission levels by 2050.

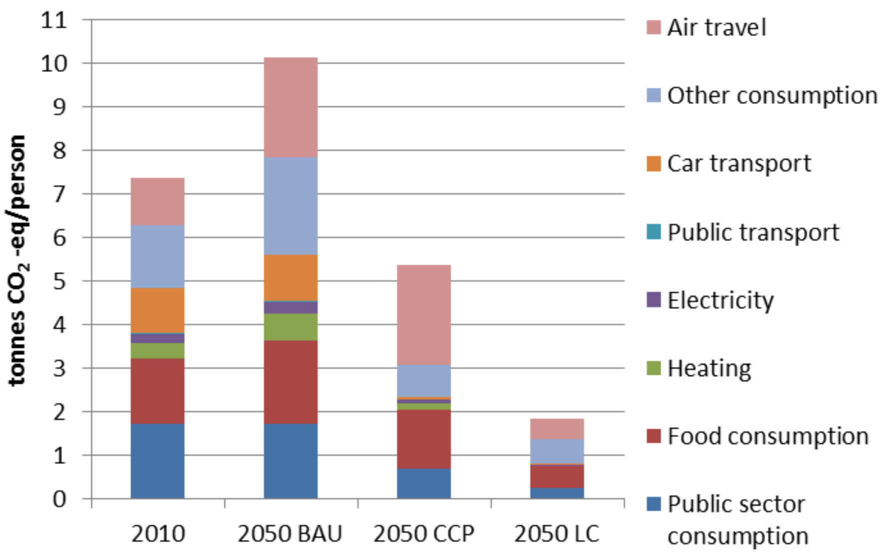

Figure. Emissions from the avarage resident in Gothenburg for the three different scenarios.

The emissions for the average resident in Gothenburg would, according to our calculations in *Business as usual (BAU*), increase from about 7.4 tonnes today to 10 tonnes by 2050. The increases in volume are not offset by improvements in efficiency.

The scenario *Current climate policy scenario (CCP)* indicates that the emissions from the average resident in Gothenburg would be just less than 5.5 tonnes by 2050. Emissions from cars, electricity and heating will be virtually eliminated. We assume that no stringent control measures have been introduced in order to significantly reduce emissions from air travel and food.

The assumptions in the scenario *Low-carbon transition (LC)* leads to emissions lower than two tonnes by 2050 for the average Gothenburg resident and for the low-income family, while the high-income family causes emissions of over 2.5 tonnes.

Impact of a low-carbon transition on quality of life

In the first instance, we must emphasise that it is absolutely crucial for the quality of life of future generations that the climate targets are met. The focus here, however, is the impact on quality of life of a transition to a low-carbon society per se, i.e. the potential impact of new technology and a change in lifestyle on the current generation. Research carried out in connection with the work on this report has analysed the links between wellbeing and greenhouse gas emissions. The results below are based on data from 1,000 people. Wellbeing is measured as a combination of how satisfied the respondent is with their life as a whole and how happy they feel in general.

The figure below summarises the results of this analysis, subdivided into decile groups, each comprising of approx. 100 individuals (the 10% with the lowest emissions in decile group 1 etc.). The lower part of the diagram shows that the emissions of the first decile group are less than a third of those of the decile group with the highest emissions. At the same time, the upper part of the diagram shows that the differences in wellbeing between the different decile groups are very small.

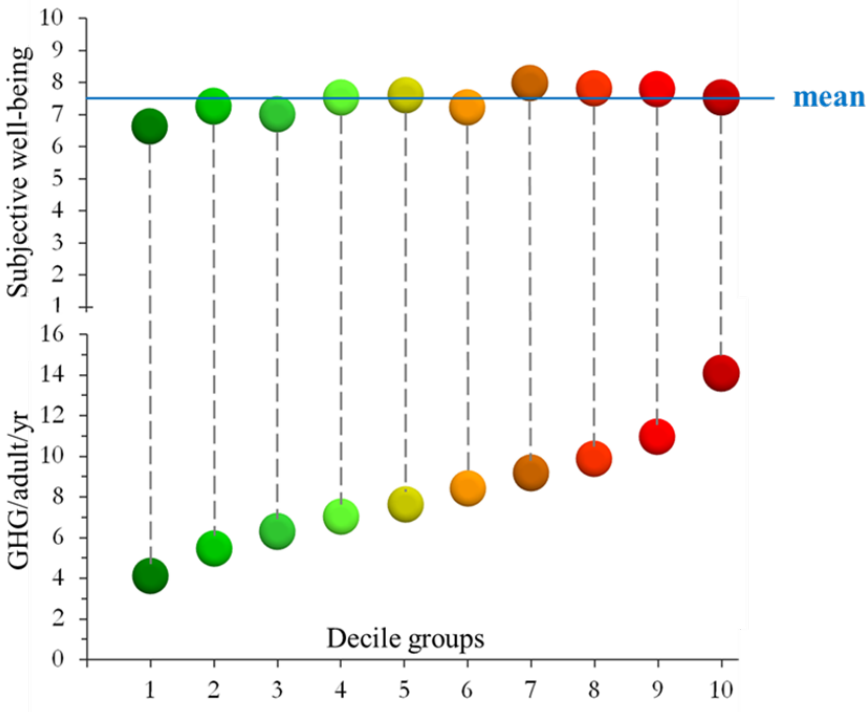

Figure. Greenhouse gas emissions and wellbeing classified by emission deciles.

In addition, a more detailed analysis was made of the effect on wellbeing of the amount of air travel, meat consumption, car usage and dwelling size. There was no indication that these factors were linked in any way with the level of wellbeing. There does not appear, therefore, to be an obvious trade-off between a low-emission lifestyle and a high level of wellbeing.

These analyses are, however, based on the difference in lifestyle between different individuals. Clearly, we cannot, based on this draw the conclusion that it would be unproblematic for individuals to change their own lifestyles overnight. But since the transition to a low-carbon society would be implemented gradually over the course of several decades, the above-mentioned results have certain relevance. However, even if people's level of wellbeing would scarcely be affected by a transition to a low-carbon society, individual measures may of course be perceived as both positive and negative. Many people would no doubt automatically regard less traffic in the city, better public transport and more cycling as positive developments. Changes in the Low-carbon transition scenario which could be seen to be more controversial are considered in brief below.

The Low-carbon transition scenario provides for a *50% reduction in the consumption of beef and pork* by 2050 (the level for chicken will remain the same as 2010). Halving the consumption of meat would bring health benefits (among other things, a reduced risk of cancer), since it corresponds to the maximum level for red meat (500 g a week) recommended in Nordic food recommendations.

So, how might a *certain reduction in air travel* affect quality of life? Although the above-mentioned study did not find any measurable effects of air travel on people's general wellbeing, the current rate of increase indicates that people enjoy flying for leisure purposes. This may, for example, be connected with the values which are associated with flying to long-haul destinations (e.g. sun and cultural differences) but it may also be that flying is associated with getting away from a life which is characterised by stress and too little time for socialising and relaxation. As the amount of air travel increases, it is likely that people will increasingly come to regard regular trips abroad as a standard feature of a good lifestyle.

The Low-carbon transition scenario also provides for a 25% *reduction in working hours*. Here it is assumed that a third of the future increase in productivity is taken out in the form of a reduction in working hours. This would slow down the increase in consumption, would scarcely have any significant disadvantages in terms of quality of life and, on the other hand, would bring with it climate-related benefits. One potential problem with a reduction in working hours is that it is likely to make the funding of hospitals, schools, healthcare and pensions more difficult. Whether or not these risks can be avoided, e.g. by raising taxes, is far too big and complex a question to deal with here.

Finally, the Low-carbon transition scenario provides for a *greater proportion of service-based consumption* (+200%), e.g. eating out (restaurants and cafés) and other services (e.g. hairdressers, movie theaters and membership fees). Services have a far lower impact on climate than the consumption of goods. At the same time, service-based consumption can have a positive impact on quality of life. Certain types of services can reduce time pressure and free up time for other things. Experience-based consumption can also have a significant and long-term impact on wellbeing. Another form of service-based consumption with similar positive effects on climate is services which are funded through taxes, such as hospitals, schools and healthcare.

In summary, any fears that a low-carbon transition would mean people having to revert to a standard of living and quality of life such as that which prevailed many years ago are, according to our analyses, totally unfounded. A low-carbon transition has both positive and less positive features but it is unlikely to have a dramatic impact on people's quality of life. This should, therefore, not constitute a significant obstacle to the process of transitioning to a low-carbon society. Problems are more likely to include, for example, people thinking that it's not a good idea for a city or country to adopt such a progressive approach or that technology will automatically solve everything, and the view commonly held by both voters and politicians that there must be as little political control as possible.

Transitioning to a low-carbon society will necessitate major changes in our society, in technology and in our lifestyles. Private individuals, companies, associations, public bodies and politicians at local, regional, national and international level must all contribute in different ways to the development of environmentally sustainable technological and social innovations for everything from our day-to-day transport needs to our food and our holidays. Not least, politicians must be brave enough to introduce, and voters must be willing to accept, control measures which are sufficiently stringent to ensure that the technological and behavioural changes required actually take place.

The intention is that this report will act as a basis for a more informed dialogue over the appropriate course of action for the future. Our reports, the spreadsheet on which this analysis is based, plus an online dialogue forum are available at
www.mistraurbanfutures.org/en/project/wise –- well-being-sustainable-cities

Jörgen Larsson (Chalmers) and Lisa Bolin (SP Technical Research Institute of Sweden) are the main authors of the report and are responsible for the majority of the work associated with it. However, the methodology used was developed in close consultation with a number of researchers from Chalmers and civil servants from the City of Gothenburg and Region Västra Götaland. The work is being carried out under the auspices of Mistra Urban Futures, a research Centre where researchers and practitioners implement projects which aim to promote sustainable social change.

Background and purpose

The EU, Sweden and Gothenburg have adopted the 2°C target, which says that the global average surface temperature should not increase more than 2°C above the pre-industrial temperature level. At policy level, Region Västra Götaland and the City of Gothenburg are aiming high. The City's objective is ‘to make Gothenburg a role model for environmental and urban development and one of the world's most progressive cities in the area of climate-related and environmental issues’ (City of Gothenburg Budget 2014). Region Västra Götaland's vision is to be fossil-independent by 2030.

Studies show that if there is to be a 75% probability of achieving the 2°C target, global CO_2 emissions must be halved between the base year 1990 and the year 2050 and be in the region of zero by the end of the century (Rogelj et al. 2011). For Gothenburg, the target has been formulated as follows: ‘By 2050, Gothenburg will have a sustainable and fair emission level for greenhouse gases’. If Gothenburg is to achieve a fair emission level, we must not emit more per person than would be sustainable if everyone globally emitted that same amount. In order to achieve the target, all emissions to which Gothenburg residents give rise through their lifestyles, including all consumption of goods and services, must be taken into account. We believe that a sustainable and fair emission level by 2050 means that emissions must be below, or well below, 2 tonnes of CO_2 equivalents per inhabitant per annum. The City of Gothenburg has besides this target a target that by 2035 the consumption based emissions for the citizens of Gothenburg shall be less that 3.5 tonnes of greenhouse gas emissions per person.

The way this target has been defined is unusual in that it is based on a consumption-related perspective. Traditionally, climate targets and statistics are based on the emissions that occur within a particular area, e.g. a country or municipality. This territorial perspective is problematic because it doesn't take into account emissions from international air travel and imported goods, for example. This report will therefore adopt a consumption-based perspective.

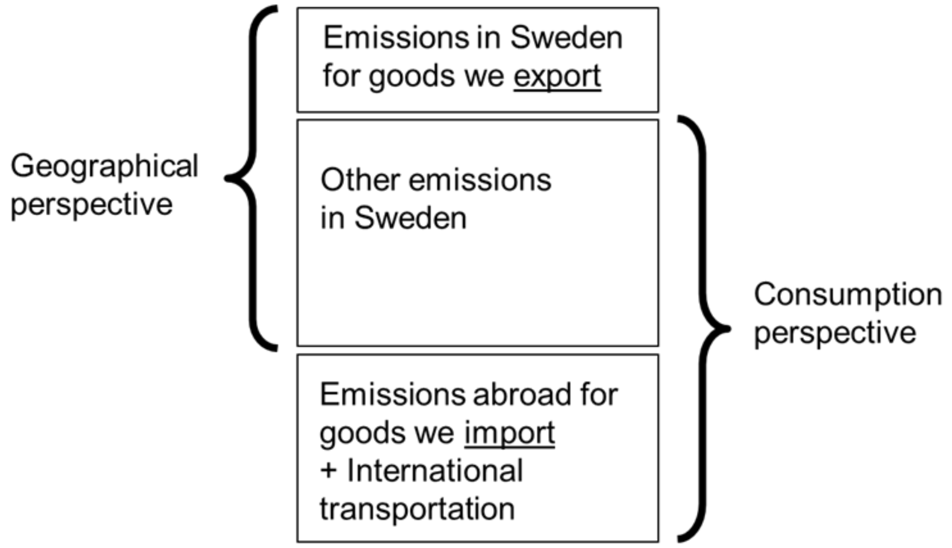

Figure. Two different perspectives on greenhouse gas emissions

Purpose and questions

One commonly held view is that the transition to a sustainable society can be realised through advances in technology and will therefore not have a major impact on people's lifestyles. For example, that we will be able to drive our cars just as much but that emissions from cars will be so low that we will still be able to achieve the climate targets. Another view is that the transition to a low-carbon society, in addition to new technological solutions, will also require sacrifices. And a third view has emerged which says that the transition to a low-carbon society will certainly require changes in behaviour but that some of these may be beneficial to people's wellbeing.

Clearly, nobody can be certain what will happen in the future. But through this report, we aim to provide as much factual evidence as possible. The purpose of this report is to raise awareness of potential ways in which the emissions of Gothenburg residents can be reduced to a level which is sustainable from a climate-related perspective. The report tackles the following questions:

1. How do the greenhouse gas emissions of low-income and high-income households in Gothenburg currently differ?
2. What reductions in emissions can be expected by 2050 if the objectives of current climate policy approach will be achieved?
3. Which technological and lifestyle changes could result in emission levels of less than 2 tonnes per annum by 2050?
4. How might different climate-motivated changes affect people's wellbeing?

Methodology

The aim is to incorporate all greenhouse gas emissions, including areas which, although they have a major impact, have so far been little researched in climate-related studies, e.g. food and leisure travel. The greenhouse gas emissions have been calculated for the following domains:

- Car transports
- Public transport
- Air travel
- Heating
- Electricity consumption
- Food
- Other consumption
- Public consumption

There are various ways of calculating the extent to which a person has an impact on climate and different methods can be used depending on the purpose of the calculations. One of the main purposes of this project has been to demonstrate how various changes to household consumption can have an impact on environmental emissions. In order to be able to identify how individual changes affect emissions from household activities, the emissions caused by each activity must be clearly established. This gives us a clear indication of how the different households live, e.g. how much they use their car(s), how big their house is, how much electricity they use etc. This was then used as a basis for calculating the greenhouse gas emissions of the various households. This bottom-up methodology is a kind of life cycle analysis of one year's activity in the different typical households, calculated for each individual. Wherever possible, the emissions over the entire life cycle of the product (e.g. emissions from fuel production) are taken into account. All emission figures in this report refers to carbon dioxide equivalents (CO2e), which means that not just carbon dioxide but also the greenhouse gases methane and nitrous oxide, have been included.

TYPICAL HOUSEHOLDS

We started by analysing the greenhouse gas emissions in 2010 for two typical households. The typical households were selected on the basis of data supplied by Gothenburg City Council. They supplied statistics for all households in Gothenburg based on type of housing (individual house, leasehold property, rented accommodation), household composition (single, married/living together, with/without children), age and income (sub-divided into three groups: high, medium and low-income households).

We selected the two most commonly occurring groups in the category of those aged between 30 and 64 who are married/living together and have children. These were high-income families in detached houses and low-income families in rented accommodation. The emissions of these two groups are likely to differ significantly from each other given that earlier research indicates that income and type of housing (detached house or apartment) are two key factors behind differences in greenhouse gas emissions (Nässén 2014). In addition to these two groups, the emissions of the average Gothenburg resident were also analysed.

High-income family living in a detached house

The household is comprised of a couple living together with children. The family has a high income and lives in a detached house. In 2010, the average disposable income (i.e. income after tax) of a high-income household with children living in a detached house was SEK 723,667[1]. Based on the statistics for car ownership in areas comprising of detached housing, it has been assumed that the family has two cars. The average dwelling size was 126 square metres.

Low-income family in rented apartment
The household is comprised of a couple living together with children. The family has a low income and live in rented accommodation. In 2010, the average disposable income (i.e. income after tax) of a low-income household with children living in a rented apartment was SEK 293,751[2]. Car ownership in areas comprising rented accommodation and among those on a low income in Gothenburg is low and it has therefore been assumed that this household does not have a car. Based on national statistics, we have assumed a dwelling size of 76 square metres. The statistic for dwelling size applies to the area known as Greater Gothenburg.

Average Gothenburg resident[3]
While the above-mentioned typical households are generally comprised of four people, two adults and two children, the number of people in an average Gothenburg household[4] is 1.7. The average household also has a low income, mainly because there is often only one adult in the household: SEK 222,221 per annum after tax in 2010. The average Gothenburg household has 0.58 cars. However, this figure is slightly lower than it should be as company cars are not included in the statistics. The average dwelling size in Gothenburg is 76 square metres.

All emissions specified in the report are reported per person, not per household.

DEFINITION OF SCENARIOS

In the project, we work with three potential scenarios which portray three different ways in which technology, lifestyles and society could evolve up to 2050. In order to have something to compare these future scenarios with, we also analysed the current situation, taking the year 2010 as the base year. The three different scenarios are described below.

Business as usual (BAU)

The idea of this scenario is to demonstrate what things would look like in 2050 if climate policy, technological advances and trends in consumption continue in the same way as they have done for the past 2–3 decades. We assume in this case that the trends we have seen in recent years will continue. In some cases, this means continued increases in emissions, e.g. from air travel, food and other consumption, but with gradual improvements in efficiency, which will, to some extent, help mitigate emissions. In this scenario, patterns of consumption will continue to develop as they are doing at the moment, which means that no further measures or controls will be introduced.

Current climate policy scenario (CCP)

This scenario assumes that the objectives of current climate policy approach have been achieved, i.e. significant reductions in emissions from energy systems and fossil-independent road transport by 2050. This means focusing on changes in the field of energy supply, energy efficiency and fossil-independent vehicles. Greenhouse gas emissions from electricity generation throughout Europe have fallen by just over 65%. Car usage is assumed to have fallen by 20% and journeys by public transport have increased by 100%. In principle, emissions from air travel and food will, however, develop in line with the BAU scenario since we have assumed here that control measures which are sufficiently stringent to affect emission levels have not been imposed.

Low-carbon transition scenario (LC)
In this scenario, radical technological changes are combined with behavioural changes in order to reduce emissions to less than 2 tonnes per person and annum. As in the Current climate policy scenario, it is assumed that society manages to achieve the objectives of current climate policy. Besides this, additional features of this scenario are fossil-independent district heating, a 50% reduction in residential energy consumption, no increase in living space per person, a 50% reduction in the consumption of beef and pork, air travel at year 2000 levels, a greater proportion of service-based consumption and a reduction in working hours.

The next section provides detailed information on the assumptions made when calculating the various emissions. The table below gives an overview of the assumptions we made for the average Gothenburg resident in 2050 in the three different scenarios (in some cases, different assumptions were made for the low-income and high-income households).

	Assumptions for 2050 scenarios, in comparison to 2010		
	BAU **Business as usual**	CCP **Current climate policy scenario**	LC **Low-carbon transition scenario**
Emissions from electricity (affects emissions from domestic electricity and electric cars)	Emissions per kWh: same as 2010 (based on Nordic electricity mix)	Reduction in emissions per kWh: 65%	Reduction in emissions per kWh: 65%
Air travel	Air travel kilometres: + 350% Efficiency: 40%	As BAU	Air travel kilometres: reduction to year 2000 levels. Efficiency: 40%
Other consumption	Volume: + 120% Efficiency: 20%	Same as BAU + approx. 65% reduction in emissions from industrial electricity consumption	Increased service-based consumption: +200% Reduction in working hours: -25% Approx. 65% reduction in emissions from industrial electricity consumption
Car usage	Volume: + 32% Efficiency: 20%	Volume: - 20% No fossil fuels Efficiency: 50%	Same as Current climate policy
Public transport	Volume: same as 2010 Reduction in emissions per km: 20%	Volume: double Reduction in emissions per km: 90%	Volume: double Reduction in emissions per km: 95%
Electricity consumption	Volume: +25%/person	Volume: +12%/person	Volume: -50%/person
Heating	Dwelling size: +58%	Dwelling size: +58% Efficiency: 25%.	Fossil-independent district heating Dwelling size: +/- 0% Efficiency: 50%
Food consumption	Volume of meat: +50%	Volume of meat: +50% Fossil-independent production	Volume: beef and pork -50% Fossil-independent production
Public consumption	Same as 2010	Falls in proportion with above-mentioned items (excluding air travel)	Falls in proportion with above-mentioned items (excluding air travel)

Greenhouse gas emissions from future energy consumption

We cannot estimate the greenhouse gas emissions of the typical households in the future without saying something about the nature of the energy systems of the future. In order to calculate emissions from the consumption of heating and electricity, emission factors were defined for the different scenarios.

Emission factors for electricity on the Nordic electricity market are used in all the calculations. In this study, the emission factor for the Nordic electricity mix in 2010 was defined as 125.5 CO_2e/kWh, which is the figure used by the Swedish Energy Agency (Martinsson 2012). The BAU scenario assumes that emissions per unit of energy will be the same in 2050 as they are at the moment. The emission factors for electricity in the Current climate policy and Low-carbon transition scenarios are based on data from the EU's Energy Roadmap 2050 (European-Commision 2011). On the assumption that emissions from Nordic electricity will decrease in line with European levels, the emission factors for Nordic electricity in the Current climate policy and Low-carbon transition scenarios will be just over 43 CO_2e/kWh. Details of how we calculated the emission factors for electricity can be found in Appendix 1.

In order to calculate emission factors for heating, data on the fuels used in district heating production were compiled from the annual report of the municipal energy company (Göteborg Energi) and the environmental reports of its production facilities, as well as from the environmental report of waste management company Renova. Where electricity is generated, the emissions were allocated using the alternative generation method (Martinsson et al. 2010). Based on these calculations, the emission factor for district heating produced in Gothenburg in 2010 was 92g CO_2e/kWh of heat. The Business as usual scenario assumes that emissions per unit of energy will be the same in 2050 as they are at the moment. As a result of a reduced requirement for heating in the future due to improvements in efficiency, the emission factors for district heating in the Current climate policy and Low-carbon transition scenarios are lower than they were in 2010: 67 CO_2e/kWh and 1 CO_2e/kWh respectively. Details of how we calculated the emission factors for heating can be found in Appendix 1

Detailed assumptions for scenario estimates

In this chapter we describe our assumptions for estimates in the following emission domains:

- Car transport
- Public transport
- Air travel
- Heating
- Electricity consumption
- Food consumption
- Other consumption
- Public sector consumption

All emissions are quoted per person, i.e. not per household.

CAR TRANSPORT

In order to estimate distances driven for the different typical households, a selection of cars from the Swedish Transport Administration's vehicle registry has been used. Data on carbon dioxide emissions per kilometre is based on two 'typical' cars (one large or older car which emits 180g CO2/km and one which just complies with the old environmental car requirement of 120g CO2/km). Since the actual emissions exceed the declared test values (which are based on a standardised driving cycle – without air-conditioning, for example) 25g CO2/km has been added to the emissions of all cars. The table below shows emission figures for the cars of the different households.

Table 1 Emission figures for the cars of the different households, g CO2e/km.

	Car 1	Car 2
High-income family	205	145
Low-income family	-	-
Average Gothenburg inhabitant	181.6	-

Car – Business as usual

Traffic department measurements of traffic at various measurement points in Gothenburg show that traffic in the inner city has decreased somewhat since the 1990s. However, traffic is continuing to increase when flows at the 28 fixed measurement points used by the municipality are added together. In the BAU scenario, car driving is assumed to increase at the same rate as during the period 1970–2012. This means a 32 per cent increase up to 2050.

Between 1975 and 2002, the average fuel consumption per car journey decreased by 20 per cent (Sprei et al. 2008). It has been assumed here that fuel consumption will continue to decrease by 0.6 per cent per year as a result of more efficient cars.

Car – Contemporary climate policy approach

The target set by the Swedish government for the transport sector is that by 2030, Sweden should have a vehicle fleet which is independent of fossil fuels (Regeringen 2008). The Swedish Transport Administration's interpretation of this target is that, in Sweden, we will reduce fossil fuel use in road transport by at least 80 per cent compared with 2004. The

CCP scenario means that we will achieve the climate target of a fossil-independent vehicle fleet in accordance with the Swedish Transport Administration's definition by 2030. We assume that our vehicle fleet will be fossil-free by 2050, in the sense that no vehicle will run on fossil fuel.

It is important to point out that emission factors for electricity in this study are based on the Nordic electricity mix, which means that an electric car causes carbon dioxide emissions as long as the electricity mix is not fossil-free. This is the reason why there is nevertheless a certain amount of carbon dioxide emission in the scenario for 2050, even though all vehicles run on either electricity or biofuels. Emission factors for electricity and fuels are described in Appendix 1.

This scenario is based on the report produced by the Swedish Transport Administration in order to describe what is required to achieve the target of a fossil-independent vehicle fleet (Trafikverket 2012). The report thus describes what would be required, but it is still optimistic, in view of today's climate policy, to believe that the target will be achieved. The Transport Administration's scenario requires vehicles to become 50 per cent more efficient, i.e. around 3.5 per cent per year, while annual increases in efficiency have historically been around 0.6 per cent per year (Sprei, Karlsson et al. 2008). This scenario reflects the existing climate policy ambition but in order for a fossil-independent vehicle fleet to be achievable, determined efforts are also needed to implement all the measures which the Transport Administration regards as necessary.

In this scenario, car traffic decreases by 20 per cent up to 2050, compared with 2010. According to the Transport Authority's report, this is necessary in order for the climate target to be achieved. The report summarises the potential of a number of changes for reducing car traffic – see the table below.

Table. Reduced traffic growth compared to 2011 – table from Swedish Transport Administration (2012)

	[%] Potential 2030
Urban planning for reduced car travel	-10
Improved public transport	-6
Investment in cycling and walking	-2
Car pooling	-5
Non-travel and e-commerce	-3
Congestion charging, parking policy and charges	-5
Lower speed limits	-3
Fuel tax (fuel price + 50 %)	-15
Traffic changes compared with 2011	**-19**

In addition to reduced car traffic, this scenario assumes cars to be 50% more efficient in 2050. We also assume in this scenario that 65 per cent of vehicles are electric cars and that 35 per cent of cars run on renewable fuels.

Car – low-carbon transition
In this scenario, the proportions of different vehicle types are the same as in the CCP scenario. In 2050 there are no fossil-fuelled cars; 35 per cent run on renewable fuels and the rest run on electricity.

PUBLIC TRANSPORT

In the BAU scenario, we assume that travel by public transport remains at the same level as at present[5]. But we assume an annual increase in vehicle efficiency corresponding to the increase used for cars, i.e. 0.6 per cent per year (Sprei, Karlsson et al. 2008).

The City of Gothenburg and its region have the ambition of doubling travel by public transport as early as 2020. In the CCP scenario, it has been assumed that the households of 2050 travel by public transport twice as much as today. It has been assumed in this scenario that public transport in Gothenburg runs on 90% fossil-free energy. This is based on Västtrafik's target of being 90% fossil-free as early as 2020[6].

In the LC scenario we also assume that travel by public transport doubles. But emissions from public transport in Gothenburg have also been further reduced in this scenario. We assume that measures taken will result in 95% lower emissions than today.

AIR TRAVEL

Emissions for domestic travel are based on the Swedish Environmental Protection Agency's emission statistics and those for international travel are based on analyses by Jonas Åkerman (2012). Emission estimates are based not only on the quantity of fossil aircraft fuel but also on the fact that emissions at high altitudes have a greater climate impact. Carbon dioxide emissions are therefore estimated upwards by a factor of 1.7 (Azar & Johansson 2012).

If a consumption perspective is used, as in our report, then the climate effect of work-related air travel is allocated not to the person travelling but rather to the products or services which he/she is working with. In our method, this is included under 'Other consumption'. Here, we therefore take into account only private air travel (work-related air travel accounts for 18% of air travel[7]).

Assumptions about how far the different types of household fly are based on data concerning the Swedes' private air travel (Sika 2007). On this basis, we assume that a person in the high-income family flies 2.3 times longer distance per year than the average Swede in the 18–64 age group. We assume that the average Gothenburg inhabitant flies as much as the average Swede. In the absence of relevant data, we make an arbitrarily assumption that a person in the low-income family flies half as much as the average Gothenburg inhabitant.

Emissions for 2010, based on these assumptions, are 2 400kg CO2e for the high-income earner, just over 1 100 kg for the average Gothenburg inhabitant and 550kg for the low-income earner. Of these emissions, around 15 per cent are caused by domestic air travel and 85 per cent by international air travel.

Air travel – Business as usual

The number of passengers on international flights from Sweden increased by 5.5.per cent per year between 1980 and 2007, which means that air travel has doubled every thirteen years (Åkerman 2012). In SOU's report 'Fossil-free air traffic?' (Karyd 2012) there is a projection that air travel will increase by 2.2 per cent per year (48 per cent up to 2030). This projection appears improbably low. In our BAU scenario, we assume that air travel increases at a rate half-way between the historic increase of 5.5 per cent per year and the projection of 2.2 per cent per year. This yields an annual increase of 3.85 per cent per year and a cumulative increase of 350 per cent up to 2050.

At the same time, there is a certain increase in the efficiency of air travel. According to the report 'Fossil-free air traffic?' (Karyd 2012) air traffic will achieve a maximum increase in efficiency of 20 per cent up to 2030; this represents approximately 1.2 per cent per year. Increased efficiency of air travel therefore seems unlikely to be able to compensate for the increase in air traffic. Some people set their hopes on the planes of the future flying on renewable fuels. But biofuel resources are limited by the amount of biomass available and, according to the 'Fossil-free air traffic?' report, there is no reason to use biofuels in aircraft since they can be used at least as efficiently on land or at sea. A study indicated that if aviation was to use biofuels and if the flying would continue to increase with five per cent per year then the main part of the global biofuel potential would be used solely for aviation in 2050 (Krammer et al. 2013).

Assuming an annual increase in air travel of 3.85 per cent and an annual increase in efficiency of 1.2 per cent, fuel consumption and emissions will increase by about 2.65 per cent per year, which is equivalent to almost 185 per cent up to 2050. Emissions are then over 5,000kg CO2e for the high-income earner, around 2,300kg CO2e for the average Gothenburg inhabitant and just over 1,100kg CO2e for the low-income earner.

Air travel – Contemporary climate policy approach

There are at present no control measures to slow down the ongoing increase in air travel. We assume that the entry of air travel into the trading of emission rights will not affect emissions from air travel. One reason is that it will probably be cheaper to reduce emissions in other sectors of the trading system. Another reason is that countries outside Europe do not form part of the trading system. We therefore assume that emissions from air travel increase in the CCP scenario as in the BAU scenario.

Air travel – Low-carbon transition

In order to arrive at a figure of less than two tonnes per year by 2050, we have assumed a slight reduction in air travel in the future. In the LC scenario, we have assumed that the households fly as much in 2050 as they did in 2000. This assumption means a very big difference compared with the large amount of air travel in the BAU and CCP scenarios. Such a development would require very forceful control measures. Air travel is currently increasing at a very fast rate; between 2000 and 2010 alone, the number of international departures rose by 26%.

HEATING

In Gothenburg, 90 per cent of apartment blocks are supplied with heating from the district heating grid[8]. We assume not only that the low-income family's rented apartment is heated by district heating, but also that this form of heating is used in the high-income family's detached house (which is not unusual in Gothenburg). We have used information on energy use for heating from national building statistics. The average heating requirement for apartment blocks[9] heated by district heating is 147 kWh/m^2 and the average heating requirement for small detached houses in Sweden is 117 kWh/m^2 (Energimyndigheten 2010).

The emission factor for district heating has been calculated from the energy balance formulated as part of the environmental administration's work on a climate strategy. The calculations are based on data from 2010. According to these calculations, the emission factor for district heating generated in Gothenburg in 2010 was 92g CO2e per kWh of heating. Details concerning how this emission factor was calculated can be found in Appendix 1.

Heating – Business as usual

In this scenario, it is assumed that the residential areas of the typical households continue to increase as they did during the period 1975–2000. During this period, residential areas increased in single-family houses by 34 per cent and in apartment blocks by 29 per cent (Nässén & Holmberg 2005). This means, therefore, an annual increase in residential area of 1.18 per cent and 1.02 per cent respectively. On this basis, an increase in residential area of 1.15 per cent per year has been assumed for all households. This means an increase in residential area of 58 per cent up to 2050.

As well as this increase in residential area, it has also been assumed that the households in the BAU scenario require the same amount of energy per area heated and that district heating in Gothenburg has the same emission factor as in 2010.

Heating – Contemporary climate policy approach

In this scenario, the residential areas of the households also increase by 1.15 per cent per year. However, the dwellings become somewhat more energy-efficient in this scenario, which produces a smaller increase in energy consumption. According to the Swedish Energy Agency's statistics for 2011, 22 per cent less energy was used for heating and hot water in that year than in 1985 (Energimyndigheten 2011). This is based on temperature-corrected data. It has been assumed here that the same annual increase in efficiency will continue up to 2050. This means an annual increase in efficiency of 0.7 per cent and an increase in efficiency of around 25 per cent up to 2050.

In its report 'Energy-effective building and district heating in the future', Gothenburg Energy states that the heat basis in Gothenburg is expected to decrease by 15 per cent up to 2030 (Nyström 2009). This also agrees well with an increase in energy efficiency of 0.7 per cent per year. The reduced heat basis means that district heating generation will use less fossil fuel in 2050. In this scenario, the emission factors for district heating in 2050 are 67g CO2e/kWh, compared with 92g CO2e/kWh in 2010. The reason why emissions from district heating do not decrease more is that the proportion of fossil waste in Renova's waste incineration is assumed to be half of the proportion in 2010 and that Rya natural gas combined heat and power plant accounts for a large part of the district heating.

Heating – Low-carbon transition

In this scenario, the residential areas do not increase but are assumed to be the same per person in 2050 as in 2010. In the LC scenario, dwellings become 50 per cent more energy-efficient up to 2050 (Boverket 2008). As a result of the low heating demand, no fossil fuels are required in the district heating system. Furthermore, fossil material (plastics) is separated from waste and recycled. As a result, waste incineration generates only biogenic carbon dioxide emissions. This means that emissions from the use of district heating are only 1g CO2e/kWh in 2050. The district heating do not reach zero emissions due to lifecycle emissions from biofuel production.

ELECTRICITY CONSUMPTION

Electricity consumption in the households is based on the end-user metering carried out in 400 households in Sweden in 2009 (Zimmermann 2009). The reason for using this report is that it divides households in a similar way to our study. It is, furthermore, the only known study of its type carried out in Sweden in which the actual electricity consumption of households is measured. The table below shows the annual electricity consumption for the different households; the right-hand part of the table shows the household name and the source.

Table. Current annual electricity consumption in the different households (Zimmermann 2009)

	Specific electricity consumption	Description in the reference
High-income family	4143	Family, 26–64 years old, house
Low-income family	3710	Family, 26–64 years old, apartment
Average Gothenburg inhabitant	2498	This figure is not taken from the same source as the other data on electricity consumption. It is, rather, the total electricity consumption in households in Gothenburg divided by the population.

The emission factors for electricity are based on electricity from the Nordic electricity grid. This means that emissions connected with electricity consumption are somewhat higher than in the case of emissions solely from Swedish electricity generation.

Electricity consumption – Business as usual

Electricity consumption per person has increased by around 20 per cent during the past 26 years[10]. This scenario assumes a linear increase in electricity consumption per person at the same rate as between 1985 and 2009. This means that electricity consumption will increase by almost 25 per cent up to 2050, compared with consumption in 2010. In this scenario, it has therefore been assumed that the emission factors for Nordic electricity do not change but that the proportion of fossil fuels is the same as in 2010.

Electricity consumption – Contemporary climate policy approach

In this scenario, too, it is assumed that electricity consumption in the households will increase. Over the past 10 years, household electricity consumption has remained at a relatively stable level (Energimyndigheten 2011). Electricity consumption is affected by two trends: firstly by an increase in the efficiency of household appliances, which brings electricity consumption down, and secondly by an increase in the number of household appliances, which contributes to increased electricity consumption. It is difficult to say whether electricity consumption will remain stable, increase or decrease. It has therefore been assumed in this scenario that electricity consumption per person will be stable up to 2030 but will then increase at the same rate as between 1985 and 2009. This is based on the assumption that appliances will continue to become more efficient but that the continually increasing number of appliances will eventually mean that electricity consumption will nevertheless increase.

Electricity consumption – low-carbon transition

In the climate plan produced by the Danish Society of Engineers IDA in Denmark, Danish households can reduce their electricity consumption by 50 per cent up to 2030, compared with the 2008 level, if certain preconditions are met (Mathiesen et al. 2009). In order for this to be possible, extensive information and labelling of energy-effective appliances is needed. There is also a need for campaigns to promote the most energy-effective products and reduce electricity consumption. It has been assumed that this potential also exists in Sweden. In the LC scenario, electricity consumption in the typical households is reduced by half up to 2050. Emission factors for electricity are described in Appendix 1.

FOOD CONSUMPTION

The scenarios for food consumption are based on the report 'Scenarios for greenhouse gas emissions from food consumption in 2050', (2013) produced by David Bryngelsson, Fredrik Hedenus and Jörgen Larsson at Chalmers as part of the same project as this study. The report describes how emissions increase or decrease as a result of different diets and different technological changes in food production. The report shows that emissions from the Swedes' food consumption were around 1.5 tonne per person in 2006. Of the emissions, about 800 kg CO_2e are caused by meat consumption.

It has been assumed here that all three typical households have the same food consumption in 2010 as the average Swede in 2006. It is likely that food habits differ among different income groups in society. However, we have not had access to any data which could be used as a basis for estimating differences between high-income and low-income families. We have therefore assumed the same emissions from food consumption for all the typical households.

Food – Business as usual

Business as usual corresponds to the 'No measures' scenario in Bryngelsson's report (2013). Consumption is assumed to be the same in the future for all food categories except meat, milk and cheese. Meat consumption is assumed to increase by 50 per cent up to 2050, reaching a level which corresponds to today's levels in the USA and Australia. Milk consumption decreases, however. This is based on historic trends in food consumption since 1980. According to Bryngelsson, emissions in this scenario will be around 1.9 tonne in 2050. This would mean that the entire emissions capacity of two tonnes is used for food consumption.

Food – Contemporary climate policy approach

Here, food consumption is assumed to be the same as in the BAU scenario but the energy system is assumed to be entirely fossil-free. This corresponds to the 'Fossil-free energy' scenario in Bryngelsson's report. In this case, emissions per year and per person from food consumption are assumed to be around 1.3 tonne in 2050.

Food – Low-carbon transition

The LC scenario assumes considerable changes in the food domain. In addition to the assumption that the energy and transport system is entirely fossil-free, it is also assumed that a large number of other technological measures have been taken to reduce emissions, including the use of methane from manure treatment for biogas production and a decrease in nitrous oxide from artificial fertiliser production (Bryngelsson, Hedenus et al. 2013). With only technological measures, emissions in 2050 will be around one tonne per person, which is high in the context of the LC scenario's premise of reducing total emissions to less than two tonnes. To achieve further reductions, changes in people's eating habits are assumed. New calculations have been made together with David Bryngelsson.

For the consumption of chicken, fish, reindeer meat, game, cheese and eggs, the same consumption levels as today have been assumed. However, milk consumption continues to decrease at the same rate as it has done since 1980. For beef and pork, we have assumed a reduction in consumption to half of today's level (from around 50 kg per person to around 25g). The reason for this is that beef has by far the greatest greenhouse gas emissions but that pork also results in relatively high emissions. The current consumption level of 25 kilos per year corresponds to the maximum level (500 grams per week) for red meat in the Nordic food recommendations (Norden 2014).

These technological and dietary changes will result in emissions of around 500 kg CO2e per person per year in 2050.

OTHER CONSUMPTION

In addition to emissions calculated for specific domains – air travel, car use, heating, electricity and food – we have also estimated emissions from other consumption. This includes clothing, shoes, furniture, restaurant meals, alcohol, tobacco, consumer goods, cars, home electronics, telecommunication and entertainment (child care fees, invalid care fees, etc. have not been included but are instead included in public sector consumption). The estimates are based on the disposable incomes of the typical households. These have been adjusted on the basis of the number of adults and children in the household. Then SCB's database of household expenditures (HUT) has been used[11]. This has information about the total expenditures of various income groups and what proportions are attributable to various categories. On this basis, the other consumption of the various typical households has been estimated. No account has been taken of the 'quality effect' (the fact that high-income earners buy more expensive clothes, etc.), which results in a certain overestimation for the high-income household. (Girod & De Haan 2010)

Figures for expenditure in various categories have been produced and then combined with the emission levels for various goods and services. These emissions are calculated per SEK spent and have been taken from SCB's department for environmental reckoning. These emission intensities are based on the assumption that all goods are produced in the EU. This may mean an underestimation of emissions due to other consumption, since many countries outside the EU have even more fossil fuels in their energy systems than the EU.

Other consumption – Business as usual

In the BAU scenario, it is assumed that the households' incomes increase at the same rate as growth. It has been assumed that the households' real disposable incomes increase by 2 per cent per year, which is based on historic growth rates and which is approximately the future increase in income assumed in, for example, the government's long-term investigations and the National Institute of Economic Research's predictions[12]. This results in real income increases of 120 per cent up to 2050. We assume that the households' consumption in 2050 is divided between the various categories of goods as in 2010. Emissions from other consumption arise to a large extent from industrial energy use. In the BAU scenario, we assume the same emissions per kWh in 2050 as in 2010.

Other consumption – Contemporary climate policy approach

In the CCP scenario, the households' real disposable incomes are also assumed to increase by 2 per cent per year. But since electricity generation in the EU uses less fossil fuel in this scenario, emissions from the production of goods decrease to some extent.

Other consumption – low-carbon transition

The premise of the LC scenario is that emissions from other consumption are the same as in the CCP scenario. In both these scenarios, emissions from other consumption are assumed to decrease in proportion to the decrease in emissions from electricity generation in the EU (i.e. 65 per cent lower carbon dioxide emission per kWh in 2050 than today).

In the scenarios above the whole of the assumed increase in productivity is allocated to increased private consumption with about 120 percent. However, this contributes to higher greenhouse gas emissions. There are in principal two other alternative ways of "using" the productivity increase; higher public consumption or work time reduction.

If the increase in productivity is allocated to a reduction in working hours, it causes, broadly speaking, no greenhouse gas emissions. This is supported by a number of studies which are based on comparisons between countries – shorter average work time is linked to lower greenhouse gas emissions (Rosnick & Weisbrot 2007, Hayden & Shandra 2009). A detailed micro analysis showed that a work time reduction of one percent was linked to 0.8 percent less greenhouse gas emissions (Nässén & Larsson 2014).

We also assume that a third of increased productivity is neutralised by shorter working hours. This means that we assume not 2 per cent growth but only 1.33 per cent. For a period of 40 years, this means that average working hours decrease by around 25 per cent. Someone who works a 40-hour week today and whose working hours decrease at the same rate as the average in society then arrives at a working week of around 30 hours.

In line with earlier analyses, (Holmberg et al. 2012, Nässén & Larsson 2014) we assume that someone who works less also earns less and therefore consumes less, on average. In these reports it has been calculated how energy use changes when working hours are shortened by 1 per cent. The result indicates that a shortening of working hours by 1 per cent reduces the household's and individual's energy use and greenhouse gas emissions by 0.83 per cent (Nässén & Larsson 2014). On the basis of this, we assume that the households' emissions from "other consumption" decrease by 21 per cent as a result of a 25 per cent reduction in working hours. We make no specific calculations of how work time reduction affects e.g. the volume of car driving, flying or residential areas of the households. However, in the low-carbon transition scenario there are specific assumptions for these sectors compared to Business as usual. But it is important to note that our way of calculating the total effect of the work time reduction is very uncertain. More on reduced working hours can be found in the chapter on consequences for quality of life.

Another part of the low-carbon transition scenario is that we have assumed that consumption of services increases and consumption of goods decreases to an equivalent extent. We have assumed that the proportion of expenditure attributable to eating out (restaurants and cafes) and other services (e.g. hairdressing, movie theatre and association fees) increases from 5 to 15 per cent (i.e. + 200%). At the same time, we have assumed that expenditure on clothing, shoes, cars, sports equipment etc. has decreased to an equivalent extent. Since emissions for consumption of these services is considerably lower than for many goods, the households' emissions decrease.

PUBLIC SECTOR CONSUMPTION

As part of this report, a degree project was conducted at Chalmers Technical University with the purpose of analysing in greater detail which activities generate these two tonnes of emissions. References to sources and details concerning method and results can be found in the degree project 'Greenhouse gas emissions from public consumption in Gothenburg' (Sinclair 2013).

Emissions from public sector consumption were calculated by using emission intensities expressed in tonnes of carbon dioxide equivalent per million SEK for each activity (based on the SNI code for Swedish industry branches) which forms part of public consumption. Firstly, economic expenditures (operating costs and investments) were collected from municipalities, regions and the state and these expenditures were then categorised according to activities and multiplied by the appropriate emission intensity. The emission intensities used were derived from SCB with the help of Swedish input-output data and are presented in the table below.

Table. Emission intensities for each SNI activity used in estimating emissions from public sector consumption.

SNI activity	Emission intensity (tonnes/million SEK)
75 Authorities	14
80 Education sector	8
85 Healthcare and other care	7
92 Recreation, culture and sport	19
45 Construction industry	30
01 Agriculture	255
33 Medical and optical instruments	15
35 Manufacture of other means of transport	21

The result showed that emissions from public sector consumption were 1.74 tonne carbon dioxide equivalent per person per year. This level is in line with an analysis by the Swedish Environmental Protection Agency (2008). The division between Gothenburg municipality, the Västra Götaland region and the state can be seen in the figure below.

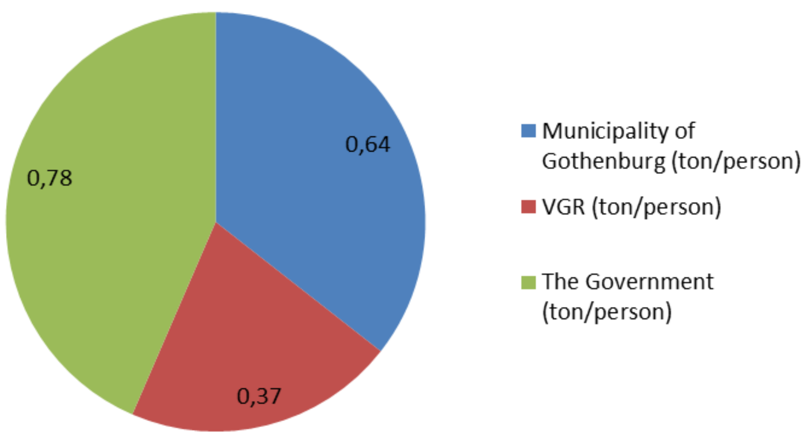

Figure. Division of greenhouse gas emissions from public activities between municipality, region and state.

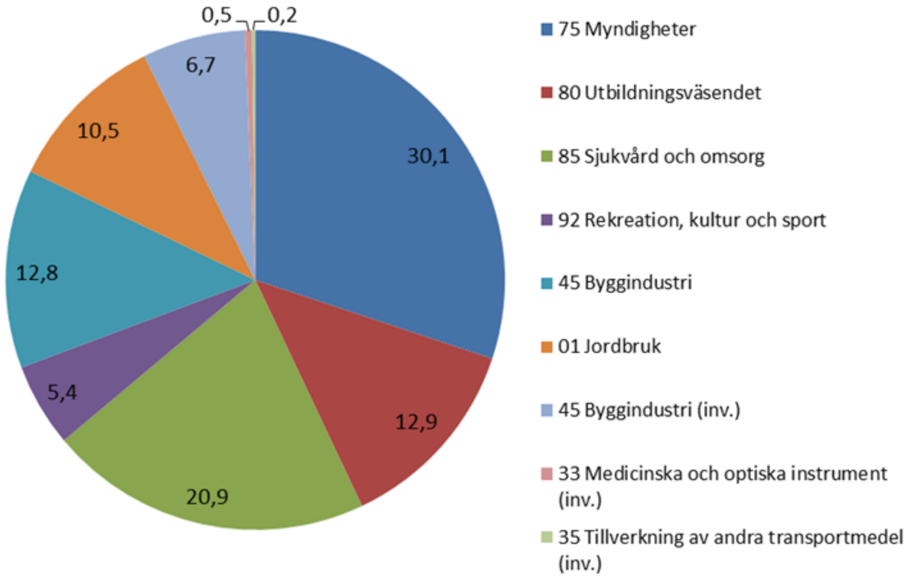

Figure. Emissions from different activities by municipality, region and state.

Emissions from the categories of Authorities (office activities), Education sector and Healthcare and other care are relatively high, since these accounts for a large proportion of public activity. These activities generate emissions through heating, electricity and car use, etc. The Construction industry category includes, for example, construction of buildings and roads.

In addition to the above overall analysis, a detailed analysis has been conducted of the greenhouse gas emissions of the meals which the municipality serves, for example in schools. Firstly, an estimate was made of the average emissions per meal (SIK 2011). This resulted in emissions of 1.46 kg CO2e per meal. When this is multiplied by the figure of around 19 million meals served annually by the municipality, the result is that food accounts for over 8 per cent of the municipality's total greenhouse gas emissions (i.e. 0.05 tonne CO2e of the total of 0.64 tonne CO2e per person per year – see figure above).

Public sector consumption – scenario calculations

We have not made a detailed analysis of future emissions from public sector consumption. Instead we have, for each scenario, assumed that public sector consumption develops in the same way as the other domains (except air travel).

Results

In this section we outline the results of our calculations. It is important to remember that any assertions we make about the future are clearly extremely uncertain. Also, the results are based on a very large number of assumptions and, had those assumptions been different, different results would have been obtained.
We start by describing the greenhouse gas emissions of the typical households in 2010 and then report the results for 2050 for the respective scenarios: Business as usual (BAU), Current climate policy and Low-carbon transition.

EMISSIONS IN 2010

The figure below shows the households' current emissions. The high-income family has the highest emissions, 10 tonnes of CO2e per person per annum, while the low-income family generates 5.5 tonnes of CO2e. The main reason for the difference in emissions between the households is the extent to which they travel by car and by plane. The Other consumption emissions are also lower for the low-income family. The average Gothenburg resident gives rise to 7.4 tonnes of CO2e emissions over the course of a year.

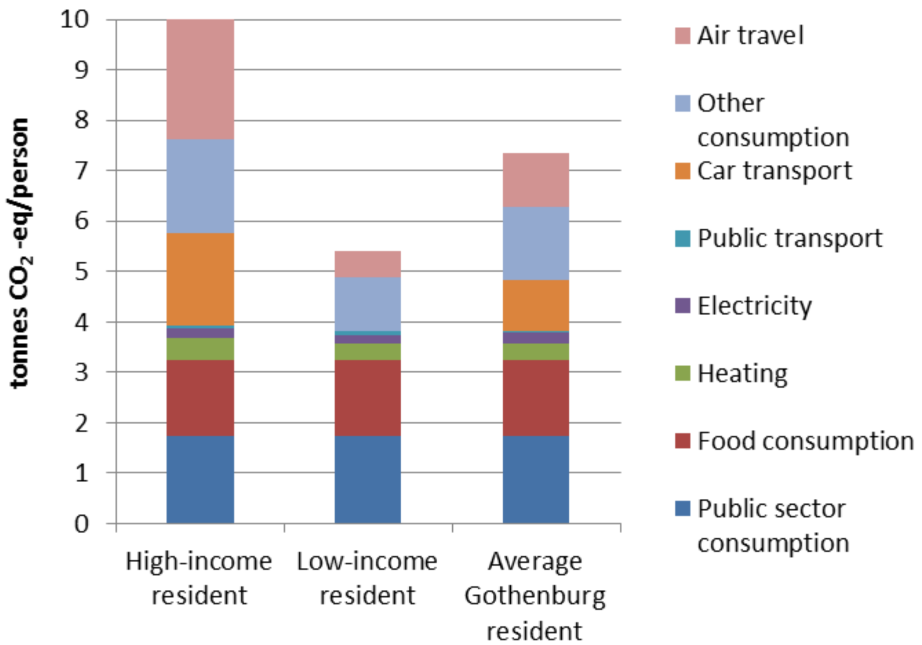

Figure. Emissions from the different typical households in 2010 sub-divided into different domains.

According to this study, the average Gothenburg resident currently gives rise to 7.4 tonnes of CO2e emissions per annum through his/her consumption of different goods and services. According to the Swedish Environmental Protection Agency's report ‘Konsumtionens klimatpåverkan’ (2012) (The Greenhouse gas emissions of Consumption (2012) the average Swede gives rise to just over 10 tonnes of CO2e per annum. This figure is significantly higher than it is for the average Gothenburg resident in this study.

The main reason for this is probably that different methods have been used. The method used by the Swedish Environmental Protection Agency is more suitable for calculating total emissions. They work on the basis of the total emissions and divide them on a per capita basis.

This top-down method, which is known as an input-output method, encompasses all emissions. Our main purpose, however, was not to calculate the total emissions but rather to demonstrate how each individual has an impact on climate through their lifestyle. Also, it was important to be able to demonstrate how different technological and behavioural changes can reduce the impact households have on climate. In this context, a bottom-up method based on the lifestyle of households and calculating emissions based on that lifestyle was used. This is similar to a life cycle analysis of a year's activity in the different households.

There may, however, be reason to believe that the average Gothenburg resident gives rise to lower emissions than the average Swede. Research indicates that income level and type of housing (apartment/house) are two key factors behind differences in greenhouse gas emissions (Nässén 2014). The average Gothenburg resident is a city dweller and more often than not lives in an apartment (80%). This is associated with a smaller dwelling size, lower energy consumption, better access to public transport and lower car ownership. The average Gothenburg resident also has a lower income than the average Swede (SEK 222,221 per annum after tax for an average Gothenburg household, compared to SEK 275,000 for the average Swede[13]).

BUSINESS AS USUAL SCENARIO

The idea of this scenario is to demonstrate what things would look like in 2050 if climate policy, technological advances and trends in consumption continue in the same way as they have done for the past 2–3 decades. The scenario assumes continued improvements in efficiency for cars and air travel, among other things, but also that electricity consumption, dwelling size, meat consumption and air travel will increase.

The figure below shows that this results in significant increases in emissions for all households. The high-income family's emissions increase from approximately 10 tonnes CO2e per person to 14.8 tonnes per person in 2050. The low-income family's emissions increase from 5.5 tonnes to 7.5 tonnes and the average Gothenburg resident's emissions increase from approximately 7.4 tonnes to 10 tonnes in 2050.

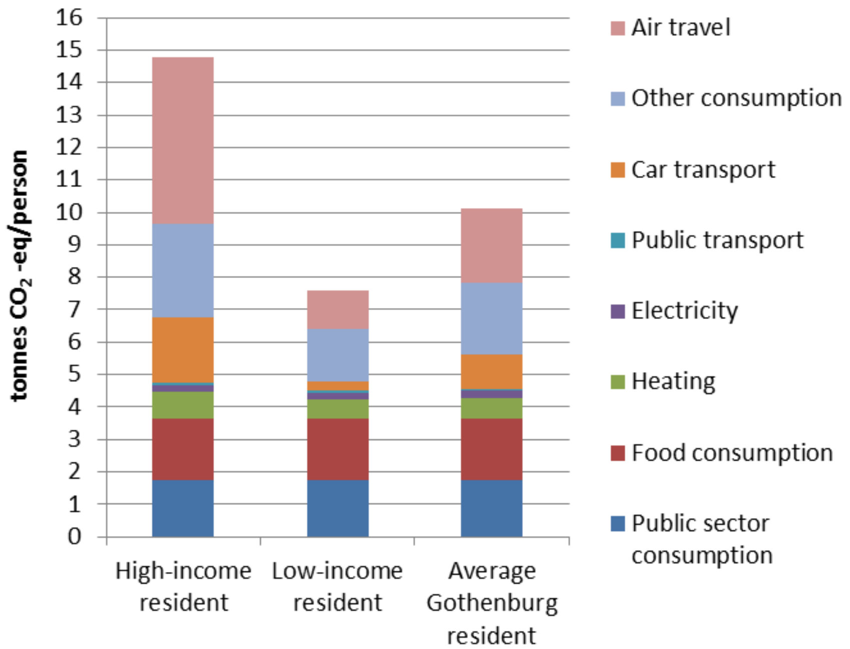

Figure. Emissions from the different typical households in 2050 in the Business as usual scenario.

CURRENT CLIMATE POLICY SCENARIO

This scenario assumes that the objectives of current climate policy have been achieved, i.e. significant reductions in emissions from energy systems and fossil-independent road transport by 2050. In principle, emissions from air travel and food will, however, develop in line with the BAU scenario since we have assumed that control measures which are sufficiently stringent to affect emission levels have not been implemented.

The figure below shows that this scenario results in slightly lower emissions in 2050 compared to today. For the high-income family, emissions fall from around 10 tonnes per annum per person to 8.7 tonnes. The low-income family's emissions fall from 5.5 tonnes to 4.2 tonnes. For all three households, food and air travel are the two biggest categories of emissions. In 2050, more than half of the high-income family's emissions will come from air travel.

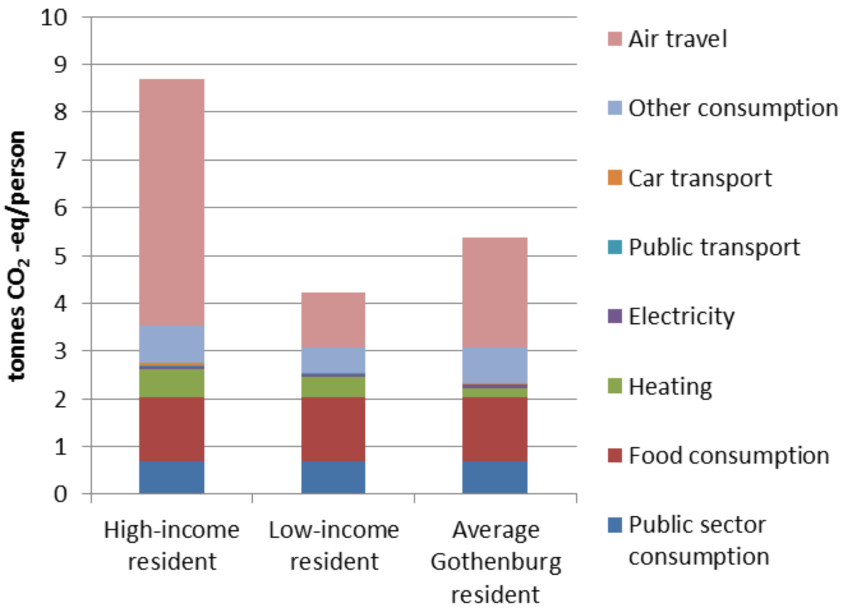

Figure. Emissions from the different typical households in 2050 in the Current climate policy scenario

LOW-CARBON TRANSITION SCENARIO

In addition to the Current climate policy scenario's assumptions about changes in energy and transport systems, further technological and behavioural changes are assumed in this scenario in order to reduce emission levels to less than 2 tonnes per annum. The main features of this scenario are a 50% reduction in residential energy consumption, a 50% reduction in the consumption of beef and pork, air travel at year 2000 levels, a greater proportion of service-based consumption and a reduction in working hours.

The figure below indicates that these changes mean that the average Gothenburg resident and the low-income family will have an emission level of less than 2 tonnes per person by 2050. This is not the case, however, for the high-income family. For all three households, 80% or more of emissions come from the air travel, food and other consumption categories.

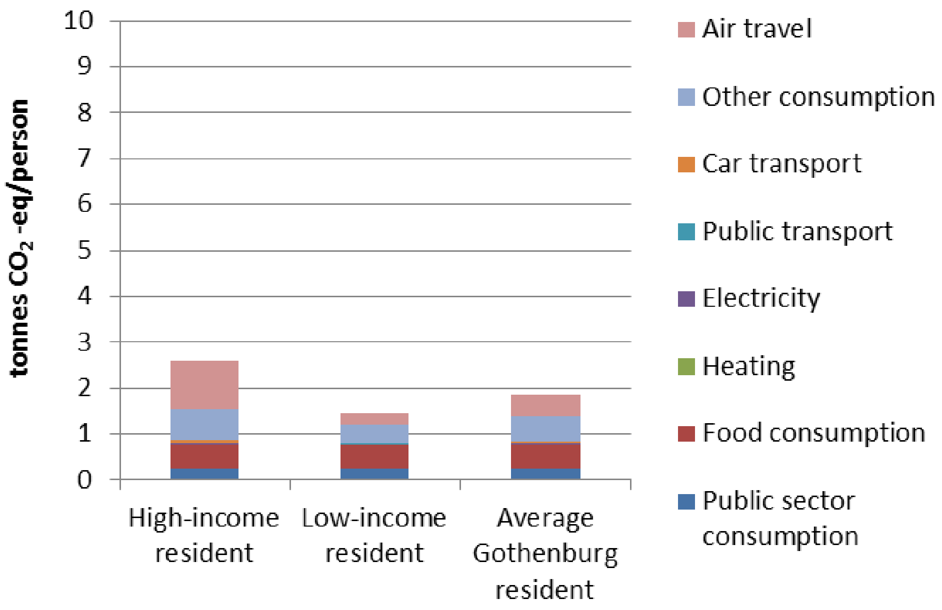

Figure. Emissions from the different typical households in 2050 in the Low-carbon transition scenario

SUMMARY OF THE SCENARIO RESULTS

The figure below summarizes the results from the three different scenarios för 2050 in relation to the emissions in 2010.

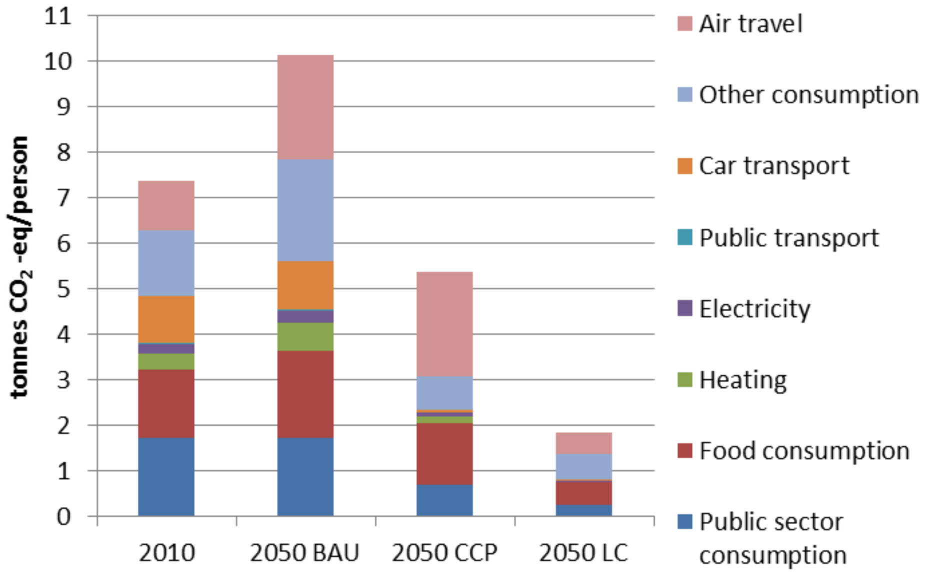

Figure. Emissions from the avarage resident in Gothenburg for the three different scenarios.

The emissions for the average resident in Gothenburg would, according to our calculations in *Business as usual (BAU*), increase from about 7.4 tonnes today to 10 tonnes by 2050. The increases in volume are not offset by improvements in efficiency. The scenario *Current climate policy scenario (CCP)* indicates that the emissions from the average resident in Gothenburg would be just below 5.5 tonnes by 2050. Emissions from cars, electricity and heating will be virtually eliminated. We assume that no stringent control measures have been introduced in order to significantly reduce emissions from air travel and food. The assumptions in the scenario *Low-carbon transition (LC)* leads to emissions lower than two tonnes by 2050 for the average Gothenburg resident and for the low-income family, while the high-income family causes emissions of over 2.5 tonnes.

Impact of a low-carbon transition on quality of life

This section will discuss the links between climate and quality of life[14]. In the first instance, we must emphasise that it is absolutely crucial for the quality of life of future generations that the climate targets are met. In this section, however, the focus is on those changes which may result in the climate targets being met, i.e. the potential impact of new technology and a change in lifestyle on the quality of life of the current generation. People often have very different ideas about how the climate targets can be met and how this would affect their lives. Some people think that the climate targets can be met entirely through advances in technology and that they will therefore not have a major impact on people's lifestyles. For example, that we will be able to drive our cars just as much as before but that emissions from cars will be so low that we will still be able to achieve the climate targets. Others, on the other hand, stress that the climate targets, in addition to new technological solutions, will also require sacrifices in the form of negative lifestyle changes. And a third school of thought has emerged, which says that the transition to a low-carbon society will certainly require changes in lifestyle but that these do not have to be perceived as sacrifices and, in some cases, they may even be beneficial to people's quality of life.

Hopefully, this report will provide more evidence-based information on how the climate targets can be met. According to our calculations, under the Business as usual and Current climate policy scenarios, the climate targets will not be met. The Low-carbon transition scenario, on the other hand, gives a rough idea of how the climate targets could be met. This section will discuss this scenario from a quality of life perspective.

When we talk about quality of life, it is important to be clear about what we mean by the various terms we use. A large number of different words with similar meanings, e.g. quality of life, happiness and wellbeing, are used in everyday language. In the field of research and statistics, a number of different types or dimensions of quality of life are commonly used. In this section, we will primarily use the two main types of subjective quality of life: life satisfaction and emotional wellbeing.

Life satisfaction is a cognitive dimension which indicates how people rate their life, i.e. how satisfied they are with their life. In order to capture this, researchers usually ask how satisfied people are with their lives. *Emotional wellbeing* (also known as subjective wellbeing or hedonic level) is about how a person feels. Common questions include whether a person generally feels happy or sad or how often a person has felt happy in the past week.

In addition, two other dimensions will be used in this investigation. *Income* is often used as an indicator of a positive development, e.g. in the form of higher GNP or individual income. This is because income levels affect the extent to which people can fulfil their needs and desires. One problem with using income as an indicator is that what people want is not always what ultimately brings them quality of life. *Temporal wellbeing* is also used to indicate both people's perception of time pressure and whether or not they are satisfied with how they actually divide their time between different types of activities.

LINKS BETWEEN WELL-BEING AND GREENHOUSE GAS EMISSIONS

The links between wellbeing and greenhouse gas emissions were analysed in a study based on data from 1,000 people in Region Västra Götaland (Andersson 2014). Greenhouse gas emissions were quantified in detail for all emission areas: transport, heating, electricity, food and other consumption. Subjective wellbeing is measured as a combination of how satisfied the respondent is with their life as a whole and how happy they feel in general (Argyle 1999, Inglehart, Foa et al. 2008).

The figure below summarises the results of this analysis, subdivided into decile groups, each comprising of approximately 100 individuals (the 10% with the lowest emissions in decile group 1 etc.). The lower part of the diagram shows that the emissions of the first decile group are less than a third of those of the decile group with the highest emissions.

At the same time, the upper part of the diagram shows that the differences in wellbeing between the different decile groups are very small. The only group that stands out slightly is the one with the absolute lowest emissions, which includes a large number of unemployed people and people on sick leave. These are factors which, according to earlier research, have a significant impact on people's wellbeing and which also affect their income and, consequently, their impact on climate. Between decile groups 2 and 10, which correspond to major differences in emissions, there are no significant differences in wellbeing.

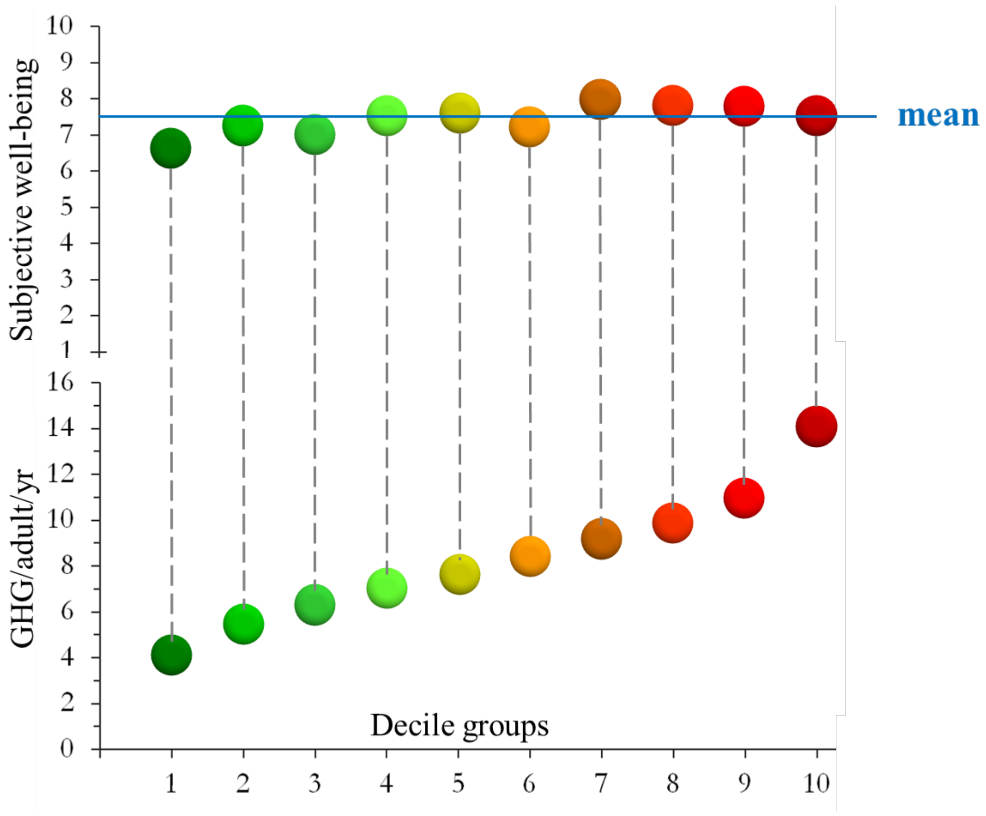

Figure. Greenhouse gas emissions and subjective wellbeing (SWB), classified by emission deciles (Andersson 2014)

There does not appear, therefore, to be an obvious trade-off between a low-emission lifestyle and a high level of wellbeing. In addition, a more detailed analysis was made of the effect on wellbeing of a number of different greenhouse gas emissions factors. A regression analysis incorporating both known wellbeing factors and greenhouse gas emissions factors was carried out (Andersson 2014). As expected, differences in the following factors had an effect on wellbeing: having a job, having a partner, good health, less time pressure and the opportunity to spend a lot of time with family and friends. In addition, it was investigated whether the following factors had any effect on wellbeing:

- air travel (number of flights per year)
- red meat (number of times a week)
- car usage in addition to commuting (km/year)
- dwelling size (square metres per person)

The statistical analysis gave no indication, however, that these factors were linked in any way with the level of wellbeing (Andersson 2014).

These analyses are based on differences between different individuals. Therefore, we cannot conclude from this that it would be unproblematic for individuals to change their own lifestyles overnight, e.g. for a person in decile group 10 to swap their patterns of consumption with a person in decile group 2. It is well known from earlier research that it is difficult for people to change behaviours and patterns of consumption, particularly if these are part of established habits and practices. But the absence of a link between emission-intensive activities and wellbeing, on the one hand, and the absence of direct links between greenhouse gas emissions and the factors which are important in determining our wellbeing, on the other hand, give a strong indication that these two objectives are not incompatible. And since a low-carbon transition would be have to be implemented gradually during several decades these results have some relevance.

The results of the analysis of car usage, meat consumption and air travel will be discussed further on in this section. First, however, we will consider costs associated with the transition to a low-carbon society.

THE COSTS OF TRANSITION AND THE CONSEQUENCS THEREOF

In some cases, transition to a low-carbon society may be more expensive than continuing with the current climate-damaging energy and transport systems. Estimates of the associated costs may appear to be very high and be perceived as a threat to the economy. A study by Christian Azar and Stephen Schneider takes a different approach to this issue (Azar & Schneider 2002). They base their analysis on the view commonly held by economists that global GNP will be roughly 10 times higher in 100 years. If costs sufficient to meet the climate targets are deducted, it would take 102 years for GNP to be 10 times higher, instead of 100 years.

Nicholas Stern, former Chief Economist of the World Bank, compared the costs associated with climate change with the costs of measures designed to meet climate targets (Stern et al. 2006). According to his calculations, a five degree increase in the average temperature, which, it is believed, would result, among other things, in both London and New York being under water by 2100, would reduce global GNP by between 5 and 20 per cent. Conversely, the Stern Review asserts that it would cost only 1% of global GNP to implement measures to avoid climate-related changes.

These analyses are very general and abstract. The specific cost of making the buses in the public transport system climate-neutral can be calculated. According to Volvo, the hybrid buses introduced in Gothenburg in 2013 have 75% less impact on climate (Sinclair 2013). Volvo says that mass production of the hybrid buses will start in 2015 and that they will then be cheaper overall than the buses that are currently in service. Remaining fuel stocks could be replaced with biogas or biodiesel. These fuel types currently cost SEK 0.5–5 per vehicle kilometre (Sinclair 2013). The opportunities for making the buses almost climate-neutral without necessitating significantly higher overall costs are good. Achieving the same climate improvement for cars may, however, result in greater increases in costs, since a higher purchase cost cannot be divided over as many kilometres as it can for a bus.

You might imagine that both the Current climate policy scenario and the Low-carbon transition scenario would increase households' energy and transport costs and that this would slow the rate of increase in private consumption. If taxes need to be increased slightly in order to finance shared climate-related investments, this would also reduce private consumption. How would this affect people's quality of life? You might imagine that this would have a negative effect because lower incomes lead to fewer choices. Research indicates, however, that for people in countries where the standard of living is already high, this effect is minimal or non-existent. This is evident, for example, in the diagram below, which illustrates differences between different countries with respect to GNP and average quality of life.

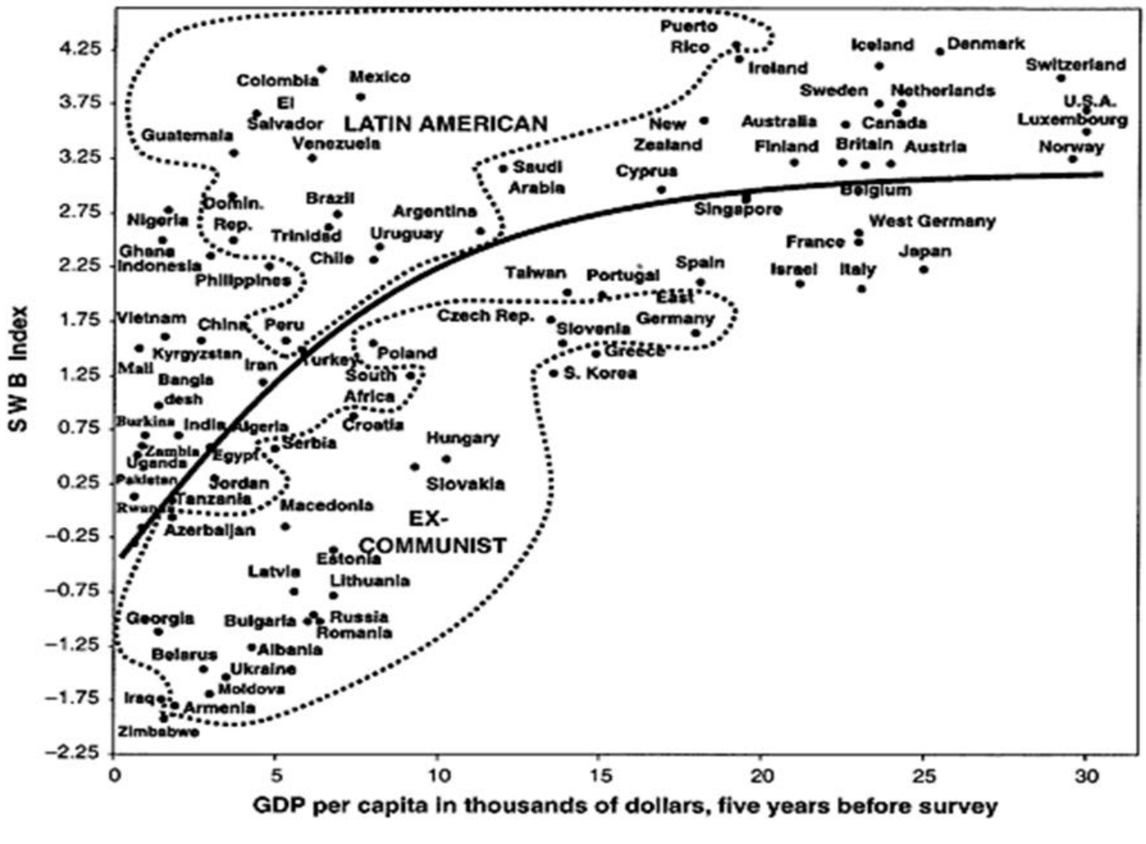

Figure. Quality of life and GNP per capita (Inglehart et al. 2008)

The quality of life indicator on the y-axis of the diagram is a combination of both life satisfaction and emotional wellbeing. The figure can be interpreted as indicating that GNP helps improve quality of life up to a level of approximately USD 20,000 per person (for Sweden, GNP was USD 57,000 in 2012).

The marginal effect of increased income is minimal or non-existent (Kahneman & Deaton 2010). Having a higher income than other people in the same social group is, however, associated with a higher quality of life. However, this factor is not relevant to this debate. But even if an increase in GNP in countries which already have a high standard of living does not appear to be linked significantly to a higher quality of life, a reduction in GNP may result in a lower quality of life, e.g. since it may lead to greater unemployment. However, according to both Azar & Schneider and Stern, a low-carbon transition would hardly result in a negative change in GNP in absolute terms but rather in the rate of increase of GNP being slightly slower in the short term.

In the context of the above, it would appear that, quite apart from the ethical reasons, there is also a significant financial imperative for investing heavily to cut greenhouse gas emissions. Stern emphasises that, in the long term, GNP will be considerably higher if climate change is avoided than if it is not. In the short term, the transition to a low-carbon society will entail greater costs than doing nothing. This will slow down the rate of increase in private consumption slightly. However, according to quality of life research, there is no reason to believe that this will reduce quality of life, provided that the slower rate of increase primarily occurs in industrialised countries.

Whilst it appears that a low-carbon transition is not associated with insurmountable economic costs, it may be wondered whether a low-carbon transition, with the lifestyle changes it requires, would come with a price in the form of a lower quality of life. We will look here at individual changes and their potential impact on quality of life. The Current climate policy scenario includes a fair number of technological changes which are not expected to have a major adverse effect on people's quality of life, e.g. renewable district heating, more energy-efficient homes, reduction in domestic electricity consumption as a result of more efficient appliances and conversion to electric cars. The Current climate policy scenario indicates, however, that this will not be sufficient to meet the climate targets. Consequently, the Low-carbon transition scenario also includes lifestyle changes: less car traffic/car usage, reduced consumption of red meat, reduction in air travel to year 2000 levels, reduced working hours and a greater proportion of service-based consumption. We discuss below how these lifestyle changes could affect people's quality of life. The lifestyle changes may have positive or negative effects on quality of life, both per se and through the control measures which are required to ensure that the change actually occurs. The focus of this report is on the former. Potential control measures designed to enforce the lifestyle changes will, however, be touched on briefly in order to give an all-round picture of the situation.

LESS CAR TRAFFIC AND CAR USAGE

While the Business as usual scenario assumes that car traffic will increase by 32 per cent by 2050, the other scenarios assume that it will decrease by 20 per cent. The Swedish Transport Administration, Trafikverket, has made it clear that if the climate targets are to be met, car traffic must be reduced (Trafikverket 2012). Both in the Swedish Transport Administration's analysis and in our scenarios, this reduction in car traffic is based on a number of different changes, including greater use of public transport, more cycling and walking and less travelling, through densification, teleworking or e-commerce, for example.

So, what impact on quality of life is a reduction in car traffic and car usage likely to have? Clearly, this is a highly complex question and we do not claim to have a simple answer to it.

What we can do, however, is highlight a number of key issues. We will consider both how a reduction in car traffic could affect the people of Gothenburg as a whole and how it could affect the individuals who actually reduce their car usage.
The large volume of car traffic currently using our roads has a wide range of negative consequences. One example that is pointed out in a study carried out in Stockholm, indicated that children who grow up in areas where there are high levels of air pollution from traffic have an increased risk of developing asthma, reduced lung function and hay fever[15]. Another study indicates that children who are often driven around by car have less opportunity for exercise and less spontaneous contact with friends (Freeman & Quigg 2009).

A reduction in the volume of traffic in cities is often seen as a policy objective because it can help make a city more attractive, i.e. less noise, better air quality, less congestion in traffic etc. However, if significant climate benefits are to be achieved, it is not sufficient simply to reduce the volume of car traffic in cities but rather car usage as a whole must be reduced, e.g. by reducing the amount of long-distance commuting by car. Taking a job a long way from home means commuting over a long distance and since the majority of commuting in Gothenburg and Western Sweden is by car, this means a trade-off between regional expansion and reduced emissions from passenger transport. If regional expansion actually leads to a higher quality of life (e.g. through increased growth and lower unemployment), measures to reduce commuting by car could have a negative effect on quality of life.

A reduction in car usage also has specific consequences for the individuals who in practice have to reduce their car usage. Around half of households in Gothenburg have a car and it is this group that could be directly affected by a reduction in car usage. Comparisons between individuals give no indication that a reduction in car usage would be associated with a decrease in wellbeing (Andersson 2014)[16]. However, we cannot conclude on the basis of this result alone that a particular individual would not perceive a reduction in their car usage as having a negative effect on their quality of life. People's transport choices are often the result of deeply entrenched habits (Gärling & Axhausen 2003). A reduction in car usage would require a change in habits which may be perceived as arduous and, at worst, may even have a negative effect on quality of life. Moreover, a car is not just a means of transport, it is also associated with social norms and identity, e.g. it gives people a sense of status. Gothenburg University's Centre for Consumer Science (CFK) studied the role of the car in wellbeing in a report (Jakobsson Bergstad et al. 2009). They found, however, that the positive feelings (link to status, identity etc.) associated with owning and driving a car were less important than the ability of a car to make everyday activities easier. The ability of a car to make everyday activities easier is therefore more important for subjective wellbeing than the emotional effect (e.g. sense of status).

If a reduction in car usage is not to have a negative effect on people's subjective quality of life, they must have good *access* to work, services and friends, for example. Current transport planning has been criticised for focusing to too great an extent on time saving for car drivers. People with disabilities, people on low incomes and people who are too old to drive, for example, are limited in their ability to obtain good access through the use of a car. Good access can either be achieved by travelling long distances or by living in an urban environment which offers good access.

A better *public transport system* is essential if we want to reduce car usage and, at the same time, maintain a good level of access. However, while people still have their own cars, there is always a risk that this will automatically be the means of transport that they choose. If a person sells their car and uses a car pool instead, car usage normally decreases because they are forced to make a more active transport choice every time they travel. Car pools also reduce overall travel costs and, for some, offer an improved quality of life as a result of no longer owning a car. However, if a car pool is to be an attractive alternative to having your own car, it must offer a good level of access. According to an Austrian study (Prettenthaler & Steininger 1999), 22 per cent of all car owners would benefit, both financially and in terms of time, if they sold their cars and used a car pool instead. This takes into account the additional time required to get to the car pool vehicle.

Another way of reducing car usage is to make certain journeys by *bike* or electric bike instead. As well as health benefits, research indicates that cycling also has more emotional benefits. A comprehensive Canadian study found that far more people who cycle or walk to/from work love this method of commuting. As many as 19 per cent of those who cycled to work said that this journey was the best part of their day, while the corresponding figure for car drivers was 2 per cent. This was corroborated by a Swedish study which found that people who cycled at least once a week had a significantly higher quality of life than people who did not (Brülde & Fors 2013). Another way of reducing car traffic is to implement *densification.* Densification of a city basically means increasing the number of inhabitants in a given area. Comparisons between different international cities confirm that a high population density reduces travel (Newman & Kenworthy 1999). In recent decades, development in the Gothenburg area has, however, been characterised by population growth through the building of residential estates on the outskirts of the Municipality of Gothenburg and in adjoining municipalities. This decentralisation of the city means increased commuting times. According to one study, the benefits associated with long commuting times, such as a better place to live, a better job etc., are not sufficient to offset the negative impact that long commuting times have on life satisfaction (Stutzer & Frey 2008). The study indicates that life satisfaction is significantly lower for each 10-minute longer commute a person has, in spite of the positive effects which their choice was presumably expected to have.

Densification and shorter travelling distances can reduce commuting times, which is positive for quality of life. Studies have shown that commuting is the everyday activity which results in the lowest emotional wellbeing while it is taking place (Krueger et al. 2009). Densification can help reduce commuting times and lessen the greenhouse gas emissions of daily transport requirements. So, there is every indication that a reduction in car traffic, in combination with public transport, car pools, cycling and densification is conducive to a higher quality of life. The difficulty will probably be more that people may be negative about the introduction of the control measures which will be required in order to reduce the volume of car traffic. In order to achieve a 20 per cent reduction, the Swedish Transport Administration specifies, among other things, a high congestion charge, higher parking charges, lower speed limits and a fuel tax which will result in a 50 per cent increase in the fuel price (Trafikverket 2012).

REDUCED MEAT CONSUMPTION

In the 'Business as usual' scenario, emissions from food consumption would, according to our assumptions, increase from today's level of 1.5 tonnes per person to 1.9 tonnes in 2050. In the 'Contemporary climate policy approach' scenario, the corresponding figure would be 1.3 tonnes.

Both scenarios are therefore incompatible with the target of reducing greenhouse gas emissions to two tonnes in total for transport, housing, goods, etc. The Low-carbon transition scenario therefore includes further technological changes and changes in what we eat in the future. We assume that the consumption of chicken, fish, reindeer meat, game, eggs, fruit, grain and vegetables is at the same level as today. Cheese consumption has also been assumed to be the same as today, while we have assumed that milk consumption continues to decrease at the same rate it has since 1980. In order to reduce emissions of climate gases we have, however, assumed that beef and pork consumption decreases by a half from today's level (from around 50kg to around 25kg).

How would such a dietary change affect people's subjective wellbeing? On the basis of a questionnaire survey conducted in Region Västra Götaland (described above) an analysis of the links between consumption of red meat and subjective quality of life was also carried out (Andersson 2014). In exactly the same way as for driving, the analysis shows neither positive nor negative effects on quality of life for higher meat consumption[17]. This investigation indicates, therefore, that people who eat a lot of meat enjoy neither higher nor lower quality of life than those who eat only a little meat. There is therefore no reason to believe that the level of meat consumption affects wellbeing.

One way to illustrate the extent of dietary changes in the 'Low-carbon transition' scenario is to compare them with dietary changes over the most recent decades. Today's high level of meat consumption in Sweden does not have a particularly long history. From 1990 to 2005 alone, meat consumption increased by no less than 45 per cent (Dahlin & Lundström 2011), from around 57 kilos to 83 kilos per person per year. This is equivalent to an average annual increase of around 1.7 kg. This increase can be compared with the 'Low-carbon transition' scenario, where consumption of red meat would be reduced by less than one kilo per year, reaching around 25 kg in 2050. A fundamental difference is, of course, that in this case the change would be a decrease instead of an increase.

According to an analysis by the environmental project 'Live Life', participants did not experience many difficulties in switching over to vegetarian food (Larsson & Svenberg 2012). One difficulty was simply that they thought meat tasted good and that meat was necessary in order for children to eat as much as their parents expected. Another reason for continuing to eat meat was that people were used to and skilled at cooking meat dishes. A third reason was that the trend towards meat-based diets for weight loss has enjoyed great success, for example GI (glycaemic index) and LCHF (low carbon high fat). These difficulties apply when people switch to vegetarian food over a short period of time. What would happen in the case of gradual changes in the future may be quite different. It depends, among other things, on our knowledge and our criteria in the future. It it is also something that may be affected by political decisions (Klintman 2012). Below, we make a number of comments regarding factors which suggest that reduced meat consumption may even be compatible with a better quality of life than today.

Reduced consumption of meat (especially red meat) could be promoted by increased knowledge of the negative effects which meat (e.g. enhanced risk for cancer) has on health and the positive effects of eating green. There is a considerable amount of research which suggests this. The Association for International Cancer Research[18] recommends that people limit their consumption of red meat radically and avoid butchers' products such as sausages and pâté entirely. Food recommendations for the Nordic countries prescribe a maximum of 25 kilos of red meat per year (Norden 2014), i.e. the same level as is assumed in the Low-carbon transition scenario.

Changed criteria may also play a big role in opportunities for reducing meat consumption. One possibility is that people's views of animals change. This could, for example, mean that a majority of people would decide not to eat meat from animals which they believed might not have been treated well. Such a change would probably mean that people would buy more expensive meat and therefore less of it. Another possible change would be that in a future with a much bigger global population, it would not be considered ethically defensible to eat meat which requires large areas of land for the production of animal fodder and for grazing.

With future changes in knowledge and criteria, reduced meat consumption might be regarded as positive from an ethical perspective and might also be associated with better quality of life in the form of better health. In order for such a future to become a reality, however, there is a need for insight and acceptance of the fact that powerful control measures are required to reduce meat consumption. Both the Swedish Board of Agriculture (Lööv et al. 2012) and the Swedish Environmental Protection Agency (Dahlin & Lundström 2011) have, in reports, discussed possible control measures to achieve a sustainable level of meat consumption. One example of a radical measure would be to have vegetarian pre-schools, so that municipalities would accustom children to eating vegetarian food right from the start. Another suggestion is to introduce a climate tax on livestock production (Wirsenius et al. 2011). The fact that meat consumption has increased so much during recent decades at the same time as meat prices have fallen indicates that a climate tax would have the effect of reducing consumption.

REDUCTION OF AIR TRAVEL TO THE 2000 LEVEL

The 'Business as usual' and 'Contemporary climate policy approach' scenarios mean substantially increased emissions from air travel in 2050. This is incompatible with the target of less than two tonnes of emissions per person and the 'Low-carbon transition' scenario therefore includes a reduction of private air travel to the same level as in 2000. This, in combination with increased energy efficiency in the aviation sector, makes for considerably lower emissions. (See the section on air travel in the 'Detailed measures' section above).

How, then, might a minor reduction of air travel affect quality of life? The study by Andersson described above (2014) found no relation between the amount of air travel and level of wellbeing. There is, however, another study which did find a certain correlation (Brülde & Fors 2013). If there is such a correlation, it may be connected with the specific values connected with flying to far-away places (e.g. sun, warmth and other cultures) or it may be because flying is associated with getting away from day-to-day life at home, which is characterised by stress and too little time for social relations and relaxation. Further research is needed here.

As air travel increases, it can be assumed that people see regular travel abroad as part of a normal pattern of consumption and a natural component of a good life. The greater the increase in flying, the greater the reduction needed to come down to the same level as, for example, 2000.

Aviation is today tax-free, in principle, since it pays neither fuel tax nor value-added tax. Since 2012, however, aviation has been part of the EU's trade in emission rights (this applies only to flights within the EU, however.) But the price levels of emission rights are so low that the effect is not noticeable and government researchers drew the following conclusion in 2013: “If the price level of emission rights does not rise to such a level that the system contributes to the achievement of environmental targets to the extent intended – and there is little indication of this – alternative means of taxation should be considered.” (Karyd 2013).

A carbon dioxide tax on aviation fuel would be effective but the international aviation industry ICAO claims that it would be an infringement of the Chicago Convention of 1944. Government researchers suggest that Sweden should promote the proposal that air travel within the EU should be subject to value-added tax or, even better, that the current system for EU air traffic control should be used to charge climate taxes. A national alternative is a climate tax per plane seat based on distance. Great Britain has such a tax, which amounts to over SEK 1,000 for long-haul, intercontinental flights.

SHORTER WORKING HOURS

Productivity in Sweden normally increases by around two per cent per year and how this increase is 'used' affects both quality of life and greenhouse gas emissions (Holmberg, Larsson et al. 2012). In the BAU and CCP scenarios, the whole of the assumed increase in productivity is allocated to increased private consumption (+120% from 2010 to 2050). This contributes to greenhouse gas emissions, however. If the increase in productivity is instead allocated to a reduction in working hours, it has, broadly speaking, no greenhouse gas emissions. In developing the low-carbon transition scenario, we therefore decided to build in a reduction in working hours as part of the reduction to less than two tonnes of emissions per person in 2050 (see the section on other consumption in 'Detailed measures' above.)

We assumed that a third of increased productivity is neutralised by shorter working hours. This means that we assume not 2 per cent growth but only 1.33 per cent. For a period of 40 years, this means that average working hours decrease by around 25 per cent. Someone who works a 40-hour week today and whose working hours decrease at the same rate as the average in society then arrives at a working week of around 30 hours.

How a reduction in working hours would affect quality of life is a complicated question; here, we can only introduce a structure for analysing it and report some of the research. Below we firstly discuss the effects of a reduction in working hours on the working part of the population and then effects on society as a whole.

As regards the effects on the working population, one consequence is that private consumption would not increase as fast as it otherwise would. We assume that a third of increased productivity is neutralised by shorter working hours. This means that private consumption will rise not by 120 per cent by 2050 as in the other scenarios but 'only' by around 70 per cent. Such a gradual reduction in working hours does not, therefore, lead to an absolute reduction of private consumption; it means, rather, that the rate of increase is slower. Comparisons of both countries and individuals over time show that the effect of higher income on wellbeing is small or non-existent (see 'Costs and consequences of the transition' earlier in this section.) The figure below, showing development in Sweden, can be seen as an illustration of this.

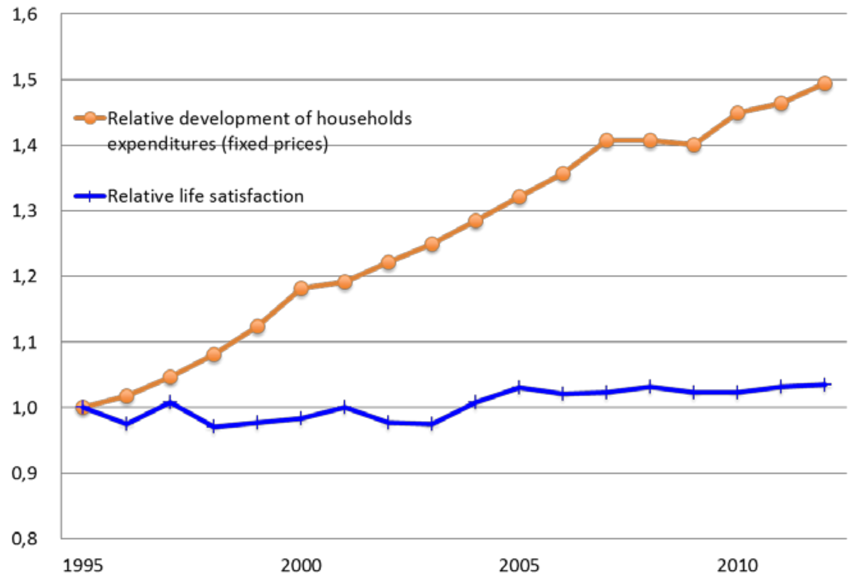

Figure. Development of relative lifestyle satisfaction and household expenditure (in fixed prices) 1993–2012 Source for lifestyle satisfaction: SOM Institute, Gothenburg University Source for expenditure: SCB

On the basis of questionnaire data described earlier, based on 1,000 people in Västra Götaland, an analysis was made of the links between greenhouse gas emissions and temporal wellbeing (Larsson et al. 2013). One dimension of *temporal wellbeing* is the experience of *time pressure*, i.e. the feeling of unease which results from the difficulty of finding time to do everything you need to do (Larsson 2012). But there is also at least one other dimension: how satisfied people are with the way they actually spend their time. This may be called time satisfaction and it reflects, among other things, whether people have a good balance between their work and their private lives and how satisfied they are with the amount of time they have, for example, for sleep, relationships and leisure interests[19].

The links between working hours and other aspects of time were investigated in a study (Larsson, Andersson et al. 2013) by dividing people into three groups: those who work approximately 30, 40 and 50 hours per week[20]. For the sake of clarity, we show how those who work 30 and 50 hours differ from those who work 40 hours. A 30-hour week results in a much lower carbon dioxide emission from an individual's whole lifestyle than a 50-hour week. This result agrees closely with previous studies. The result is, in essence, that shorter working hours bring lower incomes and lower consumption.

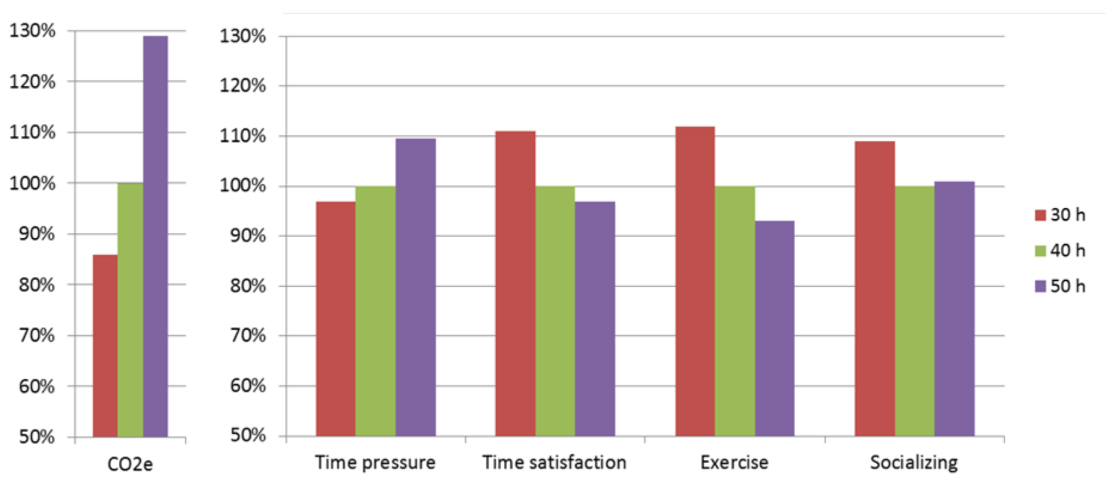

Figure. Links between working hours, greenhouse gas emissions and temporal wellbeing. The figure on the left is based on 172 single people[21] and the one on the right on 767 people (both single and living together/married).

Shorter working hours are also linked to reduced time pressure and greater satisfaction with time use. The bar chart also shows that people with shorter working hours tend to devote more time to exercise and friends. Other analyses of this material, however, did not show any significant links between working hours and satisfaction with life or subjective wellbeing. One possible interpretation of this is that working hours are not one of the most important factors in explaining lifestyle satisfaction and subjective wellbeing overall but that other factors, such as genes, social relations and simply having a job, are more important. But the dimensions of quality of life related to working hours, such as time pressure, satisfaction with use of time and time for exercise and friends, are more time-related and subject to influence on an individual basis.

In 2005–2006, a study was carried out in which 400 employees in 17 different public workplaces worked six hour daysfor one and a half years (Bildt 2007). The result showed positive effects on people's quality of life and subjective perception of health, for example back problems or sleep problems (the experiment did not lead to a decrease in sick leave; according to the researchers this may, however, be because the period of the study was too short).

There is good reason to believe that a future with shorter working hours at the cost of a slower increase in private consumption might have positive consequences for the individual's quality of life. The question is what effect a reduction in working hours would have on society as a whole. A reduction in working hours could have both positive and negative effects on the population as a whole.

There is also reason to believe that a reduction in working hours would be good for equal opportunities. The experiment with a six-hour day described above (Bildt 2007) showed that on average men increased the time they devoted to housework and children more than women, while women increased the time they devoted to leisure (relationships with people, exercise, TV etc.) more than men. It can also be assumed that an overall reduction in working hours would increase equal opportunities by reducing women's need to go part-time in order to look after their homes and children. This would improve women's competitiveness in working life.

If shorter working hours result in lower unemployment, this naturally brings positive effects for society. There are, however, differing views regarding whether reduced working hours actually have such an effect on division of labour (Golden & Figart 2000, KI 2002).

The most obvious problem with a reduction in working hours is that it can be assumed to lead to increased difficulties in financing schooling, nursing and other forms of care. Longitudinal research by the Swedish Ministry of Finance (Swedish Ministry of Finance 2004, Swedish Ministry of Finance 2008) suggests that there will be reduced scope for maintaining welfare and income from taxation unless private consumption continues to increase and we continue to work long hours. Furthermore, demographic development is heading in the direction of a higher proportion of pensioners in the population and this also requires increased income from taxation. On the other hand, countries such as France and the Netherlands have recently succeeded in introducing reductions in working hours. There are also different conceptions of how today's welfare society could be made compatible with reduced working hours. It may be possible to impose tax increases without any negative effect on the international competitiveness of companies, for example by means of environmental taxes (e.g. by raising existing carbon dioxide taxes or introducing new environmental taxes on meat and air travel, for example) by raising value-added tax, property tax or higher marginal taxes. People may also become healthier as a result of working less, resulting in lower costs for sickness benefit and healthcare.

Individual reduction in working hours is an alternative to a general reduction in working hours. One way of implementing this is to introduce a universal part-time entitlement giving everyone the right to reduce their working hours, just as parents of young children have today. The Netherlands have since 2000 had a law permitting all full-time employees to reduce their working hours by 20 per cent and all part-time employees to increase to full-time, unless the employer can show that this would have detrimental consequences. For individuals, an individual reduction in working hours is more difficult because it entails, among other things, a break with the full-time norm and a reduction in capacity for consumption (Larsson 2012). If more women than men chose this option, the differences in income between the sexes would also increase. However, the advantage for individual quality of life which derives from the ability to determine your own working hours is probably decisive. Another possible advantage is that if only a proportion of people elected to reduce their working hours, the effect on tax income would be limited.

INCREASED PROPORTION OF SERVICE CONSUMPTION

The low-carbon transition scenario also includes an increased proportion of service consumption. We have assumed a considerable increase in the proportion of expenditure attributable to eating out (restaurants and cafes) and other services (e.g. hairdressing, skin care and association fees). The reason for this is that consumption of services has considerably less greenhouse gas emissions than consumption of goods (see the section on other consumption in the chapter 'Detailed assumptions' above). But what effect would an increased proportion of consumption of services have on people's wellbeing?

In the same way that a reduction in working hours has the potential to make time available for meaningful activities and reduced stress, you could also conceive of unchanged working hours but with households buying e.g. cleaning services or gardening services which, additionally, have relatively low emissions. Services located close to households, however, form only a small component of the total consumption of services. Another important component consists of entertainment and cultural services. Van Boven & Gilovich (2003) show in their research that entertainment and consumption of entertainment have a very positive happiness effect, which can be stronger than consumption of goods and which also has a longer-lasting effect on wellbeing.

There is a widespread belief that we are gradually moving towards a service society. Eva Alfredsson & Sandro Scocco (2008) analysed the development of the proportion of households' consumption attributable to services and found that this is not the case. Overall, private consumption of personal services fell, in fact, during the period 1963–2005. The main reason for this is probably that services have gradually become more and more expensive in relation to goods (Baumol 1967). This is caused, among other things, by the transfer of goods manufacturing to low-income countries and by the fact that the rate of productivity increase is faster for goods manufacturing than for services.

Increased public sector consumption

As well as being used to reduce working hours or to increase private consumption, society's increased productivity can be used to increase public sector consumption. International comparisons confirm that higher taxes which are used to improve healthcare, schools and other care make for better quality of life, even at the cost of an increase in private consumption (Layard 2006). If society raises taxes, climate-damaging private consumption (e.g. goods and travel) decreases and less climate-damaging consumption of public services increases.

SUMMARISING DISCUSSION OF QUALITY OF LIFE

The overall picture of the 'Low-carbon transition' scenario is that it would, perhaps, have both negative and positive effects on people's quality of life. The fear that a low-carbon transition would mean that people would revert to a standard of living and quality of life which prevailed long ago is, according to our analyses, unfounded. On the other hand, the idea that a low-carbon transition would be associated with a greatly improved quality of life is probably also an exaggeration. There are elements in the low-carbon transition scenario which can be perceived as both negative and positive. Broadly speaking, people's quality of life after a low-carbon transition would probably be roughly the same as today. In this chapter, the changes have been commented on primarily from the point of view of individual quality of life. To get a better picture of what these changes would mean for society as a whole, deeper and more extensive analyses are required.

The changes entailed in the low-carbon transition and the control measures required would, however, affect the different typical households to differing extents. Low-income households drive less and fly significantly less than high-income households. This means that restrictions on car use and air travel would primarily affect high-income households. The advantages and disadvantages of reduced meat consumption, however, would affect all the typical households to roughly the same extent.

A key aspect is how people perceive the transition process. Certain changes would perhaps be perceived as positive right from the start, for example, beginning to cycle more but in view of the strong influence our habits and the status quo have on us there are likely to be misgivings. People may be uncertain how the changes in lifestyle will affect their own quality of life or they may dislike the control measures which will bring about the changes. But there are examples of how such misgivings wear off with time. On example is the decrease in car use in Stockholm resulting from the introduction of a congestion tax. Before the system was introduced, most people's attitude was negative and there were great fears that the system would be complicated and expensive and would not reduce traffic jams. As time passed, however, attitudes became increasingly positive. Almost half of Stockholm's inhabitants have switched from a negative to a positive attitude (Klintman 2012). With the passage of time, control measures are often accepted if the advantages of the system are clear.

In a democracy, however, politicians' ambitions to introduce control measures must keep pace with citizens' appreciation of the fact that the control measures are necessary. There is currently a gulf between, on the one hand, the control measures which a low-carbon transition requires and, on the other hand, interest among both politicians and the public in introducing this kind of control. There is probably a need for broad popular support for a more radical climate policy in order for a low-carbon transition to be initiated with the support of the authorities. The scope for popular acceptance of new control measures in the future is influenced, as was mentioned above, by prevailing criteria, among other factors. The environmental sociologist Mikael Klintman points out that criteria change over time and that, for example, if large amounts of air travel began to be regarded as undesirable, this would promote acceptance of taxes on air travel (Klintman 2012).

Another aspect which influences acceptance of control measures is whether they are perceived as fair. If a control measure hits low-income earners harder than high-income earners, it can contribute to increased inequality (Wilkinson et al. 2011). It may seem that a tax on air travel would affect low-income earners more than high-income earners, since the latter can pay such a tax more easily. At the same time, though, high-income earners currently fly several times more than others, and air travel taxes would therefore be paid primarily by high-income earners, while low-income earners who do not fly at all would not pay any air travel tax. In addition, low-income earners would benefit from the ways in which the taxes are used (for example, higher quality through better public services). In the case of a climate tax on meat, the differential effects on different income groups are less clear, since low-income earners also eat a lot of meat. One way to reduce this problem is to compensate low-income groups through other parts of the taxation or transfer system (for example with increased child support, increased housing support or increased income tax relief).

Conclusions

Based on the method we selected and the scenarios we defined, it is possible to achieve our climate target of a sustainable and fair emission level in Gothenburg. We do not believe that this would have to mean a deterioration of our quality of life. However, the current climate policy is not sufficient and, on the basis of our assumptions, further measures will be required if we are to achieve the target. The technological measures adopted in our energy and transport systems must be supplemented by measures which change our consumption, primarily of air travel, food and goods. If the transition to a low-carbon society is to be successful, action and measures are required from a number of different stakeholders. This transition requires tough controls at different levels of our society, not least from the City of Gothenburg. Stringent control measures, which may not be readily accepted, must be introduced. Those households which currently account for the largest emissions will also be the households whose lifestyle will be most affected by these measures and controls.

Clearly, it is not enough for the people of Gothenburg alone to make the transition to a low-carbon society: if major climate changes are to be avoided, all societies must make changes. Below is a list of examples of the choices and measures required to achieve a sustainable and fair emission level. The list was primarily drawn up by individuals working for the City of Gothenburg and Region Västra Götaland in order to clarify what their own organizations need to do and what needs to be done at other levels.

- International level – the EU and other stakeholders must introduce measures which are stringent enough to:
  - bring about a transition to a fossil-independent energy system
  - achieve improvements in energy efficiency
  - bring about climate-related changes to the food and agriculture sectors
  - reduce air travel as a whole.

- National level – Sweden must introduce measures which are stringent enough to:
  - achieve the objective of fossil-independent road transport
  - increase the generation of renewable energy, both for domestic use and for export
  - change Swedes' eating habits
  - reduce air travel
  - limit greenhouse gas emissions from other consumption, e.g. by reducing working hours and increasing the proportion of service-based consumption.

- Regional level – Region Västra Götaland must, among other things:
  - expand public transport
  - reduce emissions from public transport by 95%
  - stop using fossil fuels in public transport
  - initiate, manage and fund regional projects
  - coordinate agreements between stakeholders in Västra Götaland
  - promote sustainable consumption by imposing requirements on procurement

- Local level – the City of Gothenburg must, among other things:
  - stop using fossil fuels for the production of district heating
  - continue to invest in renewable energy generation
  - make housing more energy efficient so energy consumption per square metre is 50% lower by 2050
  - transform the transport system by:

        - doubling the use of public transport
        - reducing car usage by 20%
        - increasing the densification of the city and consistently building new housing in areas where public transport is good
        - improving facilities for cycling and walking
    - serve less meat, fewer dairy products and more vegetables in public sector institutions
    - promote reduced working hours and an increase in the proportion of service-based consumption
    - campaign intensively to inspire residents to change their patterns of consumption in the field of air travel and meat.

The City of Gothenburg has the ability to influence (has control over) a significant part of the transition process, e.g. by providing solutions, but, at the same time, is dependent on other parties choosing to implement changes in line with the municipality's climate objectives.

The individual also has a relatively large degree of control over his/her greenhouse gas emissions, as indicated, among other things, by the fact that emissions vary between the different typical households. What distinguishes the households' emission levels in our study is primarily the amount of air travel, the amount of car travel and the amount of other consumption. Air travel in particular, which is closely linked to income levels, made a major difference to the households' emissions in all scenarios. Emissions from food do not vary between the households because we did not find sufficient evidence to indicate that meat consumption varies between high-income and low-income households.

The question is how the responsibility for these greenhouse gas emissions is split between the individual and other players, a question to which we have no direct answers. An important factor here, however, will be the individual's acceptance of the lifestyle changes that are needed and the control measures that other players introduce.

THE WAY FORWARD

The intention is that the results of this report will act as a basis for a more informed dialogue over the appropriate course of action for the future. We hope that our method can also be used by other stakeholders, e.g. environmental organizations, businesses, municipalities and authorities, both in Sweden and abroad. Clearly, there are other changes which could equally well result in emission levels of less than 2 tonnes. This report has highlighted certain measures and, hopefully, other studies will highlight different but equally effective measures. By making the spreadsheet on which this report is based available to others, we hope to facilitate analyses of other measures. In so doing, we give critics of this report the opportunity to be constructive and to come up with alternative ways of achieving sufficient reductions in emissions. The spreadsheet and a number of supporting reports, plus an online dialogue forum (in Swedish), are available at:
www.mistraurbanfutures.org/en/project/wise —- well-being-sustainable-cities

We want the results of this project to be available for discussion and consideration by a wide range of social groups. In the future we plan to develop an online game based on this report, which is aimed at upper secondary school students. In the long term, we hope that this will result in increased engagement and acceptance of the climate-related changes that are required.

Appendix 1 – Energy systems in the future

Electricity

Emission factors for electricity on the Nordic electricity market are used in all the calculations. In this study, the emission factor for the Nordic electricity mix in 2010 was defined as 125.5 CO2/kWh, which is the figure used by the Swedish Energy Agency (Martinsson 2012). The Business as usual scenario assumes that emissions per unit of energy will be the same in 2050 as they are now.

For the Current climate policy and Low-carbon transition scenarios, the emission factor was calculated on the basis of the EU's Energy Roadmap 2050 (European-Commision 2011). To calculate emission factors for the Current climate policy and Low-carbon transition scenarios, the scenario referred to in the EU's report as the 'Current policy initiatives scenario' was used. This scenario takes into account measures included in the EU's current strategy for achieving targets by 2020. In this scenario, 4,620 TWh of electricity will be generated in the EU in 2050. In that same year, emissions from electricity generation will be 553.3 million tonnes of CO2. 7.6% of the electricity in the scenario will use Carbon Capture and Storage (CCS). The latter has been deducted from the total electricity generated; making the amount of electricity generated 4,269 TWh. With CCS, the carbon dioxide emitted during the combustion of fossil fuels is collected and stored underground, e.g. in a depleted oil or natural gas field. If the total emissions for electricity generation are divided by the electricity generated, an emission factor of 129.6 g of CO2/kWh is obtained for European electricity. This means a reduction of just over 65%. On the assumption that emissions from the Nordic electricity mix fall correspondingly, the emission factor for Nordic electricity will be just under 43g of CO2/kWh.

In order to take account of emissions which occur throughout the life cycle of the fuels and not just those which occur during combustion itself, all electricity emission factors have been multiplied by the factor 1.09. That way, emissions from extraction and refining of fossil fuels will also be included.[19]The emission factors for electricity used in the calculations in this study can be found in the table below.

Table. Emission factors for electricity, grams of CO2e/kWh.

	BAU	Current climate policy	Low-carbon transition
2010	126	-	-
2050	126	43	43

Heating

The emission factors for district heating have been calculated on the basis of the energy balance defined by SP Technical Research Institute of Sweden for the Environment Administration, City of Gothenburg, as part of the work on Gothenburg's climate strategy. The energy balance uses data from 2010. In order to calculate the emission factors, data on the fuels used in district heating production were compiled from the environmental reports of the production facilities of Göteborg Energi (municipal energy company), Renova's environmental report and Göteborg Energi's annual report. Where electricity is generated, the emissions were allocated using the alternative generation method (Martinsson, Gode et al. 2010). Emissions from industrial waste heat were defined as zero, while emissions from waste incineration were defined as 90g CO2e/kWh[22].

The table below shows how much of the various energy sources were used in Gothenburg's district heating mix in 2010. It should be noted that the value given for all fuels is the calorific value of the fuel, i.e. prior to combustion.

Table. Energy used in heat and electricity generation in Gothenburg.

INPUT CONVERSION (GWh)	
Natural gas	3,106
Oil	67
Bio-oil	30
Wood chips	285
Pellets	137
Waste	1,510
Waste heat	1,226
Electricity	65.9

Based on these calculations, the emission factor for district heating produced in Gothenburg in 2010 was 92g CO2e/kWh of heat.

In the Current climate policy scenario, heat consumption falls slightly, which means that less fossil fuels need to be used, resulting in the slightly lower emission factor of 67g CO2e/kWh of heat for 2050. We also assumed in this scenario that sorting of fossil materials in household waste had increased, thereby cutting emissions from the incineration of waste by half. Since all biogas both from anaerobic digestion and gasification is used in the vehicle fleet, Rya combined heat and power plant will continue to run on natural gas.

In the Low-carbon transition scenario, it is assumed that there will be a 50% increase in energy efficiency in the housing stock by 2050 (Boverket 2008). This means a reduction in the use of district heating and district heating is now assumed to be completely fossil-independent. Fossil materials (plastics) will also be removed from waste at source and recycled. This means that the incineration of waste will generate biogenic carbon dioxide emissions only. This means that emissions from the consumption of district heating will be no more than 1g CO2e/kWh of heat. The emission factors for district heating used in the calculations in this study can be found in the table below.

Table. Emission factors for district heating, grams of CO2e/kWh.

2010	92	-	-
2050	92	67	1

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Final comments

[14] This section is based primarily on the research which is being carried out by Jörgen Larsson and his colleagues at Chalmers: David Andersson, Jonas Nässén and John Holmberg.
[15] http://www.folkhalsoguiden.se/bamse
[16] However, there is one study (Brülde, B. and F. Fors (2013), 'Är lyckan grön?' [Is happiness green?], Ekonomisk Debatt 41(2): 45–46), which finds a certain correlation between car usage and quality of life. The benchmark in this study is whether a person drives a car at least once a week or not. Since almost everyone who has a car drives their car at least once a week, what is being investigated in this study is more the correlation between car ownership and quality of life. Their results indicate that there is a link between not having a car and having a low quality of life. The Low-carbon transition scenario does not provide for a society without cars, only a 20 per cent reduction in car usage. Continued research will, however, be required to identify the potential impact a reduction in car usage may have on the quality of life of a person who is starting to drive less.
[17] As was noted in a summarising comment above, there is a similar study by Brülde and Fors (2013): 'Is happiness green?' Ekonomisk Debatt 41(2): (45–46). This also analyses the link between meat-eating and quality of life. This study investigates whether people eat meat at least once per week, or more less frequently. Since almost everyone who is not a vegetarian eats meat at least once a week, what this study actually investigates is, rather, the link between subjective quality of life and being vegetarian. Their results show a certain relationship between being vegetarian and having a low level of subjective well-being. (They do not, however, describe any theory as to why there should be such a relationship.) The low-carbon transition scenario in this report includes a slow reduction in meat consumption up to 2050. The results in Andersson (2014) are based on the variable 'number of meals with red meat per week' and these results would appear to be more relevant here, since they reflect the effects of a somewhat lower level of meat consumption, rather than the effects of not eating meat at all, in a society in which almost everyone does eat meat. However, continued research is needed in order to clarify such relationships.
[18] www.wcrf.org
[19] Time satisfaction can be defined as people's level of satisfaction with the way they make use of their time. Do they devote a great deal of their time to things they regard as very important, or do they think that their time, for various reasons, should be used in other ways? Many people would like to devote more time to a lot of things but are not prepared to cut down on other things; in other words, they experience what can be called shortage of time (i.e. the asymmetry between available time and opportunities for using time). Time satisfaction, on the other hand, is a matter of whether people feel that there are important activities lacking in their lives, whether they have a good balance between their work and their private lives, whether they spend too much time commuting, whether the time they spend cleaning, washing, shopping for food, cooking and washing up seems reasonable, whether they feel they have enough time for sleep, meals and relaxation, whether they have time to spend with their children, partners, family and friends, etc., whether they have time for their leisure interests, and so on.
[20] 30, 40 and 50 represent the approximate median working hours for these three groups. 30 hours covers the range 1–38 hours, 40 hours covers those who work 39–41 hours, and 50 hours includes those who work 42 hours or more.
[21] For the analysis of greenhouse gas emissions, only people who live alone have been used. The reason for this is that a person's climate impact is influenced by the whole household's consumption patterns, and here the partner's level of income plays a substantial role. The climate analyses, in the left of the figure, are therefore based only on data for single people. The time variables, in the right of the figure, are however based on all working people in the data material.