THE EUCO2 80/50 PROJECT
STAGE 2
HAMBURG

SPEICHERSTADT HAMBURG
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metropolregion hamburg

Introduction to Hamburg

The Hamburg Metropolitan Region, European Green Capital 2011, covers 19,802 km² and is comprised of the city of Hamburg and 14 surrounding districts. By population, Hamburg is the second largest city in Germany. In 2005, the population of the region was 4.3 million. The Metropolitan Region reaches into the neighbouring states of Schleswig-Holstein and Niedersachsen. Hamburg is situated on the North German Plain, at the head of the Elbe estuary.

Trading and transport services have a long tradition in Hamburg. The area has a legacy as Northern Europe's main transhipment centre. It is still a key gateway for the overseas trade of the Baltic states and as a logistics hub for Eastern Europe. Its port, now the second largest in Europe, is over 820 years old and provides 150000 jobs. The Hamburg Dock Railway is the largest hub for freight distribution by rail in Europe. Hamburg's GDP per capita is €48200.

The region has the world's third largest aviation industry, with 38000 employees and 300 subcontracting firms in the surrounding districts. South of the river Elbe is Europe's largest industrial area which is situated next to Europe' largest fruit growing area and includes refineries, metal and petrochemical works and the largest copper plant in Europe. The region has a strong media sector and is home to large publishing houses, advertising agencies, computer game producers and film and television companies. The region is also an important location for the renewable energy industry, both in terms of business headquarters and installations. Agriculture is the main economic activity in most of the peripheral districts of the region.

The region has an integrated transport system. In the city of Hamburg 98% of the population live within 300 meters of a public transport station. There are six

AIRBUS A380 WITH LOGO
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SUNSET IN THE PORT OF HAMBURG
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S-Bahn lines, with 68 stations covering 239 kilometres. In total, there are 27 rail routes in the region covering 1,030 kilometres. Additionally, there are 653 bus routes that cover 15,320 kilometres.

Hamburg is a city endowed with numerous green areas, parks and trees. Of Hamburg's total area 40% is green space, which forms a nearly continuous 'green network'.

Hamburg has a target to reduce CO_2 emissions by 40% by 2020 and 80% by 2050, against a 1990 baseline. It has a Climate Action Programme covering 14 action goals. The Climate Protection Plan for 2011 includes over 450 projects aimed at households, schools and businesses. Per year, €22.5 million is provided for new climate orientated ideas and projects, but many projects are supported through existing budget or co-finance. This partnership has around 750 active business partners.

In 2009, Hamburg Energy was founded by the city administration to provide a climate-friendly, publicly owned energy supply to Hamburg's citizens. Hamburg Energy's electricity is free from coal and nuclear. Electricity is generated from photovoltaic technology, biomass, wind and geothermal. The company also supplies gas comprising 10% biogas. A sister company, Hamburg Energie Solar, offers residents the opportunity to rent out their roof space so that it can be used for grid electricity generation.

Emissions Inventory and Energy Baseline

Total emissions from the region in 2005 were 42193 kt CO_2e. This comprised of 82% from the Energy sector, 7% from Industrial Processes, 11% from Agriculture and <1% from Waste. These figures can be viewed in the table below and a more thorough presentation can be found at getagriponemissions.com.

The energy sector is the main focus of this study with emissions from four types of processes considered: combustion, distribution, transformation and extraction. Each process produces GhG emissions: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The level of emissions varies depending on the manner and state (gas, solid, liquid) of energy that is combusted/distributed/transformed/extracted within the region, as well as how the electricity the region consumes is produced. CO_2 is the dominant greenhouse gas in this sector and consequently is the focus of this study.

Hamburg Chart 1, right, displays the CO_2 emissions from the energy sector in 2005; a total of 33581 kt CO_2 associated with an end user energy demand of 116510 GWh. The figures show that in 2005 the emissions from the residential sector accounted for 22% of energy emissions, the service sector 20%, the industrial sector 23% and the transport sector 27%; the transport sector emissions comprising 85%, 2%, 2% and 11% from road, rail, marine and aviation respectively. The energy industry accounted for 6% of emissions and fugitive emissions 3%. GRIP level 1, 2 & 3 methodologies were used to estimate 98%, 2% and 0% of the emissions respectively.

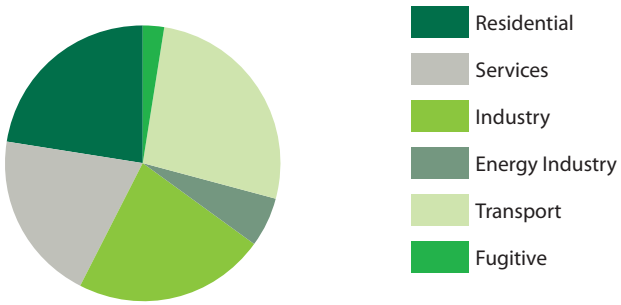
Hamburg GhG Inventory 2005

Sector	CO_2 (kt)	CO_{2eqv} (kt)
Residential	7,551	7,599
Services	6,652	6,705
Industry	7,615	7,677
Energy Industry	1,956	1,967
Transport	8,965	9,088
Fugitive	842	1,594
Total Energy	33,581	34,629
Industrial Processes	2,219	2,817
Waste	0	284
Agriculture	0	4,463
Total	35,800	42,193

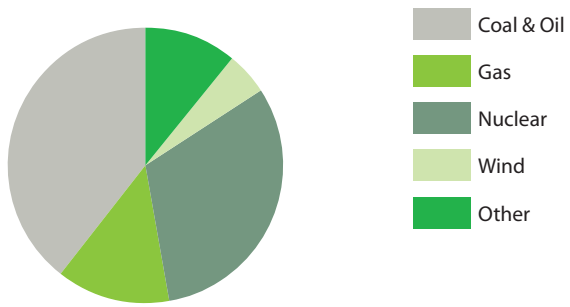
Hamburg Chart 2 below shows how electricity was generated in Germany in 2005.

In 2005, 39% and 12% respectively of electricity generated in Germany and the region was from coal generation, 13% and 4% was from combined cycle gas turbines, 32% and 74% was from nuclear power, 5% and 8% was from wind power and 11% and 0% was from other forms of renewables. The country was a net exporter of electricity in 2005.

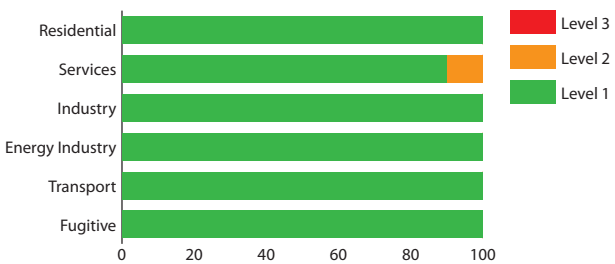
Hamburg Chart 1: Energy Sector



Hamburg Chart 2: National Electricity Generation



Hamburg Chart 3: GRIP Methodologies Used



Scenario Overview

INTRODUCTION

There were three scenario sessions conducted in the Hamburg Metropolitan Region. All three scenarios focused on reducing CO_2 emissions by 80% by 2050.

To ensure that the scenarios were developed independently, the participants in the sessions were not informed how previous groups either in the Hamburg Metropolitan Region or outside had acted. This section provides a comparison between the scenarios.

The emissions decrease by 55%, 66% and 86%; and energy demand decreases by 35%, 25% and 35% in Scenarios 1, 2 & 3 respectively.

ECONOMY AND POPULATION

In Scenarios 1 and 3, the population increases and then contracts, with the increase driven by immigration. In Scenario 2 the population growth is relatively small and mostly the result of immigration from Eastern Europe.

Average annual economic growth varies between 1% and 2% in the scenarios. In Scenario 1 there is a growth in industry relative to the rest of the regional economy, whereas in Scenarios 2 & 3 its relative size has declined. In each of the three scenarios, the commercial sector has grown. Agriculture's share of the economy increases in Scenario 2 due to biofuel production but is unchanged in the other scenarios.

RESIDENTIAL SECTOR

Emissions decrease by 79%, 76% and 88% in Scenarios 1, 2 & 3 respectively. In each scenario, energy demand for space heating and cooling, water heating and cooking decreases, driven by efficient building practices. In Scenario 1, power saving devices help to reduce electricity demand. In Scenario 2, due to single occupancy households and an aging population there is a higher demand for electricity than in the other two scenarios. In Scenario 3, electricity demand per household decreases. In each scenario on-site heat and electricity generation technologies helps to reduce emissions, although the greatest development is in Scenario 1.

SERVICE SECTOR

Emissions decrease by 34%, 59% and 90% in Scenarios 1, 2 & 3 respectively. Scenario 3 has the largest reduction in electricity and heat demand, although Scenario 1 has the largest improvement in energy efficiency. In each scenario heat demand reduces, in percentage terms, by more than electricity demand due to improvements in building efficiency. Scenario 3 has the largest deployment of on-site renewable technologies.

INDUSTRIAL SECTOR

Emissions decrease by 43%, 48% and 88% in Scenarios 1, 2 & 3 respectively. Scenario 3 delivers the greatest reductions in energy use in industry. In the residential and services sectors, heat demand reduces by more, in percentage terms, than electricity demand; in industry it is different. In Scenario 1 heat and electricity demand decrease equally; in Scenario 2 heat demand increases; in Scenario 3 heat demand decreases by more than electricity demand. These differences are reflective of the type and nature of industry present in each scenario in 2050.

TRANSPORT

Road transport emissions decrease by 49%, 76% and 81% in Scenarios 1, 2 & 3 respectively. In each scenario an increasing cost of private car use has caused slower growth than seen in the past. In each scenario road transport is more efficient and uses less energy overall. The lower road transport emissions reductions in Scenario 1 reflect the carbon-intensity of its energy mix. In the other scenarios there is a higher share of electricity and hydrogen.

ELECTRICITY GENERATION

In Scenario 1, the region gets its electricity from a national grid which has links to neighbouring countries, whereas in Scenarios 2 & 3 it is part of a European grid. In Scenarios 2 and 3, access to the renewable sources of other countries is key to Germany being part of a European grid. In Scenario 2 there are further linkages to Northern Africa, enabling Europe to utilise solar power for electricity. In Scenarios 1 & 2, CCS has developed despite public concerns over safety. In Scenario 3, no coal is used due to its expense and low efficiency levels.

THE SPEICHERSTADT IN HAMBURG
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Prof. Dr. Hans von Storch

Scenario 1: Hamburg

Scenario Characteristics

IN THIS MEDIUM GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 55% AND PER CAPITA EMISSIONS CONTRACT TO 3.6T. END USER ENERGY CONSUMPTION REDUCES BY OVER A THIRD. THE POPULATION OF THE REGION INITIALLY GROWS AND SUBSEQUENTLY DECLINES. A WARMER CLIMATE HELPS TO REDUCE RESIDENTIAL ENERGY DEMAND, WHICH HAS BEEN AIDED BY IMPROVEMENTS IN BUILDING MATERIALS AND APPLIANCES. A REDUCTION IN HEAT DEMAND IN THE INDUSTRIAL SECTOR IS LARGELY CAUSED BY COST PRESSURES. THE PETROLEUM REFINERY REDUCES ITS OUTPUT. PRIVATE VEHICLE USE INCREASES, IS MORE EFFICIENT AND REMAINS LARGELY PROPELLED BY PETROLEUM. THE REGION RECEIVES ITS ELECTRICITY FROM A GERMAN GRID THAT IS LESS CARBON INTENSIVE THAN IN 2005.

"There will be warming, and there will be warming in Hamburg."

ECONOMY AND POPULATION

The region's population increased up until 2025, but has since declined back to 2005 levels. The baby-boom generation and an influx of Eastern European migrants led to the population bubble, and the subsequent decline was due to natural mortality rates. Nationally, the population has declined by 5%, mainly in rural areas. The number of households in Hamburg has increased leading to a decline in average household size.

"The development of eastern countries will increase possibilities economically, especially harbour, transport and services. Hamburg will be at a competitive advantage over the rest of Europe."

Average annual economic growth has been 2%, due to strong industrial, research and development, and service sectors. Industry has grown slightly, in terms of its share of the economy, while the public sector has declined and the commercial sector grown.

"There will be more services for the elderly, rather than other goods and services."

RESIDENTIAL SECTOR

Emissions have reduced by 79%. The average household consumes 50% less electricity and heat demand has decreased by 60%. The main driver is improved efficiency from significant technological advances in power-saving appliances which are perceived as fashionable. New building practices and materials mean that new homes are more heat efficient and have developed to the point where ambient body heat is sufficient to warm a dwelling. The older housing stock has been retrofitted and is 60% more efficient than the stock of 2005 as a result of the implementation of regional and national legislation on buildings 'retrospectively'.

"What is cost free, and what will be painful? Can we have a business as usual projection?"

Although Hamburg has experienced warming of 3°C, on average the temperature is such that little extra energy is needed for air conditioning. CHP is used in new neighbourhoods, and as a result of renovation programmes, is increasingly available in older housing stock. CHP meets 45% of household heat demand and bioenergy meets 10%. On-site heat technologies are more popular, with 30% of both household heat and electricity coming from these. Some new and retrofitted buildings use electric heating. This change in the energy mix has required an overhaul of the energy infrastructure.

"Silver standard should be in place everywhere, not just in Hamburg."

SERVICE SECTOR

Emissions have reduced by 34%. Despite the growth in the economy, energy consumption has fallen making the sector more energy-efficient. Overall electricity demand has not changed but improvements in the insulation of buildings mean lower heat demand. In larger buildings, CHP systems have been installed and meet 17% of electricity and half of heat demand. Wood-pellet burners are used for heat in many public buildings, particularly schools. These and other types of bioenergy contribute 1% of heat demand.

INDUSTRIAL SECTOR

Emissions have reduced by 43%. The sector uses 10% less energy than in 2005 for both electricity and heat. The rising cost of resources and competition have been factors in driving down reductions in energy demand. On-site heat technologies account for 25% of heat demand, hydrogen and biofuel each contribute 5%. The region's aluminium factory has become more efficient in its use of electricity.

TRANSPORT

Road transport emissions have decreased by 49%. The population of the region has stayed the same, but the number of road vehicle kilometres has increased by 10%.

"Do we need some more fantasy to think of what the city is going to be like in 40 years? Hamburg was completely different 40 years ago..."

Vehicle kilometres have increased at a slower rate in the city than in the rest of the region. This is in part due to the extension and enhancement of public transport networks and recognition that quality of life can be

increased by reducing car use. The increasing cost of fuel led to pressure to improve engine efficiency resulting in a 40% improvement. There is a tendency for residents, particularly in the city, to buy smaller cars. Although the use of petroleum has decreased, it remains the dominant fuel. The number of kilometres travelled by rail has increased by 20% since 2005. Electricity comprises 87% of the energy used by the rail sector. Due to innovation over the last 45 years, marine traffic coming through Hamburg is cleaner and more efficient. However, few ships refuel in Hamburg, so the region's ability to influence fuel choices, and therefore the energy mix, has been limited.

"(private vehicle use) It will go down in the cities and up in the metro areas."

The aviation sector continues to be important for the region's growing knowledge economy. The overall distance travelled by planes has levelled off and the rising price of oil has motivated improvements in aircraft design, resulting in lighter materials and more efficient engines, meaning overall energy use decreased by 50%.

ELECTRICITY GENERATION

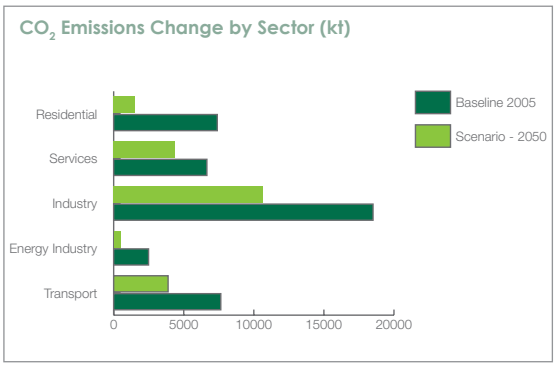
"If people see turbines offshore, they will not like them, and we can't predict that people will allow them to be built then near parkland."

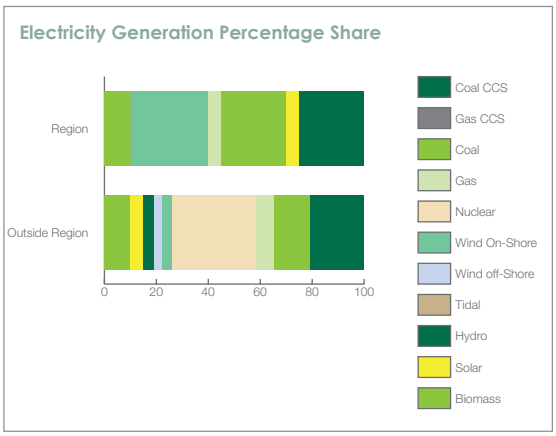
The region is part of a national electricity grid. Fossil fuels account for 42% of generation, with all coal stations fitted with CCS across Germany. There was some resistance to CCS, due to safety concerns about CO_2 storage. Power plants built early in the century, when CCS technology was not available, are still being used. There is no nuclear power nationally but Germany continues to import some electricity from countries with nuclear power.

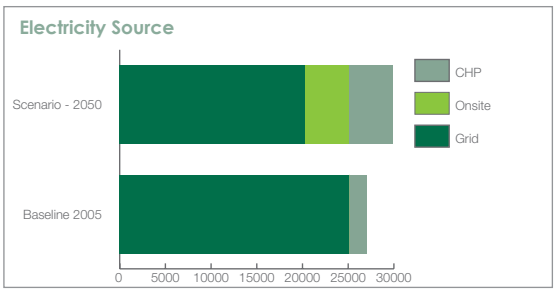
"There was a plan for tidal production in Hamburg port, but the promise of return was so low that it was written off."

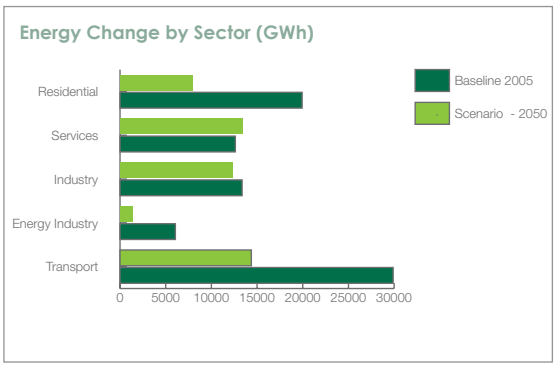
Tidal production was investigated but rejected, as the potential energy return was viewed as being too low. There is some hydroelectric power supplying the national grid. There have been significant improvements in the efficiency of electricity transmission, resulting in lower losses in the grid. Electricity generation in the region is largely met by coal and gas stations fitted with CCS. Onshore wind farms provide 30% of electricity generated in the region, and bioenergy 10%.

"Nuclear power, Germany may have some issues, but many other countries are interested in keeping nuclear power, like Finland and Eastern Bloc countries."









Emissions Change	-55%
Energy Change	-35%
Emissions per Capita	3.6t

Scenario 2: Hamburg

Scenario Characteristics

IN THIS MEDIUM GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 66% AND PER CAPITA EMISSIONS CONTRACT TO 2.6T. END USER ENERGY CONSUMPTION REDUCES BY A QUARTER. THE POPULATION OF THE REGION GROWS, DRIVEN BY IMMIGRATION FROM EASTERN EUROPE. DUE TO POLICY IMPLEMENTATION AT THE REGIONAL, NATIONAL AND EUROPEAN LEVELS RESIDENTIAL ENERGY DEMAND REDUCES. PUBLIC ADMINISTRATION HAS LED THE LOW-CARBON TRANSITION IN THE SERVICE SECTOR. THE PETROLEUM REFINERY HAS CEASED PRODUCTION AND IS NOW A STORAGE SITE. PRIVATE VEHICLE USE DECREASES DUE TO COST AND THERE IS A SWITCH TO PUBLIC TRANSPORT USE. THE REGION RECEIVES ITS ELECTRICITY FROM A EUROPEAN GRID PROVIDING LESS CARBON INTENSIVE ELECTRICITY THAN 2005, WHICH HAS HELPED TO DELIVER THE EMISSIONS REDUCTIONS IN THIS SCENARIO.

"Climate is going to put a limit on our way of life, and we're going to have to figure out what we can do within that limit."

ECONOMY AND POPULATION

The population of Hamburg Metropolitan Region has grown to 4.4 million, driven by immigration from Eastern Europe and an influx of rural and suburban dwellers into the city region. The population is aging and as a result it is common to have smaller dwellings with fewer occupants.

"People moving from the country side to the city for the attractiveness of the city."

The economy of Hamburg has grown on average by 2% per year and now accounts for 9% of the German economy. The commercial and agricultural sectors have increased their share of the economy whilst public administration and industry have decreased.

"Industrial sector of the economy is likely to decrease, although the industrial spokesman is not conceding this willingly."

RESIDENTIAL SECTOR

"There will be market decisions as well as legislative decisions, people will chose more efficient homes."

Emissions have reduced by 76%. Heat demand has reduced by 40%. One of the greatest challenges in achieving this goal was attracting the appropriate contractors and construction personnel to complete the necessary new build and retrofits. The region has struggled to keep electricity demand down, as the greater number of single-occupant dwellings has led to greater use of cooking facilities and the aging population stays at home for longer periods of the day.

"More single people will mean more cooking, and people living at home on their own may mean they're at home longer"

There are 400000 new buildings in the region, each meeting high efficiency standards, and most of the existing housing stock has undergone a programme of retrofitting. Policy was implemented by three levels of government, the European Union, the central German government and the governments of Hamburg Metropoolitan Region. There have also been significant advances in energy saving technologies in consumer goods. The range of devices has increased, but in total these devices consume less energy. There has also been behavioural change as people are more aware of the affects of climate change and choose environmentally friendly goods.

"Everyone will have two or three Ipads or Ibooks but there needs to be a balance."

Half of heat demand in the residential sector is met by natural gas. Solar heating became popular as a low-cost alternative to more traditional methods of home heating and is a practical alternative since the region began to experience the effects of global warming. In new builds and some retrofitted neighbourhoods, CHP systems have been installed and contribute 30% of heat demand. New hydrogen and bioenergy heating systems are just starting to be developed beyond the prototype stage. Although natural gas is still in use it has become restrictively expensive to heat homes with petroleum.

SERVICE SECTOR

Emissions have reduced by 59%. Heat demand has remained constant and electricity consumption has increased by 20%. Public administration buildings have been presented as examples of 'green and efficient design'. On-site heating technologies, solar thermal panels and air-source and ground-source heat pumps meet 20% of heat demand. CHP contributes 30% of heat and bioenergy is used in small amounts, mainly to showcase the technology. The remaining heat demand is met by natural gas.

INDUSTRIAL SECTOR

Emissions have reduced by 48%. Although now a smaller part of the Hamburg economy, the industrial sector has continued to grow. Increased use of low-carbon grid electricity for heating and use of waste process heat have helped to reduce emissions. The use of coal and petroleum in industrial processes has been phased out in favour of natural gas supplied by the North Sea pipeline. On-site heat renewable technologies meet 10% of heat demand.

ENERGY INDUSTRY

The region's refinery now operates in a storage capacity. Market forces caused the company to re-evaluate its business strategy, and subsequently petroleum production was moved to larger plants elsewhere.

TRANSPORT

Road transport emissions have decreased by 76%. Vehicle kilometres travelled are the same as in 2005, but there has been a shift from personal transport to public transport. Recreational vehicle use has declined due to costs. Overall, road transport uses half as much energy. As well as improving vehicle efficiency there has been changes to how vehicles are powered. Hydrogen propels 15% of road transport, mainly buses. Personal vehicles are largely electric.

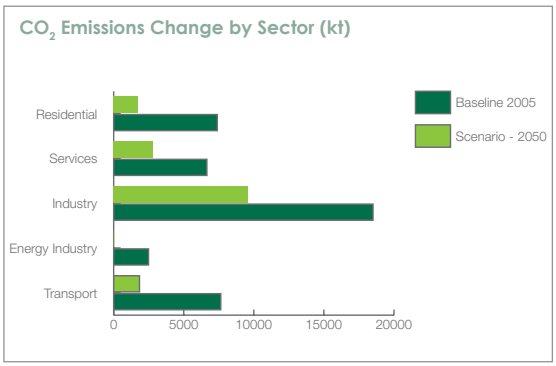
"Can't stay at the same lifestyle as now, can't do business as usual, and there's going to have to be different lifestyles with different measures."

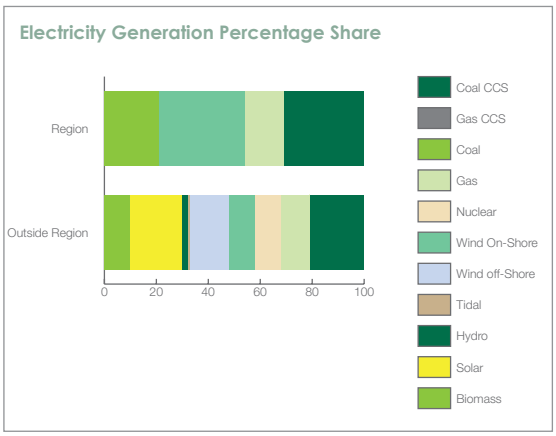
Marine and rail transport were not significant sectors in terms of carbon emissions in 2005, and their impact has been further reduced. Sailing ships have been re-introduced to Hamburg's harbour and there are more electric trains. The rail system is 60% electric, with 37% using petroleum and 3% biofuel. More people use the commuter rail system but there has been no overall increase in vehicle kilometres. Emissions from rail have reduced by 57%. The aviation industry remains important to the Hamburg region. Planes are now 20% more efficient per kilometre, and whilst airline travel to and from Hamburg has not changed in terms of vehicle kilometres, the combination of efficiency savings and the introduction of bioenergy into the jet fuel mix have helped emissions from aviation to drop by 22%.

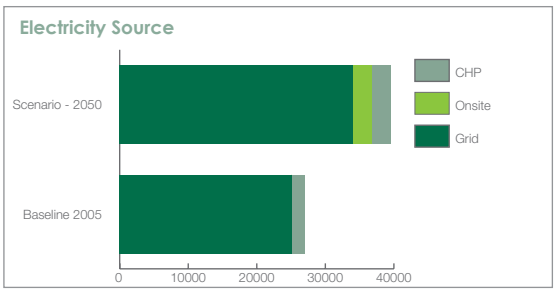
ELECTRICITY GENERATION

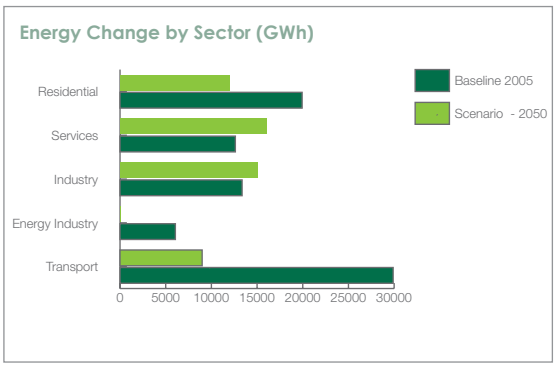
Germany is part of a European grid. Coal and gas power stations are more efficient and coal power stations have CCS technology fitted. Gas power stations are not fitted with CCS. Bioenergy generates 20% of Europe's electricity. This has led to deforestation in order to establish land to grow crops on, which in turn has affected the habitats of European wildlife. Solar power supplies 20% of the grid, sourced through co-operation with Northern Africa. Onshore and offshore wind also contribute to the European grid and there has been some development of tidal energy. Nuclear energy provides 10% of electricity, none of which is generated in Germany. The region has increased its electricity production. Generation in the region is from biomass, onshore wind, natural gas stations and coal power stations retrofitted with CCS technology.

"Market regulation is necessary, because without regulation there will only be incremental gains, whereas government regulation can ensure revolution."









Emissions Change	-66%
Energy Change	-25%
Emissions per Capita	2.6t

Scenario 3: Hamburg

Scenario Characteristics

IN THIS LOW GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 86% AND PER CAPITA EMISSIONS CONTRACT TO 1.1T. END USER ENERGY CONSUMPTION REDUCES BY OVER A THIRD. THE POPULATION OF THE REGION GREW INITIALLY BEFORE DECLINING. THE INTRODUCTION OF PASIVHAUS STANDARDS AND A RETROFITTING FOCUS REDUCES HEAT DEMAND IN THE RESIDENTIAL SECTOR. A REDUCTION IN HEAT DEMAND IN THE INDUSTRIAL SECTOR IS LARGELY CAUSED BY COST PRESSURES. THE PETROLEUM REFINERY HAS CLOSED. PRIVATE VEHICLE USE DECREASES DUE PRIMARILY TO AN INCREASE IN TELEWORKING AND CHANGING COMMUTING PRACTICES. THE REGION RECEIVES ITS ELECTRICITY FROM A LOW-CARBON INTENSIVE EUROPEAN GRID.

ECONOMY AND POPULATION

The region's population increased until 2030 but then contracted to 4.3 million. The region is an attractive and well-equipped city which encourages migration from elsewhere in Germany and beyond. Refugees have arrived in the region displaced by the effects of climate change. Household size has contracted.

"Population will be older, the growth in 2030 comes from attractiveness of Hamburg in Germany, but Germany will reduce in population, which means by 2050 there will be a migration to Hamburg and other cities whereas other regions will shrink."

Hamburg's economy has grown faster than the rest of Germany, growing on average at 1% per year. The Commercial sector has increased its share of the economy, although public investment has helped the education sector to expand, overall Public Administration has contracted. The knowledge economy has developed and is one of the region's major economic activities.

"Refugees are likely to be an issue regardless of climate change, and Germany will have to open up because of its social security system, which will collapse without influx of funds, The countryside will be empty."

RESIDENTIAL SECTOR

Emissions have reduced by 88%. Heat demand has decreased by 45%. The direct use of natural gas in homes has reduced, meeting 15% of heat demand. Bioenergy is also used to heat homes; the use of biomass as fuel has put woodlands and agricultural land in the region under pressure. Greater insulation and the popularity of the Passivhaus concept has led to a 53% increase in the average efficiency of the housing stock. Air-source heat pumps are commonplace in the city and as photovoltaic (PV) panels became cheaper, households have increasingly added these to their buildings, meeting 15% of electricity demand. The range and quantity of home appliances and electronic gadgets has increased, but these devices have become more efficient and due to the use of lower-carbon electricity their overall contribution to emissions has declined.

"Natural gas cannot sensibly exist anymore; it's counter to practically all the political intent."

SERVICE SECTOR

Emissions have reduced by 90%. Heat demand has halved. As a result of the warming climate, there has been an increase in demand for air conditioning, increasing electricity demand. The public sector took the lead in demonstrating and promoting techniques that enhance efficiency. Large buildings and spacious roofs enabled the development of on-site PV and solar thermal panels. On-site technologies contribute 30% of electricity demand and 25% of heat demand.

"We can't reduce electricity consumption in households, because there will be many more gadgets but they will be very efficient. The dishwasher will be more efficient, but any gains that are made in efficiency are lost to increases in things to gadgets."

INDUSTRIAL SECTOR

Emissions have reduced by 88%. The region continues to value industry and its contribution to the regional and national economy. Heat demand has decreased by 40%, primarily through the more efficient use of process heat. Natural gas provides a sixth of the energy mix. Consumption of electricity is at the same level as in 2005. On-site PV and wind have been popular with businesses who have taken advantage of supportive legislation, and these technologies supply 10% of electricity.

ENERGY INDUSTRY

Hamburg's refinery closed in 2020. Global demand for oil for energy has largely disappeared with comparatively more sustainable energy sources now preferred.

TRANSPORT

"There will be a massive increase in technological development in batteries and electrical top-up stations, so electricity is probably the way of the future."

Road transport emissions have reduced by 81%. Residents of the region live closer to where they work and use a range of teleworking options, reducing the need to travel. There has been a 10% reduction in road transport vehicle kilometres. Improved public transport provision has led to less private car use and most city commuters do not use cars to travel to work.

"There will be better infrastructure for public transit, commuting will occur less frequently due to telecommutes, so people will shift to different modes of transit."

The rising cost of petrol was a factor in motivating research, development, and adoption of alternative fuels. New battery technologies and investment in a network of charging stations aided the introduction of electric cars. Public transport is also electric, but the technology is not yet suitable for heavy goods vehicles. The rail sector is largely electric and though there has been no change in total rail vehicle kilometres, emissions have reduced by 86%.

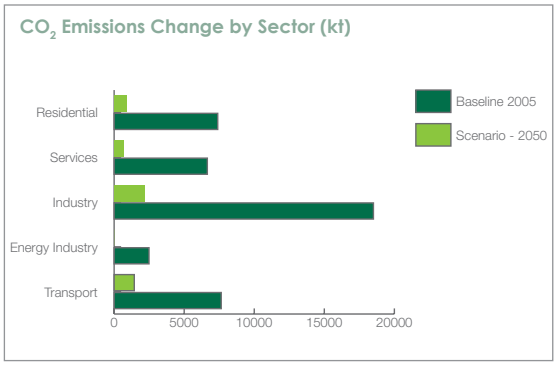
"Infeasible to assume that planes will switch to anything other than petrol."

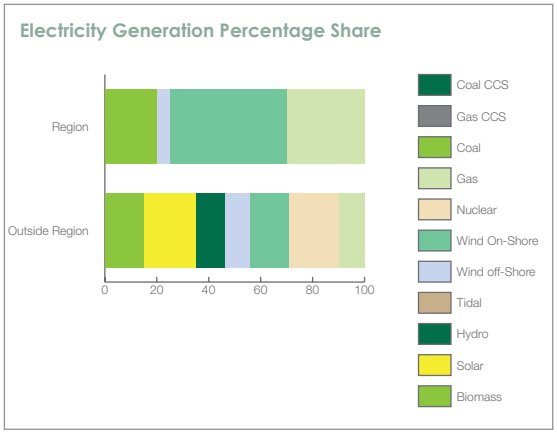
More fuel-conscious manoeuvring of marine traffic has meant a 25% increase in efficiency, and PV panels increasingly generate onboard electricity. Aviation's CO_2 emissions have reduced by 30%. The aviation industry continues to be reliant on kerosene. Initially kilometres travelled by air increased but then decreased after 2030.

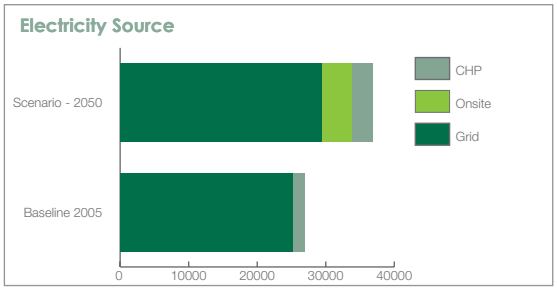
ELECTRICITY GENERATION

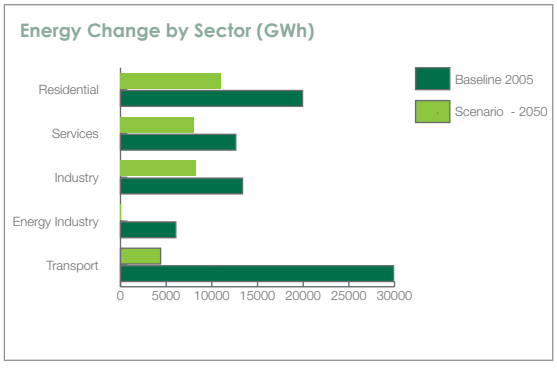
The region receives its electricity from a European grid. There are no coal-fired power stations in Europe as no new stations have been built since 2010. Natural gas generates 10% of electricity and 19% from nuclear. Germany has no nuclear plants, but Finland, France and Sweden have renewed their capacity. Wind energy generates a quarter of grid electricity and solar 20%. Large projects in Iceland and Norway have increased the contribution of hydroelectric power to 11%. Around 30% of all electricity generated in the region is from natural gas. CCS has not been adopted, primarily due to public and decision-maker perceptions of safety and cost. The remainder of regional electricity is from on- and off-shore wind generation.

"Coal power generation will be forbidden by 2050, so all coal power plants will be extinct both in the region and outside."









Emissions Change	-86%
Energy Change	-35%
Emissions per Capita	1.1t

Next Steps: Hamburg

INTRODUCTION

This section identifies how the Hamburg Metropolitan region might work towards meeting at least an 80% reduction in CO_2 emissions by 2050. It has been informed by discussions in the scenario sessions, information provided by the region, and the knowledge of the research team.

To facilitate the transition to a low-carbon economy it is important to take a full energy systems perspective. To advance the low-carbon agenda, policy makers have a range of approaches available to them including education and awareness raising, taxation, financial incentives and planning regulations. These approaches will need to work across sectors, regions and countries, and are key components of building a sustainable energy action plan. It should be noted that whilst climate change mitigation was the original focus of the $EUCO_2$ scenarios, discussion in the sessions often focused on other agendas including energy cost control, security of energy supply and energy self-sufficiency. These agendas and others may be mutually beneficial to the mitigation cause, whilst also, potentially, enabling the 'buy in' of climate sceptic stakeholders.

The $EUCO_2$ scenarios focus on achieving an 80% reduction in CO_2 emissions by 2050; in line with the European target. However, this absolute reduction target may not be appropriate for every region. This is because different regions and sectors have different opportunities to reduce their emissions due to the nature of their activities, and the availability of renewable resources. The year 2050 is used as a future trajectory point to project emissions beyond and therefore the likely global warming that will occur. The European target for 2050 can also be considered as a 2 tonnes CO_2e per capita target (including international aviation and shipping). This alternative target has the advantage of providing a common goal for each region that is not relative to a baseline, but it doesn't overcome the target setting difficulties associated with varying regional sectors and differing renewable access.

One of the scenarios produced emissions reduction of at least 80% by 2050. This scenario and the others could be further publicised to show how different actions may lead to different emissions reductions. Further analysis could examine each sector's change in energy consumption and fuel switch to explore different ways in which they may be achieved. In one scenario A quarter of heat demand in the service sector is met by on-site renewable heat technologies. One action could be to assess the current technical maximum potential for geothermal heat and set policies and actions to maximise take-up.

RESIDENTIAL SECTOR

In 2005, the sector accounted for 22% of CO_2 emissions. Most of the sector's heat demand is met by fossil fuels including those used for the district heating networks. There is potential to use bioenergy and waste in these plants, the latter having further potential environmental benefits such as reducing disposal to landfill. It should be noted that reliance on bioenergy could have wider environmental impacts such as the destruction of established forests and pressure on food crops. Whilst the district heat networks can be extended, it would be prudent to increase energy efficiency in the residential sector alongside moves to reduce the carbon intensity of the CHP fuel mix. Changes to the fuel mix for CHP are helpful as it does not entail working with each individual tenant or landlord. Whilst demand reduction measures are being implemented, changes to household fuel mix should be a priority. This may include using low-carbon electric heating and the installation of on-site technologies such as ground-source heat pumps and solar water heating.

Behavioural change is significant to the low-carbon agenda and can be promoted through education

Step	Action
1	Use the next step tick sheet at the end of this document to identify which areas of action are within the region's remit, and which need attention at national, European and/or international levels; as well as which areas of action the region would like control of to take effective action.
2	Put in place data collection protocols to monitor emissions using GRIP.
3	Establish renewable energy capacity in the province.

campaigns. Incentives and information can be used to encourage 'carbon literate' decisions when buying household products such as fridges, televisions and light bulbs. The introduction of smart meters can help householders to better understand their energy use to enable them to make reductions. Public authorities can lead the way with publicly owned housing by retrofitting buildings and subsidising the purchase of low-carbon appliances within them.

SERVICE SECTOR

This sector has similar mitigation challenges to the residential sector in terms of building operations. However, it is arguable that public authorities should be seen to be taking the 'climate change lead' in their own properties in terms of reducing energy consumption and implementing on-site generation. There may be short term benefits to the commercial sector in terms of setting a positive image by taking actions to reduce emissions. As the commercial sector's building stock turns over more rapidly than the residential sector, changes may be implemented faster. Demand reduction and switching to a low-carbon fuel mix is essential to emissions reductions, as is a transition to low-carbon intensive electricity.

It is not just a simple matter of changing the sector's buildings, but also the people that work within them. Training programmes to increase the 'carbon literacy' of staff can help to instil sustainable practices, leading to lower emissions, and potentially have a secondary impact on behaviour outside of work. Such activities can also benefit Corporate Social Responsibility (CSR) reporting. Regional level award schemes can help to motivate businesses to make energy efficiency enhancements and provide opportunities for sharing


HAMBURG CITY. TOWN HALL
© SERGEY KELIN

The Greenhouse Gas Regional Inventory Project

examples of best practice. Furthermore, where such changes involve international companies, actions may diffuse to sites elsewhere.

Energy Service Companies, often in the private sector, can provide financial structures to firms and residential developments that are seeking to reduce their emissions through improved efficiency and the use of renewable technologies. The Hamburg Energy company, described in the introduction to this section, gives an example of proactively seeking opportunities to encourage the use of renewable electricity.

INDUSTRIAL SECTOR

In 2005, the sector accounted for 23% of the region's CO_2 emissions. Energy use is primarily for heat demand and this is met by fossil fuels. The region's industry presents mitigation challenges due to the slow rate of capital stock turnover, lack of financial and technical resources, and limitations in the ability of firms to access and incorporate technological information. There may be limitations to the extent to which regional authorities can influence industry, for instance the companies may be bound by the European Union Emissions Trading Scheme (EU-ETS) and/or be part of large transnational organisations.

Industry in the region may be able to take advantage of subsidies and tax credits, which are most likely to be provided nationally. Due to their size, industrial buildings are often well suited to on-site generation, and electricity companies may be interested in renting space for installations that feed into the grid. Hamburg Energie Solar already offers this opportunity to households.

TRANSPORT

In 2005, transport accounted for 27% of CO_2 emissions. Road transport, marine transport and aviation are currently entirely dependent on oil and, if allowed to grow, may increase emissions. Regional policies can aim to reduce the amount of vehicle kilometres travelled through encouraging the use of public transport, walking and cycling, and promoting the transition

to lower-carbon fuels. Activities in other policy areas, such as the location of housing, can influence transport demand and it is therefore important that all planning measures consider the implications for transport provision. The region has relatively low car ownership and therefore further investment in public transport, and walking and cycling initiatives, will have benefits by lowering social exclusion in addition to mitigation. Providing the additional generating capacity requirements can be met and the carbon intensity of the electric grid can be reduced, electric cars could be part of a sustainable transport system for the region.

The decarbonisation potential within the aviation sector can be met by improving fuel efficiency of technology, operations, and air traffic management, for example, by introducing the continuous descent approach, or 'green landings'. However, such improvements are expected to only partially offset the increased in emissions if the sector continues to grow. The longevity of aircraft implies that enhancements in engine technology will not happen as rapidly as in the case of, for example, private cars.

ELECTRICITY GENERATION

With half of grid electricity currently generated from fossil fuels there is a need to reduce its carbon intensity by increasing the share of low-carbon generation. If a European grid was to be developed there may be opportunities to import electricity from other countries in which solar, wind, hydroelectric and/or nuclear are prominent. However, the desirability of the whole of the EU relying on a few countries needs to be considered. A renewable energy capacity study should be carried out in order to investigate opportunities


INDUSTRIAL FACILITIES, HAMBURG
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for generating electricity from low-carbon, renewable sources in the region. It is important not to delay decarbonising the grid since infrastructural longevity means that technology installed now may still be in use in several decades.

At the time of writing, Hamburg is the European Green Capital and has targets to reduce its CO_2 emissions by 40% by 2020 and 80% by 2050. We trust that the outputs of $EUCO_2$ are helpful in developing their climate change strategy and in bringing about meaningful change that embeds emissions reductions in the activities of the region.


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