THE EUCO$_2$ 80/50 PROJECT
STAGE 2
FRANKFURT

FRANKFURT WATER FRONT
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Planungsverband Ballungsraum
Frankfurt/Rhein-Main

Introduction to Frankfurt

FrankfurtRheinMain is recognised as one of the larger metropolitan regions of Germany and is named after its largest city, Frankfurt, and its two main rivers, the Rhine and the Main. The region covers 14,755km^2 and in 2009 had a population of approximately 5.5 million people. The majority of the FrankfurtRheinMain region lies within the state of Hesse, with the remainder located in the states of Rhineland-Palatinate and Bavaria.

The regional objectives and strategies of the FrankfurtRheinMain metropolitan region are managed by the Regional Association which is responsible for sports and recreation, culture, location marketing, economic development and regional transport planning and management. The Regional Association is also responsible for the development of the Regional Land Use Plan and Landscape Plan and manages projects funded by the European Union. It offers an advisory function for its communities, develops regional concepts and, represents the metropolitan region in European networks such as METREX.

The majority of generated statistics used in this research relate to the Government District Darmstadt (GDD), an area that covers the south of the state of Hesse and the core of the FrankfurtRheinMain region.

The city of Frankfurt is the fifth largest city in Germany. The landscape of the region is dominated by the upper Rhine trench and the adjoining hills of the Taunus, Odenwald and Spessart. There are areas of open countryside remaining in the region and a large urban forest in the city of Frankfurt. Within Germany, this region is one of the more economically successful areas, gener-ating around 8% of Germany's GVA with 7 % of the country's population. The service sector provides over 77% of the region's jobs. The sub-sectors of finance, logistics, transport, ICT, consulting and creative industries are significant business areas. Banking services in Frankfurt (home to the European Central Bank, the German Federal Bank, the Frankfurt Stock Exchange and many credit institutions) are key to the region's economic strength. There are several universities located within the GDD including the University of Frankfurt and the European Business School.


FRANKFURT CITYSCAPE
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PARK IN CENTRAL FRANKURT
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The metropolitan region is a major European transport hub, connected by road to Cologne, Nuremberg, Stuttgart and Kassel. Frankfurt's main train station, one of the largest railway stations in Europe, accommodates 350,000 passengers daily. In the metropolitan region there is an S-Bahn which connects the major centres and light railway and bus services. Frankfurt airport is the third busiest by passenger numbers in Europe, handling over 51 million passengers and almost 2 million tonnes of freight in 2009.

The Regionalverband is combining and linking the regional activities to the topics climate and energy in the FrankfurtRheinMain region. The region produce an exhibition that focused on the causes and consequences of climate change. It has also published and communicated the outcomes of model projects on the issues of climate protection, sustainable energy usage and adaptation to climate change. Frankfurt provides information on wider environmental issues and the actions they are taking to address them. The Energy and Climate Protection Concept adopted by the city in 2008 provides practical guidelines to reduce CO_2 emissions in the GDD.

Many municipalities and districts of the region have been active for quite some time and initiated a number of measures to protect the climate. For example the city of Frankfurt has a long history of considering energy in planning, The city of Frankfurt's Energy Office has been part of the Building Department since 1983.

Emissions Inventory and Energy Baseline

Total emissions from the district in 2005 were 50860 kt CO_2e. This comprised of 86% from the Energy sector, 10% from Industrial Processes, 3% 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.

Frankfurt Chart 1 right displays the CO_2 emissions from the energy sector in 2005. A total of 43150 kt CO_2 was emitted and this was associated with a total end user energy consumption of 152729 GWh. The figures show that in 2005 the emissions from the residential sector accounted for 28% of energy emissions, the service sector 12%, the industrial sector 30% and the transport sector 26%; the transport sector emissions comprising 93%, 4%, <1% and 3% from road, rail, marine and domestic aviation respectively. The energy industry accounted for 2% of emissions and fugitive emissions 4%. GRIP level 1, 2 & 3 methodologies were used to estimate 3%, 45% and 52% of the emissions respectively.

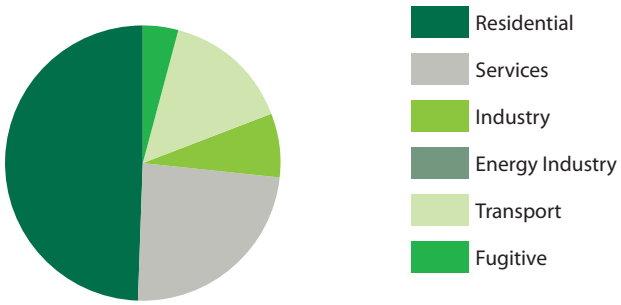
Frankfurt GhG Inventory 2005

Sector	CO_2 (kt)	CO_{2eqv} (kt)
Residential	12284	12402
Services	5248	5303
Industry	12880	13004
Energy Industry	754	765
Transport	10438	10534
Fugitive Emissions	1545	1640
Total Energy	43150	43649
Industrial Processes	3684	4987
Waste	0	610
Agriculture	0	1614
Total	46834	50860

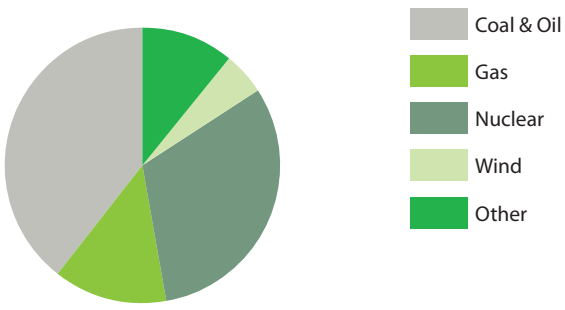
Frankfurt Chart 2 below shows how electricity was generated in Germany in 2005.

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

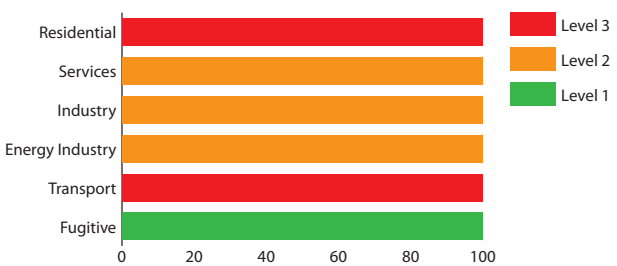
Frankfurt Chart 1: Energy Sector



Frankfurt Chart 2: National Electricity Generation



Frankfurt Chart 3: GRIP Methodologies Used



Scenario Overview

INTRODUCTION

There were three scenario sessions conducted in the GDD, two of which focused on reducing CO_2 emissions by 80% by 2050. The third session looked at what level of CO_2 reduction could be achieved by 2025 and what actions could be pursued in the short-term.

To ensure that the scenarios were developed independently the participants in the first two sessions were not informed how previous groups, either in the GDD or outside had acted. This section provides a comparison between the approaches taken in the first two scenarios.

The emissions decrease by 73% and 71%, and energy demand decreases by 50% and 45% in Scenarios 1 & 2 respectively.

ECONOMY AND POPULATION

In both scenarios the population declines due to low birth rates and low levels of immigration. Despite the population decrease, the number of households increases in both scenarios; the low birth rate and aging population mean there are more one and two person households. This increase is more pronounced in Scenario 2.

The GDD's economy grows by 0.5% and 1.5% in Scenario 1 & 2 respectively. The lower growth rate in Scenario 1 is due to a dependence on manufacturing and resource scarcity. In Scenario 2, service and IT industries continue to grow. In both scenarios the GDD's economy outperforms the national economy. The industrial and public service sectors decline and the agricultural and commercial sectors grow.

RESIDENTIAL SECTOR

Emissions decrease by 85% and 80% in Scenarios 1 & 2 respectively. In both scenarios, households consume less heat energy. Furthernore, the use of CHP, solar thermal and bioenergy to generate heat increases whereas the use of petroleum and natural gas declines. In Scenario 2, on-site generation from heat pumps increases due to an overall decrease in heat demand and regulations requiring installation of technologies on new buildings. CHP systems generate 41-43% of electricity in both scenarios. The natural gas used in CHP plants and directly in homes, meets over 40% of the GDD's heat. The decrease in electricity demand has been greater in Scenario 1 than in Scenario 2. In Scenario 1, cultural changes, increases in efficiency and a move away from electric heating has contribute to reduced demand.

SERVICE SECTOR

Emissions decrease by 81% and 90% in Scenarios 1 & 2 respectively. The reduction in energy demand is lower in Scenario 1 due to varied working hours that require buildings to be lit and heated for longer periods. In Scenario 2, energy demand decreases, in part, because tenants demand energy-efficient buildings. In both scenarios a large proportion of heat demand is met by district heat networks, some is met by solar thermal panels, heat pumps and natural gas. The low-carbon intensity of electricity is a significant contributor to the emission reductions in both scenarios.

INDUSTRIAL SECTOR

Emissions decrease by 57% and 63% in Scenarios 1 & 2 respectively. In both scenarios approximately half the heat demand is met by onsite CHP systems, primarily fuelled by natural gas. The remainder of the heat demand in both scenarios is met by natural gas and bioenergy. The introduction of solar thermal and heat pumps in both scenarios is limited by the high temperature demands of industry. The electricity generated from CHP plants is more carbon intensive in Scenario 1 than in Scenario 2.

TRANSPORT

Emissions decrease by 71% and 61% in Scenarios 1 & 2 respectively. Road vehicle kilometres remain static in Scenario 1 and display a small reduction in Scenario 2. Road vehicles are more efficient in Scenario 1 than in Scenario 2. In Scenario 2 heavy vehicles continue to use petroleum, whereas in Scenario 1 more vehicles use electricity, biofuels and LPG. In Scenario 1 energy use and rail vehicle kilometres increase, but rail transport is more efficient. Due largely to the low-carbon intensity of electricity, emissions in both scenarios decrease. Domestic air travel reduces in both scenarios because more people travel by rail rather than air. In Scenario 1, planes use biofuel rather than kerosene resulting in greater emissions reductions than Scenario 2.

ELECTRICITY GENERATION

In both scenarios, the region's electricity is supplied by an EU grid. Electricity generation includes on-shore wind, solar power, and bioenergy in both scenarios. In Scenario 1, 10% of Europe's electricity is generated using nuclear power and 23% using natural gas. In Scenario 2, 27% of Europe's electricity is generated using nuclear power and 15% using natural gas. There is more use of offshore wind in Scenario 1 than in Scenario 2. The carbon intensity of electricity decreases in both scenarios.


Matthias Drexelius


Wendelin Friedel

Scenario 1: Frankfurt

Scenario Characteristics

IN THIS LOW GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 73% AND PER CAPITA EMISSIONS CONTRACT TO 3.2T. END USER ENERGY CONSUMPTION SHRINK BY HALF. THE EMISSIONS REDUCTIONS ARE LARGELY DUE TO EFFICIENCY IMPROVEMENTS. THE LARGEST EMISSIONS REDUCTIONS OCCUR IN THE RESIDENTIAL AND SERVICE SECTORS. PRIVATE VEHICLE USE DECLINES PER HEAD OF POPULATION DUE TO HIGHER LEVELS OF HOME WORKING THAN IN 2005. THE REGION RECEIVES ITS ELECTRICITY FROM A EUROPEAN GRID, WHICH PARTIALLY CONTRIBUTES TO THE EMISSIONS REDUCTIONS IN THIS SCENARIO.

"Germany's economic growth will slow because developing countries and emerging countries will catch up and we will have trouble keeping up. Countries like China will also have to start thinking creatively."

ECONOMY AND POPULATION

"It is difficult to have environmental improvements in the cities if we're bringing more and more people into the cities. Perhaps we should actually locate jobs in the areas where people are living?"

The population of the region is 3.6million; it expanded up to 2030 due to an increase in life expectancy, but has since declined due to a low birth rate and low levels of immigration. This population decline has been larger nationally than in the region because of urbanisation. Household size has decreased due to an older population who often live alone, and a higher divorce rate, but has been offset by larger groups of people sharing houses and flats for economic reasons.

"In Darmstadt, people are living with their parents for longer because house prices have gone up so much."

Economic growth in Germany has slowed, as developing countries have taken a bigger role in the global economy. Resources for manufacturing in Germany have become scarcer, limiting economic growth. However, the GDD's economy has grown by 0.5% per year, increasing its share of the national economy. The increased cost of imported food has resulted in a stronger regional food market with many people growing their own food. Public administration's share of the economy has decreased slightly as it has begun to buy back previously privatised services. The commercial sector, particularly information technology, has increased its share of the region's economy.

"We would be in a position to allocate areas of land to PV production, but wouldn't we think that it's better to allocate land to growing food?"

RESIDENTIAL SECTOR

Emissions have decreased by 85% since 2005. This has been largely achieved through a 70% reduction in heat demand. This was driven by a combination of climatic change reducing heat demand in winter, new homes being built to PassivHaus standards, retrofitting and the cost of energy increasing. One third of heat demand is met by CHP, fuelled by natural gas and bioenergy. A quarter of heat demand is met by natural gas and bioenergy. Solar thermal panels are the preferred choice for onsite renewable heat generation because permission is not required to install them.

Electrical devices have become more efficient but are used more often. In particular, large televisions, espresso machines and saunas has counteracted some efficiency gains. However, these efficiency gains combined with the declining use of electrical heaters and behavioural change has led to electricity demand reducing by 40%.

SERVICE SECTOR

"Internet nodes of Frankfurt need as much electricity as a city with 150000 inhabitants. These are the servers for the whole of Europe and they are the reason that our electricity has increased so much in the city region."

Emissions have reduced by 81%. Heat demand has halved; retrofitting has improved. Building's are efficient enough for them to be partly warmed by waste heat from electronic products. Demand for air conditioning has limited efficiency improvements. Three quarters of the heating and cooling consumed in the service sector is generated by CHP plants. The remainder is met by natural gas, solar thermal panels and heat pumps. Electricity demand has decreased by a fifth as appliances and lighting systems have become more efficient. However, the sector has grown and office hours extended, meaning that lights and equipement are often on for longer than they were at the start of the century. Emissions have reduced largely because of the low carbon intesnsity of electricity.

INDUSTRIAL SECTOR

Emissions have reduced by 57%. Heat demand has reduced by 35% driven by basic efficiency saving measures and the cessation of energy-intensive manufacturing in the district. The remaining heat demand is largely met by fossil fuels (80%). Over half

of the energy used for heating and cooling is met by natural gas, either used directly in buildings or in CHP plants. Solar thermal panels are used to pre-heat water for industrial processes to reduce the requirement for fuels. Overall, 60% of heat demand and 85% of electricity demand is met by onsite CHP plants.

TRANSPORT

"It would be hardest to replace mineral oil-based fuels in heavy goods traffic. We need to have a substantial amount of biofuel to replace those fuels."

Emissions have reduced by 71%. People travel further than they did in 2005 and there has been an increase in freight transported by road. However, more people work at home and they make greater use of home deliveries. Cars are smaller and are on average 50% more efficient. Half of road vehicles are propelled by electricity; fossil fuels power a third and bioenergy fuels 10%. Globally, policies have tended to prioritise agriculture for growing food rather than fuel.

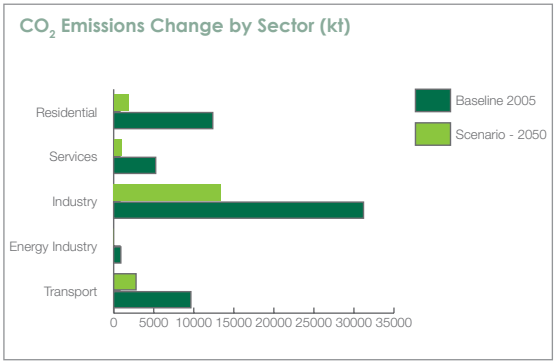
There has been an increase in rail travel as policies and incentives have encouraged the use of railways over the private car. Petroleum is no longer used. Instead, 95% of energy used in rail vehicles is electricity and 5% is bioenergy. Domestic air travel has declined by 25% and energy demand in the sector has reduced by 40% as aircraft have become more efficient. There have also been technological leaps in the production of bioenergy making the fuel suitable for air travel; 80% of domestic flights now use biofuel instead of kerosene.

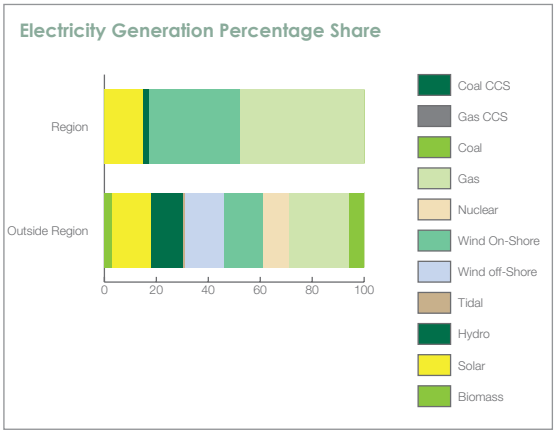
ELECTRICITY GENERATION

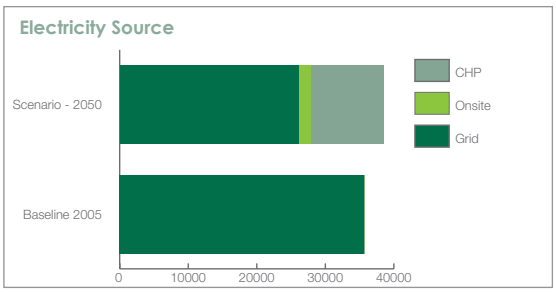
"If regional planning was less restrictive, 30% of our energy requirements could be produced from wind power, but regional planning is only going to change its mind a little bit in 40 years."

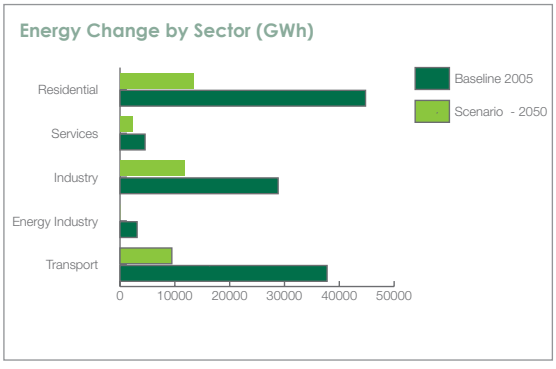
Germany is part of a European grid. Less than a third of the electricity generated in Europe is from fossil fuel power stations which are largely located in Eastern Europe. Solar power in Italy, Greece and Spain generates 15% of Europe's electricity. Offshore wind turbines, mainly in the Baltic Sea, generate a further 15%. Onshore wind turbines, whilst politically difficult to implement, generate an additional 15% of electricity. Hydropower, nuclear power and small tidal power plants generate the rest. CCS technology has not been taken up as the technology was deemed unproven. As a result of efforts to increase local electricity generation, the region now generates half the electricity it consumes. Just under half of this electricity is met by natural gas, with the rest from solar power, on-shore wind turbines and hydroelectric power. Given the population density of the region, developing these plants has been a challenge.

"It's also a matter of convincing the population. There was a referendum in Linberg apparently and they voted in favour of wind power."









Emissions Change	-73%
Energy Change	-50%
Emissions per Capita	3.2t

Scenario 2: Frankfurt

Scenario Characteristics

IN THIS MEDIUM GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 71% AND PER CAPITA EMISSIONS CONTRACT TO 3.5T. END USER ENERGY CONSUMPTION SHRINKS BY JUST UNDER HALF. THE EMISSIONS REDUCTIONS ARE LARGELY DRIVEN BY EFFICIENCY IMPROVEMENTS. BEHAVIOURAL CHANGE IS A KEY DRIVER IN THE REDUCTION OF EMISSIONS IN THE RESIDENTIAL SECTOR AND IS COMPLEMENTED BY AN UPTAKE OF ONSITE RENEWABLE ENERGY GENERATION. PRIVATE VEHICLE USE DECLINES PER HEAD OF POPULATION DUE TO GREATER ACCESS TO PUBLIC TRANSPORT, EMISSIONS REDUCTIONS ARE FURTHER AIDED BY IMPROVEMENTS IN THE EFFICIENCY OF ROAD VEHICLES. AN INCREASE IN CYCLING CONTRIBUTES TO THE EMISSIONS REDUCTION. THE REGION RECEIVES ITS ELECTRICITY FROM A LOW-CARBON EUROPEAN GRID WHICH SOURCES ITS RENEWABLE ELECTRICITY FROM AREAS WITH THE HIGHEST CAPACITIES.

"I don't think 2°C will make that much difference, socially or economically."

ECONOMY AND POPULATION

The population in rural areas has decreased steadily. The urban population increased up until 2020 and declined to 3.5million in 2050. There has been some internal migration from North and East Germany and some immigration from other OECD countries. Immigrants have mostly been highly skilled workers in the financial sector. Household size has reduced as Frankfurt has a healthy, older population who live alone in their own homes.

"Because of global warming we might move away because of the humidity. I would prefer to move away from Frankfurt because of the heat and humidity in the future."

The region's economy has grown faster regionally than nationally, 1.5% on average annually, partly due to the region's service and IT sectors. The agricultural sector has grown due to increased production of energy crops and desire for local produce. Public administration has reduced its share of the economy to 24% due in part to privatisation. Industry has reduced its share of the economy and the commercial sector has increased its share.

RESIDENTIAL SECTOR

"Now people have two fridges; they have a cool store to store their wine, the efficiency gains have been more than offset in the past by the increase in the number of appliances."

Emissions have reduced by 80%. Household electricity demand has contracted by 25%, due to more efficient appliances and behavioural change. Smart grids enable a more even distribution of demand. Onsite renewables meet 15% of electricity demand; 30% of roofs proved to be suitable for PV and each installation generates 35% of household electricity consumption.

"In the 1970s we thought we would dramatically bring down energy consumption, but with hindsight there have not really been major changes. We can't say electricity consumption will go down by 25% because we will fall into the same trap that we fell into 30 years ago. I find it difficult to believe we will bring down electricity this much."

Heating demand decreased by 65% overall and 70% on average per household. On-site heat generation technologies, a requirement for new buildings, meet 40% of demand. CHP systems, fuelled mainly by natural gas, meet 30% of heat demand.

"I started from the assumption that in 2020 there will be EU regulations about Passiv Haus [standards] for new buildings."

It has been difficult to reduce the use of natural gas because of the 'lock-in' caused by the existing infrastructure. Bioenergy is used directly for 10% of heating and cooling needs. Concerns about air pollution and the availability of resources have reduced its use.

"Water-based heat pumps will become more common but they have limits; there are certain external temperatures where they become inefficient."

SERVICE SECTOR

Emissions have decreased by 90%. Heat demand has reduced by 80% due to the energy efficiency of new buildings and the retrofitting of old buildings. CHP, predominantly fuelled by natural gas and bioenergy, meets 60% of heat demand. A further 25% of requirements are met using solar thermal and ground-source and air-source heat pumps. Most on-site technologies are located on large service sector buildings with a high heat demand such as schools, hospitals and gyms. Overall, 58% of heat demand is met by fossil fuels, but the reduction in demand has enabled large emissions reductions. Electricity use in the sector has halved because tenants have demanded energy-efficient buildings and intelligent lighting. Modern elevator systems for example have helped to decrease electricity demand. Onsite renewable technologies meet 14% of electricity demand.

INDUSTRIAL SECTOR

Emissions have reduced by 63%. Heat and electricity demand has reduced by 30% and 20% respectively. Economic growth and the difficulty in reducing energy use in industrial processes kept demand high. Furthermore, the industrial sector's long term focus on efficiency savings means it had less opportunities than other sectors

to reduce demand. Half of heat demand and two fifths of electricity demand is met by CHP plants fuelled by natural gas and bioenergy (including biological waste products from the chemical industry). Most of the rest of heat demand is met by natural gas and bioenergy.

TRANSPORT

Emissions have reduced by 61%. Road vehicle kilometres have reduced by 10% as urbanisation has made public transport more viable. Interventions that encouraged cycling and car sharing, such as parking restrictions, have helped to constrain private car use. Reductions have been limited by people liking car travel such as the elderly, who have driven all their lives, continuing to do so into old age. On average road vehicles are nearly twice as efficient as they were in 2005. A transition has been made to more efficient electric cars and regulations that affect the way people drive. Electric buses have been introduced as public transport routes have been adapted to ensure charging points are available at appropriate points. Road transport is largely propelled by fossil fuels.

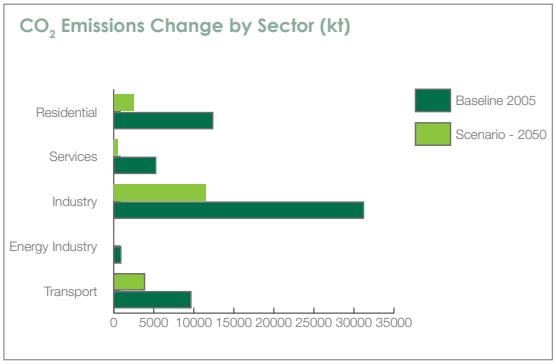
An increase in cycling and a decrease in population have reduced rail travel, trains are more efficient, so energy use has decreased by 15%. The majority of rail transport (80%) is electric. There has been a 60% decrease in domestic flights from Frankfurt airport. Frankfurt's location makes it easier, cheaper and more convenient to travel by train. The remaining flights, propelled by kerosene, include connecting flights for people who are, for example, travelling from Hamburg to New York via Frankfurt.

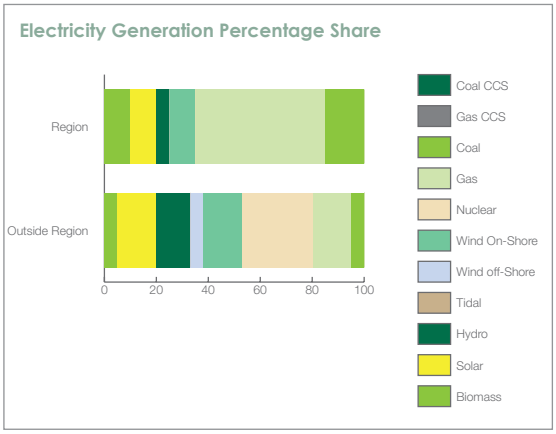
ELECTRICITY GENERATION

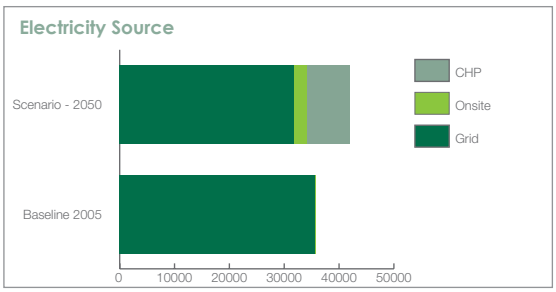
"I think it is sensible to separate regional and out-of-regional production because it stops people assuming that everyone else will solve our problems, like we'll get all our energy from desert tech and offshore wind somewhere."

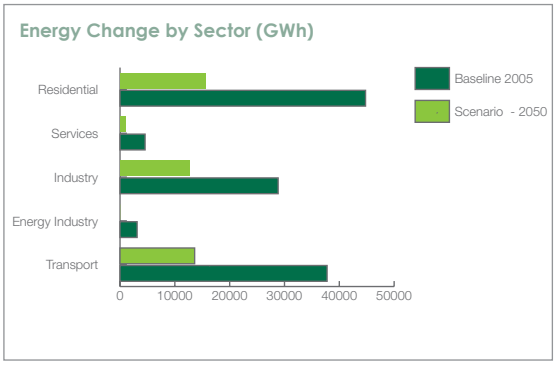
The region obtains its electricity from a European grid. Consequently, generation technologies are now developed where it is most efficient, for example large scale PV plants are located in southern Europe. Over a quarter of electricity generated in Europe is from nuclear power, although no power stations are located in Germany. Onshore wind turbines, mainly located in Ireland, Germany, Spain, Denmark and France, generate 15% of Europe's electricity. Offshore wind in Denmark, Netherlands and Germany generates 5%. Hydroelectric power plants generate 13% of Europe's electricity. Solar power plants in Spain, Greece and North Africa provide 15% of Europe's electricity. Approximately 20% of Europe's electricity is generated using fossil fuels, mainly natural gas. The region generates electricity from natural gas, coal, hydroelectric power, onshore wind, solar power and bioenergy.

"CCS is wishful thinking; it won't happen. I don't know where we can possibly bury the carbon underground; I really don't know where you are going to put it."









Emissions Change	-71%
Energy Change	-45%
Emissions per Capita	3.5t

2025 Synthesis Scenario: Frankfurt

INTRODUCTION

The purpose of the final scenario session was to identify, based on the outcomes of the 2050 scenario sessions, what emissions reductions might be achieved in the region by 2025. This session included stakeholders that took part in both the 2050 scenario sessions. A full scenario was completed which led to an emissions reduction of 38%. The scenario largely focused on the residential and transport sectors, as well as the supply of electricity. Discussions on the service and industrial sectors were limited and so are not reported here.

RESIDENTIAL SECTOR

The amount of heat demand met by fossil fuels has reduced due to their rising cost. However this represents the beginning of a transition away from petroleum and natural gas. There has been increased deployment of district heating due to the implementation of agendas mandating that new houses be connected to district heating systems and incentives and regulations that enabled people living in older housing stock to connect to district heating systems.

As appliances (e.g. fridges) take some time to wear out the impacts of EU efficiency standards on electricity consumption are just starting to emerge. Furthermore, short-term reductions have been difficult to achieve due to population growth. However, a 10% reduction has been delivered due to the following factors:

Heat demand has reduced by 30%, due to a combination of increased energy prices, retrofitting programmes, a small amount of rebuilding, technical solutions (particularly for historic buildings) and resident commitment. The latter was particularly problematic due to complications relating to poorer residents, those that rent and those unlikely to recoup their investment (e.g. elderly people or those planning to move in the near future). This reduction has been achieved due to the following actions being implemented:

Residential Actions	Individual	Organisation	Province	Region	State	Nation	EU	Global	Other
Ceasing the use of storage heaters.									
Political pressure for stringent EU regulations on appliance and lighting efficiency.									
National regulations requiring that all residential buildings are retrofitted.									
Regulations pertaining to minimum efficiency standards of windows and boilers.									
Tiered financial incentives for retrofitting programmes including grants for the poorest in society.									

"Won't there be a saturation effect? I don't need a fifth television set in my house."

"At what point in life do you refurbish? If you buy a house you are not able to refurbish because of costs and when you get older you don't see the point."

TRANSPORT

The main focus of policy has been to encourage the use of public transport. Policies aim to increase access to and the capacity of public transport systems. These actions to support and expand public transport included:

Transport Actions	Individual	Organisation	Province	Region	State	Nation	EU	Global	Other
The introduction of 'shuttle services' between key areas at peak times.									
A regional plan to improve local public transport systems, particularly in the city of Frankfurt.									
A set of integrated cycle routes.									
Promotion of the cycle rental scheme in Frankfurt.									
Incentivising electric vehicle use by providing special parking places for electric cars, introducing a congestion charge for all non-electric vehicles across the region and supplying regional support for EU regulations on road vehicle efficiency.									

"I would speak in favour of cycling taking a much bigger role, and we saw examples from Copenhagan [where] 50% of all journeys are done by bicycle and it's only 9% [in Frankfurt]."

ELECTRICITY GENERATION

There is a European grid with a range of nuclear and coal power stations still in existence. The technical and financial barriers to offshore wind turbines have hindered their deployment and along with other offshore technologies they have been further constrained by their impacts on biodiversity and their ability to cope with storm surges. There has been limited success in the development of electricity storage technologies. Nimbyism ('not in my back yard' thinking) has made the deployment of new renewable electricity difficult. In total, renewable technologies generate 27% of Europe's electricity, including hydroelectric power in Norway, offshore and onshore wind farms in England and solar power in Spain, Greece and Italy. This generation mix was achieved by:

Transport Actions	Individual	Organisation	Province	Region	State	Nation	EU	Global	Other
Introducing EU legislation compelling countries with a large potential for solar power to develop solar systems.									
Standardising incentives for renewable generation across Europe.									
Providing regional-level planning policies that allocate areas for onshore wind farms.									
Introducing incentives for farmers to grow energy crops.									
Planning provision for distribution lines for renewable technologies, particularly those located offshore.									

"We need to look at what can be achieved, what biomass we have, what wind is available... It is easier to think in percentages, so this is a good methodology, but we need to then think about absolute numbers."

[On financial incentives for renewable electricity) "We need a uniform rule about rewards at the European level. It is unacceptable that some countries have these solutions and some don't."

"I think offshore wind is overrated. There have been problems feeding the electricity into the grid and the stability of sea-borne systems has become an issue since the oil spill in Mexico."

"I think we agree that it's not up to the UK and Germany to pay for generation outside these countries through the EU."

Next Steps: Frankfurt

INTRODUCTION

This section identifies how the GDD 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 district 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.

Neither of the scenarios produced emissions reduction of at least 80% by 2050. However, both the scenarios 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 both scenarios there is a reduction in residential heat demand of 65%. One action could be to assess how quickly this reduction could be achieved and implement policies and actions accordingly.

The city of Frankfurt has carried out research in to how it could reduce CO_2 emissions. Sharing this experience with the wider metropolitan area could facilitate learning, providing a route to developing a metropolitan area wide plan.

RESIDENTIAL SECTOR

In 2005, the residential sector generated 28% of the district's CO_2 emissions. Heat demand was met by fossil fuels, mostly natural gas. To reduce emissions the approach should focus on demand reduction and fuel switching. If the carbon-intensity of the grid is reduced, electric heating will be an option, and this approach was taken in both scenarios. Behavioural change is key to demand reduction, particularly in the short term, and can be promoted through education 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 better understand their energy use, and budget to make reductions. The authorities can lead the way with publicly owned housing by retrofitting buildings and subsidising the purchase of efficient household appliances.

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 district.

SERVICE SECTOR

The service sector faces similar mitigation challenges to the residential sector in terms of building operations. However, it is arguable that the public authorities should be seen to be taking the 'climate change lead' in their own properties by 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 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 Greenhouse Gas Regional Inventory Project

grip

INDUSTRIAL SECTOR

The industrial sector accounted for 30% of the district's CO_2 emissions in 2005. 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 in the extent to which regional authorities can influence industry: 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 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.

TRANSPORT

The transport sector generated 26% of the district's CO_2 emissions in 2005. 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 road vehicle kilometres travelled through encouraging the use of public transport, walking and cycling, and by 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 schemes, 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 emissions reduction potential of 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 growth of 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

Electricity generation in Germany is currently carbon intensive, so developing low-carbon and renewable electricity generation plants could have a significant impact on emissions. Power stations and associated infrastructure have long life-spans, so it could be difficult to decarbonise the electricity supply quickly. Conversely, this means that action is required urgently at the national and regional levels so the metropolitan region is not 'locked in' to high-carbon sources of electricity.

The metropolitan region currently has a set of district heating networks and could work to integrate and expand them. This could optimise the efficiency and effectiveness of generation plants, reduce operation costs and enable more buildings to be connected to the network. At present, these networks are largely powered by fossil fuels.

The metropolitan region of FrankfurtRheinMain has already begun to develop actions and plans to reduce greenhouse gas emissions and has signaled its commitment to this process through its involvement in the

FARMING IN FRANKFURT
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$EUCO_2$ project. Some of the cities in the metropolitan region have joined the EU Covenant of Mayors. We hope that the outputs and process of the $EUCO_2$ project are helpful in developing the metropolitan region's climate change and energy strategies and can support meaningful change that embeds emission reductions in the activities of the metropolitan region.

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