THE EUCO2 PROJECT STAGE 2
OSLO AKERSHUS

SCULPTURE PARK
IN OSLO
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AKERSHUS
FYLKESKOMMUNE

City of Oslo

Introduction to Oslo

Oslo Metropolitan Region comprises the City of Oslo and the county of Akershus. Oslo is Norway's only metropolis, consisting of a compact urban core surrounded by forests, agriculture and coastline. Akershus is the second largest populated county in Norway. The population of the region in 2005 was 1.04 million which rose to 1.14 million in 2011. The city of Oslo has just over half of the region's population. Population growth in the Oslo region is due to high rates of immigration from within and outside of Norway, combined with a young population with a high birth rate.

Although politically independent from each other, Oslo and Akershus work jointly in many key areas, such as the regional energy and climate programme, industrial and commercial development and transport policy; including, for example, the Oslo toll ring. Oslo and Akershus, along with neighbouring Buskerud, have worked together on climate change mitigation since 1999.

The 2008 Municipal Master Plan for Oslo identified the strengths of the city to be its regional economy and a high quality of life. Weaknesses were identified as Oslo's peripheral location, the high cost of living and a lack of venture capital[1]. Oslo and Akershus has put up a joint public transport company, RUTER, who runs both busses, trams and metro. During the first half of 2011, there was a growth in public transport by 7% in Oslo and 12% in Akershus.

The region has a public transport network that includes a six line metro, an eight line commuter railway and a six line tramway. The majority of public transport journeys are by rail, tram or metro[2]. The region's bus operating company aims for its fleet to be fossil fuel free by 2020. Road user charging has been in place since 1991 and has provided funds for expansion to the road and public transport networks. The regional airport, Gardermoen, served 19 million passengers in 2010; 65% of these travelled by public transport (bus or train) to the airport. As the region is located in the

TRAIN COMING
TO LJAN STASION
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periphery of Europe, it is dependent on air transport for accessibility to European markets.

The bulk of employment in Oslo and Akershus is in the service sector. The region is host to internationally competitive businesses including maritime, energy and environment, life science, ICT and culture. Oslo is also home to some of the world's largest shipping companies, shipbrokers and maritime insurance brokers. The region accounts for nearly 50% of national R&D expenditure. Unemployment in the Oslo metropolitan region was 3% in 2005.

In 2005 the region set a target to reduce GhG emissions by 50% against a 1990 baseline. One of the goals of the 2008 Oslo Municipal Master Plan is to 'consolidate its position as one of Europe's most environmentally sustainable capitals'. Oslo City Council has adopted a 10 point plan to reduce emissions, which includes the implementation of energy certification for property transactions, new municipal buildings meeting either PassivHaus or low-energy standards and establishing a network for charging electric vehicles. There is a Climate and Energy Fund to support activities that reduce emissions in municipal buildings. The 22 municipalities in the county of Akershus are developing their own energy and climate action plans.


WINTER IN OSLO
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1 City of Oslo (2025) *The 2008 Municipal Master Plan, Oslo Towards 2025* p5
2 City of Oslo (2025) *The 2008 Municipal Master Plan, Oslo Towards 2025* p11

Emissions Inventory and Energy Baseline

Total emissions from the region in 2005 were 3449kt CO_2e. This comprised of 92% from the Energy sector, 3% from Industrial Processes, 2% from Agriculture and 3% 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.

Oslo Chart 1 right displays the CO_2 emissions from the energy sector in 2005; a total of 3084kt CO_2. The figures show that in 2005 the emissions from the residential sector accounted for 8% of energy emissions, the service sector 11%, the industrial sector 10% and the transport sector 71%; the transport sector emissions comprising 86%, 3%, <1% and 12% from road, rail, marine and domestic aviation respectively. The energy industry accounted for 0% of emissions and fugitive emissions <1%. GRIP level 1, 2 & 3 methodologies were used to estimate 89%, 11% and 0% of the emissions respectively.

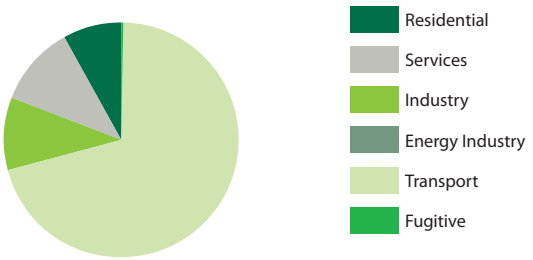
Oslo GhG Inventory 2005

Sector	CO_2 (kt)	CO_{2eqv} (kt)
Residential	248	279
Services	335	341
Industry	311	314
Energy Industry	0	0
Road Transport	2,180	2,228
Other Transport	11	12
Total Energy	3,084	3,173
Industrial Processes	0	108
Waste	0	108
Agriculture	0	60
Total	3,084	3,449

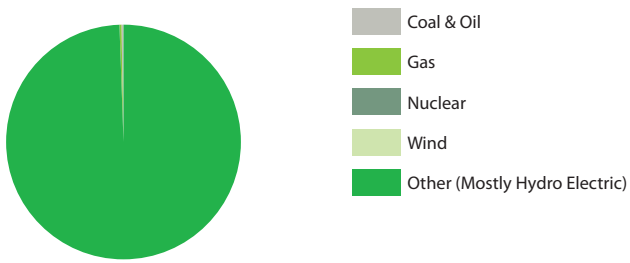
Oslo Chart 2 below shows how electricity ws generated in Norway in 2005.

In 2005, 0% of electricity generated in Norway and the region was from coal generation, 1% and 0% was from combined cycle gas turbines, 0% was from nuclear power, 1% and 0% was from wind power and 99% and 100% was from other forms of renewables (mostly hydroelectric power). The country was a net exporter of electricity in 2005.

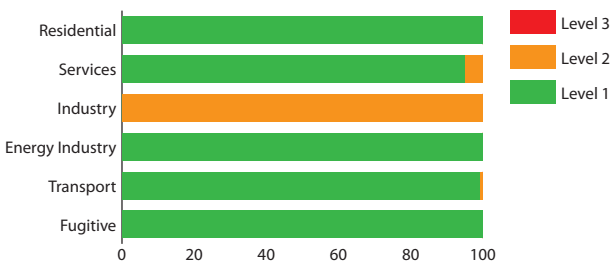
Oslo Chart 1: Energy Sector



Oslo Chart 2: National Electricity Generation



Oslo Chart 3: GRIP Methodologies Used



Scenario Overview

INTRODUCTION

There were four scenario sessions conducted in the Oslo Akershus Region. The first three scenarios focused on reducing CO_2 emissions by 80% by 2050. The remaining 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 sessions were not informed how previous groups, either in the region or outside had acted. This section provides a comparison between the first three scenarios.

The emissions decrease by 75%, 39% and 77%, and energy demand increases by 48%, 104% and 30% in Scenarios 1, 2 & 3 respectively.

ECONOMY AND POPULATION

In each scenario the region attracts inward investment, climate change provides a more pleasant climate than the rest of Norway and the population increases by at least 60%. In Scenario 3, there are climate refugees.

In all scenarios, average household size reduces due to a combination of factors, including a tendency to marry later in life, an aging population, and an increased divorce rate. In each of the scenarios the commercial and the public administration sectors increase their share of the economy whilst the industry sector decreases its share.

RESIDENTIAL SECTOR

Emissions change by -97%, 65% and -93% in Scenarios 1, 2 & 3 respectively. Heat and electricity demand increases in Scenario 1, electricity is near zero-carbon, and much of heat demand is met by on-site heat technologies and combined heat and power (CHP). In Scenario 2, there is a larger increase in energy use, and a greater reliance on CHP, natural gas and petroleum, leading to a rise in emissions. Heat demand remains static in Scenario 3, however petroleum and CHP are replaced with electricity and on-site heat technologies. In each scenario, building efficiency improves and there has been adoption of Passiv Haus approaches. There is some use of on-site technologies for heating and cooling in each scenario. The greatest contribution from these technologies is in Scenario 2.

SERVICES SECTOR

Emissions decrease by 99%, 18% and 95% in Scenarios 1, 2 & 3 respectively. In Scenario 1, the sector's energy changes mirror those of the residential sector, due to similar policies and changes in behaviour. In Scenarios 2 & 3, energy efficiency improvements are larger than in Scenario 1 due to economies of scale. In Scenario 2, energy demand is highest with a greater reliance on fossil based district heating.

INDUSTRIAL SECTOR

Emissions decrease by 75%, 60% and 91% in Scenarios 1, 2 and 3 respectively. In the three scenarios it is harder to reduce the use of fossil fuels than in other sectors due to specific process heat requirements. In Scenarios 2 and 3 bioenergy has displaced some fossil fuels. There is electrification in Scenario 1, mirroring the experiences of other sectors.

TRANSPORT

Road transport emissions decrease by 71%, 77% and 93% in Scenarios 1, 2 and 3 respectively. In all the scenarios, road vehicle kilometres increase. The lowest increase is in Scenario 2, which has the highest population increase. In all scenarios, vehicle kilometres on rail increase by more than they do on road, reflecting modal shift. Scenario 2 exhibits the greatest level of modal shift, with the greatest population increase, the lowest increase in road kilometres and the greatest increase in rail kilometres. In each of the scenarios, road transport is predominantly electric with some utilisation of hydrogen in larger vehicles. In Scenarios 2 & 3, marine vehicle kilometres double, with energy demand remaining static.

The change in aviation kilometres varies between 0% and 200%. Scenario 3 has the largest increase but technological improvements and 'smarter' flying practices also deliver the greatest improvement in energy efficiency.

ELECTRICITY GENERATION

In Scenarios 1 & 2, Norway continues to have a primarily hydroelectric national grid. Wind energy develops and provides a slightly greater share of electricity in Scenario 2. This is bolstered by the development of CCS on natural-gas-fired power stations. In Scenario 3, the region is connected to a European grid and therefore the carbon intensity reflects electricity generation across the whole continent. In each of the scenarios there is little development of on-site electricity generation, due to cheap grid electricity.

Scenario 1: Oslo

Scenario Characteristics

IN THIS MEDIUM GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 75% AND PER CAPITA EMISSIONS CONTRACT TO 0.4T. END USER ENERGY CONSUMPTION INCREASES BY A HALF. THE POPULATION INCREASES DUE TO THE ATTRACTIVENESS OF THE REGION. BEHAVIOURAL CHANGE REDUCES THE CONSUMPTION OF ENERGY IN THE RESIDENTIAL SECTOR BY A FIFTH. THE SERVICE SECTOR ALSO EXPERIENCES EFFICIENCY IMPROVEMENTS. A CHANGE IN THE NATURE OF INDUSTRY REDUCES EMISSIONS. PRIVATE VEHICLE USE INCREASES, HOWEVER AS IT IS ELECTRICIFIED EMISSIONS REDUCE. THE REGION RECEIVES ITS ELECTRICITY FROM A NORWEIGIAN GRID THAT CONTINUES TO BE CONNECTED TO NEIGHBOURING SCANDINAVIAN COUNTRIES.

ECONOMY AND POPULATION

The population of the region has grown to 1.8 million. Oslo continues to offer attractive prospects for employment and quality of life. As Oslo is both the capital and the largest city, and offers a pleasant climate relative to the rest of Norway, immigrants entering the country tend to come to, and stay in, Oslo and neighbouring Akershus. At the start of the century, Akershus had greater capacity for new residential and business buildings and has therefore accomodated most of recent growth.

There has been an influx of workers from Scandinavia and further afield, particularly in the service sector. Whilst the student population continues to favour house sharing, divorce rates have meant that many family units are separating. This has led to a slight decrease in household size. The region now occupies 35% of Norway's households.

Some heavy industry remains, but most industrial activity is now closely connected to the construction and renovation of buildings. Public administration has decreased from 26% to 16% of the economy, with the commercial sector growing to 69%. Average annual economic growth has been 2%.

RESIDENTIAL SECTOR

The residential sector has reduced its emissions by 97%. The consumption of energy per household has reduced by a fifth. The younger generations have played an important role in increasing environmental awareness. The standard of insulation in houses has improved. Whilst district heating has remained popular, its growth has slowed as the overall heating requirements of the sector have reduced. No fossil energy sources are used to meet heat demand partly because of the increased use of electric heating. On-site generation technologies meet 25% of heat demand, mainly through heat pumps.

"When you have more efficient heating, they tend to use the same amount of electricity and you turn up the heat. So the moral aspect of climate change and energy consumption needs to be invoked."

SERVICES SECTOR

Emissions have been reduced by 99%. Developments in the services sector have been similar to those in the residential sector. The buildings are of comparable scale and the two sectors have been subject to similar policy initiatives. The sector is connected to the same district heating network as the residential sector.

INDUSTRIAL SECTOR

Industry has reduced its emissions by 75%. The demand for high temperature process heat has restricted further emissions reductions. Employment in the industrial sector has increased. Much of the industrial activity is in the construction and renovation of housing. However, there continues to be a mineral extraction industry and paper and print. Heat demand is met by the development of hydrogen, biofuel and electricity. Some industrial buildings are connected to the district heating network. On-site electricity generation meets 5% of demand.

TRANSPORT

Emissions from road transport have decreased by 71%. There has been an increased demand for transportation associated with the increased population. The number of vehicle kilometres travelled by motorised road transport modes has increased by 40%. Vehicle efficiencies have restricted the growth in the amount of energy used by the sector. Almost all local transport is electric. Some hydrogen is used, primarily in bigger private cars, buses and in some HGVs. As people renew their cars with more energy-efficient models, the car fleet as a whole has become more efficient

"We're going to be through four generations of cars, so we'll be almost out of petroleum by 2050."

Rail is entirely electric. The development of high-speed trains with additional carriages means that energy use has gone up overall. Marine transport, consisting almost entirely of the ferries between Oslo and Akershus, continue to run on LPG but, after successful trails on buses, hydrogen is beginning to be introduced on rolling stock.

"As we get more population we'll need more rail transport."

Air travel has not grown as rapidly as population but has continued to be an important part of the economy, particularly due to its role in international relations, travel and trade. The development of rail has helped to keep the growth of aviation lower than it would otherwise have been. Residents and businesses in Oslo and Akershus continue to account for one third of the kilometres travelled in Norway. Kerosene remains the main fuel, but biofuels have been trialled and are beginning to be used, accounting for 30% of fuel use.

"We're not going to be less international, we're not going to travel less, but we're running out of things to fuel airplanes, so it's natural to assume that planes will start using alternative fuel sources along the same lines as cars and other vehicles."

ELECTRICITY GENERATION

Norway has a national grid which is connected to neighbouring Scandinavian countries. Decision-makers were concerned that by joining a European grid they would in effect be importing 'dirty' carbon-intensive electricity over which they had little control. Nationally, grid electricity is primarily hydroelectric (95%), which is complemented by some development in tidal, wind and solar generation.

"If you use Norway's mix we've got hydro plants, but if we go European we'll have to go to coal."

The region is now producing slightly more of its own electricity than it did in 2005. Generation is primarily hydroelectric (95%), but large-scale solar PV has begun to develop and now accounts for 5% of regional generation. The availability of land and the local climate have been the primary limiting factors in developing wind and solar.

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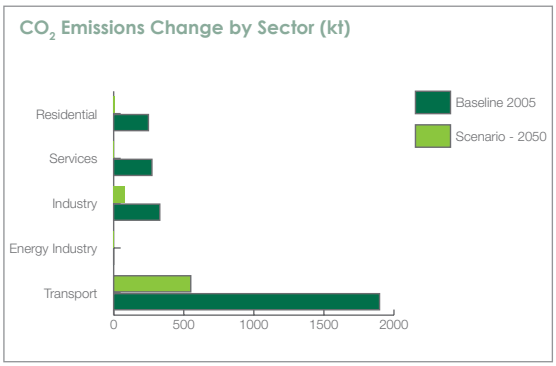
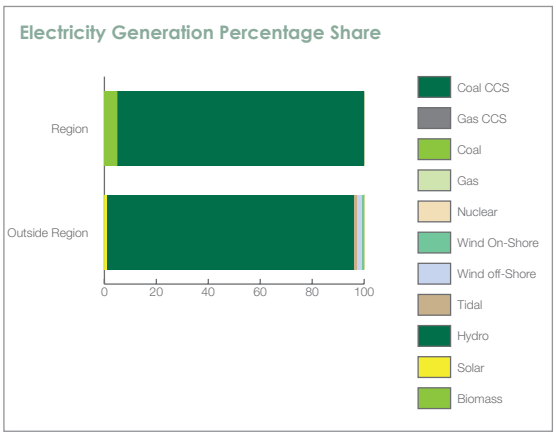
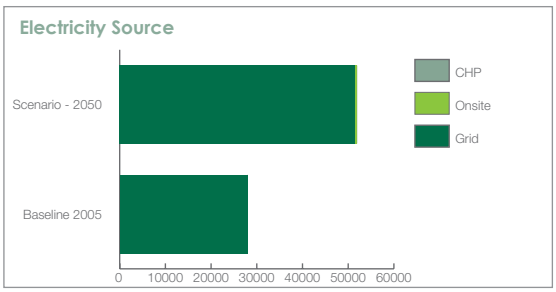
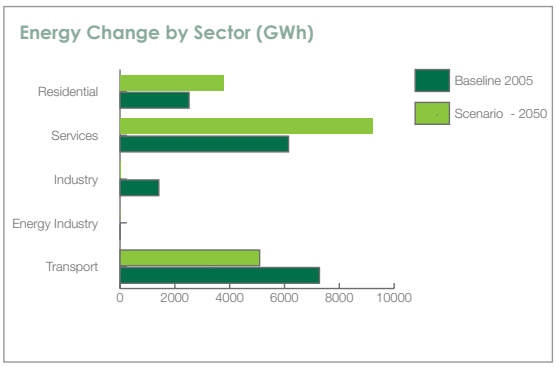








Emissions Change	-75%
Energy Change	+48%
Emissions per Capita	0.4t

Scenario 2: Oslo

Scenario Characteristics

IN THIS MEDIUM GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 39% AND PER CAPITA EMISSIONS CONTRACT TO 0.9T. END USER ENERGY CONSUMPTION MORE THAN DOUBLES. THE POPULATION DOUBLES DUE TO THE ATTRACTIVENESS OF THE REGION. BEHAVIOURAL CHANGE AND THE COST OF ENERGY HAVE DRIVEN THE CONSUMPTION OF ENERGY IN THE RESIDENTIAL SECTOR DOWN. THE SERVICE SECTOR DUE TO CHANGING PRACTICES EXPERIENCES EFFICIENCY IMPROVEMENTS. A CHANGE IN THE NATURE OF INDUSTRY AND AN INCREASE IN THE USE OF RENEWABLE TECHNOLOGIES HAS REDUCED EMISSIONS. PRIVATE VEHICLE USE INCREASES AS DOES INVESTMENT IN BOTH THE ROAD AND PUBLIC TRANSPORT NETWORKS. THE REGION RECEIVES ITS ELECTRICITY FROM A NORWEIGIAN GRID THAT IS LARGELY SERVED BY HYDROELECTRIC STATIONS, NORWAY DECIDED AGAINST CONSTRUCTING NUCLEAR POWER STATIONS.

"If Oslo was developed with the same density as Copenhagen, then we'd save thousands in emissions."

ECONOMY AND POPULATION

The population has nearly doubled to 2 million, accounting for a third of the nation. This is driven by a high birth rate with young families tending to stay in the region, and is complemented by younger people and immigrants from the rest of Scandinavia moving to the city, partly because of the region's more attractive climate. Elderly people form a decreased percentage of the population. The population is spread evenly throughout the region. The household size in the region is smaller than at the beginning of the century and is smaller than the national average.

The industrial sector has decreased its share of the economy whilst public administration and commercial sectors have grown. The regional economy has grown by 2% each year on average and now accounts for 40% of the national economy.

RESIDENTIAL SECTOR

"We're not comparable to other EU countries, we are a cold country so we need to heat our houses."

Emissions have increased by 65%. Homes require less energy for heating. Rising energy prices have factored in the reduction in energy consumption and people have become more energy-efficient in their behaviour. Waste heat from household appliances also contributes to heating. Norway has cold winters, constricting the impact that behavioural change and improved building standards can impact on. Petroleum and natural gas have been replaced by bioenergy, sourced largely from Akershus. District heating still contributes to the region's heat demand, powered mostly by bioenergy.

SERVICE SECTOR

Emissions have reduced by 18%. As new services have developed and older ones modernised, efficiency has improved and the sector has invested in low-carbon technologies. There are no fossil fuels used directly to heat buildings. Bioenergy, district heating, on-site technologies and electricity make up the energy mix.

"Innovation in building techniques is a factor but the growth in the building sector will set in motion the need for more transport."

INDUSTRIAL SECTOR

Emissions have decreased by 60% despite electricity and heat demand increasing by 60% and 40% respectively. Fossil fuels meet 17% of heat demand, due to the nature of certain types of processes. Hydrogen technologies have been developed to a much greater extent than in other sectors. On-site heat technologies, including heat pumps and solar water, now provide 15% of heat demand due to land and roof space availability.

TRANSPORT

"Lots of people like living outside Oslo and commuting in, so we need to do something with the railways and the roads."

Emissions from Road Transport have decreased by 77%. Road vehicle kilometres have increased by 20% because most of travel demand is met by public transport rather than private cars. Investment in public transport has occurred following difficult political discussions regarding increasing road capacity. The majority of road transport is electric and battery storage has improved. The remainder of road vehicles use bioenergy, petrol or hydrogen. Larger vehicles, such as buses and HGVs, are the main users of hydrogen.

The rail sector has quadrupled in size in terms of vehicle kilometres and there has been a seven fold increase in emissions. This increase in emissions is due to a combination of increased energy consumption and an increase in the carbon intensity of electricity. The marine transport sector has grown. Ferries now travel twice as many kilometres and are fuelled by bioenergy and LPG. In the aviation sector, the number of vehicle kilometres is the same as in 2005, but improvements in engine efficiencies have reduced overall energy consumption by 15%. Short haul journeys of less than two hours in duration are now travelled by rail, and bioenergy now forms 40% of the aviation energy mix.

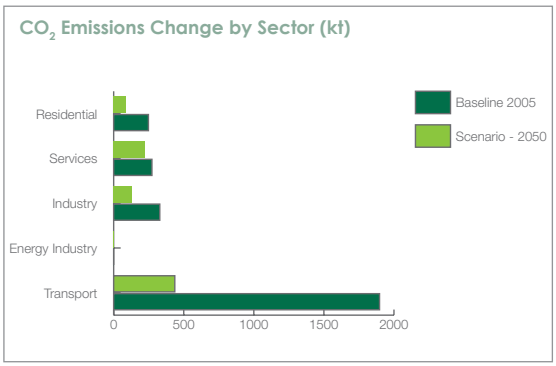
ELECTRICITY GENERATION

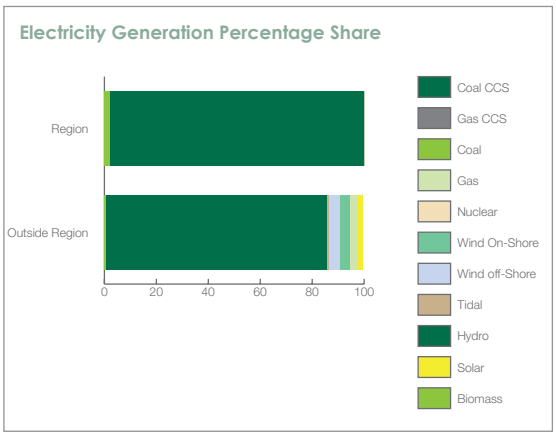
"I think there will still be the increased need for electricity, unless there's a catastrophe, so we import and we have co-produced electricity."

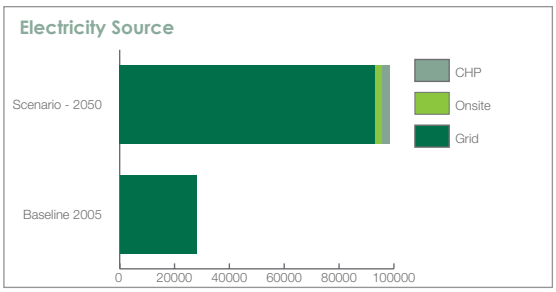
Norway has a national grid, rather than a European one, and there have been improvements in transmission technologies. The majority of electricity demand is met by hydroelectric power, with the remainder from wind, tidal power, biomass and gas. The majority of gas power stations are fitted with CCS. The country decided against the development of nuclear power.

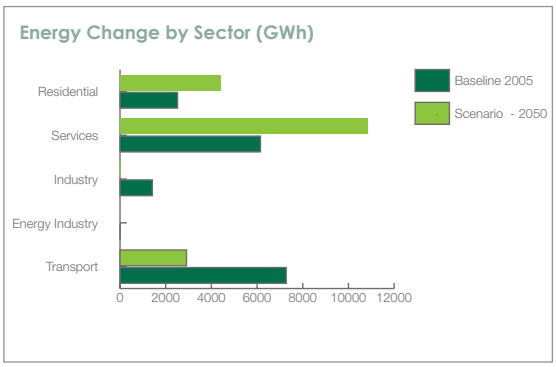
The region contributes the same amount of electricity to the grid as in 2005, and 98% of the region's electricity generation is from hydroelectric power, with the rest from bioenergy. In the residential and service sector, cheap and green electricity from the grid has meant there has been little incentive to invest in on-site renewable technologies, and they generate only a small amount of electricity.

"There could be more hydro plants and micro-generation in 100 years, but not 40 years."









Emissions Change	-39%
Energy Change	+104%
Emissions per Capita	0.9t

Scenario 3: Oslo

Scenario Characteristics

IN THIS MEDIUM GROWTH SCENARIO CO_2 EMISSIONS REDUCE BY 77% AND PER CAPITA EMISSIONS CONTRACT TO 0.4T. END USER ENERGY CONSUMPTION INCREASES BY NEARLY A THIRD. THE POPULATION INCREASES PARTLY DUE TO THE ATTRACTIVENESS OF THE REGION. POLICIES REGARDING BUILDING CONSTRUCTION HAVE DRIVEN THE CONSUMPTION OF ENERGY IN THE RESIDENTIAL SECTOR DOWN. THE SERVICE SECTOR INCREASES ITS USE OF ENERGY DUE TO THE GROWTH IN THE ECONOMY. EMISSIONS REDUCTIONS IN THE INDUSTRIAL SECTOR ARE PARTLY DRIVEN BY ELECTRIFICATION. ELECTRICALLY PROPELLED PRIVATE VEHICLE USE INCREASES AS DOES PUBLIC TRANSPORT. THE REGION RECEIVES ITS ELECTRICITY FROM A EUROPEAN GRID THAT IS LARGELY SERVED BY LOW-CARBON GENERATION TECHNOLOGIES INCLUDING NUCLEAR POWER.

"You can be optimistic in scenarios, but I need to be pessimistic in my planning."

ECONOMY AND POPULATION

The population has increased to 1.7 million and forms 30% of the national population. As the climate has changed, the region has become pleasanter and there has been an influx of people from elsewhere in Norway and Europe (for example Spain), areas more severely affected by climatic change. Immigrant families often had large families when first arriving in the country but have adopted Norwegian ways of life and now have smaller household units. Due to this and a combination of people marrying later, elderly people living on their own and a wealthy student body able to afford individual flats, the average household size has decreased.

There is no new industry in Norway and 'green' developments in technology have occurred in existing industrial areas rather than in new locations. As a result, industry's share of the economy has reduced, whilst public administration and commercial sectors have grown. The economy of the region is changing to a service-based economy and has grown on average by 2.3% each year, forming 44% of the national economy.

RESIDENTIAL SECTOR

Emissions have reduced by 91%. The average household now uses half as much energy. PassivHaus approaches have been developed in some new housing stock and building codes are strict with mechanisms in place to monitor energy efficiency.

"Renewables will be a large part of what replaces petroleum."

On-site technologies such as ground and air-source heat pumps meet 40% of heat demand. Solar water technologies are unpopular due to the installation of storage tanks. Fossil fuels are no longer used directly to heat homes. The district heating network, powered by bioenergy, meets 25% of heat demand. The introduction of financial incentives has led to an increase, particularly in new apartments, in the use of electricity for heating. The remaining heat demand is met through the use of bioenergy in homes.

SERVICE SECTOR

"Service sector is the most responsive to costs, so therefore they'll move more quickly when it comes to consumption."

Emissions have reduced by 95%. Electricity and heat demand have increased by 25% and 20% respectively. This is due to growth in the sector driven in part by a trend for people to eat in restaurants more often. Building efficiency has improved through the development of stricter buildings codes. The sector has responded to incentives and changes in energy prices. Half of the sector's heating requirements are met through the district heating network, and as in the residential sector use of electric heating has increased. On-site technologies for heat, principally heat pumps, meet 35% of heat demand.

INDUSTRIAL SECTOR

Emissions have reduced by 91% since 2005. There has been a switch to bioenergy which required fewer changes to existing infrastructure. Electricity meets 25% of heat demand in industry because it is suitable for many applications. Fossil fuels have been largely phased out. Development of stand alone hydrogen technologies means it provides 1% of heat demand. Industry is connected to the district heating network, which meets 30% of heat demand and on-site heat renewable technologies meet 20% of heat demand.

TRANSPORT

Road and rail transport emissions have decreased by 93% and 70% respectively. There is more travel within the region, reflecting its economic development and the affluence of the people. Road and rail vehicle kilometres have grown by 50% and 90% respectively. Engine technology improvements have improved the efficiency of road and rail transport. Most road vehicles are propelled by electricity.

"There will be such traffic jams on the roads; we'll have to fly."

Aviation emissions have increased by 90%. The growth of aviation observed in the first decade of the century

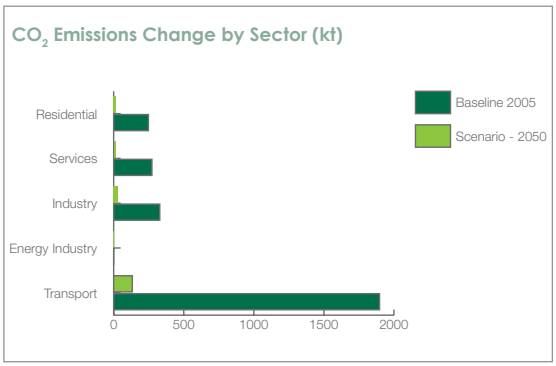
continued, leading to a tripling of vehicle kilometres. Plane travel is increasingly popular as the region forms further connections with the rest of Norway, facilitating international travel from a hub in Oslo. Engine efficiency improvements and 'smarter' approaches to flying have led to less energy being consumed per km.

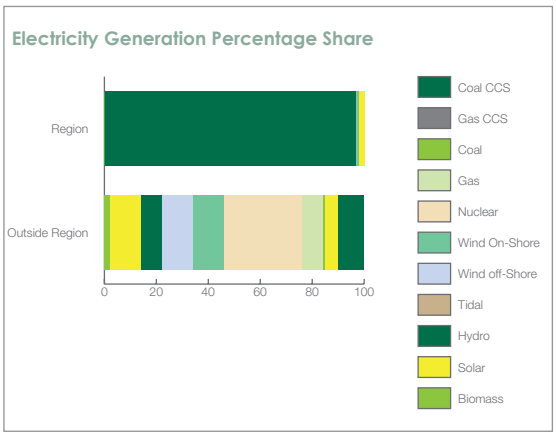
"There's no good reason to assume that the growth rate [in aviation] will not continue, at least until there's a high-speed train between Oslo and Bergen."

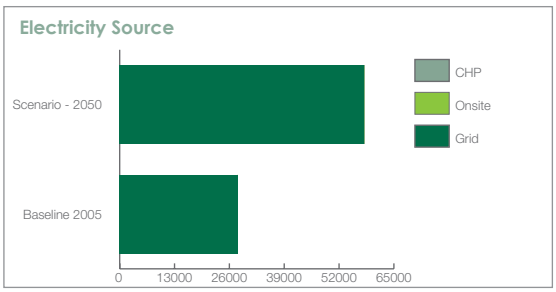
ELECTRICITY GENERATION

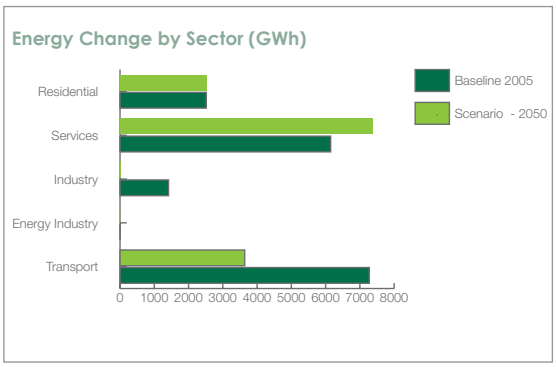
"There will be demand from [Europe for a] grid because people will want to buy cheap green Norwegian electricity."

Norway is part of a European grid. The carbon intensity of the electricity reflects generation across Europe including, for example, onshore and offshore wind generation in Germany, the Netherlands and Denmark, nuclear power in France and elsewhere. There is also a contribution from solar PV and concentrated solar thermal from southern Europe. In the region, electricity generation is almost entirely from hydroelectric power, with some from natural gas and wind turbines.









Emissions Change	-77%
Energy Change	30%
Emissions per Capita	0.4t

2025 Synthesis Scenario: Oslo

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. The final scenario session in Oslo involved 3 representatives from each of the three 2050 scenarios.

ECONOMY AND POPULATION

The population has risen to 1.4 million, constituting 30% of Norway's population. Household size has decreased because there are more elderly and young people living alone. The majority of housing construction has happened in the last five years. Average annual economic growth has been 2% per year, a faster rate than nationally. Industry's share of the economy has reduced and the service sector's share has increased.

RESIDENTIAL SECTOR

Petroleum use has halved, representing the middle of a transition to a zero fossil fuel future. Wood pellets are used in central heating units in older apartment complexes. The use of electricity for heating has increased. New homes have been built and 1% of houses have been retrofitted to PassivHaus standards, reducing heat demand. Behavioural change has further reduced heat demand.

SERVICE SECTOR

Efficiency improvements in service sector buildings have been similar to those in residential properties. Smart metering has helped to manage appliance electricity use. However, electricity consumption has increased due to the nature of service operations changing. There has been little change in heat demand, and the sector has not embraced on-site heat technologies.

INDUSTRIAL SECTOR

Petroleum has been substituted by bioenergy in the energy mix. Heat demand has reduced, aided in part by the changing nature of industry. On-site renewable technologies for heat and electricity generation take the form of pilot projects and showcase developments. The residential, service and industrial sectors share a CHP network that is mainly powered by bioenergy and waste.

TRANSPORT SECTOR

Road vehicles kilometres have increased by 20%. The region is growing, both in terms of land and population. There have been improvements in energy efficiency as vehicles are replaced and electric cars are becoming more mainstream. Buses run on hydrogen. Rail kilometres have increased by 50%. Efficiency improvements inherent in new vehicles are taking longer to materialise due to the comparatively longer lifespan of rail transport's rolling stock.

Aircraft kilometres have increased by 25%. High-speed rail has been developed but has not impacted on European air travel. Improvements to flight practices, for example ensuring the continuous smooth descent of aircraft, are helping to reduce emissions. The aviation energy mix contains a blend of kerosene and 5% bioenergy.

Many of the changes made by 2025 are intermediate solutions, designed to reduce emissions in the short to medium term, which will be phased out by 2050 as newer technologies become available.

HOLMENKOLLEN SKI JUMP
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Next Steps: Oslo

INTRODUCTION

This section identifies how the Oslo Arkershus Region might work towards 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.

None of the scenarios produced emissions reductions of at least 80% by 2050. These scenarios 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. A quarter of heat demand in the residential sector is met by bioenergy. One action could be to assess the current potential for bioenergy production in the region and set policies and actions to maximise take-up.

RESIDENTIAL SECTOR

The residential sector consumed 32% of the region's energy, but generated 8% of the region's CO_2 emissions in 2005. The CHP system that provides 45% of the heat and cooling energy is fired mainly with biofuel and therefore has low-carbon intensity; extending this system, if demand could be met, could help to further reduce emissions.

Over reliance on biofuel could have wider environmental impacts, such as the destruction of established forests and pressure for agricultural land to be turned over to energy crops. Whilst existing CHP in the region could usefully be extended, it would be prudent to increase energy efficiency in the residential sector alongside moves to decarbonise the CHP fuel mix. Where a CHP unit serves an apartment building or several buildings, changing the fuel in CHP can be seen as a 'quick win' since it may not entail working with each individual tenant or landlord. Decarbonising the household fuel mix, by removing the petroleum used directly in heating, should also be a priority. Using electric heating is an option, especially considering the low-carbon content of the grid, as is the installation of on-site technologies such as ground-source heat pumps and solar water heating.

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 region.

Behavioural changes will also be important 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 metres can help householders to better understand their energy use and budget to make reductions.

SERVICE SECTOR

The 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

The Greenhouse Gas Regional Inventory Project

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.

INDUSTRIAL SECTOR

Although the region's industry is declining, the sector emitted 10% of the region'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 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.

TRANSPORT

In 2005 ransport accounted for 71% of the CO_2 emissions of the region and is therefore a key sector for mitigation initiatives. Road transport, aviation and marine transport are almost entirely dependent on petroleum and, if left to grow, could therefore significantly add to 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. Road charging in the region provides an opportunity to reduce traffic and raise funds for improvements in sustainable transport options. Providing the additional generating capacity can be met, the dominance of hydroelectric power in the national grid makes electric cars a relatively low-carbon prospect.

The emissions reduction potential of the aviation sector can be met by improving fuel efficiency in 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 means that enhancements in engine technology will not happen as rapidly as in the case of, for example, private cars.

ELECTRICITY GENERATION

The national grid is relatively low-carbon with 98% of electricity generated from hydroelectric power, giving grid electricity a low emissions factor. Norway has a greater proportion of hydroelectric in its grid than any other of the $EUCO_2$ regions. If a European grid is developed then Norway may be able to benefit from offering low-carbon electricity to other countries. However, the country also needs to anticipate its future electricity needs and think about whether hydroelectric can continue to meet demand, especially if electro-mobility becomes popular. The potential risk to hydroelectric supply from climate change should also be considered.

It is important not to delay action on decarbonising electricity generation, since infrastructural longevity means that technology installed now is likely to still be in use in several decades.


INSIDE OSLA CITY HALL
© GARY718

Oslo's Municipal Master Plan recognises the importance of sustainable development and climate change mitigation, and the City Council has an action plan to reduce emissions. The Akershus municipalities are developing energy and climate action plans. Policy developments also reflect anticipation of the adaptation challenge. The county council has started a process of a new action plan on environment, where transport will be one of the main elements. We trust that the outputs of $EUCO_2$ are helpful in developing their climate change strategy and in bringing about meaningful change that embeds emission reductions in the activities of the region.


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