MANCHESTER 1824
The University of Manchester
Centre for Urban and Regional Ecology
School of Environment and Development

grip
The Greenhouse Gas Regional Inventory Project

Brussels - Frankfurt - Glasgow - Hamburg - Helsinki - Madrid - Napoli - Oslo - Paris - Porto - Rotterdam - Stockholm - Stuttgart - Torino

Project EUCO2 80/50 Summary

350 European stakeholders develop consensual roadmaps for mitigation

Partner
metropolregion hamburg
METREX
The network of European Metropolitan Regions and Areas
Covenant of Mayors
Committed to local sustainable energy

EUCO2 80/50 is an awareness raising project focused on energy policy and climate change. The project raises awareness through an ongoing stakeholder engagement process called GRIP™ (The Greenhouse Gas Regional Inventory Protocol). In each of the 14 partner regions greenhouse gas (GhG) emissions inventories and energy baselines were constructed by regional stakeholders with support from the GRIP™ team at Manchester University. These results were subsequently transferred into the GRIP™ energy and mitigation computer simulation tool (The GRIP™ Scenario Tool) which was used, with a total of 350 stakeholders spanning 50 workshops and 14 regions, to form energy and emissions scenarios.

METREX, the Network of European Metropolitan Regions and Areas. The Network has members from some 50 metropolitan regions and areas and partners in many others. The EUCO2 80/50 project has been conceived, initiated and promoted by METREX over the period 2006 to 2009 in partnership with the Metropolitan Region of Hamburg and the University of Manchester.

The GRIP™ methodology was developed by Dr Sebastian Carney at the University of Manchester. The University of Manchester is the sole academic partner of project EUCO2 80/50.

The GRIP™ methodology was evaluated in 2009 by a study commissioned by the Joint Research Centre of the EC (European Commission) and subsequently recommended by the Covenant of Mayors (CoM) office as a best practice methodology to its members.

The Metropolitan Region of Hamburg has coordinated project EUCO2 80/50 from the beginning in conjunction with the Coordination Centre for Climate Issues in the Hamburg Ministry for Urban Development and Environment.

General Electric's **ecomagination** initiative concentrates on the development of clean technologies and renewable energy. Through this initiative it supports project EUCO2 80/50 as “Europe's biggest and probably most ambitious cities initiative to reduce urban greenhouse gas emissions”. GE is the exclusive industrial partner of the project.

Foreword

The Metropolitan Region and the Free and Hanseatic City of Hamburg felt and feels honoured to be the coordinating Lead Partner of project EUCO2 80/50, currently the most important European climate protection initiative.

The project has experienced a lot of critical moments. Twice, in 2007 and 2008, the Secretariat of the InterregIVc programme refused to approve project EUCO2 80/50. The project uses the GRIP™ methodology which is recommended as a best practice tool by the Joint Research Centre of the European Union.

It speaks for the extraordinary commitment of the cities and regions involved that they could not be discouraged and decided to realize the first step, the production of regional CO_2 inventories, at their own expense.

For the scenario step, General Electric decided to become the exclusive industrial partner of EUCO2 80/50 which allowed the project to be continued.

I thank the sponsor GE, the University of Manchester and all the representatives of the partner regions for their tireless commitment in the interest of climate protection.

The results of project EUCO2 80/50 presented in this brochure are a milestone for Europe. Never before have so many regional European stakeholders worked together in order to anticipate and plan for a low carbon European future in a consensus building process.

The results of this big European effort indicate us the next steps that we must go through in order to limit and mitigate climate change. The results also show the size of the task to be undertaken and indicate the support that regional stakeholders need tat both national and European level.

I am convinced that the regions involved will integrate the results of EUCO2 80/50 into their regional climate strategies, and I do hope that many other cities and regions will use the GRIP methodology.

Hamburg, June 2011

Holger Lange
Secretary of State
Hamburg Ministry for Urban Development and Environment


Helsinki


Paris


Hamburg


Naples


Rotterdam


Brussels

Overview

The EUCO2 80/50 project has been conceived, initiated and promoted by METREX over the period 2006 to 2009 in partnership with the University of Manchester and the Metropolitan Region of Hamburg. There are 14 metropolitan regions involved in the project, which together account for approximately 10% of the population of the EU.

The Metropolitan Region of Hamburg is the Lead Partner of the project. Manchester University is the sole academic partner and General Electric is the exclusive sponsor of EUCO2 80/50. GE should be commended for their sponsorship and for not interfering in the research. These factors meant that the scenario stage of the project was realised.

There are three stages to the project; the first stage was the formation of an emissions and energy baseline, and this was completed in 2010. The second stage, presented here, is the formation of energy emissions reductions scenarios; this was completed in 2011. The final stage is to transfer the learning from the first two stages into policy; this is, and will be, ongoing.

The main goal of the project is to increase the understanding of energy issues and their association with carbon dioxide emissions in each region so that energy policy may be formed.
EUCO2 80/50 follows the GRIP™ methodology, and as such it is stakeholder focused. The inventory stage included training regional representatives to compile an emissions inventory - this required these representatives to liaise with regional bodies, which, in turn, enabled them to build links with relevant stakeholders in their region.

The scenario stage of the project required further engagement with these stakeholders and the formation of links with others in each region to ensure as many sectors were represented in each scenario session as possible. In some regions these links already existed; in others they needed to be formed. This was done through the support of Manchester University and the other partner regions.

If these regions are to play their part in reducing global atmospheric concentrations of GhG emissions they must reduce their emissions in the short, medium and long term. If these regions believe in climate change science then these emissions reductions targets should be considered, or referred to as, ‘necessary’ - rather than, ‘optimistic’, ‘ambitious’ or ‘optional’ by the regions.

There are no ‘good’ or ‘bad’ results in this report. In the same way that an emissions inventory shows where a region is, or was, in terms of its emissions, the scenarios presented in this document are symbolic of the discussions that took place in each of the scenario workshops. The main purpose of the EUCO2 project is to increase the understanding of climate mitigation in each of the partner regions and to transfer this learning into practice. Its purpose is not to criticise the findings or the stakeholders that were engaged.

The scenarios presented here should not be seen as providing a set way forward for policy in the regions but as providing insights into different potential futures that policy makers may seek to realise. The results of the emissions reductions scenarios presented in this report are based on exercises in energy planning; the results are therefore a valuable component of future energy strategies and understanding these results will help regions, nations and European institutions to plan for their energy futures.

This report is a brief summary of the results of EUCO2 80/50. The whole study can be found at www.euco2.eu or at www.getagriponemissions.com

Dr Sebastian Carney
University of Manchester

Rainer Scheppelmann
Metropolitan Region of Hamburg

Pre-Summary

350 European regional stakeholders participated in 50 consensus driven energy and emissions scenarios

The EUCO2 Project represents the first time that so many high-level regional stakeholders have met to debate the issue of climate change mitigation in a consistent setting. This has enabled the production of consensus driven scenarios which aimed to deliver 80% reductions in CO_2 emissions by 2050.

The EUCO2 project uses GRIP™, the Greenhouse Gases Regional Inventory Protocol developed by Sebastian Carney at the University of Manchester. GRIP™ is a recommended process by the Covenant of Mayors to its member cities.

From its outset the EUCO2 project recognised that an 80% reduction in emissions by 2050 is technically possible, but that it would be difficult to translate into policy. It also recognised that to deliver such policies would require the buy-in and understanding of regional policymakers and other key stakeholders – this is also the tenet of GRIP™.

The EUCO2 Project – Three Stages

EUCO2 80/50 is a three stage approach to mitigation. In 2009, the first stage was completed resulting in the production of a set of greenhouse gas emissions inventories and energy baselines for each participating metropolitan region in accordance with GRIP™ standards.

In 2010, these baselines were transferred into the GRIP's™ scenario software for use in regional scenario workshops. In this second stage, regional stakeholders were actively engaged. The University of Manchester worked with each of the regions to identify key stakeholders; the regional authority subsequently assembled these stakeholders into regional scenario workshops, which usually contained 8 to 10 participants.

The stakeholder's task was to produce energy-emissions scenarios that deliver at least an 80% reduction in emissions.

These scenarios were formed through facilitated discussions led by University of Manchester researchers regarding actions, policies and other drivers of change, together with potential risks associated with emissions reductions, to explore the effects of these assumptions in terms of a change in emissions. Through consensus building in these scenario exercises the stakeholders were able to produce a consensus scenario.

The third stage of the EUCO2 project will be the formation of policy together with further exploration exercises using GRIP™ by regional stakeholders as policy is implemented.

How does the scenario tool work?

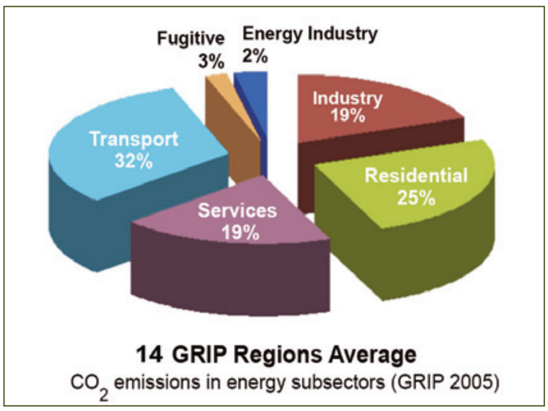
The discussions in the scenario workshops were based on the same drivers as the IPCC (Intergovernmental Panel on Climate Change) SRES (Special Report on Emissions Scenarios). Associated with these discussions the stakeholders were asked to quantify their discussions in terms of:

- Changes in the demographic and economic makeup in 2050
- Changes in technologies used for electricity generation and supply
- Changes in sectorial energy demand

The effects of these changes were instantly fed back to the stakeholders through the GRIP™ scenario software showing a change in CO2 emissions (whether an increase or a decline).

Who participated in the scenario workshops?

The level and type of stakeholders engaged varied slightly between the metropolitan regions. The stakeholders included ministers, state secretaries, representatives of the Chambers of Commerce, CEO's from the industrial, housing and service sectors, senior academics, heads of public administration and scientists.



The regional energy inventory data, energy baseline and demographics are transferred into the GRIP™ Scenario tool

Example of a scenario session assumption: changes in the non-electrical energy mix in the residential sector, the CO2 change in the sector associated with these changes (1) and the overall regional affect of these changes in terms of CO2 (2)

What do the results tell us?

The results of the scenario workshops should not be considered as predictions. **They provide us with insights, in terms of alternative futures, of how stakeholders see their regions' energy future developing up to 2050, which mitigation measures they see as possible and what the key issues are for them.** This helps analysts and policy makers to identify **what is seen as the key steps in mitigation for each region**.

Thus, the results are an important contribution to climate policy in Europe and in the world. The results will influence the regional climate strategies. They should contribute to the formulation of national and European strategies. Furthermore, they should be used to encourage other regions and metropolitan areas to use the GRIP™ approach for finding a consensual strategy in their towns and regions.

What are the key findings?

Each of the 50 scenario workshops differed **but largely reiterate** findings known by experts, but not necessarily by laymen:

1. Only 35% of the scenarios reached the target of an 80% reduction.

Whilst the target of each scenario exercise is an 80% reduction in CO2 emissions, the reductions realised in the scenarios vary between -37% and -99%. Approximately two thirds of the scenarios fell short of an 80% reduction – with these figures not including international aviation and marine emissions (which would likely result in lower emissions reductions, based upon the discussions regarding domestic aviation).

These results suggest that it is the consensus of the stakeholders engaged that a reduction in emissions of 80% is not possible. There are many potential reasons for this, but it would indicate that stakeholders need further information and guidance than is currently provided, together with additional political and economic incentives, to see mitigation targets realised.

2. Southern European stakeholders were less confident in mitigation chances than the rest of Europe.

The scenarios in Italy and Portugal deliver lower CO_2 reductions than those in the other participating European countries. The highest emissions reductions in the scenarios come from countries with lower emissions, in the baseline year, such as Norway. Further research will seek to identify if this trend is due to culturaldifferences, awareness, or something else.

3. Low Carbon Electricity generation is key to mitigation.

In each scenario the CO_2 released per unit of electricity reduces (carbon intensity). In many scenarios the carbon intensity of electricity production reduces to almost zero.

However, many scenarios include electricity production from fossil fuels without Carbon Capture and Storage (CCS) to continue in 2050 – these scenarios tend to deliver the lowest emissions reductions. More than half of the scenarios contain 20% of fossil electricity generation in 2050 without CCS.

The switch to a low carbon intensive grid is necessary to enable sectorial electrification if a mitigation focused policy is to be realised.

4. A 100% decarbonised grid would on its own reduce European CO_2 emissions by less than 25%.

A 100% decarbonised grid on its own would lead to different results in the partner regions. It would deliver an overall reduction of 5% in Rotterdam, 29 % in Hamburg and 50% in Stuttgart. Across Europe the reduction would be less than 25%.

A decarbonised grid is an important contribution to mitigation, but the remaining 55% in Europe would need to be met through changes in energy demand and the fuel mix of each sector

5. Emissions reductions in the building sector are key to mitigation.

In the residential and service sectors, demand reduction measures, such as insulation together with low carbon fuels, can deliver high CO_2 emissions reductions. In combination with changes in behaviour, these sectors could contribute 25% of Europe's CO_2 emissions reductions.

6. Increased Industrial efficiency can contribute substantially to emissions reductions.

A consistent storyline in the scenarios is that the industrial sector, for financial and efficiency reasons, will need to reduce its energy consumption per unit of economic output (energy intensity), and with this their CO_2 emissions, by at least 50% to deliver the overall emissions reductions.

7. Savings in electrical energy are necessary even with a decarbonised grid.

A supply orientated scenario would suggest that reductions in electricity demand are not necessary if a zero carbon grid is available. Nevertheless, if emissions associated with electricity production do reduce then this will make it easier to meet future demands of electrical energy in the transport sector. However, it should be noted that this approach would require larger scale implementation of policy than may be required.

8. Road transport is key to mitigation.

In the majority of scenarios the road transport sector delivers the highest sectorial emissions reductions. These emissions reductions are realised through efficiency improvements and 'fuel' switching to electromobility, hydrogen and bioenergy. If the common approach taken in the scenarios was to be realised across Europe it would result in a decrease of European CO_2 emissions of 20%.

Example of Stakeholder's Participation


Madrid

Common key findings of EUCO2 80/50

Contribution of the different sectors to the overall 80% reduction goal

Renewable GRID ≈ -25%

Savings in residential and service sector ≈ -25%

Higher efficiency in industry ≈ -10%

Switch to electromobility and hydrogen ≈ -20%

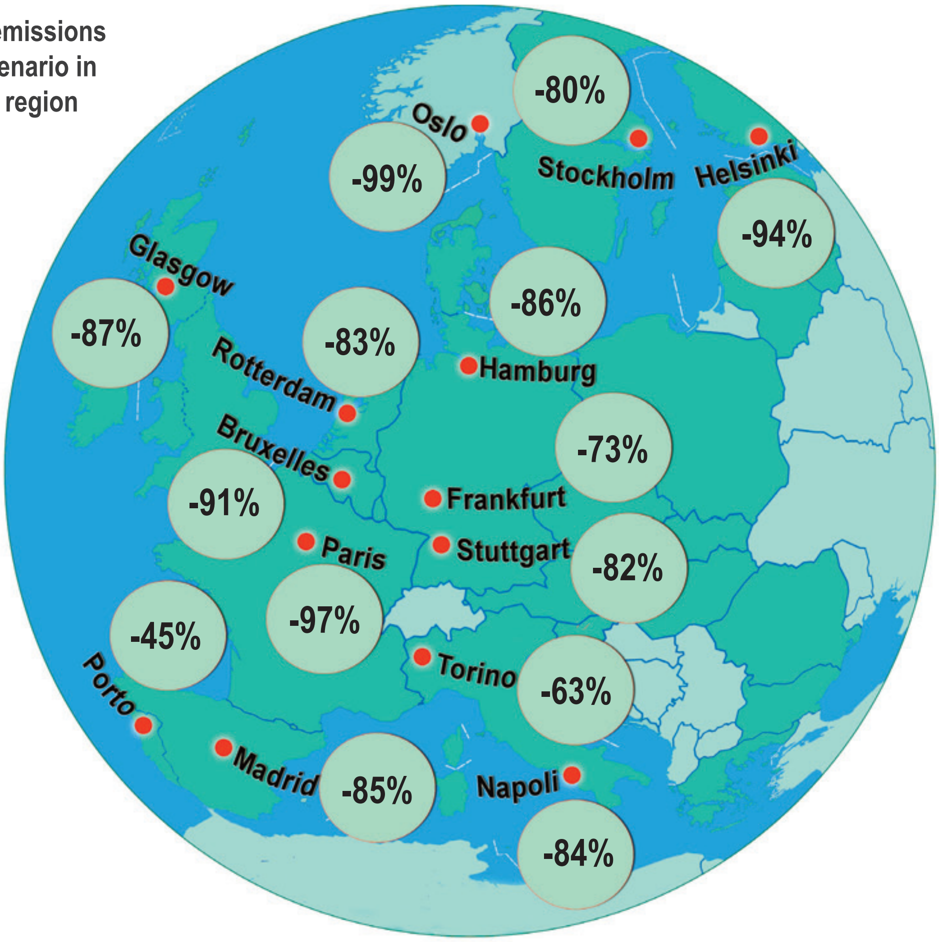
≈ -80%

A 25% reduction in emissions due to a near zero carbon grid is reflected in the different sectors in the scenario tool according to each sectors electrical consumption and the change in the carbon intensity of the electricity produced.

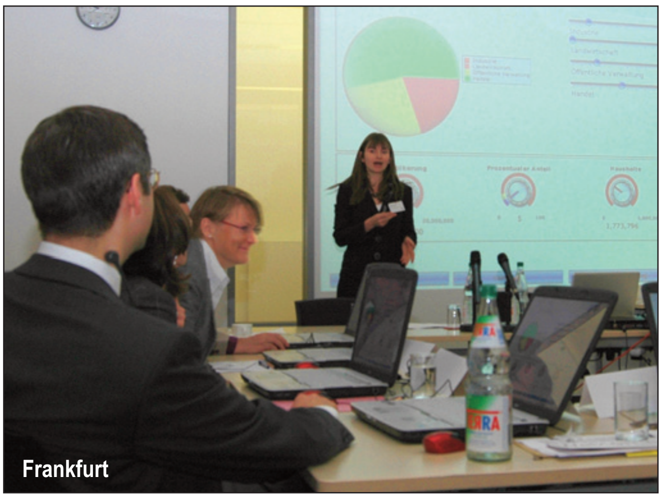

Oslo


Brussels

The largest emissions reduction scenario in each partner region



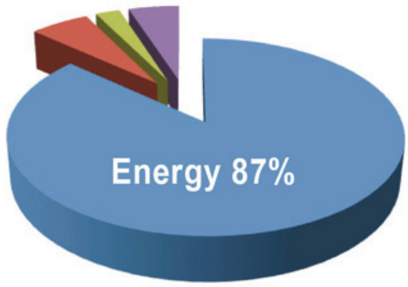

Turino


Frankfurt

Inventory Step

CO_2 emission sectors

In the first stage of the project, in 2009, greenhouse gas emissions inventories and energy baselines were formed for each partner region. These were produced using the GRIP™ methodology, which is largely based on the standards of the UNFCCC (United Nations Framework Convention on Climate Change) for national inventory submissions.



14 GRIP Regions Average
Emissions by sector (CO_2e)

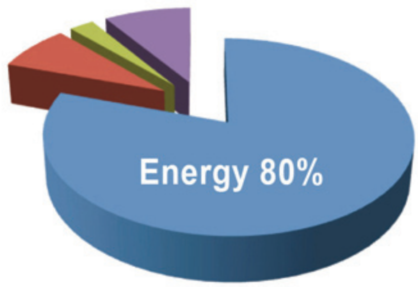
Year of reference

The emissions inventories used the baseline year of 2005 as this was the earliest year that the appropriate data was available for the majority of the partner regions

What has been measured?

The emissions of the ‘Kyoto basket’ of six greenhouse gases were estimated for each key sector in each partner region. These are presented in the charts in terms of each their CO_2 equivalents (CO_2e).

The four sectors considered in GRIP™ are **Waste**, **Agriculture**, **Industrial Processes** (without energy consumption) and **Energy**.

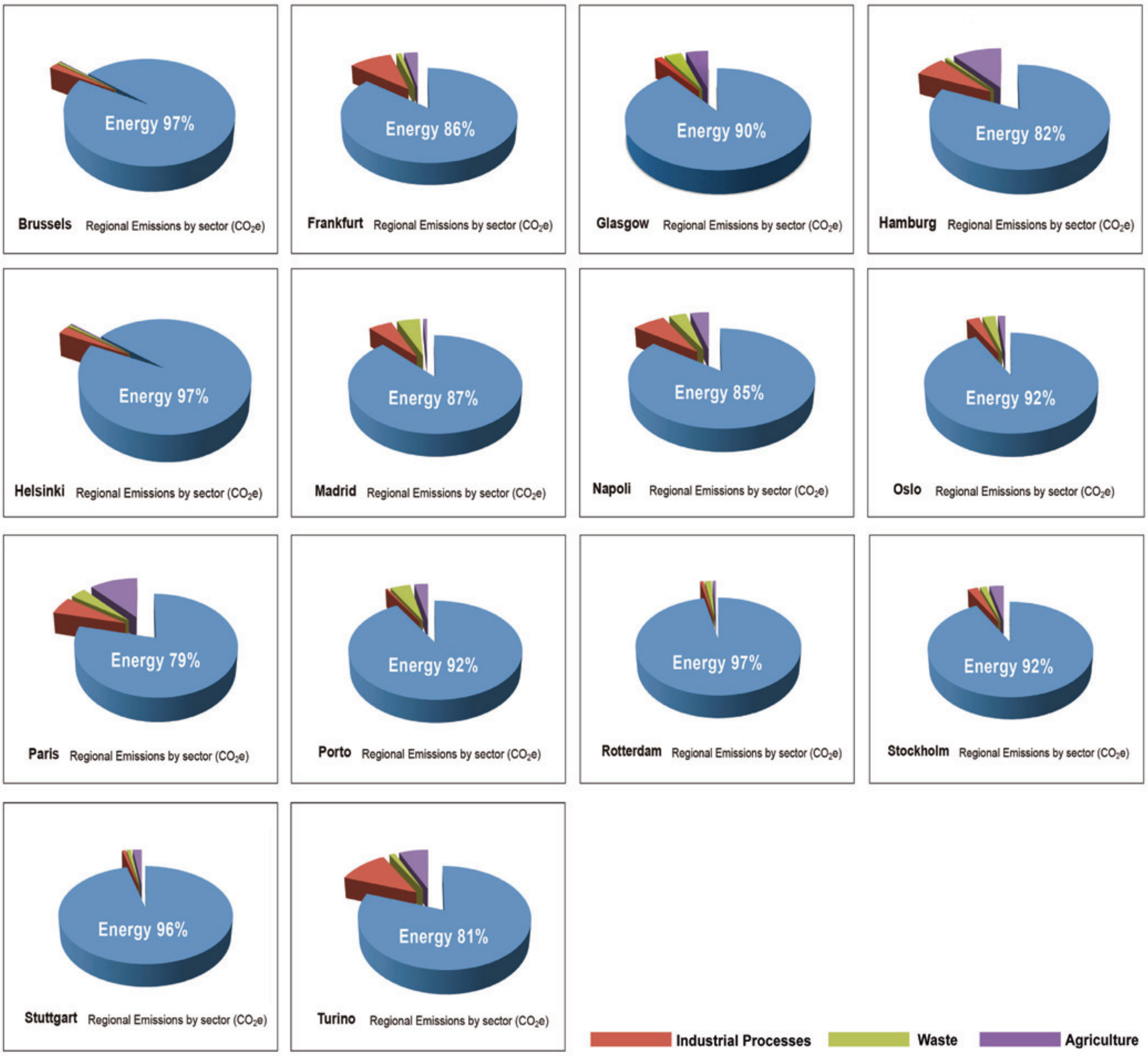


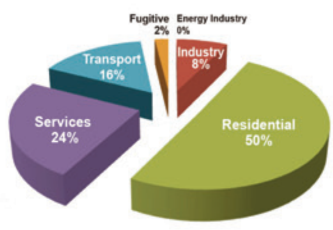
European Union
Emissions by sector (CO_2e)

Significance of the energy sector

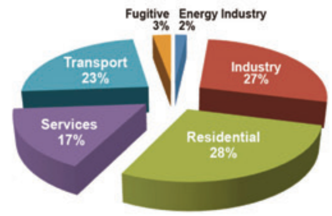
The inventories produced showed that the combustion, transformation and extraction of energy - both electrical and non-electrical - is the main source of CO_2 emissions in the partner regions. The emissions associated with the combustion, distribution, transformation and extraction of energy accounted for between 79% (Paris) and 99% (Brussels/Helsinki) of the overall CO_2e emissions in the partner regions.

The dominance of energy as a cause of emissions is the reason why the EUCO2 project, and policy internationally, focuses on energy planning as the mechanism to reduce GhG emissions, and is the reason why the GRIP™ process also focuses on energy planning and CO_2.

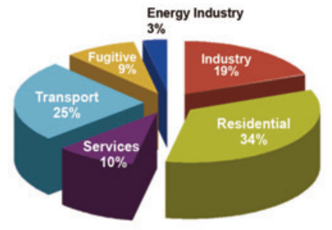

Energy 97%
Brussels Regional Emissions by sector (CO_2e)
Energy 86%
Frankfurt Regional Emissions by sector (CO_2e)
Energy 90%
Glasgow Regional Emissions by sector (CO_2e)
Energy 82%
Hamburg Regional Emissions by sector (CO_2e)
Energy 97%
Helsinki Regional Emissions by sector (CO_2e)
Energy 87%
Madrid Regional Emissions by sector (CO_2e)
Energy 85%
Napoli Regional Emissions by sector (CO_2e)
Energy 92%
Oslo Regional Emissions by sector (CO_2e)
Energy 79%
Paris Regional Emissions by sector (CO_2e)
Energy 92%
Porto Regional Emissions by sector (CO_2e)
Energy 97%
Rotterdam Regional Emissions by sector (CO_2e)
Energy 92%
Stockholm Regional Emissions by sector (CO_2e)
Energy 96%
Stuttgart Regional Emissions by sector (CO_2e)
Energy 81%
Turino Regional Emissions by sector (CO_2e)
Industrial Processes
Waste
Agriculture



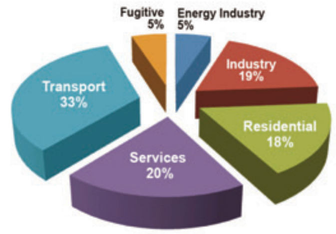
Brussels CO_2 emissions in energy subsectors (GRIP 2005)



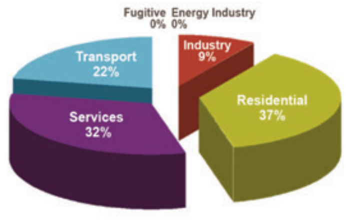
Frankfurt CO_2 emissions in energy subsectors (GRIP 2005)



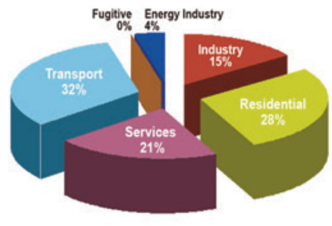
Glasgow CO_2 emissions in energy subsectors (GRIP 2005)



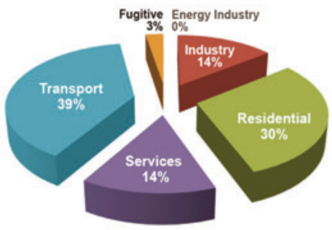
Hamburg CO_2 emissions in energy subsectors (GRIP 2005)



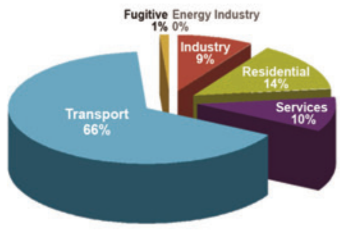
Helsinki CO_2 emissions in energy subsectors (GRIP 2005)



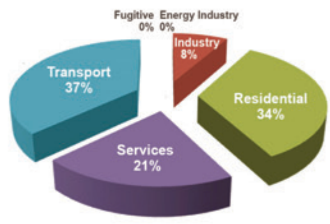
Madrid CO_2 emissions in energy subsectors (GRIP 2005)



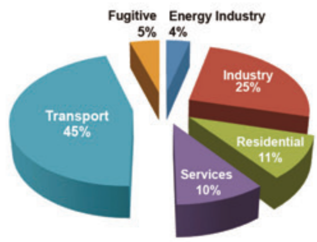
Napoli CO_2 emissions in energy subsectors (GRIP 2005)



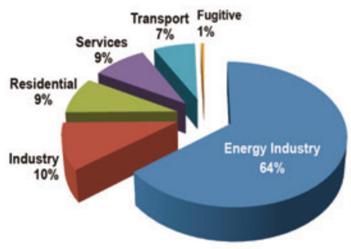
Oslo CO_2 emissions in energy subsectors (GRIP 2005)



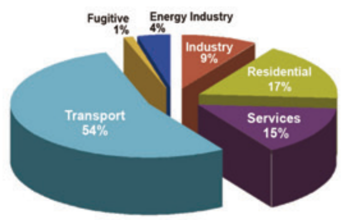
Paris CO_2 emissions in energy subsectors (GRIP 2005)



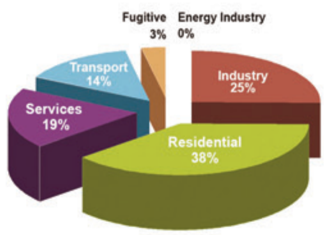
Porto CO_2 emissions in energy subsectors (GRIP 2005)



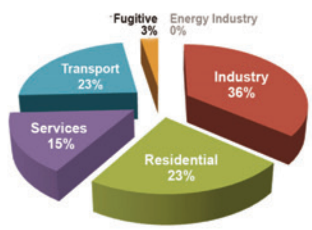
Rotterdam CO_2 emissions in energy subsectors (GRIP 2005)



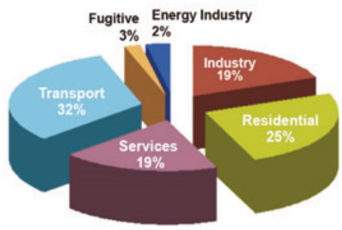
Stockholm CO_2 emissions in energy subsectors (GRIP 2005)



Stuttgart CO_2 emissions in energy subsectors (GRIP 2005)



Turino CO_2 emissions in energy subsectors (GRIP 2005)



14 GRIP Regions Average
CO_2 emissions in energy subsectors (GRIP 2005)

Energy Consuming Sectors

In GRIP™, the combustion, distribution and extraction of energy which cause CO_2 emissions is primarily considered in terms of five sub-sectors:

- Residential
- Services
- Industry
- Energy Industry
- Transport

GRIP™ considers emissions in terms of these sectors because the methodology allocates emissions associated with electricity generation to the end user.

Electrical versus non-electrical

The percentage split of electrical and non-electrical energy consumption varies between the above five energy sub-sectors.

In 2005, the transport sector was nearly completely propelled by non-electrical energy (petrol, diesel, kerosene etc) with a small percentage from electricity (primarily rail transport). The industrial sector had a share of approximately 33% electrical energy consumption while in the residential sector more than 70% of energy consumption was usually non-electrical energy consumption (for space heating and warming water).

Big differences in the partner regions

The reasons for the differences in the regional inventories presented here vary between the regions. This may be due to economic differences, to the way electricity is produced and to the share of electrical and non-electrical energy consumption.

In **Rotterdam**, the energy industry is responsible for 64% of the overall GhG emissions. This is due to Rotterdam's energy industry largely consisting of petroleum refineries transforming crude oil into usable fuels for parts of northern Europe, and as a consequence of the current process, they combust petroleum fuels – thereby emitting CO_2.

Under a future with lower petroleum consumption (e.g. in road vehicles) there will be a decline in the need for oil refineries by 2050, and with this emissions will decrease, however, where this decrease will take place is unknown (e.g. which petroleum refineries).

Mitigation is not just a long term problem, it requires instant action. Higher levels of energy efficiency together with Carbon Capture Storage (CCS) may be ways in which emissions may be reduced by petroleum refineries in the longer term.

The contribution to overall emissions reductions of the sectors identified above varies between the scenarios and the regions.

In **Oslo**, emissions from transport in 2005 made up 66% of overall emissions, a similar level to **Stockholm** (64%). This is due to the low carbon intensity of the national grids in Norway and Sweden, in comparison to the carbon intensity of petroleum; this enables other sectors to have lower emissions, rather than Stockholm or Oslo having a comparatively highly polluting transportation sector. These regions are well placed to further reduce emissions if the low carbon electricity generation is maintained. Both regions need to explore further opportunities in low carbon road transport and are well placed to lead the way.

In **Brussels**, the service sector is the dominant source of emissions partly because of its size; it for example, includes the key European institutions. The majority of emissions in Brussels are split between the residential and service sectors. In the Brussels scenarios, strategies to reduce energy demand in buildings is a special point of interest.

All sectors have to contribute, but potentially to differing degrees.

The EUCO2 project identified through the inventory stage the otential key focus areas for mitigation in each region. Each sector in each region must make a contribution to the common target of at least an 80% reduction in CO_2 emissions – however we must recognise that the reductions will vary between the regions and their sectors reflect their current and future economic and energy makeup.

A scientist or another expert can provide guidance on the measures needed to reduce emissions, for example: a decarbonised grid, insulation and energy efficiency in the building sector, higher efficiency in industrial production and reducing fossil fuels in the road transport sector.

Mitigation requires more than a simple knowledge dissemination approach. It requires that the stakeholders are engaged and understand how emissions reductions may be delivered rather than being prescribed a set trajectory on how they should be delivered. This is why the EUCO2 project focused on stakeholders and why it used GRIP™.

Per Capita emissions

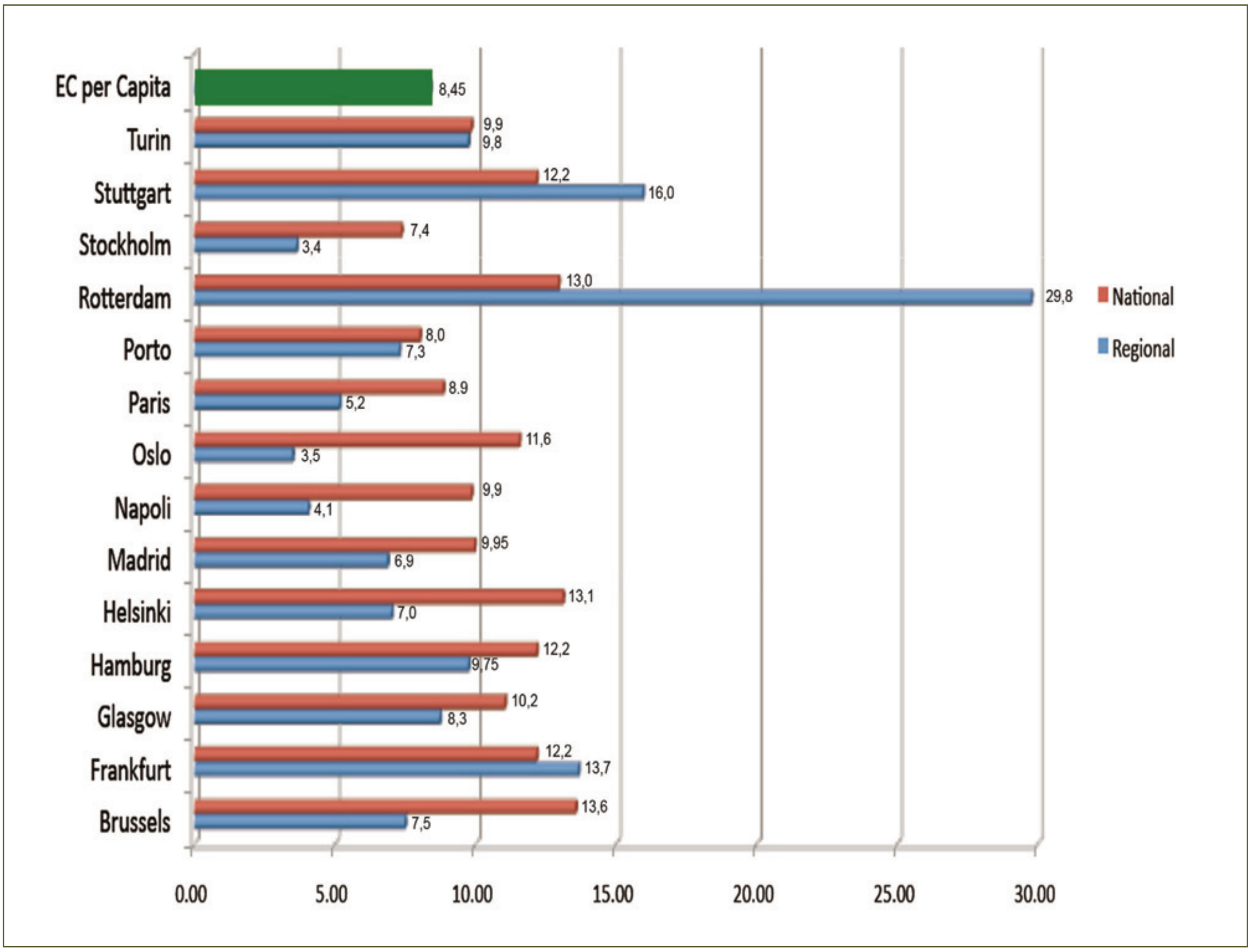
The per capita emissions in the participating partner regions vary both in terms of the baseline year and in terms of the scenarios. There are no “good” or “bad” results or, indeed, good or bad partner regions. Every difference can be explained. For instance, regions with a very small industrial sector like Helsinki, Oslo or Stockholm can be expected to have lower per-capita emissions than regions with a strong industrial sector like Turino, Stuttgart or Hamburg.

Whilst some regions have comparatively lower per capita emissions, which may be construed as a “better” per capita value, this should not necessarily be seen to be the case.

Rotterdam, whilst having the “worst” per capita emissions value of the partner regions, should be viewed in terms of its industrial makeup. These high emissions are due to its oil refineries (energy industry) – if it is considered in terms of its other sectors it has an average emissions value.

Without the energy industry, the per capita value in Rotterdam would be comparable to Frankfurt.

The target for 2050 is for Europe to meet an 80% reduction in emissions, which requires each region to contribute towards this target, with many regions going beyond this target and some below.

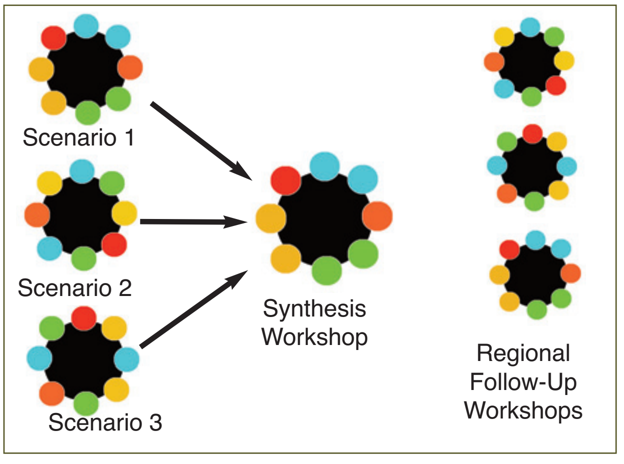


CO2 emissions per capita (tonnes) in 14 Metropolitan Regions (Data 2005)

Scenario Step

Overall results

Like the Inventory Stage, the Scenario Workshops of project EUCO2 80/50 were led in 2011 by Dr Sebastian Carney and his team from the University of Manchester.



Number and structrure of the workshops

In total there were 50 GRIP™ scenario sessions conducted across the partner regions. There were 38 scenario sessions that examined how the region in focus could reduce its CO_2 emissions from energy by at least 80% by 2050, and a set of 12 synthesis workshops that focused on emissions reductions by 2025.

In each scenario session there were approximately 8-10 stakeholders that represented different sectors. The stakeholders were generally high level stakeholders who included Head Planners, Members of Parliament, Chief Executive Officers and Secretaries of State. The stakeholders were selected due to them having an active interest in climate change either personally or as a key component of their jobs.

The partner regions were provided with criteria for selecting the stakeholders and then sourced the stakeholders for the research. In several regions, regional follow-up workshops have been conducted with the participation of Heads of Department, Public Enterprises, environmental groups, university students and groups of primary aged children.

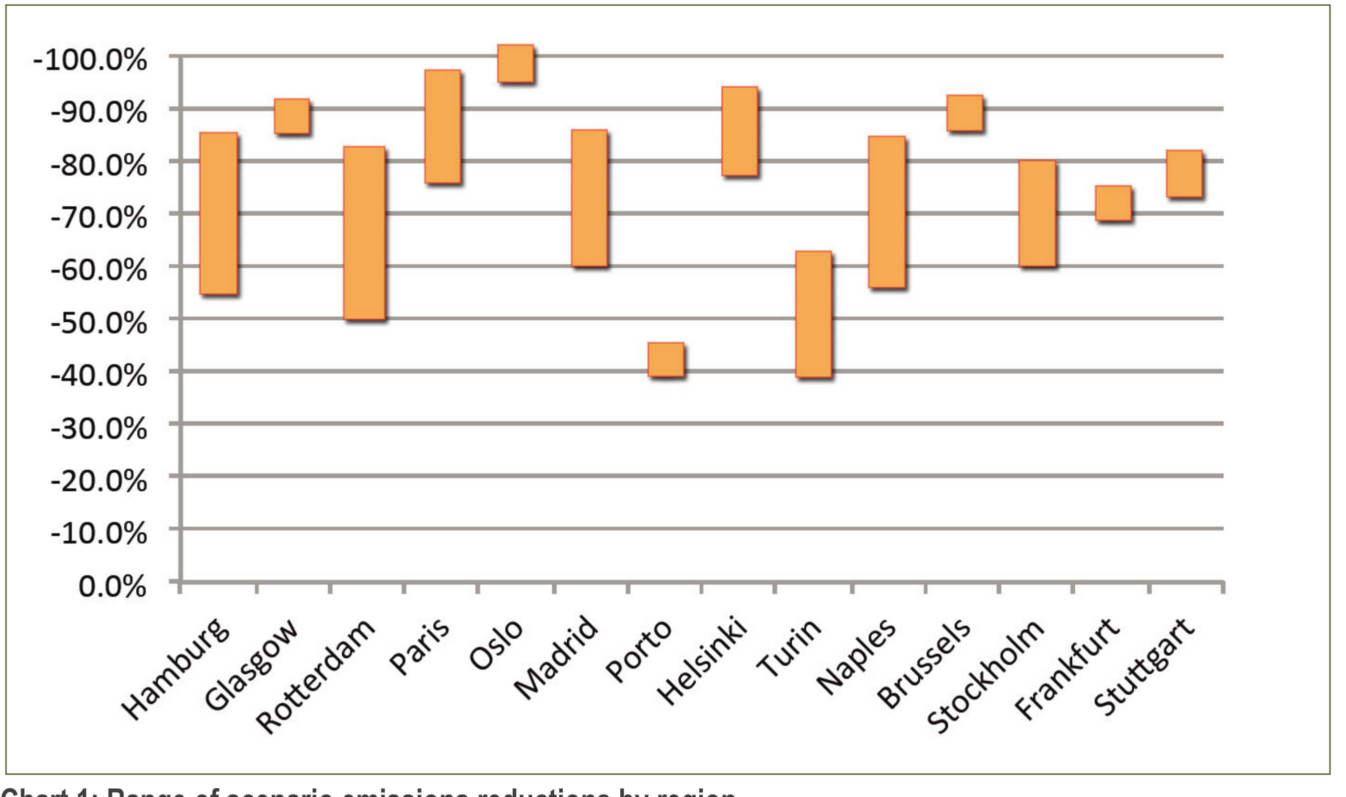


Chart 1: Range of scenario emissions reductions by region

Overall reduction in CO_2 emissions

The CCO_2 reductions delivered in the scenarios varied between 37% and -99%. The orange bars in Chart 1 display the range in emissions reductions delivered in each regional set of scenarios.

In 6 scenario sets there was a low difference in the emissions reductions delivered of between 5% and 10% between the lowest and highest scenario. In 8 regions there is a higher level of difference between the three scenarios. This was mostly due to the composition of the workshops.

In some workshops, unavoidably, certain strong willed participants pushed the group into certain policy approaches and convinced the other participants to examine every possibility of reduction.

In other workshops, stakeholders may be considered to have been more conservative in their assumptions, consequently failing to meet the reductions required in 2050.

Chart 1 (page 15) shows the range of emissions reductions within each scenario set.

In the Rotterdam scenarios emissions per capita remain comparatively higher than in the other regions scenarios.

In this case the underpinning reasons are the assumptions of how the energy industry will evolve. This is because the energy industry – notably petroleum refineries – dominates the Rotterdam emissions inventory and it is a highly energy intensive sector.

Overall reduction in energy consumption

The amount of energy consumed also varied between the scenarios, with 34 scenarios seeing a reduction of between 9% and 68% and 4 scenarios seeing an increase of between 7% and 104%. This can be seen in **Chart 2**.

The difference between CO_2 reduction and energy consumption in a region is a consequence of energy efficiency in buildings, the type of fuels used, the efficiency of vehicles and the use of onsite generation.

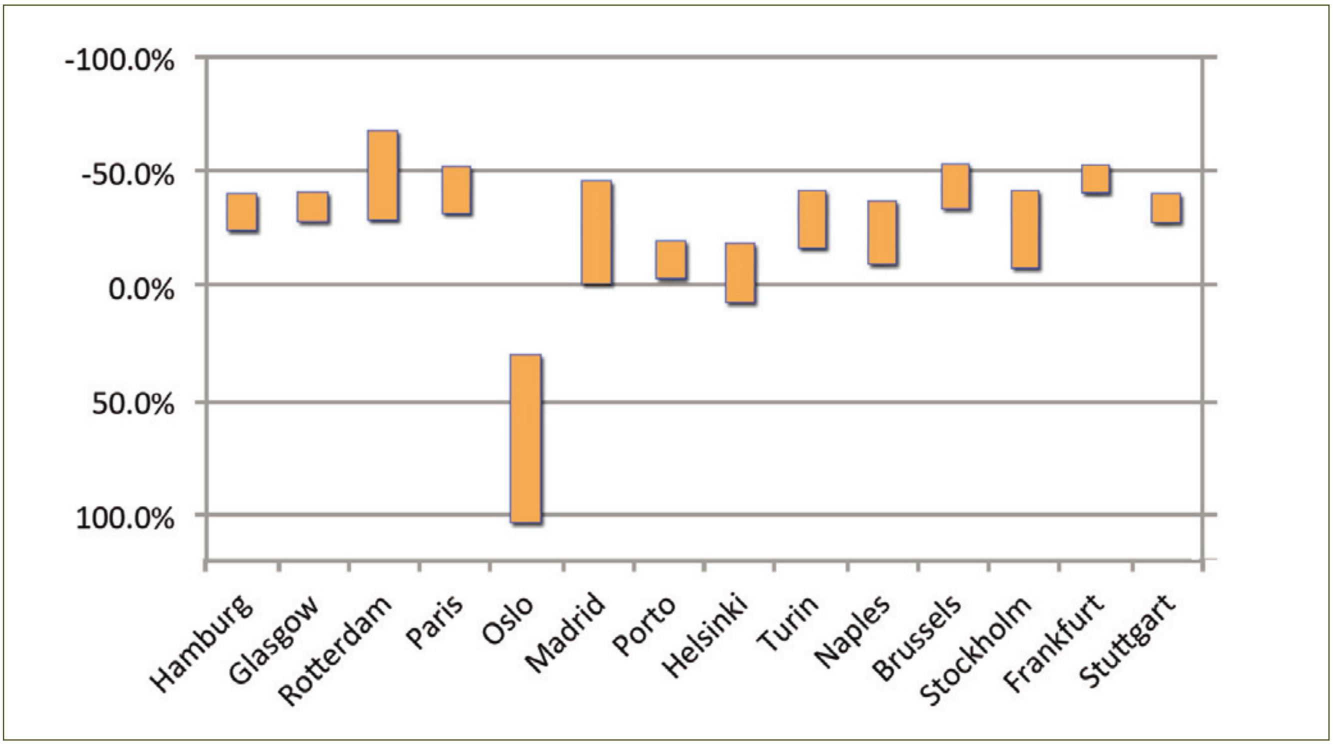


Chart 2: Range of changes in energy consumption by region

It is interesting to note that 3 out of 4 increases in energy consumption occurred in the Oslo Metropolitan Region, which displayed the lowest carbon intensive energy supply in 2005; the remaining scenario that showed an increase in energy consumption was in Helsinki.

Whilst the scenarios vary quantitatively across the regions there is less variation in energy consumption within the scenario sets.

Final tons per capita

A reduction in emissions in percentage terms, in each scenario, should be seen in conjunction with the final tonnes of CO_2 emissions per capita.

This is partly because the baseline for each scenario is different. This is represented in Chart 3; this shows that in 23 of the 38 scenarios emissions fell to less than 2 t CO_2 per capita, with 18 of these scenarios showing emissions of below 1 t CO_2 per capita.

This is a more positive result than if we consider how the regions faired in terms of an 80% emissions reduction target.

The remaining 15 scenarios display emissions per capita of between 2 t CO2 and 18 t CO_2. Considering the emissions in these terms is potentially more useful than an absolute emissions reduction target as it enables a relative focus.

However, using this statistic should carry similar cautions to using absolute emissions targets, in that it does not take into account sectorial differences (e.g. a large energy industry). This is why a combination of absolute and sector specific targets should be used when forming and assessing policy.

It is recognised that different sectors have differing abilities to reduce their emissions and therefore regions with differing economic make ups, affluence, industries and access to renewable resources are likely to seek differing emissions reductions.

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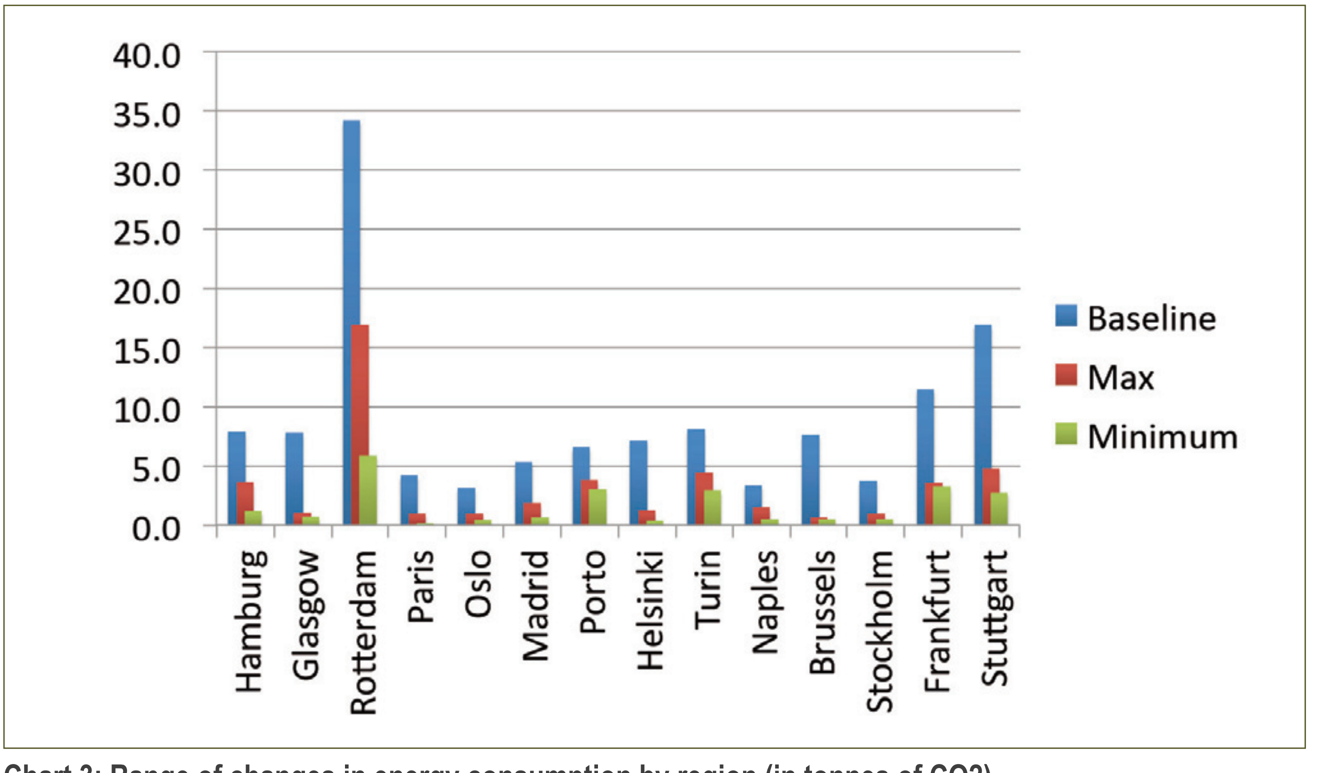

Chart 3: Range of changes in energy consumption by region (in tonnes of CO2)

The **lowest tonnes per capita** outputted from each scenario set are shown in **chart 4**. The circles in orange represent emissions per capita that are higher than 2 t CO_2 per person.

Chart 5, 6 and 7 show the maximum, the average and the minimum reduction scenario in each partner region's scenario set

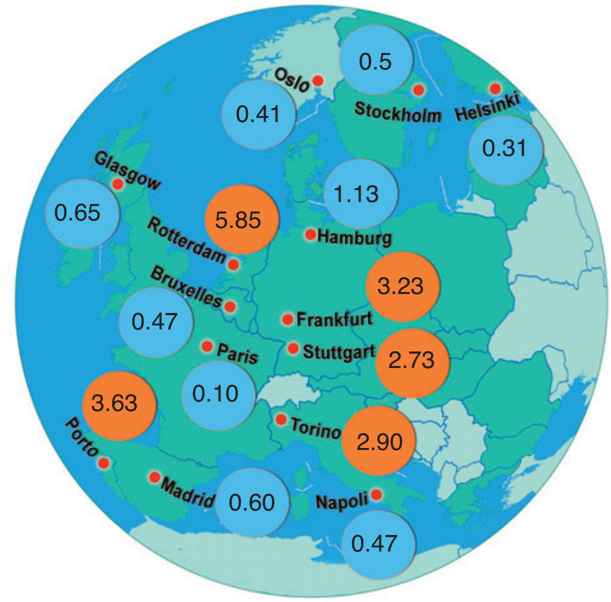

Chart 4: Lowest tonnes per capita scenario

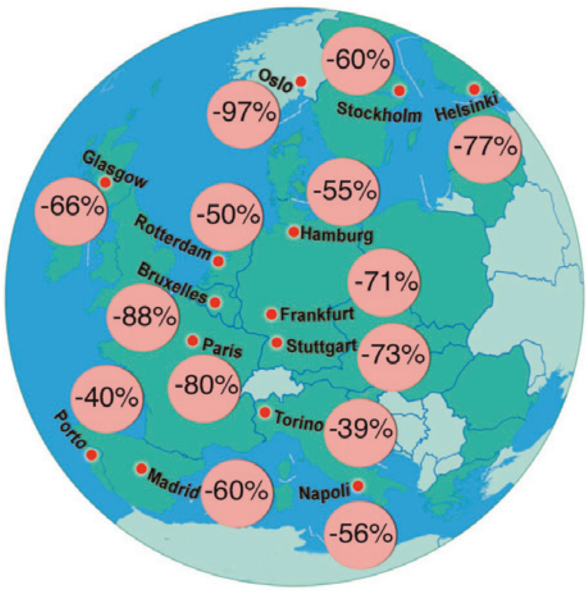

Chart 6: Minimum reduction scenario

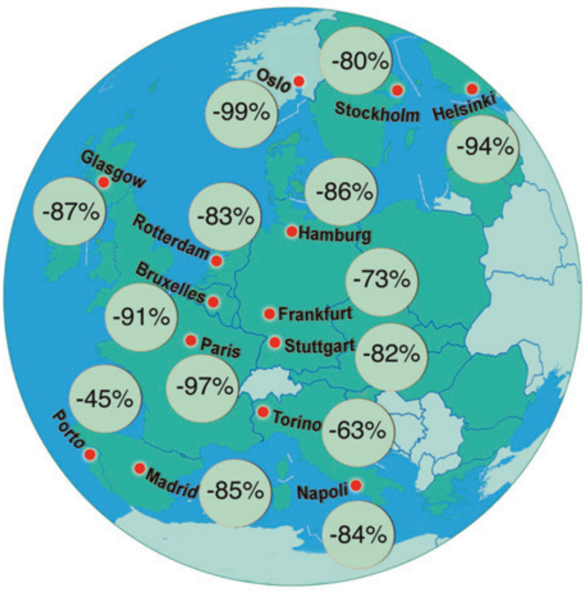

Chart 5: Maximum reduction scenario

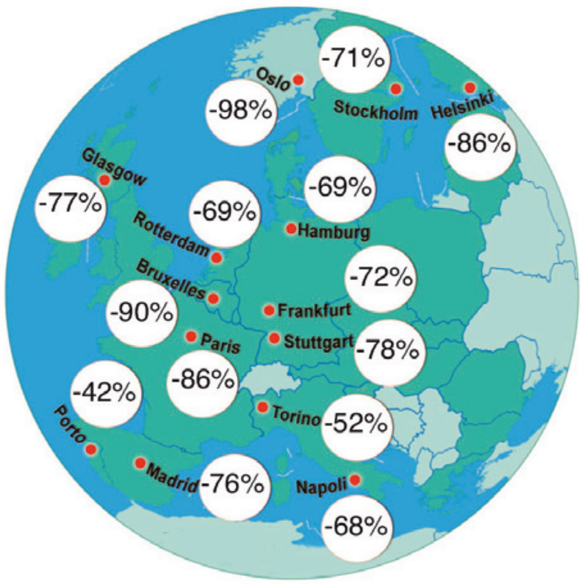

Chart 7: Average reduction scenario

Electricity Generation

A key component of the scenario process is to vision how electricity may be generated in the future. In GRIP™, the emissions associated with the production of electricity are allocated to the end user of the electricity.

Changes in the technologies used to produce electricity are reflected in terms of overall and sectorial CO_2 emissions according to the type of generation and how much electricity is consumed in each sector. The effects of a low carbon grid to certain sectors differed in the partner regions due to differences in energy consumption. A decarbonised grid will be very important for road transport if electromobility increases electromobility increases (see Transport, p 26).

All scenarios produced a greener grid

The type of electricity generation varied by scenario; this was partially influenced by where the electricity was sourced in the scenario.

However, in nearly every scenario the carbon intensity of electricity generation decreases by more than 90%. In the majority of scenarios the change in the carbon intensity of electricity production was the key determinant of the resulting emissions reductions.

The scenarios varied in terms of the utilisation of Carbon Capture and Storage (CCS) technologies; 12 of the 38 scenarios do not display a role for the technology in 2050. Of the remaining scenarios CCS accounts for between 2% and 41% of electricity generated; it accounts for between 10% and 20% of generation in 11 scenarios and for between 21% and 41% in 5 scenarios.

The reason for the difference in uptake in the scenarios is mostly due to perceptions of the safety of CCS balanced against a “reluctant need” for the technology to realise emissions reductions. In total 9 scenarios show fossil fuel based electricity generation (not including CCS) to have disappeared from electricity generation.

Of the remaining scenarios the amount of fossil generation varies between 4% and 50%. The highest levels of electricity generation from fossil fuels is shown in the scenarios in Southern Europe, which partly explains the lower overall emissions reductions realised in those scenarios. In total 3 scenarios contain no fossil generation with or without CCS.

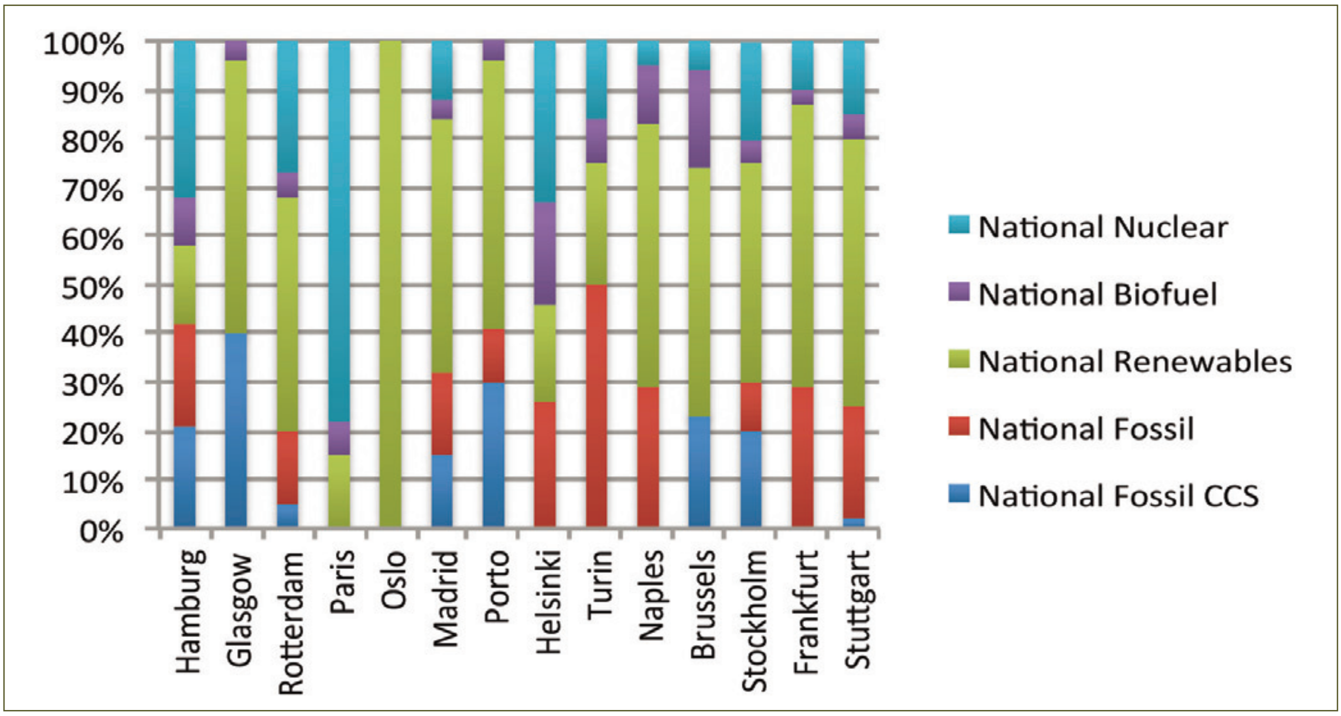

Chart 8: Electricity Generation technologies used in Scenario 1

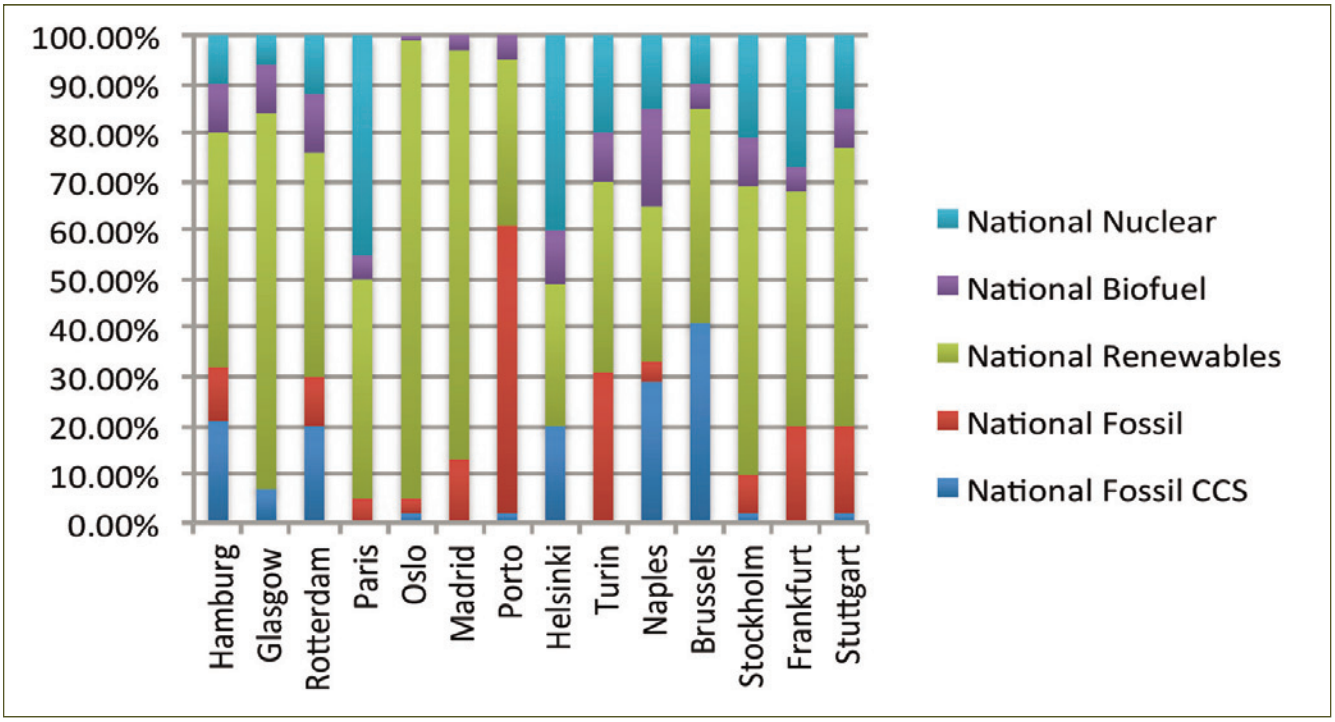

Chart 9: Electricity Generation technologies used in Scenario 2

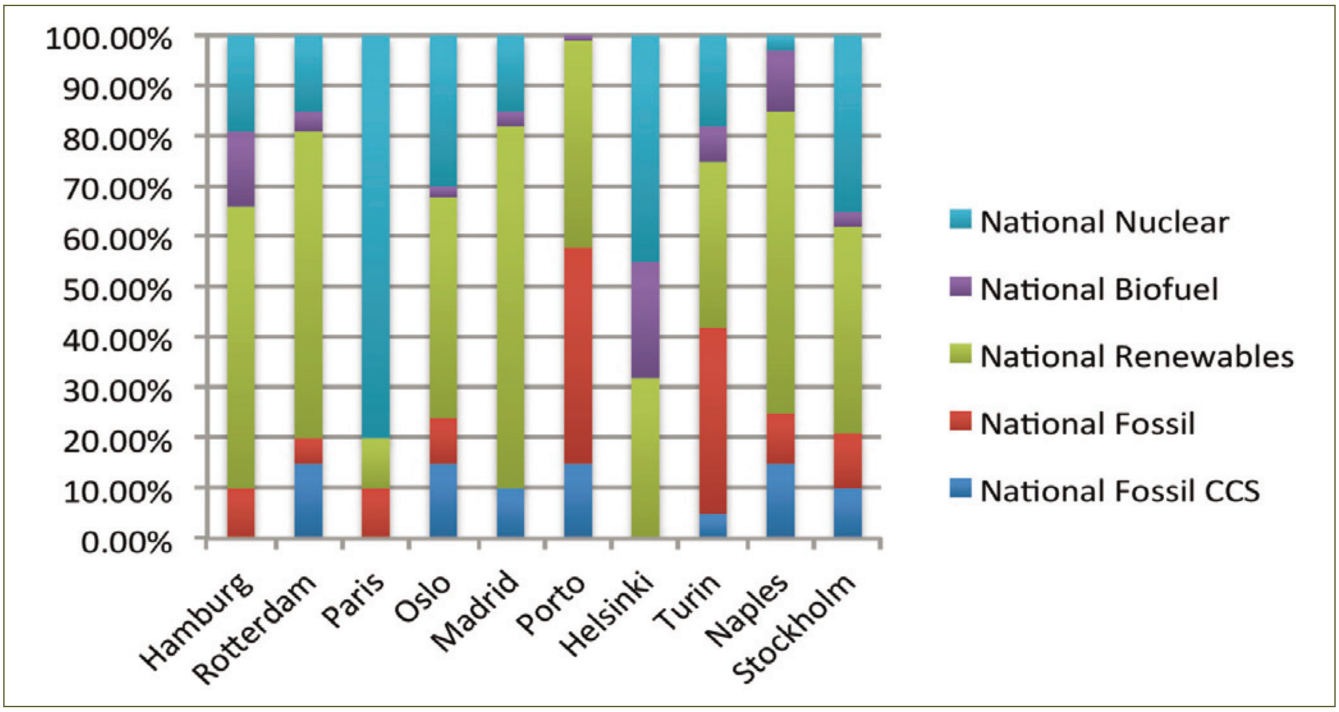

Chart 10: Electricity Generation technologies used in Scenario 3 (in 4 regions only 2 scenarios were carried out)

The amount of electricity generated by renewables, namely wind, hydro, tidal and solar, accounts for between 10% and 100% of generation in the scenarios.

The highest levels of generation from renewable technologies is shown in the scenarios from the Northern European regions. Hydroelectric power featured highly in the Oslo Metropolitan Region scenarios, as it mirrors their generation baseline in 2005.

Wind generation is the most prevalent form of renewable generation in the scenarios otherwise. Bioenergy and waste combustion accounts for between 1% and 23% of electricity generated in 36 of the scenarios.

Nuclear generation does not feature in 7 of the scenarios, with it accounting for between 3% and 78% of generation in the remaining scenarios. It was highest in the scenarios in Ile de France, reflecting the generation mix of 2005.

Charts 8-10 show that electricity generation varied between the energy mix of the grid in the 14 partner regions.

National or trans-European grid?

The boundaries of the generation for the grid vary between the scenarios. The scenarios either have electricity remaining within the country (some contained electricity from an extra-national sharing scheme such as the Nordic network), or in other scenarios electricity was shown to be generated from across the EU and some include additional production in Northern Africa.

The consumption of electricity that was generated from across Europe and/or Northern Africa features in the majority of scenarios.

The main reasons for this was either an acceptance of an ‘energy security policy’ set by Europe that had additional benefits of lowering emissions, or it was an intervention policy required by the region to help it meet its emissions reductions targets, in what it saw was a limited level of renewable generation available to it from within the region and the rest of the country in which the scenario was based.

In some scenarios there was the opposite concern; that the region and the country in which it was based would be placed at a disadvantage by sharing its renewable resources with other regions and countries within Europe, preferring instead to export any excess in electricity generation ensuring a low carbon supply.

Regardless of where the out of region electricity is sourced from, we will now refer to it as the “grid”. In total 18 of the scenarios showed a decline in electricity demand from the grid of between 1% and 55%.

This was driven by a variety of factors already highlighted, including the electrical efficiency of products together with displacement of electricity from the grid to on-site renewable generation and local CHP plants. In the remaining scenarios the amount of electricity sourced from the grid increased due to electrification of heat provision, transportation and hydrogen production.

What can a decarbonised grid contribute to the 80% reduction target?

In the partner regions the share of emissions associated with electricity use varies. The more industrialised a region is, the likelihood is that the lower its share of electricity emissions will be. A decarbonised grid, therefore in general, will likely decrease regional CO_2 emissions more in service based regions than in industrial regions (unless a regional industry is largely based on electricity like Hamburg and Stuttgart)).

There are differences in the share of low carbon electricity generation in the partner regions. For example, Oslo and Stockholm currently have a low carbon grid because of hydro and nuclear power. Ile De France (Paris) has a low carbon intensive grid because of the high share of nuclear power in France.

The contribution of a decarbonised grid to emissions reductions varies among the regions, therefore any change in the carbon intensity of electricity will vary in terms of its impacts on the resulting scenarios.

In Helsinki, nearly all electricity is produced by Combined Heat and Power (CHP). In this case, we have to look what would happen with the emissions if all CHP was based on renewable fuels, or CCS, or if CHP was no longer used.

In Europe a completely decarbonised grid (on its own) would result in a reduction of less than 25% of CO_2 emissions. With electrification, such a decarbonised grid, however, would be an important contribution to mitigation.

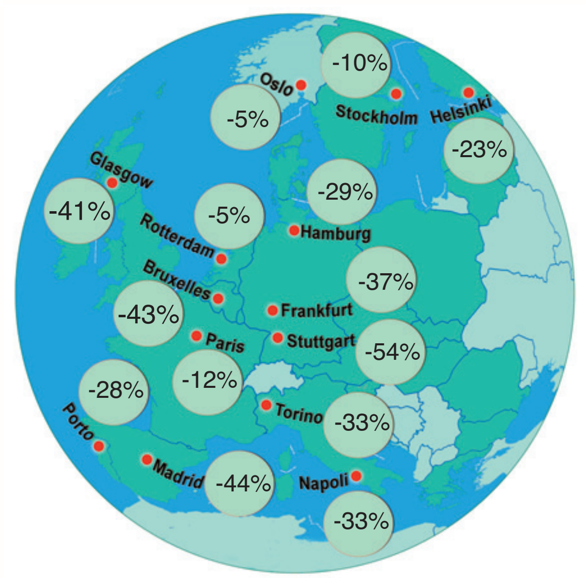

Chart 11:
Regional CO_2 reduction effects of a carbon-free grid

Chart 11 shows the different effects of a hypothetical decarbonised grid in the 14 partner regions of project EUCO2 80/50 (if electrification is not considered).

Most stakeholders assumed for 2050 a transnational grid with electricity generated from across Europe and Northern Africa.

The Residential Sector

The residential sector contains emissions from the direct combustion of fossil fuels within residential buildings in each region together with indirect emissions associated with the consumption of electricity and heat from public distribution networks.

The emissions reductions from the residential sector in the scenarios are driven by a variety of factors including behavioural changes, changes to buildings' standards, retrofitting and increases in the efficiency of devices.

These drivers, together with increases in the production of electricity and heat on-site from renewables, and a reduced carbon intensity of the electricity grid, contribute in varying degrees to the emissions reductions in each scenario.

The emissions reductions from this sector vary between 35% and 100%. In total 18 scenarios show emissions reductions of 80% or more, with 10 of these displaying emissions reductions of more than 90%.There are 7 scenarios that display emissions reductions of 60% or less from the residential sector, with all of these coming from Southern Europe: Turin, Naples, Madrid and Porto.

The changes in energy consumption vary between the scenarios with the amount of heat consumption reducing per household in 35 out of the 38 scenarios; one of the remaining scenarios, in Southern Europe, does not contain active policy action on energy efficiency, which partly explains the increase.

In total 21 of the 38 scenarios contain energy reductions per household that are in excess of 50%, with 7 that exceed 70% and 7 that display less than a 20% reduction in heat demand.

The amount of electricity produced on site by either solar photovoltaics or wind power varied between 0% in Scenario 3 in the Oslo Metropolitan Region to 50% in Helsinki in Scenario 3.

All the remaining scenarios show on-site electricity meeting between 2% and 40% of total electricity demand in the residential sector with the majority of scenarios showing on-site renewable generation from these technologies to provide between 10% and 30% of residential electricity consumption.

Chart 12 shows the regional range of emissions reductions in the residential sector by region.

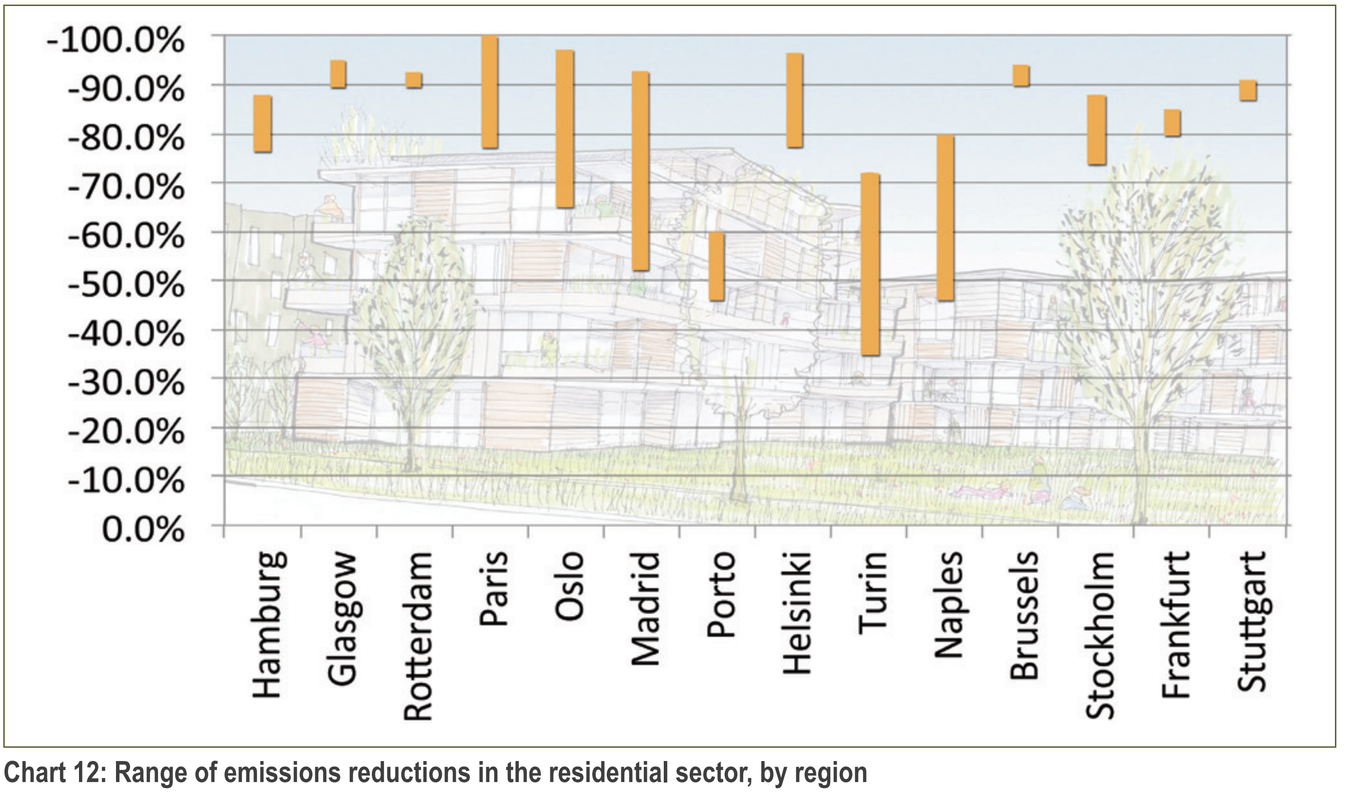

Chart 12: Range of emissions reductions in the residential sector, by region

The Service Sector

The service sector contains emissions from the direct combustion of fossil fuels within the commercial and public administration buildings in each region together with indirect emissions associated with the consumption of electricity and heat from public distribution networks.

The emissions reductions from the service sector in the scenarios are driven by a variety of factors including behavioural changes, changes to buildings standards, retrofitting and increases in the efficiency of devices. These drivers, together with increases in the production of electricity and heat on-site from renewables and a reduced carbon intensity of the electricity grid, contribute in varying degrees to the emission reductions in each scenario.

The scenarios display qualitative differences between them and the emissions reductions from the residential sector, due in part to the presence of public administration that was deemed to be able to take the lead in emissions reductions together with differences in the type of buildings and their usage.

The emissions reductions from this sector vary between 18% and 100%. In total 22 scenarios show emissions reductions of 80% or more, with 11 of these displaying emissions reductions of more than 90%.

There are 6 scenarios that display emissions reductions of 60% or less from the service sector, with 3 of these coming from the Southern European regions of Porto and Turin and the remaining 3 from the Northern European regions of Oslo and Hamburg.

The changes in energy consumption vary between the scenarios with the amount of heat consumption reducing within the sector in 29 out of the 38 scenarios, remaining unchanged in 3 scenarios and increasing in 6 scenarios. These 6 scenarios contain all 3 of the scenarios from the Oslo Metropolitan Region; however, due to switching to less carbon intensive energy in two of these scenarios emissions reduce in the sector by over 90%.

Of the remaining scenarios, Scenario 2 from the Helsinki region shows an increase in heat demand of 65%, with an emissions reduction of 89%. The remaining 2 increases were both in the Napoli Province with emissions reductions of 62% and 77%.

These increases are largely driven by expansions in the size of the economy and the sector's share within it. The amount of electricity produced on site by either solar photovoltaics or wind power varies between 0% in 2 scenarios and 50% in Napoli, Scenario 3.

All the remaining scenarios show on-site renewable electricity contributing between 1% and 35% of total electricity demand for the service sector with the majority of scenarios showing on-site renewable generation providing between 10% and 25% of the service sector's electricity consumption.

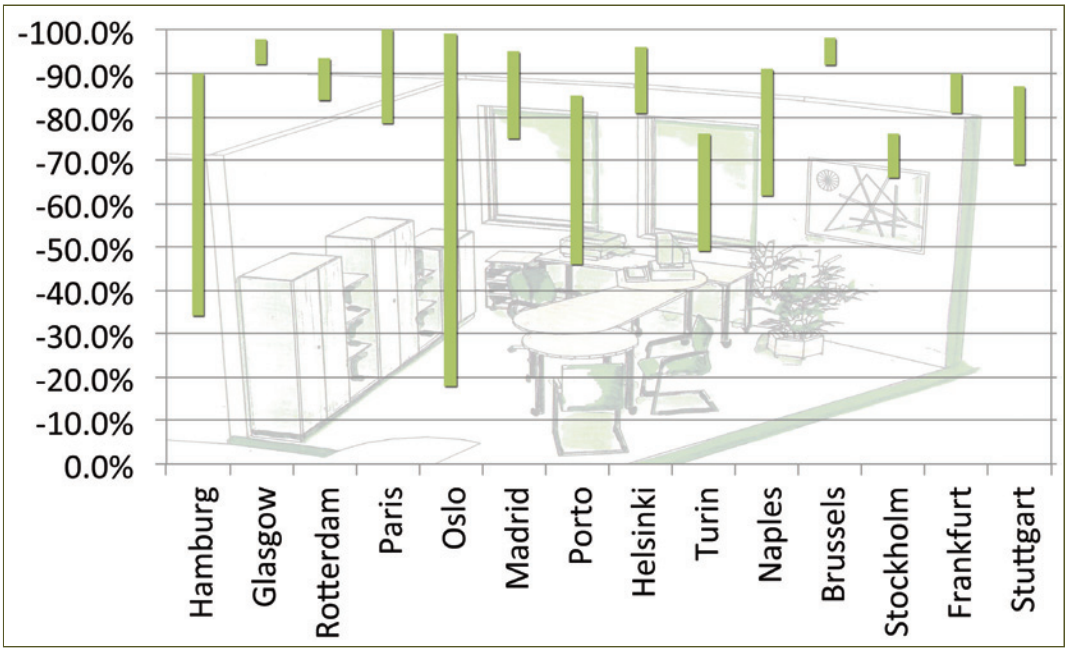

Chart 13: Range of emissions reductions in the service sector, by region

The Industrial Sector

The changes to emissions in the industrial sector in the scenarios are driven by a variety of factors including increased emissions trading, the cost of fuels, improvements in the efficiency of devices, changes in the type and nature of industry and contractions, and growth in the size of industry within each region.

These drivers, together with increases in the production of electricity and heat on-site from renewables, and the carbon intensity of the electricity grid, contribute in varying degrees to the changes in emissions in each scenario.

The scenarios have qualitative differences between them and the other sectors largely due to the nature of the processes that lead to emissions in this sector and the movement of the energy intensive components of this sector overseas – this is a storyline that does not feature in the other commercial or energy industry sectors.

The emissions changes within this sector varied between an increase of 44% in Stockholm, Scenario 3, and a reduction of 99% in Paris, Scenario 1. In total 9 scenarios show emissions reductions of 80% or more, with 3 of these displaying emissions reductions of more than 90%. There are 17 scenarios that display emissions reductions of 60% or less from the industrial sector, with these reductions being evenly spread over Europe.

The changes in energy consumption vary between the scenarios with the amount of heat consumption reducing within the sector in 24 out of the 38 scenarios and increasing in 7 scenarios.

These 7 scenarios contained all 3 of the scenarios from the Oslo Metropolitan Region; however, due to switching to less carbon intensive energy these scenarios showed reduced emissions in the sector by between 59% and 70%.

Of the scenarios that display no change, 3 of them contain the scenarios from the Madrid Region. In every one of the 38 scenarios, this sector, due to growth in the economy, displays a decoupling of energy consumption and the economy. The amount of electricity produced on site by either solar photovoltaics or wind power varies between 0% in 7 scenarios and 50% in Napoli, Scenario 3.

All the remaining scenarios show onsite renewable electricity contributing between 5% and 30% of total electricity consumption in the industrial sector with the majority of scenarios showing on-site renewable generation from these technologies to provide between 10% and 20% of industrial electricity consumption.

Chart 14 shows the Range of emissions reductions in the Industrial sector by region.

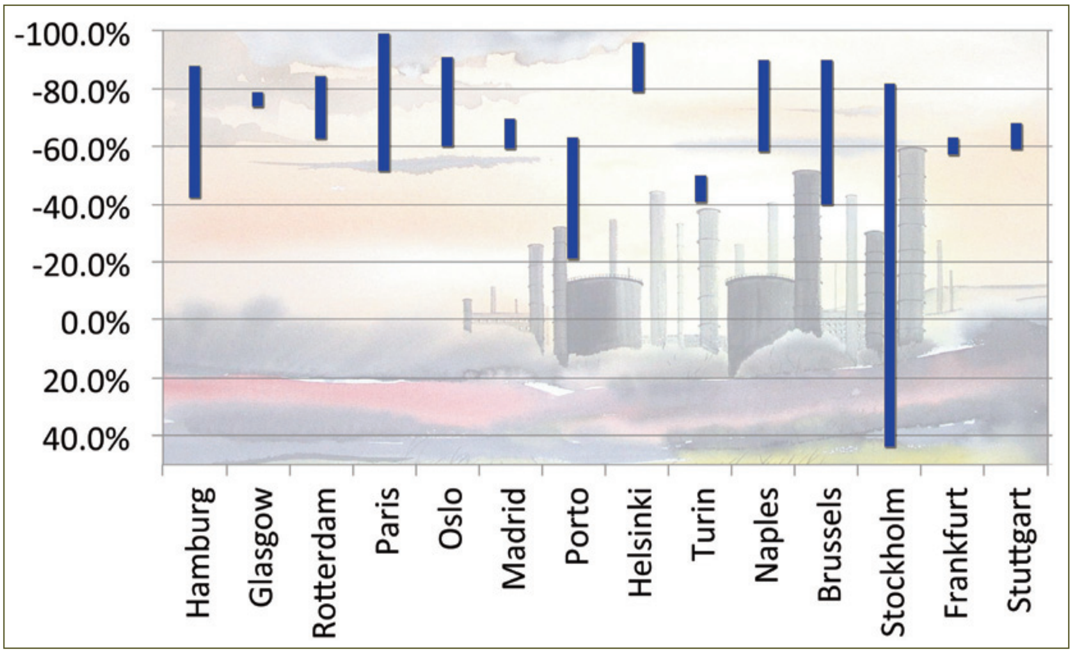

Chart 14: Range of emissions changes in the industrial sector, by region

The Transport Sector

Road transport is the largest emitting sub-sector of transport in terms of CO_2.

Emissions from road transport result directly from the direct combustion of fossil fuels in all road vehicles, including private cars, freight and public transportation; and indirectly from the consumption of electricity. The changes to emissions in road transportation are driven by a variety of factors including behavioural change, the cost of energy, improvements in the efficiency of devices, changes in the type of vehicles, transportation infrastructure, energy switching and usage of vehicles within each region.

These drivers, together with the carbon intensity of electricity for potential electric vehicles, and how, if appropriate, hydrogen is produced, contribute in varying degrees to the changes in emissions in each scenario. We must recognise that the scenarios are all qualitatively and quantitatively different.The emissions from road transport reduce in every scenario within this sector varying between 23% in Porto, Scenario 2 and a reduction of 97% in Paris, Scenario 1.

In total 20 scenarios show emissions reductions of 80% or more, with 7 of these displaying emissions reductions of more than 90%. There are 10 scenarios that display emissions reductions of 60% or less from road transport, with 7 of these scenarios being from Southern European regions, including all the scenarios from the Porto region.

The changes in energy consumption vary between the scenarios with energy consumption reducing within the sector in 33 out of the 38 scenarios, and remaining unchanged in 5 scenarios. Energy consumption in this sector reduces by between 2% in Porto, Scenario 2 and 80% in Rotterdam, Scenario 1. The next most effective mechanism, after demand reduction, of reducing emissions in the scenarios came from the use of electric vehicles, which featured in every scenario, occupying between 10% and 80% of the energy used by road vehicles in 2050. The use of biofuels in this sector features in 36 of the scenarios, occupying between 3% and 50% of energy consumption in this sector.

Hydrogen is not seen in 8 of the scenarios; in the remaining 30 it occupied between 1% and 40% of road vehicle energy usage. In the majority of cases this hydrogen was deemed to be produced by electrolysis.

Other Transport

Rail emissions account for a low proportion of regional emissions, although it may play a large part of future emissions reductions due to switching away from road transport. In the scenarios we did not consider emissions associated with international aviation and marine (although it was often discussed). The emissions associated with domestic aviation make a minimal reduction contribution of 1% or 2% of each region's emissions although this percentage share may increase as other sectors reduce their emissions.

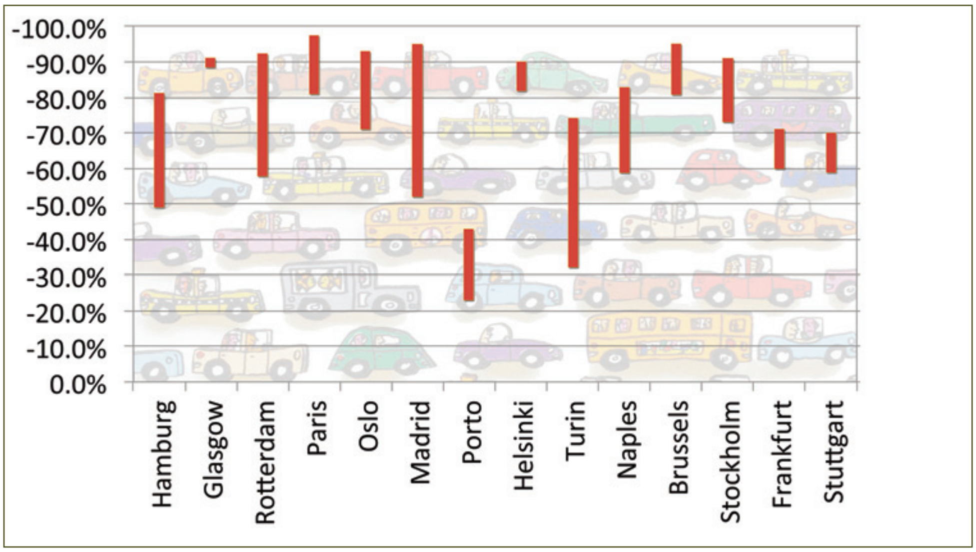

Chart 15: Range of emissions reductions in road transport , by region

Next Steps

Background

On this tandem-bicycle the interests of the riders appear to be in conflict, however, they are brought together by cooperation between the riders and the technical solution of the tandem bicycle. This is a message that the EUCO2 80/50 project tried to deliver on a broad scale.

The purpose of the EUCO2 Stage 2 exercise was to engage and bring together a wide variety of stakeholders representing differing sectors to discuss how each region may reduce its CO_2 emissions.

A focus on decarbonisation, whilst key to the goal of climate change mitigation, is not necessarily the best focus when trying to engage stakeholders. There are other benefits and motivations that may be associated with decarbonisation, including cost savings, energy security, and energy self-sufficiency.

When considering how to aid delivery of decarbonisation, a region should consider what its main or principal foci are. In this research, our main focus has been on decarbonisation; however, we are mindful of the benefits of other approaches for a “transition to a low carbon economy” (decarbonisation) to regional authorities especially when gaining a “buy-in” of stakeholders – particularly with those who are sceptical or lethargic in respect of climate change.

Indeed, whilst the initial focus of the scenario sessions was decarbonisation, the discussions often focused on concerns over energy security and rises in the cost of energy (largely fossil fuels).

Options for Decarbonisation

When a region looks to decarbonise, it must focus on the energy it consumes within the region, particularly that which has a fossil fuel base. To decarbonise, a region must reduce the amount of fossil fuels combusted to provide it with the heat, propulsion, and electricity it consumes. This requires a full energy systems' perspective, and leads us to consider four key options in which decarbonisation may be achieved:

1) Reduce demand for fossil based energy within the region;
2) Change the type of energy that the region consumes to lower/zero carbon forms;
3) Change the way in which a region's energy is generated;
4) Lastly, a combination of these.

The first option is key and is an important step when delivering an efficient decarbonisation transition because it enables relatively quicker energy savings and CO_2 reductions than the other decarbonisation options. It also reduces the amount of energy or power that may need to be provided by the other options. Furthermore, it is generally quicker to implement due to some technologies already being in place – power stations, road vehicles, boilers, for example – that have long life spans, making replacement harder to justify. Reducing energy demand in the residential sector can be achieved through initiatives such as improved building insulation, behavioural change, and slightly slower technological change in the form of white goods and other products.

The second option is also important. A dependence on fossil fuels, as demand is being reduced, will need to be substituted with other sources of energy and power. This may take the form of low carbon combustion from bioenergy or reactions involving hydrogen, it may also see a switch towards electricity (primarily) for heat and propulsion demands.

The third option is a vital aspect of decarbonisation for the region. Energy and power are often provided to users, having undergone a previous process in potentially another location. This involves conversion of crude oil in refineries into petrol, diesel and kerosene etc.

It may also be conversion of coal, oil, natural gas and bioenergy into electricity. All of these processes result in the release of CO_2. The type of energy and power demanded by the region, as a consequence of options one and two, will determine what energy and power must be produced to meet regional demand and potential demand for energy outside of the region.

This may include transferring bioenergy into usable forms, for example for transportation. It may include how hydrogen is produced in the future. It is almost certain to include how electricity is generated in the future to meet the region's demands.

A key component for planning is how much of these differing types of energy/power generation will take place in the region and through which technology, as well as how much will need to be

Imported from outside the region. It is likely that a decarbonisation strategy will include a mixture of these three options; it is also likely that this mix will differ between regions and nations. The degree of difference will depend on a variety of factors.

However, ultimately, how successful a region is at decarbonising will impact its economic viability, and long-term energy security and energy self-sufficiency.

Top Down or Bottom Up Policy?

The purpose of each scenario outlined in this summary was to explore how each region may reduce CO_2 emissions by at least 80%. However, the results of the scenarios conducted produced a range of reductions between 37% and 99%.

A key component of the discussions was to identify what policies would need to be implemented and at what level. This has provided us with an insight into how stakeholders perceive the necessary changes will be delivered.

Moving forward, each region must establish what it sees as being within its own remit, what it sees as being within the remit of its constituent authorities, and what it sees as being outside of its remit (whether it may be national, at EU level, or beyond (e.g. through Council of the Parties agreements)). The region must also establish what risks exist outside of any particular authority's control – at all scales, e.g. sideswipes caused by unrest over certain technologies.

The regions should also establish what they would like to have more legislative power over, particularly any areas they deem as weak, to deliver the necessary short, medium and long-term

decarbonisation necessary for them to play their part in mitigating climate change. For example a regional authority may view feed-in tariffs as the province of the national authorities, but enhanced building standards as being within its own remit.

A Word of Warning

Within policy circles there is a strong focus on improving baseline data – this often leads to a continuous pursuit of improving past data sets. This pursuit has a tendency to get in the way of action – with policy-makers waiting for the result of improved data sets.

However, when considering decarbonisation our primary focus is, and should be, on where we are going and how we are going to get there, rather than 'where we were'. The target of "at least an 80% reduction in emissions by 2050" from a baseline is misleading because this target is related to a global per capita emission of approximately 2 tonnes of CO_2e per capita in 2050.

Therefore it may be considered that accurately defining the baseline is a red herring. However, in densely populated areas this target should potentially be lower than 2 t CO_2e pc due to greater provision of transportation links, smaller dwellings, greater household occupancy, industrial make-up and so on.

Biomass plant in Lower Saxony

Fuel based on biomass gas (lower Saxony (Germany)

We would contend that it is not an appropriate use of a region's resources to continuously pursue better data sets regarding past emissions, especially where these are collected at the cost of decarbonisation.

This is especially the case when many mitigation measures need to be implemented. However, we recognise that it is vital for ongoing monitoring to check on mitigation progress and improve implementation of mitigation actions. It should be noted that the target of 2 t CO_2e pc includes all CO_2 emissions, including those from international aviation and marine. These latter sectors were discussed in the scenarios but not included in the baseline

Presenting Progress on Targets

We know what our options are to decarbonise. Therefore, reframing how we address the decarbonisation targets may be necessary.

We suggest that rather than the region promoting how far it has progressed towards an 80% reduction, the region should promote how close it is to a 2 t CO_2e pc target (or lower).

This should be the case because it is reflective of our current, long-term goal, but also because an 80% target is not the same for a region that emitted 10 t CO_2e (potentially 2 t CO_2e pc 2050) as one that emitted 20TCO2e pc (potentially 4 t CO_2e pc 2050) in the baseline year.

A Key Overall Activity

The regional authority should engage relevant and qualified expertise to ascertain the renewable generation capacities of the region at as fine a spatial scale as practicable.

Understanding this, together with assumptions of improvements in efficiencies of the renewable technologies, will provide the regional authority with a clear indication of what the potential is for energy self-sufficiency, and thereby the potential for promoting their own energy security.

This will also help the regional body and its constituents place greater emphasis on certain types of renewable macro and micro-generation when promoting these to citizens and businesses, as well as internally to its own energy managers or relevant personnel.

General Aspects

Considerable diversity exists across the regions involved in this study with regard to the lifestyles that inhabitants enjoy, as well as the associated consumption patterns in which they engage. This has a direct impact on the region's energy consumption.

It is true that through increased education of the workforce and greater public awareness of the environment, cost savings associated with decarbonisation may be promoted – although it is not proven that this will lead to emissions cuts. A decarbonised region should ultimately seek to be one that is equitable and sustainable in terms of resources and in terms of the global commons. Governments at all scales have a crucial role in providing an appropriate environment in which decarbonisation can take place. This includes setting the institutional, policy, legal and regulatory frameworks necessary to implement change.

Without such market interferences, delivering the necessary emissions reductions is likely to be hindered. This means identifying appropriate bodies or setting up organisations to manage certain processes. Taxes on inefficient appliances or setting a price for carbon may help reduce emissions; however this "polluter pays" principle will not necessarily lead to a reduction in emissions in a particular region.

It may cause equity issues due, in no small part, to the relative affluences of differing regions and the areas within them. Regulations and standards for appliances and buildings offer certainty about associated energy consumption, and therefore emission levels.

They may also provide a valuable information source to consumers. Increased standards may lead to innovations and more advanced technologies.

Financial incentives through subsidies, for example, may be needed to encourage the take up of new technologies. Through increased demand, the technologies may undergo further development and consequent diffusion. Decarbonisation policies should not be seen in isolation from other policies, they need to be integrated within the wider actions of the regions and the nations in which they reside. It is not expected that the region will have within its staff the skill set and the competences required to implement and deliver all the suggested changes, however the region should identify what skills it has within its staff, and which it needs to outsource.

A region will, in all likelihood, need to take on a proactive and coordinating role. Indeed, a region should not seek to operate in isolation; it should collaborate with other regions in the EUCO2 partnership, and outside, as well as with other regions within its country, and co-ordinate at a national level to encourage learning and knowledge sharing.

There is a need for a change in language if we are serious about implementing strategies to decarbonise. Particularly for climatic change reasons, we should stop using words like optimistic or ambitious, and start to use words such as necessary – as used in Energy 2020: A strategy for competitive, sustainable and secure energy, by the European Commission.

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Sector Based Targets

The route to decarbonisation is possibly best considered on a sectorial basis because different sectors have different perceived abilities to decarbonise.

This is partly associated with each sector's perceived ability to reduce its energy demand, and partly associated with the sector's perceived ability to substitute differing forms of energy and power to meet energy demands.

These abilities are also affected by many other factors, including weather and renewable resource availability. There are multiple barriers to action. These include the availability and viability of renewable technologies, as well as concerns related to their financing. The financing aspect is most noticeable in terms of upfront installation costs of energy efficient measures, and installation of renewable technologies. In certain regions, issues of poverty also exist. Furthermore, there are differences in affluence in areas within the regions that may hinder decarbonisation and may place a higher burden on the constituent authority to finance decarbonisation. This may be due to properties being publically owned or owned by housing schemes.

A lack of appropriate and targeted information provision is also a limiting factor for action. Moreover, limitations inherent in existing building designs that hinder retrofitting may stall decarbonisation. Indeed, the lack of an appropriate portfolio of policies and programmes in place is a major factor in slowing down the implementation of decarbonisation. These are factors that the region must overcome and tackle. It was one of the purposes of the scenario sessions to highlight these problems that transcend sectors, such that solutions can be implemented across and between sectors that lead to appropriate decarbonisation measures being implemented, rather than sectors operating in silos, as is often the way in planning.

Decarbonising Buildings

Many commonalities exist between decarbonisation approaches throughout the different types of building stock. These relate to the use of all types of energy and power within individual buildings.

This includes space and water heating, as well as lighting and other forms of electrical products. Solutions might require installation of the most efficient electrical appliances, as well as heating and cooling devices; this can be facilitated through

labelling of products and potentially through local by-laws that prohibit the sale of less efficient appliances within the region – possibly in collaboration with neighbouring areas. The region should require and encourage the uptake of insulation across its building stock in both new and old homes. Building designs should include passive and active solar design to minimise demand for heating and cooling. All new homes, as opportunities arise, should include smart metering that provides feedback to a property's inhabitants, as well as information to energy suppliers.

New building stock and old building stock, where possible, should install micro-generation or other forms of renewable energy. It should be recognised that decarbonising building stock comes with multiple barriers. For example, occupants may not always be owners; this may make it difficult to realise the decarbonisation potential, and may also require the buying in of expertise and promotion of organisations that can facilitate such changes.

The regional body should provide guidance to homeowners, landlords, tenants, and businesses on the likely energy consumption of their properties, how it may be reduced, and the likely costs and paybacks to bring properties up to the highest standards affordable, as well as the costs of not implementing changes in terms of energy expenditure. This could take the form of 'rough guides', and should be available both online and provided in direct communications when they take place.

The regional body should collate information on how to obtain grants, together with any discounts or schemes available through the regional body, its constituent authorities, or nationally, to deliver energy savings and emissions reductions. This should be advertised on council buildings and through other means, including supporting lines. It is clear from this study and other GRIP™ workshops conducted globally that even environmentally aware stakeholders are unacquainted with existing grants and support structures available within their regions, so additional promotion is necessary (as is more active seeking by the stakeholders).

The region should identify skills that exist within the region, across sectors including Non Governmental Organisations (NGOs), pressure groups, academia, and businesses. It should draw up lists of suppliers that it, or its constituent bodies, accredits to perform installation of renewable technologies, and those skilled in wider retrofitting.

Residential

Emissions from the residential sector arise from space and water heating, and indirectly through the use of electricity for lighting and electrical appliances.

Behavioural change is a key element to demand reduction, but is not necessarily one that we should rely on. Insulation and more efficient appliances require people to use them appropriately and are therefore not indicative of an emissions reduction.

We would recommend that regions actively encourage and/or legislate that homeowners, landlords, managing agents, and tenants implement decarbonisation measurements by providing minimum standards for energy performance in relation to decarbonisation when houses are being refurbished or redeveloped.

Establishing policies that require improvements to the rest of an existing building when an application is received for planning permission for extensions, conversions, or annexes to it.

Putting in place minimum standards for buildings that take into account their lifetime energy consumption and associated emissions, and how this relates to short, medium, and long-term targets.

Furthermore, a region ought to consider providing educational material on the relative differences of practices within the home, e.g. switching off lights, installing energy efficient lighting, not leaving the television on standby, and so on; this could be provided in multiple forms including downloads from the Internet.

Public Administration

It is arguable that public authorities should be seen to be taking the lead on reducing energy demand, improving energy efficiency in general, and installing localised renewable energy generation where appropriate in relation to their direct activities.

This requires the regional authority to liaise with its constituent authorities to improve the energy performance of their building stocks. There is also an onus on the regional body to reduce its energy consumption and the fuel source of its vehicle fleet. These factors should also be considered together with the travel habits of its staff whilst commuting and during their working activities for meetings, etc.

If the region's administration cannot lead by example, the region may find itself hindered in delivering the targets. One of the ways in which this may be delivered is through public sector leadership programmes, including procurement strategies that specify minimum standards for appliances and lighting within its building stock.

An additional example of this would be requirements for staff activities such as travel and accommodation that promote lower energy consumption. Furthermore, the regional body should ensure that its relevant staff are placed on Continuous Professional Development (CPD) courses that provide an increase in carbon intelligence.

It is a noticeable common feature of the GRIP™ scenario sessions that stakeholders, even when operating in a scenario exercise, struggle to visualise the scale of changes necessary to deliver the emissions targets of their regions.

Such courses, in combination with additional GRIP™ exercises conducted internally, will enable staff to envision, promote, and explain the strategies and changes that need to be implemented.

Commercial and Vital Services

The commercial sector has a role to play with its own building stock; these changes can be delivered through multiple means. Regulation is likely to play a large role.

The region may seek to target larger commercial developments including retail outlets, office developments, hotels, hospitals and schools. They may, through their own policy levers or nationally imposed standards, require installation of certain energy technologies. These buildings, due to their size, may be better placed than the residential sector to install renewable technologies. It may be that large commercial organisations have a vested interest in being green – regional bodies can tap into this interest.

However, one key way in which the commercial sector can contribute towards emissions reductions is through Energy Service Companies (ESCOs). These companies can provide financial structures to firms and residential developments that are seeking to reduce their emissions through improved efficiency and renewable technologies.

They also provide a potentially trustworthy source, with well established measurement approaches, to ensure that the energy savings and renewable technologies deliver on their projections. This is a factor that is not necessarily the case in relation to heat initiatives for renewable heat technologies.

This sector also has a role to play in the behaviour of its staff; the commercial sector can be encouraged through the regional authority's example to implement low-carbon procurement and staff travel habits. This may be included as part of the organisation's Corporate Social Responsibility (CSR) reporting.

Industry

Voluntary agreements between government and industry may be politically appealing and may lead to policies being implemented. However, such policies are not necessarily conducive to delivering the size of cuts needed, although such agreements may help the uptake of certain technologies.

As one of the larger consumers of fossil fuels, industry may be seen as having the largest mitigation potential. However, in many cases, 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 absorb technological information, decarbonising is harder to achieve than it may appear.

It is also questionable what role the region should play in the decarbonisation of industry, with many large sites being bound by the European Union Emissions Trading Scheme (EU-ETS) that acts on a European basis. Industry can decarbonise through multiple means, including more efficient electrical equipment. It can also make better use of heat and power recovery in inefficient processes.

It can use a wide array of process specific technological improvements, and tap into new technologies and efficiency and performance standards that have been subject to benchmarking. Industry may be able to take advantage of subsidies and tax credits, although these are unlikely to be provided regionally. Industry may also be able to utilise carbon capture and storage (CCS) in the future.

Energy Industry and Fugitive Emissions

The energy industry and fugitive emissions, considered in GRIP™, refers to oil refineries, gas terminals, manufactured solid fuel production, and oil and gas extraction and distribution. The demand for these industries is likely to decline over time as efficiency improvements and fuel switching take place elsewhere within the economy.

However, additional forms of production may become prevalent including bioenergy plants and hydrogen production units. This ultimately means a switch in the nature and type of energy industry as it reacts to demand elsewhere in the economy.

Petroleum refineries, as significant emissions' sources, may be well placed for CCS technologies; however, emissions associated with the combusted petroleum they produce dwarf the emissions they cause.

GRIP™ considers losses associated with electricity distribution as a separate emissions source that ultimately belongs to the energy industry. Losses can vary considerably between countries, but average approximately 10%.

By switching to a more 'intelligent' grid, a direct current grid, and more localised generation, these losses can be reduced. Depending on the amount of electricity and heat generated, this may equate to up to 10% of the emissions generated from public electricity and heat production.

The energy industry also includes the transformation of bioenergy. If a region intends to consume bioenergy to meet its energy demands, it must consider the kind of bioenergy and its source. This will have a direct impact on the region's energy security and self-sufficiency.

Electricity Production

The nature and type of electricity generation infrastructure has long-term impacts on greenhouse gas emissions; this is because of infrastructure longevity. It is partly for this reason that investment in end use energy efficiency improvements is preferential to increasing fossil fuel based supply to satisfy increasing electricity demand that will, in the absence of CCS, increase emissions. We mentioned above that the renewable capabilities of a region should be well understood.

This will identify how much of its electricity needs can be met within the region and how much will need to be imported. This will identify possible sources of risk to the region. The region will need to be sure it can secure future low-carbon electricity if it is to meet its emissions reductions targets. If it chooses to rely on an EU GRID that has not yet been created, then it may need to make contingency plans.

Road Transport

A key component of decarbonising road transport is demand management. This includes urban planning that may lead to lower car use. It may also include education regarding driving techniques, and greater reliance on walking and cycling. New vehicles may be subjected to mandatory levels of fuel consumption or CO_2 emissions per km.

This change in CO_2 emissions per km may be aided by biofuel blending, a switch to hybrid or plug-in hybrid, hydrogen, compressed air (referred to in 2 scenarios), and electrical energy based vehicles.

Continued use of higher emitting vehicles may prompt regions and nations to impose subsequent charges to owners through annual registration costs, fuels, and road and parking pricing. However, these approaches are not necessarily equitable, as they can lead to the more affluent being able to pollute more. The region can, however, influence mobility demands through land use regulations, and infrastructure planning. As time goes on more efficient vehicles are likely to become available as are second, third and potentially fourth generation biofuels. Electric vehicles are also likely to become more efficient and available as battery technologies improve.

However, these technologies will require an infrastructure to support them; this infrastructure can be supported by the region in the form of electricity outlets for charging electrical vehicles and plug-in hybrids. How much the region decides to promote different vehicle technologies will be key to facilitating this change.

Aviation

The decarbonisation potential within the aviation sector can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations, and air traffic management, such as the continuous descent approach (where aeroplanes switch their engines to idle when landing). However, such improvements are expected to only partially offset the growth of aviation emissions.

It is fairly well documented that emissions reductions opportunities from this sector are limited, with the aviation sector in the UK suggesting that demand expansion in the industry will offset improvements in the efficiency and fuel switching within the industry so that emissions will remain at 2005 levels in 2050. This is partly a function of the longevity of the aeroplanes, as well as a function of perceived limitations in technological change.

Conclusions

This summary represents a synthesis of one of the most detailed, consistently produced, set of stakeholder led energy emissions scenarios undertaken on a city-region scale. The research presented here is the culmination of one of the most intensive periods of fieldwork undertaken in the field of energy and climate change policy by one team of university researchers.

Context

The scenarios presented here are not policy recommendations by the authors, or of any particular stakeholder. The scenarios do not prescribe probabilities of their likely occurrence – largely because we do not have the statistics of the future to make such judgements. The scenarios and the interpretations of them should be used to help influence and inform climate policy in each region, nation and Europe. Through the scenario process, we encouraged the participants to enjoy the exercise, blending their imagination with perceptions of plausibility, breaking down boundaries between 'silos' and perceived norms. The scenarios produced are indicative of the consensus views within scenario sessions and are therefore not necessarily representative of any individual stakeholder.

Chart 16 below shows the level of global emissions reductions that are associated with different global temperature changes. They are based on the outputs of a range of climate change models from institutions around the world. The table shows the range of temperatures and associated sea level rises with different atmospheric concentrations of CO_2, and highlights the spread of uncertainty in the figures. These climate change scenarios - in contrary to the emissions reductions scenarios developed in project EUCO2 80/50 – are scientific forecasts.

They are based on a 'climate sensitivity' of 3°C, within a range of 1.5 - 4.5°C. Under the lowest temperature rises, it is likely that there would need to be negative global emissions by the end of this century (this is often referred to as geo-engineering).

Currently we are at 392ppmv CO_2 globally and are increasing at the rate of 2ppmv each year. This means that it is likely that global atmospheric concentrations of CO_2 will exceed the 2 - 2.4°C and potentially 2.4 - 2.8°C ranges.

To bring this atmospheric concentration down will require the removal of CO_2 from the atmosphere through natural, enhanced natural or artificial means.

Chart 16: Scenarios based on climate change models

CO_2 concentration at stabilisation (2005 = 379 ppm)	ppm	350 – 400	400 – 440	440 – 485	485 – 570	570 – 660	660 – 790
CO_2-equivalent at stabilisation including GHGs and aerosols (2005 = 375 ppm)	ppm	445 – 490	490 – 535	535 – 590	590 – 710	710 – 855	855 – 1130
Peaking year for CO_2 emissions	year	2000 – 2015	2000 – 2020	2010 – 2030	2020 – 2060	2050 – 2080	2060 – 2090
Change in global CO_2 emissions in 2050 (percent of 2000 emissions)	percent	-85 to -50	-60 to -30	-30 to +5	+10 to +60	+25 to +85	+90 to +140
Global average temperate increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity	degrees C°	2.0 – 2.4	2.4 – 2.8	2.8 – 3.2	3.2 – 4.0	4.0 – 4.9	4.0 – 6.1
Global average sea level rise above pre-industrial at equilibrium from thermal expansion only	metres	0.4 – 1.4	0.5 – 1.7	0.6 – 1.9	0.6 – 2.4	0.8 – 2.9	1.0 – 3.7
Number of assessed scenarios (output of climate change models)		6	18	21	118	9	5

Action

Globally, the atmospheric concentrations of greenhouse gases must be reduced to much lower levels before the natural carbon removal processesof the terrestrial systems and oceans saturate. In the project EUCO2 80/50 we have focused on CO_2 because it is the most important human caused contributor to radiative forcing which is key to global warming.

The variation between the scenarios conducted is due in part to the complex relationships that exist between society, technology and the economy. For example, there are difficult financial issues to address for investment in a low carbon pathway. However, any decisions that delay emissions reductions globally are likely to increase the risk of severe climate change impacts.

The risks of this delay are heightened due to knowledge regarding carbon being of insufficient strength. Recognition is required that the short-term decisions made by policy makers are likely to have a direct impact on climate change outcomes. This means that the buildings constructed, the infrastructure implemented and the systems adopted today, and in the future, will impact energy consumption and emissions alongside it. Decisions made today are significant for the future.

The purpose of the scenarios presented in this report is not to provide a set way forward, but to enable a process of learning that allows the exploration of differing futures, that may enable each region to deliver its emissions reductions. Indeed it is inadvisable to place ourselves along a set trajectory.

Rather, policy on mitigation should allow flexibility over direction regarding energy systems and leave opportunities for learning during the progression to a low carbon economy. It would for instance, be inadvisable to plan for a future energy system with low levels of energy demand in case demand exceeds supply. A flexible approach therefore allows for learning and mid-course corrections. Therefore, an appropriate energy strategy should be chosen, which will enhance the potential for long-term success in emissions reductions.

Many of the scenarios in this report utilise non-intervention (not climate orientated) approaches that result in emissions reductions, such as through energy efficiency measures. When considering a transition to a low carbon economy it is useful to think about it in terms of the extent of the regulatory framework available to the regions, the level of centralisation of decision making and the value of market approaches against regulatory ones given the scale of the emissions reductions that we need to deliver.

A greater emphasis on demand reduction in the near term followed by increases in low carbon forms of production was a common approach in the scenarios conducted in this research.

Cumulative Emissions

Cumulative emissions can be expressed as a total amount of emissions released over a given period. In their nature publication of 2009 Meinhausen et al postulated that a total of 1,000Gt CO_2 could be released between 2000 and 2050 leading to a 25% probability of exceeding 2°C by the end of the century.

Approximately a quarter of this was released between 2000-2006. For a 50% chance of staying under the 2°C target this global amount could be 1,440Gt CO_2 . However, these scientists note that due to the build-up of emissions in the atmosphere, if global emissions are more than 25% above 2000's levels in 2020 (which they currently are) then the chance of exceeding 2°C this century increases from 53% to 87%.

During the production of the scenarios, the way in which ownership and importance of action on mitigation was viewed by the stakeholders, and how they perceived it being dealt with, (and at which scale) will have had an influence on the nature of energy supply and demand.

Furthermore, the level of education and awareness regarding mitigation is likely to have varied between and within the regions. The norms, beliefs and values of the stakeholders and their institutions are difficult to change.

However, education through continuous professional development is one way in which this could be addressed. Manchester University is exploring setting up such a course.

The level at which mitigation takes place and its timing is dependent on the target. This timing of climate policy is key to the debate. For example early implementation of energy efficiency standards and stimulating low-carbon technology development are key factors in facilitating the transition to a low carbon future.

Europe, to be most effective on climate mitigation, needs to tackle policy within a global context. The EU target of an 80% reduction in GhG emissions seeks to address this as it is set within a reduction framework for industrialised countries of between 80% and 95%.

Final Conclusions

Chart 17 displays the low, median and high emissions reductions in each region's scenario exercises. If the regions were considered as a single entity these scenario results deliver an emissions reduction of 65% in the low emissions scenarios, 74% in the median emissions reductions scenarios and 82% in the high emissions reductions scenarios. These headline results, together with the research presented in this document leads us to certain observations:

1) The majority of the GRIP™-EUCO2 scenarios if realised and replicated across Europe would fail to deliver the EU goal of an 80% emissions reduction. This is compounded by the fact that these figures do not include international aviation and marine emissions. Even taking into account that the EU emissions reductions goal refers to 1990 data and not to 2005 like EUCO2 80/50 does, most scenarios would fail to deliver the goal - this is partially because emissions of CO_2 have increased by 3% within the European Community between 1990 and 2005 (although not necessarily in each of the participating regions in this study).

2) The GRIP™-EUCO2 scenarios do not take into account the emissions of the non-CO_2 greenhouse gases. This means that additional burdens on the emissions reductions would need to be met by other regions, potentially largely rural, if high level emissions reductions are to be achieved.

3) The GRIP™-EUCO2 scenarios were produced by stakeholders representing a selection of Europe's leading regions on climate change mitigation action. In line with the GRIP™ approach, there were limited constrictions on how the scenarios were produced (e.g. there were no limitations over efficiencies).

This would suggest a lack of stakeholder confidence in meeting the emissions reductions goals, and may offer an insight into the potential likelihood of meeting the targets in regions that are less well informed on climate change policy.

4) The majority of the regions in this study are largely urban in form. These areas, whose economies are primarily service driven, may be expected to deliver much higher levels of GhG reductions than rural areas in order to deliver wider national, European and global targets. This is because the majority of emissions within urban centres in the western world result from energy use in buildings and transportation. These are emissions sectors that are deemed easier to mitigate than industry.

5) The EUCO2 scenarios focus on an emissions reduction by 2050. 2050 is seen as a reference point indicating the likely future trajectory of GhG emissions up to 2100. Assumptions regarding this trajectory enable an estimation of the likely global temperature rise in the period 2100-2150. However, in the near term it is the emissions released between now and 2050 that we must focus on, as these will be key to prevent dangerous climate change in the long term - even if we overshoot our temperature targets this century.

If these scenarios are a true reflection of the approach to policy 'on the ground' then this would indicate an increased need for research on geo-engineering. In the first instance, action is equired to support these regions to develop new strategies that can work towards, and beyond, the 80% and 2°C targets – that are likely to require negative global emissions by the end of this century.

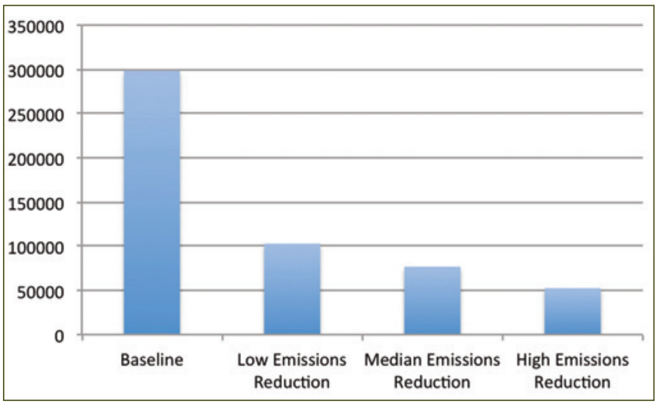

Chart 17:
Low, median and high emission reduction scenarios of the 14 partner regions as a whole (in tonnes CO_2e)

Imprint

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It is based on the results of Stage 1 and 2 of the EUCO2 80/50 project which comprises two reports:

The EUCO2 project Stage 1: Greenhouse Gas Emissions Inventories for 18 European Regions. S.Carney; N. Green; R. Wood with R. Read

The EUCO2 project Stage 2: Energy Emissions Scenarios in 14 Metropolitan Regions. S.Carney; E.Prestwood; G. Sherriff with A. Parker.

Please refer to the appropriate report when referencing. The policy recommendations contained in this summary report are based upon the knowledge of the authors and advice provided by the IPCC and the UK's Energy Saving Trust.