

BRIEF ON MACRO-ECONOMICS

Introduction

The mission of Roadmap 2050 is to provide a practical, independent and objective analysis of pathways to achieve a low-carbon economy in Europe, in line with the energy security, environmental and economic goals of the European Union.

The Roadmap 2050 project findings can be summarized as follows: The decarbonisation of the European power sector is practical, technologically and economically feasible and a pre-requisite for meeting the EU goal of at least 80% green house gas emissions by 2050.

Roadmap 2050 examines the costs and benefits of the following decarbonisation pathways for the European power sector, with:

- 40% renewables, with the remaining 60% supplied evenly between non-renewable low-carbon technologies: CCS and nuclear
- 60% renewables, with the remaining 40% supplied evenly between non-renewable low-carbon technologies: CCS and nuclear
- 80% renewables, with the remaining 20% supplied evenly between non-renewable low-carbon technologies: CCS and nuclear

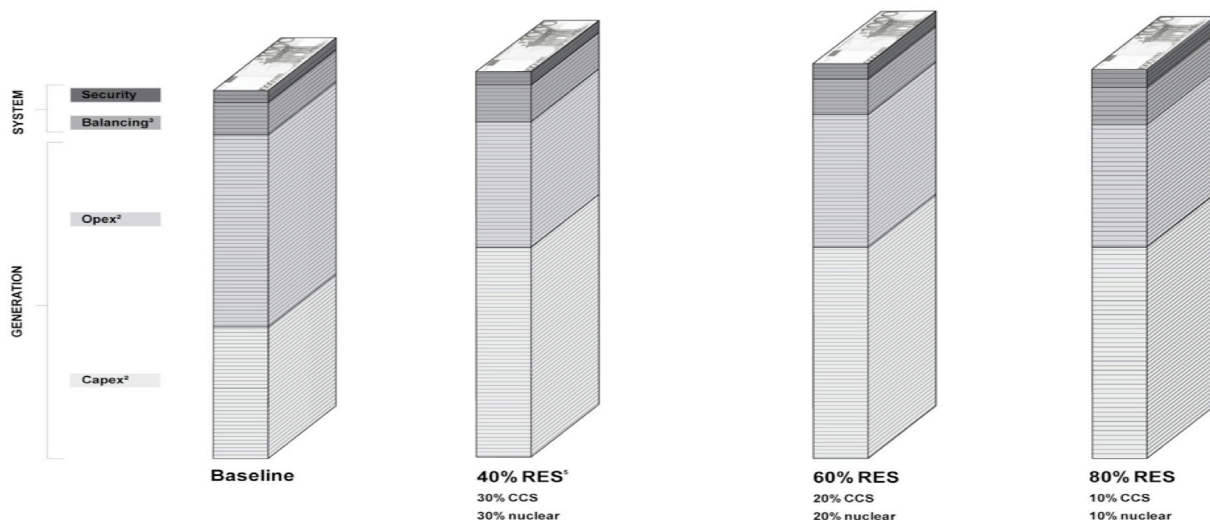
The study has also assessed the technical and economic feasibility of a scenario with 100% renewable electricity, requiring no nuclear power and limiting CCS application to heavy industry.

This paper sets out in summary the findings of the report relating to the economic impacts of the various decarbonisation pathways explored in the report.

COST OF ELECTRICITY

THE HIGHER CAPITAL
COST IS OFFSET BY A
LOWER OPERATIONAL
COST.

Average new built CoE from 2010 to 2050¹, EUR/MWh (real terms)



¹ Weighted average based on the CoE in each 10-year time frame (2010, 2020, 2030, 2040, 2050)
² Generation only
³ Cost related to non-optimal plant use, system dispatch cost for secure operation, running backup plants, storage losses, reserve and response cost
⁴ Transmission and additional generation capex as well as fixed opex for transmission and backup

Regardless of which pathway is chosen, the Roadmap 2050 study has **established that the average cost to the economy over 40 years is not significantly different to the baseline. The baseline is defined as the current trend in technologies and policies for power, transport and buildings.**

Therefore, when assessing the decarbonisation strategy and the technology mix other factors, such as security and climate, acquire an importance at least equal to the cost and reliability of electricity.

Investments required in Renewable Energy Sources and Grid infrastructure

To initiate the decarbonization transformation, current annual capital expenditure (capex) in the power sector needs to double to about €55 billion per year by 2020, depending on the share of renewables. Capital investments further peak towards 2035, after which the levels decline as the majority of the new power infrastructure is built.

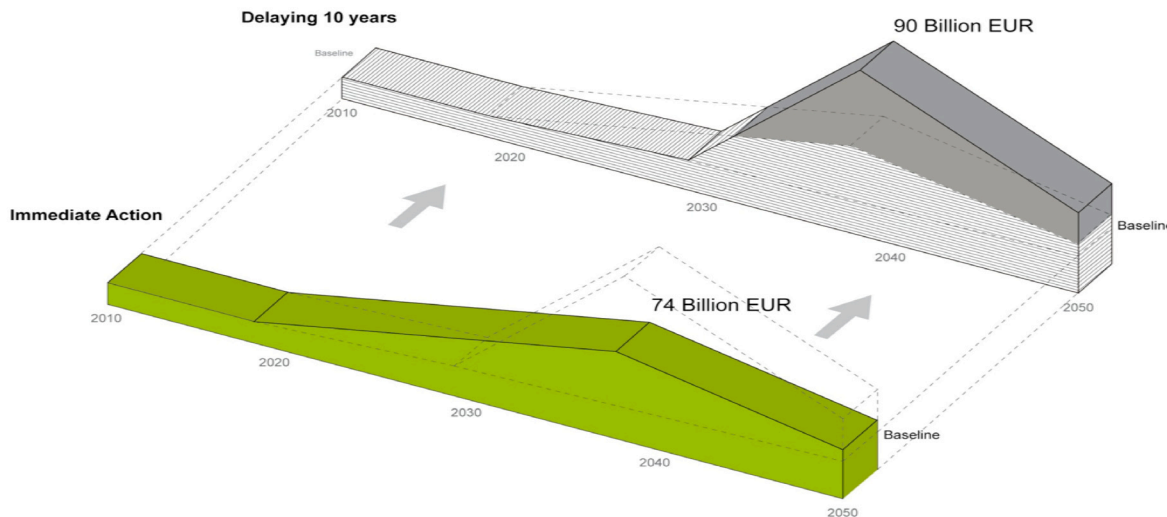
Overall, the capex for the decarbonized pathways is 50-100% higher than for the baseline. This increase is mostly offset by lower operating expenditures due to a reduction in the demand for fossil fuels. The average cost of electricity over 40 years in the decarbonized pathways is similar to the cost in the baseline, assuming a carbon price of €20-30/t CO₂.

The decarbonised pathways would also affect other areas of the economy, reducing capital expenditure in oil and gas, as fossil fuel imports radically decline, as well as increasing capital investments for efficiency in buildings and industry and for electric vehicles and heat pumps.

Delay in action will squeeze the same investments in a shorter amount of time, significantly increasing the required annual investments. This would increase the risk of temporary shortages of construction and installation capacity, potentially leading to high prices in certain parts of the supply chain.

DELAYING ACTION INCREASES COSTS

ALTHOUGH INVESTMENT IS INITIALLY HIGH, THE ANNUAL COST OF DELAYING INVESTMENT IS MUCH HIGHER.



SOURCE: Roadmap 2050 Technical Analysis

Effects on European GDP output and growth are limited

The Roadmap 2050 analysis shows that Europe can significantly reduce its GHG emissions and meet the 80% target by 2050 with relatively little impact on the aggregate GDP.

Due to energy efficiency measures and a shift away from high cost fossil fuels, particularly in transportation, the energy bill per unit of output of the economy starts to fall by 2020 in all decarbonisation pathways. In the longer-run the EU-27's low-carbon economy becomes more resilient

against fossil fuel price spikes and more competitive in terms of energy intensity, mostly thanks to the change in the structure of the economy and efficiency measures in industry, residential and transport sectors.

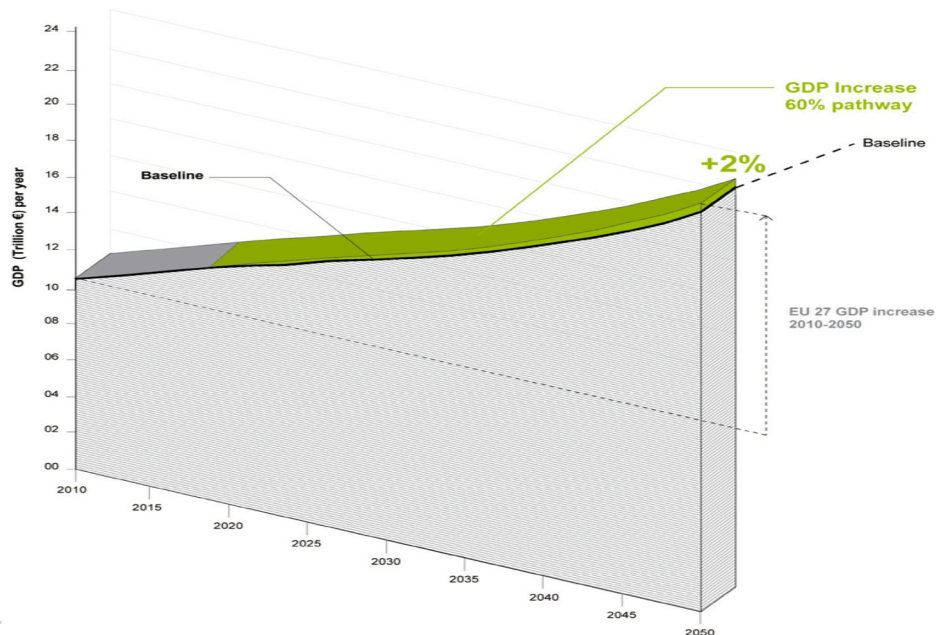
As with all transitions, while technologies will become cheaper once they are deployed at large scale, the start-up phase will require more cash than the baseline.

The de-carbonized economy requires a significant increase in capital expenditure, while the benefits of reduced operating expenditure come in the period after 2030. In the short term, the model therefore foresees negligibly lower growth in GDP due to higher power prices and higher

capex investments, which are compensated by decreased operating cost in later years. Policy intervention may be necessary to compensate for potential impacts in certain energy intensive sectors. In the high renewable pathways, the long-term productivity of the economy is higher than in the baseline thanks to a 27% reduction in energy intensity by 2050. Moreover, the increased renewable energy sources (RES) investments could give the European economy a

competitive advantage in clean tech exports, which could contribute up to €250 billion to GDP by 2020, assuming that the EU27 manages to preserve such competitive edge for a decade. After 2030, the EU-27's low-carbon power becomes cheaper than more carbon-intensive power outside of Europe, so that several sectors of the European economy gain competitiveness.

LONG-TERM EU27 GDP



Overall effect on Employment is limited, with progressive businesses on the winning side

The aggregate effects on employment in Europe are limited, but the transition will create winners and losers in specific sectors and regions. By 2020, fossil industry jobs suffer most from shift to renewable energy sources (RES) but are made up by increased employment in the RES and efficiency sectors.

New job creation is also bolstered by increased capital expenditure in the energy market and increased clean-tech exports in both technology and services. Roadmap 2050 estimates the creation of approximately 400,000 jobs by 2030 through the investments required to decarbonise the power sector, versus the 250,000 jobs at stake in the fossil fuel industry, though many more new jobs could result from implementation of increased efficiency measures assumed

in the project. The net impact on the overall stock of jobs is driven by GDP projections and therefore, as noted above, is close to the baseline.

The cost of Electricity remains within similar ranges in all pathways as well as the baseline

The 2010-2050 average cost of electricity (COE) is roughly 10% higher in the decarbonised pathways than in the baseline, if no carbon price is assumed.

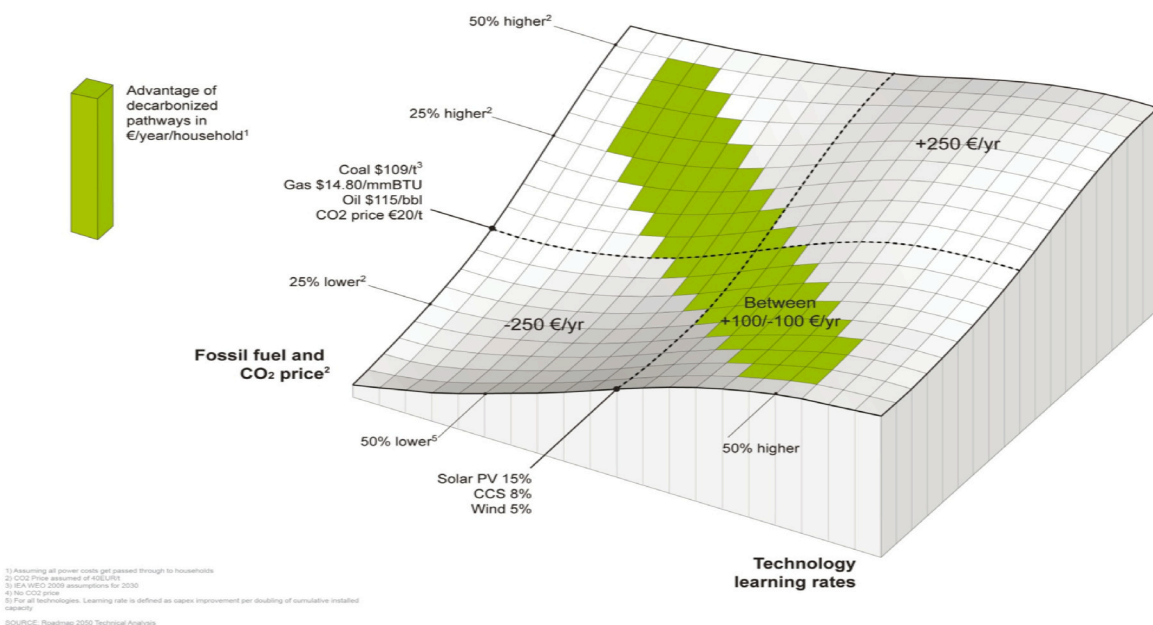
A carbon price of 20-30 €/t CO₂ would make the COE in the decarbonised pathways comparable with the baseline, and this does not assume any technology breakthroughs, fossil fuel price spikes or structural supply constraints, all of which would make the high-RES pathways more economical.

Thanks to efficiency and a shift away from fossil fuels, the energy bill per unit of output of the economy starts to decline

by 2020. In the period 2030-2050, energy cost per unit of GDP output could be 27% lower than in the baseline. The benefit of the decarbonised pathways is equivalent to a lower total cost of energy of €330 billion per year by 2050, an energy cost reduction across all energy use of roughly €1,500 euro per year for each European household by 2050.

Gas and coal price increases are a vital factor in the cost of electricity. Fossil fuel price shocks will have significantly more impact in the baseline than in the high RES pathways. Roadmap 2050 assumes fossil fuel prices in line with IEA forecasts.

DECARBONIZED HOUSEHOLD BILL COSTS



Decarbonising the European power sector may have a small effect on the cost of electricity

The transition will not significantly increase the average cost of electricity over 40 years. Moreover, the EU economy will become more resilient to fossil price fluctuations and will grow due to clean tech exports. The Roadmap 2050 analysis shows clearly that the economic impacts themselves make the case in favour of the transition to a decarbonised power sector, including supply scenarios based on very high shares of RES.

Sensitivity analysis indicates that ineffective policy and technology risk could limit efficiency improvements and would add significant cost to the transition. Policy making therefore has a crucial role to play in providing a clear and unambiguous signal in the direction of low-carbon prosperity, enabling businesses to plan investments and business development plans within this framework. The economic impact of decarbonisation of the power sector, sometimes perceived as a threat, is clearly found to be a major opportunity for Europe in the decades to come.

Glossary

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|-------------------|-----------------------------|
| CCS | Carbon Capture and Storage |
| t CO ₂ | ton carbon dioxide |
| IEA | International Energy Agency |

The Roadmap 2050 project is an initiative of the European Climate Foundation (ECF) and has been developed by a consortium of experts funded by the ECF. In addition, a wide range of companies, consultancy firms, research centres and NGOs have further supported the preparation of this report. The ECF is the sole author of the Roadmap 2050 report, is solely responsible for its content and will act as a guardian of the content.

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