A research and policy agenda for the transition to a low-carbon, competitive and secure EU society

D1.3 - Policy Brief

July 2019

About this report

This Policy Brief synthesizes the messages and policy insights of the REEEM project. It is based on the impact assessment of three deep decarbonisation pathways co-designed with stakeholders: Coalitions for a Low-carbon path, Local solutions and Paris Agreement. For these, it highlights *often hidden challenges and opportunities* of decarbonisation, which emerge when considering the *connections between sectors and the cascade effects* between scales. Those scales range from EU-wide, to regional, national and local. Recommendations are provided to policy makers to exploit the opportunities and minimise the challenges. A set of tools is presented to *facilitate engagement*.

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REEEM partners

About REEEM

The REEEM project aims to gain clear and comprehensive insights relating to the system-wide implications of energy strategies in support of transitions to a competitive low-carbon EU energy society. This project is developed to address four main objectives: (1) to develop an integrated assessment framework (2) to define pathways towards a low-carbon society and assess their potential implications (3) to bridge the science-policy gap through a clear communication using decision support tools and (4) to ensure transparency in the process.

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Context: The need for a deeper socioeconomic change

The Clean planet for all strategy issued in November 2018 analyses several decarbonisation scenarios compatible with the Paris Agreement, all of which will entail ***deep change across all sectors*** of the society.

Such change brings with it challenges, which may be summarised as follows:

- **Pervasive impacts**: they will differ by sector, region, geographic scale (EU vs regional vs national vs local) and income group. Not all impacts are obvious, but many might imply changes that affect society deeply.
- **Regional differences**: Member States and regions are constrained by security issues and the structure of the economy. This gives rise to different policy priorities and potential resistance to large-scale changes.
- **Multiple actors**: will be affected by and need to co-create a deep and fast change. But the role that each group may have depends on a multitude of factors. Households may need to leave familiar energy use habits, while producers may need to embrace unforeseen levels of recycling to ensure efficient stewardship of the scarce resources needed in an electrified Europe.
- **Technology constraints**: will be seen, for example sectors such as heavy industry and certain segments in transportation will be harder to decarbonise.

Three deep decarbonisation pathways

The REEEM project helps shed light on the heterogeneity of possible impacts and enablers of an EU-wide energy system transition. It does this by developing and modelling three diverging pathway narratives, with a wide range of analytical tools. The pathways and models help reveal key cross-sectoral, -temporal and -scale dynamics that could arise on the path towards a deeply decarbonised EU energy system (over 80% compared to 1990). They are co-designed with researchers, industry and the European Commission through a process illustrated in Figure 1. This is done to ensure important drivers and barriers of the transition – as currently conceived - are captured. Each pathway is summarised as follows:

Coalitions for a Low-carbon path (CL): has a supply-side focus, with energy carrier suppliers and industry taking on the highest burden in the decarbonisation of the EU energy system. Consumers are assumed to observe this transition in mostly a passive way and are reactive to policies as they emerge.

Local Solutions (LS): increase participation of consumers (especially households). They are engaged more proactively in the transition, through choices on end use appliances, energy efficiency measures and transportation technologies.

Paris Agreement (PA): is extended and stronger decarbonisation efforts are adopted. The EU aims for and meets a more ambitious target of 95% reduction of CO_2 emissions by 2050. Both energy carrier suppliers and consumers engage in the challenge.

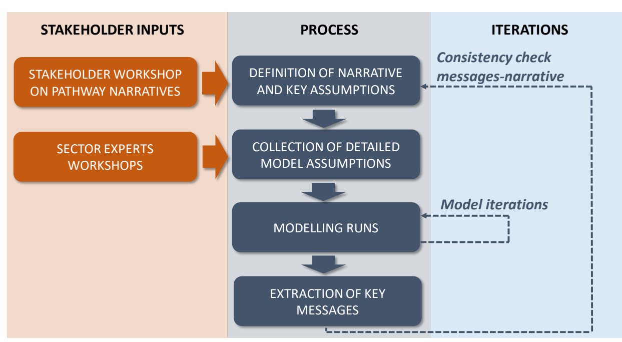

Figure 1. Pathway design process in REEEM.

Risks and opportunities of the transition

For each of the three pathways, the largest available suite of best-in-class analytical toolkits was simultaneously applied in a semi-structured framework. Data transparency was ensured and the first fully open PanEU energy system investments model was created in the process. Emergent risks, and opportunities to mitigate them, become apparent when the impacts of decarbonisation are assessed using this analytical framework.

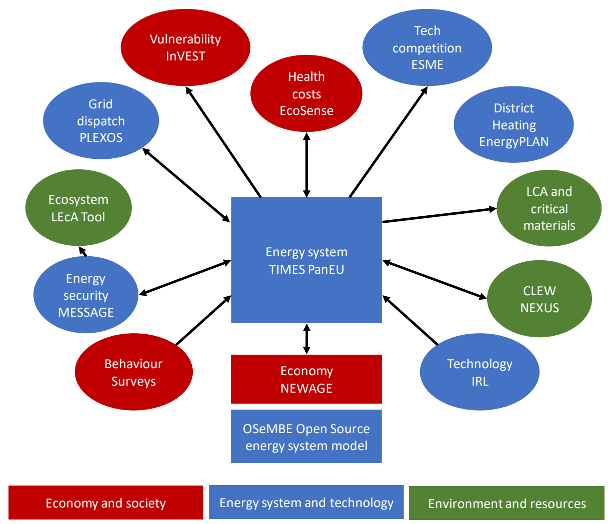

Figure 2. REEEM analytical framework.

Selected risks and opportunities are summarised as follows.

Risks

Carbon leakage. When indirect GHG emissions are considered (i.e. including the energy technology production processes), reductions are significantly lower than when only direct emissions are considered. In other words, meeting mitigation targets the way governments commonly do, masks increases in GHG emissions that they cause elsewhere. In the Paris Agreement pathway, EU governments are tasked with meeting a conventional mitigation target of 95%. By standard measures they do, but over half of the emissions reduced emerge as increased emissions elsewhere. The climate change impacts of fossil fuel-based energy technologies used today are mostly due to combustion processes. They are thus accounted for in the emission inventories of the EU. However, the renewable energy technologies that replace these cause emissions mostly during their production stage. And this often takes place outside the EU. As a consequence, the switch from fossil fuels to renewables may tend to shift the climate change impacts outside the EU. Options to rectify this would be to internalise the production of RET to the EU (and thus direct and indirect emissions are simultaneously targeted). Or to ensure that embedded emissions of imports are explicitly measured and included in conventional target setting.

Regional variation in sector vulnerability. *Household* energy affordability concerns are most prominent in regions of eastern and southern Europe. Factors giving rise to this vulnerability include insufficiency of heating systems during colder periods of the year (notably in Southern Europe), while in Eastern Europe factors may relate to a range of issues from poor building fabric to inefficient energy systems. Affordability is also a key factor in these regions, where incomes are typically lower than in other EU countries. Not explicitly evaluated here, but related vulnerabilities are being seen with respect to cooling needs in extreme heat events in households, hospitals and industry.

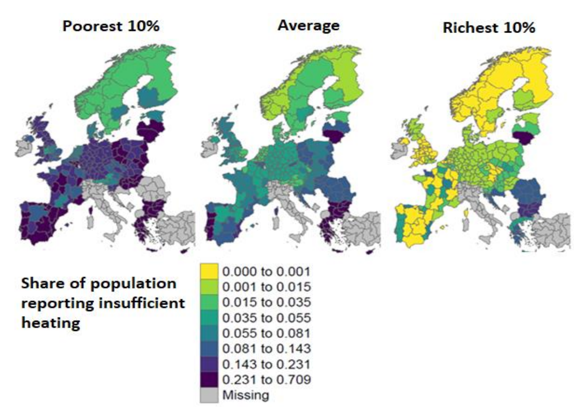

Figure 3. Share of population reporting insufficient heating.

For industry, vulnerability concerns arise in regions with a high number of employees in the coal sector such as Poland and Germany (especially Śląskie in Poland, situated in the Silesian basin). Coal phase out could lead to detrimental unemployment and societal impacts, if not managed. Regions with higher shares of employees in energy intensive industries could be subject to higher energy cost pressures, such as Eastern Europe, BENELUX, and parts of Scandinavia. Pressures may also be seen in service industries, becoming increasingly dependent on energy intensive data centres. Some regions of Europe that are highly coal dependent also see higher household energy vulnerability. Thus, regions that will experience job losses may at the same time be exposed to increased energy poverty stress. A situation that needs proactive intervention, particularly in some regions in Eastern Europe. Regions having both high employment in energy intensive industry sectors and household energy vulnerability, include parts of Slovenia, Hungary, Lithuania and Estonia. Regions in Spain and Italy are also identified due to their relatively lower disposable incomes and higher levels of unemployment.

Impact on ecosystems. Strategies aiming at high shares of biomass in primary energy supply curb GHG emissions effectively. However, their impact goes beyond the energy system. Over-intensive exploitation of biomass sources can cause irreversible damage to the ecosystem, potentially harming the economy of local communities. Further, increased extreme hot and dry periods elevate the potential for fires (and arson) making biomass production particularly vulnerable.

Scarcity of rare materials. Several low carbon technologies require so called critical materials during the construction. Across the pathways, critical material demands are consistently dominated by vehicle technologies.

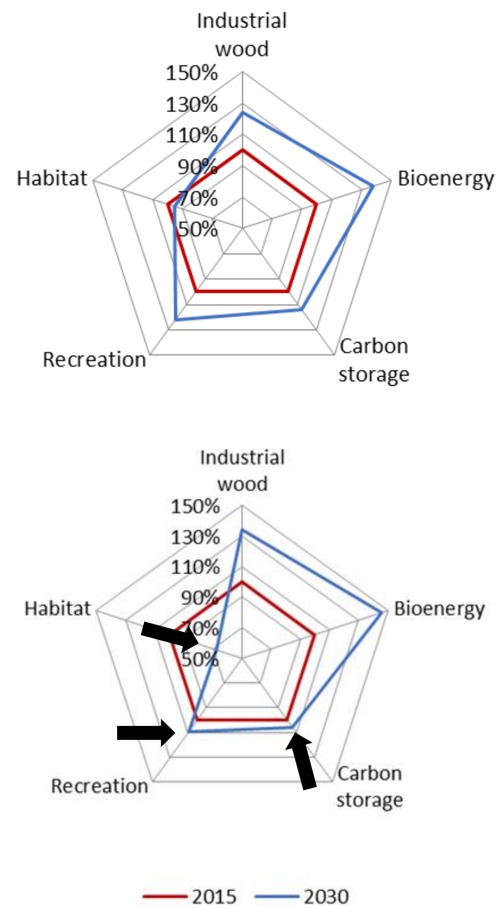

Figure 4. Impacts of the use of biomass for bioenergy on other ecosystem services in case of less intensive (top) or more intensive (bottom) use of biomass by 2030.

According to the analysis, the most scarce materials are cobalt and tellurium, with a second grouping including platinum, rare earths (particularly dysprosium and neodymium), gallium, and indium. Potential supply bottlenecks exist across the geological, economic and geopolitical dimensions. This will require the EU to actively embrace and promote material efficiency, recycling and substitution. Similarly, the EU should promote global cooperation and standards for the use of critical materials.

Non-EU drivers of the transition. As the development rates of technologies mainly follow global processes, the EU energy system developments are, to some extent, linked to decarbonisation targets and supporting schemes in different parts of the world. Discrepancies in mitigation ambition between the EU and the rest of the world may impact exports, and consequently competitiveness. For example, decarbonisation will increase regional investment. If that investment is not in EU products, it will likely reduce purchases in EU products and slow its economic development.

New risks in a changing world. Centralised and decentralised solar PV and wind infrastructure, increasingly important in the energy supply mix, has higher exposure to extreme weather events than many conventional power plants. Further, the information systems used for simultaneous control of demand, storage and intermittent production will require massive ICT automation. This will increase cyber security risks as energy service supply will be determined by interconnected and remotely controllable power plants, transport, distribution and appliance systems. Regulations and security of supply assessments need to adapt to these new paradigms.

Opportunities

Energy efficiency is able to mitigate several risks. Mature and low-cost technology options exist and their uptake will require proactive leadership across sectors. For example, the renovation of the old residential building stock in the EU will affect sectors including welfare, construction and energy. Deep renovation and new building practice will mitigate the increase in energy demand across the EU. It will reduce heating needs of vulnerable customers. And will require new skills and increased construction labour force.

Electrification can be an effective way to decarbonise economies, especially sectors, which are the hardest to decarbonise, such as heavy industry (through power-to-heat solutions). Low-carbon electricity may be provided by a mix of renewable resources. For heavy continuous industry that will require baseload generation, apart from variable RET + storage, nuclear and biomass are consistently calculated as a reliable cost optimal option for such purpose.

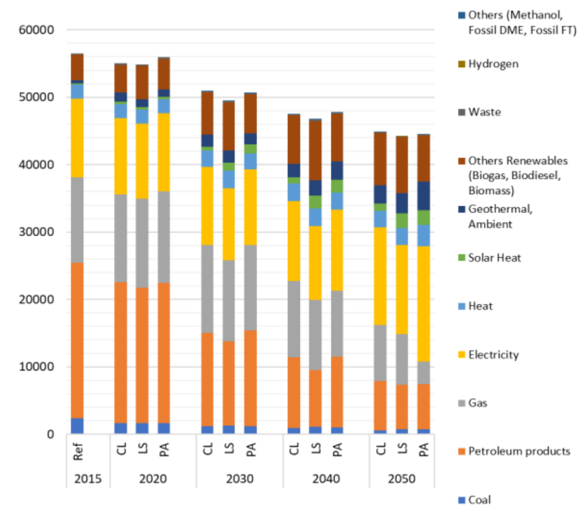

Figure 5. Total Final Energy Consumption in the EU28 in the three REEEM pathways, by source [PJ].

Investments in industries in vulnerable regions (primarily in countries in Eastern and Southern Europe) also present potential for equitable and just development. This may include the aforementioned ramp up in residential efficiency measures, or the deployment of RET investments, such as biomass and others.

Potential of technology and innovation. Studies carried out with industrial partners on specific technologies and published in the REEEM Technology and Innovation Roadmaps unveil investment opportunities. The EU is already a world leader in certain technology production chains (e.g. insulation materials for buildings). It has the potential to consolidate its position in the production chain of technologies where demand is increasing (e.g. batteries). It also has the potential to benefit from innovation (e.g. breakthroughs in off-shore wind and solar tiles).

Reduced health costs. There are clear synergies between CO_2 reduction and air pollution control in identified locations. That is because many fossil fuel options emit local emissions, while many RET and nuclear options do not. Integrated climate change mitigation and air pollution control policies may accelerate CO_2 emissions reduction, especially in the next decade. Additionally, reduction in local air pollution following from climate policies are expected to bring welfare benefits in terms of reduced health costs of 76-84 billion € cumulative by 2050 compared to 2015. Health benefits are expected particularly in Central European countries (such as Germany and Poland). The graph below shows a significant decrease of Disability-Adjusted Life Years (i.e. lost years of healthy life) for such countries in the pathway with the highest decarbonisation ambition (Paris Agreement).

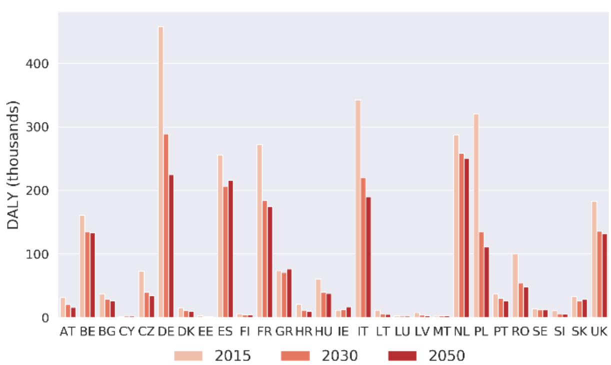

Figure 6. Country-specific health impacts in DALY attributable to air pollution from EU28, CH and NO for selected years, in the PA pathway.

Role of biomass. The modelling suggests that deep decarbonisation of the EU energy system is possible, but the marginal effort of pushing it beyond 95% CO_2 emission reduction in 2050 (compared to 1990) is high, especially in heavy industry and segments of the transportation sector (aviation and maritime). CCS applied to biomass-fired generation, a carbon-negative option, could allow carbon-neutrality at lower cost. Further, while they have inherent risk, biomass farms can be employment intensive and improve local economic performance.

Balance of costs and benefits across sectors. The fundamental change to the European energy system will create differentiated impacts across countries, sectors and socioeconomic groups. While some may be negatively affected by the transition in some respects, they may benefit from it in others. For instance, Central European countries, such as Germany and Poland may see lower GDP growth with higher decarbonisation targets, but they will likely benefit the most in terms of reduced health damage costs. As for industrial sectors, some are expected to thrive, in terms of gross added value and employment rate, (e.g. non-metallic minerals and vehicles), while others, such as coal production, are likely to be affected in a negative manner. This provides an important opportunity for EU leadership to take advantage of regional and local competitive advantages.

A research and policy agenda

A discussion of the risks and opportunities listed above with representatives of the European Commission took place. That was in the final meeting of the REEEM project on July 16th, 2019, and led to the further development of a policy and research agenda emerging from REEEM research, including the following recommendations.

Research recommendations

- Comprehensive and multi-sectorial modelling frameworks such as the one piloted in REEEM may be used to analyse the benefits of new policy options (e.g. co-benefits of GHGs and air pollution control measures) and risks mitigation options in the transition (e.g. climate impacts – extreme events impact on biomass – energy/water nexus).
- Creating transparency in the inputs and outputs of model-based assessments is of paramount importance for ensuring comparability between the modelling efforts within and outside of the European Commission. This will lead to creating

a family of models able to extract broad and robust insights but which garner support from different stakeholders.

- Biomass-fired technologies emerge consistently as a key option for mitigation, critical in the path towards carbon neutrality. Their role, potential trade patterns, employment implications and potential impact on land use, carbon sinks and ecosystem services deserve specific research.
- Further research focused on the co-benefits of policies cutting across several sectors will help the elaboration of policy packages and ultimately help increase the pace of the transition. The analysis of risks and opportunities in each sector and the elaboration of innovative metrics (such as a 'green GDP') is a means to this end. The REEEM project showed that it is possible to undertake simultaneous multi-sector analyses. Given the demonstrable gains, that should be expanded.
- Research on the impacts of transition pathways on the vulnerability of sub-sectors and income groups must be prioritised. An approach to vulnerability assessment includes the use of the TIA (Territorial Impact Assessment) approach alongside quantitative scenario analysis as in REEEM, and the creation of a Just Transition Observatory to further collate and develop analytical tools, data, and policy experience.
- Engaging citizens in the research around the deep decarbonisation of EU societies is essential for a fast transition. Co-creation approaches for research actions and involvement of social scientists in the study of energy consumption behaviours (e.g. at the EMP-E) is advised.
- The approaches for assessing the impacts of decarbonisation pathways on the environment and the use of critical resources created in REEEM and applied to specific regions can be extended to the whole EU and systematically applied on all geographical scales, down to local realities.
- Deeper assessment of technical aspects of pathways to carbon-neutrality across scales is needed. Evaluation of extreme scenarios will help test how much electrification can be pushed across sectors, what role storage and different trade patterns are going to have, and how resilient energy infrastructure is to extreme weather events.

Policy recommendations

- An integrated perspective comprising different environmental aspects may result in earlier actions, additional benefits and welfare savings out-balancing any extra effort required. For instance, combining GHGs mitigation policies with policies aimed at the control of air pollutants, use of critical materials, use of resources along the value chain and impact on ecosystem services may accelerate the transition to a low carbon society and reduce its costs.
- In the EC analyses, greater coherence is needed and a coordination framework should be investigated. Analysis between scales, sectors, resources, fuels, employment, local and global emissions would be of aid. With it, co-benefit (and co-cost) actions can be identified.
- Purpose- and social-oriented tax reallocation mechanisms may enable a just transition while saving emissions and reusing income for renewable investments.
- An industrial policy is needed, aimed at unlocking the production potentials within the EU and direct investments where the Union may be competitive (e.g. biomass-based and geothermal technologies, production of batteries, insulation materials for buildings).
- Synergies between value chains of innovative technologies (e.g. insulation of roofs-solar tiles, offshore wind-ocean) could lead to opportunities for cost reductions and economies of scale. Support schemes for

technology coupling will enable them, allow for a more efficient transition and a more secure energy mix.

- Recognition that regions differ significantly in terms of vulnerability and capacity to respond, both between and within regions, should be mainstreamed into the policy process. Fair and Just transition planning is vital for coal-dependent regions. Effective planning focused on new opportunity for workers needs to be in place over the next decade.
- A package of measures integrating regulations, subsidies and information campaigns, rather than separated measures, could help address behavioural barriers. Furthermore, measures must be targeted to take into account the different needs and habits between regions in each Member State.

Tools at hand to create engagement

Engagement by all actors involved in the transformation of the energy system appears essential for a fast and effective transition. REEEM created tools to promote engagement, including:

- ***A comprehensive modelling framework for integrated policy assessment***. It is documented and available, to draw insights on key dynamics of the transition (e.g. benefits of burden sharing vs no cooperation) and to analyse a large number of scenarios with selected policy and decision levers.
- ***An open source PanEU energy investment model***. OSeMBE - a low-threshold-to-access open source model of the EU28+2 electricity system, representing key features of the whole REEEM modelling framework, has been created based on the widely used OSeMOSYS tool. It is used both as engagement model, in higher education teaching and training sessions for experts and non-experts across Europe, as well as open access research infrastructure.
- ***Online learning platforms.*** REEEMpathways is an accessible online platform to present key cause-effect relationships between sectors and key dynamics of the transition to a low-carbon EU energy system as computed in REEEM. It is open and ready to host new insights from further actions. The REEEMgame is a gaming platform for students, researchers and policy makers based on OSeMBE, which allows the player to make decisions on key drivers of the transition and measure the outcomes.
- ***Energy Modelling Platform for Europe (EMP-E)***. With inputs by DG R&I, DG Ener and DG JRC, REEEM created in 2017 the Energy Modelling Platform for Europe (EMP-E), with the intention to provide a forum of models and applications around the transition to a low-carbon society for researchers and policy makers. It culminates in an annual event hosted at DG R&I with the past sessions having more than 100 participants and its outcomes feeding into a Special Issue in the journal Energy Strategy Reviews (Elsevier). The Special Issue on EMP-E 2017, with joint preface by DG R&I, DG Ener and DG JRC, is one of the largest in the field, featuring 22 peer-reviewed publications, of which 10 fully open access;
- ***An open access body of research outcomes.*** 11 open-access peer-reviewed scientific publications available to date document in detail the advancements in science brought about by REEEM and outline the challenges for future research. More will be made available in an open access Special Issue of Energy Strategy Reviews (Elsevier). An open access research database provides all key inputs and outputs of the analyses and is linked to the Open energy Platform, reference point of the Open Energy Modelling Initiative.