FFF - Future of Fossil Fuels in the wake of greenhouse gas neutrality

The objective of this project was to investigate previously under-researched aspects of decarbonizing the German electricity sector in the European context. We base our analysis on three pillars, namely (i) the drivers and hurdles for implementing a European fossil fuel phase-out by 2050; (ii) the interaction between national plans and European policy; and (iii) interactions between fossil fuel phase-out and power system flexibility requirements. Our results provide insights on the different economic, technical, social and political hurdles of the needed transformation away from fossil fuels in Europe, and are summarised in Figure 8.

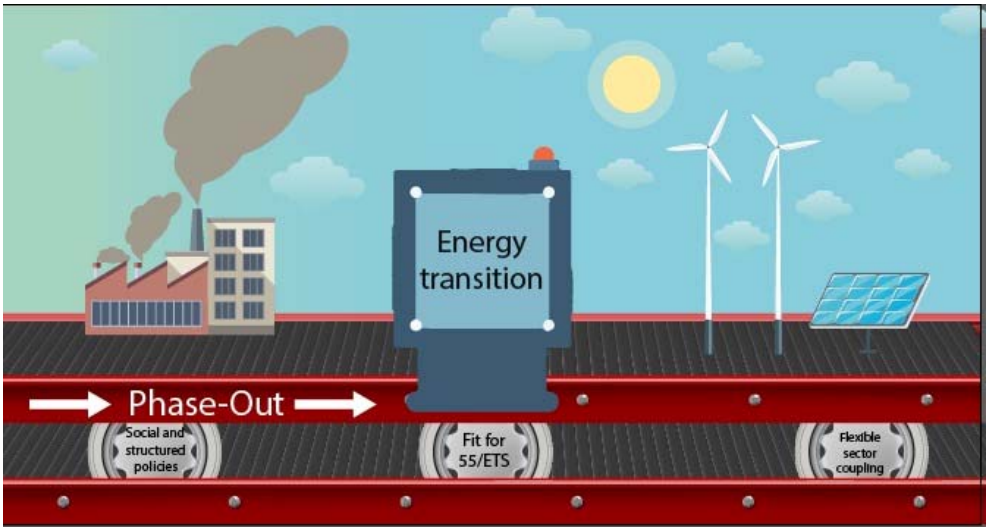

Figure 8 Transformation away from fossil fuels in Europe

The environmental benefits from phasing out fossil-based generation are well acknowledged. However, as such phase-outs can create negative regional economic and social effects, they are often politically difficult to achieve. Therefore, policies targeting a reduction in coal and natural gas need to be implemented jointly with social and structural policy measures in order to ensure political feasibility. We find that main hurdles arise from concerns about energy security, price increases and past negative experiences with structural change.

Even if phase-out plans are implemented in a satisfactory manner, since the power sector is embedded within the Emissions Trading System (EU ETS), they might lead to carbon leakage. To avoid this, the EU ETS should be strengthened. Our results show that with more ambitious EU targets (in line with the 'Fit for 55' package), coal (by 2030) and natural gas (by 2035) based-generation are phased-out due to high carbon prices. However, very high carbon prices might backfire: Therefore, alternatives to release the pressure on the ETS and non-ETS sectors should be provided, de-risking renewable energy investments is necessary to safeguard the energy transition, and a price-based mechanism instead of the Market Stability Reserve (MSR) should be considered.

Finally, even if the transition proves just and politically acceptable, its technical feasibility needs to be ensured. With increasing sector coupling, leading to rising electricity demand resulting from decarbonization efforts in other sectors, the required transformation in the power sector is substantial. We find that long-duration electricity storage and flexible sector coupling are key components of future renewable energy systems and can mitigate merit order and cannibalization effects of variable renewables. In particular, power sector flexibility provided by battery-electric vehicles may outweigh its additional electricity demand effects.

“Future of Fossil Fuels in the wake of greenhouse gas neutrality”

TU Berlin, DIW Berlin und PIK

Future of Fossil Fuels

Technische Universität Berlin

PIK

DIW BERLIN

SPONSORED BY THE
Federal Ministry of Education and Research

The project‘s key research questions and goals

Analyses focus on **three aspects of the future of fossil fuels**:

(1) identifying the **drivers and hurdles** for implementing a European fossil fuel phase-out by 2050

(2) investigating how **national pathways** for phasing out fossil fuels **interact with European climate policies,**

(3) analyzing the **interactions between a fossil fuel phase-out and power system flexibility** requirements, as well as the implications for sector coupling

- The project builds on model-based analyses of the European power sector and on political economy case studies.
- We focus on the concrete and inevitable challenge of a controlled disestablishment of industries involved in the production and consumption of fossil fuels.
- Our products, scientific publications, regular stakeholder engagement formats, policy papers, and concrete policy advice have and will stimulate the scientific and public debate on how to phase-out fossil fuels while minimizing negative side-effects and societal costs.

Some major project insights

- Regions with **high amounts of natural gas- and/or lignite coal capacities face the biggest challenges** when strict decarbonization goals are enforced.
- To achieve **political feasibility**, policies targeting a reduction in coal need to be implemented jointly with social and structural policy measures. Main hurdles arise from concerns about energy security, price increases and past negative experiences with structural change.
- **Unilateral phase-out** plans might contribute to achieve national targets but there is risk of **carbon leakage** under the EU-wide ETS. **Strengthening the EU policy** is desired and could lead to coal (and eventually gas) phase out already in the medium-term resulting from **high carbon prices**.
- Rising carbon prices might also face **political backlash**. First, alternatives to **release the pressure** either on the ETS or non-ETS sectors should be provided. Second, **de-risking RES** investments is necessary to **safeguard the energy transition**. Third, a **price-based alternative** might be necessary to the Market Stability Reserve (**MSR)**, given its related added complexity to the market and high price uncertainty.
- **Long-duration electricity storage** and **flexible sector coupling** are key components of future renewable energy systems and can mitigate merit order and cannibalization effects of variable renewables
- A methodological contribution: how to avoid **unintended storage cycling** (or more general: unintended energy losses) in optimization models with renewable constraints
- Battery-electric vehicles: with flexible charging and vehicle-to-grid, **the power sector flexibility provided by BEV may outweigh its additional electricity demand effects**

Utilization of results: who are the main recipients of your project´s results and how do you make sure the results reach these recipients?

Our main recipients are stakeholders from academia, policy-makers, NGOs, but also unions, practitioners, and civil society.

We already had a large stakeholder engagement with relevant stakeholders in Germany and Europe:

In particular **various meetings** in Germany in 2019 and 2020 regarding the coal phase-out, including the „coal commission“, the Environment Committee of the Bundestag, and the Saxon state parliament on the implementation in the Lausitz.

- We organised **several online workshops** on the future of natural gas, the European Green Deal, the history of coal, and modeling storage aspects addressing various German, European, and international audiences, including the final project conference.

– We presented and will in the future present results at academic conferences.

- There was already **media coverage on project results,** such as an IPPR Podcast & a Deutschlandfunk Nova interview, and other media outlets; we also published a **project brochure** and will publish further op-eds and blog posts.

- We have made most of our scientific results available for other researchers via **publications in highly ranked and widely read outlets** such as *Nature Energy*, *Joule*, *Environmental Innovation and Societal Transitions, Applied Energy, Energy Policy, Energy Strategy Reviews.*

- We also provide extensions and applications of **open-source modelling tool**s such as DIETERpy and emobpy via GitLab

What are the most pressing research needs that should be addressed as a next step, also considering the political developments? (I)

- Especially due to the gas price crisis, the ongoing debate about whether to label natural gas as sustainable in the EU taxonomy, and the need to plan whether to invest in new gas capacities or not, a focus on **natural gas' role in energy transitions** is needed.
- Natural gas' role should be analysed on an EU wide scale, but phase-out dynamics and how to organise the **decline in natural gas use**, and what that means for power plant capacity factors, the economics of gas grids or potential alternatives such as heat pumps and low-temperature district heating networks should be **analysed for specific local contexts**.
- Research on **oil phase-outs** is lacking, which also becomes more and more important due to rising oil prices and needed emission reductions in the transport sector.
- Research on the required **mechanisms to decarbonise the buildings sector**. To what extent could **renovation** play a role, and how to trigger it? What are the required **incentives for electrification and district heating expansion**? Is a **phase-out for fossil-based boilers** necessary or could the new ETS do the work?

What are the most pressing research needs that should be addressed as a next step, also considering the political developments? (II)

- With increased **sector coupling**, the two EU carbon schemes, namely **ETS and ESR**, are getting more intertwined. Overall, there is need to understand how to better **integrate** them and how to avoid large price differences that might lead to technology lock-ins.
- We need practical, integrated and **open-source models of fully renewable energy systems**, representing **flexibility** aspects of sector coupling in sufficient detail, and also considering rare periods of **renewable energy droughts**.
- There is a need to efficiently facilitate adequate **investments** and **system-oriented operation** of **long-duration storage** and **flexible sector coupling** in real-world energy markets. This also raises questions of **market design and (tariff) regulation**.