Coal phase-out scenarios in Germany and Europe

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Outline

• Motivation for coal phase-out
• Methodology
• Assumptions and scenarios
• Results of coal phase-out scenarios
  • In Germany
  • In EU
• Conclusions
Motivation

• 4th monitoring report of the German Federal Ministry for Economic Affairs and Energy (BMWi): Germany won’t be able to reach its GHG emission reduction target for 2020.

→ Phase out of coal or at least lignite capacity is discussed. 2.7 GW lignite capacity will be shifted into a strategic reserve ("climate reserve", see “Strommarktgesetz”, published in 26/7/2016)

• UK announced the phase-out of coal-based power production by 2025 (see “Guardian, 09/11/2016”)

• Objective: Analysing the impacts of a German coal phase-out and of EU-wide investment moratorium (on electricity mix and CO₂ emissions)
Methodology

• Long term capacity planning and dispatch model (PERSEUS-EU)

• Power system EU28 including Switzerland and Norway

• Minimization of total system costs under a set of technical, ecological and political constraints

• Resolution: block-sharp, with three type days and 24 time-slices in each day

• Problem formulation as a MIP
Assumptions and scenarios

- Environmentally related assumptions
  - Technology neutral EU renewable targets for each periods (2050: 80%)
  - Certificate costs are considered exogenously by integrating a CO2-price

- Scenarios for Germany
  - **BASE Scenario**: Coal and lignite investments are possible in Germany, decommissioning at the end of the lifetime
  - **Phase-Out-DE**: A linear total coal and lignite phase out until 2040, about 1.6 GW p.a.
RESULTS: Production mix in Germany

- In all scenarios, fossil generation is progressively replaced by renewable energy sources due to framework assumptions
  - Technology neutral European renewable targets for each period
  - High CO2 Prices

- Germany relies on electricity imports in phase-out scenario
  - becomes an import country in both scenarios
  - RES investments are partly more feasible in neighboring countries
  - Specific targets for renewables (e.g. PV) in Germany probably would probably change this fact
Wholesale price paths

- In all scenarios, prices increase over the time horizon.
- Increase is more significant in the phase-out scenario, especially from 2025 on.
- BASE and the phase-out scenario converge over long-term.
  - Coal and lignite-fired power plants are only retrofitted in the first periods.
Additional emission reductions are observed in the phase-out scenario but only in the mid-term.

German coal phase-out has very little additional impact on total European emissions.

Decrease of the German emissions is partly compensated by increased emissions in other countries (neighboring countries like Czech Republic and Poland increase their electricity production).
Emission reduction scenarios for Europe

• **Phase-out-EU:**
  - No coal and lignite investment in Europe is allowed (investment moratorium)
  - Coal and lignite power plants are decommissioned after their technical lifetime (40 years)
  - CO₂ price are considered exogenously by integrating a CO₂ price

  *Source: EU Energy, transport and GHG emissions - Trends to 2050 - Reference scenario 2013*

• **CO₂-CAP:**
  - Resulting CO₂ emission quantity of Phase-out-Europe scenario are set as CO₂ cap
  - Coal and lignite power plants are decommissioned after their technical lifetime (40 years)
Results: Phase-out-EU

- The EU-Emission reduction targets can be reached with a European coal phase out.

- Emission reduction after 2020 are higher in phase-out-EU scenario due to lower coal capacity.

![CO2 Emissions Graph]

- The graph shows the trend of CO2 emissions from 2015 to 2050 for different scenarios:
  - BASE
  - PHASEOUT-DE
  - PHASEOUT-EU

- Emission reductions are projected to decrease over time in all scenarios, with the PHASEOUT-EU scenario showing the steepest decline by 2050.
CO$_2$-CAP vs phase-out-EU

- Higher coal and lignite production in CO2-CAP scenario as expected
- Higher gas production in phase-out-EU scenario
CO$_2$-CAP vs phase-out-EU in 2040

- Higher coal, lignite and nuclear production in CO$_2$-CAP scenario.
- Due to nuclear investments in the countries such as UK and France, lower wind offshore production in CO$_2$-CAP scenario.
  → Wind onshore production in other European countries compensates wind offshore production
Conclusion

• An early phase out of coal and lignite leads to slightly higher prices and imports in Germany

• Coal phase out in a country leads to “carbon leakage” within Europe. A EU-wide coordinated carbon or coal policy is more effective

• European coal phase-out further reduces the emissions in Europe.

• CO\textsubscript{2} certificates can be a solution as an EU-wide coordinated carbon policy. → Increasing CO\textsubscript{2} prices up to 80€/t in 2035 and 150 €/t in 2050 is required to reach the same effect as in the coal phase-out scenario

Outlook:

• Uncertainties and sensitivities, higher time-resolution
References I

• BMWi. (2016). Zahlen und Fakten Energiedaten.
References II


Thank you for your attention!

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CO$_2$-CAP certificate prices

- Certificate price increases up to 150 € in 2050.
Capacity Mix CO2-CAP

CO2-CAP capacity mix Europe

- 2015
- 2020
- 2025
- 2030
- 2035
- 2040
- 2045
- 2050

- OTHER RES
- COAL
- HYDRO
- GAS
- LIGNITE
- OIL
- PV
- UR
- WIND
- WIND_OFF
Phase out scenario for hard coal and lignite in Germany