The future of coal

Franziska Holz in collaboration with Chris Hauenstein, Roman Mendelevitch, Tim Scherwath, Ivo Kafemann, Pao-Yu Oei, Christian von Hirschhausen, Oliver Sartor, Thomas Spencer et al.
Global (steam) coal: where to?

Source: IEA Coal Information 2019
A numerical model of the global coal value chain: COALMOD-World

[Diagram showing supply, global steam coal market, demand, and coal infrastructure]
The COALMOD-World model

Partial equilibrium model

- Large-scale multi-period model of (competitive) steam coal market
  - Haftendorn et al. 2012, Holz et al. 2015, 2016)
- Profit-maximizing players with specific constraints: producers and exporters
- Market clearing via inverse demand functions
- Demand in energy from coal (in PJ) vs. cost in $/t
- Model features:
  - Mine mortality effects on costs and production capacities
  - Endogenous investment in production and export capacities
  - Substitution between importing and domestic production

- 40 consumption nodes (C), 25 producers (P), and 14 exporters (E)
- Multi-period model with yearly equilibria in 5-years-steps from 2010 to 2050

Source: Adapted from Holz et al. 2015
Model setup

Source: Haftendorn et al. 2012

P: Producers
E: Exporters
C: Consumption
}\: Capacity restriction

Production costs → Q → Transport costs → $/t

Port fees → Freight rates → $/GJ

$/GJ

P: Producers
E: Exporters
C: Consumption
}\: Capacity restriction
Fundamental uncertainties for global coal consumption:

1) The development of the CCS technology

Figure 1. Global coal consumption in 2 alternative 2°C scenarios versus a current reference scenario

Notes: IEA’s 2016 450 ppm scenario assumes that there are 3,800 large scale commercial CCS sites operating worldwide by 2050 and that there is a feasible maximum of 125 Gt of CO2 that could be captured. McGlade and Ekins (2015) include significantly lower CCS assumptions, as they question the economic and social feasibility of reaching significant scales of deployment prior to 2050, such that emissions from coal would be likely to be consistent with the global <2°C carbon budget.

Fundamental uncertainties for global coal consumption:
2) More ambitious Nationally Determined Contributions (NDCs)

Example: possible revisions of the NDC by China

**Figure 2. CO₂ emissions under 2025 vs 2030 peaking scenarios**

- **Similar to China’s current NDC scenario**
- **Possible emissions under late peak/slow decline scenario (implies coal peak in 2025 and decline from 2030 onwards)**
- **Possible revised emissions under an earlier peak/decline scenario (implies coal peak in 2020 and decline thereafter)**

*Source: Coal Transitions project, based on data and analysis from Tsinghua University.*
Example: Coal phase-out in Germany

- Gradually shut down coal-fired (lignite and hard coal) power plants until 2038
- Close lignite mines accordingly
- Compensate lignite mining regions with public projects with a total public spending volume of up to 40 billion €
- Consensus in scenarios that stable electricity system operations is feasible without coal after 2035 (and does not require extensive imports)
Fundamental uncertainties for global coal consumption:
3) Decrease of renewable costs (incl. costs of system integration)

Figure 3. The increasing competitiveness of renewable energy with hard coal technologies

Figure 4. Cost of Lithium-ion Battery Storage

Figure 9. Renewables costs versus new coal

Source: Authors, based on tariff orders from CERC and SERCs and results of competitive bidding
Effect of uncertainties: strong uncertainty on future coal demand

- IEA had to revise (downwards) all its coal consumption predictions of the last decade.

*Figure 5. IEA WEO global coal demand forecasts evolution (Current Policies Scenarios)*

*Figure 6. IEA WEO global coal demand forecasts evolution (New Policies Scenarios)*

Source: IDDRI, based on forecast data from IEA WEO reports.
Our coal consumption pathways to 2050 – Peak coal is imminent

Total global steam coal demand in various scenarios to 2050 (in Mtpa)

Source: COALMOD-World results.
Different global coal pathways to 2050 in detail

**Reference Scenario (NDC):**
Growth rates of coal demand derived from WEO 2016 New Policy Scenario

**450 ppm Scenario (2°C):**
- Growth rates of coal demand derived from WEO 2016 450 ppm scenario (consistent with the 2°C target)
- Incl. CCS

**Enhanced Coal Transition Scenario (ECT):**
- Enhanced information on national transition scenarios from the project country teams
- Based on NDC scenario
- Better reflection of drivers of coal transition on country level

**Enhanced Coal Transition Scenario 2 (ECT 2):**
- As ECT, except for India (higher than ECT demand) and China (lower demand than ECT)
- Adequate reflection of drivers of coal transition on country level

Figures 11-12-13-14. Global coal consumption by source and destination 2010-2050 in the scenarios

Source: Coal Transitions and Coalmod:World results.
Strong effects on imports (and, hence, exporters)

- Depending on the scenario, some currently large importers may fully stop importing before 2050 (e.g. India in 2°C scenario by 2040, China in ECT2 scenario by 2045)

- Sudden shifts to such a scenario (e.g., because of strengthening NDCs) would surprise exporters
**Effect of higher climate ambition on exports**

**Figure 18.** Change in exports over time by scenario and exporter compared to NDC

Source: COALMOD-World results.
The effect on coal sector infrastructure

- If coal demand does not materialize as expected, less infrastructure will be needed: coal production capacities (mines in operation), coal transport capacity (e.g., railways) and coal export capacity (coal export terminals).

- Those assets may become „stranded“

- Existing capacities may be amortized, but particularly investments in new capacity face the risk of becoming stranded.

Note: In the COALMOD-World model, we assume mine depletion and, hence, the need for replacement investment to keep stable production capacity levels.

Source: COALMOD-World results.
Conclusions

- Global coal market modeling and country case studies show that there is a broad range of possible futures that are NDC-compatible.
- Additional scenarios with more climate ambition are becoming more and more probable, too.
- China (large domestic mining) and India (large importer) play a particularly important role in determining future market patterns.
- U.S. is the marginal coal supplier to the world markets.
- Exporter governments and coal companies need to take into account the risk of sudden changes to their coal industry which will result in:
  - Asset stranding of coal infrastructure
  - Bankruptcy of coal companies
  - Moreover, financial investors are increasingly divesting from fossil fuel companies
  - Unemployment of miners and workers in related sectors.
Coal phase-out is part of the energy transition

Source: DIW Berlin, Wuppertal Institute, Ecologic (2018) Coal Reader
Insights from a Global Coal Model

Thank you very much for your attention!

Franziska Holz (DIW Berlin)
fholz@diw.de
References


Franziska Holz

Additional slides