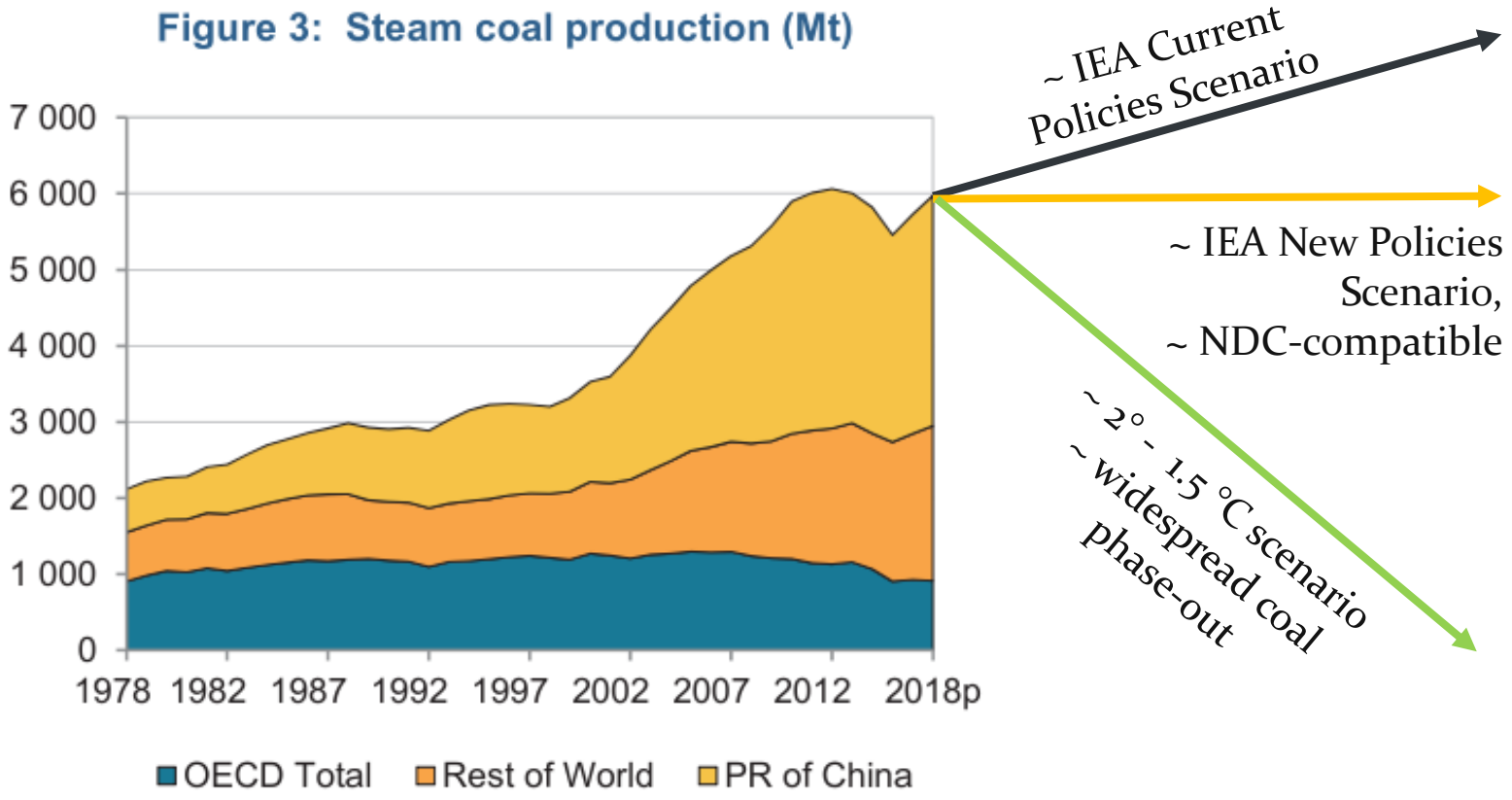
DIW BERLIN IDDRI COALEXIT www.coaltransitions.org COAL TRANSITIONS

VISTA Workshop @ Norwegian Academy of Science and Letters, November 5, 2019

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.

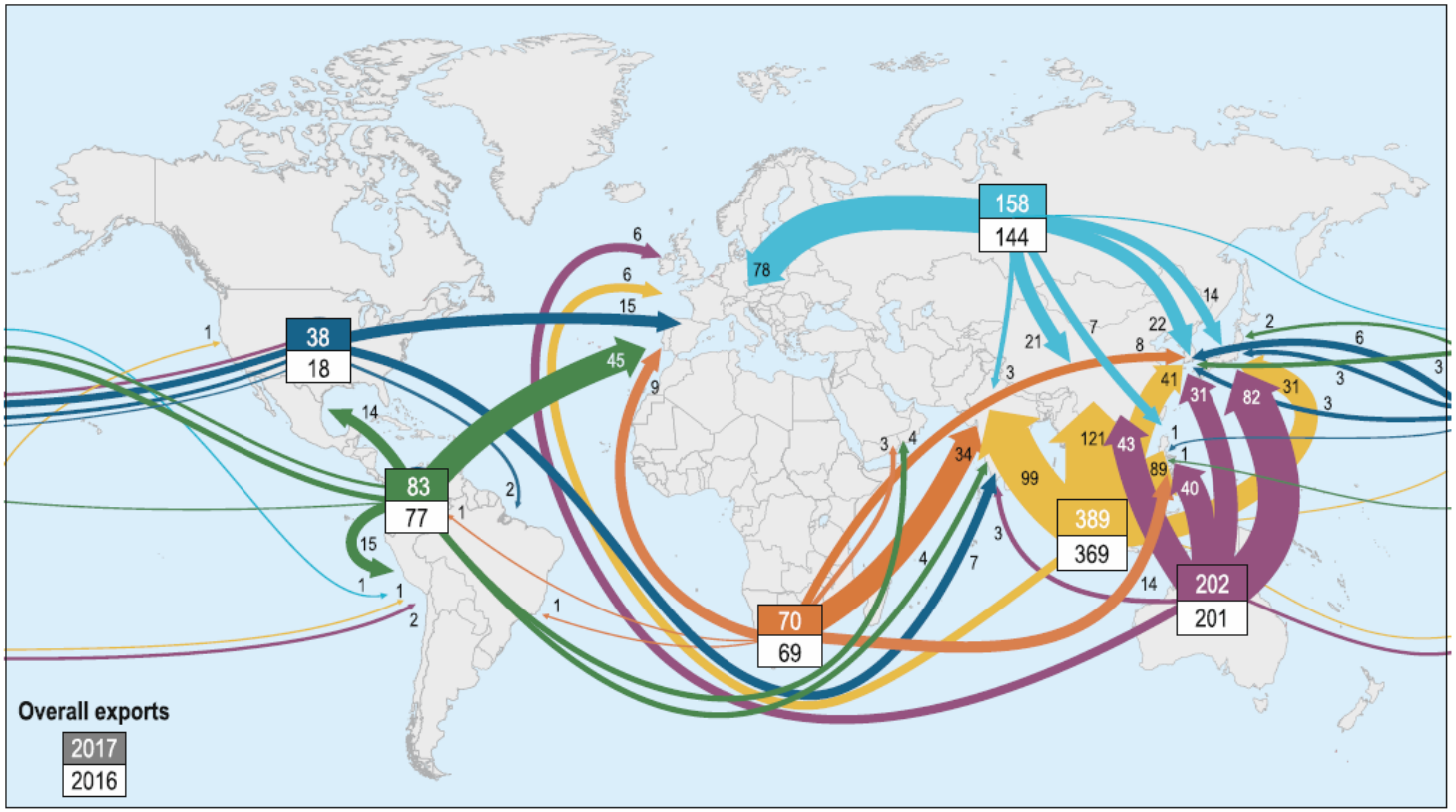
Global (steam) coal : where to ?



Source: IEA Coal Information 2019

The global steam coal market

Map 2.1 Main trade flows in the seaborne thermal coal market, 2017 (Mt)



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

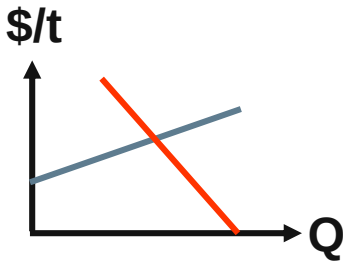
Note: Exports from Russia to Europe include exports via railway.

Sources: Adapted from IHS Markit (2018a), *Coal McCloskey Price and Statistical Data*, https://connect.ihs.com/industry/coal; IEA (2018), *Coal Information* (database), www.iea.org/statistics.

1 A numerical model of the global coal value chain: COALMOD-World

Coal Infrastructure

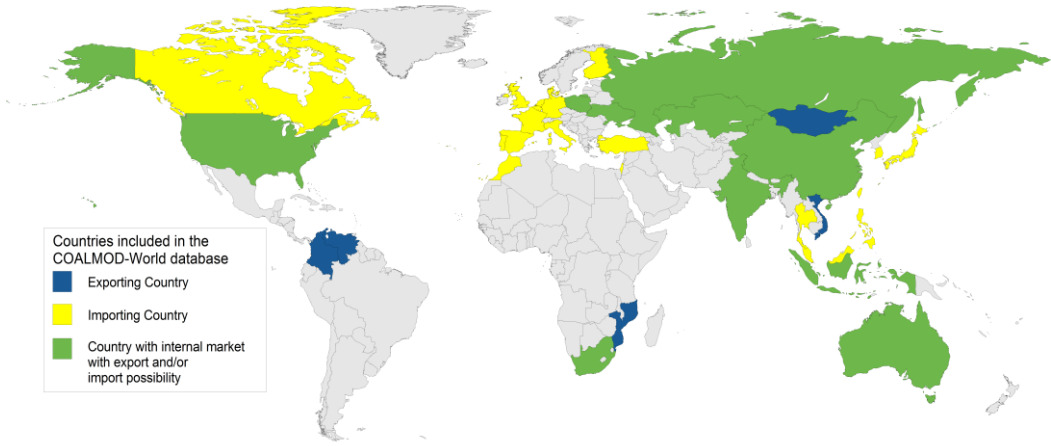
Supply → Global Steam Coal Market ← Demand



The COALMOD-World model

Partial equilibrium model

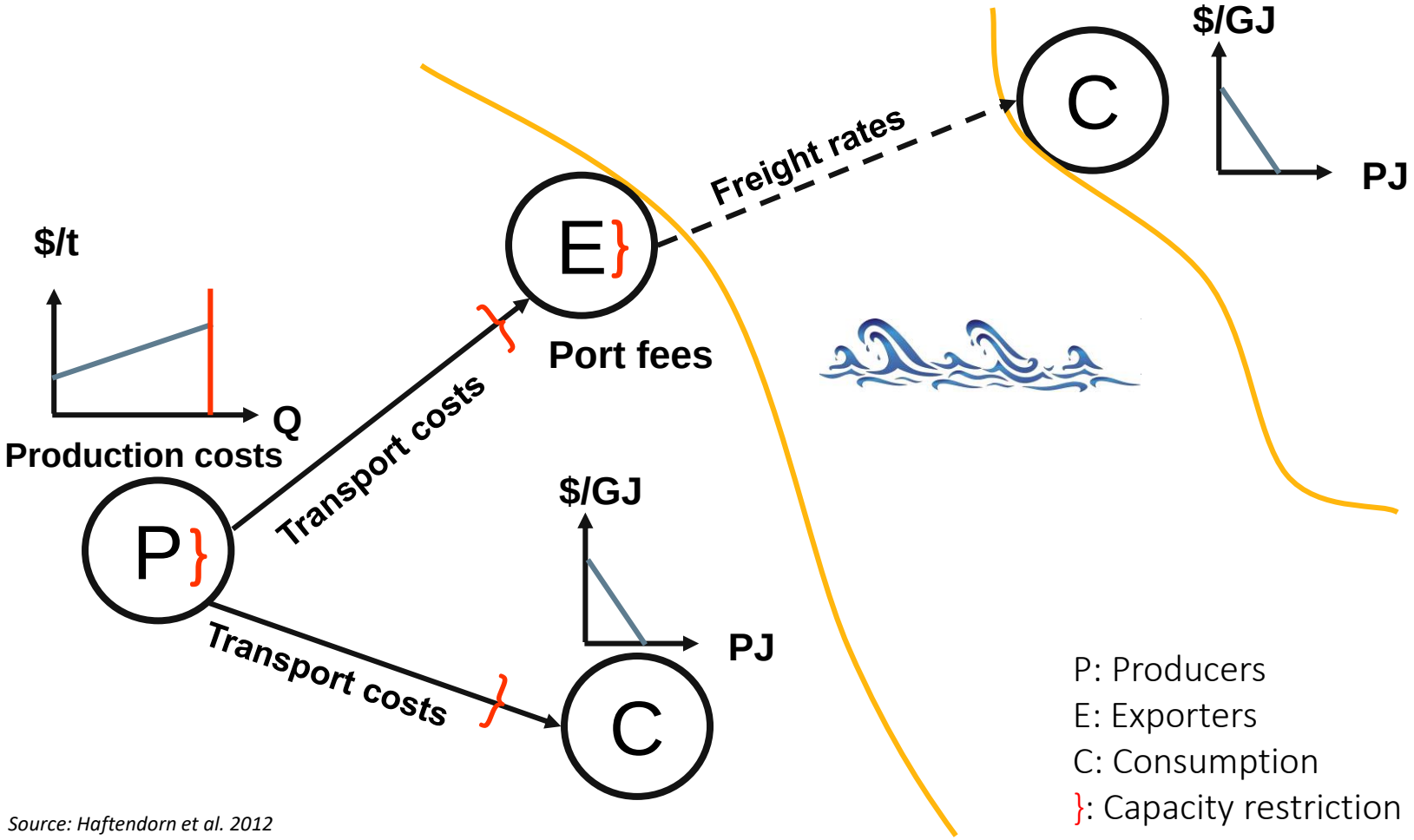
- Large-scale multi-period model of (competitive) steam coal market
  - Haftendorn et al. 2012, Holz et al. 2015, 2016)
- Profit-maximizing players with specific constraints: producers and exporters
- Market clearing via inverse demand functions
- Demand in energy from coal (in PJ) vs. cost in $/t
-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



Source: Adapted from Holz et al. 2015

- 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

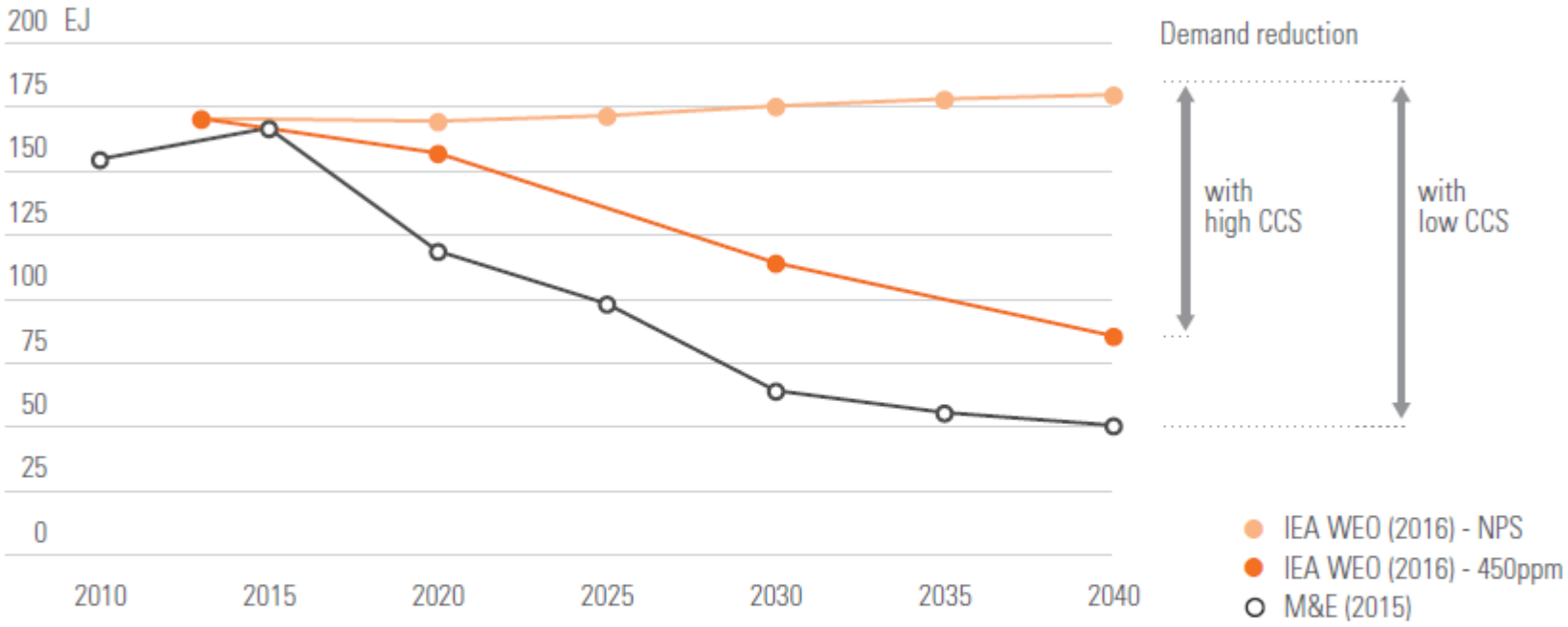
Model setup



Source: Haftendorn et al. 2012

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



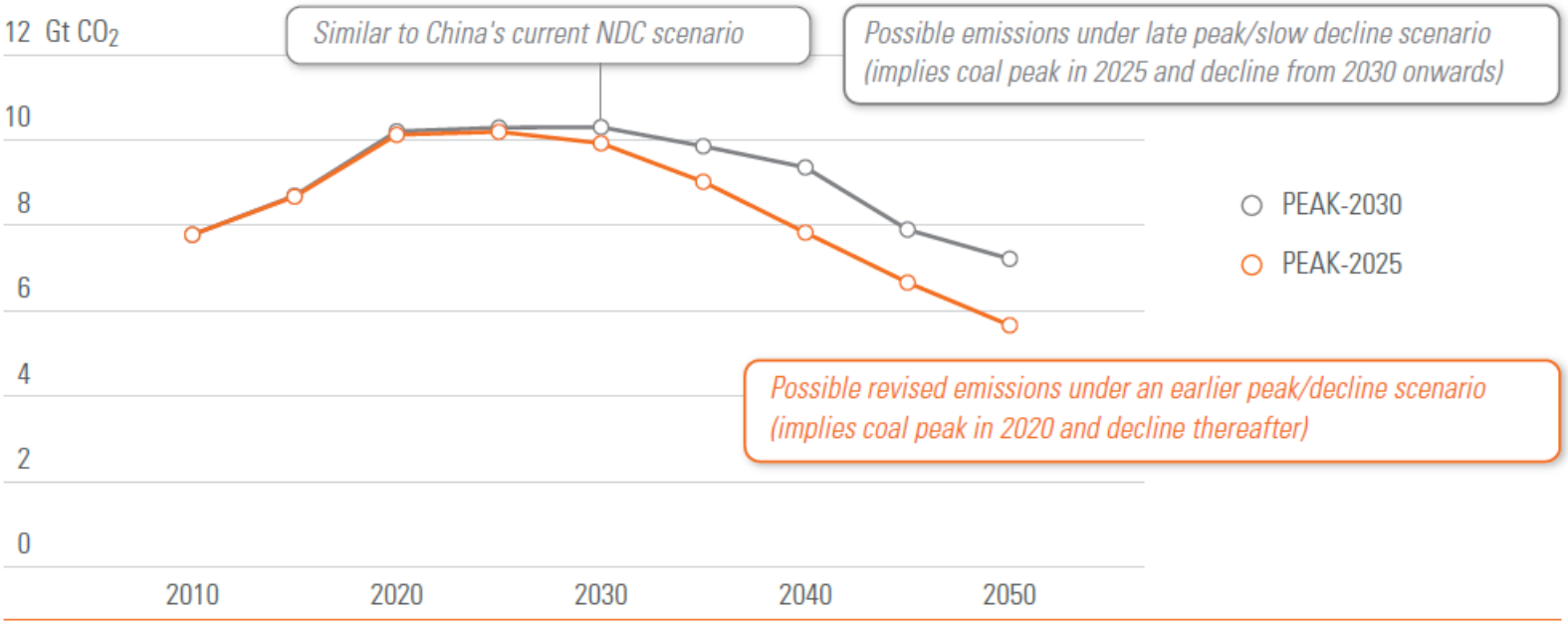
Notes: IEA's 2016 450 ppm scenario assumes that there are 3,800 large scale commercial CCS sites operating worldwide by 2050 and that there is a feasible maximum of 125 Gt of CO2 that could be captured. McGlade and Ekins (2015) include significantly lower CCS assumptions, as they question the economic 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.

Source: Illustration by DIW Berlin, based on data from IEA (2016) and McGlade and Ekins (2015).

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

Example: possible revisions of the NDC by China

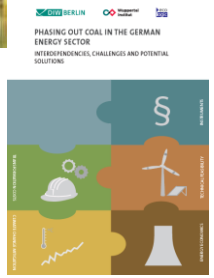
Figure 2. CO_2 emissions under 2025 vs 2030 peaking scenarios

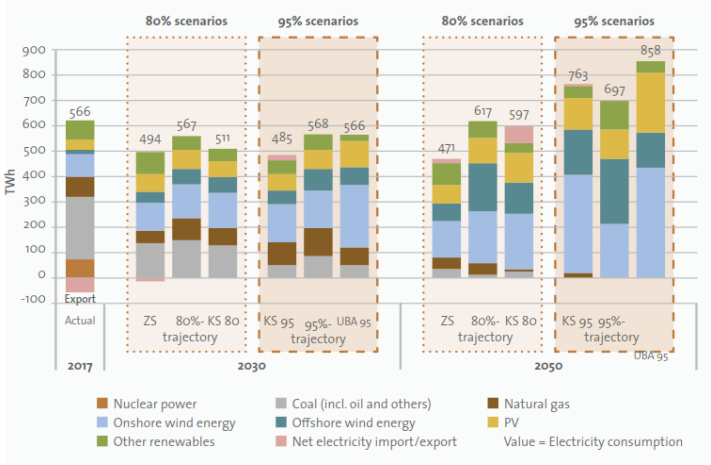


Source: Coal Transitions project, based on data and analysis from Tsinghua University.

Example: Coal phase-out in Germany

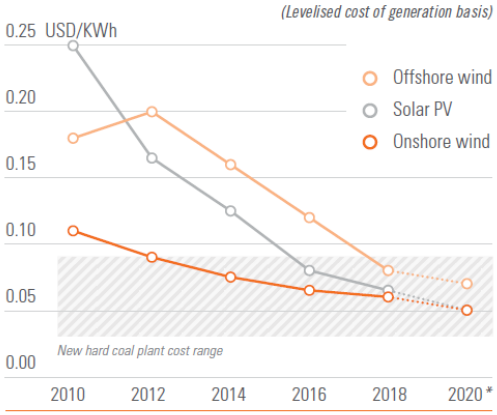
- Gradually shut down coal-fired (lignite and hard coal) power plants until 2038
- Close lignite mines accordingly
- Compensate lignite mining regions with public projects with a total public spending volume of up to 40 billion €
- Consensus in scenarios that stable electricity system operations is feasible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





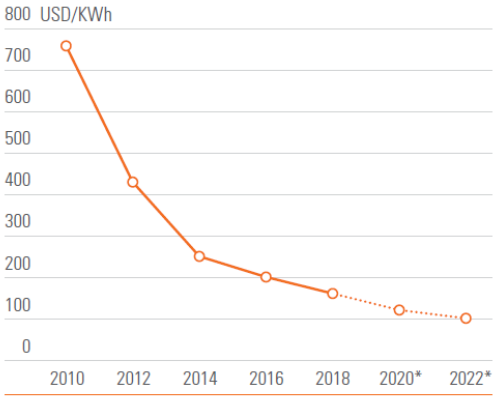
Fundamental uncertainties for global coal consumption: 3) Decrease of renewable costs (incl. costs of system integration)

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



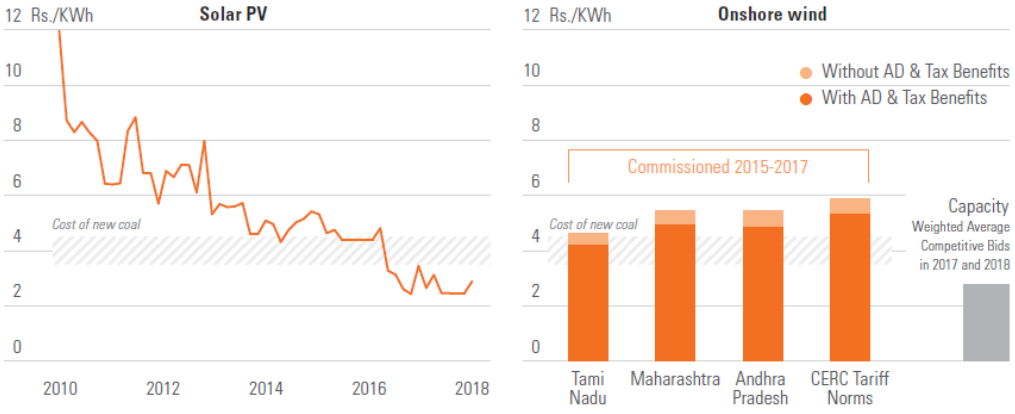
Source: IDDRI, based on data from IRENA, World Coal Association * forecast

Figure 4. Cost of Lithum-ion Battery Storage



Data Source: IEA, Energy Technology Perspectives 2017 * forecast

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)

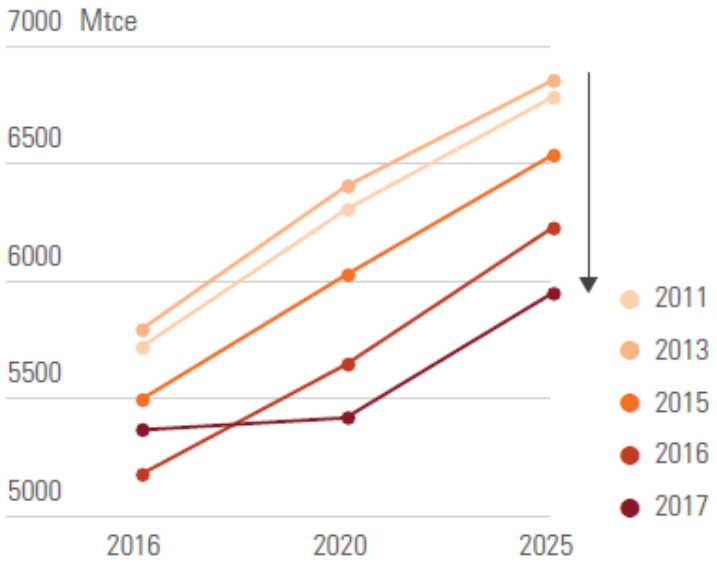
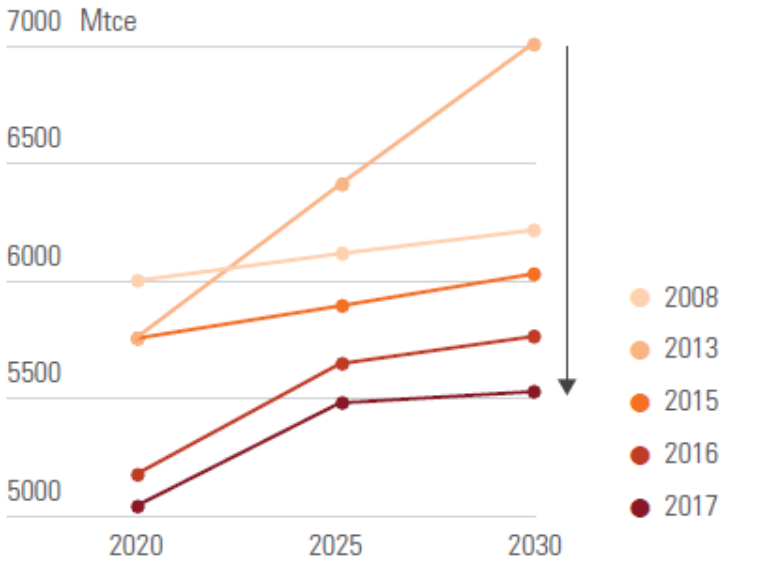


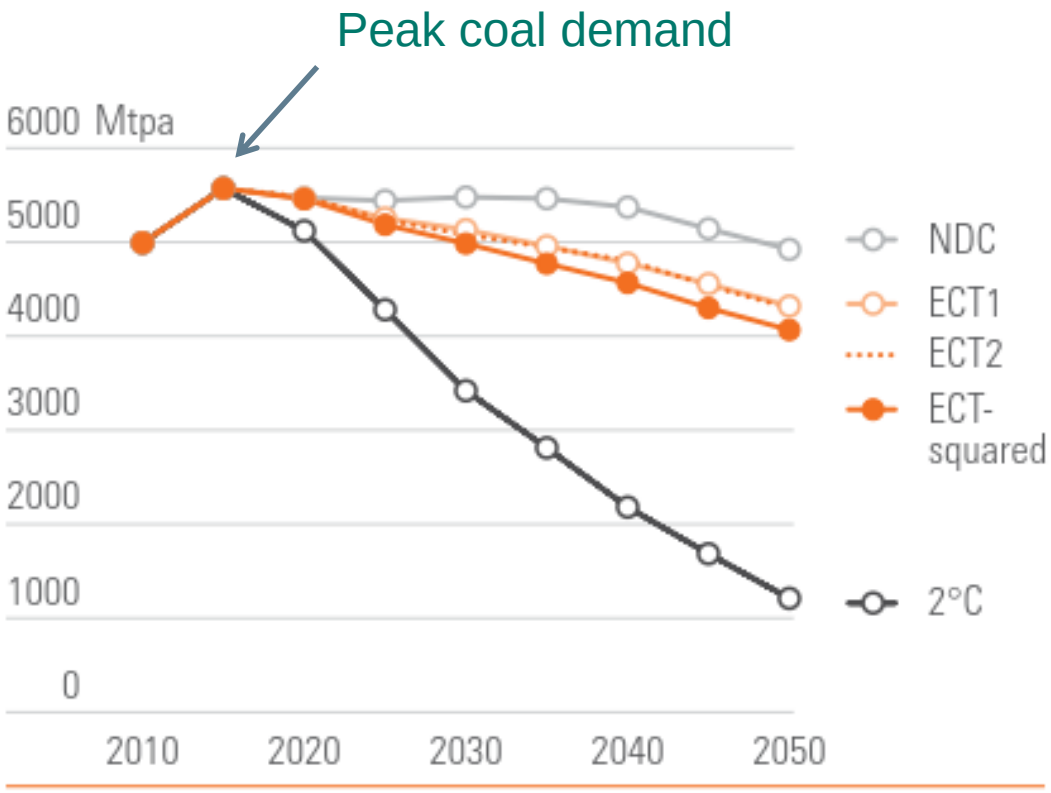
Figure 6. IEA WEO global coal demand forecasts evolution (New Policies Scenarios)



Source: IDDRI, based on forecast data from IEA WEO reports.

Our coal consumption pathways to 2050 – Peak coal is imminent

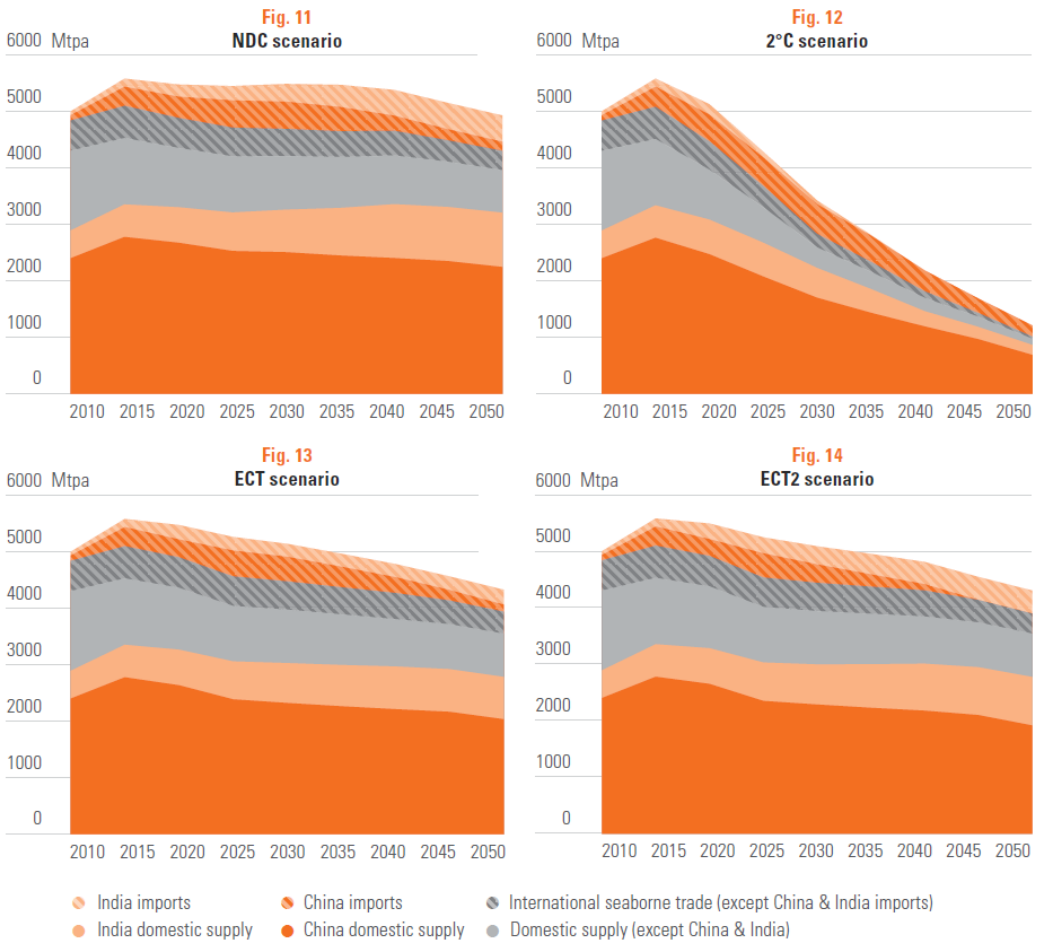
Total global steam coal demand in various scenarios to 2050 (in Mtpa)



Source: COALMOD-World results.

Different global coal pathways to 2050 in detail

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



Source: Coal Transitions and Coalmod-World results.

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

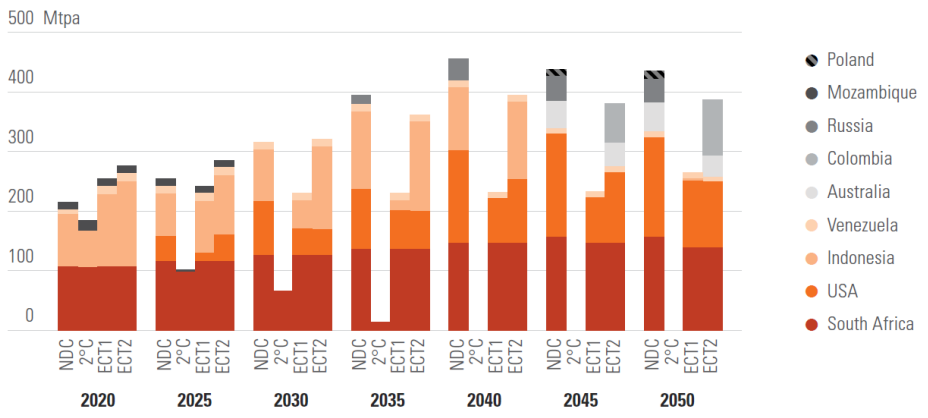
\+ Better reflection of drivers of coal transition on country level

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

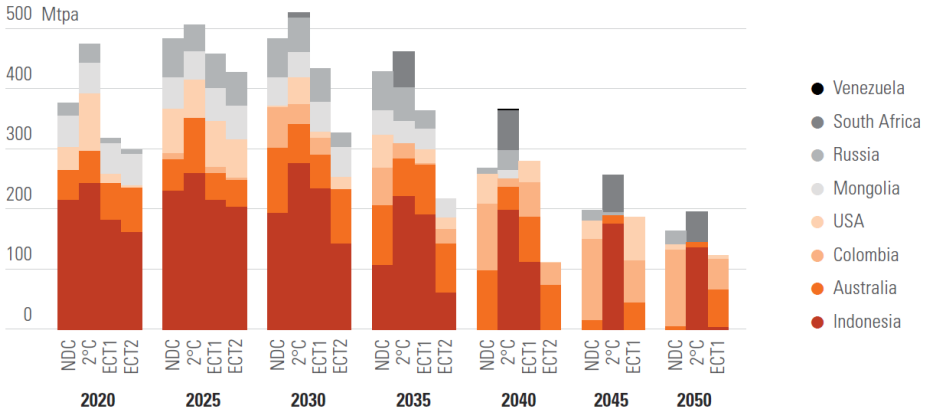
Strong effects on imports (and, hence, exporters)

Figure 16. Imports by India over time and by scenario



Source: Coal Transitions and Coalmod-World results.

Figure 15. Imports by China over time and by scenario

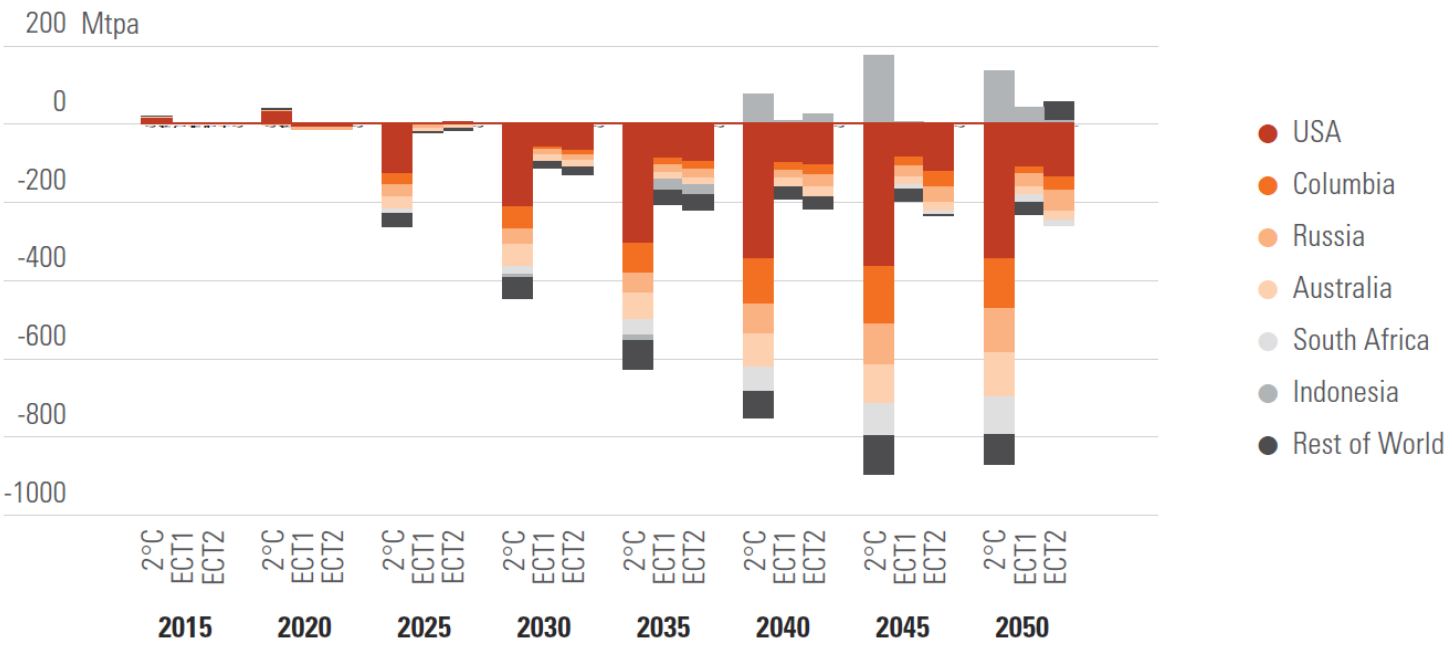


Source: Coal Transitions and Coalmod-World results.

- 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

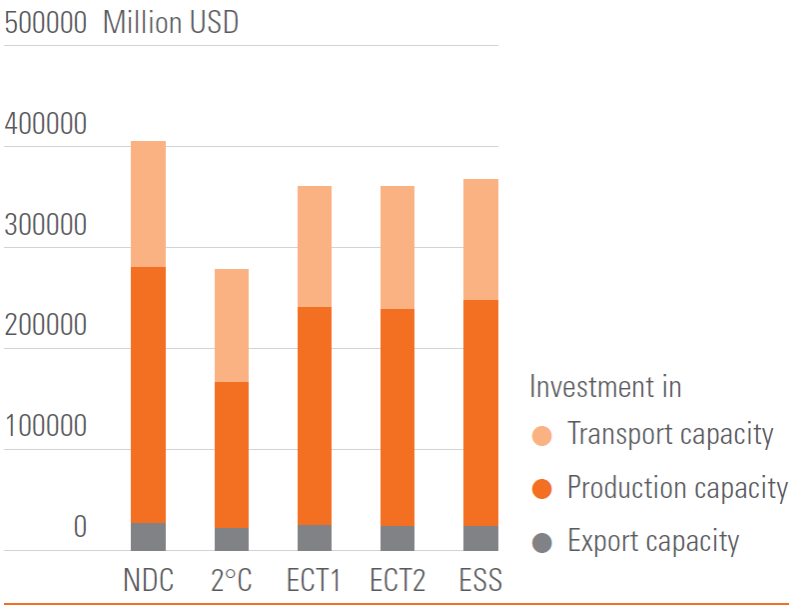


Source: COALMOD-World results.

The effect on coal sector infrastructure

Figure 17. Global investments until 2050 in the coal value chain in various scenarios

(production, inland transport and export capacities)



Source: COALMOD-World results.

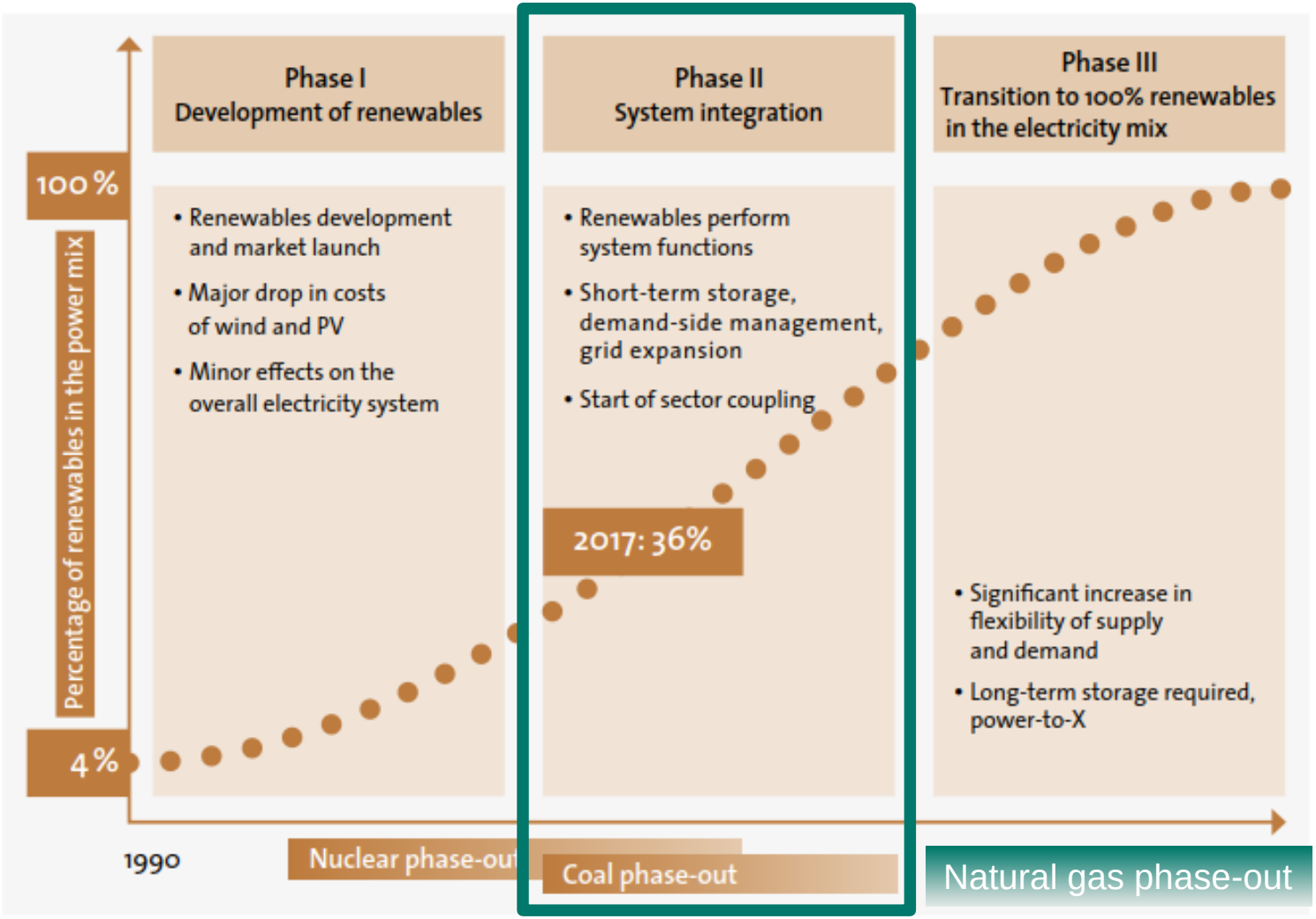
Note: In the COALMOD-World model, we assume mine depletion and, hence, the need for replacement investment to keep stable production capacity levels.

- - 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

4 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 results 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

Haftendorn, Holz, Kemfert, and Hirschhausen (2013): Global Steam Coal Markets until 2030 – Perspectives on Production, Trade, and Consumption under Increasing Carbon Constraints. In: R. Fouquet (Ed.) "*Handbook on Energy and Climate Change*", 103-122, Edward Elgar Publ.

Haftendorn, Kemfert, and Holz (2012): What about Coal? Interactions between Climate Policies and the Global Steam Coal Market until 2030. *Energy Policy* 48, 274-283.

Haftendorn (2012): Evidence of Market Power in the Atlantic Steam Coal Market Using Oligopoly Models with a Competitive Fringe. *DIW Discussion Paper* 1185.

Haftendorn, Holz, and Hirschhausen (2012): The End of Cheap Coal? A Techno-economic Analysis Until 2030 using the COALMOD-World Model. *FUEL* 102, 305-325.

Haftendorn and Holz (2010): Modeling and Analysis of the International Steam Coal Trade. *The Energy Journal* 31 (4), 201-225.

IEA (2012): Coal Information 2012. Coal information. OECD/Paris.

IEA (2016a): World Energy Outlook 2016. OECD/Paris.

IEA (2016b): Medium-Term Coal Market Report 2016. OECD/Paris.

IEA (2017): Coal Information 2017. Coal information. OECD/Paris.

Holz, Haftendorn, Mendelevitch, and Hirschhausen (2015): COALMOD-World: A Model to Assess International Coal Markets Through 2030. In: M.C. Thurber and R.K. Morse (Eds.) "*Asia and the Global Coal Market*", Cambridge Univ. Press.

Mendelevitch (2016): Testing Supply-Side Climate Policies for the Global Steam Coal Market – Can They Curb Coal Consumption?, *DIW DP 1604.*

Mendelevitch, Holz, Hirschhausen, and Haftendorn (2016): A Model of the International Steam Coal Market (COALMOD-World), DIW Data Doc 85.

Richter, Jotzo, and Mendelevitch (2015): Market Power Rents and Climate Change Mitigation: A Rationale for Coal Taxes?, *DIW DP 1471*.

DIW BERLIN

Franziska Holz

Additional slides