Fossil Resource Markets and Climate Change

15.01.2021

PRESENTATION IN THE LUNCH MEETING SEMINAR OF THE „CLIMATE ECONOMICS CHAIR“ PARIS

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BASED ON JOINT WORK WITH DAWUD ANSARI, MARIZA MONTES DE OCA LÉON, CLAUDIA KEMFERT, CHRIS HAUENSTEIN, RUUD EGGING AND OTHERS

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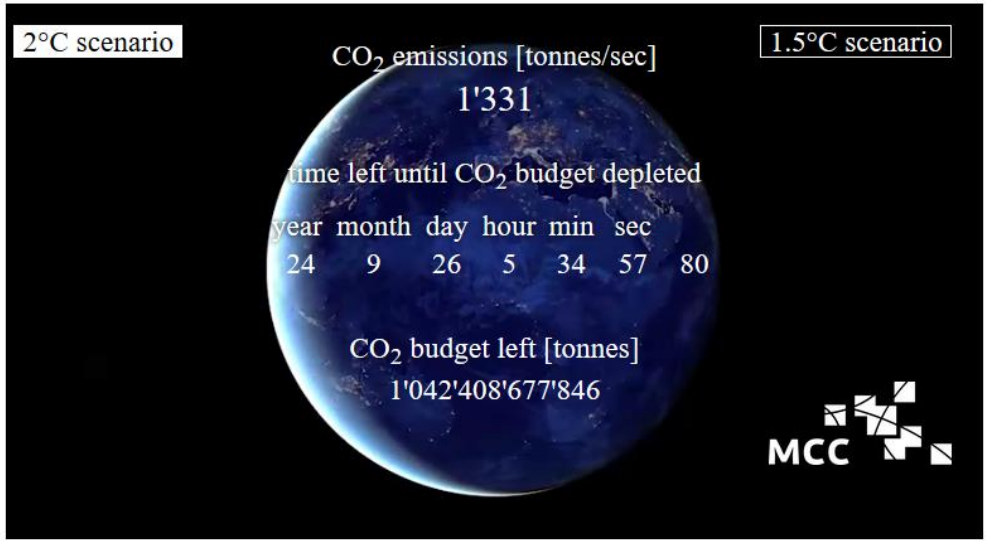
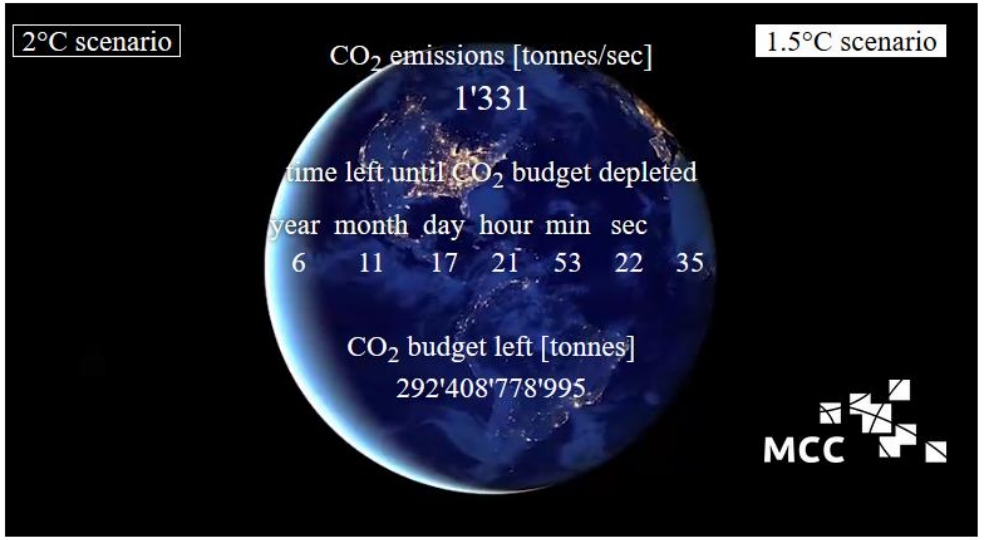
Global carbon budget

In the absence of a technology to „decarbonize“ the emissions from fossil fuel use, the carbon budget sets an effective limit on the use of fossil resources to avoid catastrophic climate change:

https://www.mcc-berlin.net/en/research/co2-budget.html





→ … each resource and countries / regions are differently affected

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The Carbon Brief

How much oil, gas and coal will we have to leave in the ground to stay under 2 degrees of warming?

(Carbon Brief, based on McGlade & Ekins 2015 in Nature)

Globally

52% of natural gas reserves

35% of oil reserves

88% of coal reserves

Canada

75%
24%
82%
0 50% 100%

US

9%
6%
95%
0 50% 100%

Central and South America

42%
56%
73%
0 50% 100%

Africa

26%
34%
90%
0 50% 100%

Europe

21%
6%
89%
0 50% 100%

Former Soviet Union countries

19%
59%
97%
0 50% 100%

China and India

25%
53%
77%
0 50% 100%

Other developing Asian countries

12%
22%
60%
0 50% 100%

Middle East

38%
61%
99%
0 50% 100%

OECD Pacific

46%
51%
95%
0 50% 100%

Our research on fossil resource markets and climate change / policy

FoReSee

How to phase our fossil fuels?

- Which strategies, which policies can be effective and how?
- Which obstacles, fundamental market structures, governance schemes, etc. to consider?
- Which assets in the markets‘ value chains are at risk of stranding?
- Market-driven vs. policy-driven phase-out?

→ Country- and fuel-specific analyses and strategies are required

- Mostly – but not exclusively – based on numerical modeling with large-scale global, sectoral models
  - Global Gas Model
  - COALMOD-World
  - Multimod
  - Oilmod

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Fossil Resource Markets and Climate Policy:

Stranded Assets, Expectations and the Political Economy of Climate Change

10/ 2018 – 09/2021 "Economics of Climate Change"

FoReSee

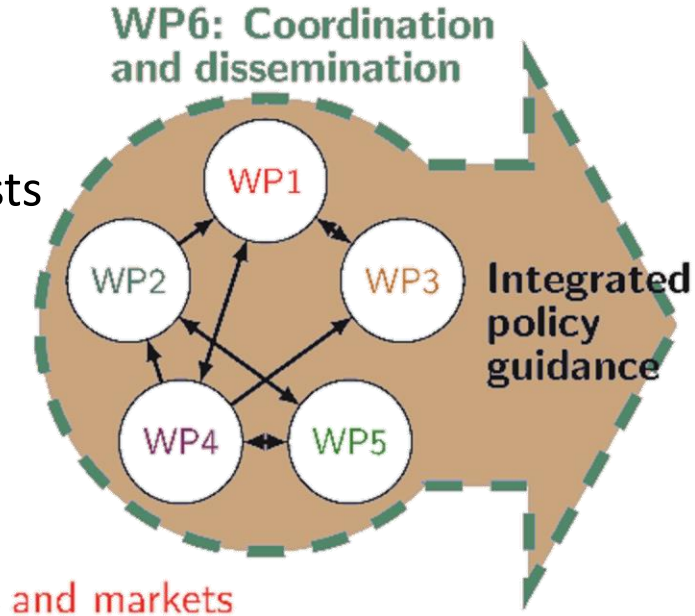
ifo INSTITUTE
Leibniz Institute for Economic Research at the University of Munich

Humboldt-Universität zu Berlin
Resource Economics

DIW BERLIN

FoReSee studies…

- the interplay between climate policies and participants in fossil fuel & financial markets
- how policies can overcome inertia of the energy system without excessive costs
- redistribution of rents in sectors and countries vulnerable to asset stranding
- private actors' responses to current and expected (uncertain) climate policies
- policy designs to correct inefficient market-side responses



Combined excellence in methods
Econometrics
Game theory
Operations research
New political economy
Stakeholder dialogue

WP1: Inter-fuel policies and markets
WP2: Carbon bubble empirics
WP3: Climate and resource curse
WP4: Fossil lobbies
WP5: Beliefs and asset pricing

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Some examples to be discussed today

1. Multi-fuel perspective: stranded assets risk in coal, oil, natural gas differs by region
2. Coal: market-driven phase-out in the U.S. (despite political resistance…)
3. Natural gas: no need for new infrastructure in Europe such as German LNG terminals and Nord Stream 2
4. Oil: phasing out gasoline subsidies in Latin America (empirical research)

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Stranded assets across fuel markets

GLOBAL MULTI-FUEL MODEL SCENARIOS

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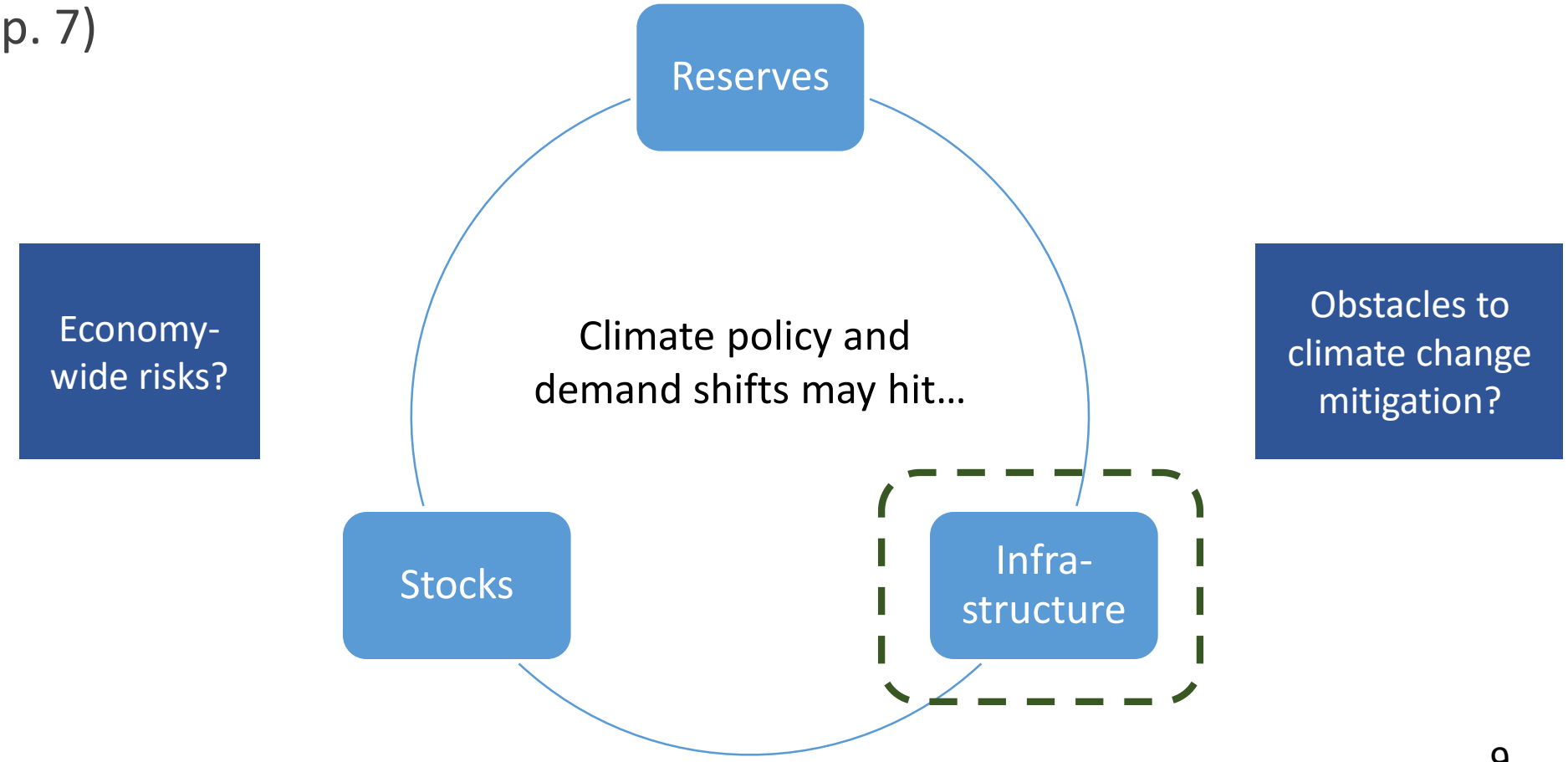
Stranded assets

Stranded assets are "assets [that] suffer from unanticipated or premature write-offs, downward revaluations or are converted to liabilities" (Caldecott et al., 2013, p. 7)



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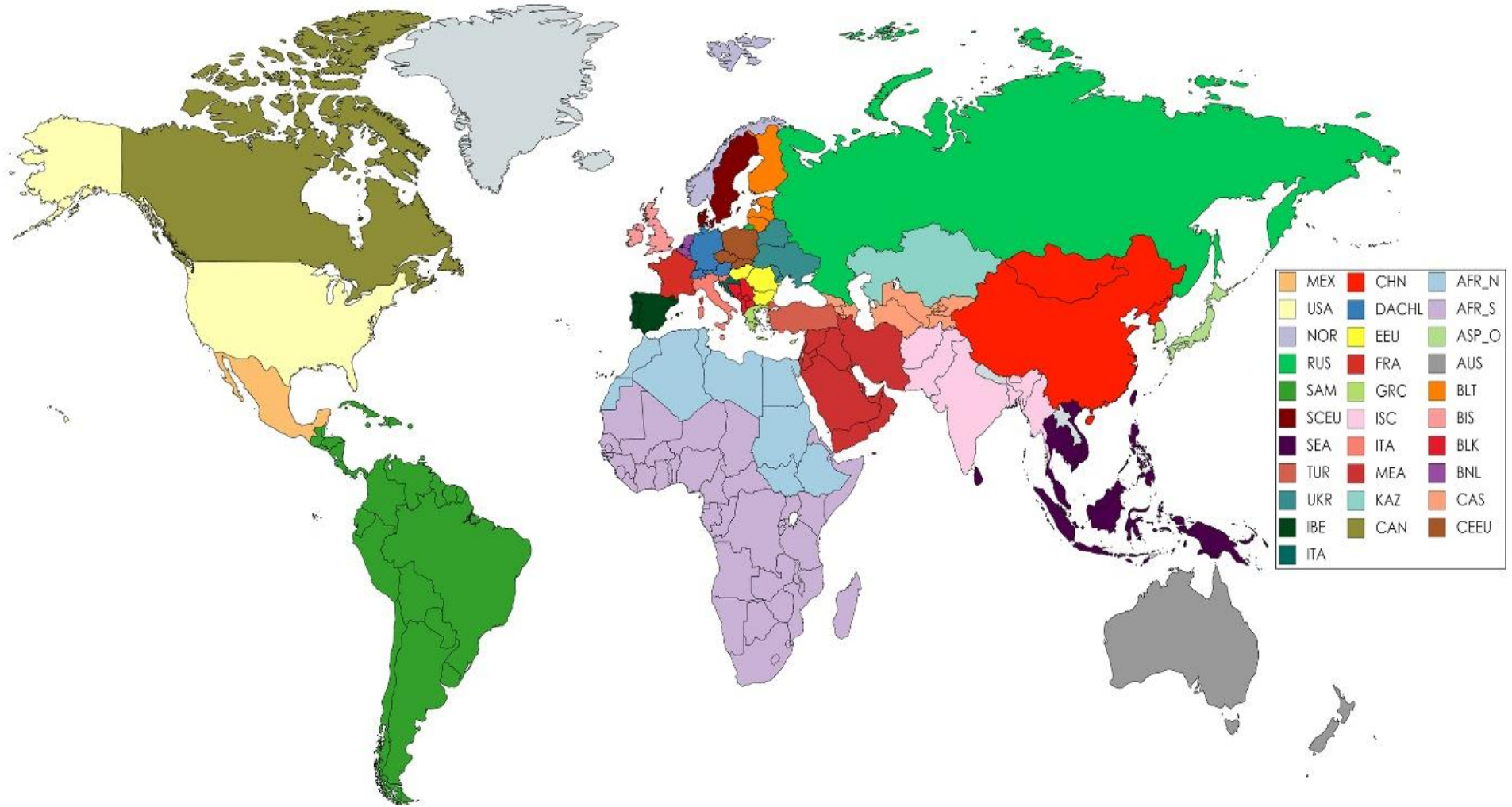
Multimod: a global multi-fuel resource market model



Ansari et al. (2019, 2020)

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Multimod: regional effects of global climate scenarios

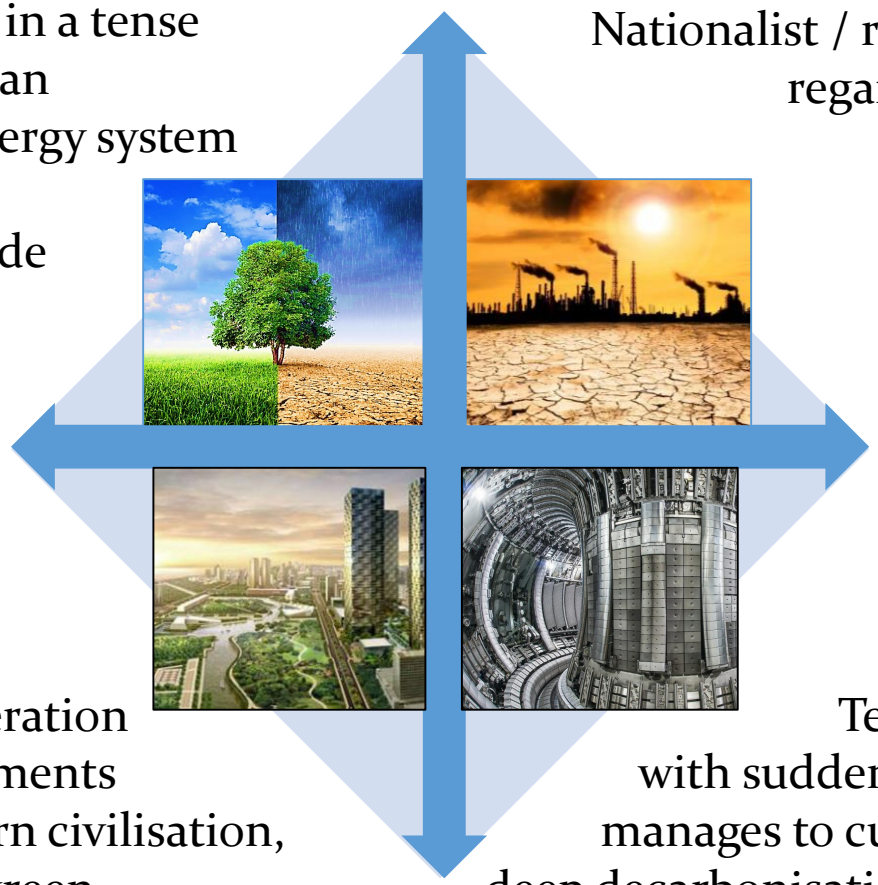
FoReSee

Business as usual

Conflicting interests in a tense environment lead to an ambiguous future energy system with fossil fuels and renewables side by side

Survival of the Fittest

Nationalist / regionalist world without regard to climate change and decarbonization ends in large-scale climate catastrophes



Ansari et al. (2019, ERSS)

Revived global cooperation and societal commitments enable markets to turn civilisation, society, and growth green

Green Cooperation

Technology-centred world with sudden technological advances manages to curb emissions but fails in deep decarbonisation and energy transition

ClimateTech

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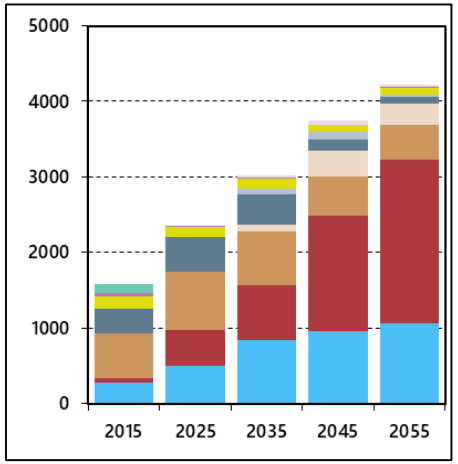
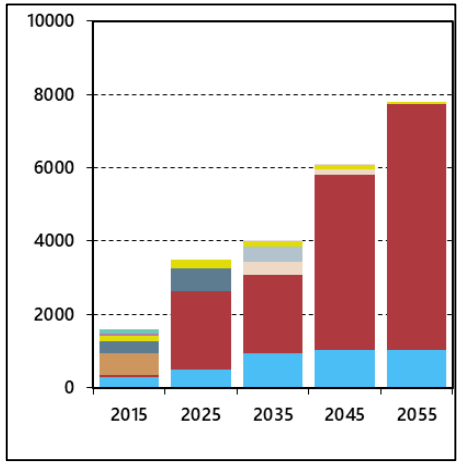
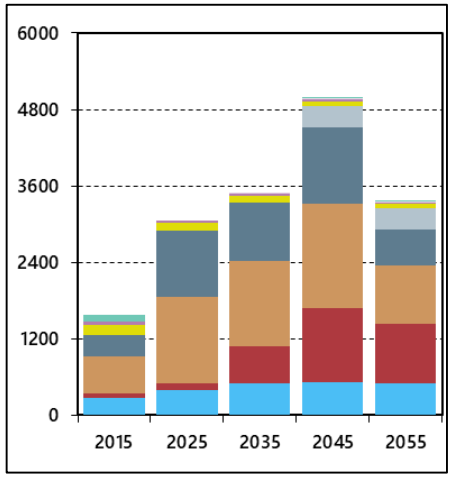
DIW-REM Scenarios: Global electricity generation and primary energy



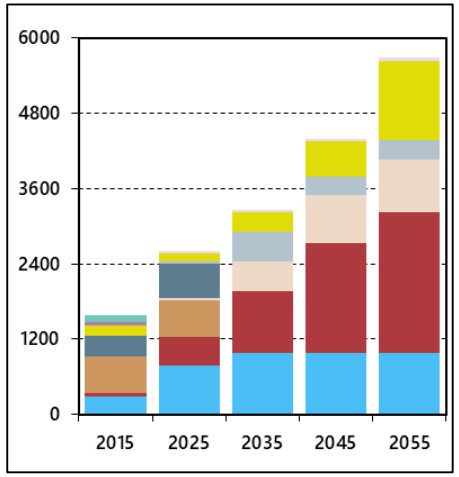
Business as Usual



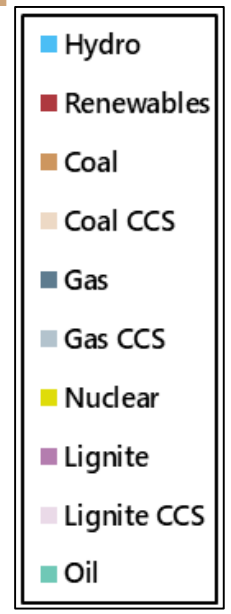
Green Cooperation

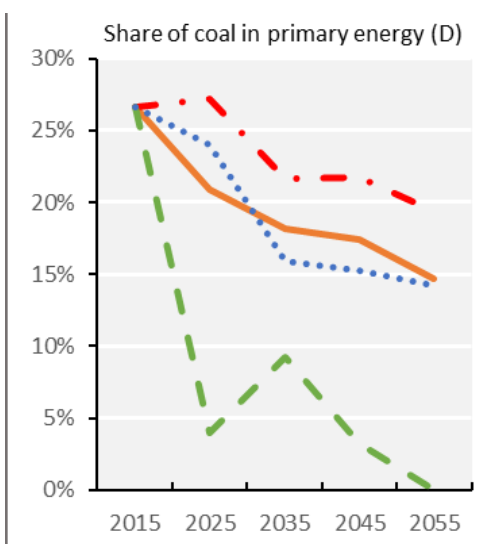


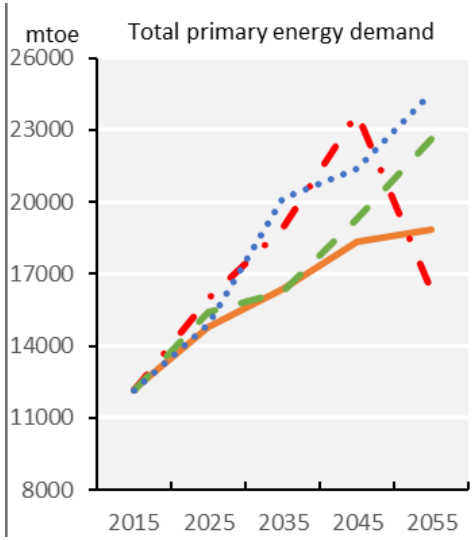
Survival of the Fittest

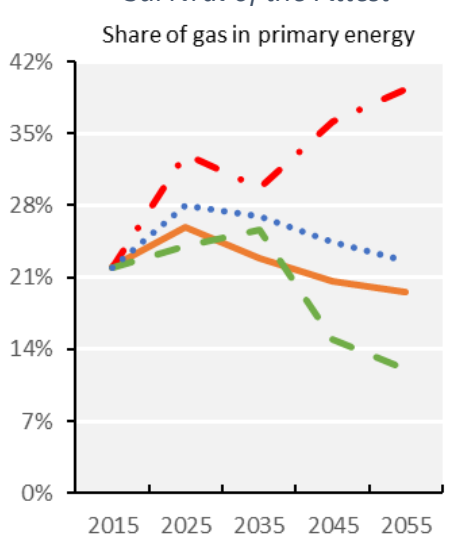


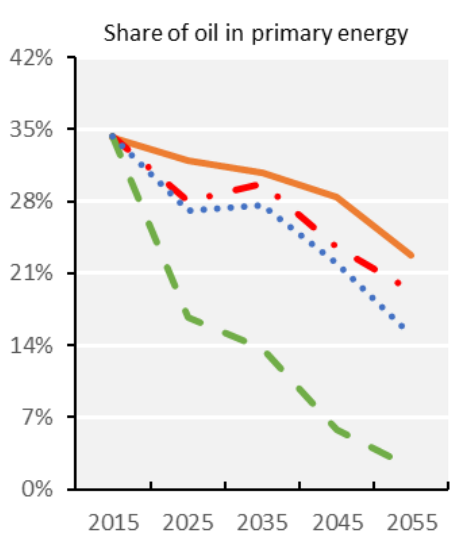
ClimateTech











Business as Usual · Survival of the Fittest · Green Cooperation · ClimateTech

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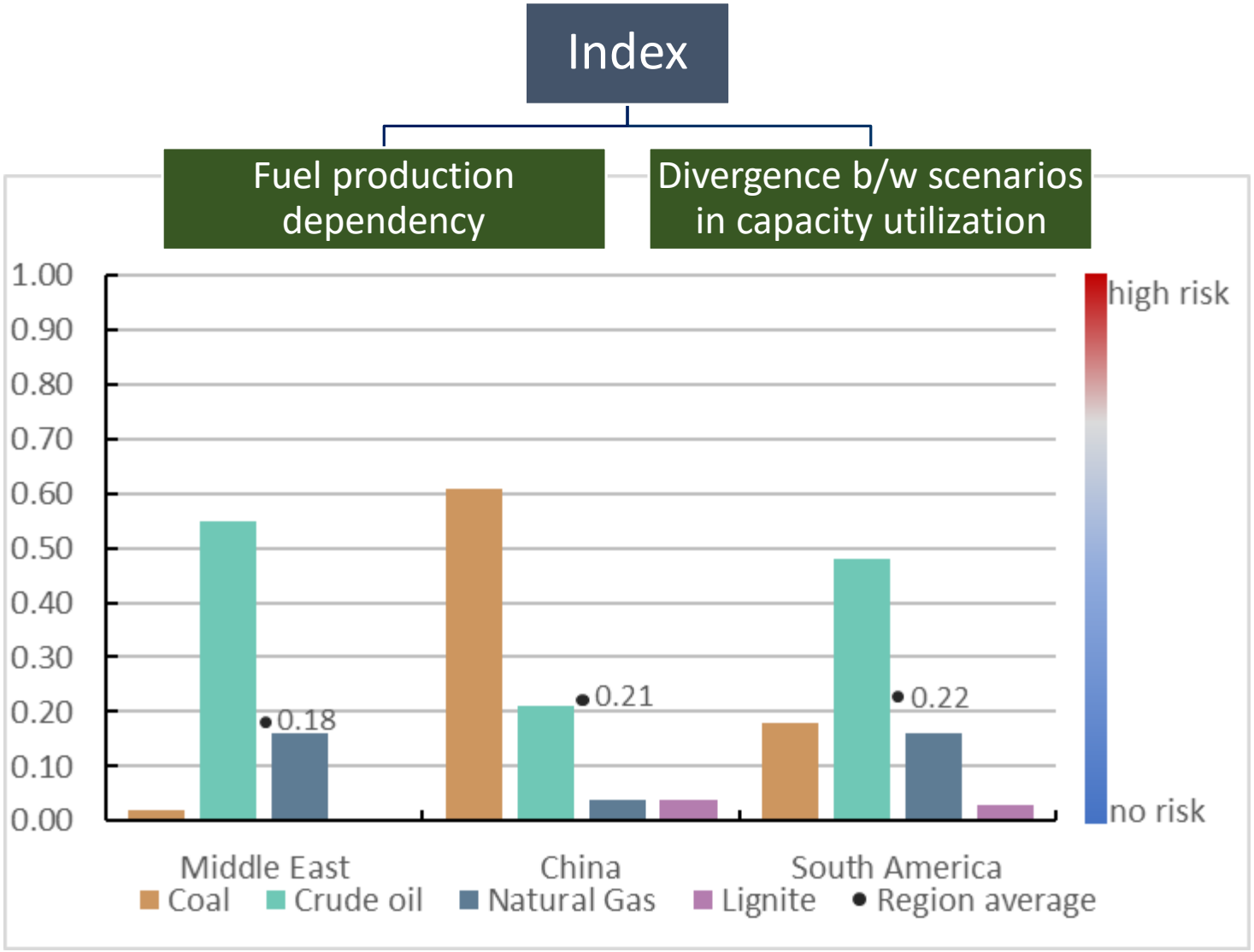
Regional, fuel-specific stranded assets risk indicator

Index:

$$I_{s,f} = \sqrt{\Delta_{\text{avg}}^{\max}\text{util}_{s,f} * \text{share}_{s,f}}$$

a) How vulnerable is a certain country/region to a loss of income from production of a particular fuel AND
b) how robust is the infrastructure capacity use of a particular fuel across scenarios?



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Coal markets

MARKET-DRIVEN PHASE-DOWN IN THE USA

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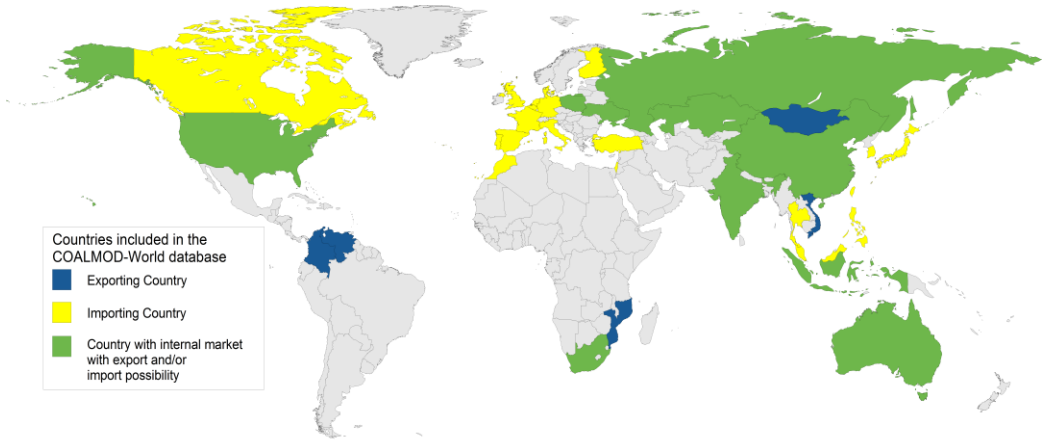
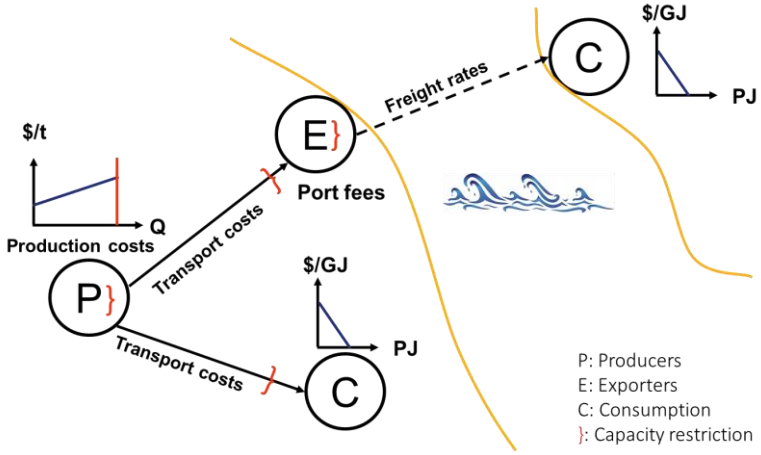
The COALMOD-World model

Open source partial equilibrium model (https://www.diw.de/en/diw_01.c.599753.en/models.html)

- Large-scale multi-period model of (competitive) steam coal market
  - CoalMod-World (Haftendorn et al. 2012, Holz et al. 2015, 2016)
- Profit-maximizing players with specific constraints in MCP
  - Producers and exporters
- Market clearing via inverse demand functions
- Model features:
  - Mine mortality effects on costs and production capacities
  - Endogenous investment in production and export capacities
  - Substitution between imports and domestic production
- 45 consumption nodes (C), 22 producers (P), and 21 exporters (E)
- Multi-period model with yearly equilibria in 5-years-steps from 2015 to 2050



Source: Adapted from Holz et al. (2016)



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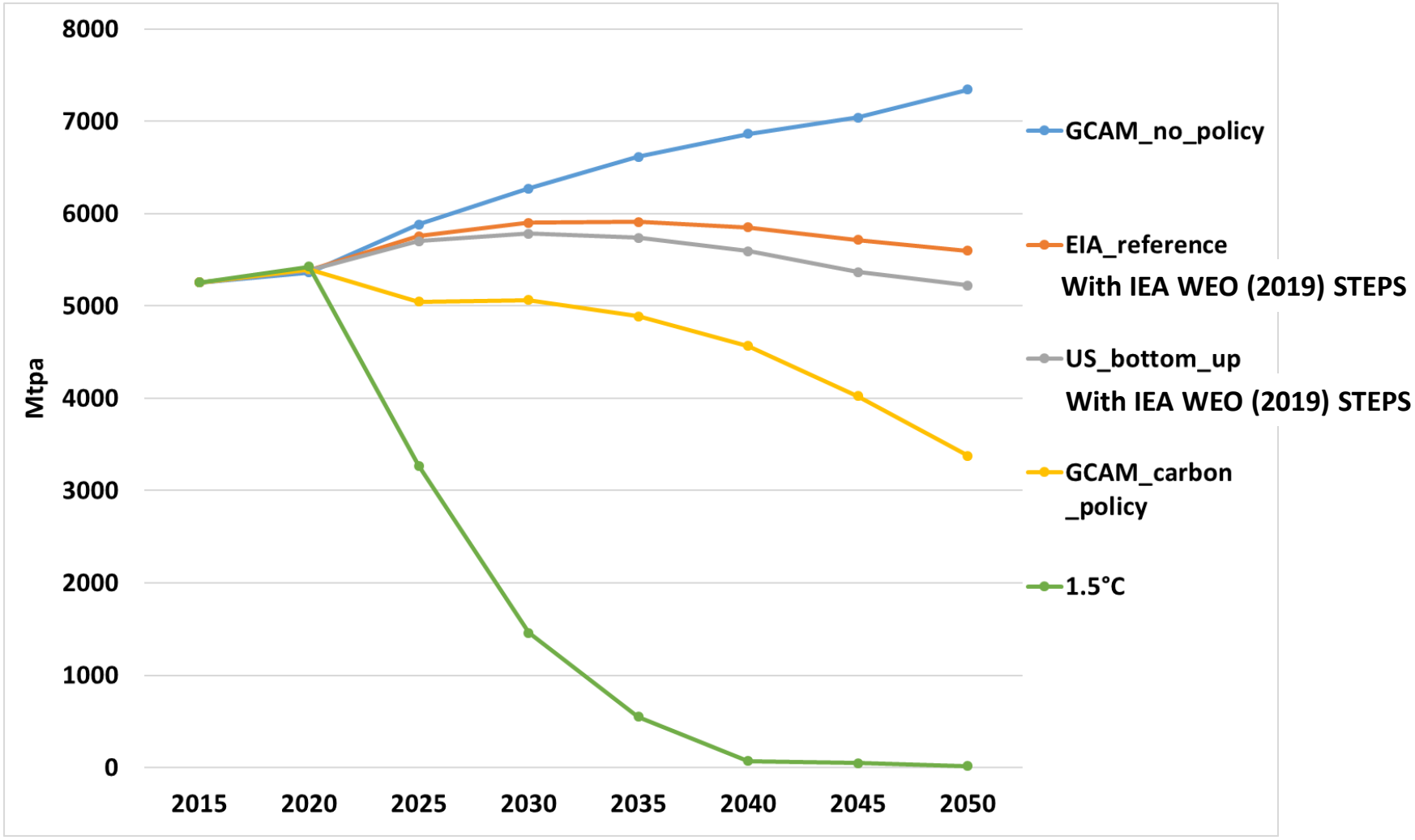
Global coal phase-out?



Hauenstein & Holz (2021)

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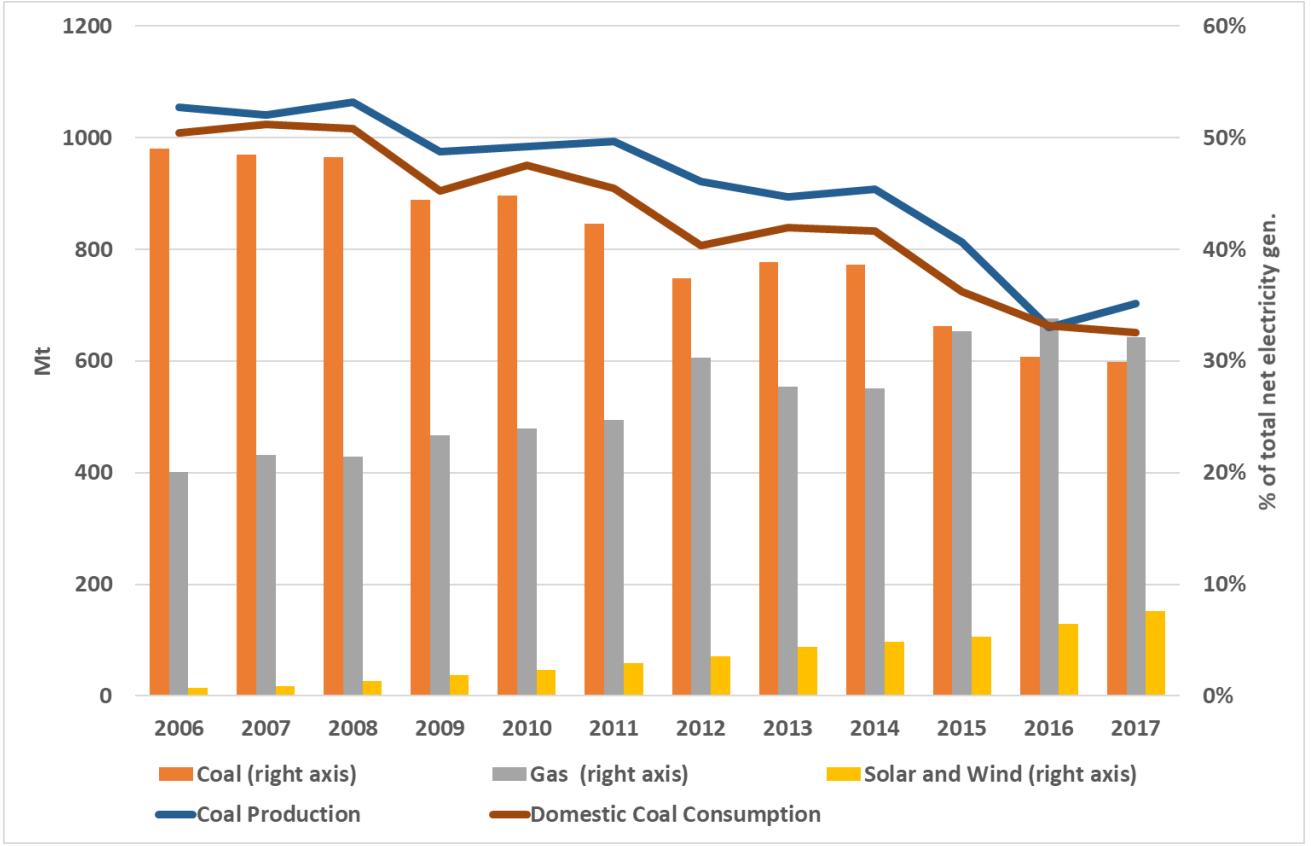
U.S. coal sector

- The electricity sector accounts for about 93% of U.S. domestic coal consumption
- Traditionally important role of coal in U.S. electricity generation, but sharp decrease in last decade: 49% → 30% (2007-2017)

Structural economic factors for decline

- Competition from renewables (RES) with declining cost
- Competition from cheap gas due to shale gas boom
- Tightened environmental regulations

Discussed in more detail in Mendelevitch, Hauenstein and Holz (2019, *Climate Policy*)



Source: EIA 2018

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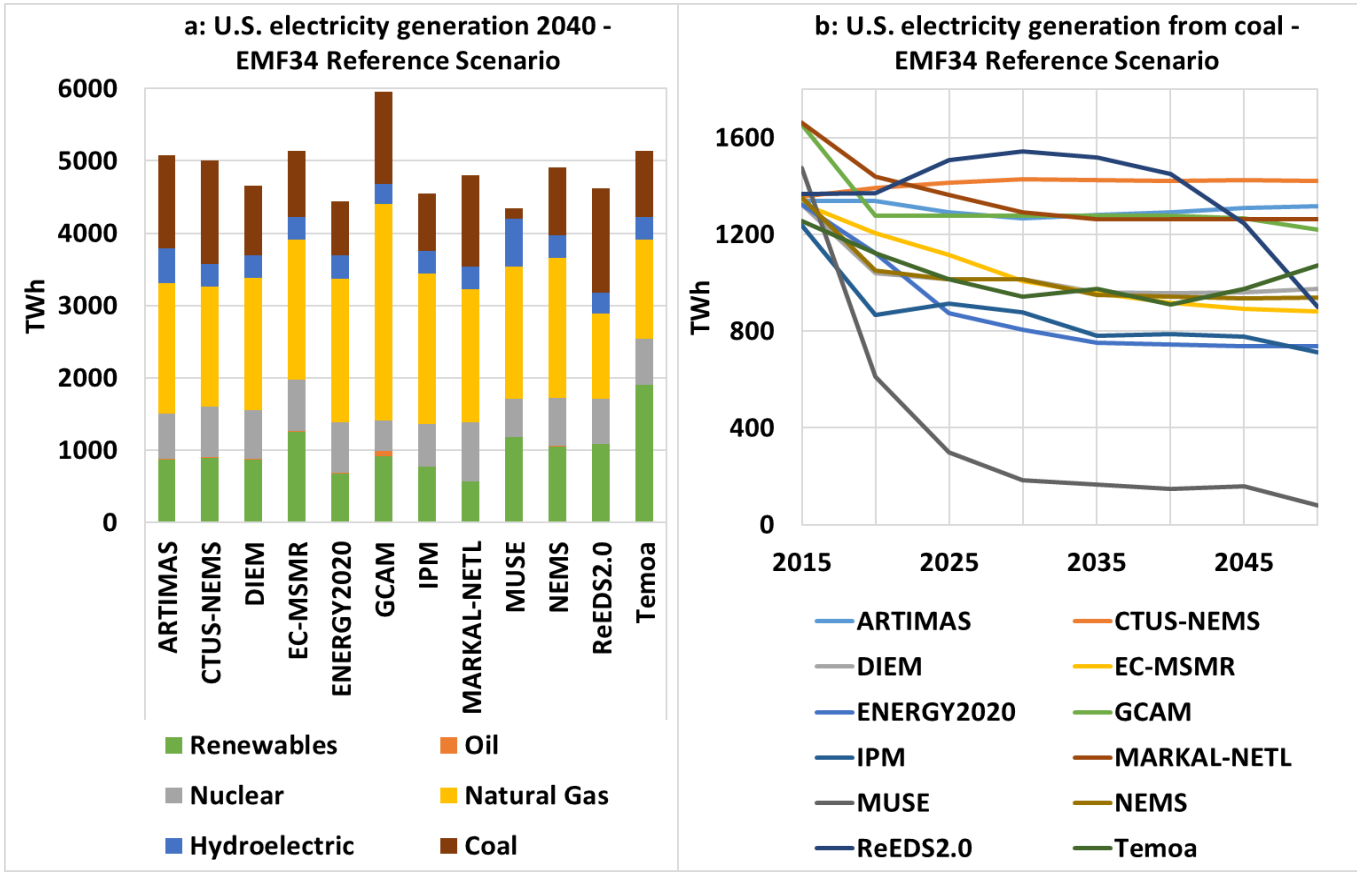
Future of coal in the U.S.? EMF 34 („N. Am. Energy markets“)

Surprisingly, the decreasing trend of coal and its drivers are hardly taken into account in North American energy market models (e.g., in EMF34), in particular not by the EIA



Hauenstein & Holz (2021)

→ We propose a scenario that accounts for the downward pressure on U.S. coal

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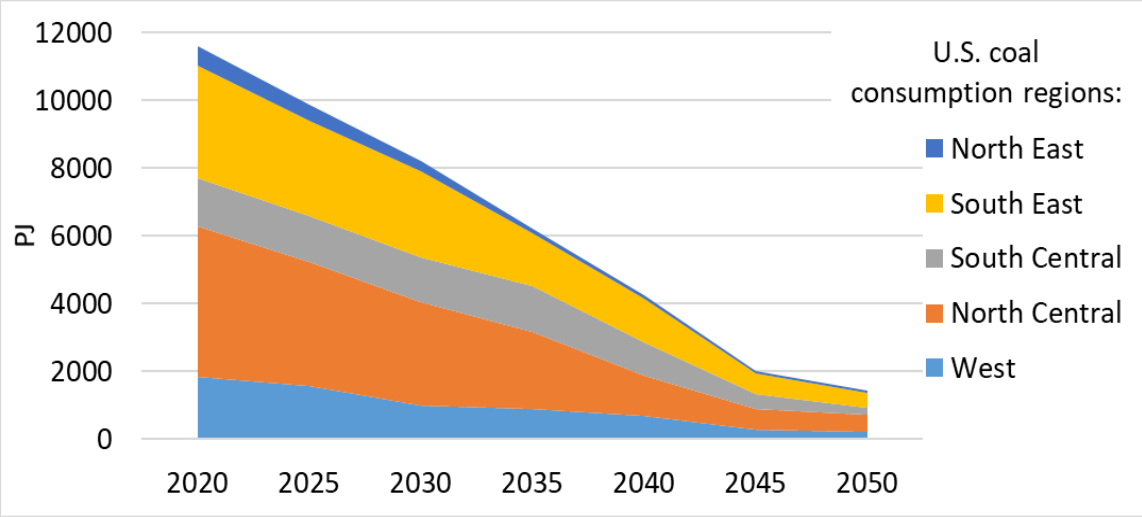
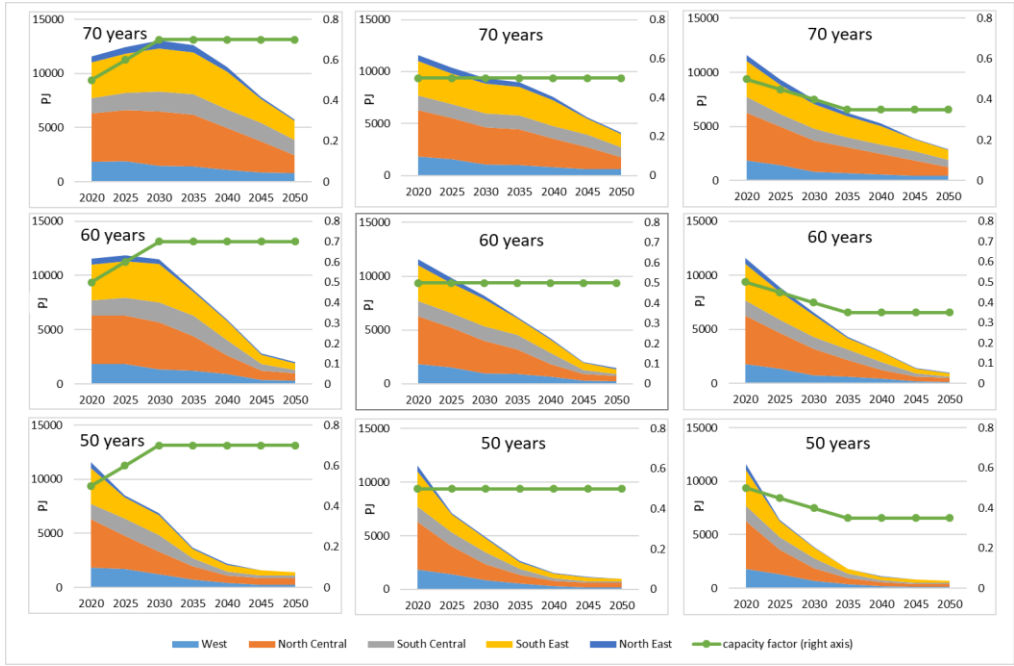
U.S. coal trend in a scenario with „bottom-up data“

Our own scenario (“bottom_up”):

- Future U.S. coal demand calculated from U.S. coal-fired power generation unit data (source: EIA) with average life-time assumption 60 years and constant capacity factor 0.5 (and sensitivity analyses)
- Global coal demand growth rate from IEA WEO 2019 *Stated Policies Scenario (STEPS)*

→ *No new coal-fired power plants, no excessive capacity factor increase*





Hauenstein & Holz (2021)

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Avoiding domestic asset stranding by turning to global markets?

FoReSee

Exports can alleviate domestic pressure on U.S. coal mining if

- West coast export terminals are allowed (scenarios „_ports“)
- and global demand is sustained (IEA WEO STEPS)

Unrealistic !

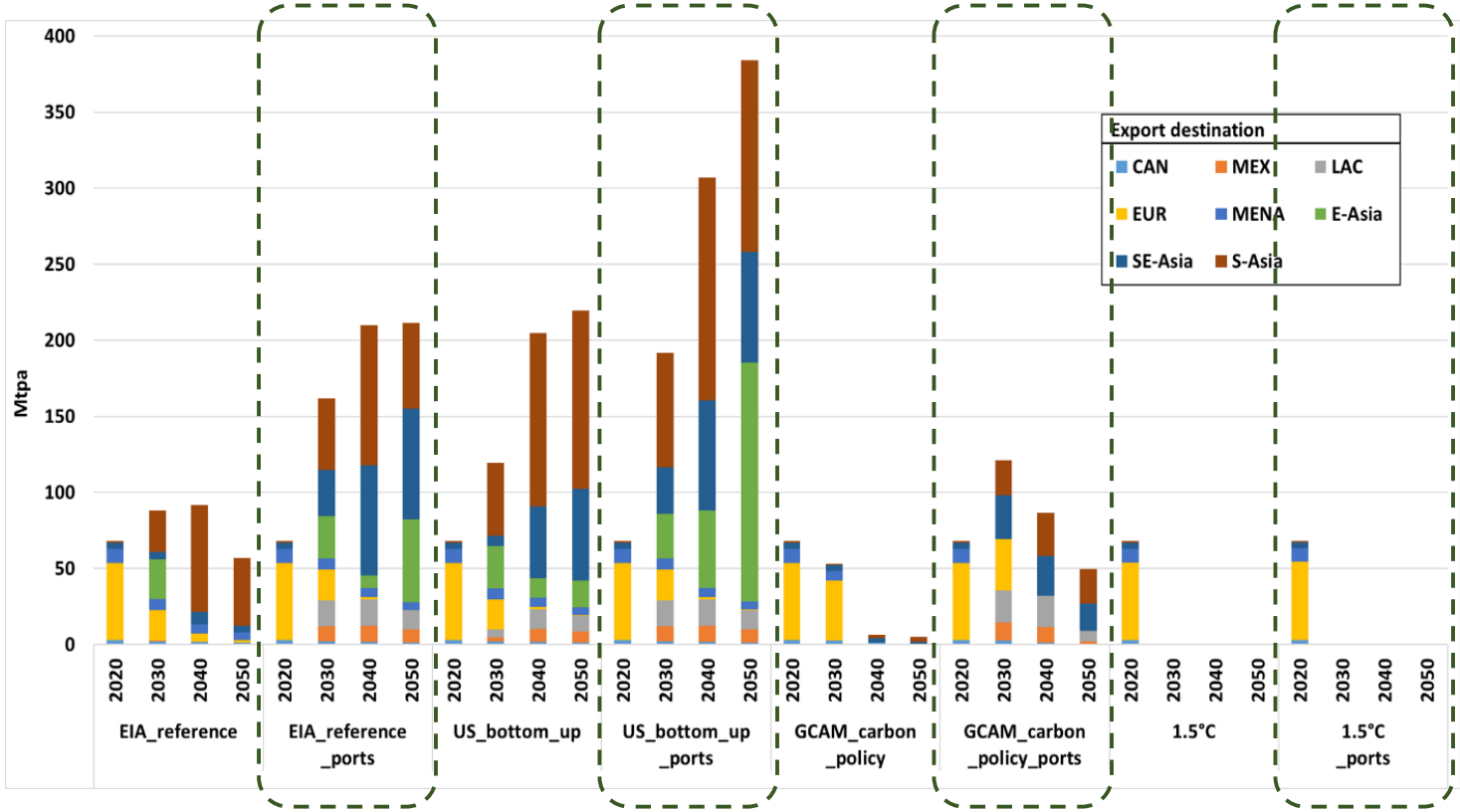

Figure: U.S. coal exports 2020-2050 and their destination in Mt per year

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Beyond stranded assets: employment

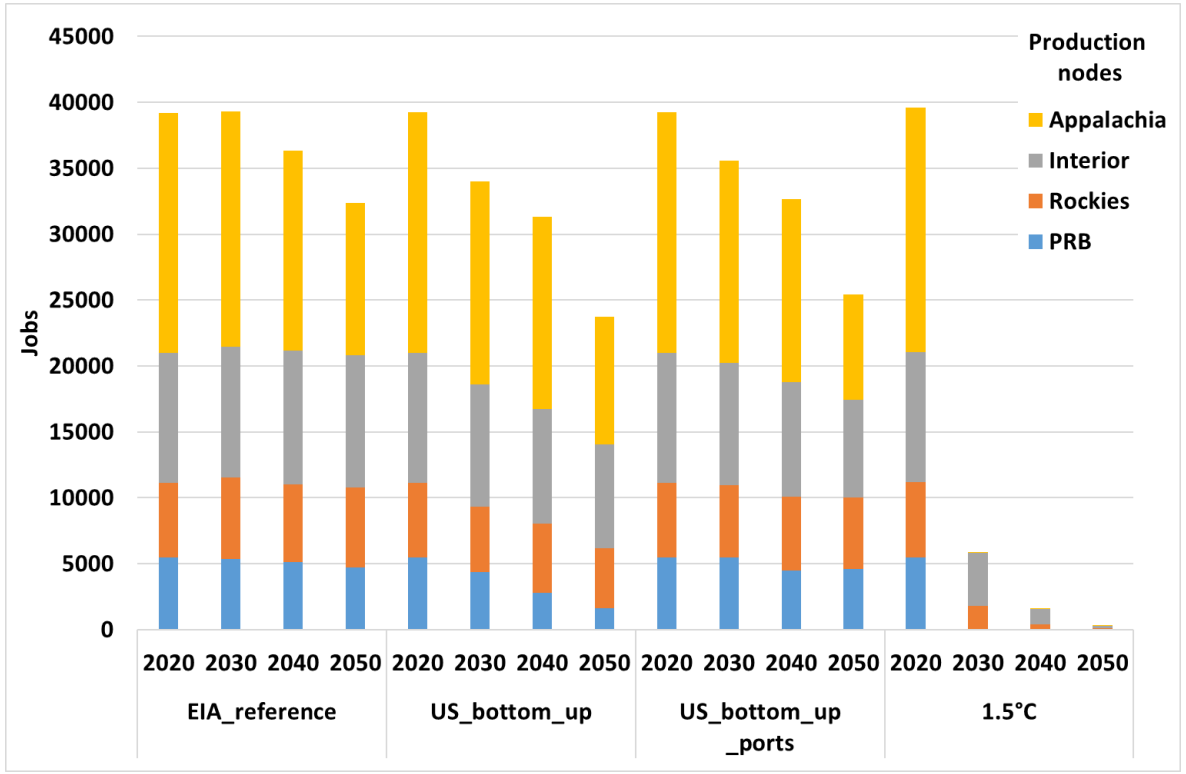

Figure: Direct coal mining jobs in the U.S. coal regions

- There need to be policy solutions for decreasing employment in coal mining across the U.S.
- Even high productivity Powder River Basin will be affected by significant job losses (more than 50% in „bottom_up“ scenario)

→ Just Transition approach includes workers, not just companies

- However, coal dependency had led to resource curse in the past

→ Coal regions need to seize this opportunity to overcome the curse

Hauenstein & Holz (2020, DIW DP)

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Natural gas markets

GLOBAL AND EUROPEAN INFRASTRUCTURE BETWEEN DASH FOR LNG AND SUPPLY SECURITY IN A CLIMATE-CONSTRAINED WORLD

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U.S. LNG exports: Freedom gas to Europe?

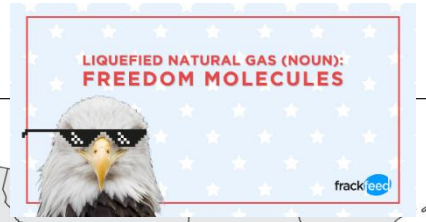

Figure 1: Existing U.S. LNG export terminals and their capacities in bcm/year

Source: Own figure based on FERC North American LNG Export Terminals (Released November 21, 2019, https://www.ferc.gov/industries/gas/indus-act/lng.asp)

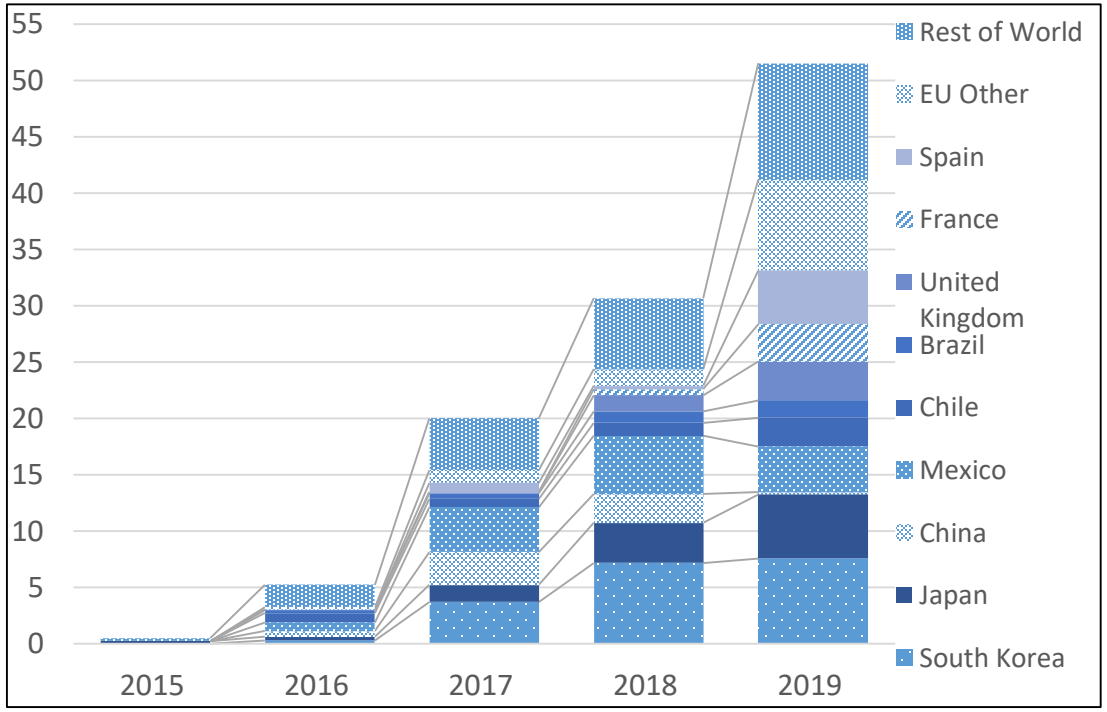

Figure 2: US LNG exports 2015-2019, in bcm/year

Note: Countries receiving largest U.S. LNG exports are indicated in the chart.

Source: Own figure based on EIA U.S. Natural Gas Exports by Country (Released May 29, 2020) www.eia.gov

Egging, Holz, Czempinski, work in progress

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The role of LNG in Europe in the last decade

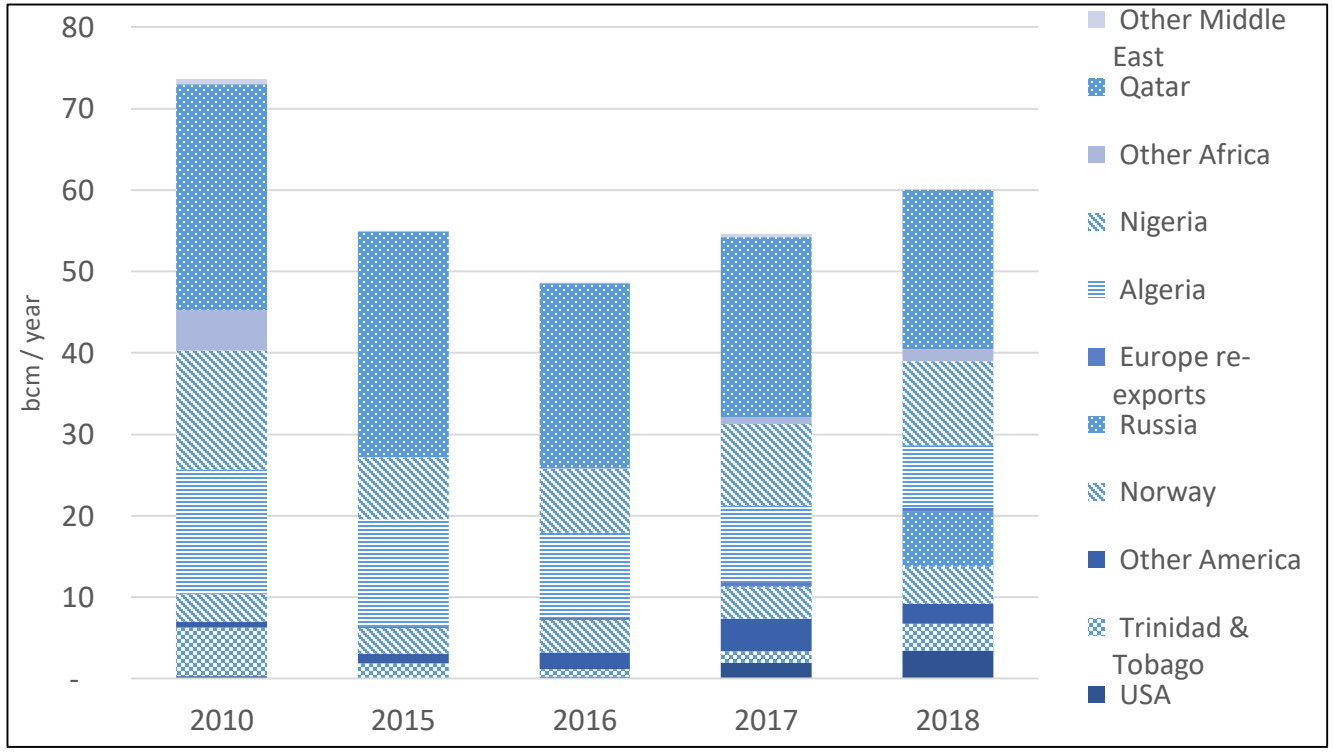

Figure 3: LNG exports to the EU 2010–2018, in bcm per year

Source: Own figure based on BP Statistical Review of World Energy (2011, 2016-2019)

Egging, Holz, Czempinski, work in progress

- Small share of total imports (< 25%)
- Main problem: pipeline transport from LNG import terminals to consumers across Europe
- National natural gas markets in Europe are still quite segmented
- However, hub development in some places has increased liquidity and made these markets attractive to LNG suppliers

2018	TRADED GAS HUBS CHURN RATES*				
HUB	2008	2011	2016	2017	2018
TTF	3.3	13.9	57.1	54.3	70.9
NBP	14.4	19.8	22.1	23.9	16.9
VTP	CEGH 2.4	CEGH 2.2	5.7	5.3	6.9
NCG	0.4	1.8	4.0	3.4	3.8
GPL		0.8	2.5	2.6	2.8

Heather (2019), OIES

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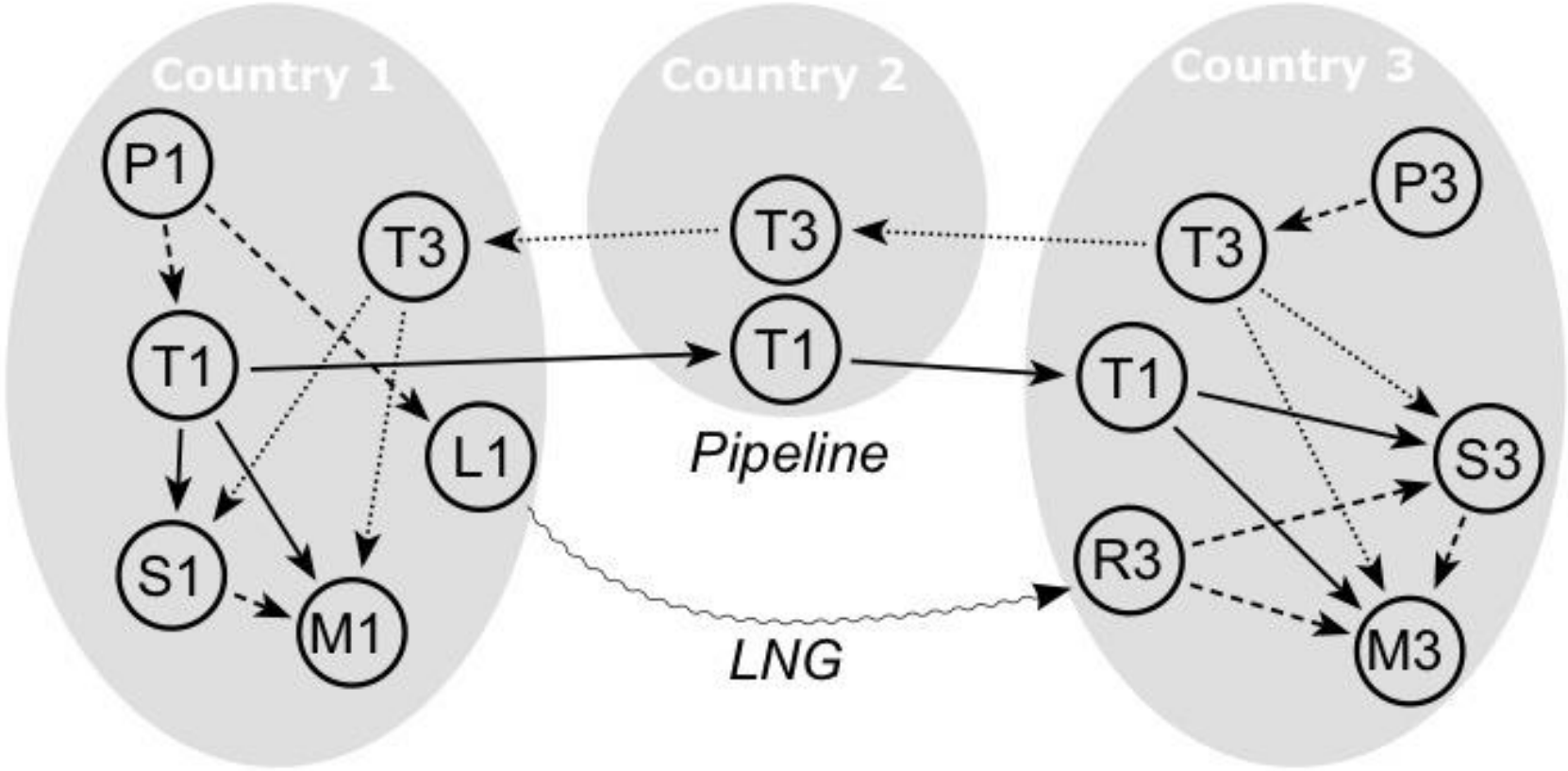
Global Gas Model



- Multiple players:
  - Producers
  - Traders
  - Pipeline operators
  - LNG liquefiers
  - LNG regasifiers
  - Storage operators
- Net present value optimization 2015-2050
- Profit maximization problems under constraints, linked by market-clearing conditions

Available open souce: https://www.ntnu.edu/iot/energy/energy-models-hub/ggm

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Scenarios for U.S. LNG exports to Europe

Scenario	Scenario description	Scenario implementation
„Base Case“	Stable natural gas demand in Europe and continuous demand increase elsewhere	IEA New Policies Scenario 2018 (World Energy Outlook) demand growth rates in the world regions, EU Reference Scenario 2016 for European countries
“Trump”	Financial support to U.S. LNG exports to Europe and sanctions on finishing Nordstream 2 pipeline	Shipping costs U.S. to Europe decreased by 0-100%; Nordstream 2 delayed by ten years
“Putin”	Disruption of all Russian exports to Europe	Russian trader not allowed to sell gas to EU and Switzerland
“Altmaier”	Support to LNG import terminals in Germany	Capital costs and/or operational costs of regasification terminals in Germany decreased by 0-100%
“Jinping”	Support to LNG import terminals in China	Capital costs and/or operational costs of regasification terminals in China decreased by 0-100%

Egging, Holz, Czempinski, work in progress

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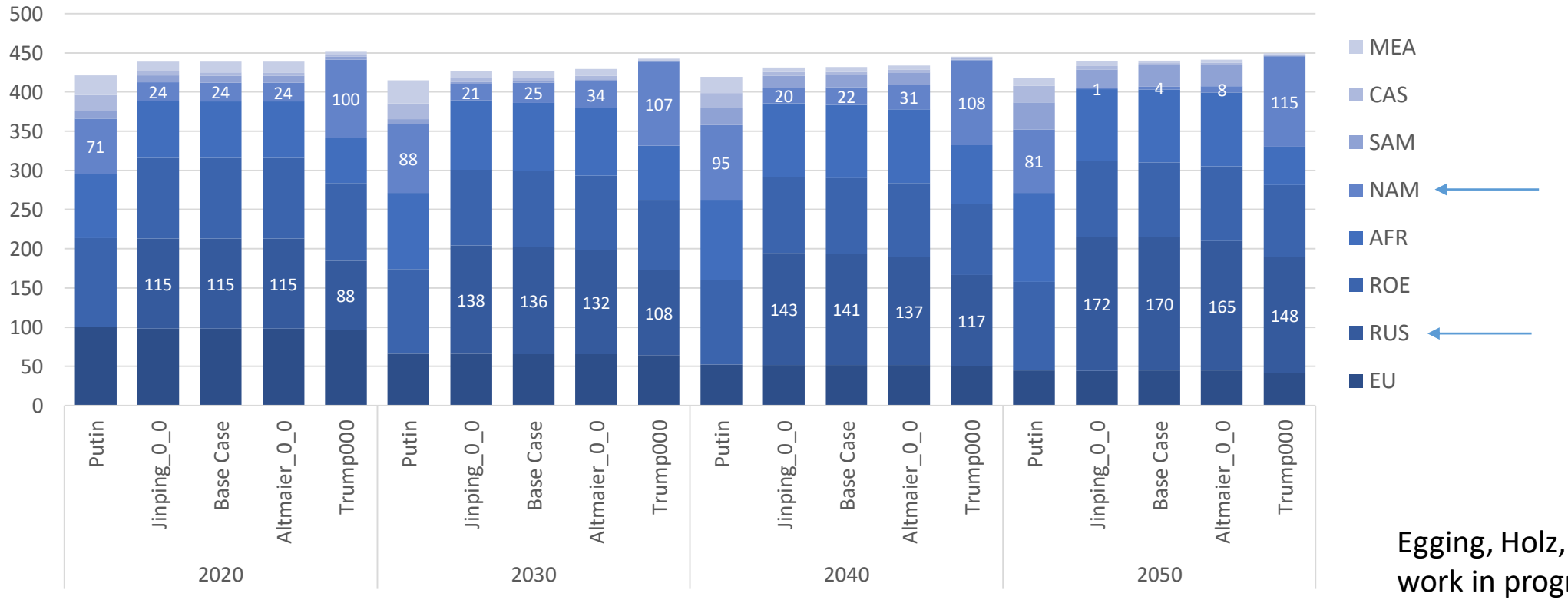
Results: EU supply is diversified and hardly affected by restrictions/subsidies



Egging, Holz, Czempinski, work in progress

Figure 6: EU supply mix by supplying region,* Base Case *and selected scenarios 2020-2050, in bcm per year

Note: The numbers succeeding the scenario name indicate the applied percentage of the Base Case *cost data (i.e., the opposite of the subsidy rate). In the* Altmaier *and* Jinping *scenarios, the first number refers to the operational costs; the second number refers to the investment costs in regasification capacity. In the* Trump *scenarios, the number is the share of* Base Case *LNG transportation costs between U.S. liquefaction and European regasification nodes. E.g., "100" means 100% of the Base Case cost, hence, a 0% subsidy on the costs.*

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LNG terminals in Germany? Only with subsidies and…

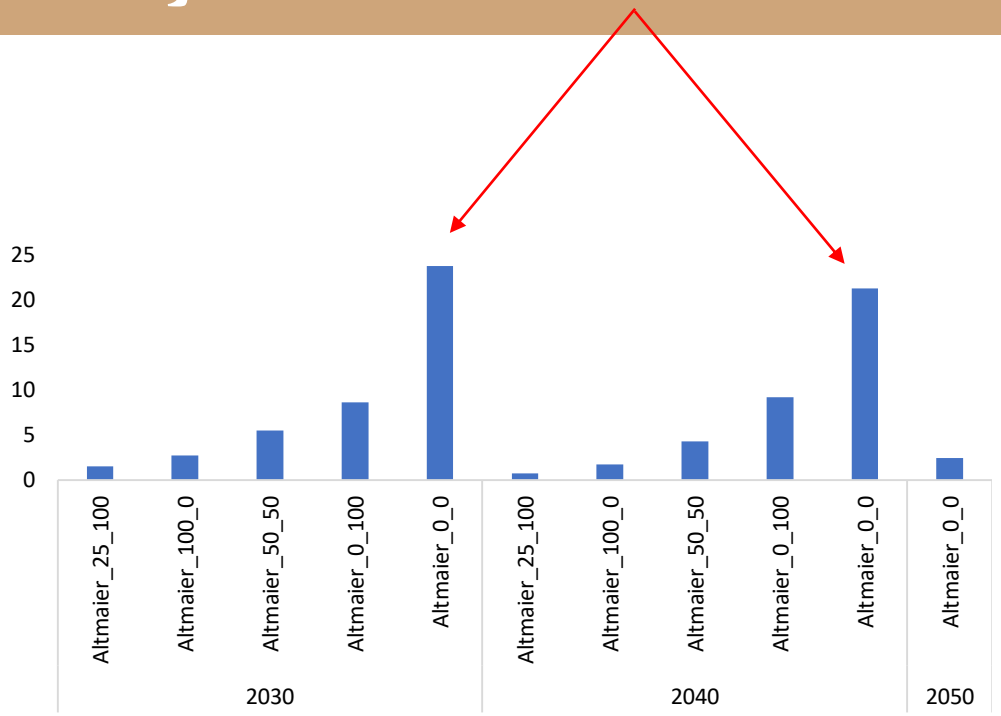

Figure 11: German LNG imports from the U.S. in different scenarios in bcm per year

Note: The numbers succeeding the scenario name indicate the applied percentage of the Base Case *cost data (i.e., the opposite of the subsidy rate). In the* Altmaier *scenarios, the first number refers to the operational costs; the second number refers to the investment costs in regasification capacity.*

… at the expense of Norway

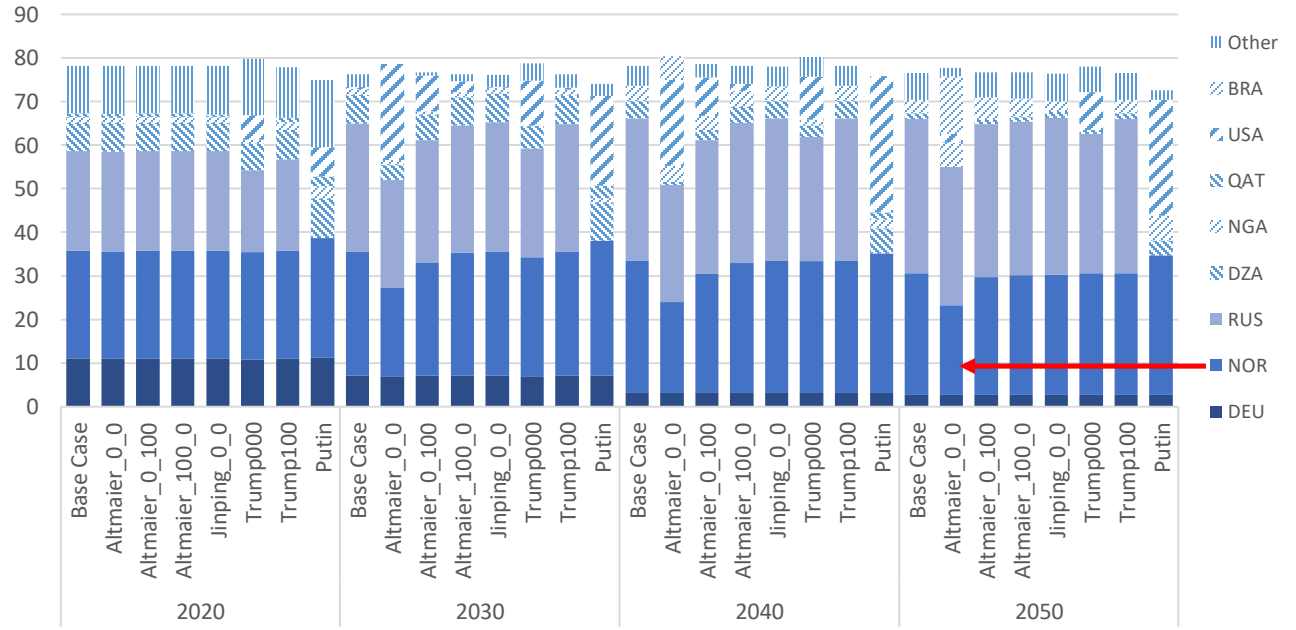

Figure 12: Germany Supply Breakdown in the* Base Case *and selected scenarios in bcm/year

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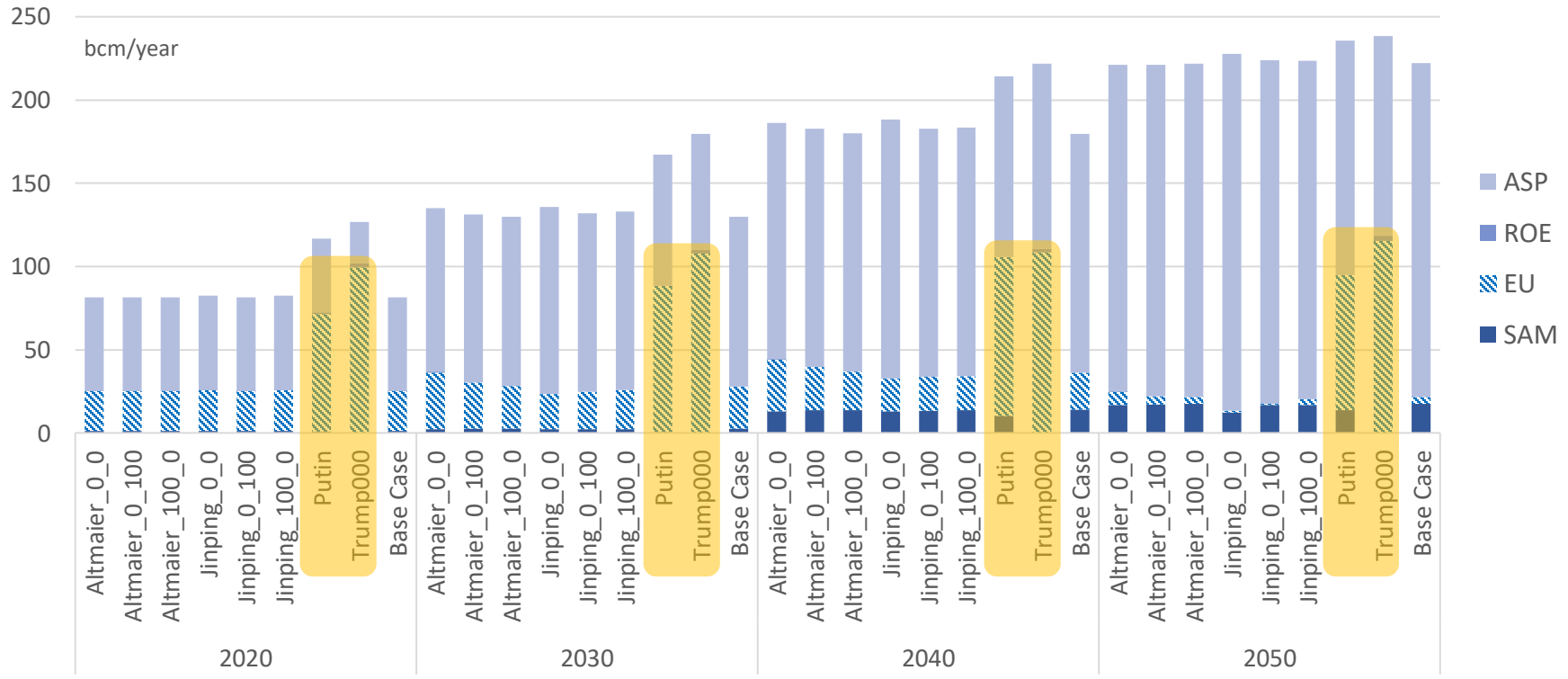
Europe in a global competition for U.S. LNG?

FoReSee



Egging, Holz, Czempinski, work in progress

Figure 7: North American exports and their destination regions in selected scenarios 2020-2050, in bcm per year

Note: The numbers succeeding the scenario name indicate the applied percentage of the Base Case *cost data (i.e., the opposite of the subsidy rate). In the* Altmaier *and* Jinping *scenarios, the first number refers to the operational costs; the second number refers to the investment costs in regasification capacity. In the* Trump *scenarios, the number is the share of* Base Case *LNG transportation costs between U.S. liquefaction and European regasification nodes. E.g., "100" means 100% of the Base Case cost, hence, a 0% subsidy on the costs.*

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Global price divergence

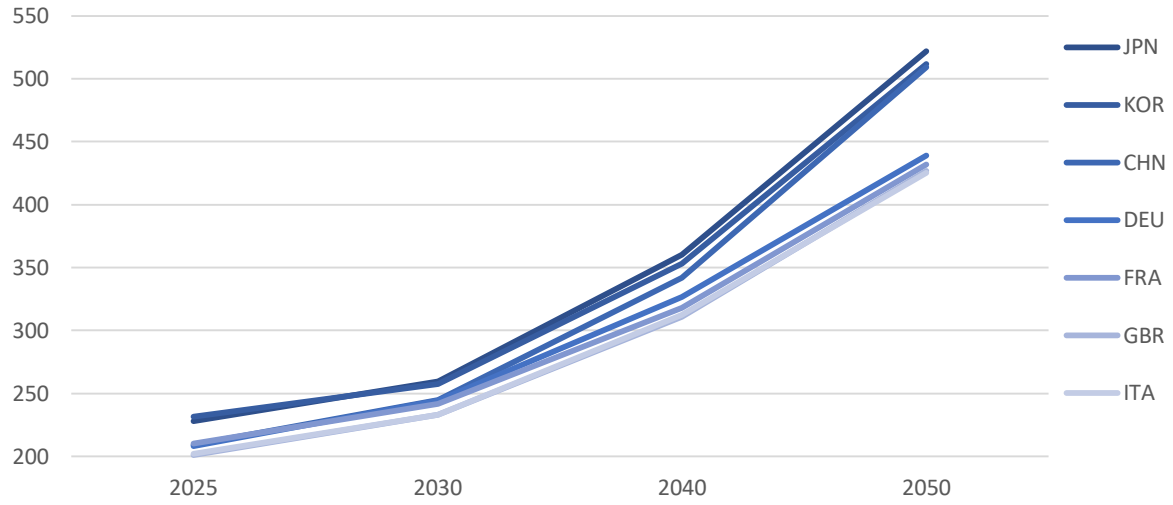

Figure 8. Price trends for selected countries in the* Base Case *(€/ 1000 cm)

- Price divergence between Europe and (East) Asia persists
- The widening price gap makes Asia relatively more attractive for global LNG supplies than Europe over time
- Due to strongly increasing demand in China, Chinese prices catch up with East Asian prices over time

Egging, Holz, Czempinski, work in progress

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Assets in the global natural gas sector

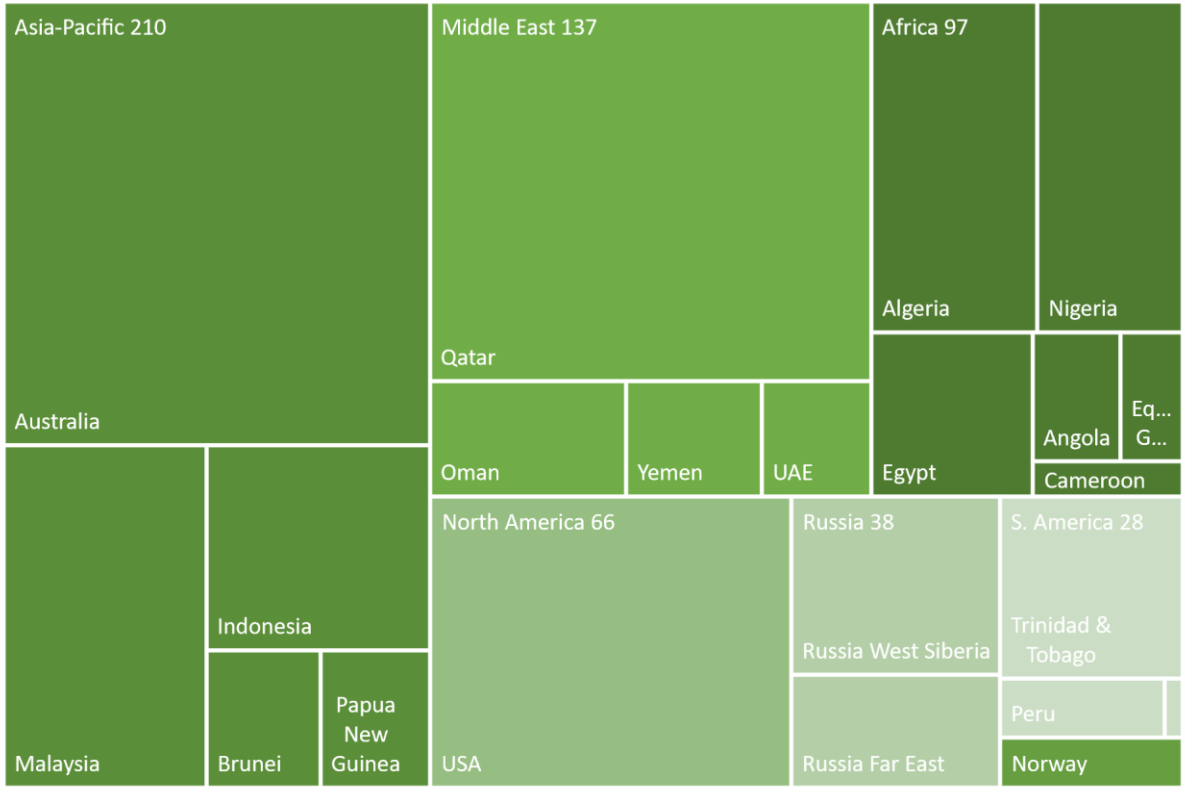

Figure 1: Global liquefaction capacities 2020 in bcm/year (Source: GIIGNL, 2020)
Total: ~ 580 bcm

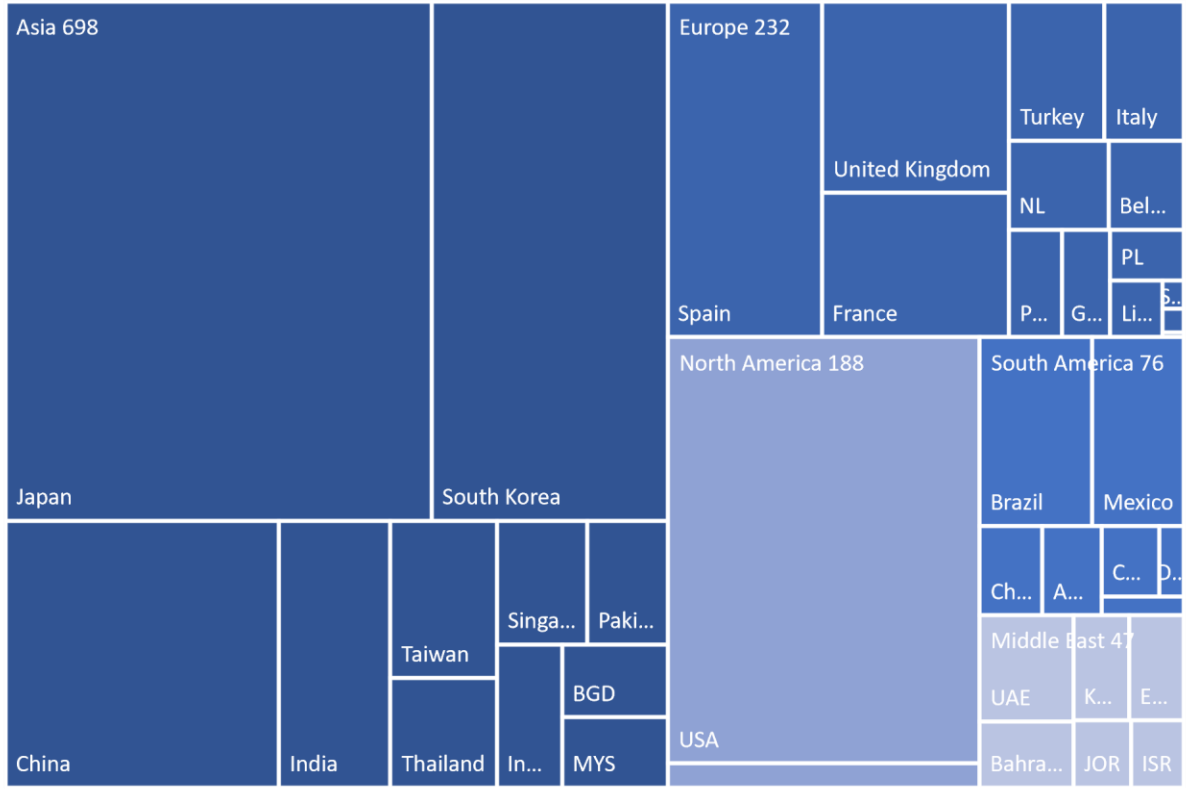

Figure 2: Global regasifcation capacities 2020 in bcm/year (Source: GIIGNL, 2020)
Total: ~ 1250 bcm

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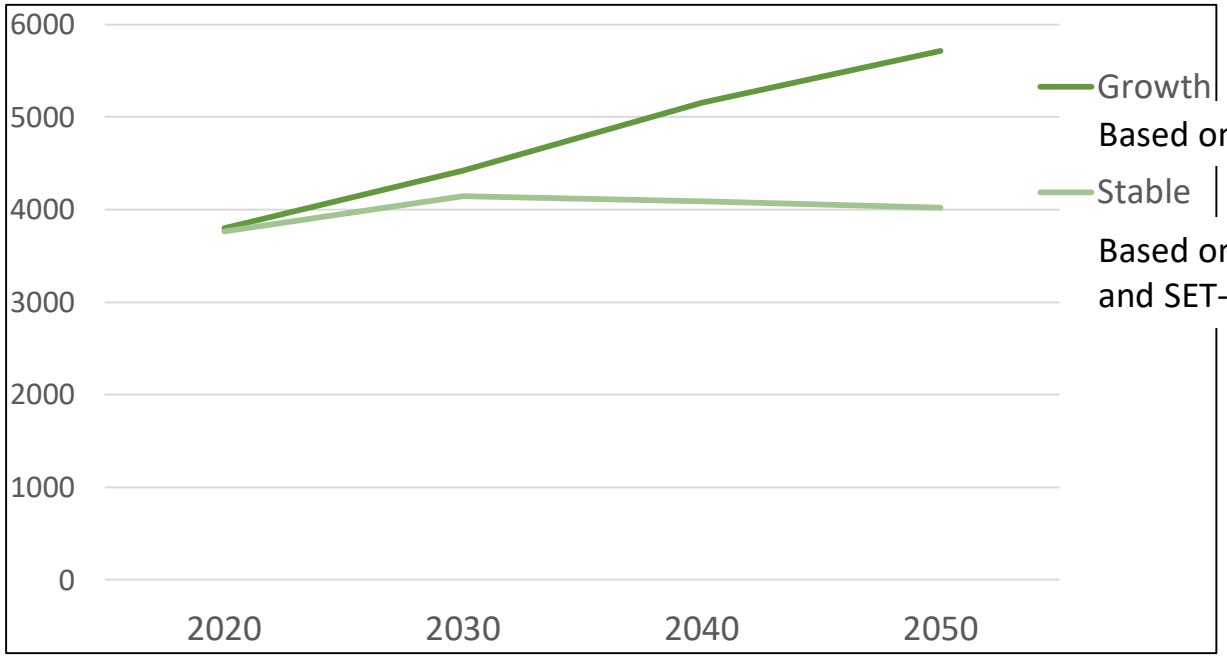
Scenarios for the global natural gas sector

Figure 1: Global supply in bcm. Source: GGM results



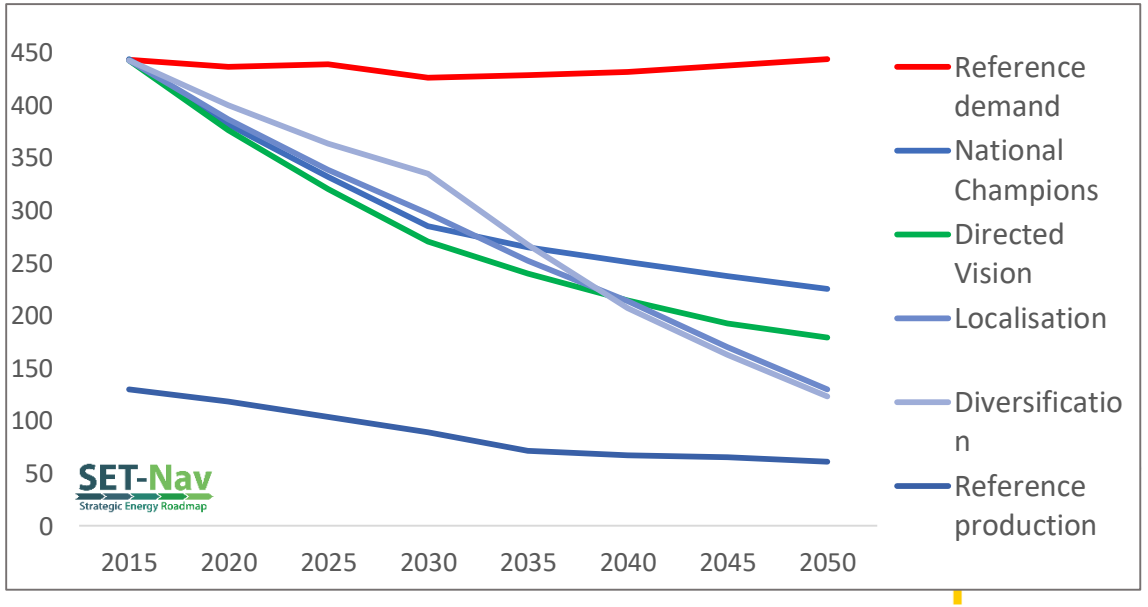
Egging & Holz, work in progress

Based on IEA WEO (2017) NPS and EC (2016) Reference Scenario

Based on IEA WEO (2017) Sustainable Development Scenario and SET-Nav „Directed Vision“

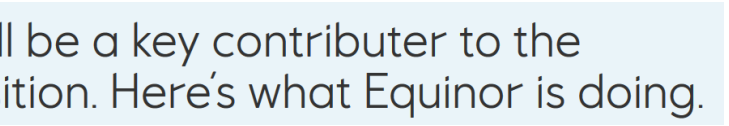
Need for global gas phase-down scenarios because the drivers are the same elsewhere than in Europe

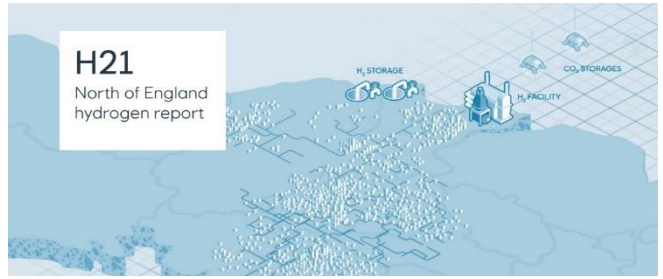
Figure 2: European natural gas demand in SET-Nav pathways and EU Reference Demand (2016). Source: Egging et al. (2019)

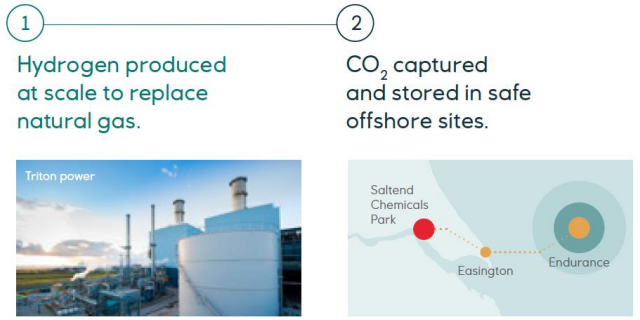


Outlook: Stranded assets in hydrogen infrastructure?

- Natural gas industry promises as „bridge“ to decarbonized economy
  - Fear of stranding natural gas assets
  - Fear of loosing business models and revenues
- Germany discusses Hydrogen Network Development Plan, following the role model of natural gas
- But: will there really be a wide-spread need for hydrogen or will it be the (expensive) fuel for those applications that cannot be decarbonized otherwise (e.g. electrified)?







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Oil markets

PHASE-OUT OF FOSSIL FUEL SUBSIDIES IN LATIN AMERICA

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How to phase out fossil-fuel subsidies ?

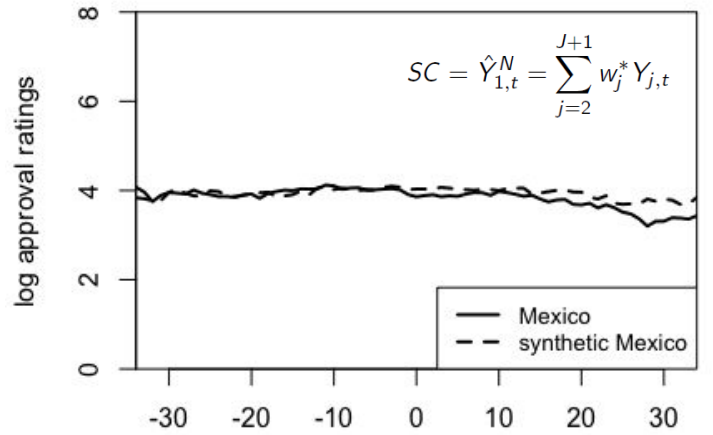
- Phasing-out FFS is compelling to fight climate change
- Despite >40 attempts 2015-17, FFS level is at 2014 levels

Fossil fuel subsidies in Latin America

- Wide-spread use of gasoline and diesel subsidies, often targeting consumer prices
- Phase-out approach differs by country

→ Can we learn something on the least controversial way of phasing out fossil fuel subsidies?

- Presidential regimes – Presidential approval can be measured over time
- Build *Synthetic Control Model(s)* to compare regimes with different subsidy phase-out approaches to hypothetical non-phase-out



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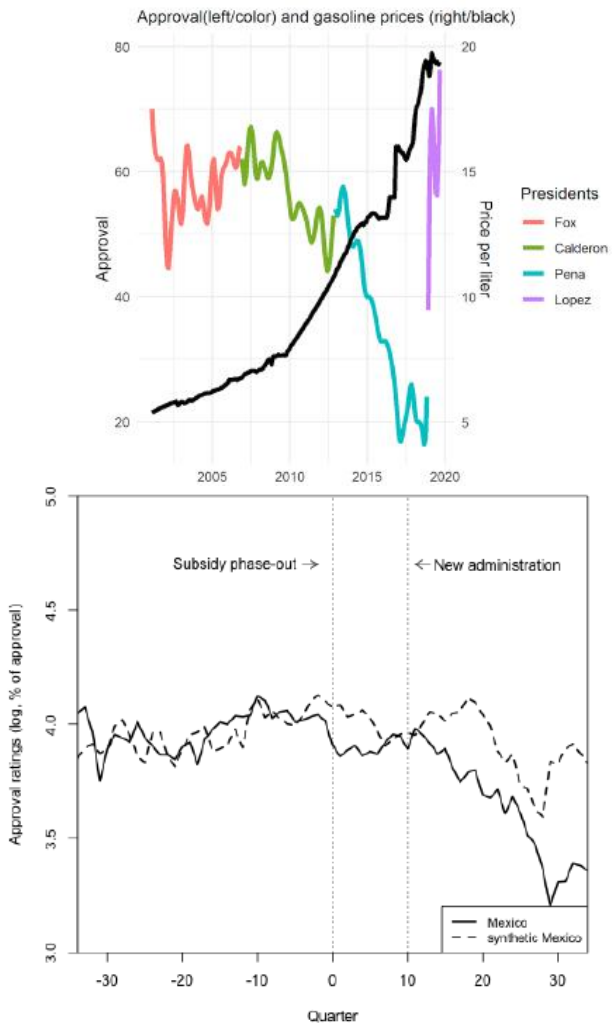
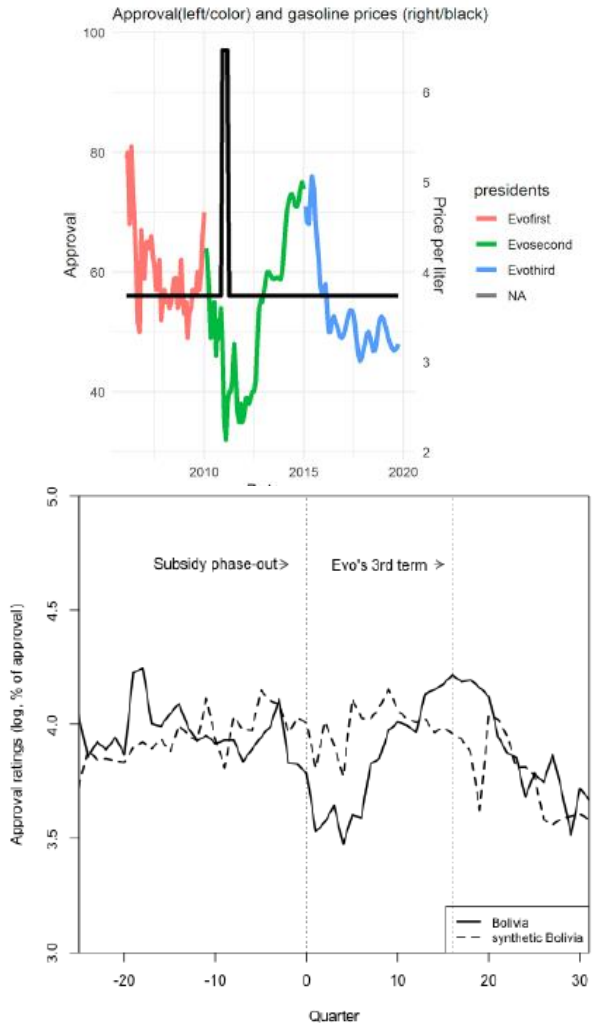
Empirical evidence on Mexico and Bolivia

Subsidy removal and approval in Mexico



Subsidy removal and approval in Bolivia



Presidential approval is 10% and 22% lower than it had been without FFS reform in Mexico and Bolivia, respectively

→ Gradual reform seems to be politically less costly than on-off reform with large price hike

Here: Pool of controls includes all LAC countries

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Conclusions

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Conclusions:
Need for much more research!

FoReSee

- Tight carbon budget and political commitments (Paris Agreement, EU Green Deal, etc.) make it inevitable to find quick solutions to reduce emissions from fossil fuel use
- Country- and fuel-specific approaches can help find effective policy approaches to reduce fossil fuel supply, use and emissions

←→ Country- and fuel-specific constraints and fundamental structures need to be taken into account, e.g. in market-specific numerical models

- Strong decrease of renewable costs and renewable integration costs makes fossil fuel phase-out already economical in some countries, similar trend in more countries

→ Risk of asset stranding in fossil sectors which can trigger political resistance, compensation requests and adverse economic effects

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Thank you for your attention! Looking forward to the discussion!

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Additional slides

FRANZISKA HOLZ

15.1.2021

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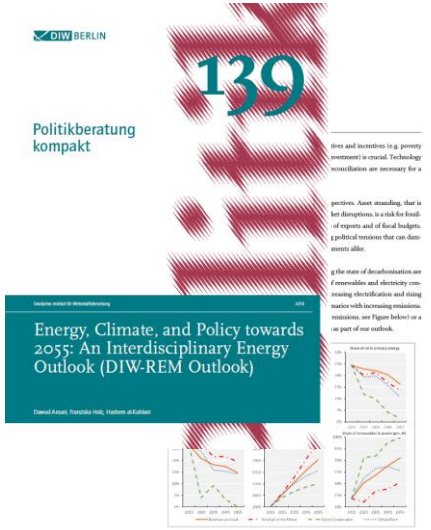
Scenarios:
Perspectives on global energy futures

FoReSee

- Generating an independent, interdisciplinary, qualitative-quantitative energy outlook to 2050: The DIW-REM Outlook
- Translating scenarios into stranded asset risks for individual regions
- Assessing and comparing prominent outlooks

Interested to hear more? Listen to the IAEE Webinar from November 26, 2020: https://www.iaee.org/en/webinars/webinar_ebers5.aspx



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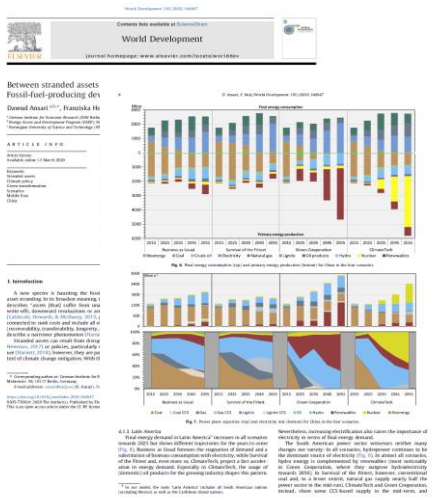

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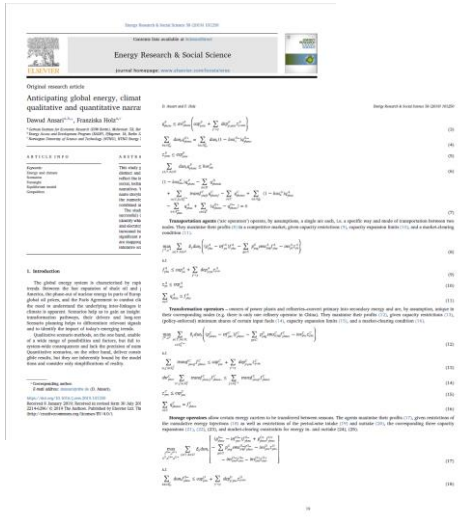
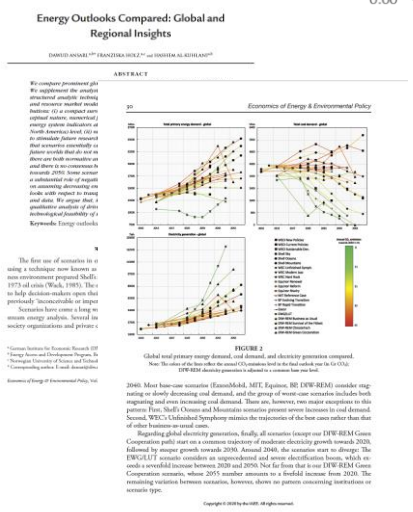
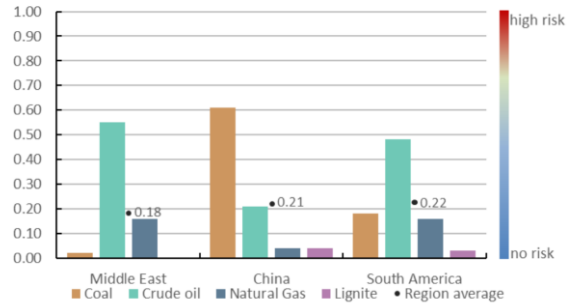


Ansari, D., & Holz, F. (2019). Anticipating global energy, climate and policy in 2055: Constructing qualitative and quantitative narratives. ***Energy Research & Social Science***, *58*, 101250.



Ansari, D., Holz, F., & Al-Kuhlani, H. (2020). Energy Outlooks Compared: Global and Regional Insights**.** ***Economics of Energy & Environmental Policy***, *9*(1).

Figure 1: Stranded asset index
Source: Ansari et al. (2019)

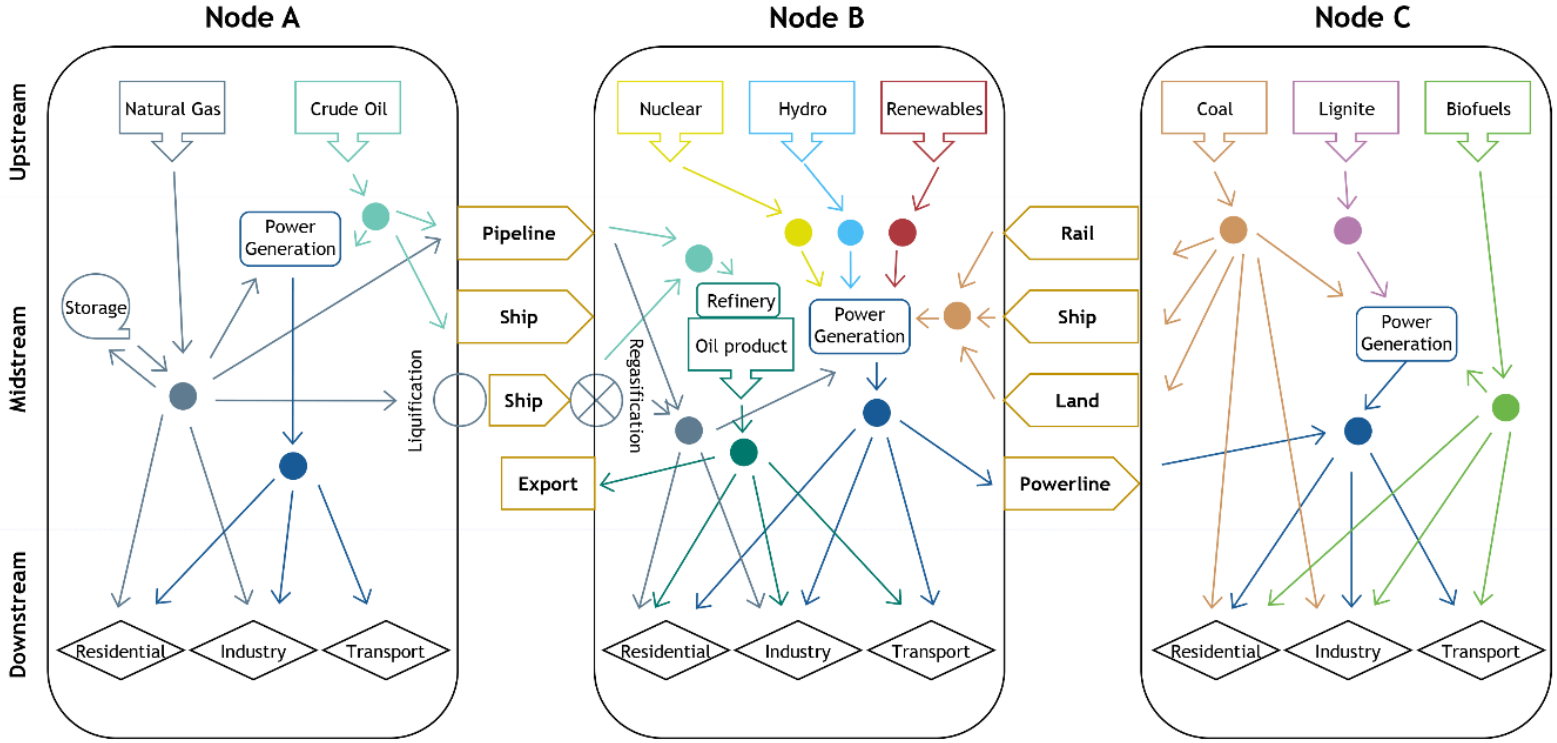


im Auftrag des Bundesministerium für Bildung und Forschung

The DIW-REM outlook: Multimod

A numerical multi-fuel, multi-sector model of global energy and resource markets:

- Resource producers / transporters, power plant owners, and service providers maximise their profits in (im-)perfect competition
- Consumers maximise their utility



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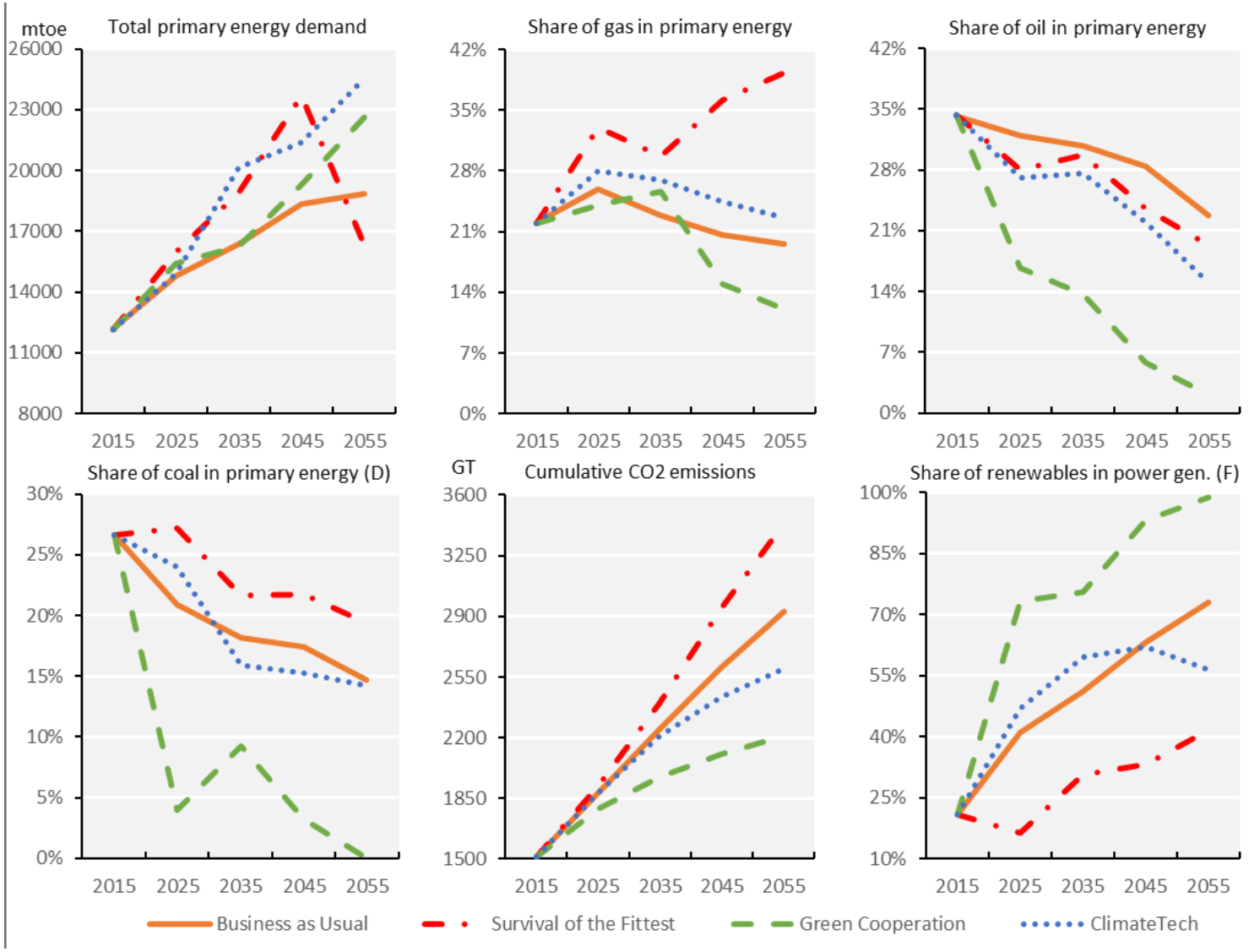
The DIW-REM outlook



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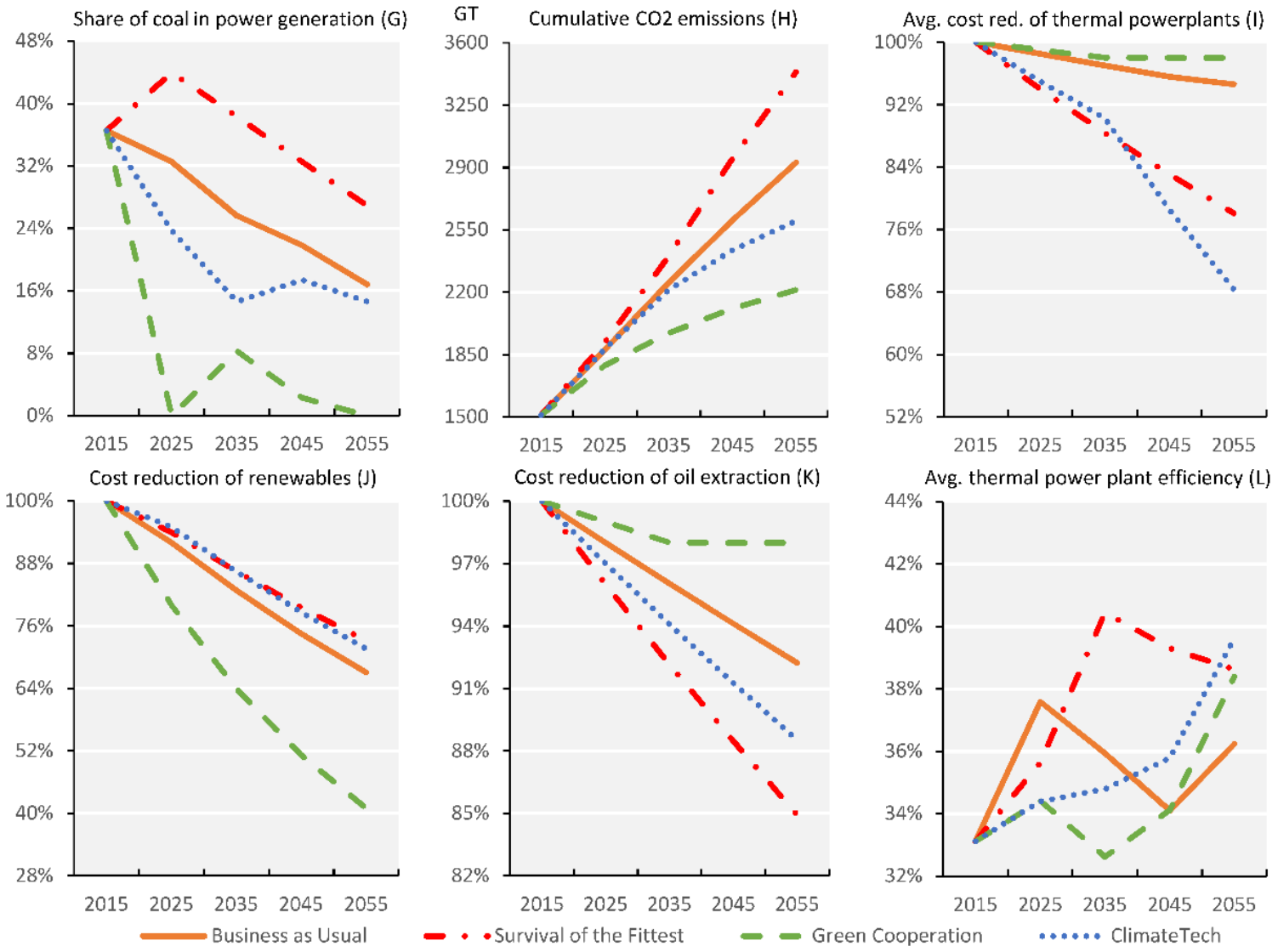
DIW-REM Outlook Indicators



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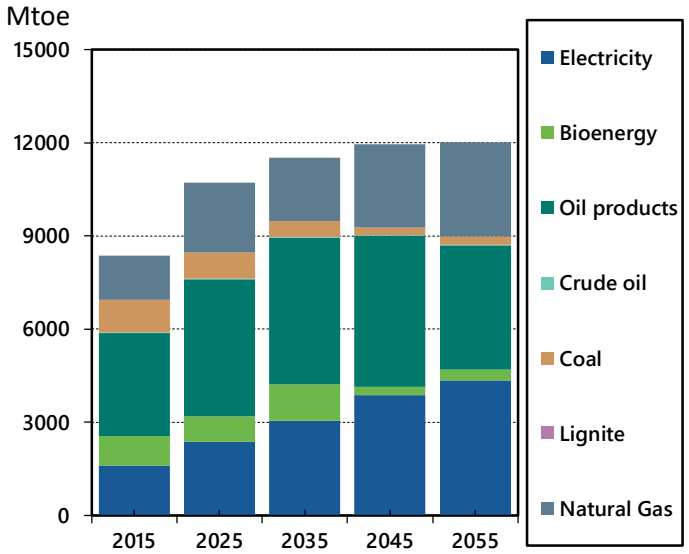
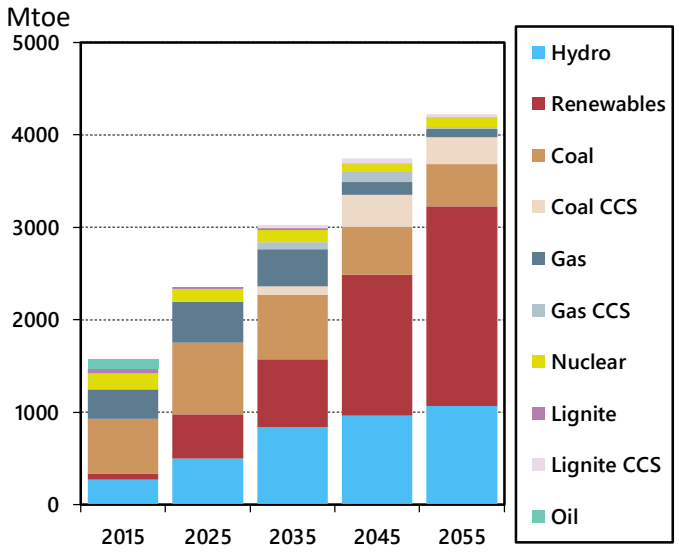
Scenario "Business-as-usual"

FoReSee

Final global energy demand



Electricity fuel mix



2020

- Prolonged localised conflicts → lower climate change mitigation efforts
- Coexistence of fossil fuels and renewables
- US catch up under a new, politically liberal administration
- Deployment of electric vehicles, renewable efficiency gains, CCS
- Still: Failure to achieve 2 deg C target leads to catastrophes

2050

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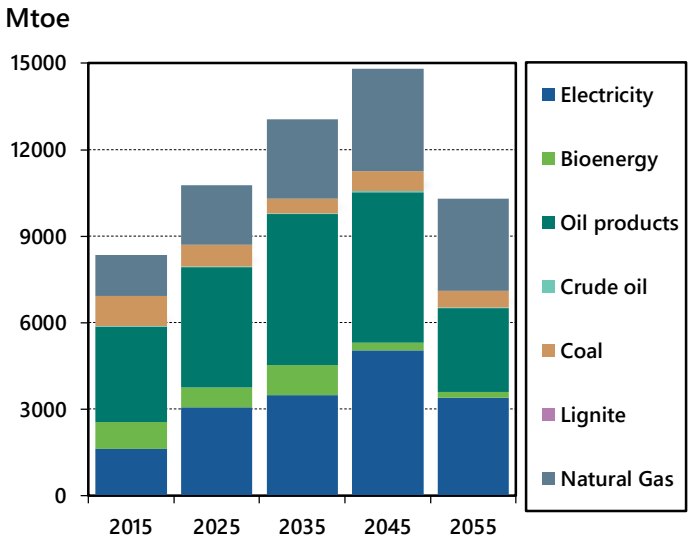
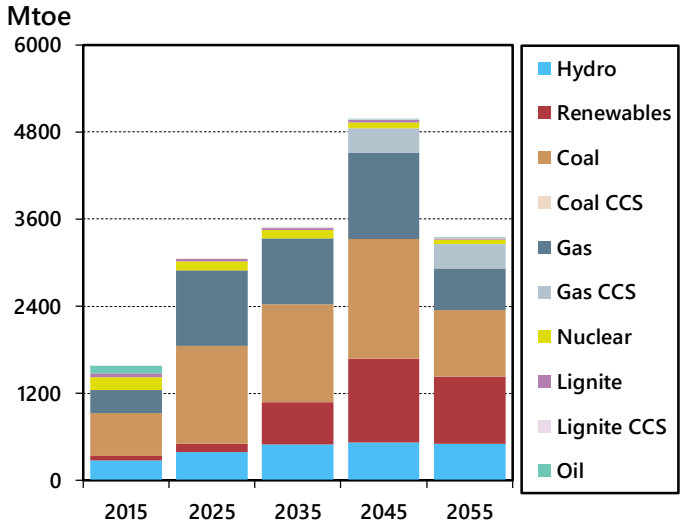
Scenario “Survival of the Fittest”

FoReSee

Final global energy demand



Electricity fuel mix



2020

- Int. governance is replaced by a multi-polar order, expanding conflict

- Efforts towards energy transition low, mostly in China and the EU
- Investments (FDI) crowded out by protectionist policies

2050

- Carbon budget filled by 2040, catastrophes, further push for isolationism
- Exploding adaptation costs, only affordable to rich nations

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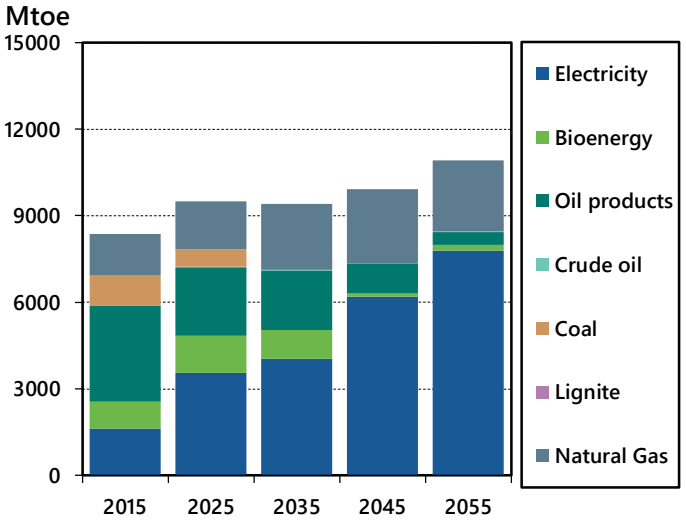
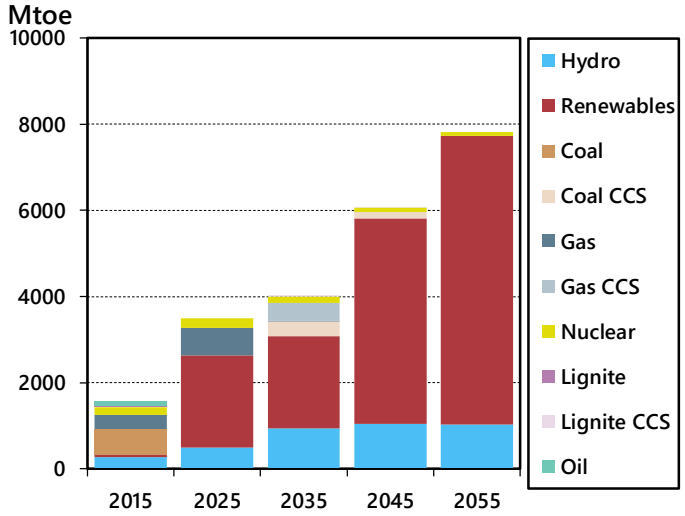
Scenario “Green Cooperation”

FoReSee

Final global energy demand



Electricity fuel mix



2020

- Rapid decrease of (armed) conflict in key regions, strong global order

- Dual objective: Poverty eradication and CC mitigation
- Population growth and urbanisation are met with green leapfrogging
- Large R&D investments drive renewables’ gains and new technologies

2050

- Achievement of the 2 °C target

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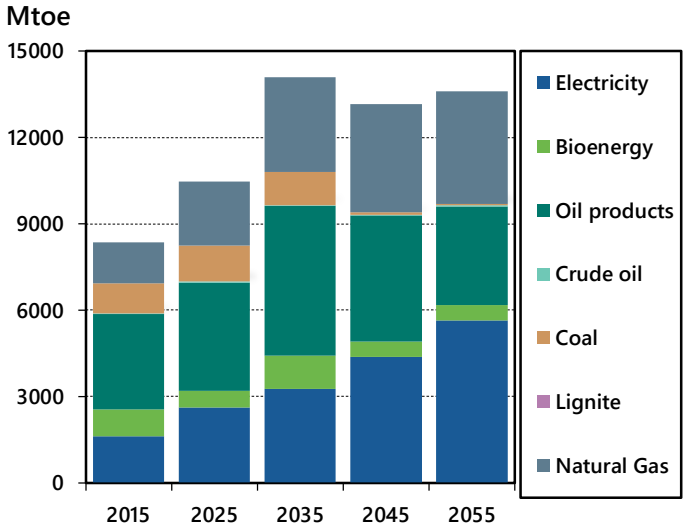
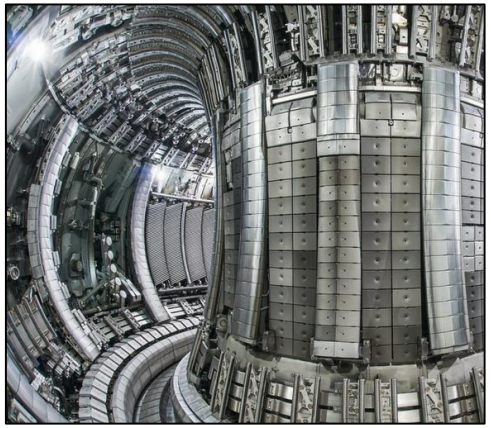
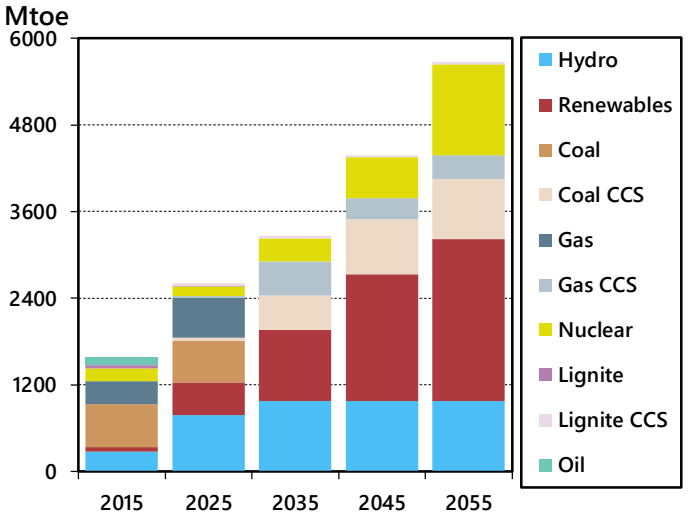
Scenario “Climate Tech”

Final global energy demand





Electricity fuel mix



2020

- BaU, but promising technological advances lead politics to neglect mitigation

- Growth and urbanisation result in increasing emissions in early decades
- Carbon budget approached but deployment of new technologies then starts
- New technologies allow for more time/emissions (despite complications)

2050

- 2°C target achieved, incl. with negative emissions, but delayed transition

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