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# Coal Phase-Out Implications for Steam Coal Producers: The Risk of Asset Stranding

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# Agenda

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- 1) Motivation**
- 2) COALMOD-World**
- 3) Preliminary results**
- 4) Conclusions**

# Unburnable coal

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**McGlade and Ekins (2015) show that large amounts of coal need to remain unburnt.**

**Climate mitigation policies (Paris Agreement) so far focus on demand-side, yet addressing supply-side (e.g., of coal) is increasingly discussed in scientific literature (e.g., Asheim et al. 2019; Lazarus, Erickson, and Tempest 2015; Mendelevitch 2018; Richter, Mendelevitch, and Jotzo 2018).**

- **How will a 1.5°C pathway affect exploitation of coal reserves?**
- **How will different supply-side coal policies affect national economies of major coal exporters?**

# Major steam coal producers and consumers

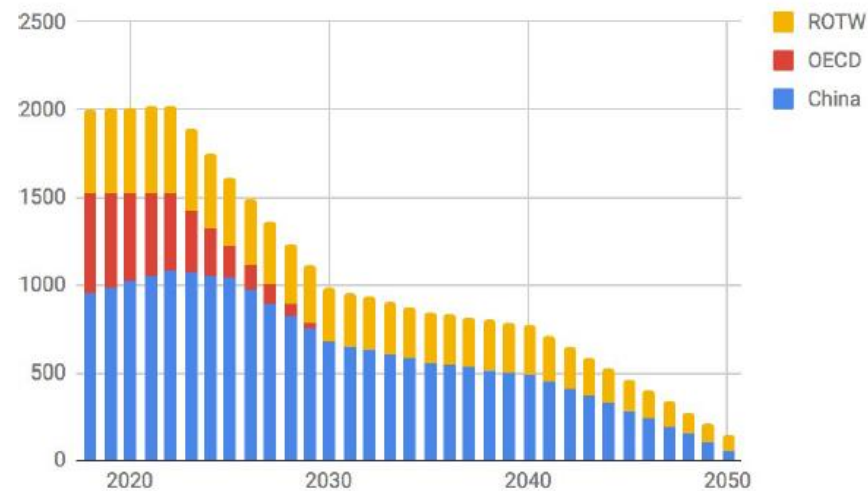
Major producers in 2016	Major consumers in 2016
China (2,720 Mt)	China (3,040 Mt)
India (609 Mt)	India (760 Mt)
United States (544 Mt)	United States (580 Mt)
Indonesia (460 Mt)	South Africa (180 Mt)
South Africa (252 Mt)	Japan (140 Mt)
Australia (250 Mt)	⋮
⋮	Germany (45 Mt), UK (15 Mt)
Colombia (86 Mt)	Colombia (6 Mt)
World production 5,460 Mt (6,060 Mt, in 2013)	World consumption 5,690 Mt (6,100 Mt, in 2013)

Source: IEA/OECD 2018.

# Scenarios: BAU vs. 1.5°C

## Scenarios:

- **Business as usual (BAU)**
  - Based on New Policies Scenario of IEA World Energy Outlook 2017 (IEA 2017) and EIA Annual Energy Outlook 2018 (EIA 2018).
  - Global community taking some limited action against climate change at the ambition level of the currently active Nationally Determined Contributions (NDCs).
- **1.5°C**
  - Based on Nace (2018) *A Coal Phase-Out Pathway for 1.5°C*.



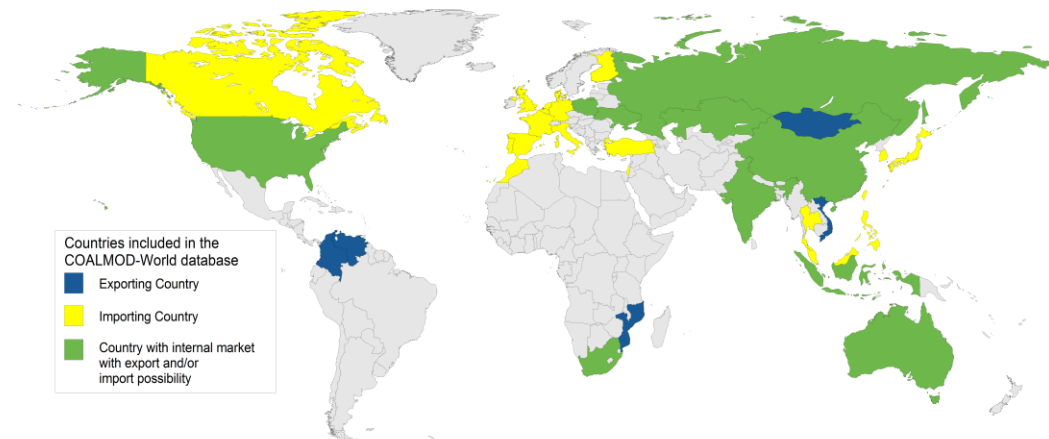
Coal power capacity in the 1.5°C Pathway, OECD, China, and rest of the world.

Source: Nace 2018.

# The COALMOD-World Model

## Partial Equilibrium Model

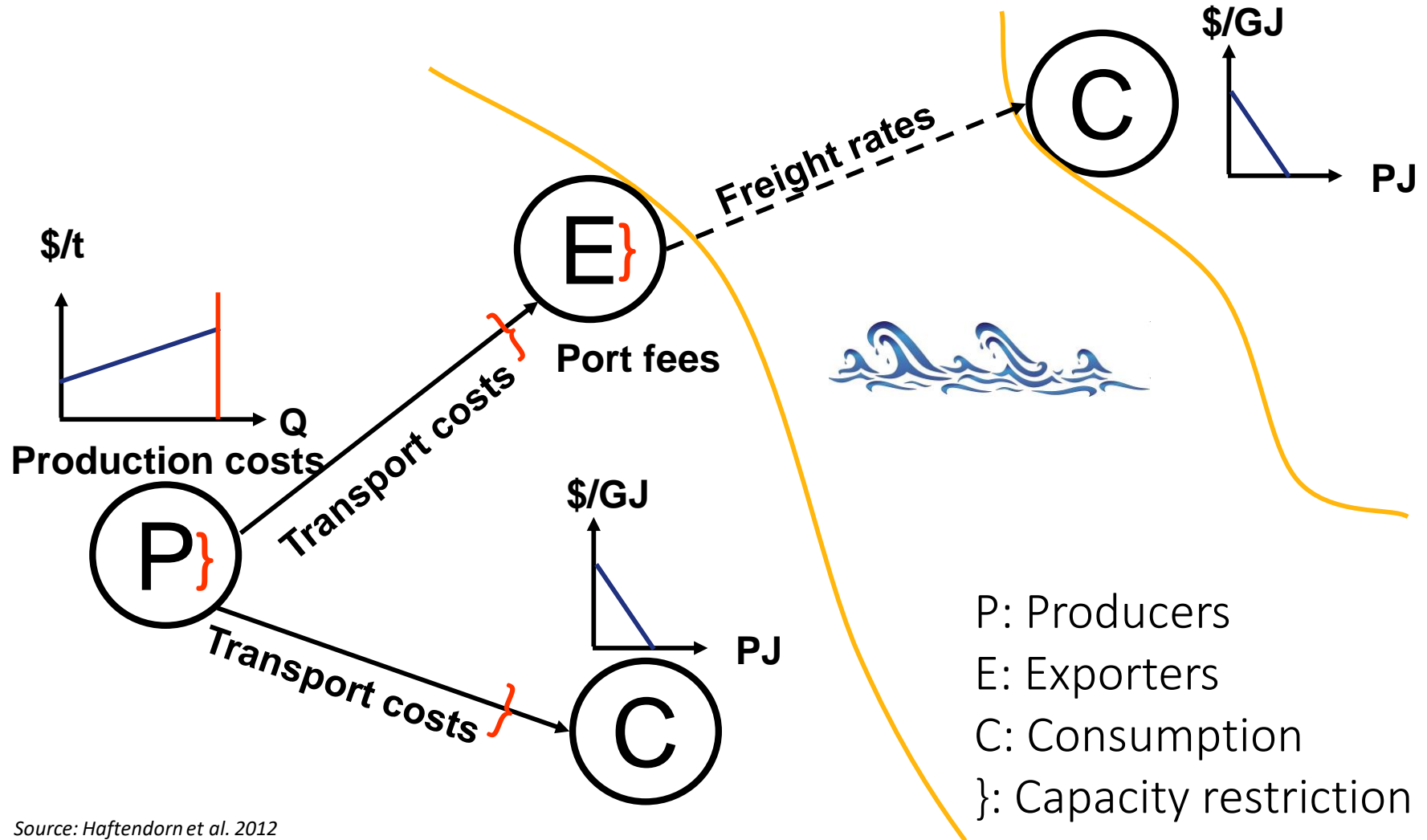
- Large-scale multi-period model of (competitive) steam coal market
  - CoalMod-World (Haftendorn et al. 2012 and Holz et al. 2015, Holz et al. 2016)
- Profit-maximizing players with specific constraints
  - Producers and Exporters
- Market clearing via inverse demand functions
- Model features:
  - Mine mortality effects on costs and production capacities
  - Endogenous investment in production and export capacities
  - Substitution between 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

# The COALMOD-World Model

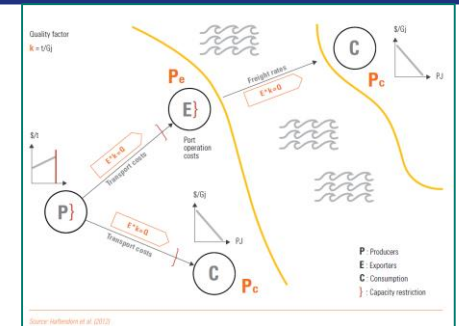


Source: Haftendorn et al. 2012

# Overview of exogenous parameters in COALMOD (data input)

P

- Production cost function parameters
- Production capacity constraints
- Transport costs to exporter and domestic consumer
- Transport capacity to exporter and domestic consumer
- Reserve constraints
- Investment data (costs and limitations for mine expansions)



E

- Export capacity
- Port operation costs or fees
- Freight rates to every consumers reachable by sea
- Investment data (costs and limitations for mine, rail, ports)

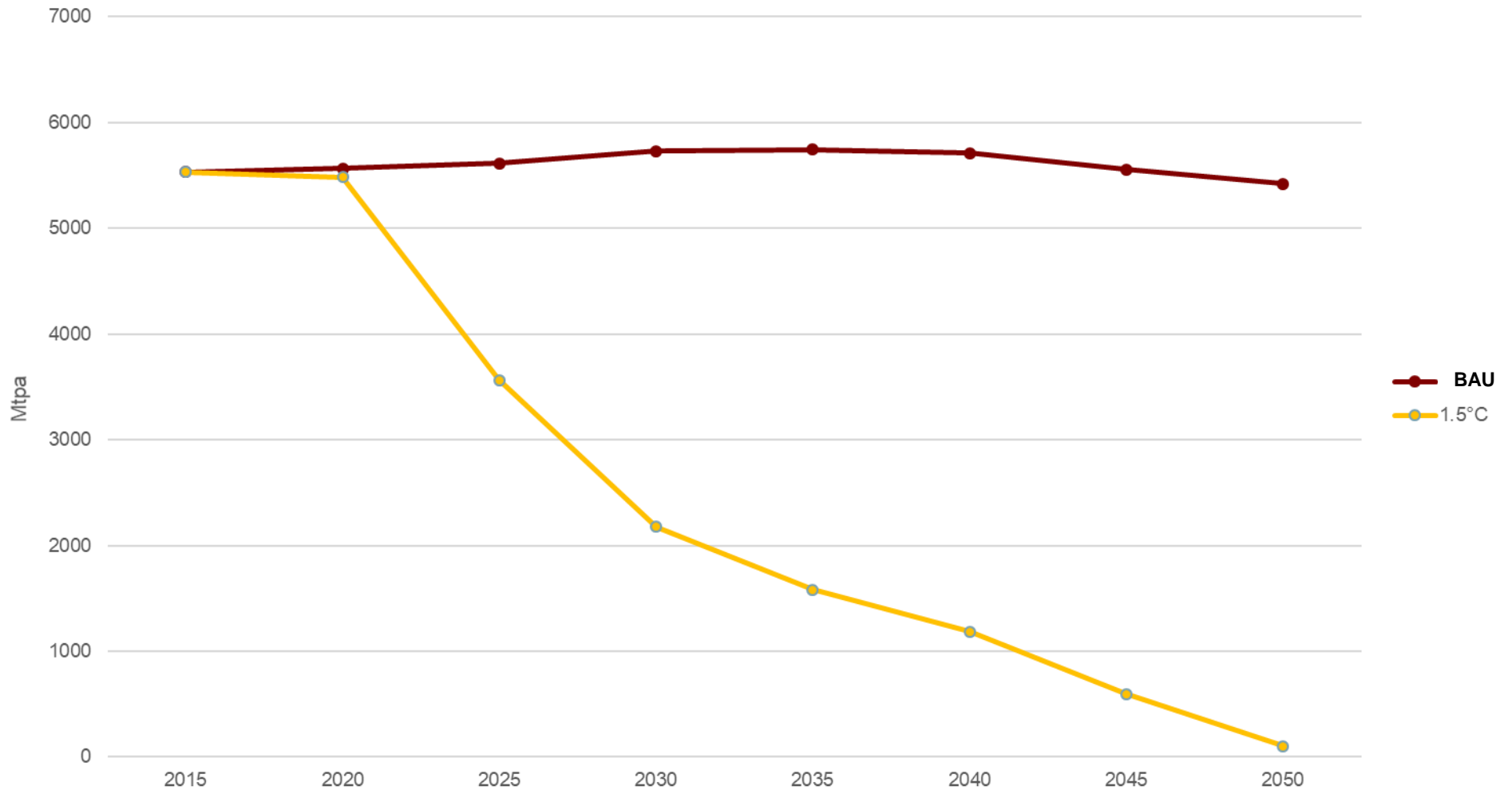
C

- Reference price for all model years
  - Reference quantity (all years)
  - Price elasticity of demand
- } Demand function

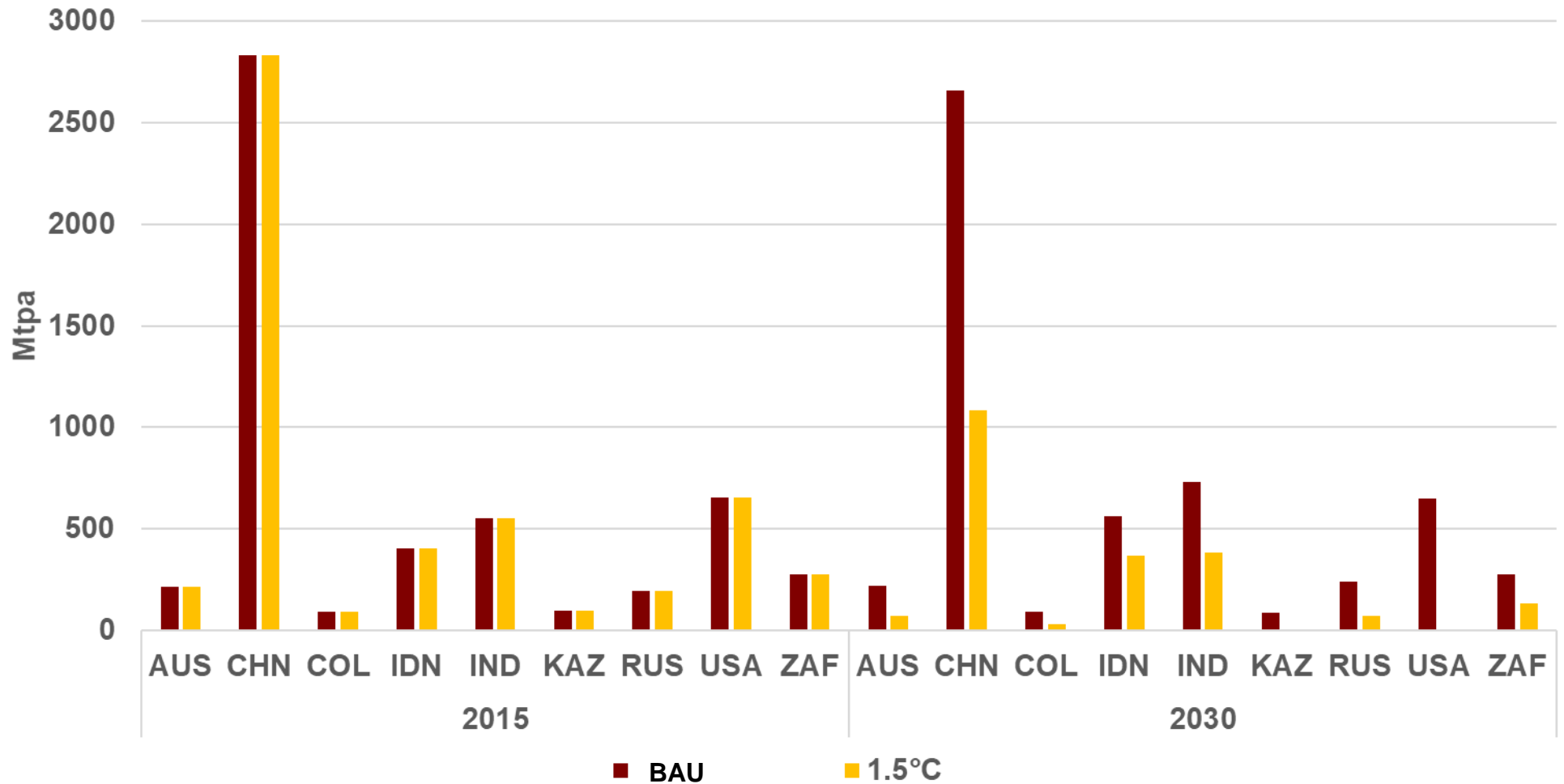
Other possible data input: Political / non-economic factors



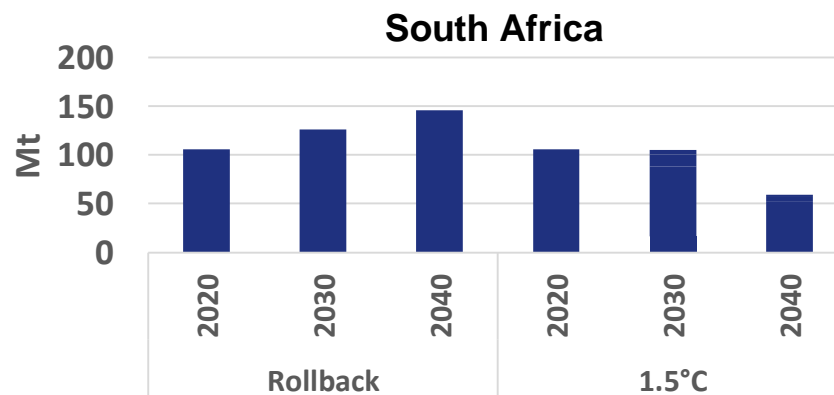
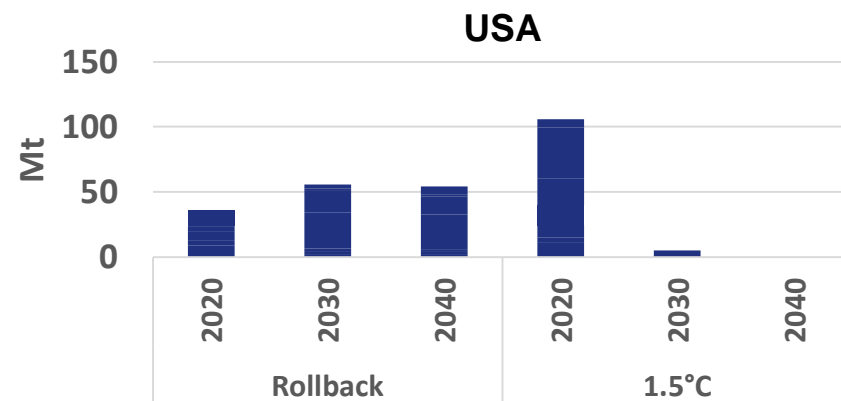
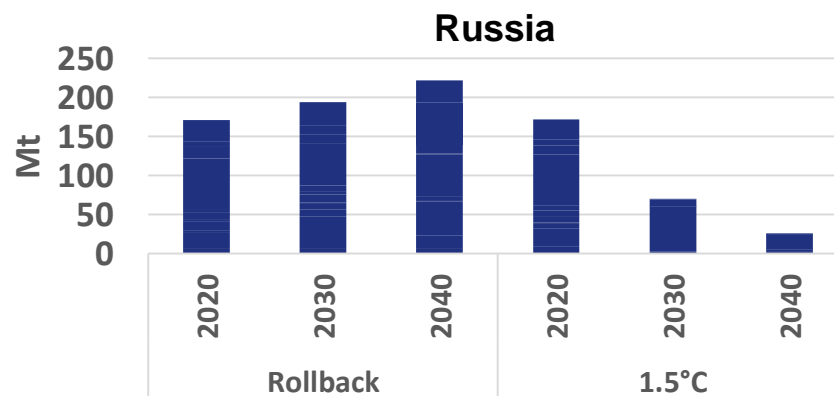
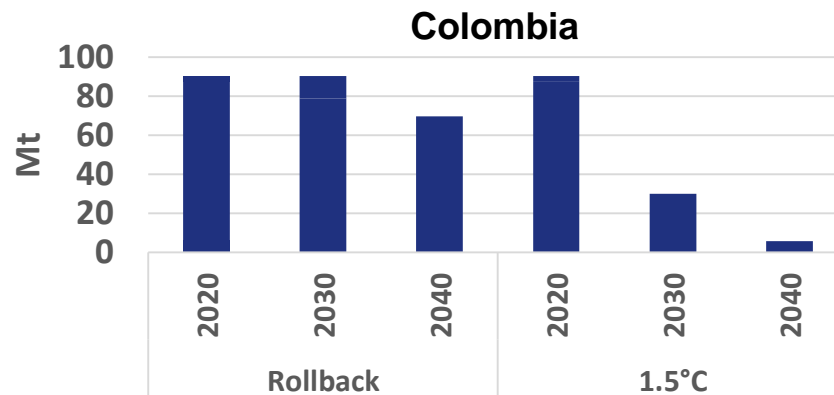
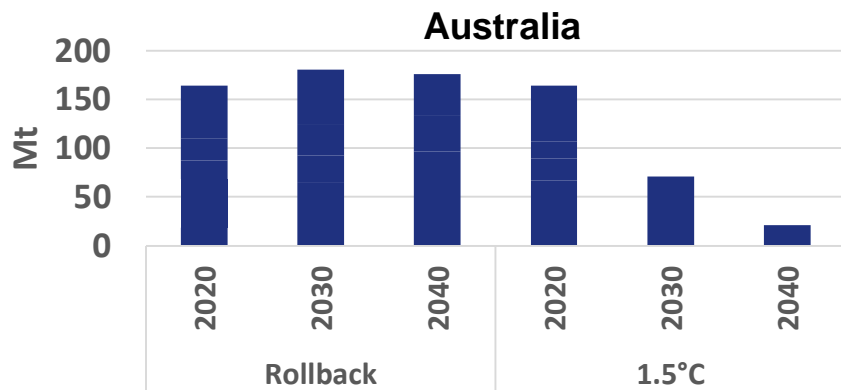
# Global steam coal consumption



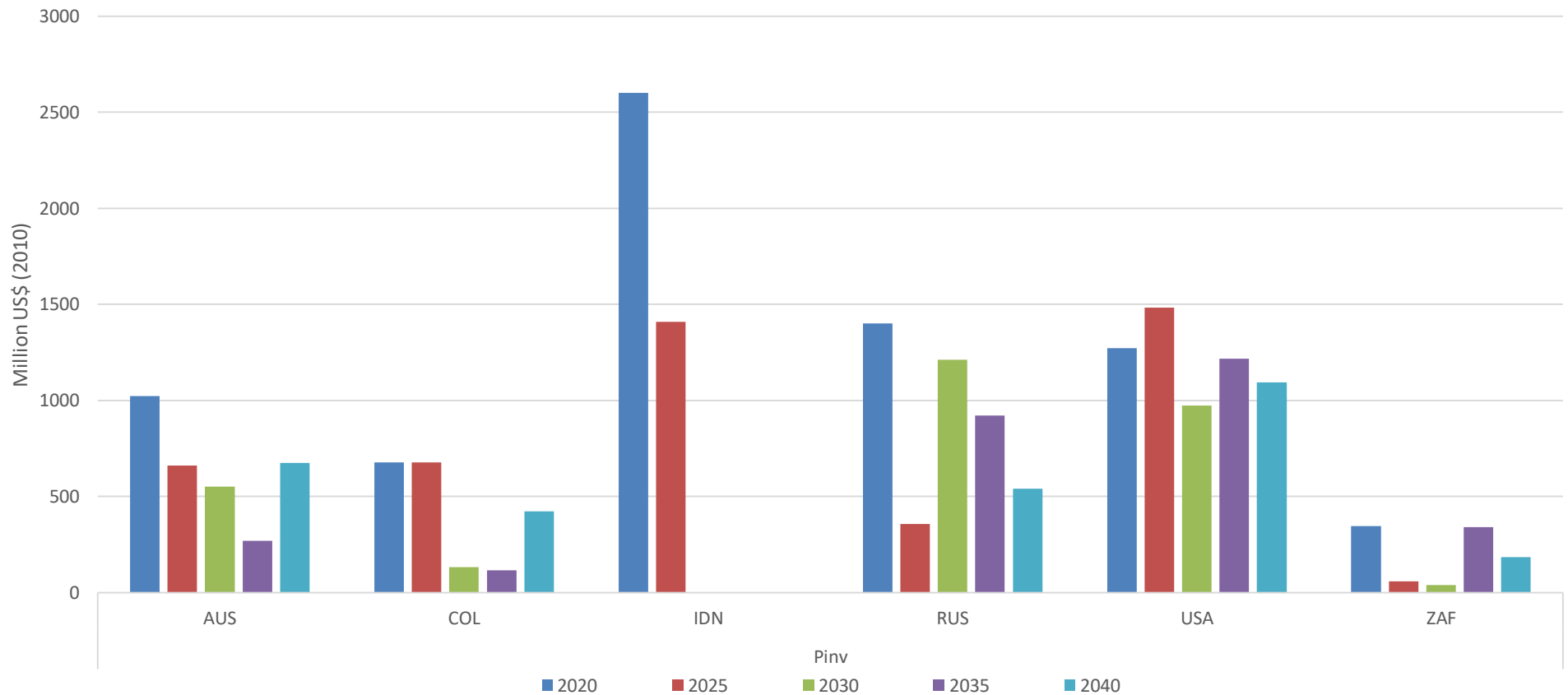
# Major steam coal producers – production amounts



# Major exporters – export volumes



# Investments production infrastructure BAU scenario



**In 1.5°C scenario: No investments in production infrastructure.**

# Conclusion

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## Key findings

- Most coal exporters will experience drastic decline of thermal coal export volumes within next decade, in case of 1.5°C pathway.
- Early alignment of investments in production capacity can avoid risk of asset stranding.
- 1.5°C pathway will lead to large amounts of foregone coal production – and possible resistance to required mitigation.

## Research outlook

- Assessing coal reserves in developed mines vs. total coal reserves (major producers).
- How will different policies affect different coal exporters?
  - Effects on revenues/GDP/labor market/taxes/...

# Further research

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## **Demand side scenarios**

- Model linking with REMIND (IAM): coal demand for various CO<sub>2</sub> prices
- Import policies by large importers (India, China, Europa)

## **Supply side scenarios, addressing committed (developed) coal reserves:**

- Modified capital costs / investment costs (“divestment”)
- Subsidy removal
- New mine moratorium
- Yasuní-type compensation for leaving coal in the ground

## **Policy implementation strategies?**

- Rich countries phase out coal first (i.e. OECD countries), poor countries follow later (coal demand, coal production)

## **Alternative Modeling methods**

- Rolling horizon optimization (fixing early investments)

# Thank you very much for your attention!

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<https://coaltransitions.org/>



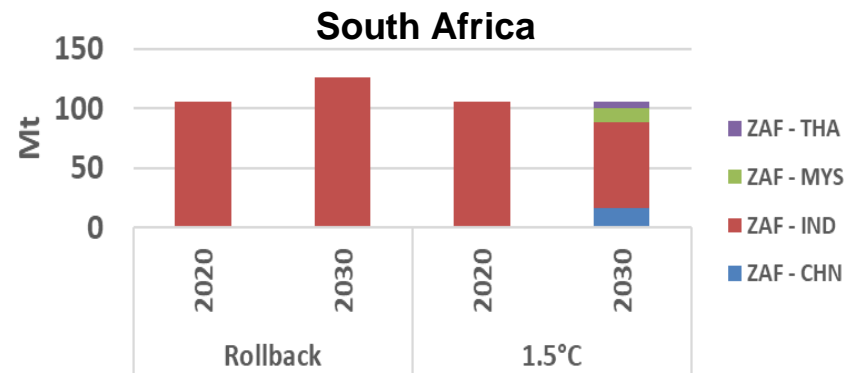
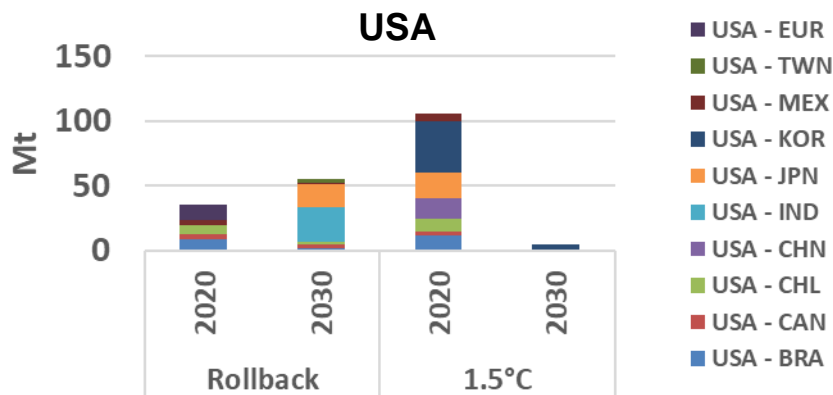
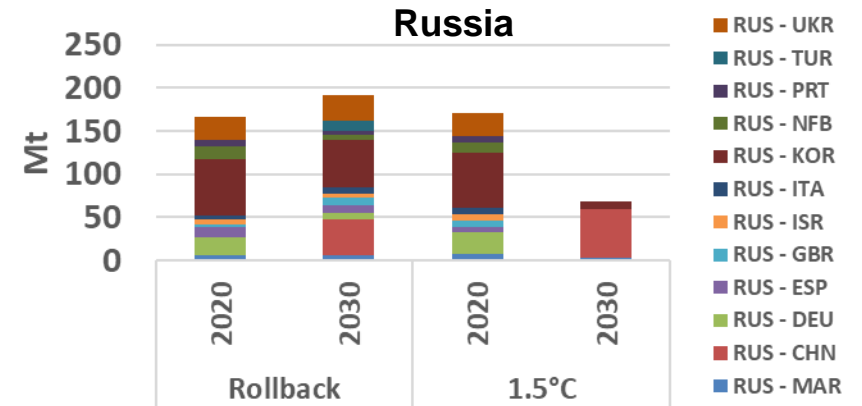
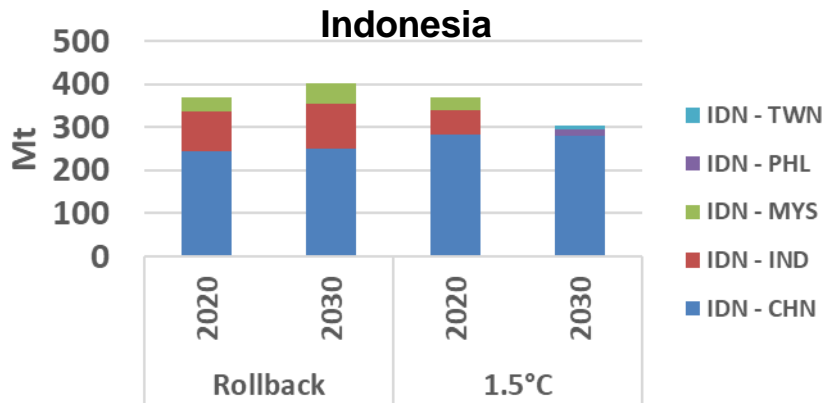
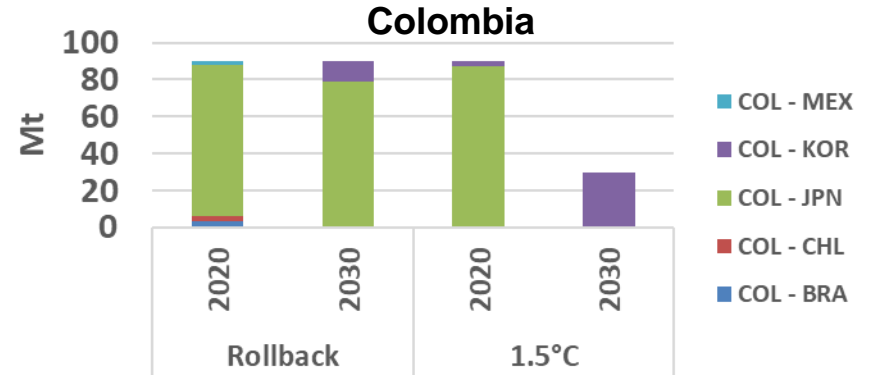
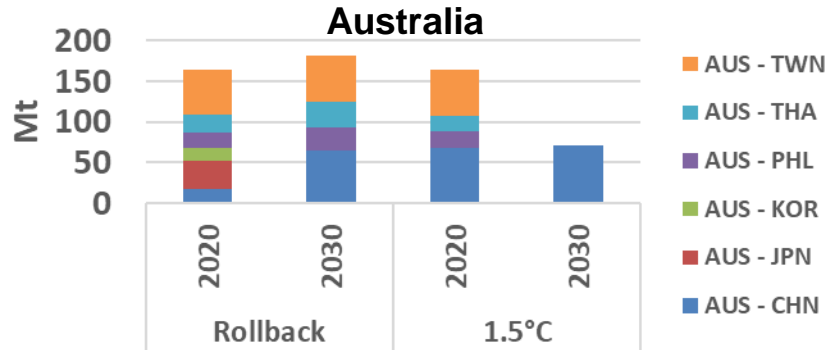
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# Major exporters – export destinations



# Hard coal reserves

	Country	Mt	Share [%]	Cumulated
1	USA	220,800	30.9	30.9
2	China	128,112	17.9	48.8
3	India	92,786	13.0	61.7
4	Russia	69,634	9.7	71.5
5	Australia	68,310	9.5	81.0
6	Ukraine	32,039	4.5	85.5
7	Kazakhstan	25,605	3.6	89.1
8	Poland	19,808	2.8	91.8
9	Indonesia	15,068	2.1	93.9
10	South Africa	9,893	1.4	95.3
11	Colombia	4,881	0.7	96.0
12	Canada	4,346	0.6	96.6
13	Vietnam	3,116	0.4	97.0
14	Mozambique	1,792	0.3	97.3
15	Brazil	1,547	0.2	97.5
16	Uzbekistan	1,375	0.2	97.7
17	Iran	1,203	0.2	97.9
18	Chile	1,181	0.2	98.0
19	Mongolia	1,170	0.2	98.2
20	Mexico	1,160	0.2	98.4

Source: BGR 2017.