# Climate and Energy Geopolitics

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# Global CO$_2$ Emissions
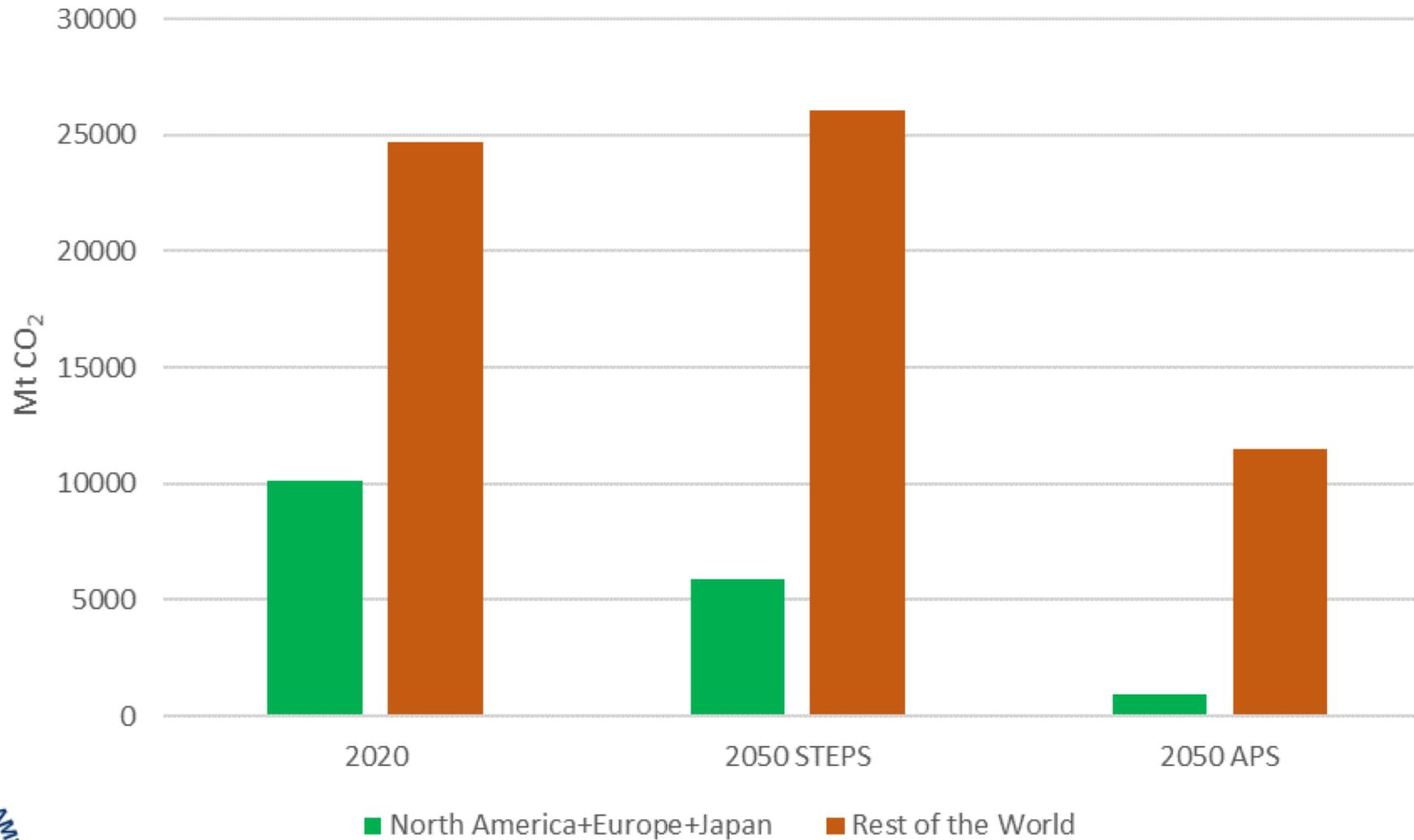


Imbalances between advanced economies and emerging markets are growing over time

# Global Energy Investment by Region



Source: IEA (2022)

**Emerging market and developing economies, other than China, account for two-thirds of the global population, but their share of clean energy investment is both low and declining**
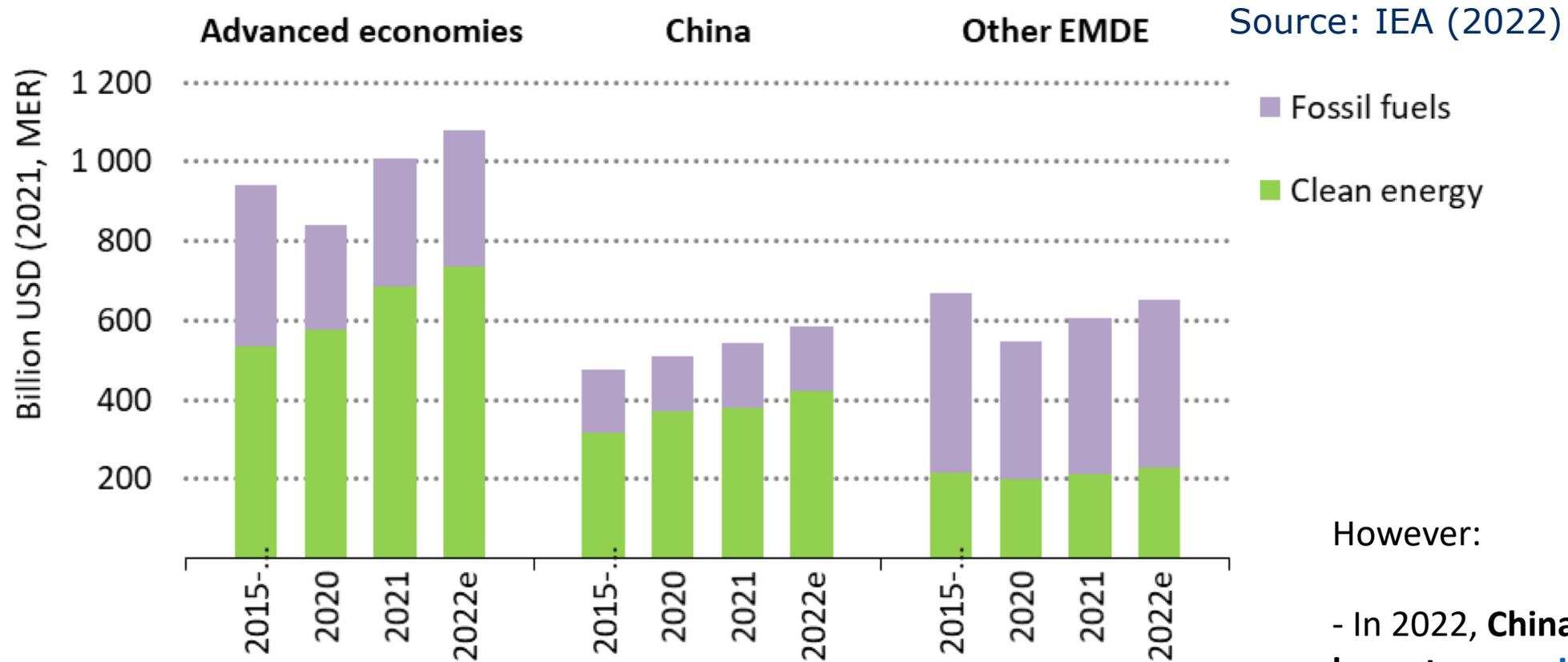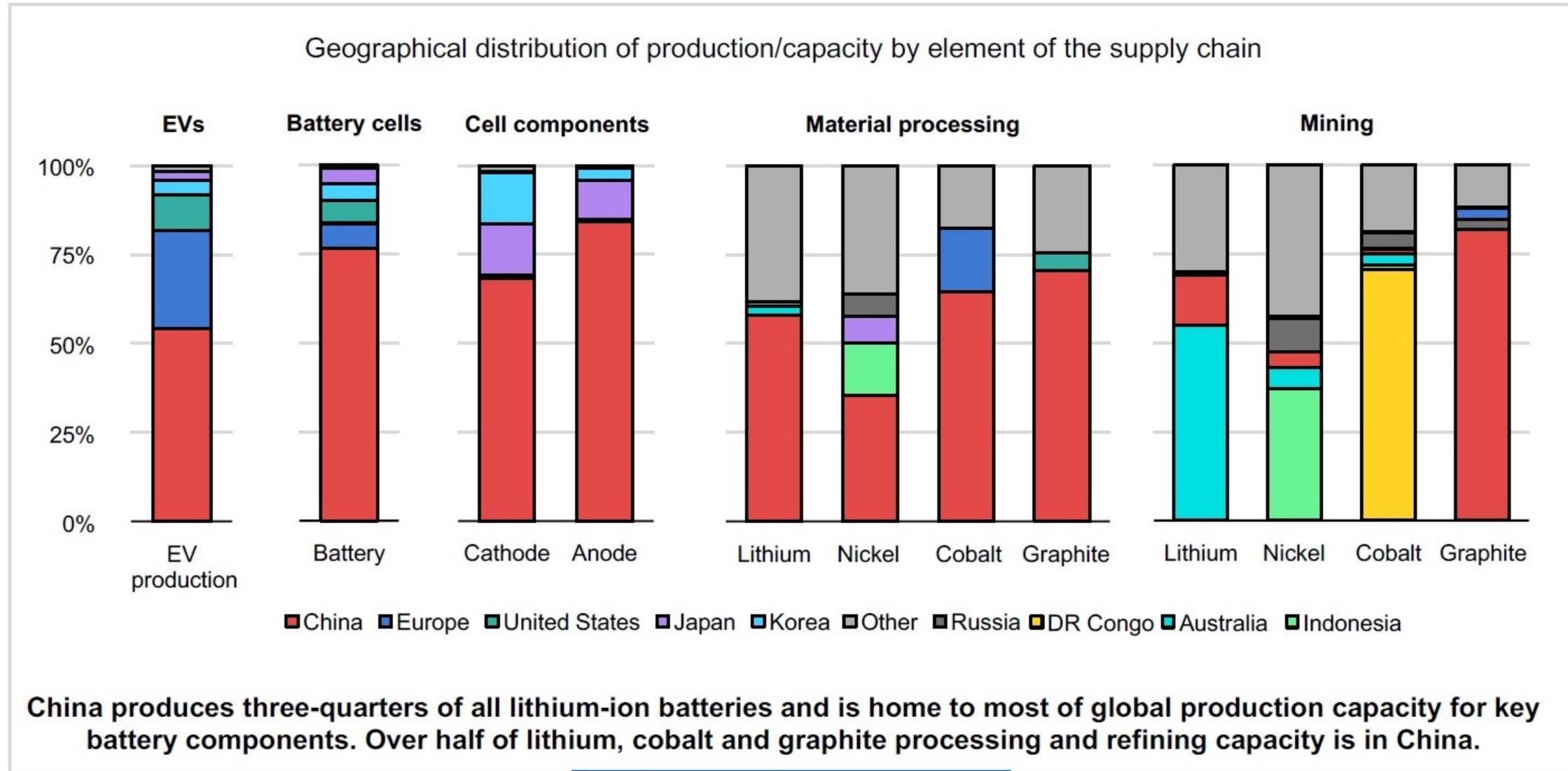
However:

- In 2022, **China approved the largest expansion of coal-fired power plants since 2015,** granting permits for 106 gigawatts of capacity across 82 locations.

3

Source: IEA (2022)

Inflation Reduction Act (IRA):
energy, jobs, and more
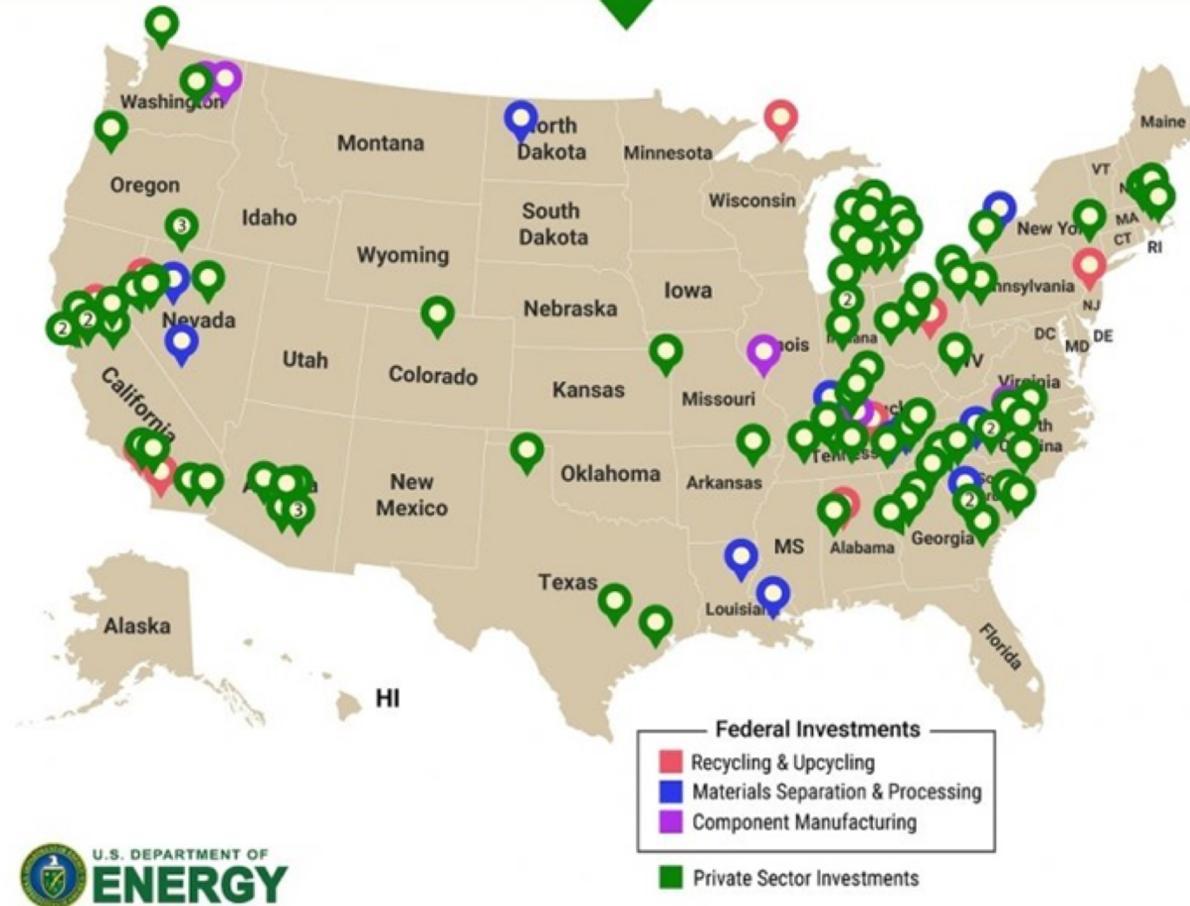


Source: DOE (2023)

Origin of the natural gas consumed in Germany
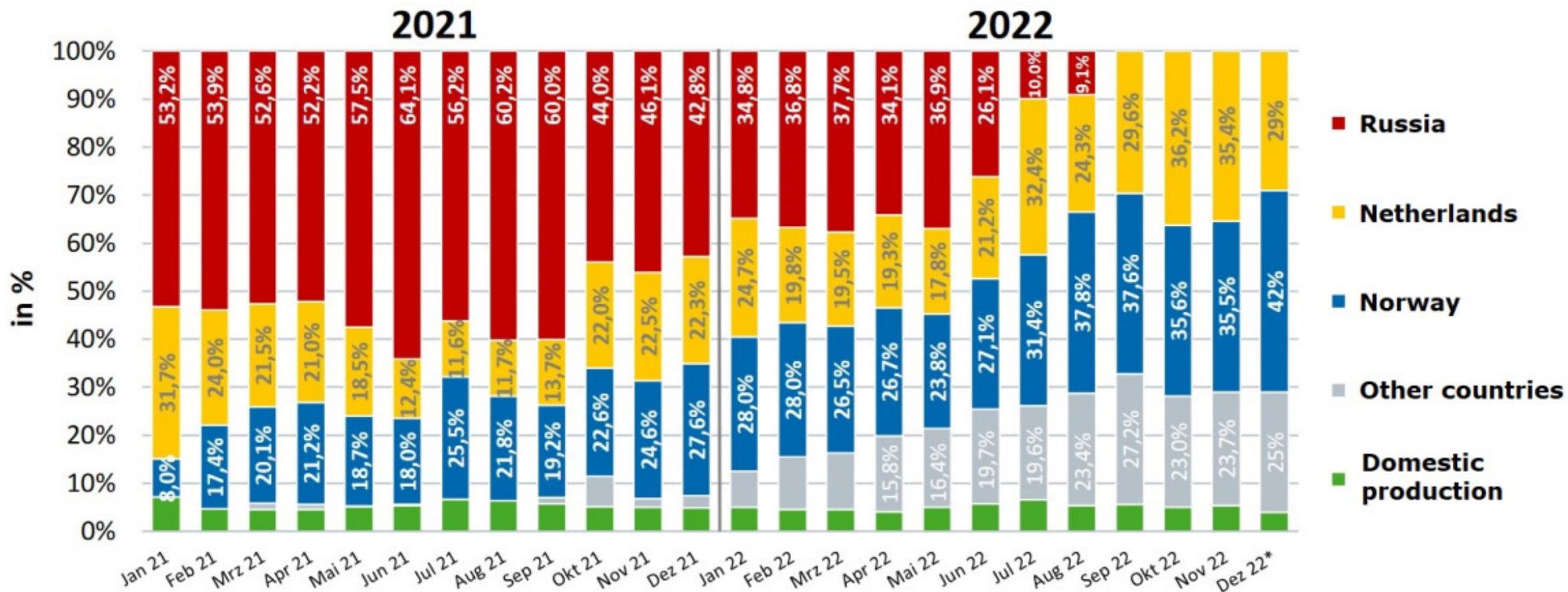
# Increased Germany Hydrogen Demand (geopolitics + new climate target)

Earlier study (pre-Feb 2022):

2020 Germany use of natural gas: 90 bcm

2020 imports from Norway: 30 bcm
2050 imports from Norway: 15 bcm

10 bcm for $H_2$ production = 2 Mt $H_2$

4 Mt Green $H_2$ = 200 TWh

2 Mt $H_2$ – other gas imports

Recall: Conventional Use of Electricity:  550-600 TWh

Additional Use of Electricity: Electricity needs for Green $H_2$, Power-to-Liquids, Power-to-Gas could be doubled or tripled depending on technology and demand assumptions

German studies: up to 25 Mt $H_2$
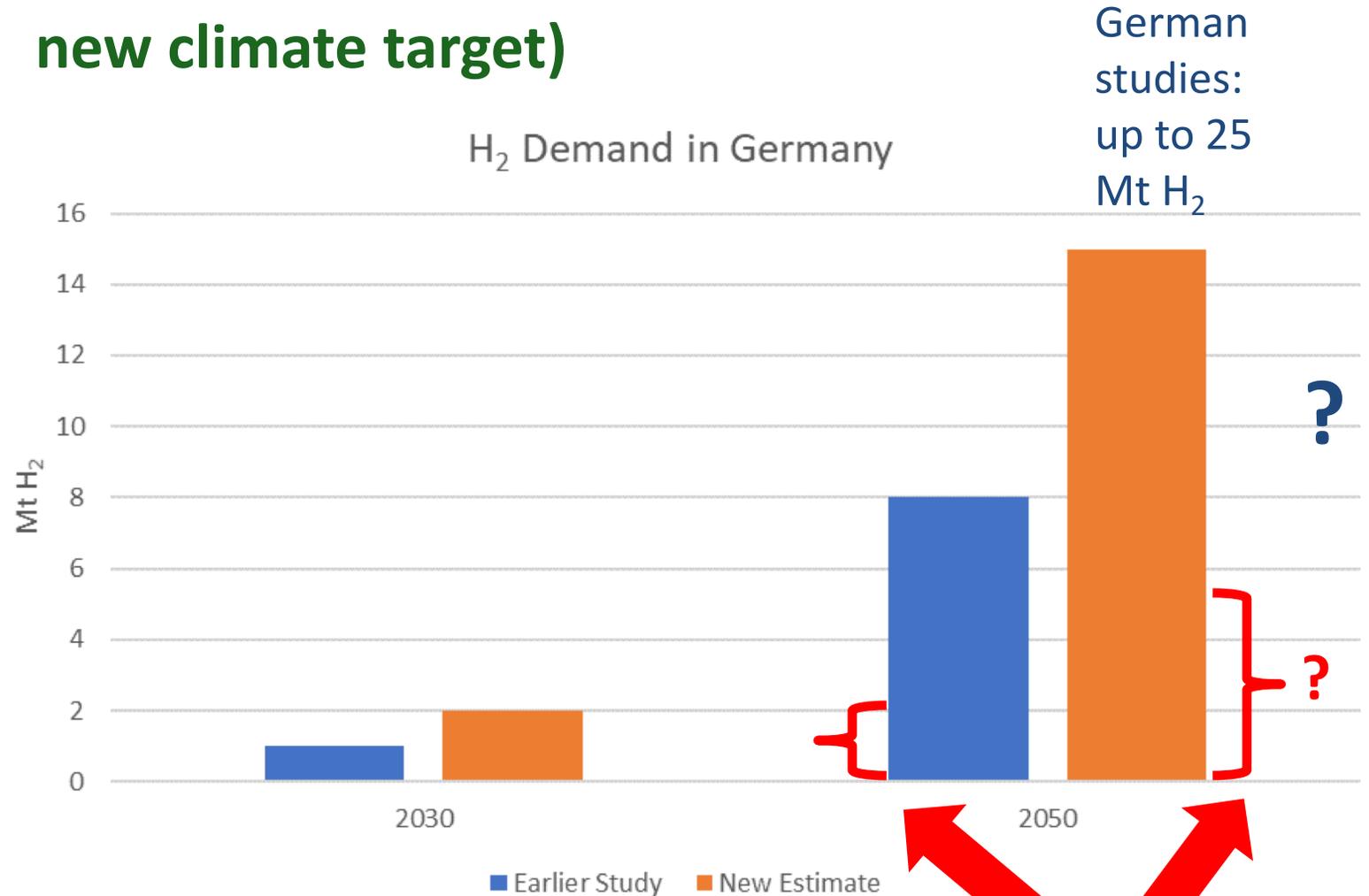


H₂ Demand in Germany — Earlier Study / New Estimate; Norway; ?

# Border Carbon Adjustments (BCA) – Carbon Border Adjustment Mechanism (CBAM)

Goal: Mitigate the drawbacks from global policy fragmentation

*In particular:*

Carbon leakage – increase production/move to countries with weaker policies;

Erosion of global competitiveness resulting from countries pursuing less stringent climate policies.

The Kyoto Protocol: Regional and Sectoral Contributions to the Carbon Leakage

The Energy Journal, 2001, 22(4), 53-79.

*Sergey V. Paltsev*

IAEE

**EU CBAM**   *Initial Application:*

Cement, Iron and Steel, Aluminum, Fertilizers, Electricity, Hydrogen

Transitional phase from October 1, 2023.

Enters into force from January 1, 2026

# EU CBAM



EU importers of goods covered by the CBAM registers with national authorities where they can also buy **CBAM certificates**. Certificates are priced based on **weekly ETS allowances**.

EU importer **declares the emissions** embedded in its imports and **surrenders** the corresponding number of certificates each year.

If importers can prove that a **carbon price has already been paid** during the production of the imported goods, the corresponding amount **can be deducted**.

#EUGreenDeal

European Commission

https://taxation-customs.ec.europa.eu/green-taxation-0/carbon-border-adjustment-mechanism_en

# MIT Economic Projection and Policy Analysis (EPPA) Model

**Multi-sector, multi-region computable general equilibrium (CGE) model of the world economy for energy, economy and emissions projections**

## PRIMARY FACTORS
capital, labor, resources

INCOME

CONSUMER SECTORS

Region A

PRODUCER SECTORS

EXPENDITURES

GOODS & SERVICES

Region C

Region B

**TRADE FLOWS BETWEEN REGIONS**

*Regions and sectors can be added for special studies*

### 18 Regions

**EPPA regions:**

| | | | |
|---|---|---|---|
| **AFR** | Africa | **JPN** | Japan |
| **ANZ** | Australia & New Zealand | **KOR** | Korea |
| **ASI** | Dynamic Asia | **LAM** | Other Latin America |
| **BRA** | Brazil | **MES** | Middle East |
| **CAN** | Canada | **MEX** | Mexico |
| **CHN** | China | **REA** | Other East Asia |
| **EUR** | Europe (EU+) | **ROE** | Other Eurasia |
| **IDZ** | Indonesia | **RUS** | Russia |
| **IND** | India | **USA** | United States |

### Technical Features
- Written in GAMS using MSPGE
- Based on GTAP Database
- Calibrated to current economic and energy levels based on IMF and IEA
- Documented in peer-reviewed literature
- Publicly Available Version
- 2100+ (in 5-year steps)

Full Input-Output Data for Every Region

|  |  | INTERMEDIATE USE by Production Sectors | | | FINAL USE | | | |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | 1 | 2 | ...j... | n | Private Consump. | Government Consumption | Investment | Export | OUT-PUT |
| Domestic Production | 1 2 i n | | | A | | | | B | | C |
| Imports | 1 2 i n | | | D | | | | E | | F |
| Value added: | -labor -capital -natural resources | | | G | | | | H | | I |
| INPUT | | | | J | | | | | | |

### Non-Energy Sectors
**Crops**
**Livestock**
**Forestry**
**Food**
**Energy-Intensive Industry**
**Manufacturing**
**Service**
**Commercial Transport**
**Household Transport**

### Energy Sectors
**Crude Oil**
**Refined Oil**
**Liquid Fuel from Biomass**
**Oil Shale**
**Coal**
**Natural Gas (conv., shale, tight)**
**Electricity**
**Synthetic Gas (from Coal)**

*New Technologies Continually Added*

Iron & Steel
Cement
Chemicals
Non-Ferrous Metals
*+ low-carbon options*

ICE (gasoline & diesel)
Plug-in Electric
Battery Electric
Hydrogen

Current Generation
Advanced Biofuel

| | |
|---|---|
| Conv. Fossil (coal, gas, oil) | Advanced Nuclear |
| Adv. Fossil (NGCC, Adv Coal) | Hydro |
| Coal with CCS | Solar |
| Coal + Bio Co-firing w/ CCS | Wind |
| Gas with CCS | Renewables with Backup |
| Gas with Advanced CCS | Biomass |
| Nuclear | Biomass with CCS |

### Key Inputs
- Policy Assumptions
- Population Growth
- Capital/Labor Productivity Growth
- Energy Efficiency Improvements
- Technology Costs
- Rate of Technology Penetration
- Elasticities of Substitution (related to labor, capital, energy, fuels, etc.)
- Fossil Fuel Resource Availability
- Urban Pollutant Initial Inventories & Trends
- Land Productivity

### Key Outputs
- GDP
- Consumption
- Emissions (GHGs, Air Pollutants)
- Primary/Final Energy Use
- Electricity Generation
- Technology Mix
- Commodity and Factor Prices
- Sectoral Output
- Land Use
- *At global and regional levels*

### Key Features
- Global Coverage & International Trade
- Economy-Wide Coverage & Inter-Industry Linkages
- Feedbacks Across Regions & Sectors
- Theory-Based (microeconomics with full input-output data)
- Endogenous Prices, Investments & Capital Accumulation
- GDP and Welfare Effects
- Policies (emissions limits/prices, sector/technology regulations...)
- Distortions (taxes, subsidies, etc.)
- Accounting for Physical Quantities (energy, electricity, land)
- *Links to MIT Earth System Model (MESM)*

### Key Equations
**Firms maximize profit:** choose technology, level of output and inputs subject to production functions and costs

**Household maximize welfare:** choose savings and consumption subject to budget constraint

**Equilibrium Conditions:** Market-Clearing, Zero-Profit, Income Balance

MIT JOINT PROGRAM
GLOBAL CHANGE

https://globalchange.mit.edu/research/research-tools/human-system-model

*Import Charges*

*Rebates on Exports*

*Free Allowances*

*Preliminary Results*

| Scenarios | Coalition | Non-Coalition | BCA design | BCA imposed | Free allowances | Sectoral coverage |
|---|---|---|---|---|---|---|
| 1) Baseline | Baseline | Baseline | - | - | No | - |
| 2) Uncoordinated | NDC | Baseline | - | - | No | - |
| 2a) Uncoordinated with allowances | NDC | Baseline | - | - | Yes | - |
| 3) Allowances + BCA (partial coverage \| tariffs only) | NDC | Baseline | Imp tariff | Coalition | Yes | Partial |

Coalition = Canada, USA, EU, Japan, Korea, and Mexico.

Non-coalition = all other countries.

Full = sectoral coverage refers to cement, coal, food, gas, iron and steel, oil, other energy intensive industries, other industries, and refined oil.

Partial = sectoral coverage excludes fossil fuels, and only includes cement, iron and steel, other energy intensive industries, and other industries.

# CBAM: Design matters

| Scenarios | Carbon leakage rate (percentage) | Domestic market share (percentage point change) | Foreign market share (percentage point change) | Welfare (percentage changes in equivalent variation) |
|---|---|---|---|---|
| **Allowances and import tariffs** | | | | |
| Allowances + BCA (partial \| tariffs only) | -1.07 | 0.52 | 0.04 | -0.71 |
| **1. Expanding the sectoral coverage** | | | | |
| Allowances + BCA (full \| tariffs only) | -1.16 | 1.01 | 0.04 | -0.71 |
| **2. Combining import tariffs and export rebates** | | | | |
| Allowances + BCA (partial \| tariffs & rebates) | -1.85 | 0.55 | 0.08 | -0.78 |
| **3. Replacing allowances with BCAs** | | | | |
| BCA (partial \| tariffs only) | 0.75 | 0.01 | 0.02 | -0.59 |

# CBAM: Coalition partners matter

*Preliminary Results*

| Scenarios | Carbon leakage rate (percentage) | Domestic market share (percentage point change) | Foreign market share (percentage point change) | Welfare (percentage changes in equivalent variation) |
|---|---|---|---|---|
| 2) Uncoordinated (No BCA) | 9.10 (6.10) | -0.64 (-0.43) | -0.03 (-0.05) | -0.34 (-0.67) |
| 2a) Uncoordinated with allowances (No BCA) | 8.43 (4.38) | -0.09 (0.12) | -0.01 (-0.03) | -0.45 (-0.78) |
| 3) Allowances + BCA (partial \| tariffs only) | 3.34 (-1.07) | 0.66 (0.52) | -0.01 (0.04) | -0.28 (-0.71) |

Numbers without brackets: USA out
Numbers in brackets: USA in

# CBAM Implications and Discussions

*Originally introduced as a threat, now gained popularity*

*Design matters (import charge, export rebate, free allowances, sectoral coverage, indirect emissions, etc)*

*Mostly positive impacts for covered domestic industries*

*Overall welfare impacts vary (in general, higher domestic prices negatively impact consumers)*

*Possible retaliations*

*U.S. proposals*

*E.U. proposals*

# New Geopolitics with Sanctions: Modeling Challenge

- Typically, CGE models that explore the effects of international trade use either "homogenous goods" assumptions (i.e., imports from different regions are perfect substitutes) or "Armington" assumptions (i.e., imports from different regions and imperfect substitutes)

- "Homogenous goods" assumption does not allow to represent bilateral trade flows because imports are not distinguished by origin (and in a two-country setting it leads to full specialization by a country)

- "Armington trade" is represented by Constant-Elasticity-of-Substitution (CES) production functions that, by design, do not drastically change the shares of trade (over time or under different policy)

- CES representation between imports makes it impossible to completely sever trade of Russia (RUS) with "non-allied regions" (i.e., those that imposed sanctions on Russia)

# Evidence so far



***Russia Sidesteps Western Punishments, With Help From Friends***
A surge in trade by Russia's neighbors and allies hints at one reason its economy remains so resilient after sweeping sanctions.

https://www.nytimes.com/2023/01/31/business/economy/russia-sanctions-trade-china-turkey.html

# New trade patterns may mitigate impacts on energy commodity production and prices



Chart. Impact of sanctions on energy commodity production
2030, (10 billion 2014 US$)
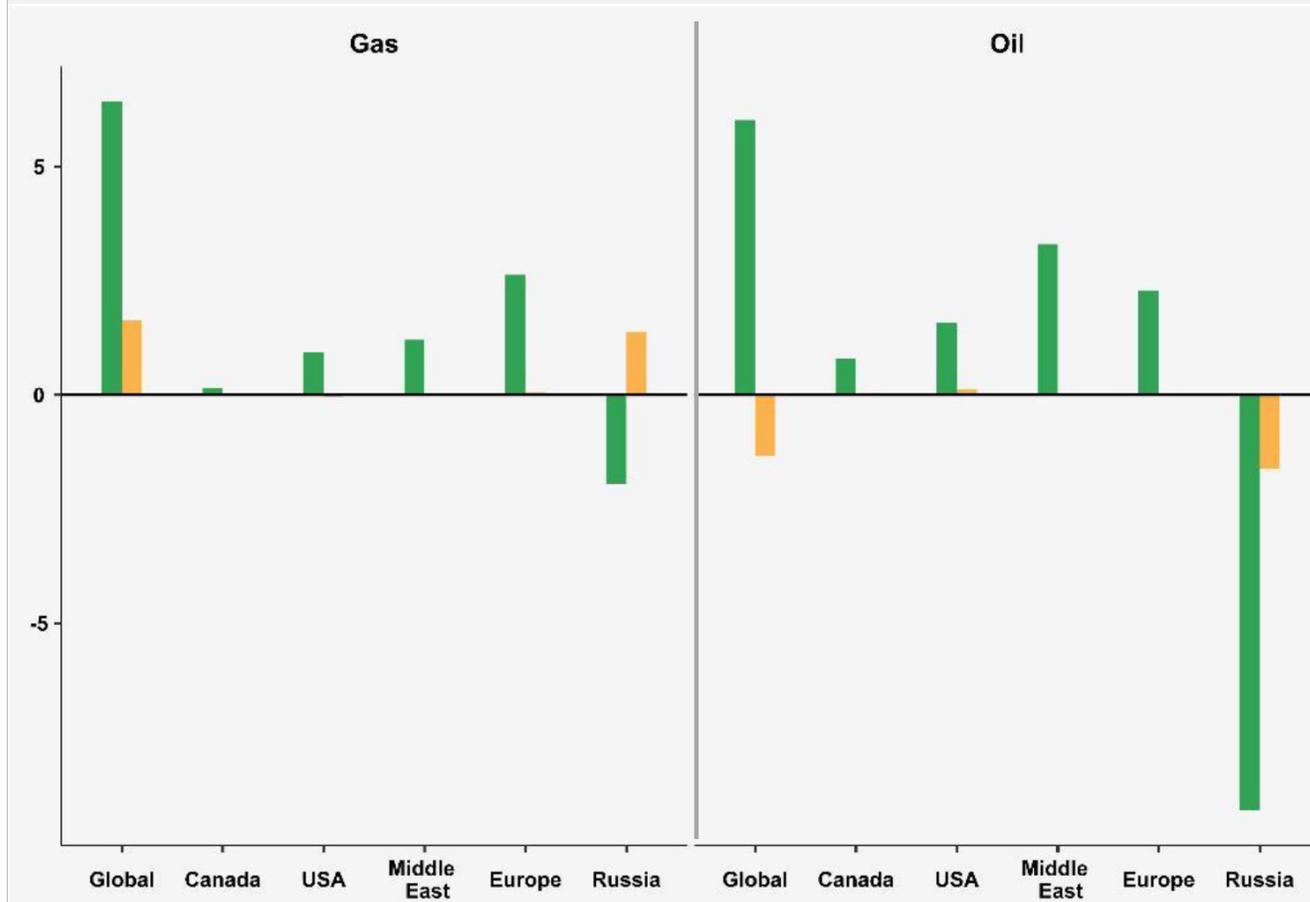
Chart. Impact of sanctions on energy commodity prices
2030, percent change

Legend:
- Historical trade patterns
- New trade patterns
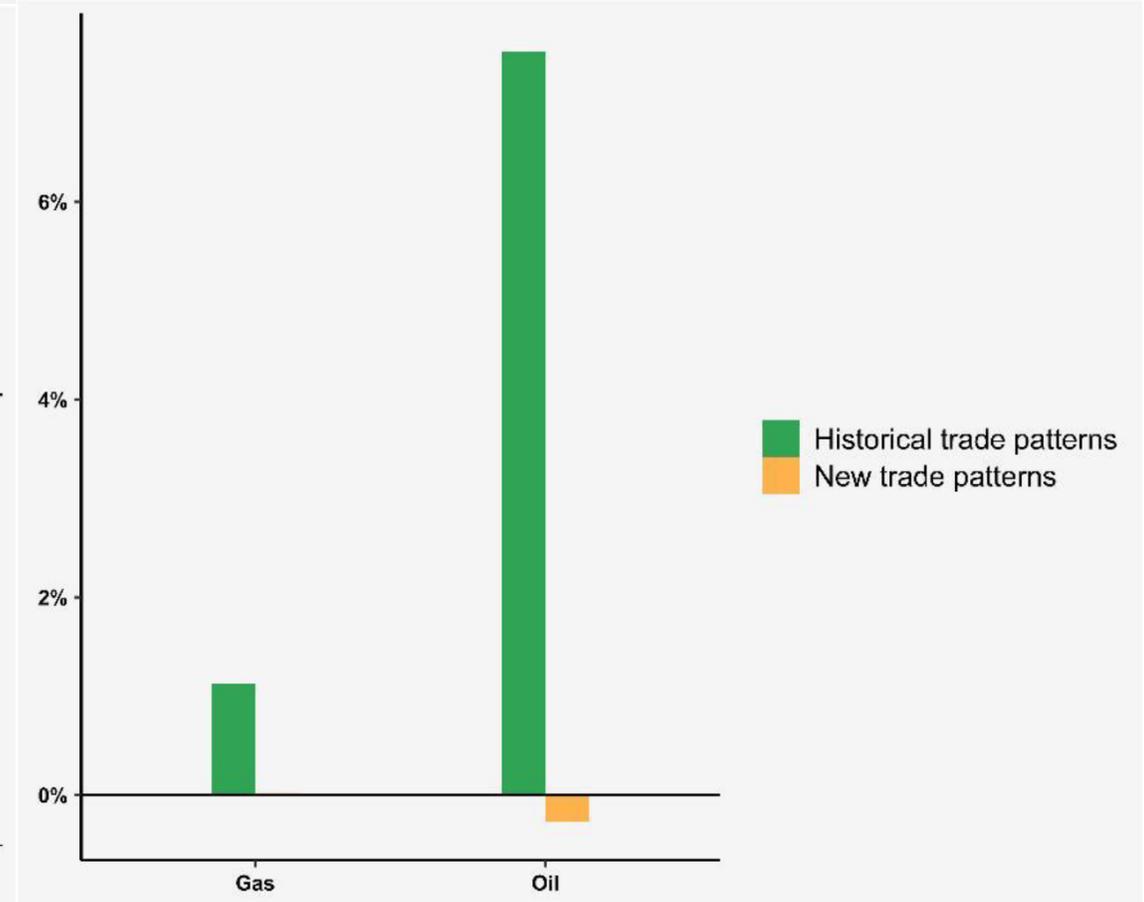
*Preliminary Results*

# Climate Geopolitics

## Water Availability



## Climate Migration



## Cooling Needs



Air conditioner stock — Air conditioners per household (right axis)
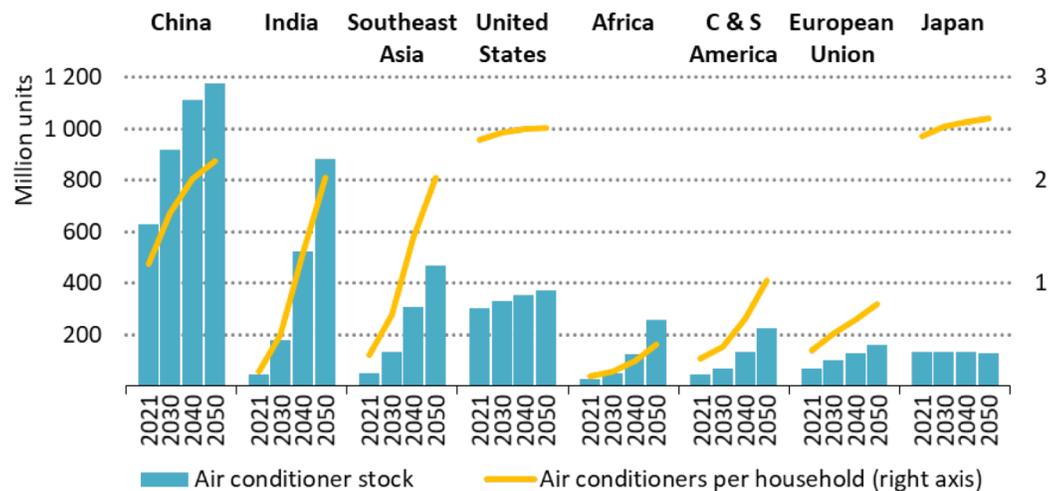
# Thank you

Questions or comments?
Please contact Sergey Paltsev at paltsev@mit.edu