Future Climate Policies

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XLVI MIT Global Change Forum

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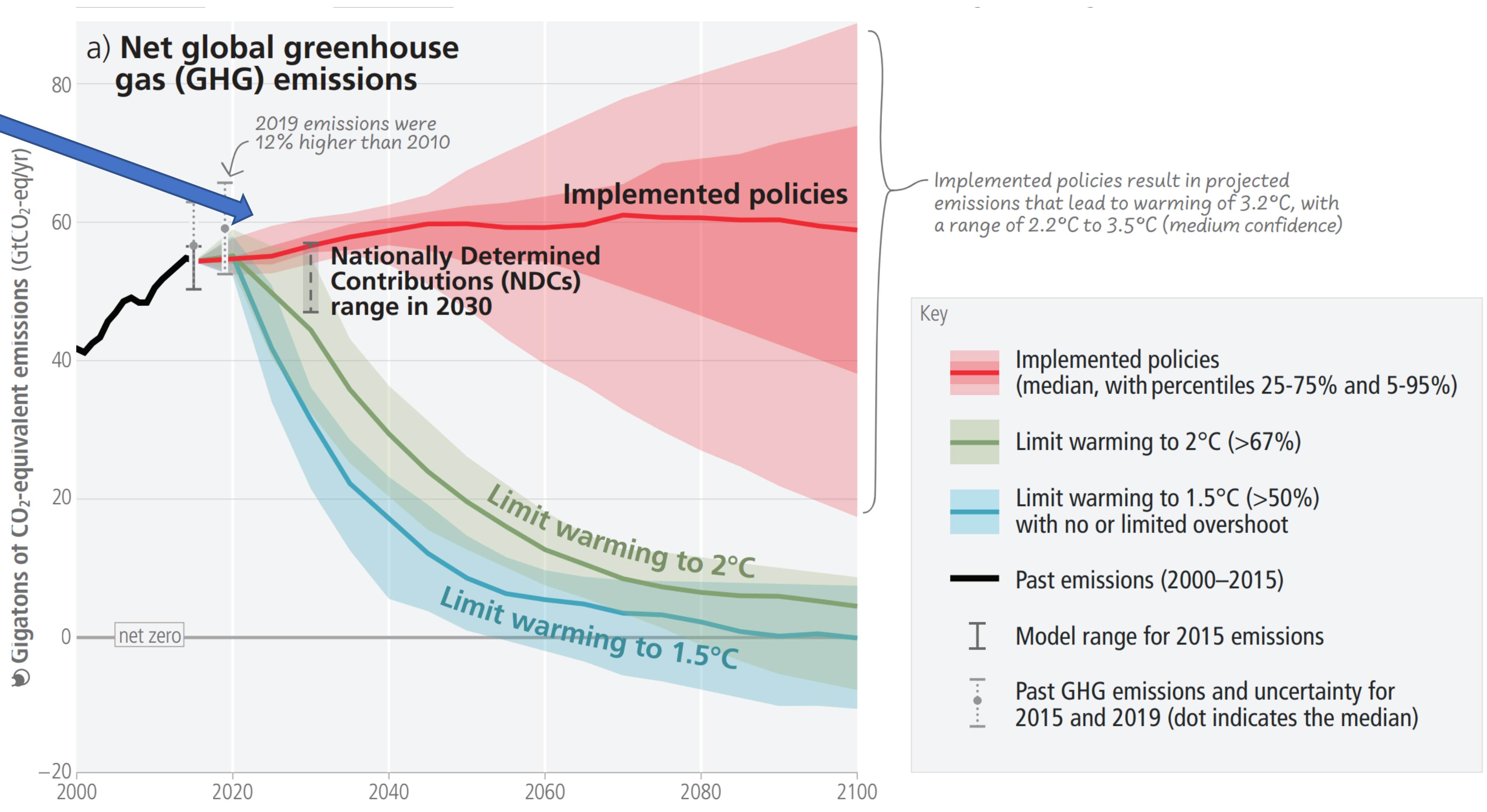
2023 IPCC AR6 Synthesis Report – Global emission pathways

2022 - 2023 emissions are outside of the IPCC range



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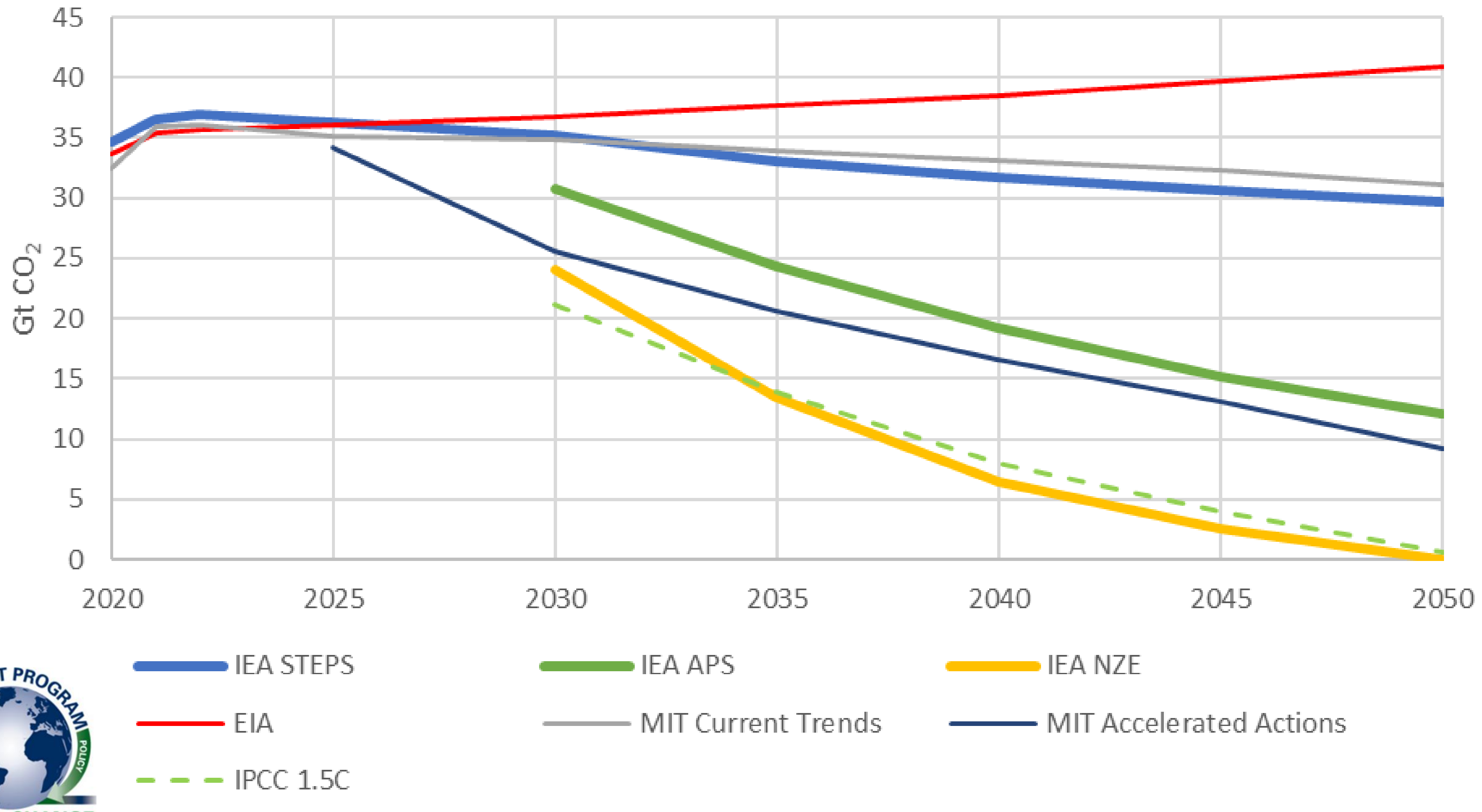
Goals vs Reality

COP-28: "transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner … so as to achieve net zero by 2050 in keeping with the science."



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STEPS (Stated Policies Scenario) reflects current policy settings

APS (Announced Pledges Scenario) assumes that all NDCs and longer term targets are met

NZE (Net zero Emissions by 2050) for global energy sector

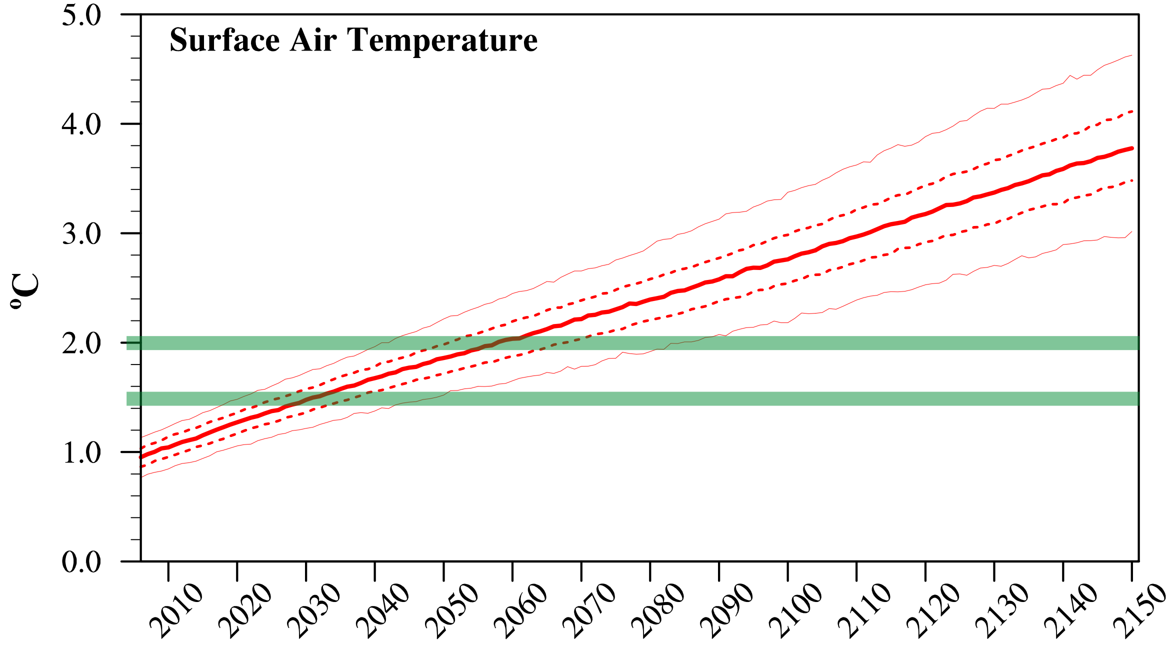
MIT Current Trends: current policies

MIT Accelerated Actions by 2050: Advanced economies: 70-80% reduction; Emerging economies: 50-75% reduction

https://globalchange.mit.edu/

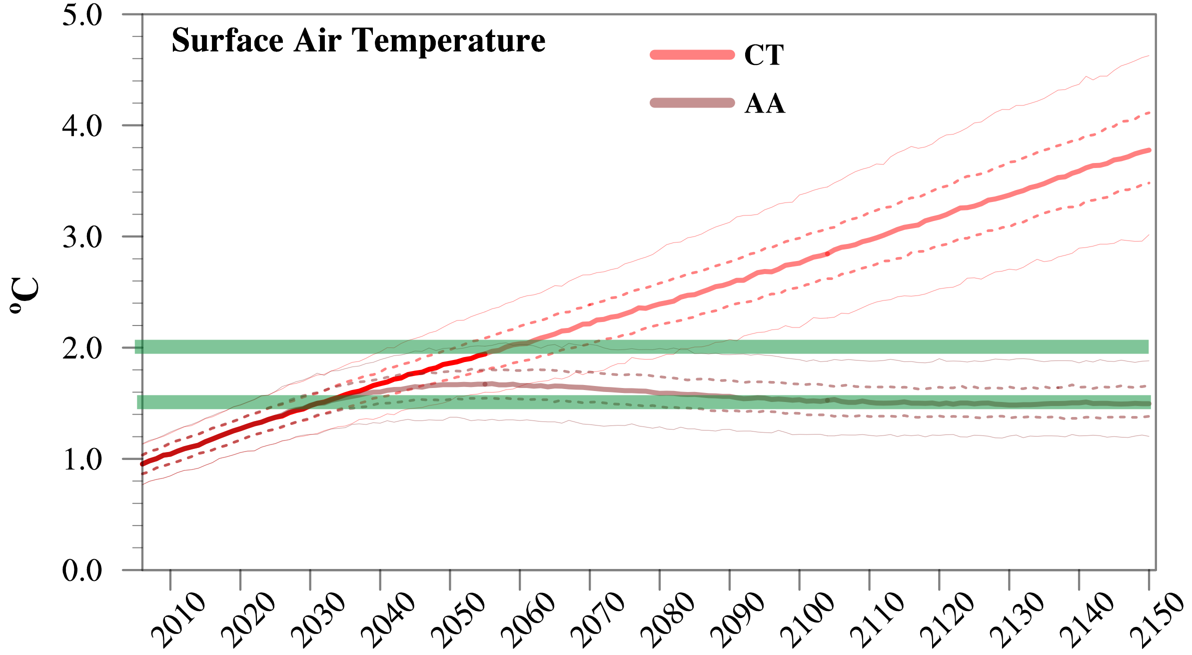
Temperature Projections: 2023 MIT Global Change Outlook

Current Trends (CT) Scenario



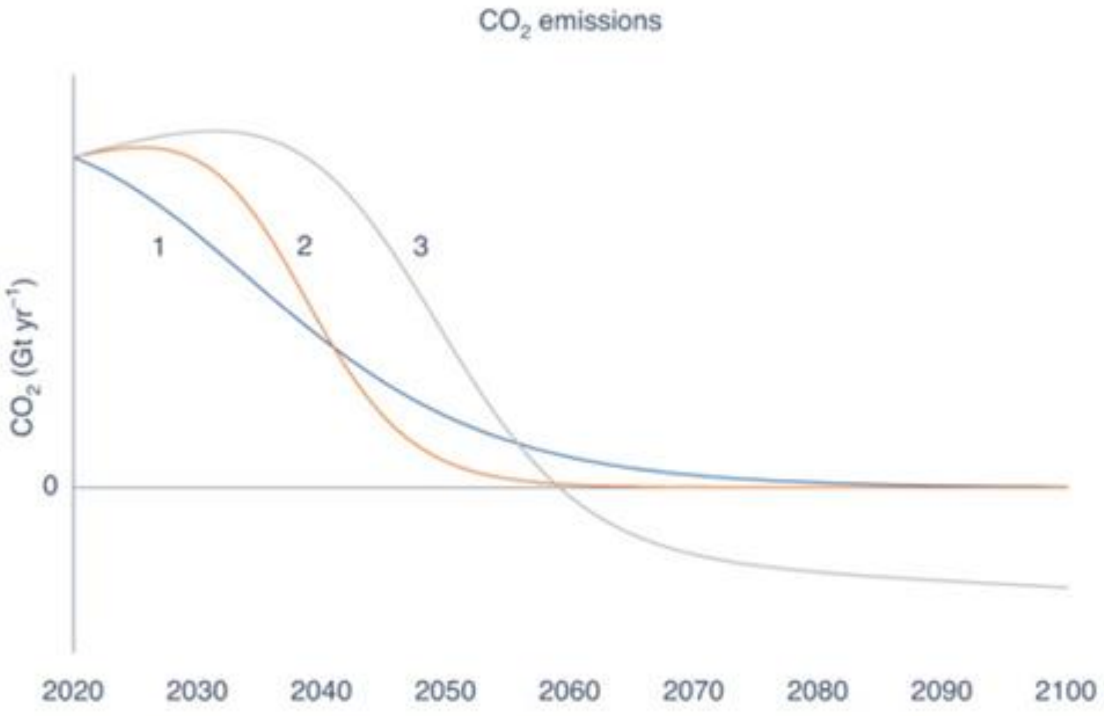
Current Trends: By 2060, more than half of the IGSM ensemble's Paris Forever projections exceed 2˚C global climate warming, a figure that rises to more than 75% by early 2070s and more than 95% by 2085.

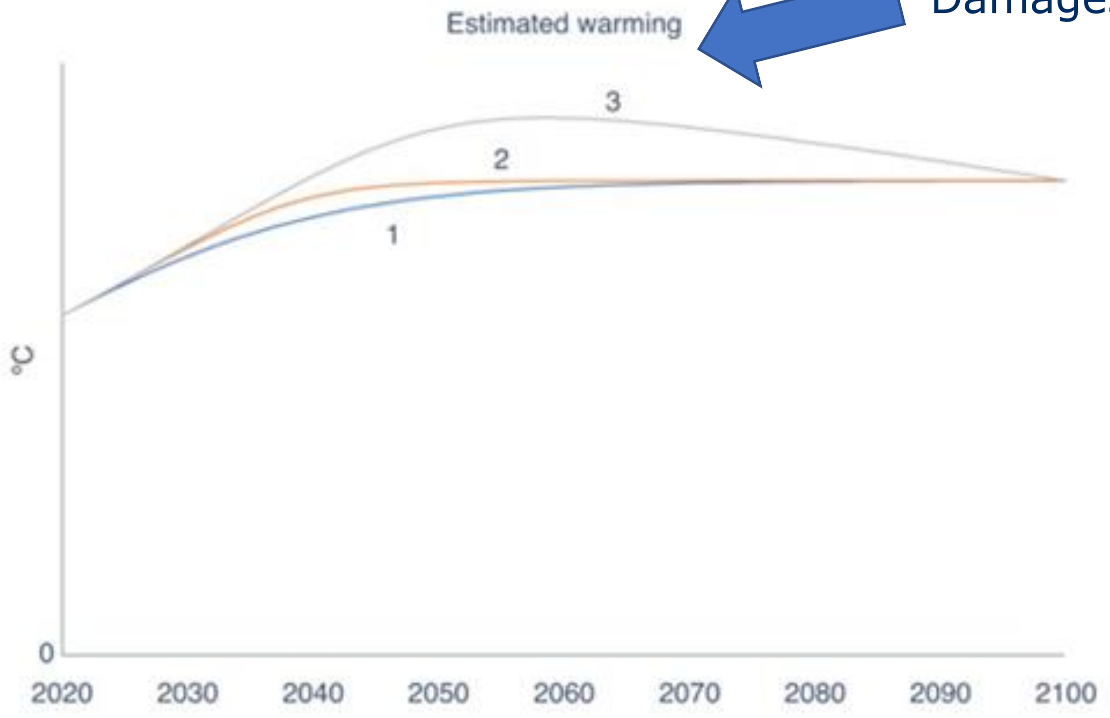
Accelerated Actions (AA) Scenario



Under *Accelerated Actions*, by midcentury global temperature rise will cease and decline slightly before stabilizing through the latter half of the century and into the 22nd century (to just below 1.5˚C median warming).

Minimize the impacts of overshoot



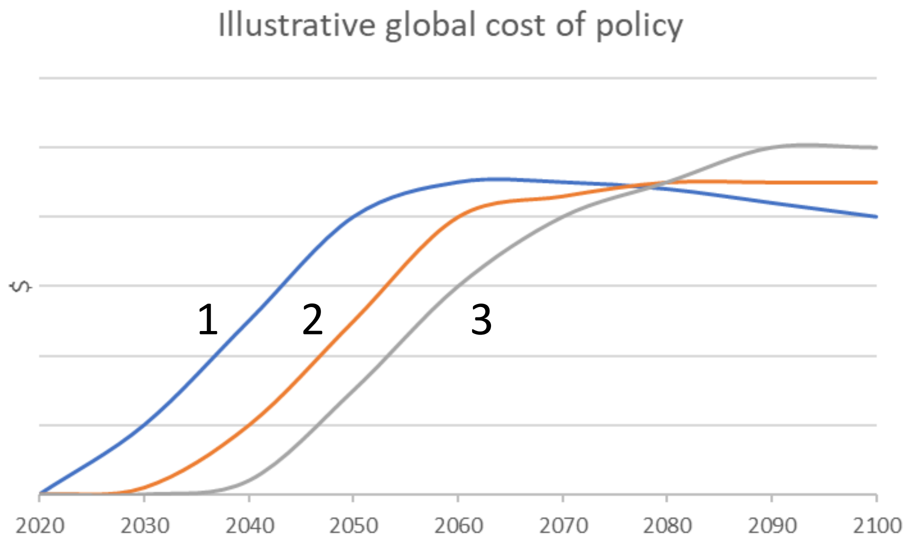


Damages

Avoided damages

vs

Cost of action



Higher Overshoot:

Larger climate damages

but

smaller initial (overall? discounted?) cost of policy

Other aspects: biodiversity, equity, finance…

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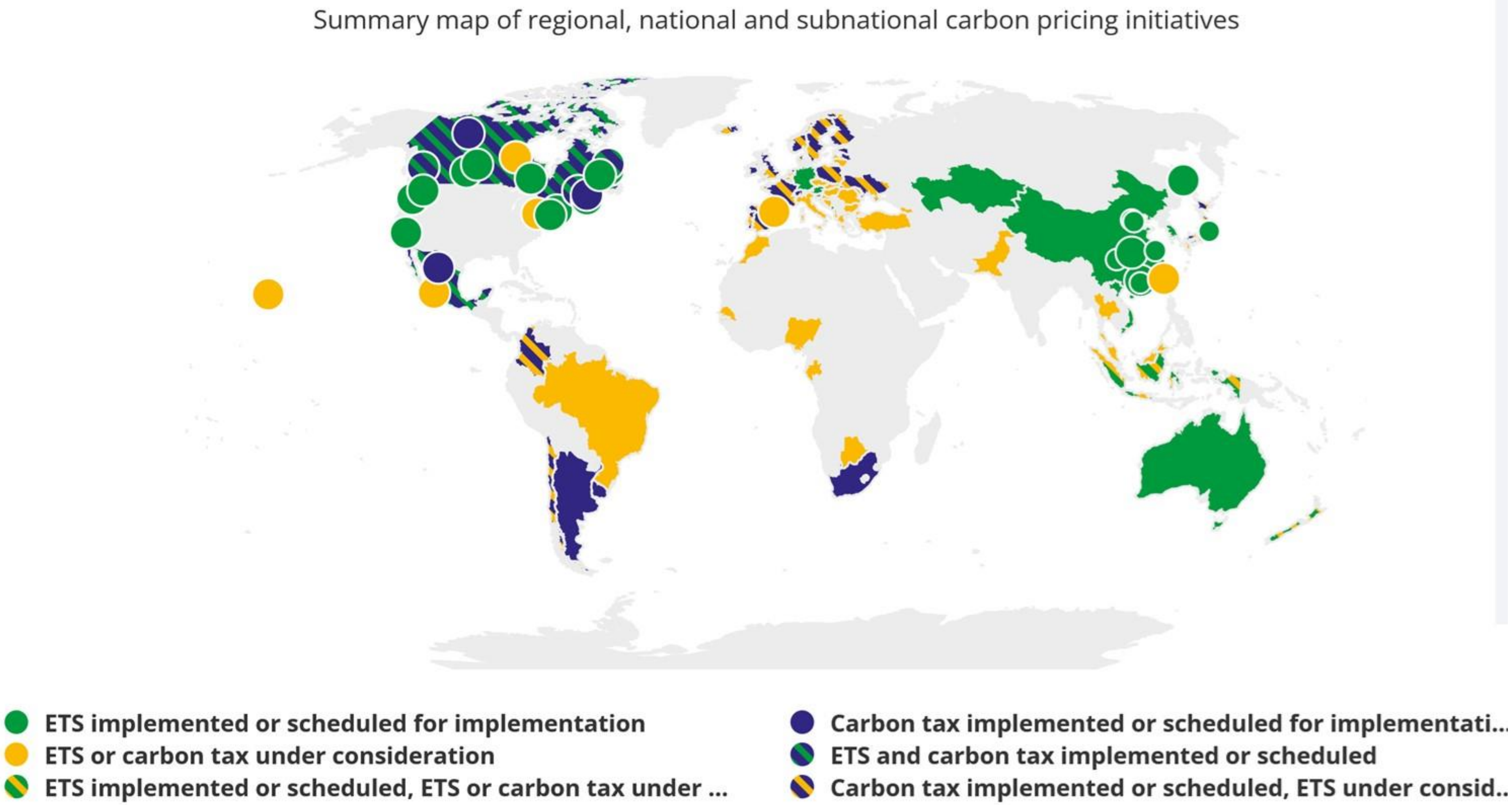
Carbon pricing by region in 2024



$/tCO$_2$

Argentina 3
Canada 50-60 (C$65-C$80)
China 8
Colombia 5
EU 65 (60 Euro)
Japan 2
Kazakhstan 1
Korea 11
New Zealand 35
Singapore 4
South Africa 9

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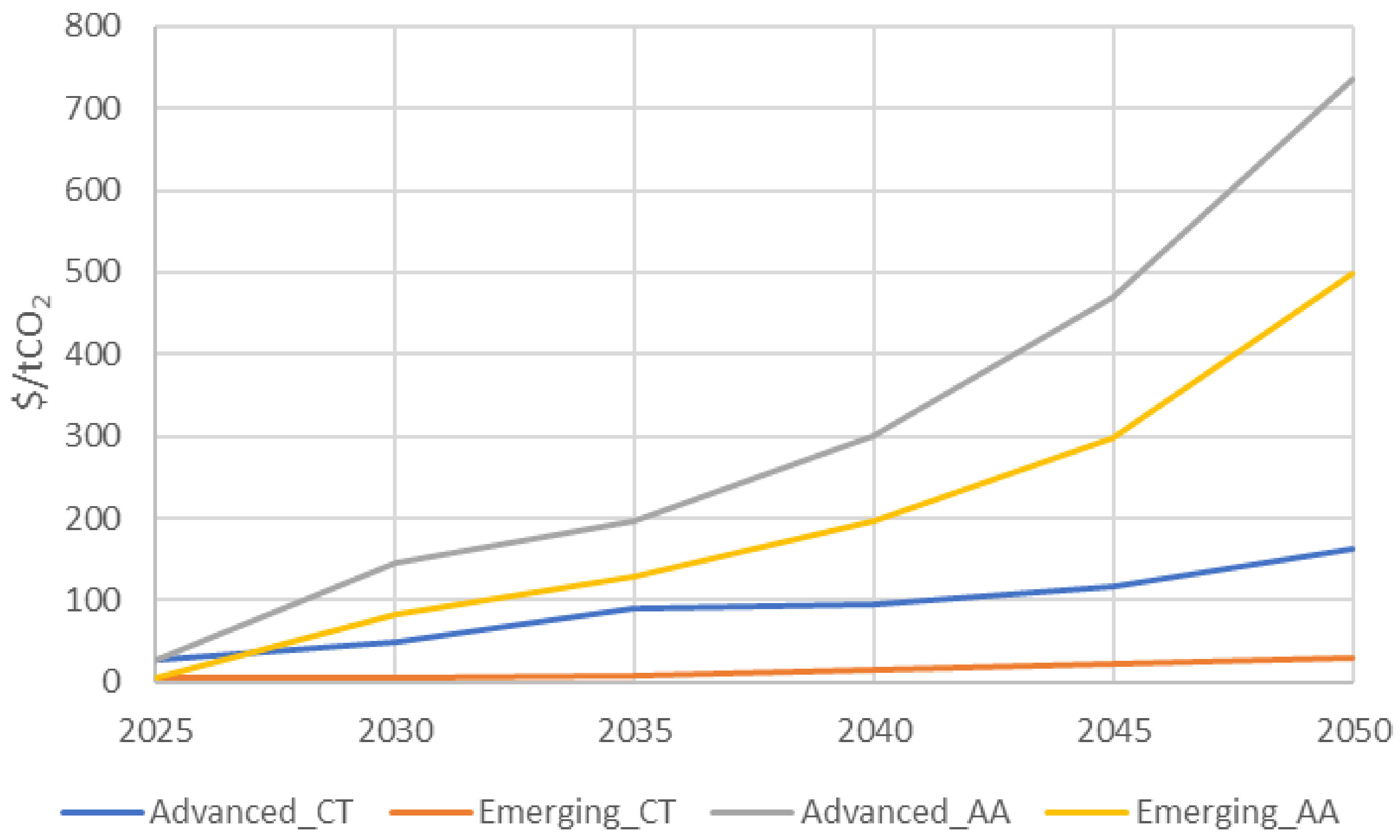
https://carbonpricingdashboard.worldbank.org/map_data

MIT 2023 Outlook: Carbon prices in different scenarios



Compare to IEA (2023):

2050 carbon prices

Countries with zero-emission pledges: \$200-250/tCO_2

Others: \$180/tCO_2

Yet others: \$55/tCO_2

Source: MIT Global Change Outlook (2023)

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Inflation Reduction Act

Environmental Impacts of the Inflation Reduction Act

Documentation of the USREP-ReEDS Model Analysis

Prepared for

U.S. Environmental Protection Agency
Climate Economics Branch
1200 Pennsylvania Ave, N.W.,
Washington, DC 20460

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September 11, 2023

EPA

ELECTRICITY SECTOR EMISSIONS IMPACTS OF THE INFLATION REDUCTION ACT

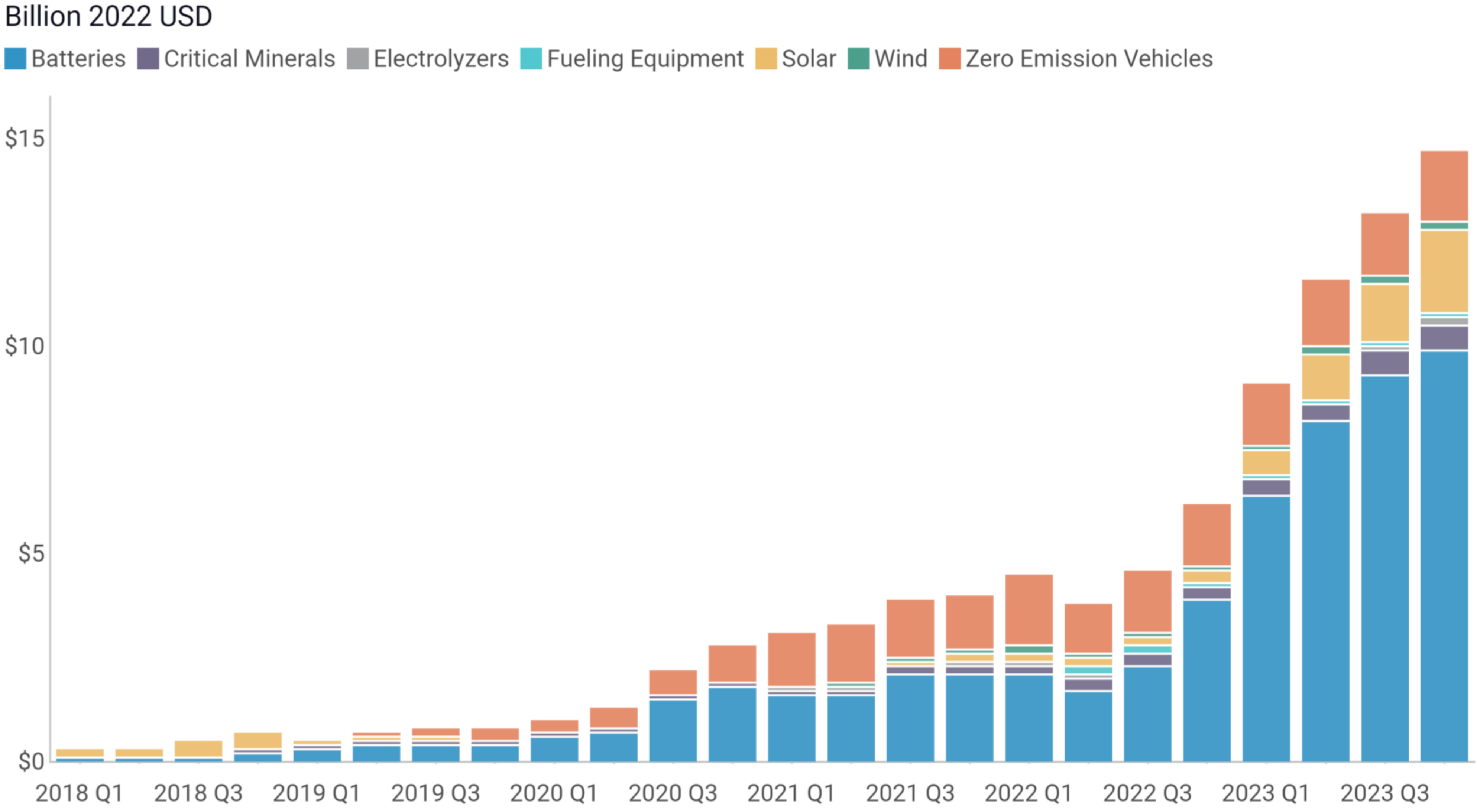
ASSESSMENT OF PROJECTED CO_2 EMISSION REDUCTIONS FROM CHANGES IN ELECTRICITY GENERATION AND USE

EPA 430-R-23-004
September 2023

Table ES.1 Summary of ranges of CO_2 emissions reductions from 2005

Sector	Year	IRA Min	IRA Median	IRA Max	No IRA Min	No IRA Median	No IRA Max
Electricity	2030	49%	69%	83%	43%	50%	59%
	2035	67%	77%	87%	40%	53%	68%
Transportation	2030	11%	17%	25%	9%	15%	22%
	2035	15%	27%	35%	13%	23%	28%
Buildings	2030	49%	55%	63%	34%	42%	47%
	2035	52%	66%	70%	36%	45%	51%
Industry	2030	17%	36%	43%	6%	25%	33%
	2035	23%	36%	57%	3%	27%	36%
Economy-Wide	2030	35%	39%	43%	26%	31%	33%
	2035	36%	46%	55%	29%	33%	39%

Actual manufacturing investments by technology in USA



https://www.cleaninvestmentmonitor.org/

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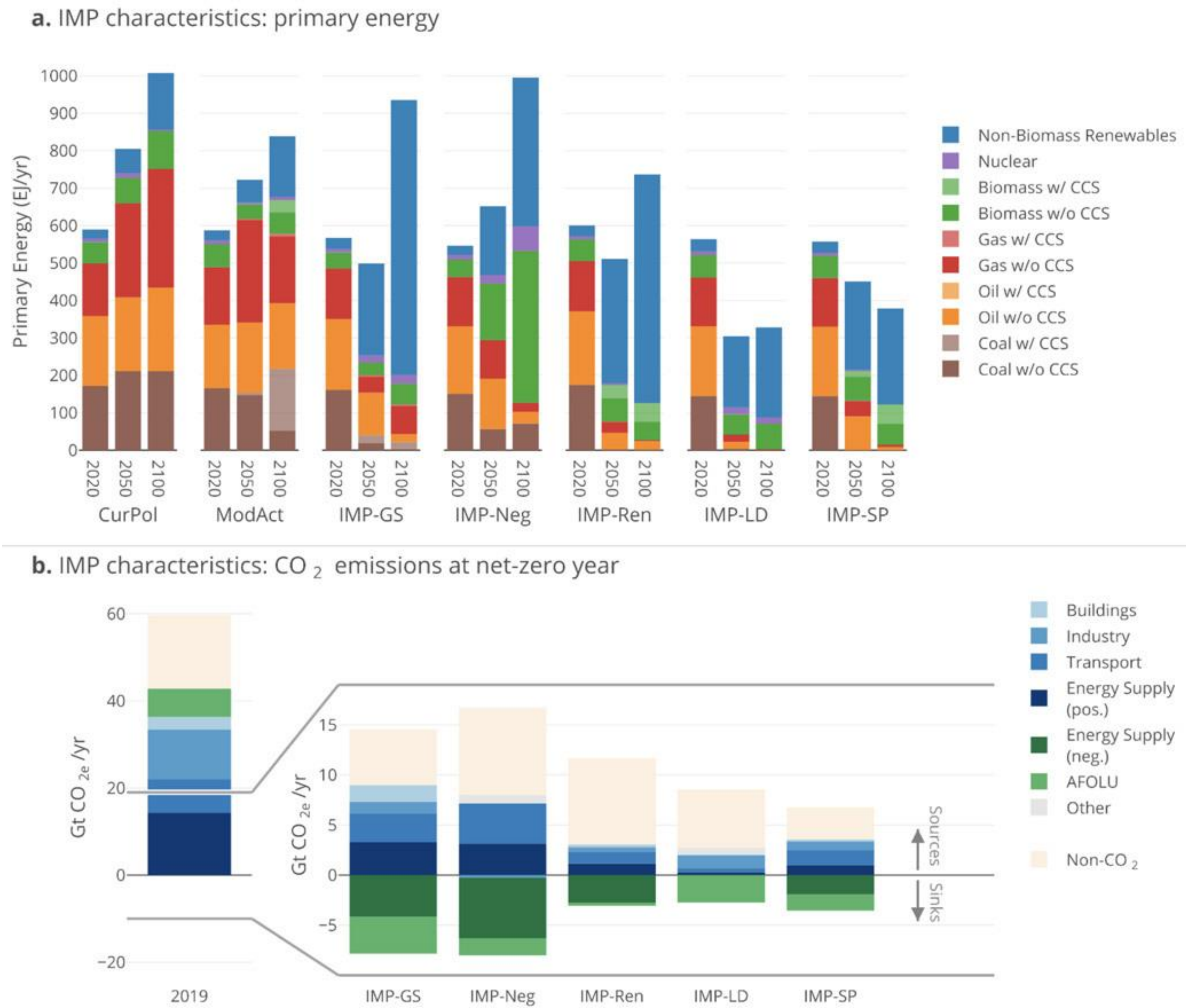

Global Energy and GHG

Need for negative emissions

Net-zero CO_2 (not net-zero GHG)

Source: IPCC (2022)

Power sector

- Nuclear fusion
- Next-generation energy storage
- Carbon Capture and Storage (CCS)

Industry

- Hydrogen in steelmaking
- Iron ore electrolysis
- Carbon Capture and Storage (CCS)

Transport

- Hydrogen aviation/shipping
- Hyperloops
- Advanced biofuel supply
- Next-generation energy storage

Buildings

- Alternative building materials for steel and cement

Carbon removal

- Bio-char
- Ocean liming
- Direct Air Carbon Capture (DACC)
- Biomass Carbon Capture and Storage (BECCS)

Graphics: EPFL

Also important: Demand Side Management

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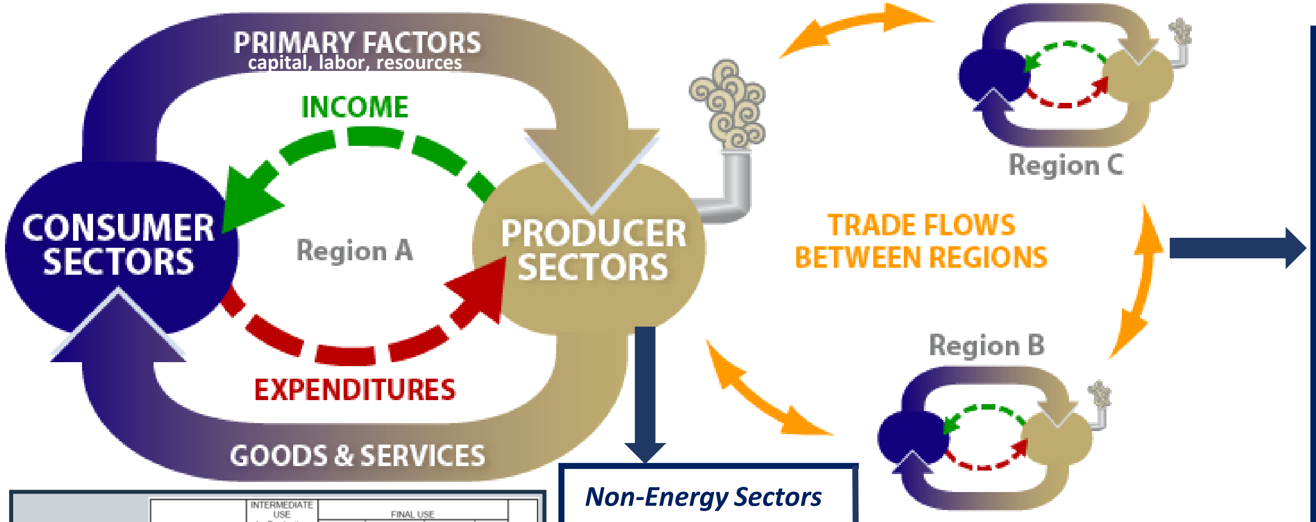
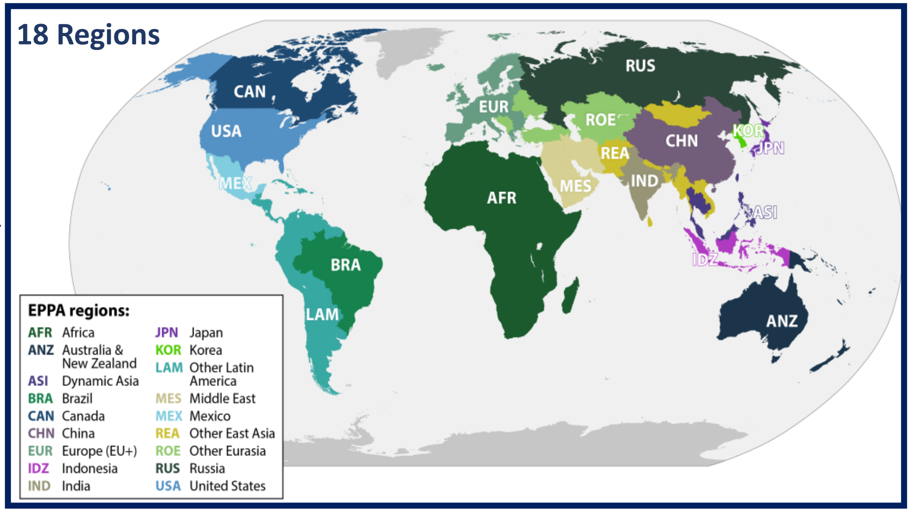
MIT Economic Projection and Policy Analysis (EPPA) Model

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



Regions and sectors can be added for special studies

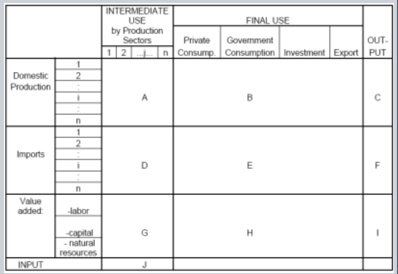
18 Regions



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



Non-Energy Sectors

- Crops
- Livestock
- Forestry
- Food
- Energy-Intensive Industry
  - Iron & Steel
  - Cement
  - Chemicals
  - Non-Ferrous Metals
  - *+ low-carbon options*
- Manufacturing
- Service
- Commercial Transport
- Household Transport
  - ICE (gasoline & diesel)
  - Plug-in Electric
  - Battery Electric
  - Hydrogen

Energy Sectors

- Crude Oil
- Refined Oil
- Liquid Fuel from Biomass
  - Current Generation
  - Advanced Biofuel
- Oil Shale
- Coal
- Natural Gas (conv., shale, tight)
- Electricity
  - Conv. Fossil (coal, gas, oil)
  - Adv. Fossil (NGCC, Adv Coal)
  - Coal with CCS
  - Coal + Bio Co-firing w/ CCS
  - Gas with CCS
  - Gas with Advanced CCS
  - Nuclear
  - Advanced Nuclear
  - Hydro
  - Solar
  - Wind
  - Renewables with Backup
  - Biomass
  - Biomass with CCS
- Synthetic Gas (from Coal)

New Technologies Continually Added

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

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

Examples of recent applications of MIT tools: variety of research efforts

Costs of Net-Zero Targets
Morris et al (2023) Climate Change Economics, 14(4), 2340002.

Decarbonizing Hard-to-Abate Sectors
Paltsev et al (2021) Applied Energy, 300, 117322.

Reality of Direct Air Capture
Desport et al (2024) Energy Economics, 129, 107244.

Climate Change Effects on Agriculture
Gurgel et al (2021) Climatic Change, 166(29).

Cost and Value of Variable Renewables
Gurgel et al (2023) Applied Energy, 344, 121119.

Global Electrification of Light-Duty Vehicles
Paltsev et al (2022) Econ of Energy and Env Policy, 11(1), 165-191.

Economics of Bioenergy with CCS (BECCS)
Fajardy et al (2021) Global Environ Change, 68, 102262.

Impacts of Border Carbon Adjustments
Chen et al (2023) https://globalchange.mit.edu/publication/18041

Transition Scenarios for Financial Risk Analysis
Chen et al (2022) https://globalchange.mit.edu/publication/17757

Climate-Related Financial Stress-Testing
Le Guenedal et al (2023) https://globalchange.mit.edu/publication/18121

MIT 2023 Global Change Outlook
Charting the Earth’s Future Energy, Managed Resources, Climate, and Policy Prospects
https://globalchange.mit.edu

Published every other year

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Thank you

Questions or comments?

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