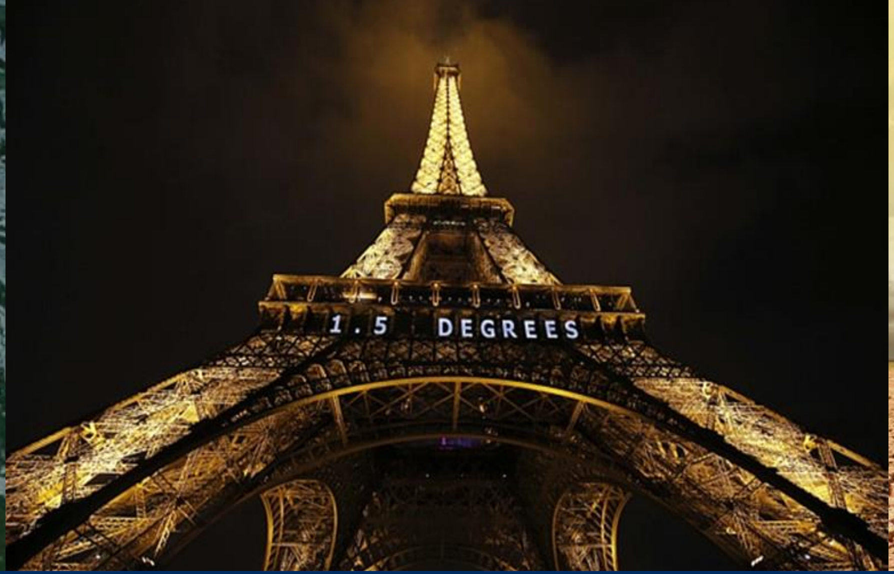


Using Energy-Economic Models for Climate-Related Financial Impact Analysis

Sergey Paltsev

Massachusetts Institute of Technology

MIT JOINT PROGRAM
SCIENCE POLICY
GLOBAL CHANGE

MathWorks®

MATLAB Computational Finance Conference

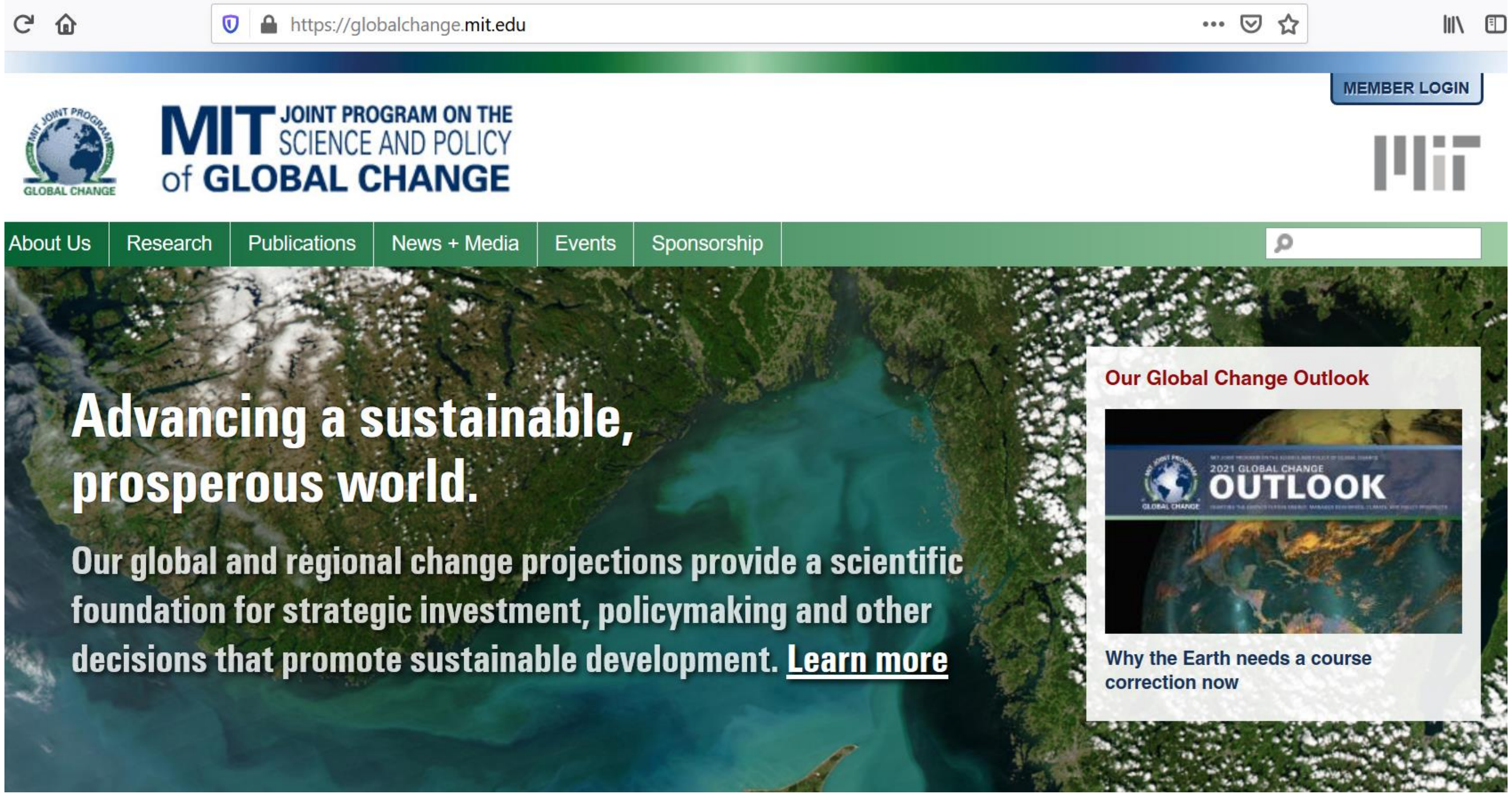
September 29, 2021

The Challenge

Many world regions face ***increasing pressures*** from ***global*** and ***regional*** changes in climate, population growth, urban-area expansion, and the ***socio-economic*** and ***environmental*** impacts of fossil-based development

Climate change imposes "***physical***" and "***transition***" risks that ***affect all*** sectors of economic activity

The Response – The MIT Joint Program



We envision a world in which community, government and industry leaders have the insight they need to make environmentally and economically sound choices

Team of ***natural*** and ***social*** scientists to provide:

- scientific research that integrates ***risk management*** with ***policy*** and ***industrial strategies***
- ***communication*** and ***interaction*** with ***decision-makers***, media outlets, government and nongovernmental organizations, schools and communities
- ***education*** of the ***next generation*** with the skills to tackle ***complex*** global and regional ***challenges***

Climate-Related Financial Risks

Physical risks

- Flooding
- Drought
- Sea level rise
- Heat stress
- Wind

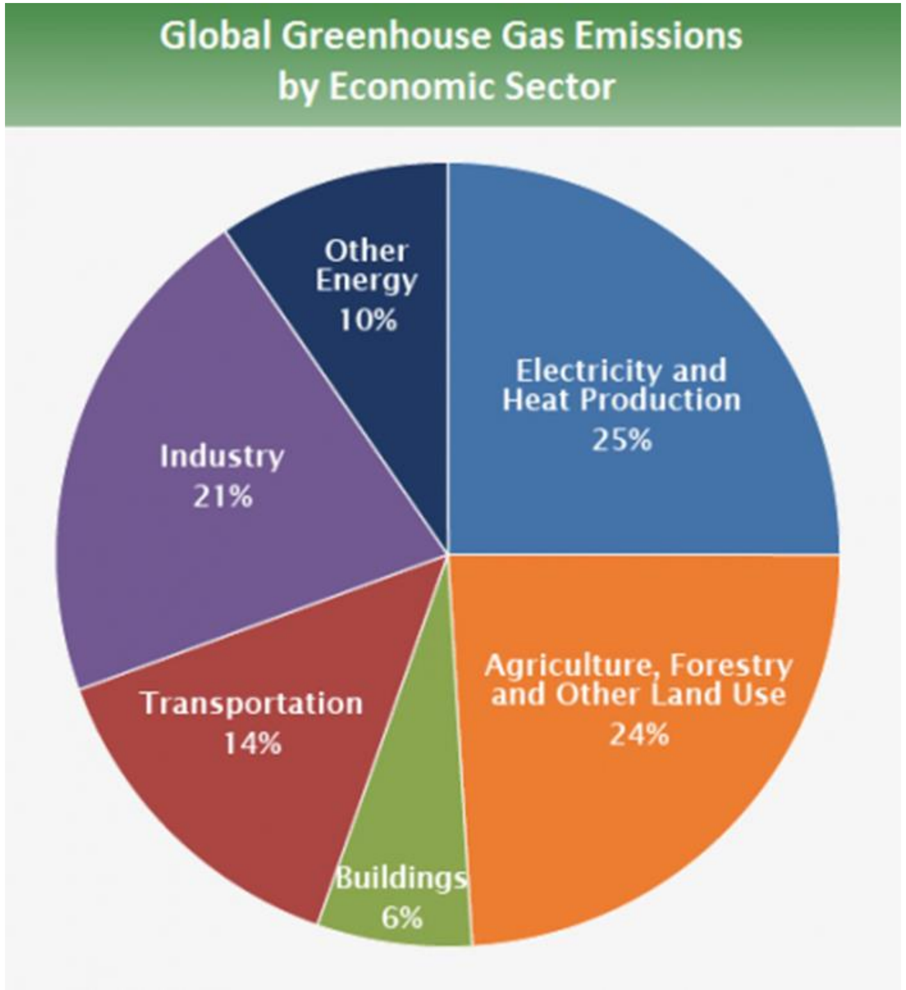
Extreme weather

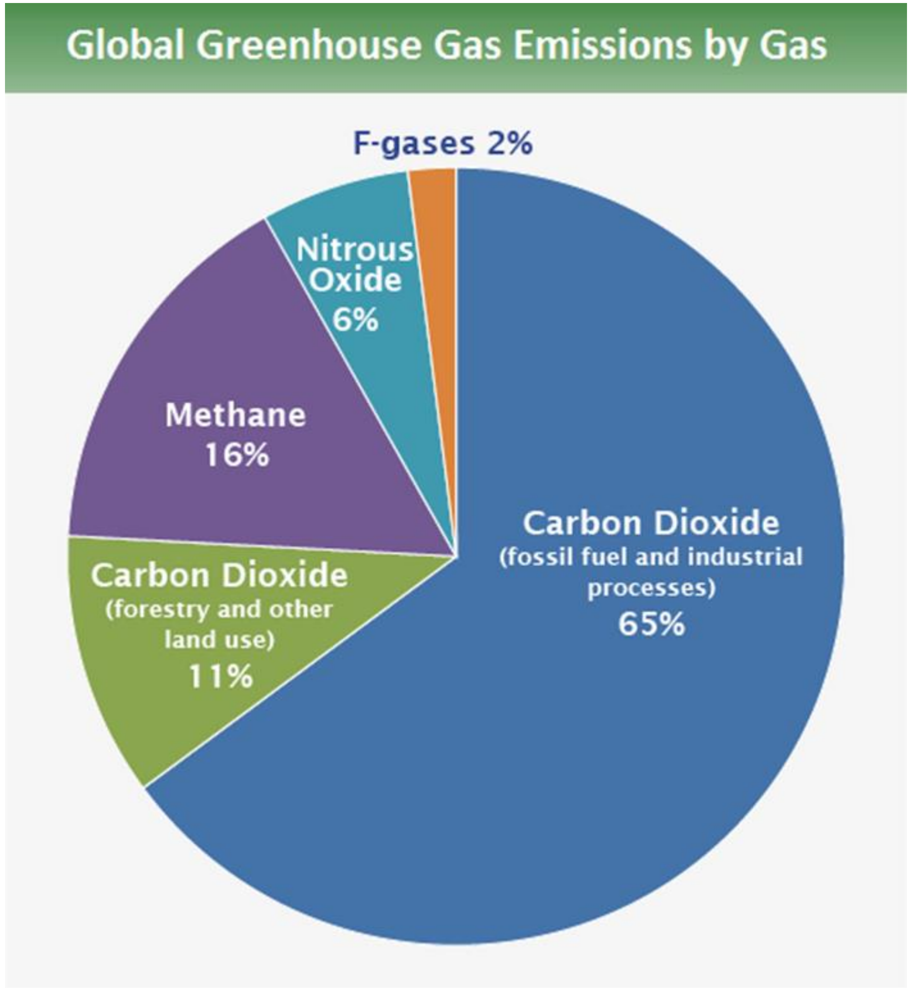
Air Pollution
Human Health

Transition risks

Policy | Economy
Technology | Society

Scaling up Transition to Zero-Carbon Economy: Energy Plays a Major Role





Source: IPCC (2014)

Economic and Financial Impacts

Numerous Impacts:

Changes in **Input Prices**
Access to **Capital**
Availability of **Inputs**
Impacts on **Supply Chains**
Border Adjustments
Imposition of **Standards and Regulations**
Changes in **Demand** for Products and Services
Changes in **Preferences**
Shifts in **Geopolitics**

Different Scales:

Company
Industry
Region
Country
Global

Incentives to change a behavior:
Relative impacts need to be **quantified**

How? **Scenario Analysis**

Example: Bank of Canada (2020)

https://www.bankofcanada.ca/2020/05/staff-discussion-paper-2020-3/

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Scenario Analysis and the Economic and Financial Risks from Climate Change

Staff Discussion Paper 2020-3 (English)

Erik Ens, Craig Johnston

May 2020

Example: Bank of Canada (2020)

https://www.bankofcanada.ca/2020/05/staff-discussion-paper-2020-3/

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Scenario analysis in this study

This paper adapts climate-economy models that have been applied in other contexts for use in climate-related scenario analysis. We consider illustrative scenarios for the global economy that could generate economic and financial risks (**Table 1**). We do this by varying assumptions on key variables such as climate policy in plausible ways. We then use a computable general equilibrium (CGE) model—the MIT Economic Projection and Policy Analysis (EPPA) model—to assess the economic impacts of these scenarios; this also provides insights into potential financial system risks. We use the results from both a Dynamic Integrated Economy Climate (DICE) model (an integrated assessment model) and the broader literature to inform physical risks.

Table 1: Overview of scenarios

Scenario	Description
Business as usual	No further action is taken to limit global warming. Rising emissions cause a substantial rise in average global temperatures.
Nationally determined contributions (NDCs)	Beginning in 2020, countries act according to their pledges under the Paris Agreement. They reduce global warming, but their actions are not enough to limit warming to an additional 2°C above pre-industrial levels by 2100.
2°C (consistent)	Countries act to limit global warming to 2°C by 2100.
2°C (delayed action)	Countries act to limit global warming to 2°C by 2100, but the action does not begin until 2030.

Extension (2021): Regional and Sectoral Risk Factor Pathways

For several scenarios, multiple regions, multiple sectors:

Direct emissions costs = carbon price x sectoral GHG emissions;

Indirect costs = price of non primary energy input x non primary energy input;

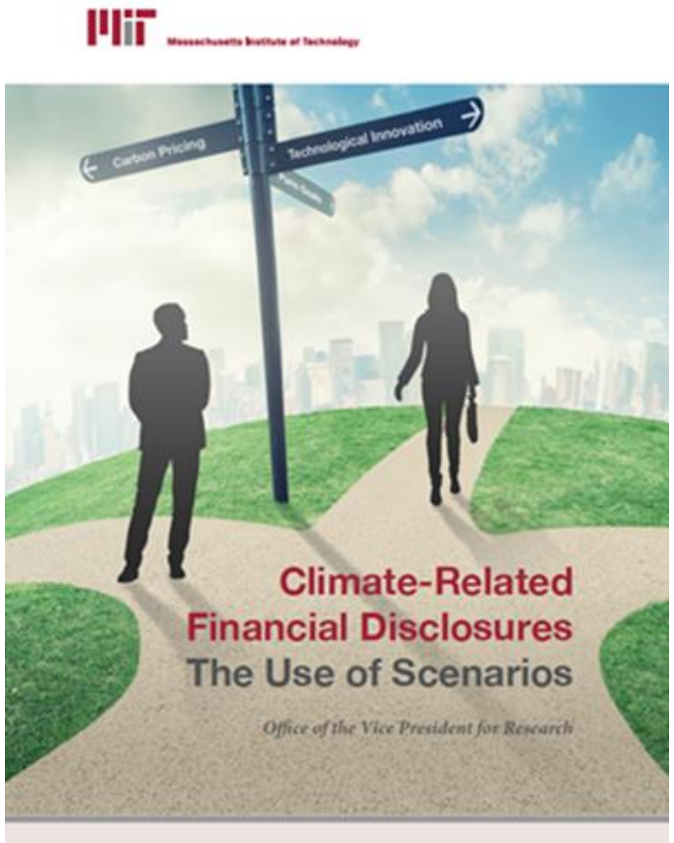
Revenue = output price x production;

Capital expenditure = price of new capital x new capital (does not include value of vintaged capital in a period);

This is further converted into *Value at Risk*

Other applications

use of our scenarios for climate-related financial disclosures



use of our scenarios for assessing transition risk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Report 339
December 2019

MIT Scenarios for Assessing Climate-Related Financial Risk

Erik Landry, C. Adam Schlosser, Y.-H. Henry Chen, John Reilly and Andrei Sokolov

use of our carbon price projections for assessing company's long-term profit margins and stock returns

Morgan Stanley

INVESTMENT MANAGEMENT

Counterpoint Global Insights

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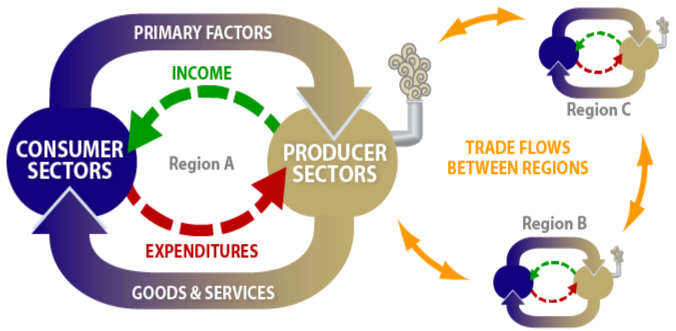
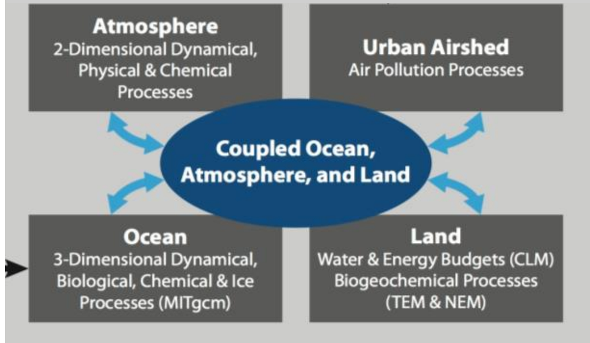
Integrated Modeling across Systems, Sectors and Scales

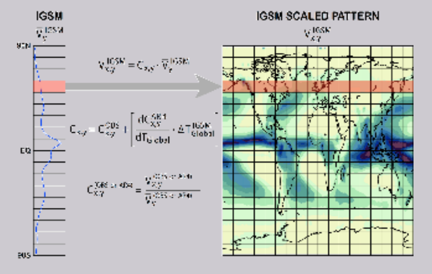
Economic Markets: *Trade, Energy, Agriculture, Transport, Industry, Land-Use Change, Population Dynamics, Infrastructure, Natural Resources* (Global to Regional Scale)



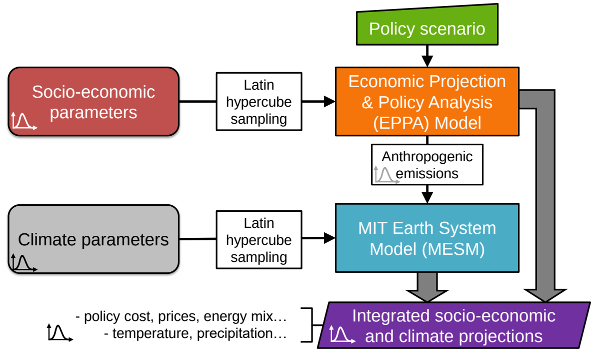
Physical Systems
MIT Earth System Model



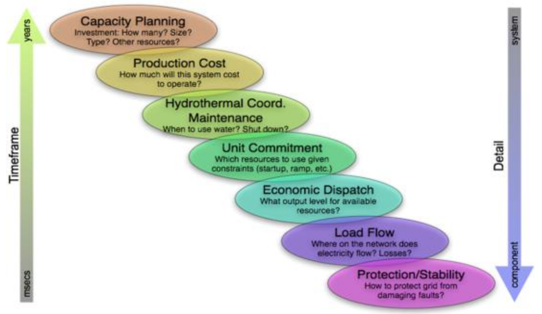
Pattern Scaling & Extreme Events



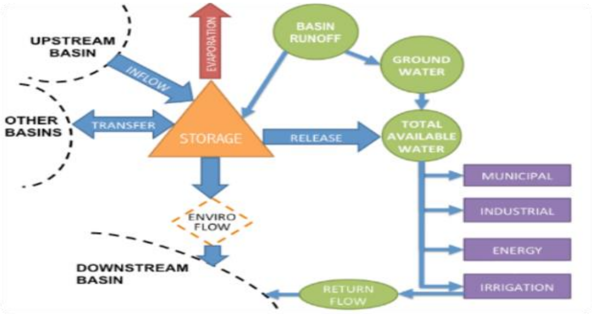
Probabilistic Ensembles & Integrated Projections



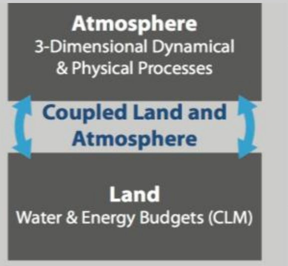
Detailed Electricity Models



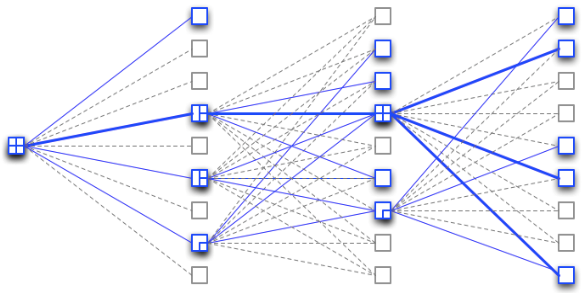
Water Resource System Model



CAM3 & WRF



Decision-Making Frameworks



Integrated complex systems and their potential evolution

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http://globalchange.mit.edu/

Recent applications of the Joint Program tools show wide variety of research efforts

Projecting Energy and Climate
Paltsev (2020) Economics of Energy and Env Policy, 9(1), 43-62.

Geopolitics of Renewables
Paltsev (2016) Bulletin of the Atomic Scientists, 72(6), 390-395.

Health Co-Benefits of Renewables
Dimanchev et al (2019) Environmental Research Letters, 14(8).

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

Covid-19 Effects on the Paris Agreement
Chen et al (2021) Humanities and Soc Sci Comm, 8(16).

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

Global Electrification of Light-Duty Vehicles
Ghandi and Paltsev et al (2020) Transportation Research D, 87, 102524.

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

Global CCS Scenarios
Morris et al (2021) Climate Change Economics, 12, 215001.

Cost of Low-Carbon Power Generation
Morris et al (2019) Int J GHG Control, 87, 170-187.

MIT 2021 Global Change Outlook
Charting the Earth’s Future Energy, Managed Resources, Climate, and Policy Prospects
https://globalchange.mit.edu

The current path is not consistent with stabilizing at 1.5°C or 2°C

MIT Joint Program Outlook Dashboard

Select Scenario to Plot

Paris Forever

Current (as of March 2021) Paris Nationally Determined Contribution (NDC) targets are met by all countries by 2030 and retained thereafter

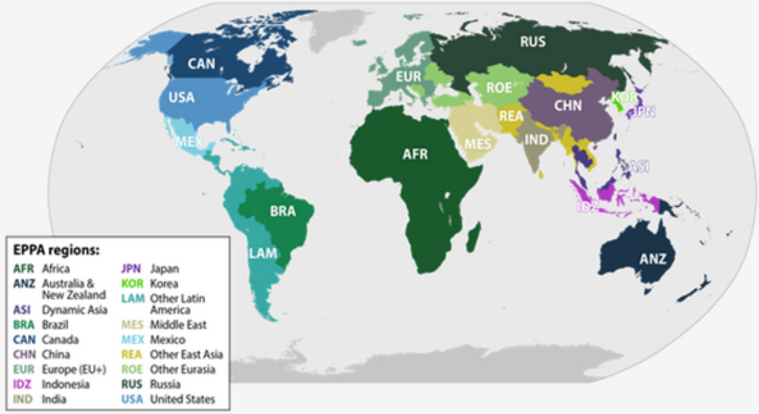
Data Type

- (•) Emissions and Climate
- ( ) Energy and Economics

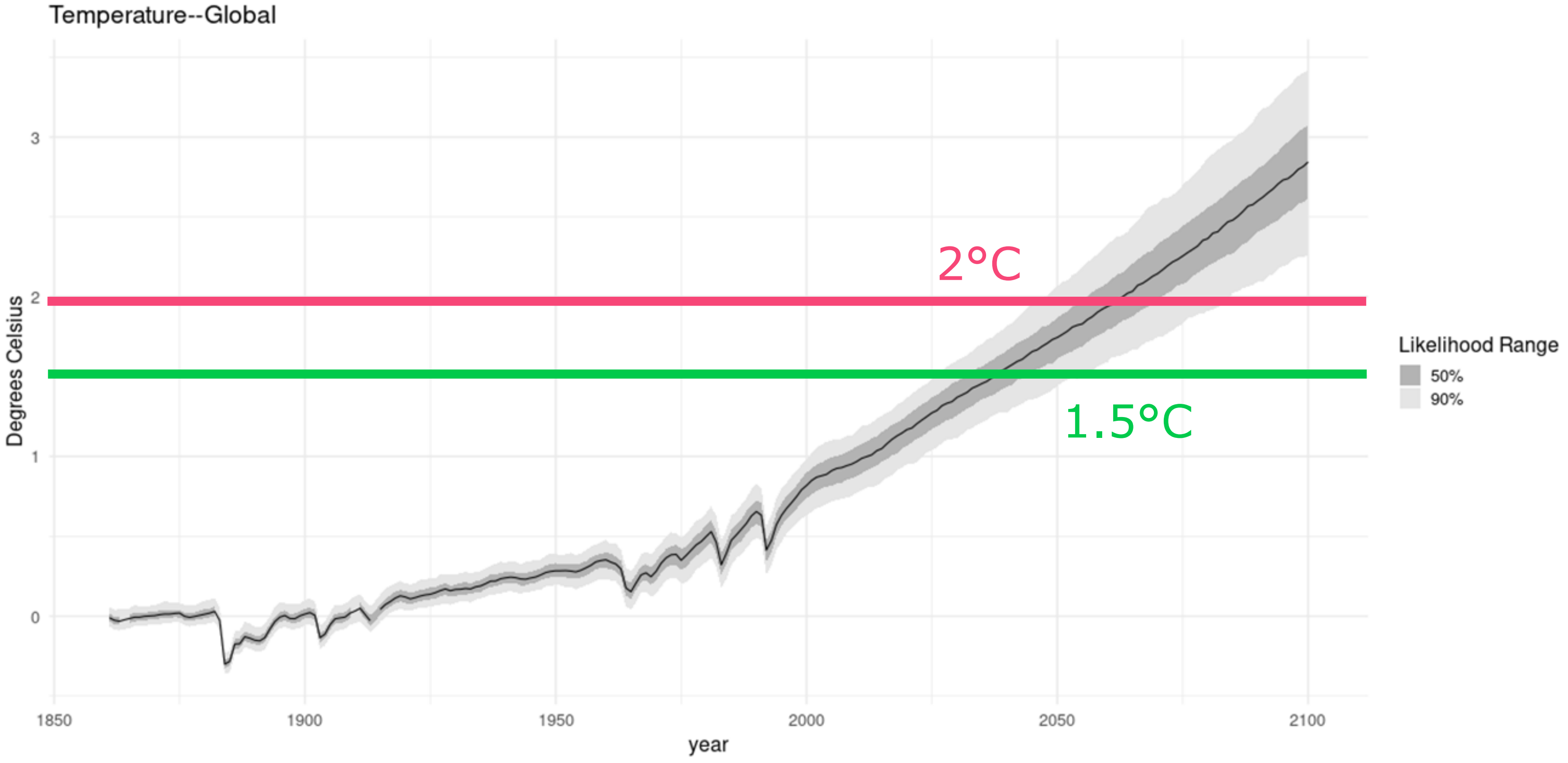
Select Data to Plot

Temperature--Global

- [ ] Plot Difference vs Another Scenario

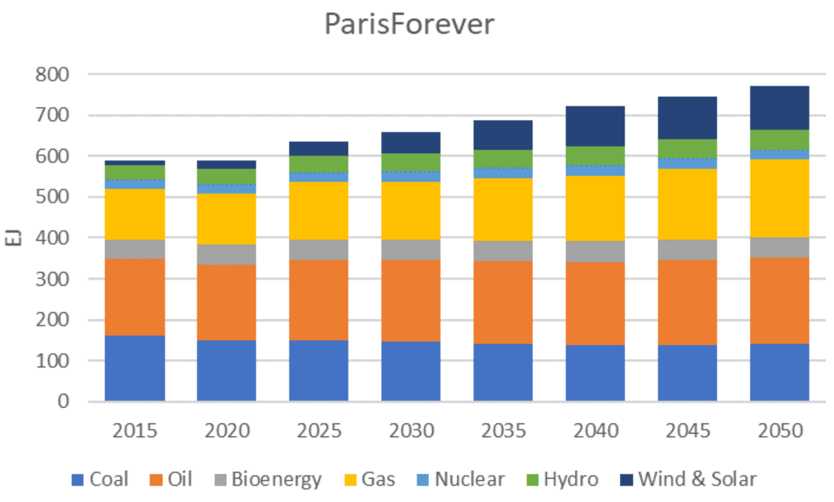


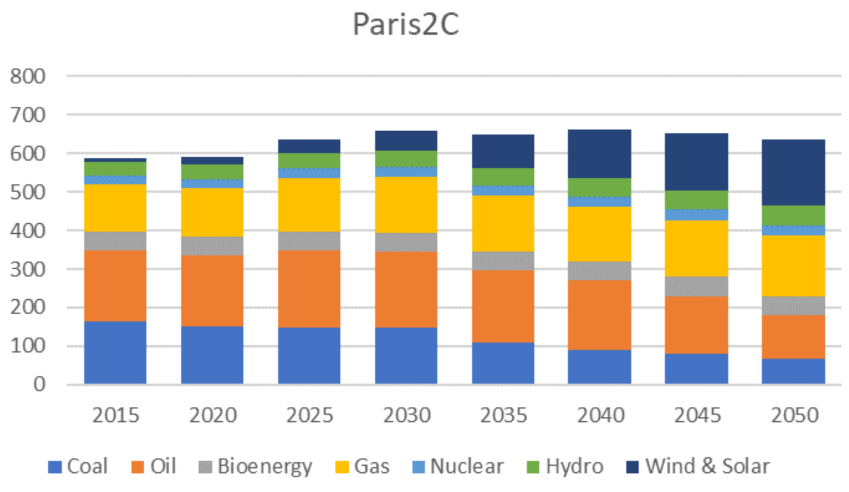
Download the full Outlook report

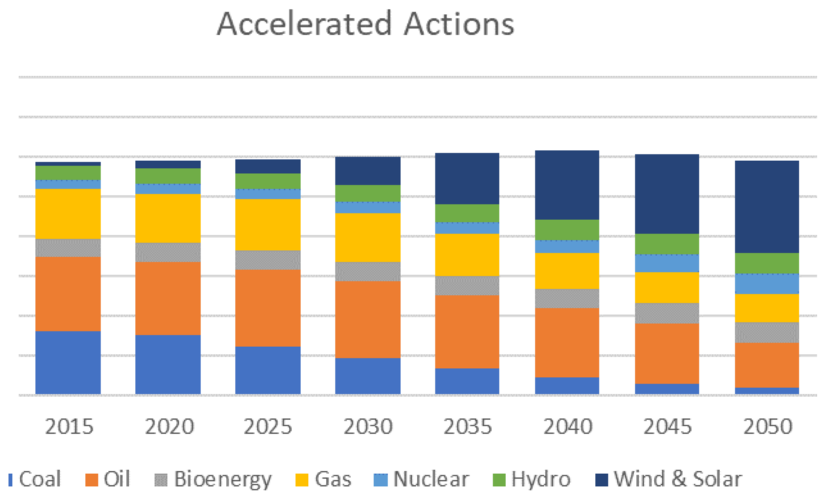


Change in global average surface air temperature relative to pre-industrial (1861-1880) levels. The thick black line is the median, the 50% likelihood range reflects the 25th to 75th percentiles, and the 90% likelihood range reflects the 5th to 95th percentiles. Likelihood ranges in historical years reflect measurements errors.

Global Primary Energy







Global primary energy use in the *Paris Forever scenario* grows to about 770 exajoules (EJ) by 2050, up by 31% from about 590 EJ in 2020. The share of fossil fuels drops from the current 80% to **70%** in 2050. Wind and solar – **6**-fold increase.

In the *Paris 2°C* scenario, the fossil fuel share drops to about **50%** in 2050, wind and solar energy grow almost **9** times from 2020 to 2050.

In the *Accelerated Actions* scenario, the fossil fuel share drops to about **34%**, wind and solar energy grow almost **13** times from 2020 to 2050.

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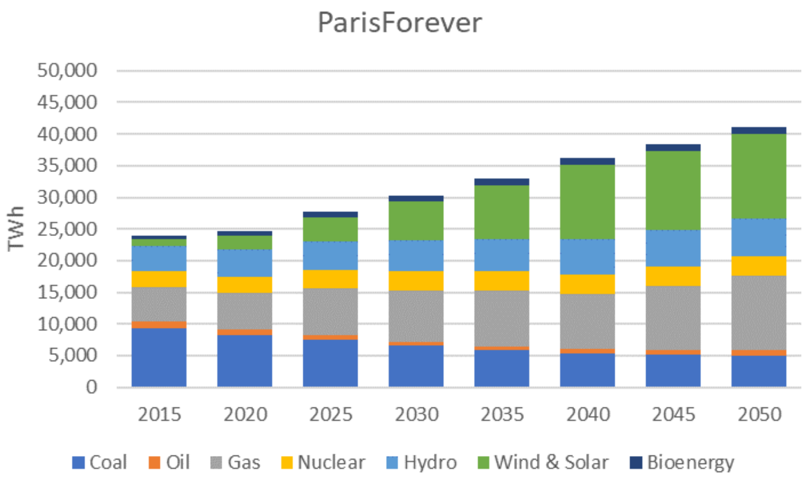
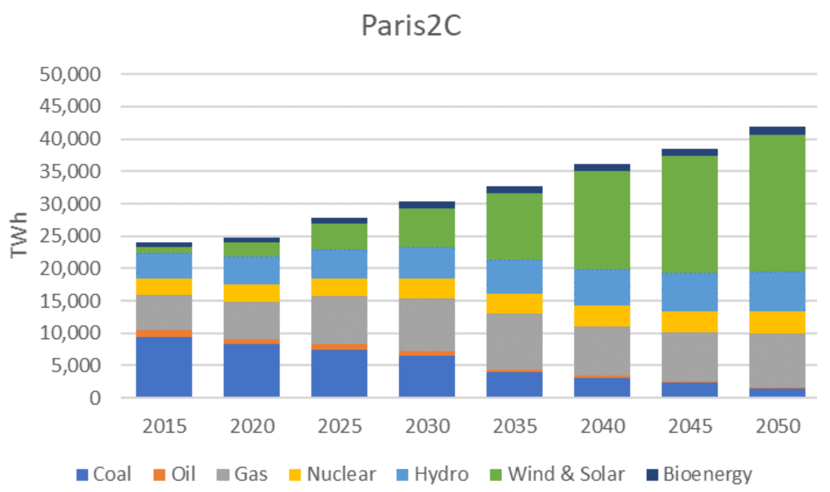
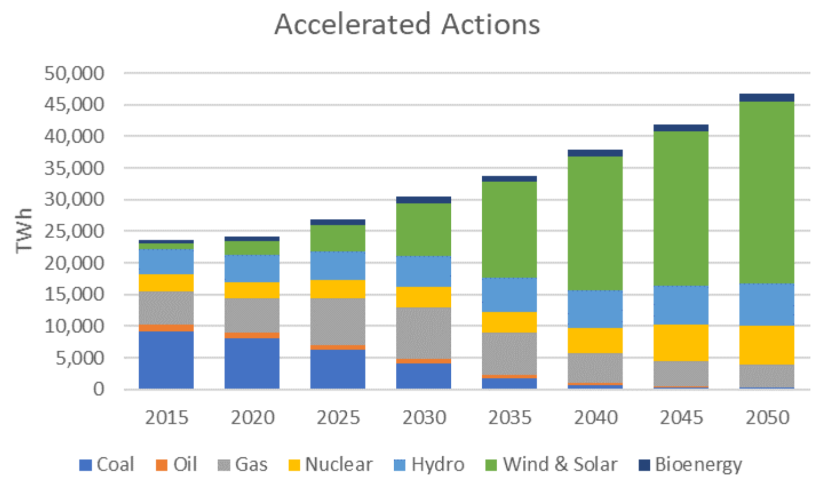
Global Electricity Production







In the *Paris Forever* scenario, global electricity production (and use) grows by 67% from 2020 to 2050. In comparison to primary energy growth of 31% over the same period, electricity grows about twice as fast, resulting in a continuing electrification of the global economy.

Electricity generation from renewable sources becomes a dominant source of power by 2050 in all scenarios, providing 70-80% of global power generation by midcentury in the climate stabilization scenarios

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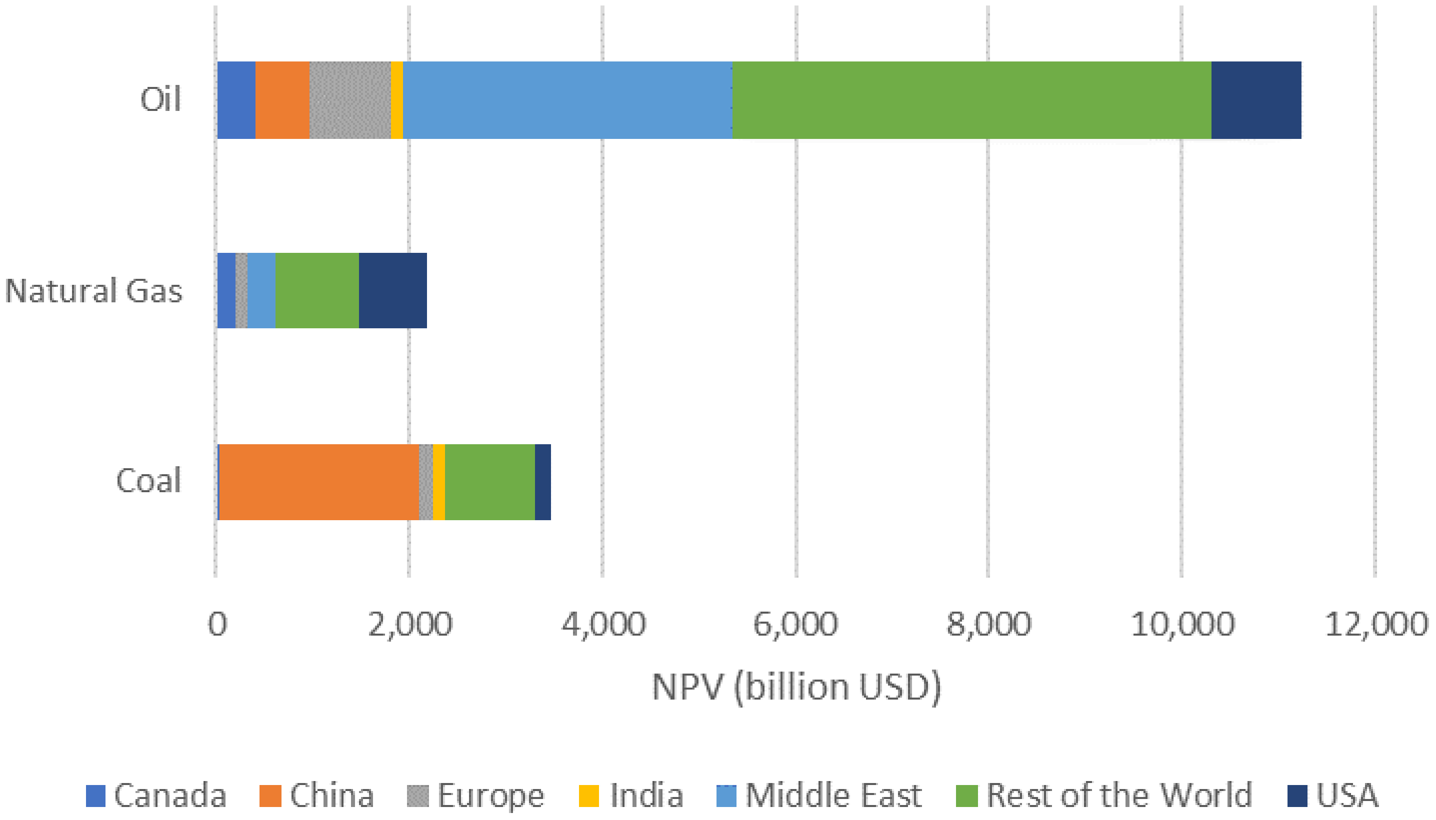
Fossil Fuels: Stranded Value



Net present value (NPV) of economic output lost from fossil fuels not produced in the *Paris 2°C* scenario.

Earnings from fossil fuel assets and resources are reduced due to lower prices, more fuels are left in the ground, and restrictions are imposed on certain types of power plants (e.g., coal-based).

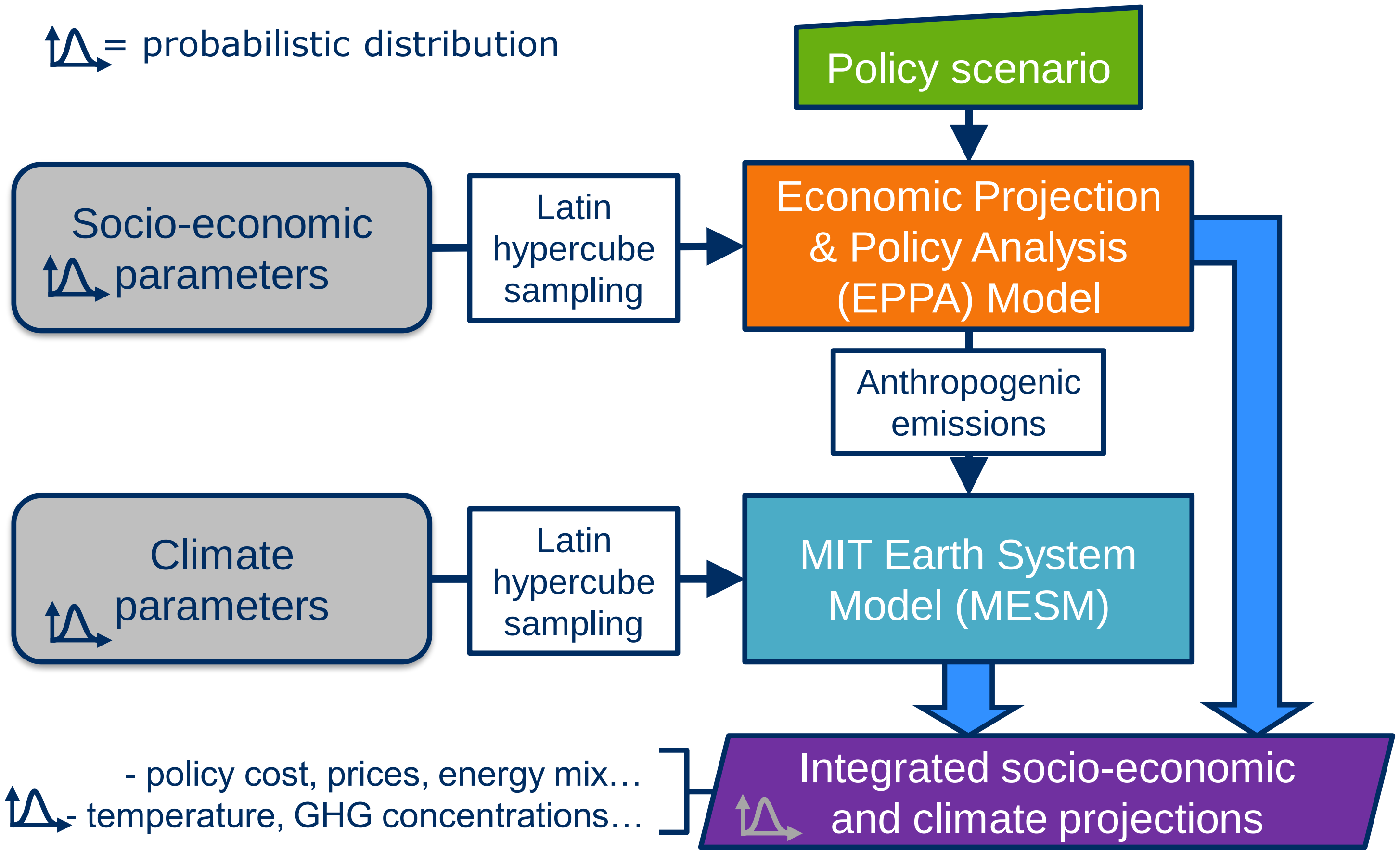
$17 trillion in stranded assets—more than the current GDP of China and slightly less than the U.S. GDP.

Note: the value is measured as a difference between scenarios. Forward-looking behavior can reduce losses.

Advantage of MIT Approach - Integrated Risk Assessment

- Socio-Economic Uncertainties
  - Population growth
  - GDP growth
  - Technology costs
  - Energy efficiency trends
  - Fossil fuel resource availability
  - Urban pollutants
  - Rate of technology penetration

- Climate Uncertainties
  - Climate sensitivity
  - Ocean heat uptake
  - Aerosol forcing



Advantages of MIT Approach

Integration across physical and transition risks

Mapping of scenarios to economic sectors

Downscaling transition pathways to countries

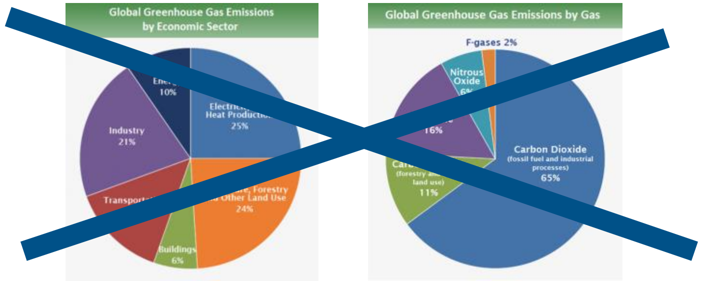
Consistency and comparability of human and climate pathways

Systematic approach to quantifying uncertainty

Experience with identifying physical risk (multi-stressor risk triage)

How do we get to net-zero emissions? How quickly?

A proliferating number of **pledges** by numerous governments and companies to reach **net-zero** greenhouse gas (**GHG**) emissions



Opportunities and challenges for **scalable** low-carbon energy options

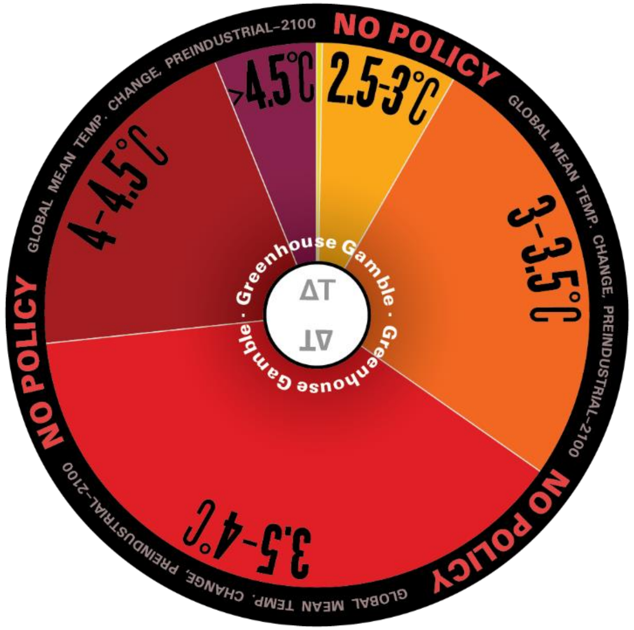
Economic: Do we have technologies? Are they economically competitive? Do we have policies to support them? Lifestyle changes?

Geopolitical: Impacts of de-carbonization on other goals? COVID implications for a rise of protectionism? Stability of energy exporters?

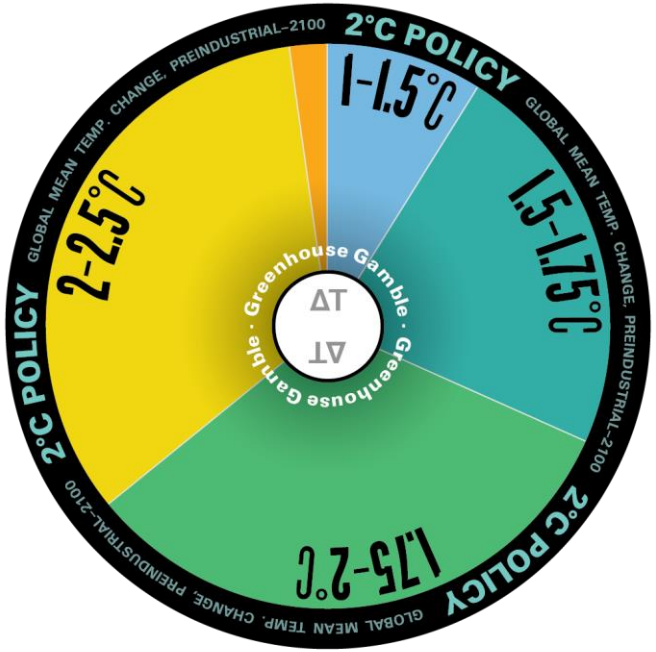
Environmental: Physical risks from climate change will be there regardless of emission reduction. Impacts from low-carbon options (e.g., car battery recycling). Air pollution impacts (lockdown evidence with some surprises).

Greenhouse Gamble Wheels

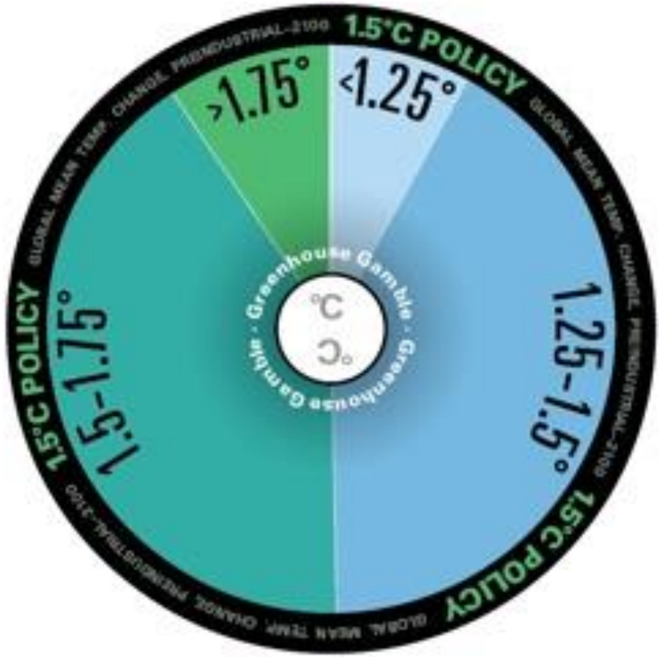
REF



2°C



1.5°C



Which wheel would you rather spin?

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Thank you

Questions or comments?

Please contact Sergey Paltsev at paltsev@mit.edu