Integrating political economy insights into integrated assessment models

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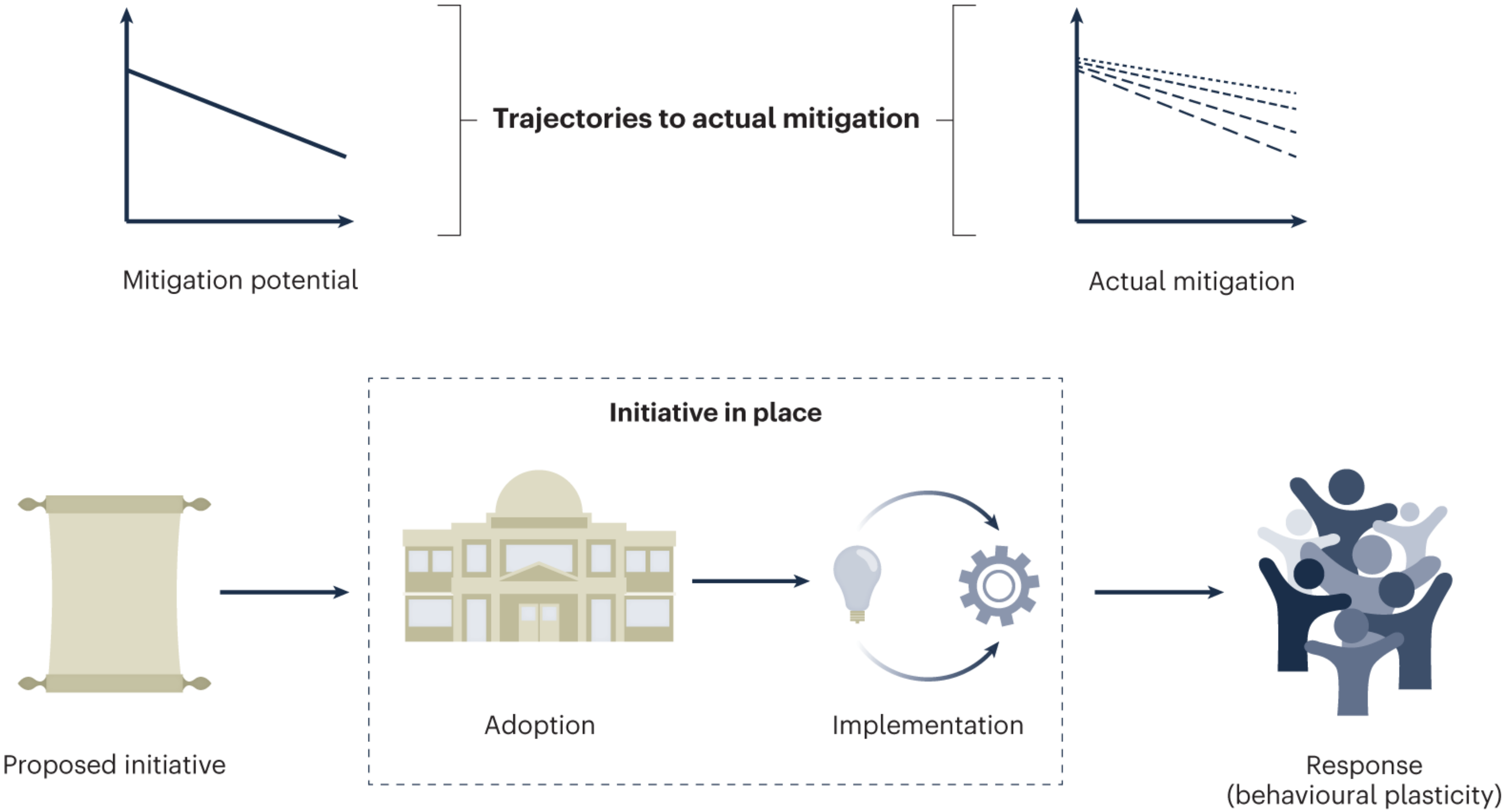
Workshop on "Macroeconomic Implications for Decarbonization Policies and Strategies"

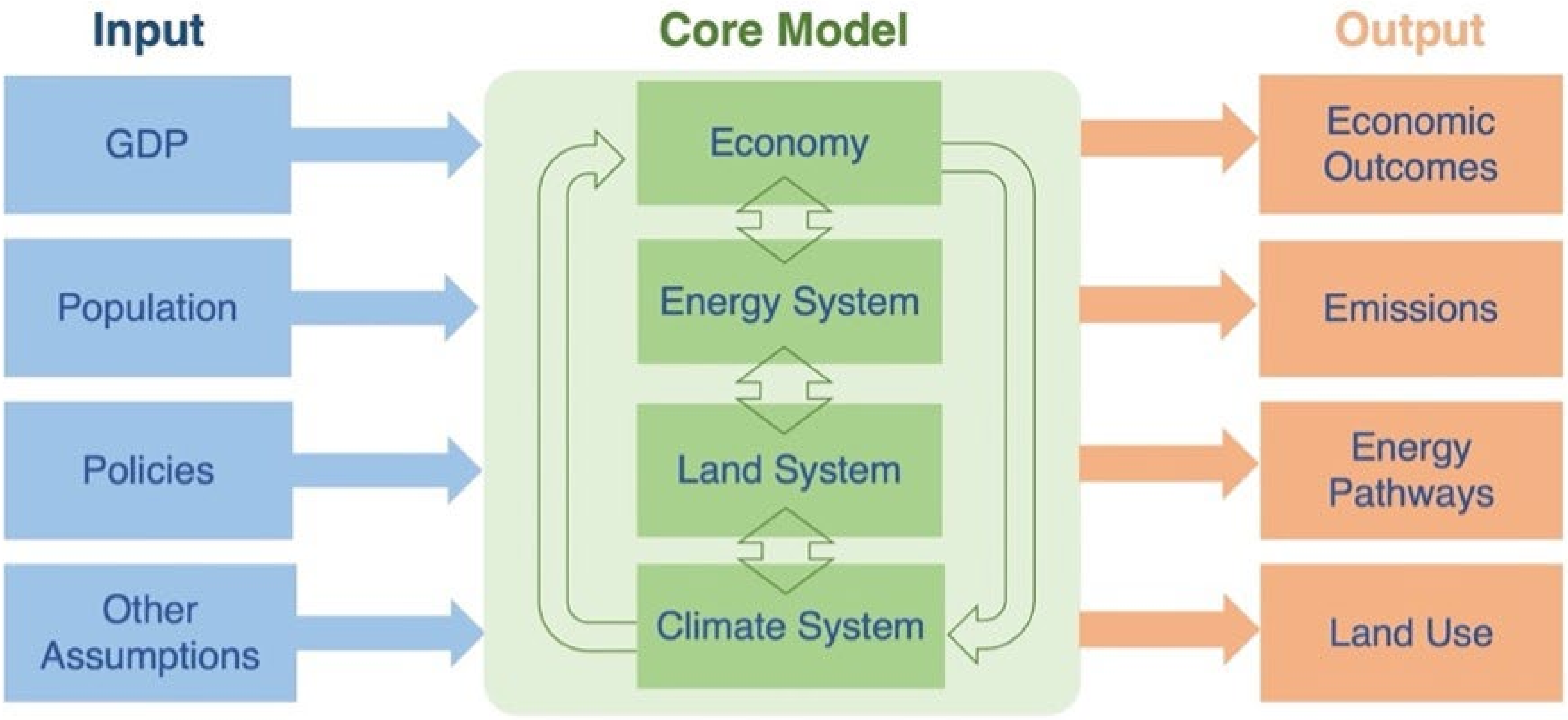
The model world vs. the real world:
How to improve policy realism in models



Stern, P.C., Dietz, T., Nielsen, K.S. *Peng, W.* et al. Feasible climate mitigation. *Nat. Clim. Chang.* **13**, 6–8 (2023).

Detailed-process integrated assessment models (IAMs)

Emission target or carbon price



Within IAM: Prioritize model advancements that are politically important and computationally tractable.

Example: Policy debate on “carrots” vs. “sticks”

Deeper integration between modeling and social sciences

Modeling strategies	Model representations
1. Improve scenario design	Design scenarios with “carrots” vs “sticks”
2. Conduct ex-post analysis	Assess winning vs losing sectors and states from “carrots” vs. “sticks”
3. Encode the process	“Carrots” → Technology cost reduction + Green coalition building → Future “sticks”

Beyond IAM: Explore model comparison and coupling opportunities based on the nature of the institutional factors.

Model	Institutions	Actors
IAM Global, national scale	Regulatory & Economic	Benevolent decision-maker at the national scale; representative household & firm
Engineering-economic optimization Modeling National, regional scale	Regulatory & Economic	Central planner managing technologically-diverse firms in different political jurisdictions
Agent-based Modeling Individual-Urban scale	Normative & Socio-cognitive	Actor: diverse boundedly rational households

Davidson M., Filatova T., *Peng, W.* et al. Simulating institutional heterogeneity in sustainability science. PNAS (2024)

Key Takeaways

Within IAM: Prioritize model advancements that are politically important and computational tractable

Beyond IAM: Explore model comparison and coupling opportunities

We need deeper collaboration between the modeling and political economy communities.

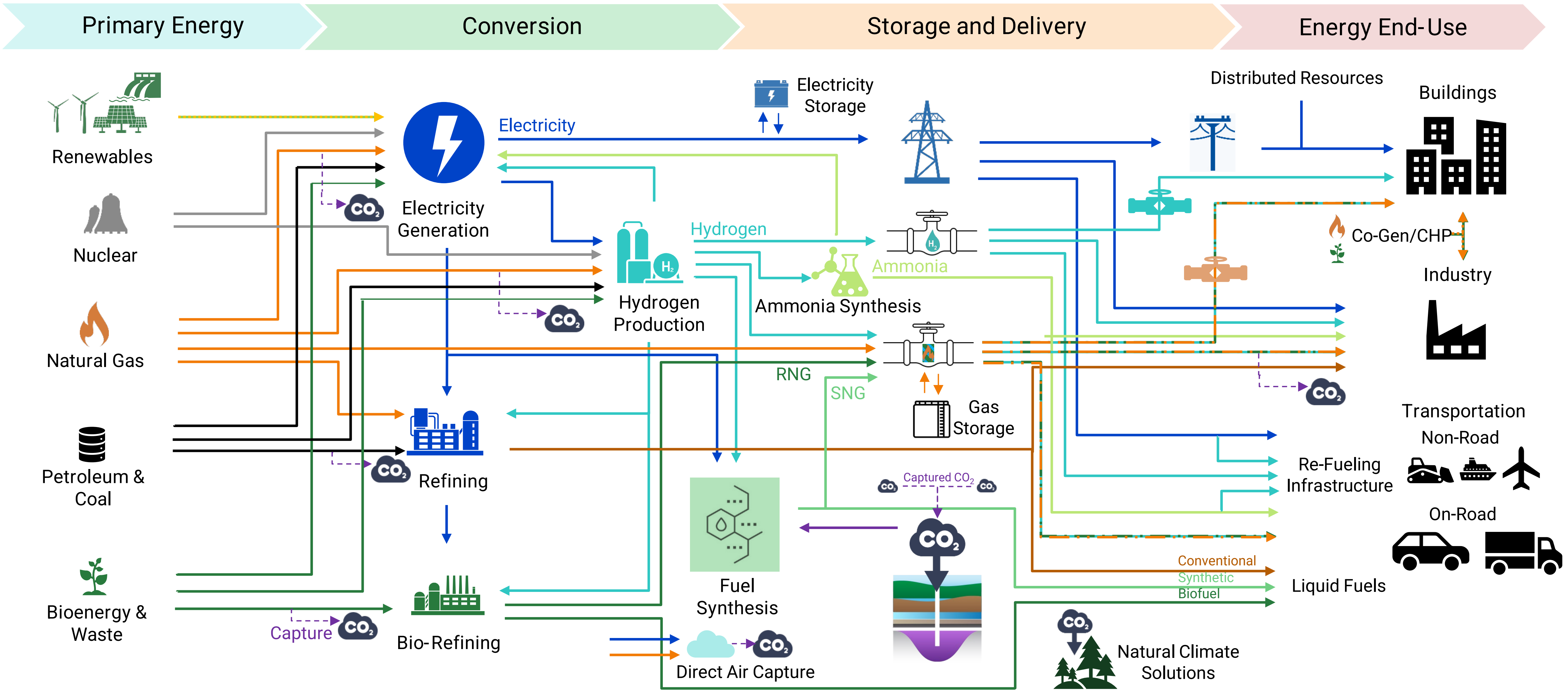
Incorporating Modeling Insights into Policy Design

Insights and Perspectives from EPRI's REGEN Model

John Bistline, Ph.D.
EPRI Energy Systems and Climate Analysis

National Academies Workshop – Washington, DC
September 13, 2024

Energy System Planning and Policy Analysis Require Advanced Models That Reflect Changing Landscape



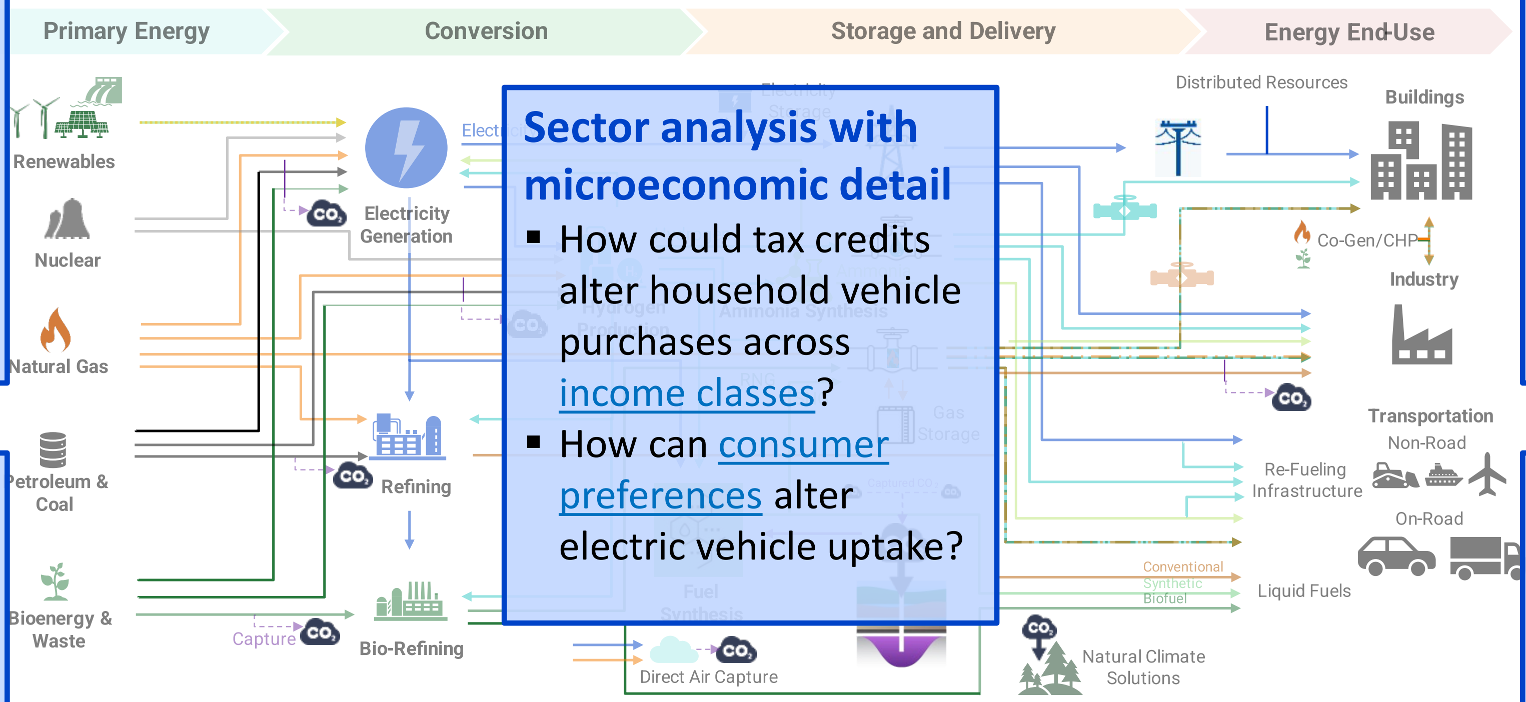
Linking Tools for Decision Support and Policy Design

Macro feedbacks

- How could tax credits affect inflation and interest rates, and how do macro conditions alter energy decisions?
- How could preexisting taxes alter prospective policy analysis?

Climate impacts

- What are frontier methods for representing climate impacts in power systems models?
- How could changing temperatures alter spacing conditioning demand and load?



Sector analysis with microeconomic detail

- How could tax credits alter household vehicle purchases across income classes?
- How can consumer preferences alter electric vehicle uptake?

Affordability and distributional analysis

- How could net-zero polices alter energy affordability outcomes?
- What are the potential distributional impacts of power sector tax credits in IRA?

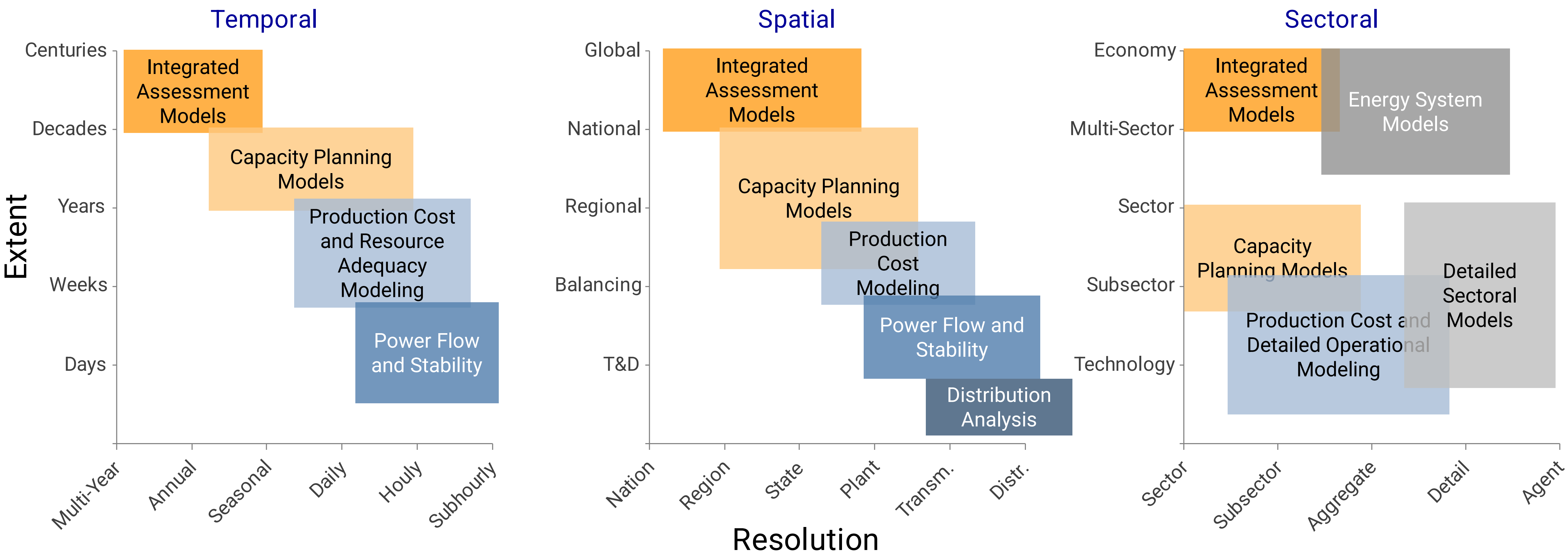
System operations for reliability analysis

- How does electric sector CO_2 policy design alter resource adequacy and reliability?
- How could integrated generation and T&D planning alter electric company decisions?

Additional modeling detail can:

1. Better capture underlying dynamics and potentially change decisions
2. Answer questions that policy-makers and decision-makers have

Model Scope/Resolution for Power Sector Policy Analysis



Temporal resolution can materially impact power sector decarbonization, IRA analysis, and electrification-driven load shapes

Spatial resolution is valuable for reflecting differences in climate policy costs, trade and CO_2 leakage, and detailed resource assessment (e.g., local ordinances)

Sector coupling alters tax credit analysis (e.g., 45V hydrogen credits), economy-wide net-zero paths, and sectoral leakage

Complex models are not always better, but detail can be valuable for accuracy and actionable insights

Example: Using Models to Quantify Policy Tradeoffs

Scenario	2035 Economy CO_2 (Decline from 2005)	Fiscal Costs to 2035 (nominal $ billion)	Revenue from Carbon Fee to 2035 (2023$ billion)	Average Abatement (2023$/t-$CO_2$)
Reference	49%	$1,570	$0	$43
Reference w/o EPA Rules	42%	$1,330	$0	$69
IRA Repeal	36%	$70	$0	N/A
IRA Expansion	51%	$2,100	$0	$50
Carbon Fee + IRA	62%	$2,010	$590	$25
CES + IRA	52%	$1,790	$0	$59
Carbon Fee + Partial IRA	57%	$840	$660	$18

Source: Bistline, et al. (2024). Climate Policy Reform Options in 2025. NBER Working Paper 32168 (link).

Modeling can assess tradeoffs across policy outcomes: "What-if" scenarios provide insights about relative magnitudes of changes and highlight system interactions

Key Learnings and Research Needs

Learnings

1 Linking Tools

Linking models is key to decision support and policy design, esp. with detailed questions and system interactions.

Needs

Guidance on linking and data transfer and conducting retrospective analysis.

2 Modular Models

Modular design can more closely match questions and facilitate uncertainty analysis.

Navigating tradeoffs between model detail and tractability.

3 Micro Modeling

Household and firm perspectives are valuable for assessing climate policy impacts.

Aligning empirical and structural modeling and linking across different model scopes.

4 Policy Design

Policy design shapes outcomes, but novel proposals stretch analytical capabilities.

Funding open data and models and communicating insights to stakeholders.

5 Multi-Model

Model comparisons can improve tools and provide robust insights.

Interpreting variance across models and providing quick turnaround results when stakeholders need them.

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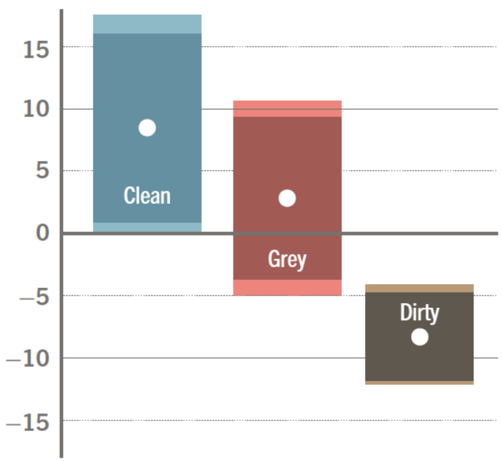
Integrating innovation in climate macro models

- Most climate models consider technological progress as exogenous. Yet:

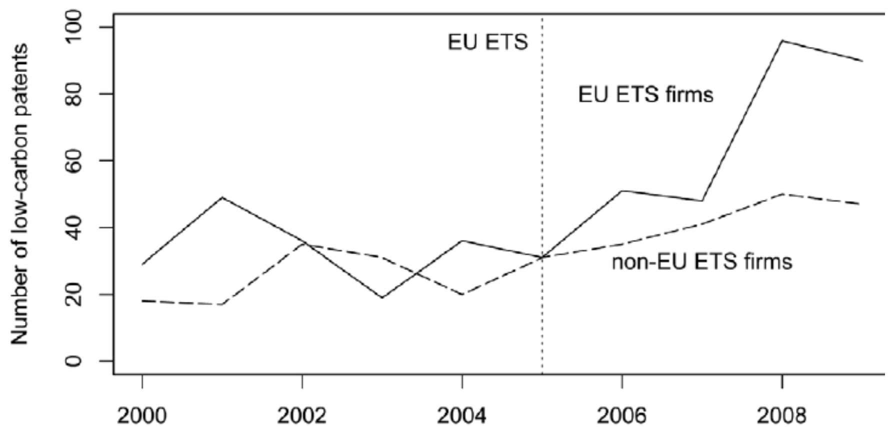
Fig.10 **Effect of a 10% increase in fuel prices**



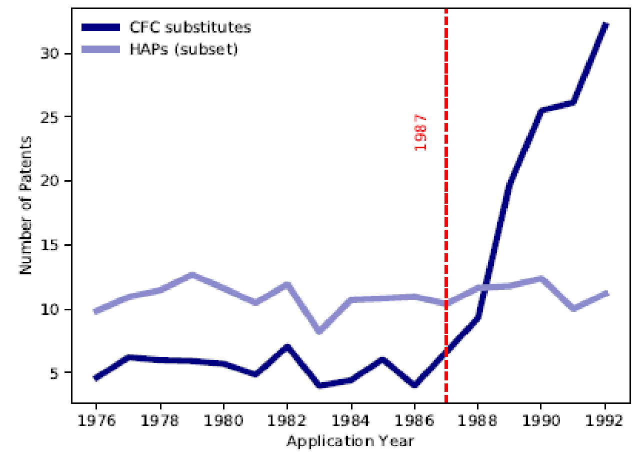
Notes: The bars denote the 90% and 95% confidence interval.

Source: Aghion, Dechezleprêtre, Hémous, Martin, and van Reenen (2016)

FIGURE 5.—LOW-CARBON PATENTS BY MATCHED EU ETS AND NON–EU ETS FIRMS



Calel and Dechezleprêtre (2016)

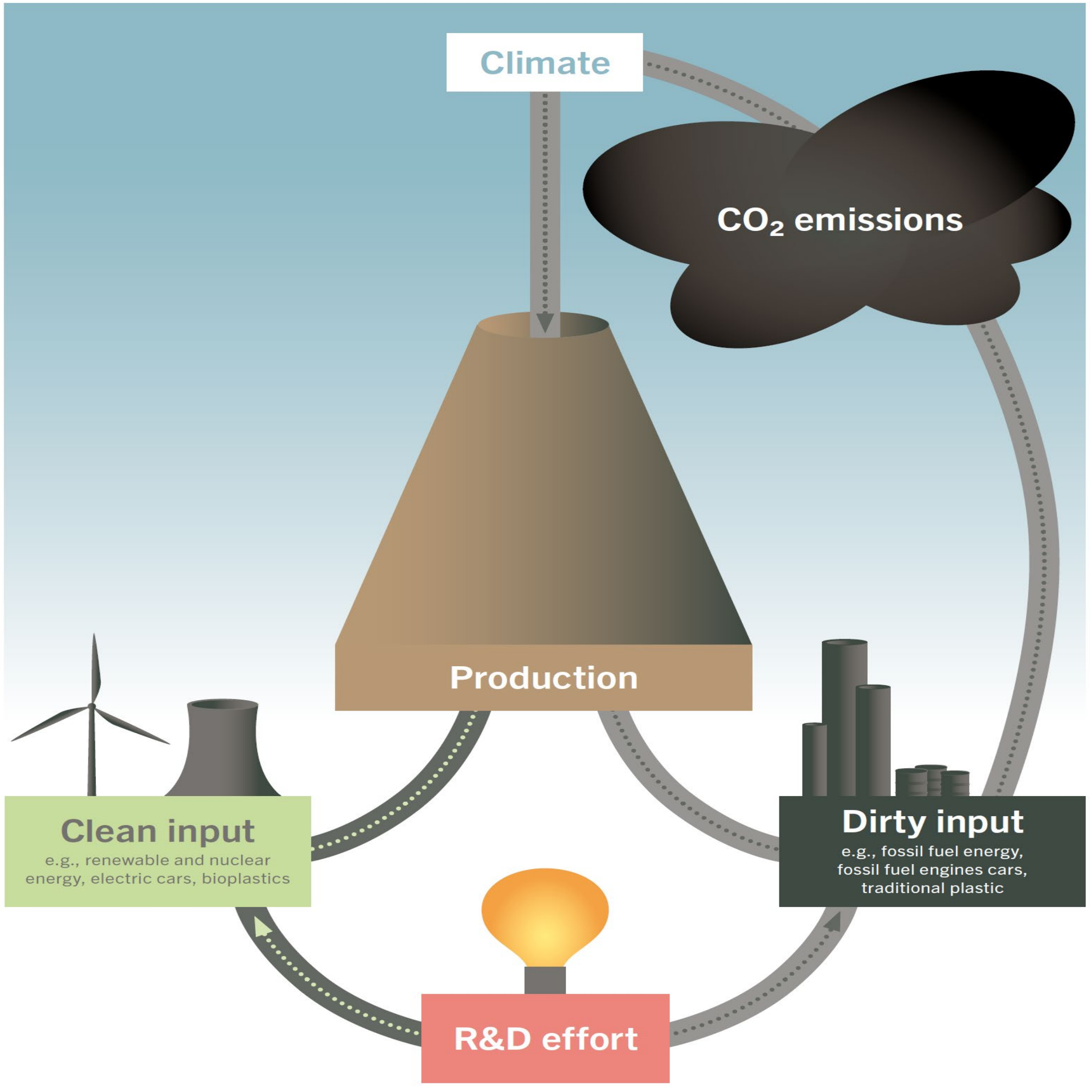


Dugoua (2022)

- Goal of my work => integrating endogenous innovation in climate models.

(David Hemous, University of Zurich)

A basic framework



Baseline model, the two inputs are substitutes (CES) and tech progress (TFP) in both sectors.

Innovation is endogenous and targets the sector with the largest profits.

Framework can be extended to consider:

- More than 2 energy inputs,
- International linkages,
- Energy-saving vs energy using inputs,
- Etc.

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What did we learn?

1. There is path dependence in innovation when the 2 inputs are substitute (Acemoglu, Aghion, Bursztyn and Hémous, 2012)

2. Delaying intervention is costly (Acemoglu, Aghion, Bursztyn and Hémous, 2012)

3. Optimal policy involves both a carbon tax and research subsidies for clean substitutes (Acemoglu, Aghion, Bursztyn and Hémous, 2012)

4. But not the same need to subsidize energy-saving innovations (Hassler, Krusell and Olovsson, 2021, Hémous and Olsen, 2021)

5. Countries willing to act alone should favor green industrial policy over unilateral carbon pricing with no border adjustment (Hémous, 2016)

6. Intermediate energy sources (natural gas) can delay / prevent the energy transition if they are not accompanied by the right economic policies (Acemoglu, Aghion, Barrage, and Hémous, 2024)

7. Energy transition may stall without support for storage technologies (Gentile, 2024).

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What is next?

1. Better integrating these models in quantitative frameworks.

2. Political economy questions.

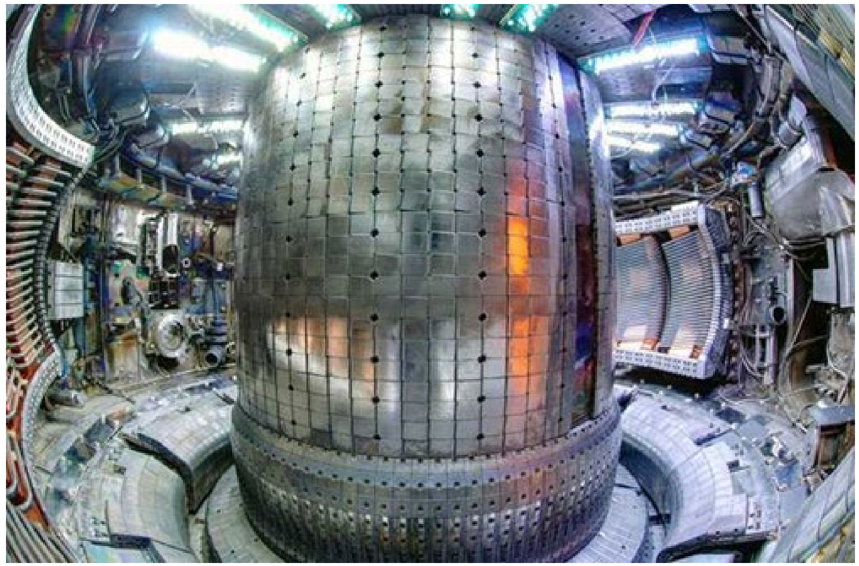
3. Beyond factor augmenting technical change.
   - Current work (Aghion, Barrage, Donald, Hémous and Liu, 2024), we explore the role of innovation in building green supply chains.
   - Technological complementarities lead to multiple steady-states => need for sector-specific interventions.

Taking stock

1. The direction of innovation is endogenous and responds to economic incentives.

2. Models with endogenous innovation bring new insights on climate policy.

3. Most importantly, there are good economic rationales for government to support innovation in green technologies (in addition to carbon pricing).



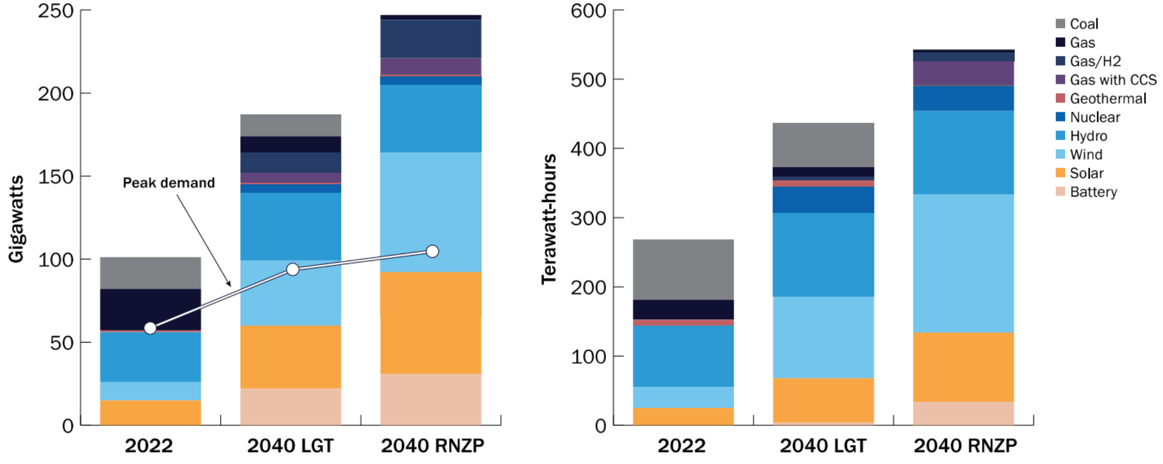
World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

Approaches of and lessons from 45+ Country Climate and Development Reports

Stephane Hallegatte, Senior Climate Change Adviser

In Türkiye: 4 sectoral roadmaps for a net zero target in 2053



Source: World Bank staff estimates
Notes: Gas/H2 = hydrogen gas; CCS = carbon capture and storage.

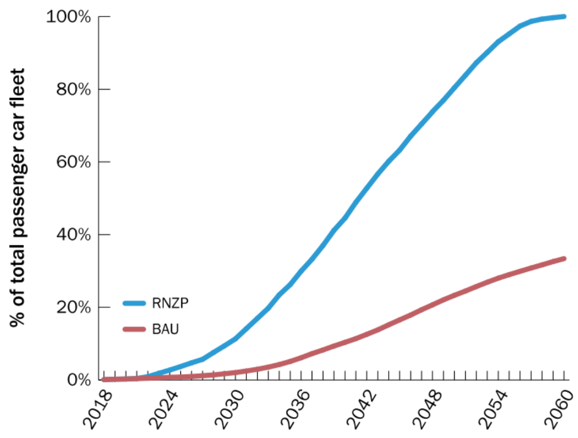
Note: LGT = least-cost with current government targets (BAU)

Incremental investment needs and economic costs to achieve net zero in 2053

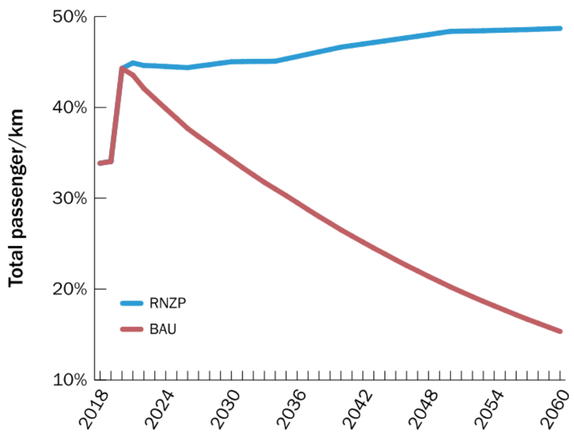
	2022–30 ($, billions)	2022–40 ($, billions)
POWER		
Additional investment: new generation and storage capacity	+5	+33
Additional investment: transmission and distribution	+8	+14
Other economic costs: operational and fuel costs	-9	-23
Other economic costs: air pollution externality costs from coal	-9	-38
Other economic costs: decommissioning of coal plants and mines	< +1	+1.4
RESIDENTIAL		
Additional investment: energy efficiency, electrification, and resilience	+45	+100
Other economic costs: gas imports	-11	-46
Other economic costs: lives lost and injuries	-1	-3
TRANSPORT		
Additional investment: new resilient infrastructure	+8	+15
Other economic costs: fuel imports	-12	-36
Other economic costs: cost of disruptions	-3	-11
Other economic costs: air pollution, congestion, and road fatalities	-40	-171
FOREST LANDSCAPES		
Additional investment: restoration, reforestation, and fire management	+2	+3
Other economic costs: loss of harvest revenues	+1	+5
AGRICULTURE		
Other economic costs: on-farm emissions reductions	< +1	–
INDUSTRY AND MANUFACTURING		
Other economic costs: cement, iron, and steel	–	+11
TOTAL INVESTMENTS AND ECONOMIC COSTS		
Net economic costs	-15	-146
includes: additional investment	68	165

Notes: All amounts are discounted using a 6 percent discount rate. Decommissioning costs do not include the social expenditures to facilitate the transition of affected workers and communities. Numbers in red are net costs; numbers in green are net benefits.

a) EV adoption for passenger cars



b) Modal share, public transit (buses and rail)



Source: World Bank staff estimates

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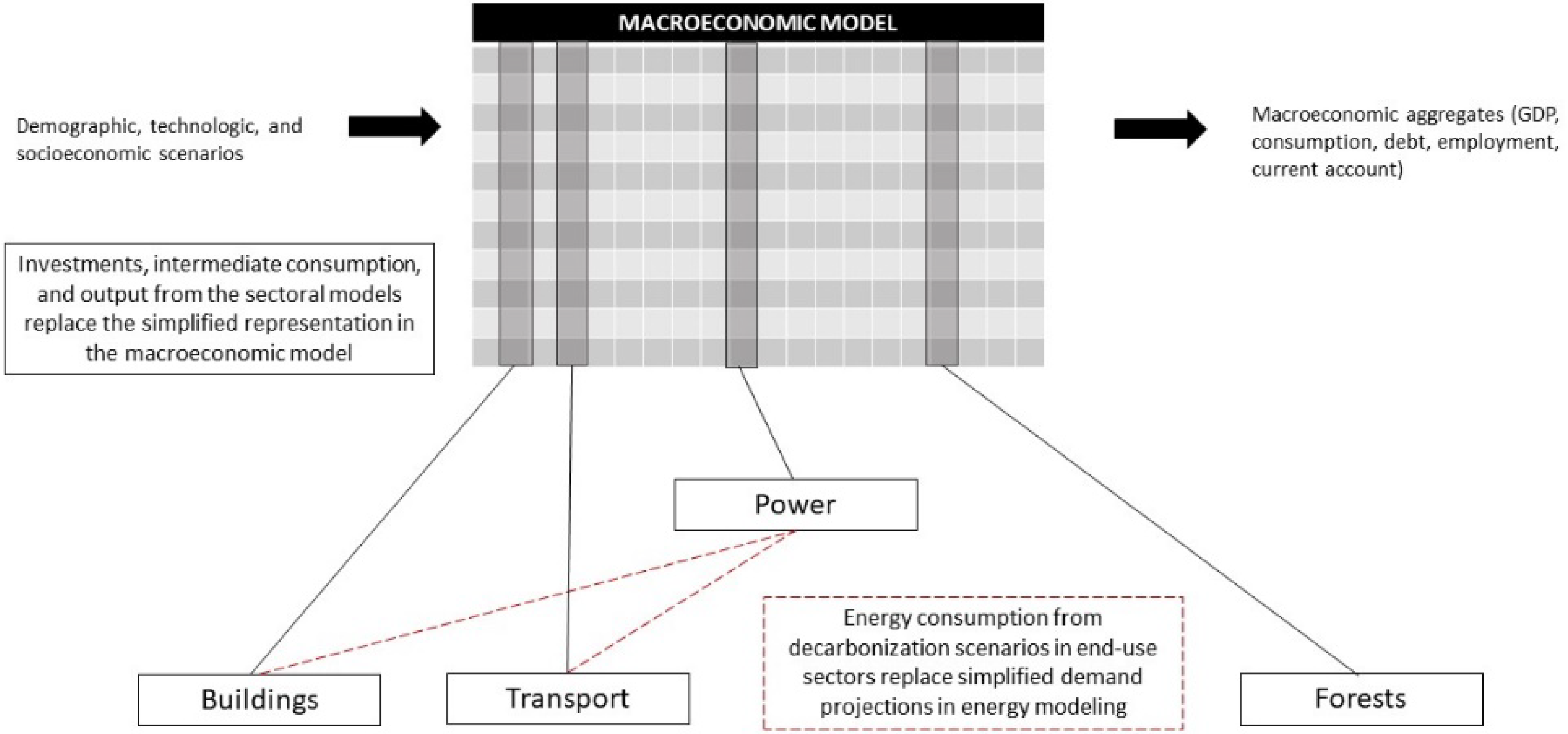
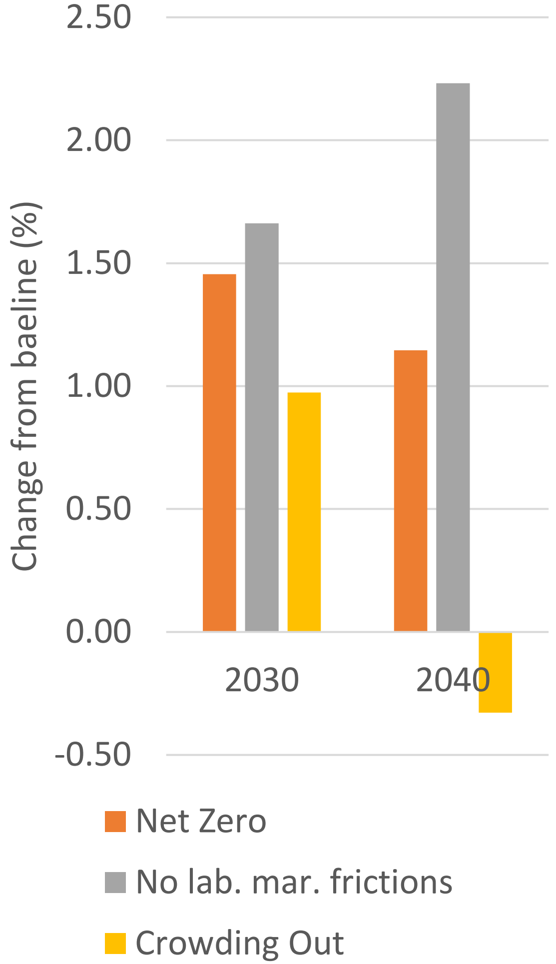
A hybrid modeling approach combining sectoral roadmap with macro modeling





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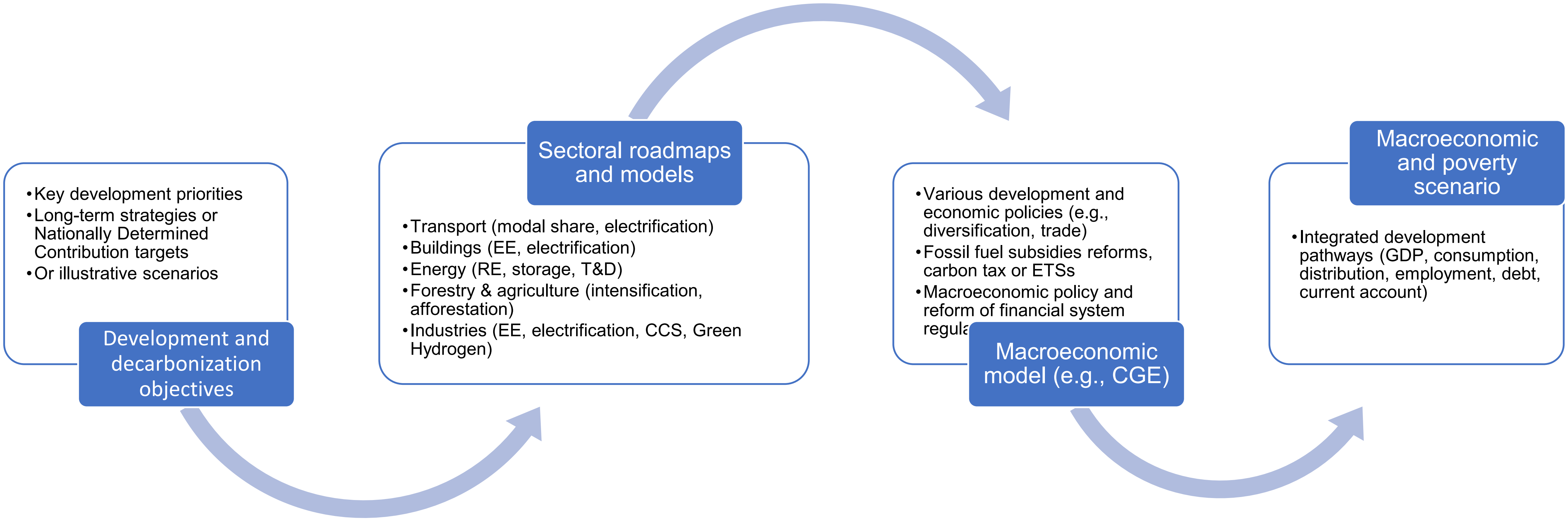
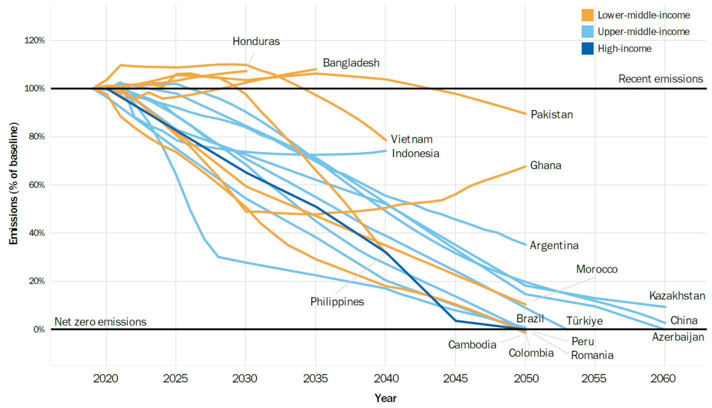
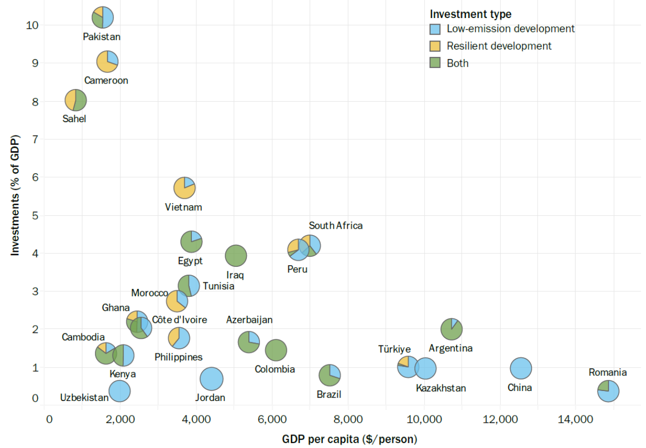


Average reduction in GHG emissions:
73%



Annual investment needs:
between 1 and 10% of GDP



Implications on GDP and consumption:
Between -0.5% and +3.3%