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P201 Back Pocket Insights

KEY INSIGHTS

• Although models broadly agree on decarbonization priorities, **there is substantial variation in specific changes** to sectoral emissions, renewables adoption, energy efficiency, electrification, and carbon removal. There is no one-size-fits all approach.

• **There is more regional variation in mitigation strategies than national scenarios indicate**, reflecting large differences in mitigation opportunities and costs.

• **Uncertainty is likely larger than scenario databases suggest** due to incomplete coverage of policy design, socioeconomic drivers, and other risks.

This brief is based on paper "Uses and Limits of National Decarbonization Scenarios to Inform Net-Zero Transitions" published in *Joule* (2024)

Uses and Limits of Decarbonization Scenarios to Inform Net-Zero Transitions

by John Bistline, Morgan Browning, Julianne DeAngelo, Daniel Huppmann, Ryan Jones, James McFarland, Anahi Molar-Cruz, Steven Rose, and Steven Davis

New research summarizes uses and challenges with applying decarbonization scenarios to inform policy and planning.

Although decarbonization scenarios are often used for policy design, company strategy, and stakeholder engagement, they have important limitations that may not be widely appreciated.

We highlight such value and limits using a new database of scenarios that reach economy-wide net-zero CO_2 emissions in the U.S. by 2050, which was compiled as part of the U.S. Fifth National Climate Assessment (NCA5).

Results from the scenario database suggest that **many emissions pathways are consistent with a national net-zero CO_2 goal** (Figure 1):

- Models agree that the **power sector has significant CO_2 reductions by 2050** with 68-103% reductions from 2020 levels, though with greater near-term uncertainty.
- **Transport has extensive reductions to reach net-zero**, but the pace is slower than power sector with more uncertainty about magnitudes of 2050 declines (39-100% of 2020 levels).
- Industry generally exhibits lower percentage reductions in emissions than other sectors, though there is **substantial cross-model variation in industrial emissions reductions**.

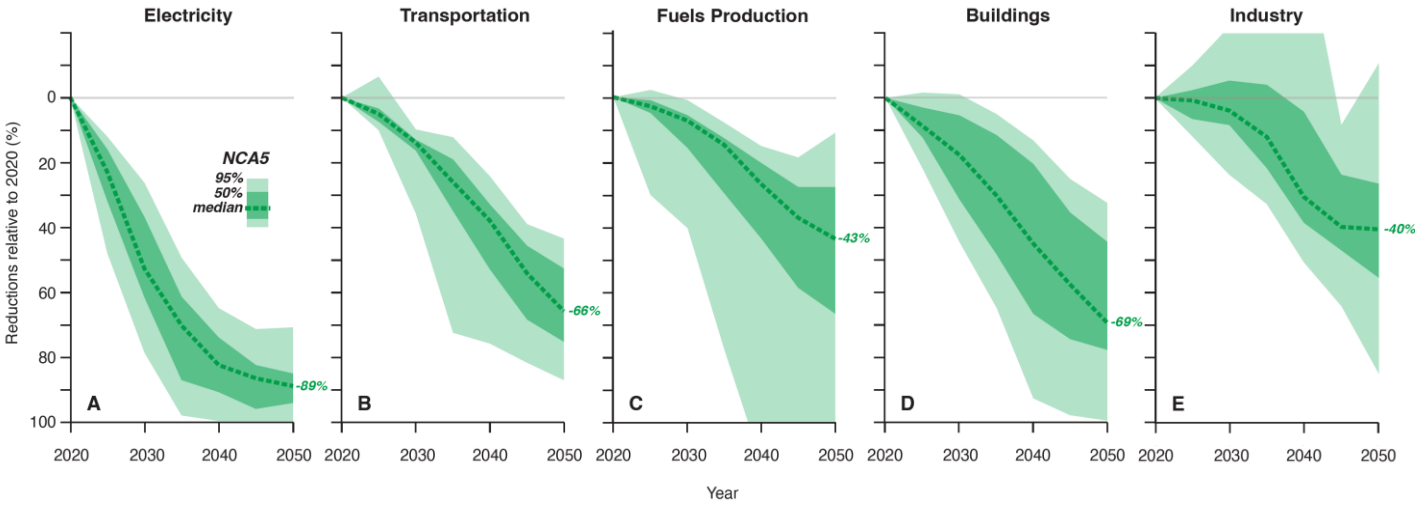

Figure 1. Sectoral CO_2 reductions across models for U.S. economy-wide net-zero CO_2 by 2050 scenarios. Panels show median (dotted line), 25th to 75th percentile range (darker area), and 2.5th to 97.5th percentile range (lighter area). Panels indicate CO_2 reductions relative to 2020 levels for electricity (**A**), transportation (**B**), fuels production (**C**), buildings (**D**), and industry (**E**). Based on Bistline, et al. (2024) with scenarios from the U.S. National Climate Assessment database.

These results suggest that applying uniform emissions targets to sectors is neither cost-effective nor equitable. Such **one-size-fits-all guidance ignores the significant heterogeneity in abatement across sectors, geographies, and companies**.

Uncertainty bounds for transition paths may be broader than current guidance suggests, especially aggregate pathways that ignore differences in abatement opportunities across regions and sectors. For instance, power sector benchmarks from Climate Action Tracker entail 90-95% reductions by 2030 from 2005 levels, compared with 43-92% in the NCA5 database (Figure 1).

Emissions targets are only one element of low-carbon transition risk that stakeholders consider, including electrification, carbon removal, infrastructure deployment, low-emitting fuels production, and policy design. Figure 2 highlights the significant variation in these areas across models and scenarios.

- Although **electrification is expected to be a key mechanism of energy system decarbonization**, scenarios project a wide range of possible electricity demand growth, ranging from 150-280% from 2020 levels.

- National models tend to project higher solar and wind shares than global models, which could be due to their more up-to-date costs, inclusion of a greater range of mitigation technologies, and policy coverage. However, **the NCA5 database indicates a broader range of renewables deployment** (1.1 to 3.8 times current levels by 2030) than international pledges at COP28, where 123 countries including the U.S. pledged to triple installed renewable capacity by 2030.

Uncertainty is likely larger than database ranges suggest because scenario ensembles may not cover the full set of uncertainties related to policy design, socioeconomic drivers, and other risks.

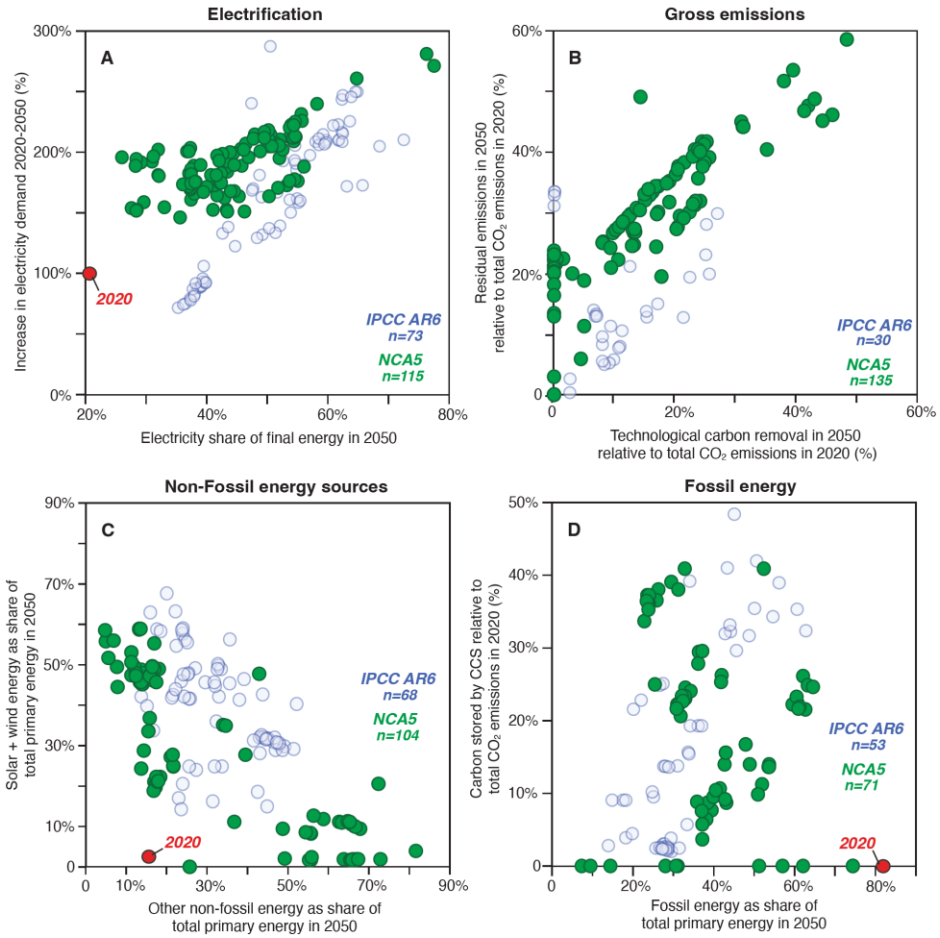

Figure 2. Energy system metrics for U.S. economy-wide net-zero CO_2 by 2050 scenarios. Scenarios show differences in electrification (**A**), carbon removal (**B**), non-fossil energy (**C**), and fossil energy (**D**). Based on Bistline, et al. (2024) with scenarios from the U.S. National Climate Assessment database (green) and IPCC results (blue) that report U.S. national results reaching net-zero CO_2 in 2050.

Existing U.S. net-zero studies typically focus on national results; however, **national values can mask considerable regional diversity in decarbonization opportunities and costs**. This is due to factors such as wind and solar resources, state policies, fuel markets, existing infrastructure, CO_2 storage costs and availability, and inter-regional transmission capacity. These differences lead to variation in emissions, system impacts, policy costs, and electricity prices.

Uncertainties in policy design represent transition risks that may not be represented in scenario databases, including uncertainty in state- and federal-level emissions and clean energy policies. Methods for setting and evaluating targets (e.g., for companies, cities, or countries) should consider uncertainties, recognize the uniqueness of company and regional circumstances, account for multiple objectives, and provide flexibility and support robust strategies due to uncertainty. EPRI's SMARTargets project is developing a new methodology for companies to set emissions targets that are grounded in the relevant science, actionable in terms of considering company opportunities and risks, and aligned with global goals.

Understanding decarbonization scenarios is important for informed policy design, company strategy, and stakeholder engagement, including discussions regarding greenhouse gas target setting, transition risk assessment, and cost-effective decarbonization.

FOR MORE INFORMATION

Read the full paper: Bistline, et al. (2024), "Uses and Limits of National Decarbonization Scenarios to Inform Net-Zero Transitions" in *Joule*.

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