REPEAT Rapid Energy Policy Evaluation and Analysis Toolkit

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Climate Progress 2024: REPEAT Project's Annual U.S. Emissions Pathways Update

Summary Report

August 2024

Climate Progress 2024

REPEAT Project's Annual U.S. Emissions Pathways Update

Summary Report

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2. Evolved Energy Research

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Forward

In this Summary Report, we provide high level results from REPEAT Project's **2024 Annual U.S. Emissions Pathways Update**. A final report with further detailed findings and an updated data portal with quantitative results will be published soon at repeatproject.org.

In this annual update, we have revised all assumptions to reflect the latest data available as of Spring 2024, including updating macro-economic conditions, fuel costs, and electricity technology cost assumptions.[1] Compared to 2023, this update includes a notable increase in economic outlook and overall demand for energy services as well as an increase in project finance costs and real capital costs for several technologies due to recent inflation. Additionally, with two years now since the passage of the Inflation Reduction Act, we now have better visibility on near-term market conditions under the current policy environment. As such, we carefully benchmarked 2023 modeled results against actual outcomes, available data on announced projects, and several published industry outlooks, resulting in a comprehensive update to near-term capacity deployment constraints.

This analysis includes three **Current Policies** scenarios ('Conservative', 'Mid-range', and 'Optimistic') which reflect uncertainty about policy effectiveness and the potential impacts of constraints on supply chains and other rate-limiting factors. Note that each Current Policies case employs consistent macro-economic assumptions. In this annual update, **the Current Policies scenarios also include a set of recently finalized federal regulations** on greenhouse gas emissions from power plants, on-road vehicles, and oil & gas methane emissions, as well as all finalized appliance and lighting efficiency standards. The report also presents two benchmark scenarios: a **Frozen Policies (Jan. '21)** scenario which only reflects policies enacted as of the start of the 117th Congress in January 2021; and a **Net-Zero Pathway** scenario, which reflects a cost-effective pathway to reduce U.S. greenhouse gas emissions from 2024 levels to net-zero by 2050, consistent with the United States' long-term climate mitigation goals.[2]

Given the significant uncertainty about future outcomes, **all results in this report should be considered approximate**. REPEAT Project updates our analysis regularly as new data and inputs become available and new policies are proposed and enacted.

Note that this work has not been subject to formal peer review.

1 - This study primarily reflects data and assumptions derived from the U.S. Energy Information Administration's 'Annual Energy Outlook 2023', National Renewable Energy Laboratory's 'Annual Technology Baseline 2023', and Evolved Energy Research's 'Annual Decarbonization Perspectives 2023'.

2 - Note that the 'Net-Zero Pathway' in this report no longer meets the US 2030 Nationally Determined Contribution target of a 50-52% reduction in emissions below 2005 levels; instead, it reflects a straight line decline in U.S. net greenhouse gas emissions from 2024 to net-zero in 2050, which results in 46% below 2005 levels in 2030 and 60% below in 2035.

Progress on the path to net-zero

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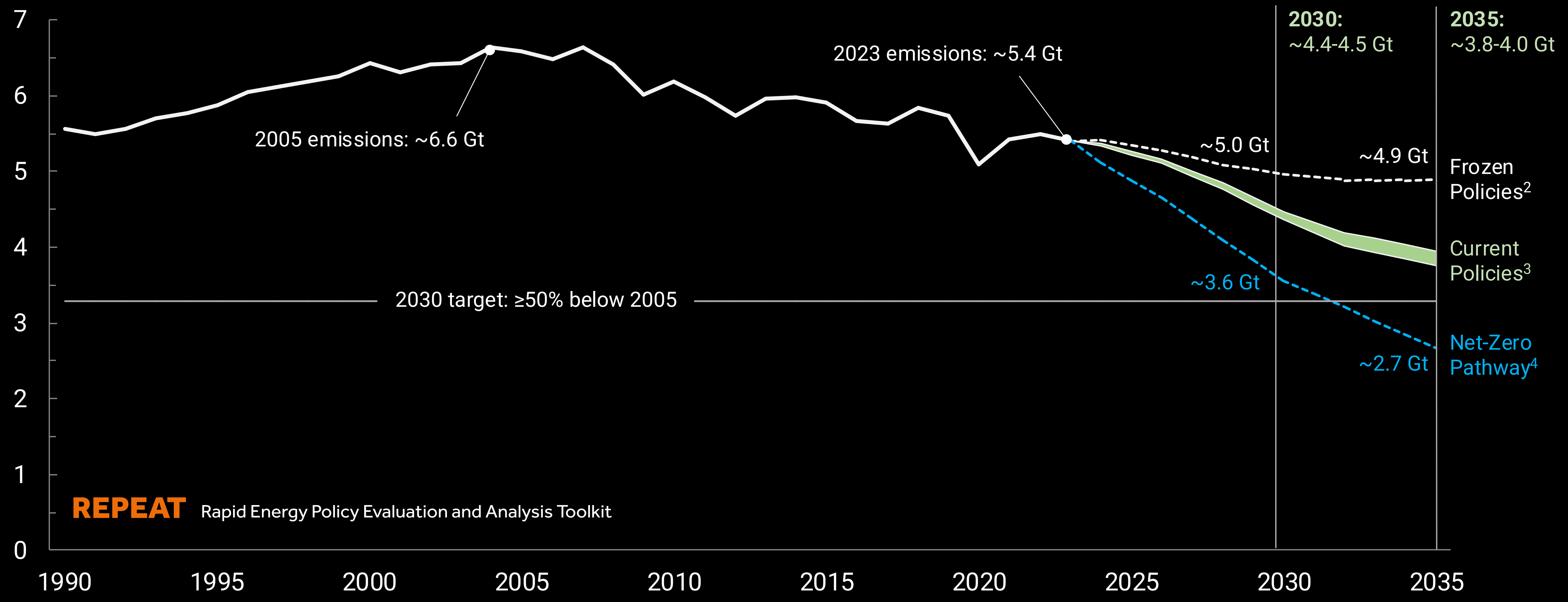
Historical and Modeled Net U.S. Greenhouse Gas Emissions (Including Land Carbon Sinks)
billion metric tons CO_2-equivalent (Gt CO_2-e)[1]



1 – Historical emissions from EPA Inventory of Greenhouse Gas Emissions and Sinks. All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values should be regarded as approximate given uncertainty in future outcomes.**

2 – 'Frozen Policies' benchmark scenario reflects policies enacted as of January 1st, 2021 (e.g., prior to the 117th Congress and inauguration of President Joseph Biden)

3 - `Current Policies' scenarios reflect all current statutory and regulatory policies as of June 2024. Variation in outcomes reflects uncertainty about policy effectiveness and the potential impacts of constraints on supply chains and other rate-limiting factors and does not include the impacts of broader macroeconomic uncertainty (which could result in larger variation in eventual emissions outcomes).

4 – 'Net-Zero Pathway' benchmark scenario reflects a straight-line reduction in emissions from 2023 historical levels to net-zero by 2050.

Reductions from 2005 emissions

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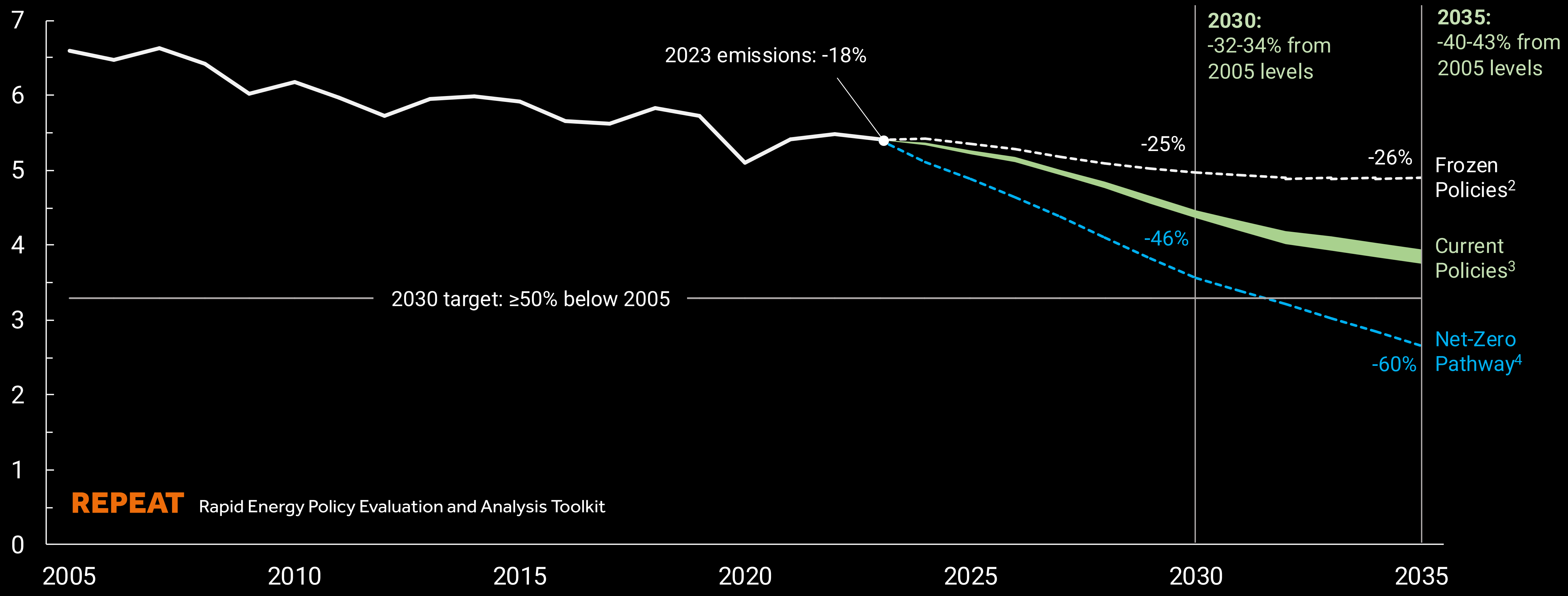
Historical and Modeled Net U.S. Greenhouse Gas Emissions Compared to 2005 Benchmark
billion metric tons CO_2-equivalent (Gt CO_2-e)[1]



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3 - `Current Policies' scenarios reflect all current statutory and regulatory policies as of June 2024. Variation in outcomes reflects uncertainty about policy effectiveness and the potential impacts of constraints on supply chains and other rate-limiting factors and does not include the impacts of broader macroeconomic uncertainty (which could result in larger variation in eventual emissions outcomes).

4 – 'Net-Zero Pathway' benchmark scenario reflects a straight-line reduction in emissions from 2023 historical levels to net-zero by 2050.

Sectoral emissions

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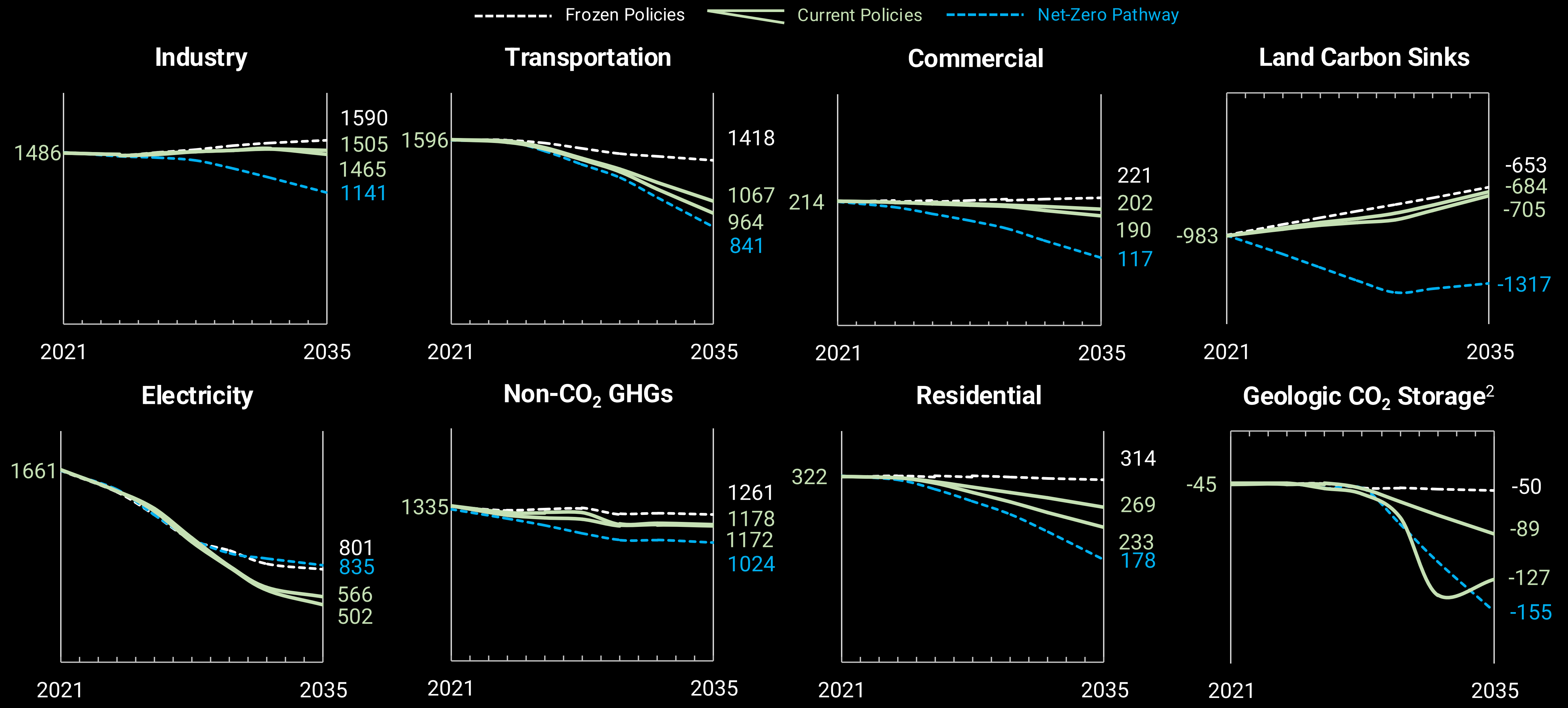
Modeled U.S. Greenhouse Gas Emissions By Sector
million metric tons CO_2-equivalent (Gt CO_2-e)[1]



1 – All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values should be regarded as approximate given uncertainty in future outcomes.**

2 – Includes 37 million metric tons/year of CO_2 injection at existing enhanced oil recovery operations (Source: EPA GHGRP).

Policy-driven declines across all sectors

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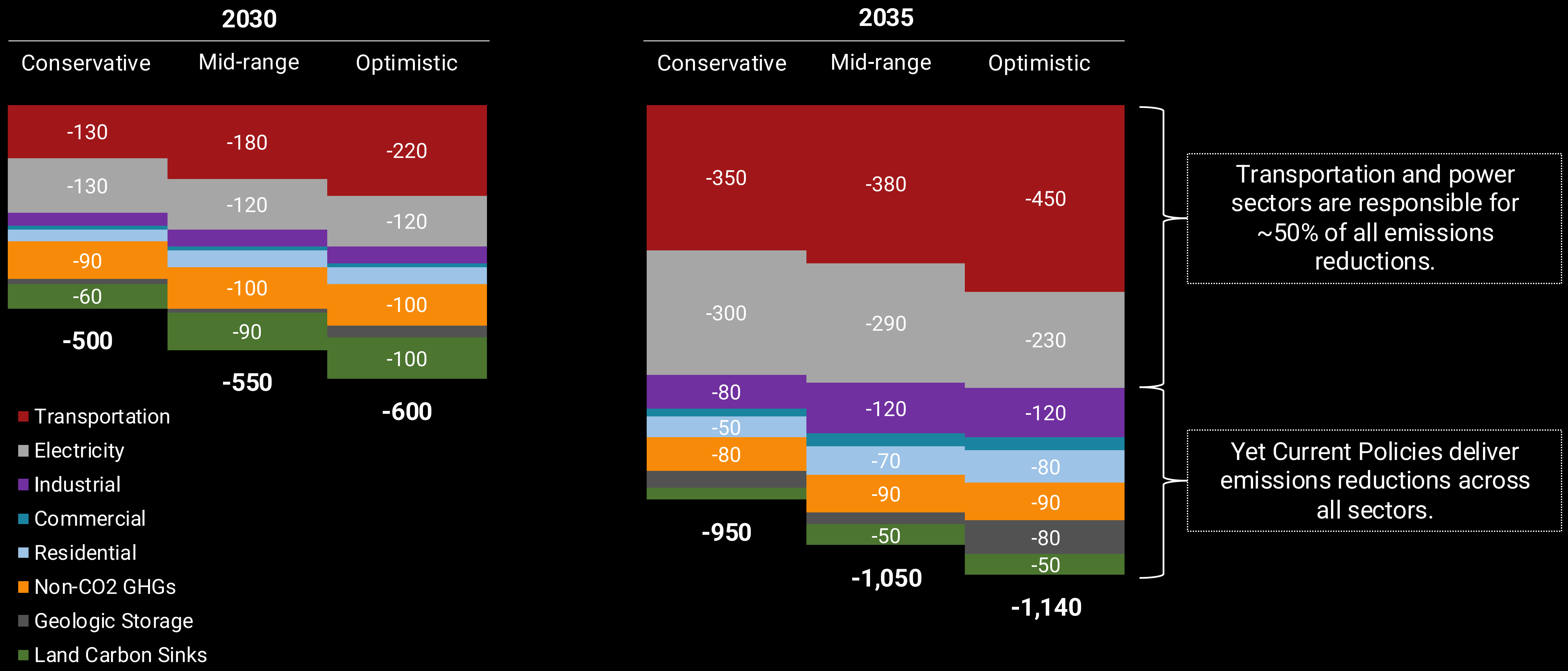
Difference in Sectoral Emissions Under Current Policies vs Frozen Policies Scenario
million metric tons CO_2-equivalent (Mt CO_2-e)[1]



1 – All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values rounded to nearest 10 Mt/yr and values less than 50 Mt/yr are excluded from data labels. All values should be regarded as approximate given uncertainty in future outcomes.**

Closing the gaps to net-zero

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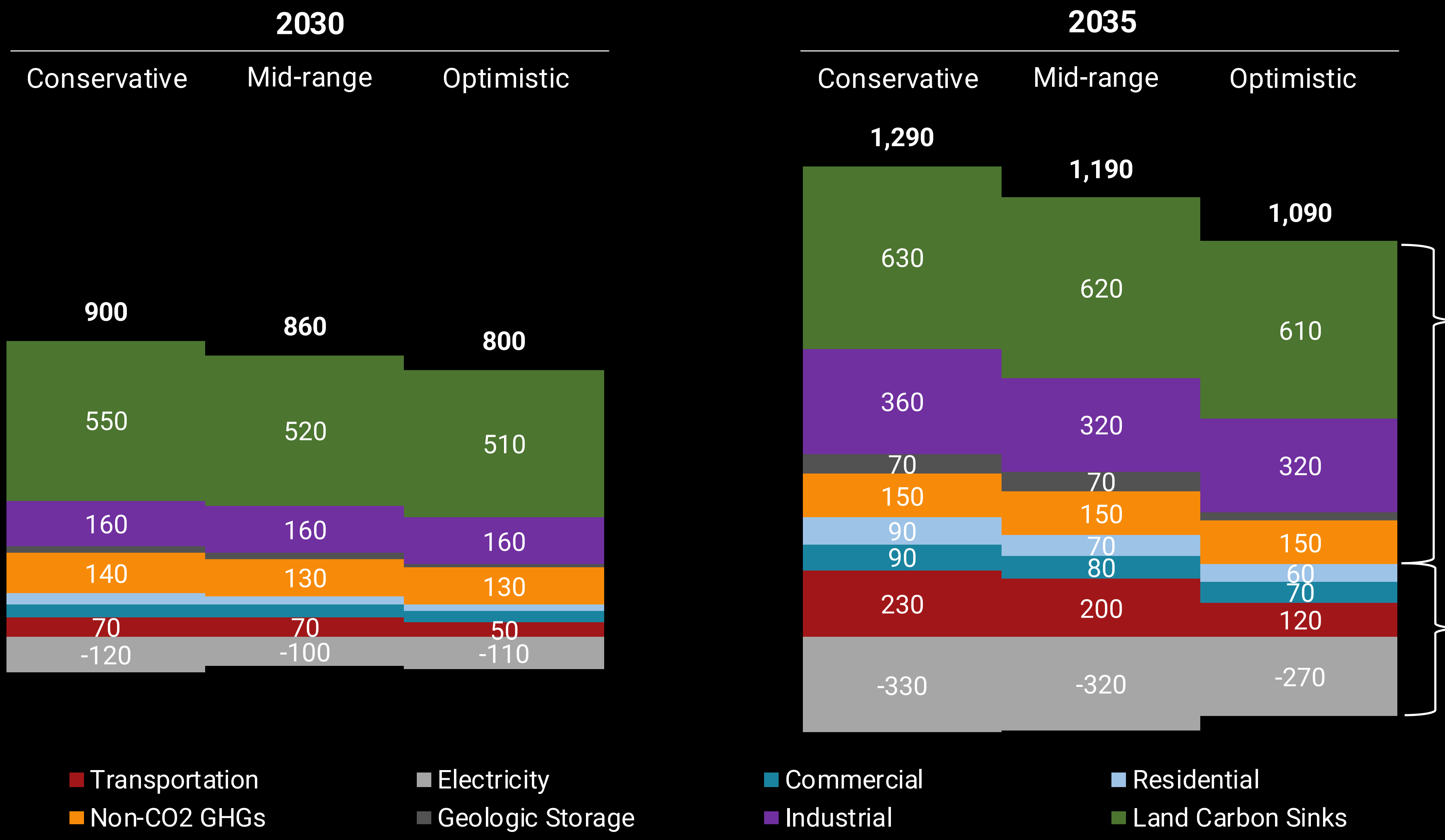
Difference in Sectoral Emissions Under Current Policies vs Net-Zero Pathway
million metric tons CO_2-equivalent (Mt CO_2-e)[1]



Further emissions reductions are needed to get on the path to net-zero.

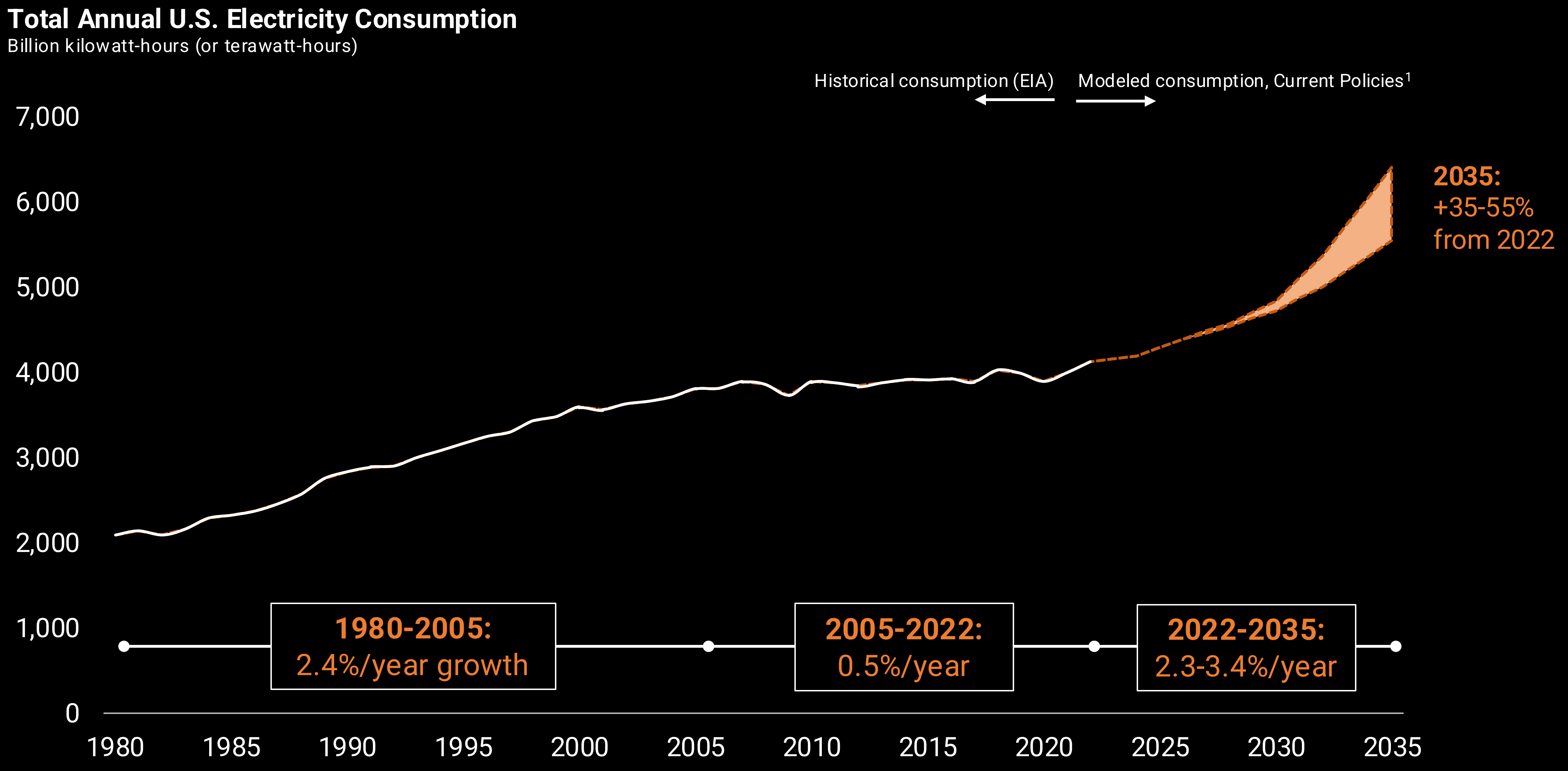
Major opportunities:

1. Agriculture: methane & N_2O, soils & forests.
2. Industrial efficiency & decarbonization

In aggregate, electricity decarbonization & electrification are largely on track, though we expect electrification to proceed more slowly and electricity decarbonization more rapidly under Current Policies than the Net-Zero Pathway

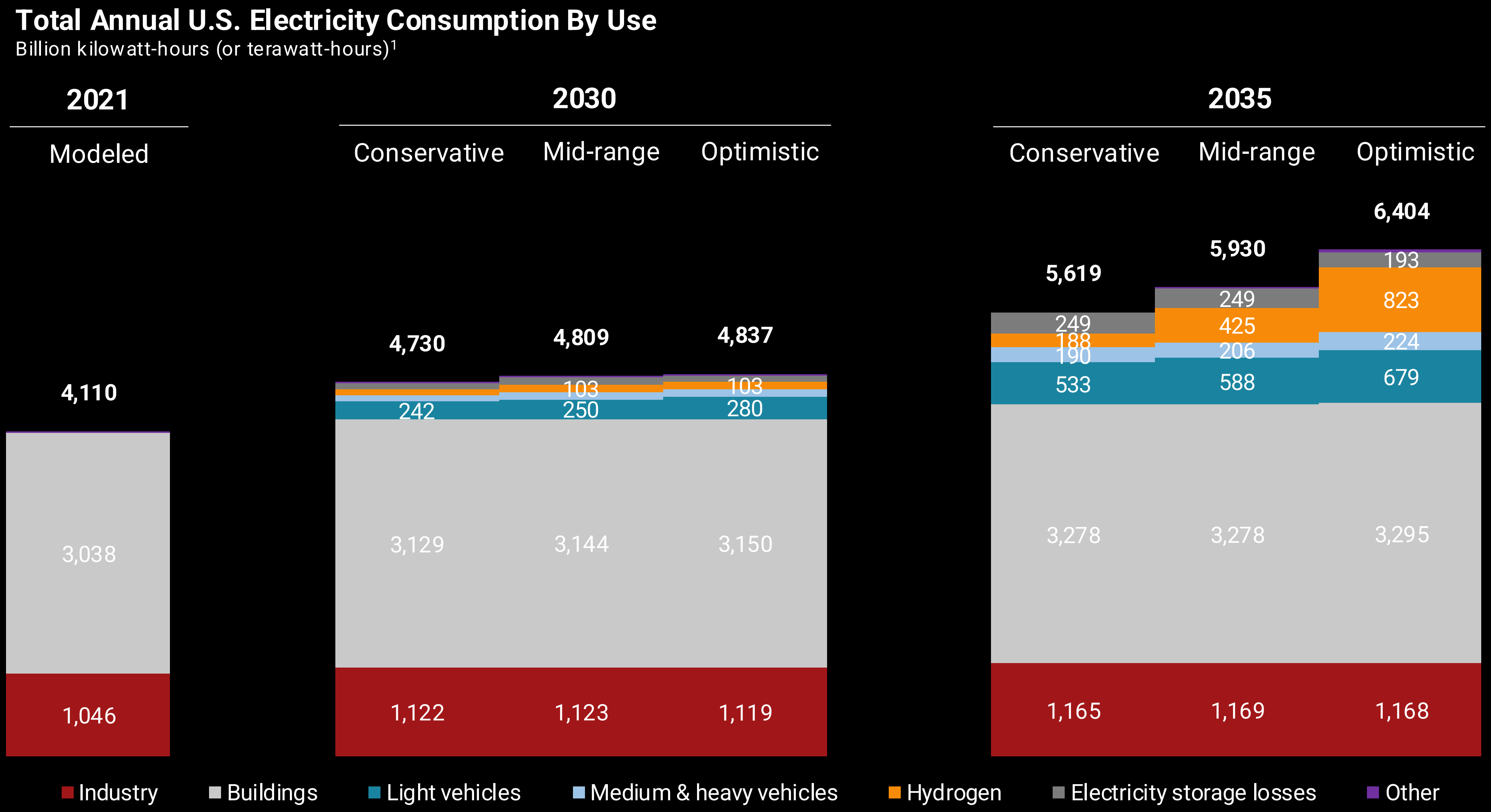
1 – All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values rounded to nearest 10 Mt/yr and values less than 50 Mt/yr are excluded from data labels. All values should be regarded as approximate given uncertainty in future outcomes.**

Electricity sector must prepare for growth



1 – Note that data center demand growth in this report is based on U.S. Energy Information Administration's *Annual Energy Outlook 2023* Reference scenario, which **does not fully account for potential growth in data center electricity demand**. Data center demand growth is highly uncertain at this time, but could add on the order of 50-260 TWh of additional demand by 2030 (and more by 2035) beyond the ~40 TWh included in the EIA scenario used herein (based on 2024 projections from Rhodium Group (see p. 14) and Goldman Sachs).

Sources of electricity demand

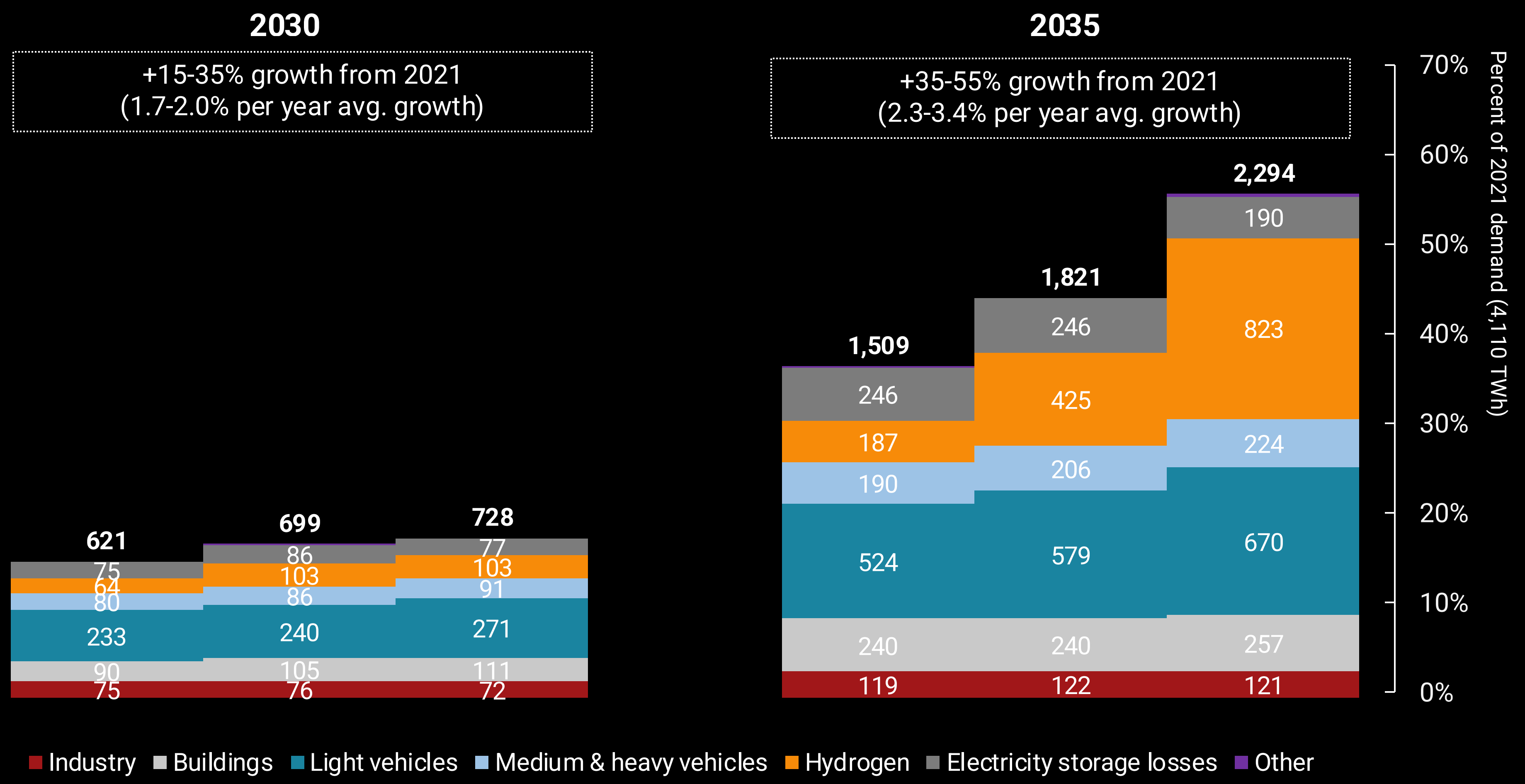


Values less than 100 TWh omitted from data labels.

1 – Note that data center demand growth in this report is based on U.S. Energy Information Administration's *Annual Energy Outlook 2023* Reference scenario, which **does not fully account for potential growth in data center electricity demand**. Data center demand growth is highly uncertain at this time, but could add on the order of 50-260 TWh of additional demand by 2030 (and more by 2035) beyond the ~40 TWh included in the EIA scenario used herein (based on 2024 projections from Rhodium Group (see p. 14) and Goldman Sachs).

Drivers of electricity demand growth

Increase In Annual U.S. Electricity Consumption By Use Vs 2021
Billion kilowatt-hours (or terawatt-hours)[1]

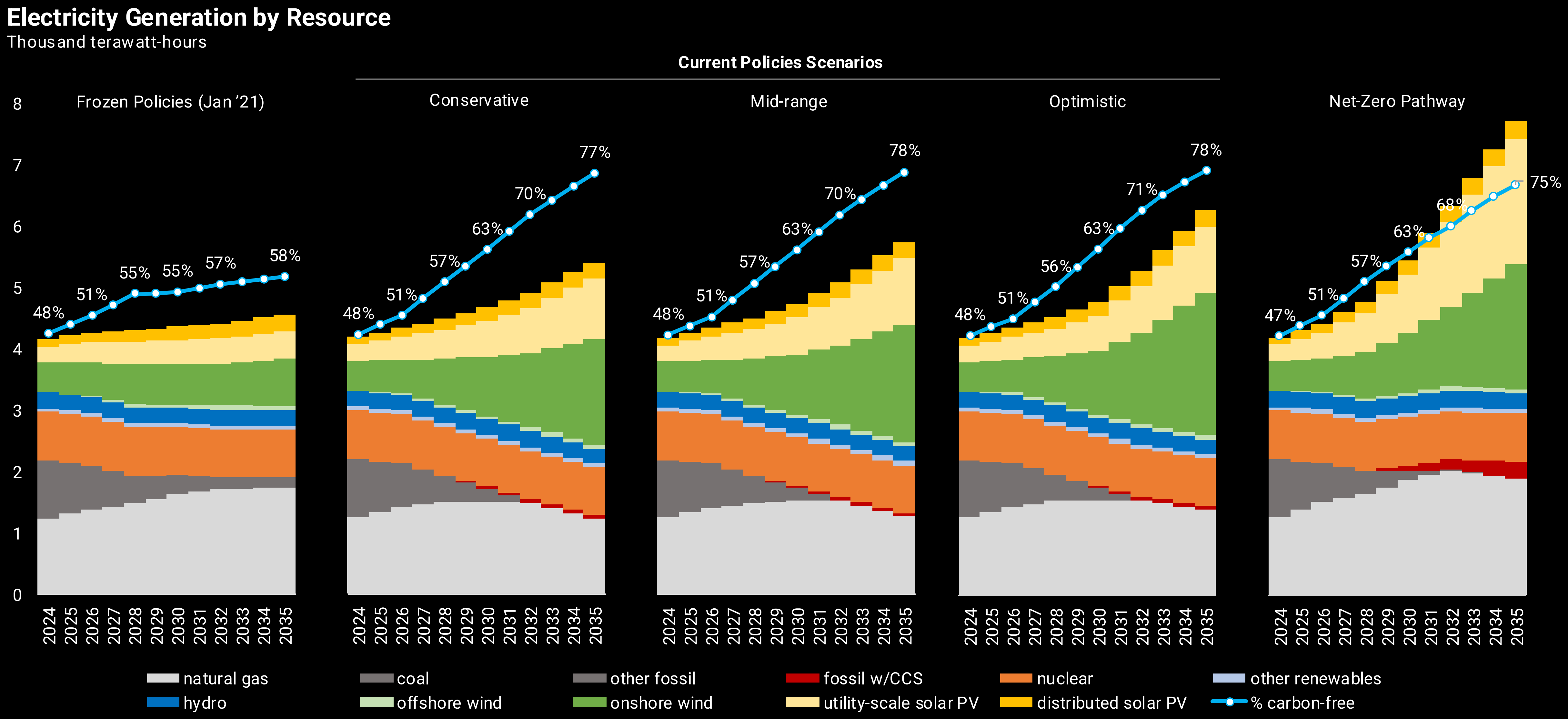


Plus more from data centers…

Growing demand from data centers could contribute on the order of 50-260 TWh of additional growth in electricity consumption in 2030 that is not accounted for in this analysis.[1]

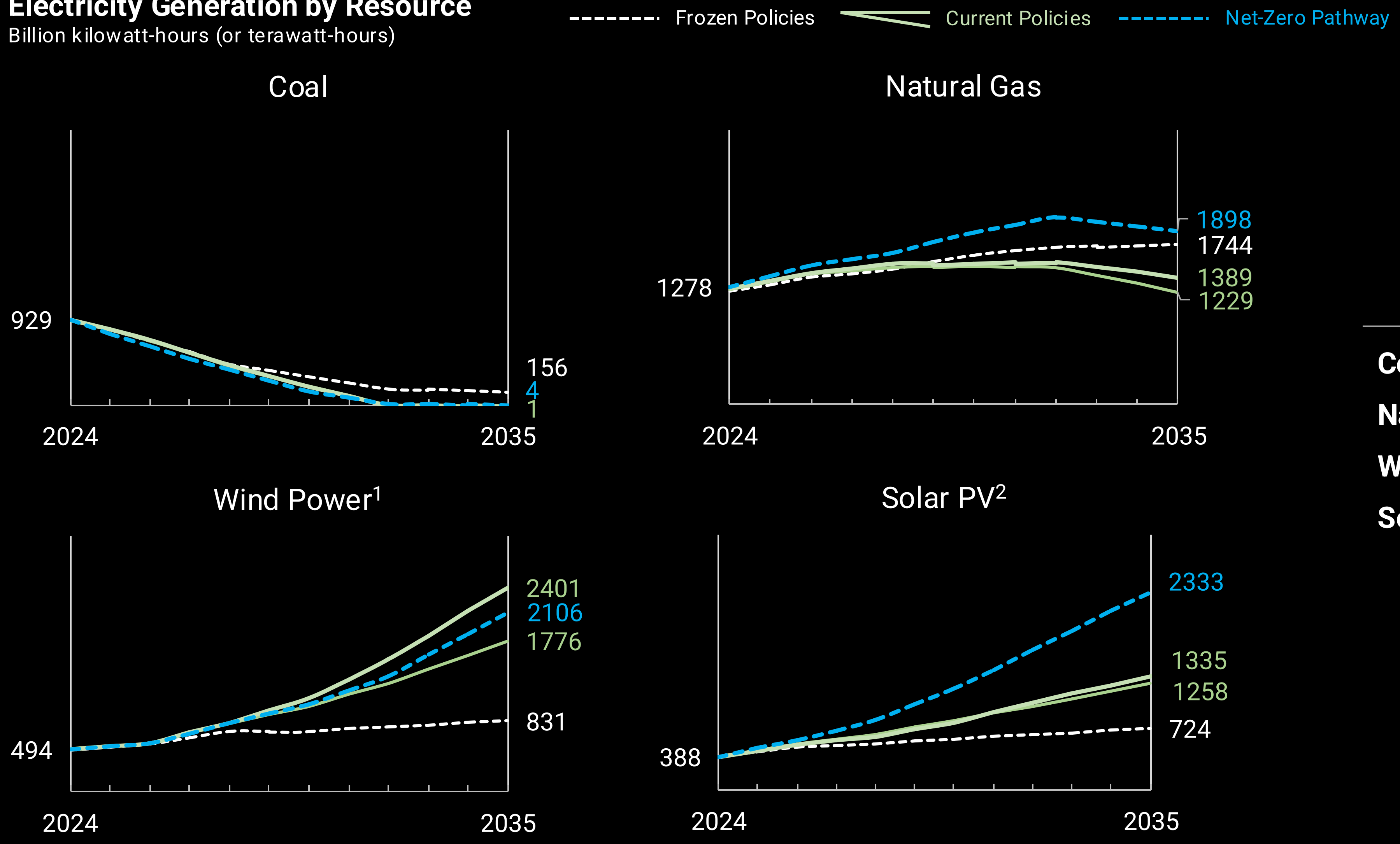
1 – Note that data center demand growth in this report is based on U.S. Energy Information Administration's *Annual Energy Outlook 2023* Reference scenario, which **does not fully account for potential growth in data center electricity demand**. Data center demand growth is highly uncertain at this time, but could add on the order of 50-260 TWh of additional demand by 2030 (and more by 2035) beyond the ~40 TWh included in the EIA scenario used herein (based on 2024 projections from Rhodium Group (see p. 14) and Goldman Sachs).

Growing clean electricity supply



An evolving electricity mix

Electricity Generation by Resource
Billion kilowatt-hours (or terawatt-hours)



Change from 2024 to 2035 under Current Policies:

Coal: more than -99%

Natural Gas: -3% to +10%

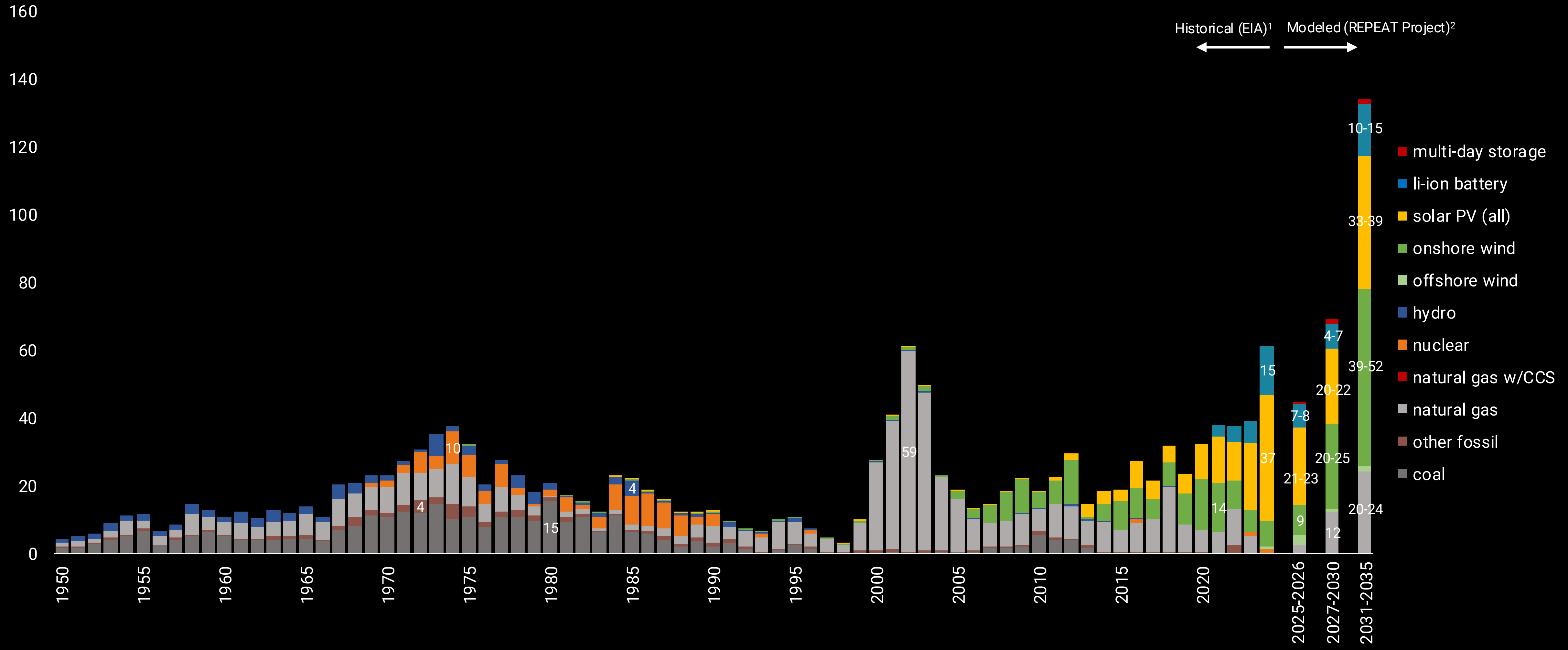
Wind Power: +259% to +384%

Solar PV: +225% to +245%

1 - Includes onshore and offshore wind
2 - Includes distributed and utility-scale solar

New capacity additions

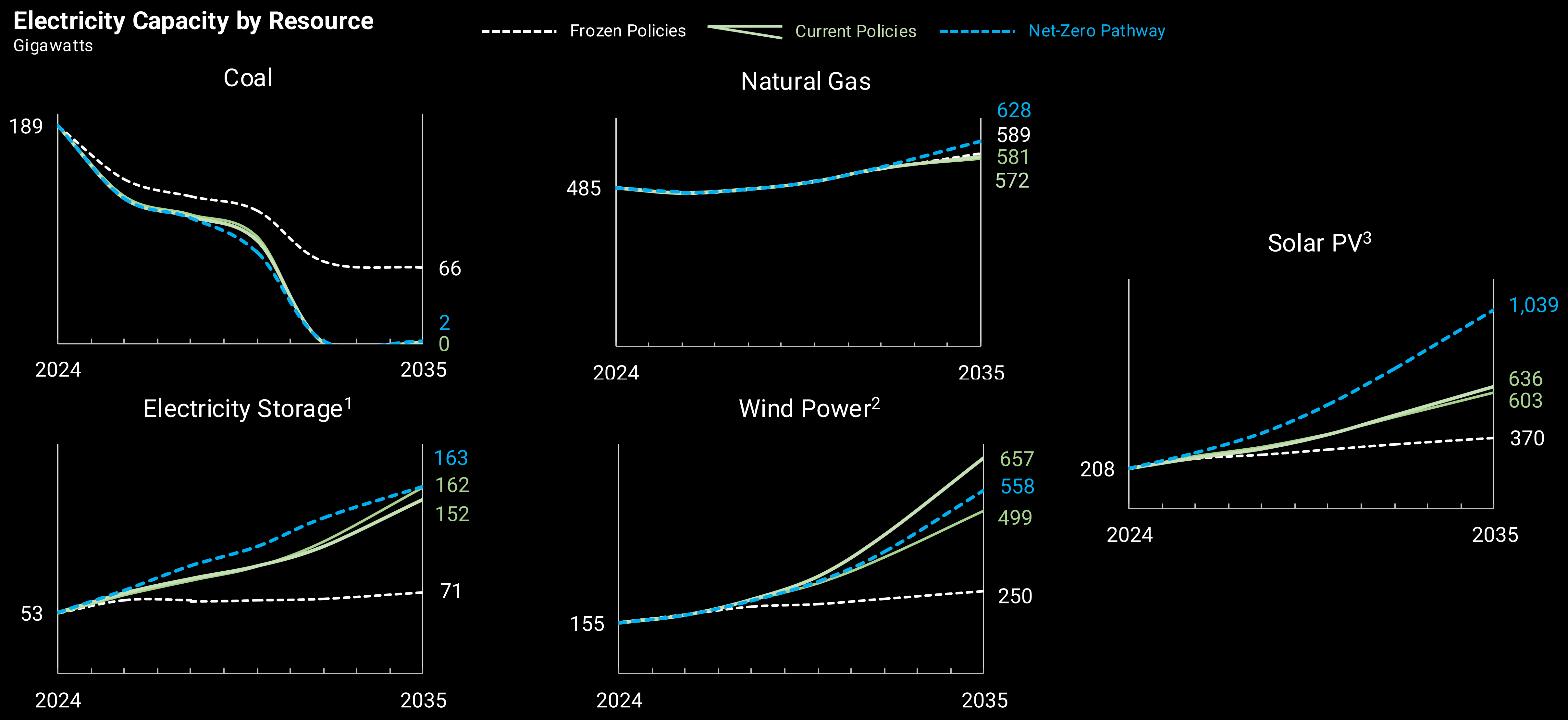
Historical Annual Electricity Capacity Additions vs. Modeled Annual Average Capacity Additions Under Current Policies Scenarios
average gigawatts/year (GW/year)



1 - Historical data labels represent peak historical annual additions for each resource (source, 1950-2020: EIA Form 860; 2021-2024: EIA Short-term Energy Outlook, August, 2024)

2 - Modeled data labels reflect range across Current Policies scenarios (Conservative, Mid-range and Optimistic). Depicted bars represent results for the Mid-range scenario.

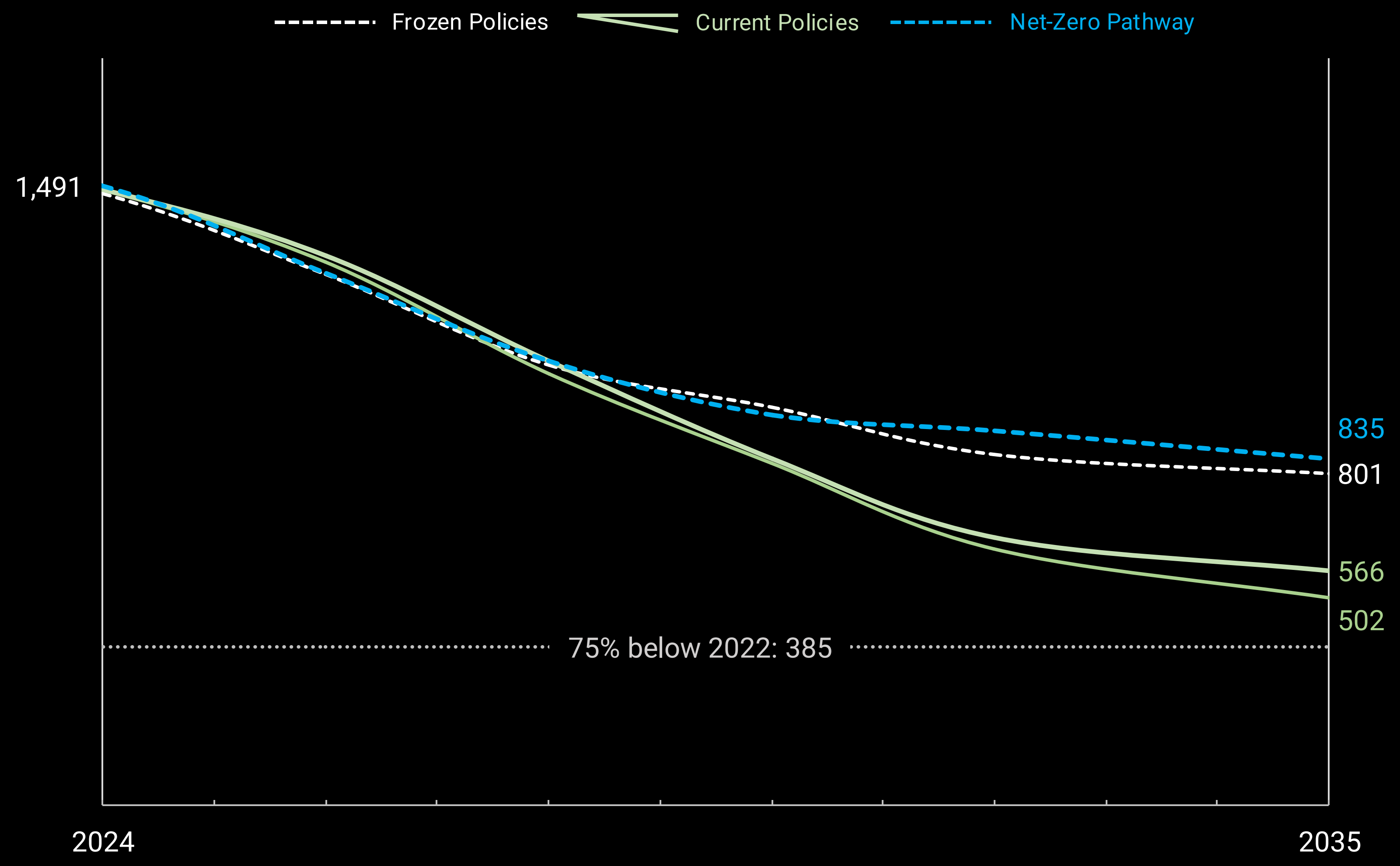
Changes in electricity capacity



1 - Includes pumped hydro, lithium-ion and multi-day storage
2 - Includes onshore and offshore wind
3 - Includes distributed and utility-scale solar

Declines in electricity sector emissions

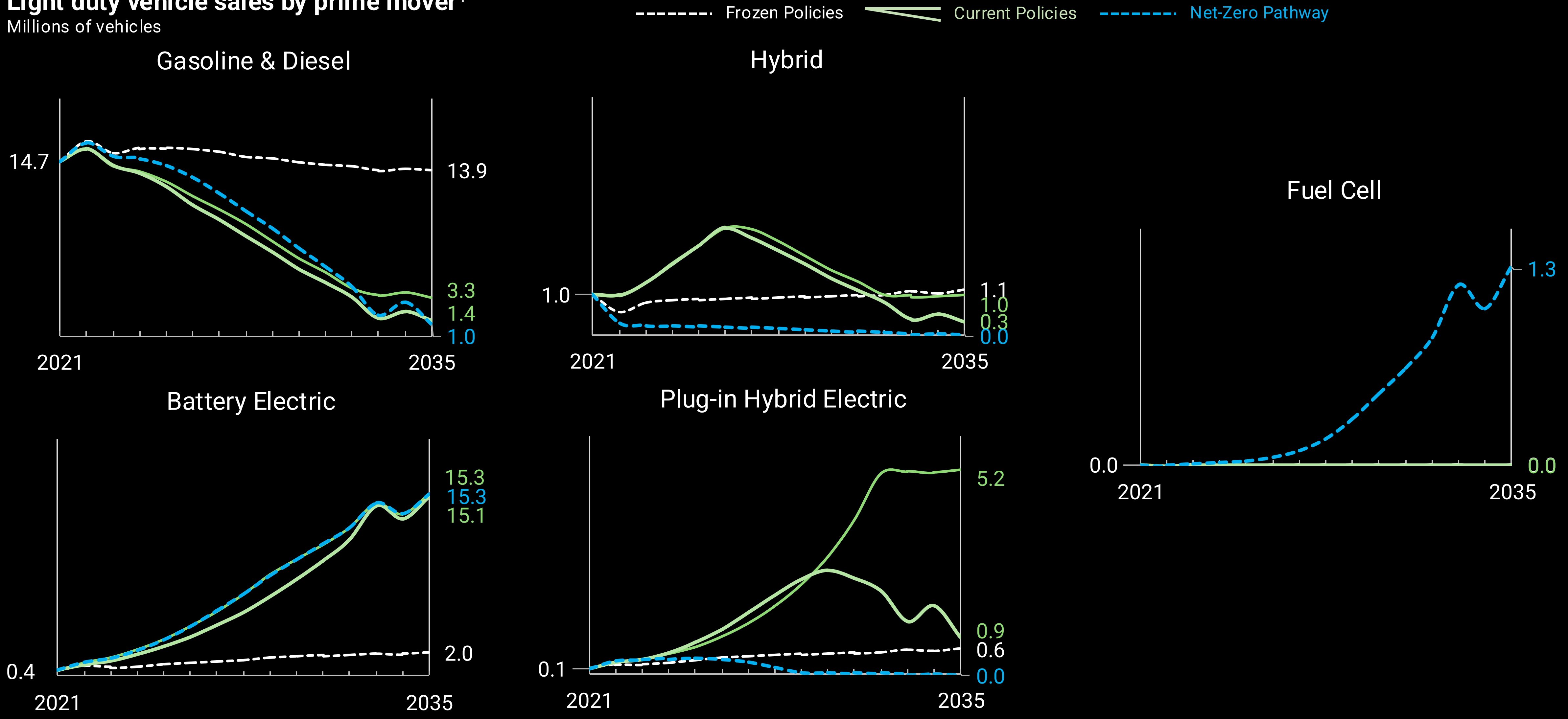
Electricity sector carbon dioxide emissions
Million metric tons of CO_2 (Gt CO_2)



Due to substantial electricity demand growth (see p.11), modeled electricity sector emissions do not fall below the threshold that would trigger phase-out of the technology-neutral production and investment tax credits established by the Inflation Reduction Act (75% below 2022 historical emissions)

Electrifying transportation

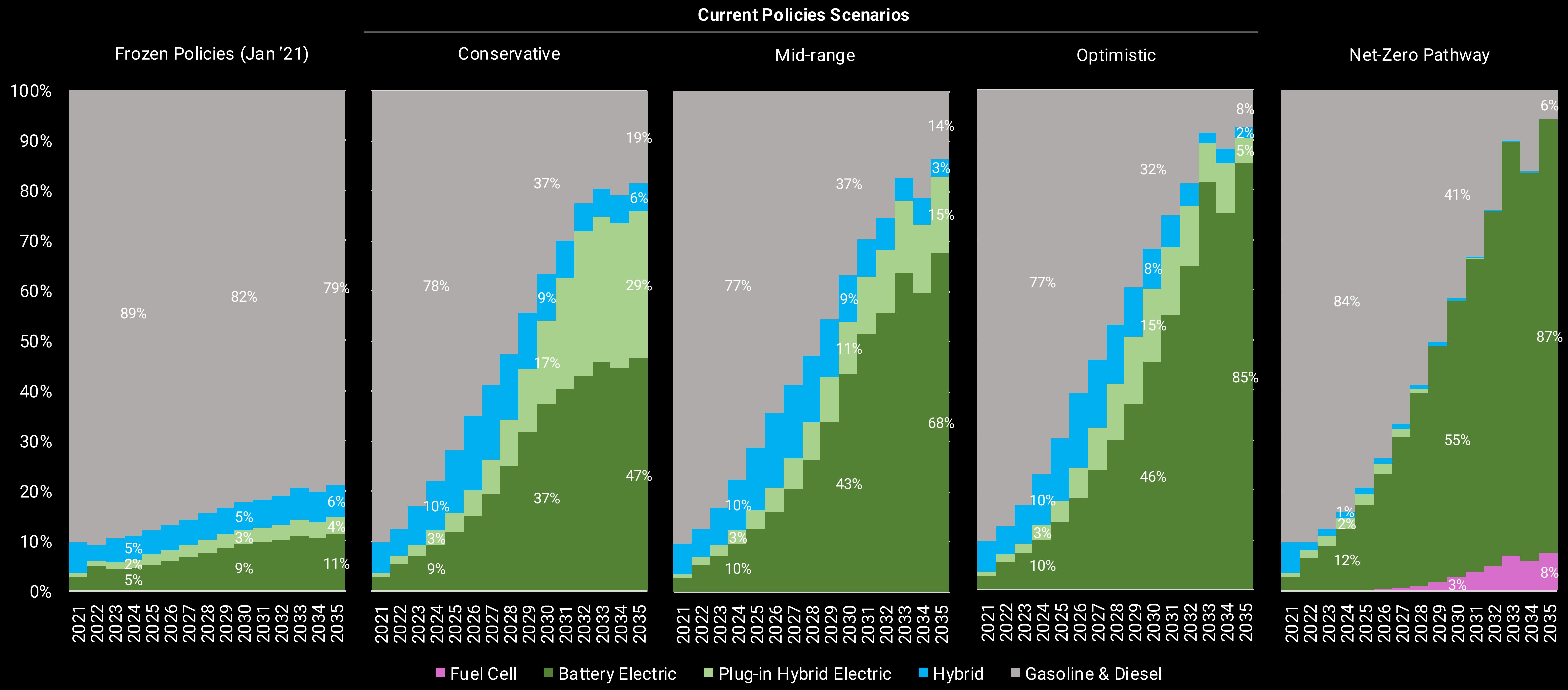
Light duty vehicle sales by prime mover[1]
Millions of vehicles



1 - Vehicle sales in Current Policies scenarios are each compliant with final Environmental Protection Agency regulations on light vehicle tailpipe emissions and California Advanced Clean Cars 2 program, which is assumed to be adopted by CA, CO, DE, ME, MD, MA, NJ, NM, NY, OR, RI, VT, VA, & WA.

The automotive sector in transition

Light duty vehicle sales share by prime mover[1]
Percent of annual sales



1 - Vehicle sales in Current Policies scenarios are each compliant with final Environmental Protection Agency regulations on light vehicle tailpipe emissions and California Advanced Clean Cars 2 program, which is assumed to be adopted by CA, CO, DE, ME, MD, MA, NJ, NM, NY, OR, RI, VT, VA, & WA.

Impact of final regulations

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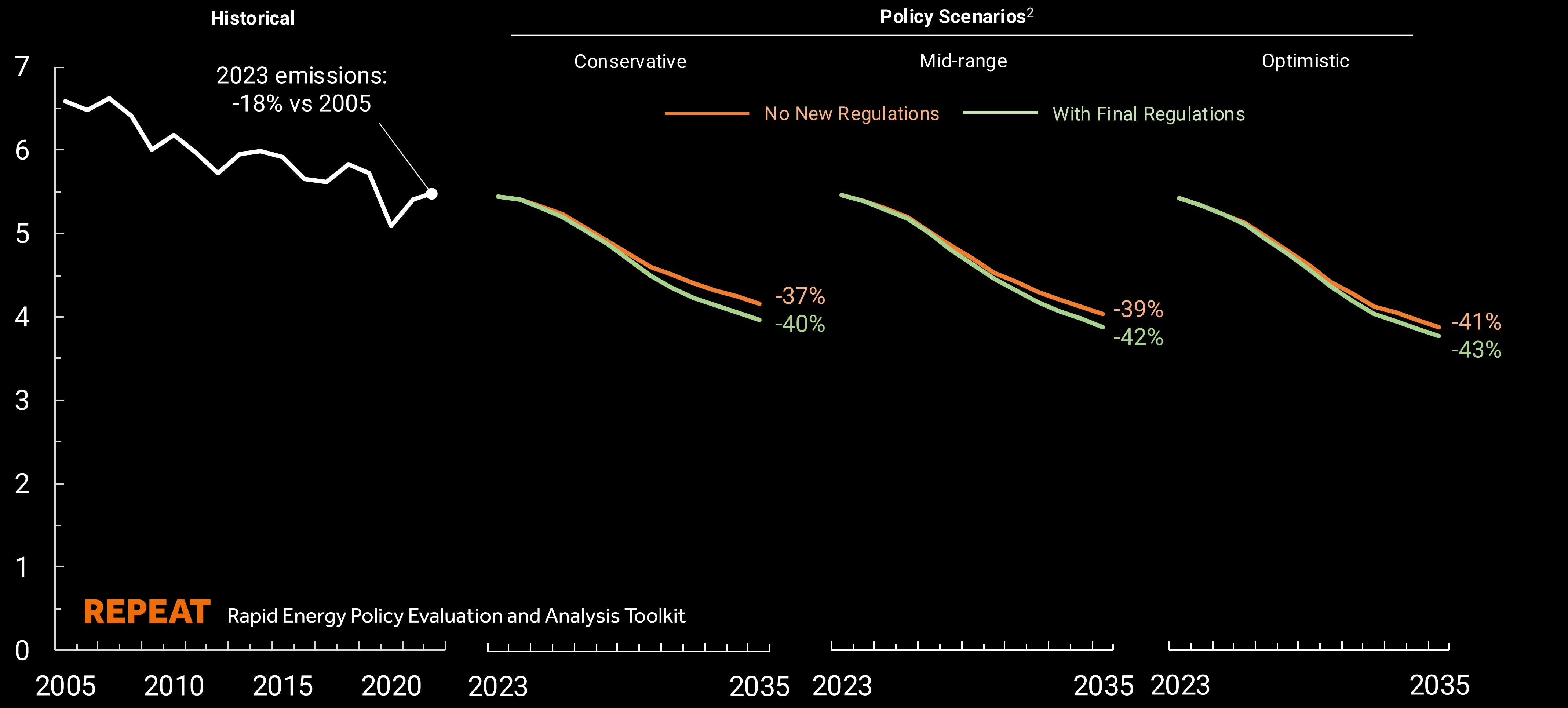
Historical and Modeled Net U.S. Greenhouse Gas Emissions Compared to 2005 Benchmark
billion metric tons CO_2-equivalent (Gt CO_2-e)[1]



1 – Historical emissions from EPA Inventory of Greenhouse Gas Emissions and Sinks. All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values should be regarded as approximate given uncertainty in future outcomes.**

2 - `Current Policies' scenarios reflect all current statutory and regulatory policies as of June 2024. `Without Finalized Regulations' excludes final Environmental Protection Agency regulations on oil & gas methane emissions, light and heavy vehicle tailpipe emissions and power plant greenhouse gas emissions, as well as all Department of Energy appliance and lighting efficiency standards finalized during the Biden Administration.

Comparison to REPEAT 2023 results

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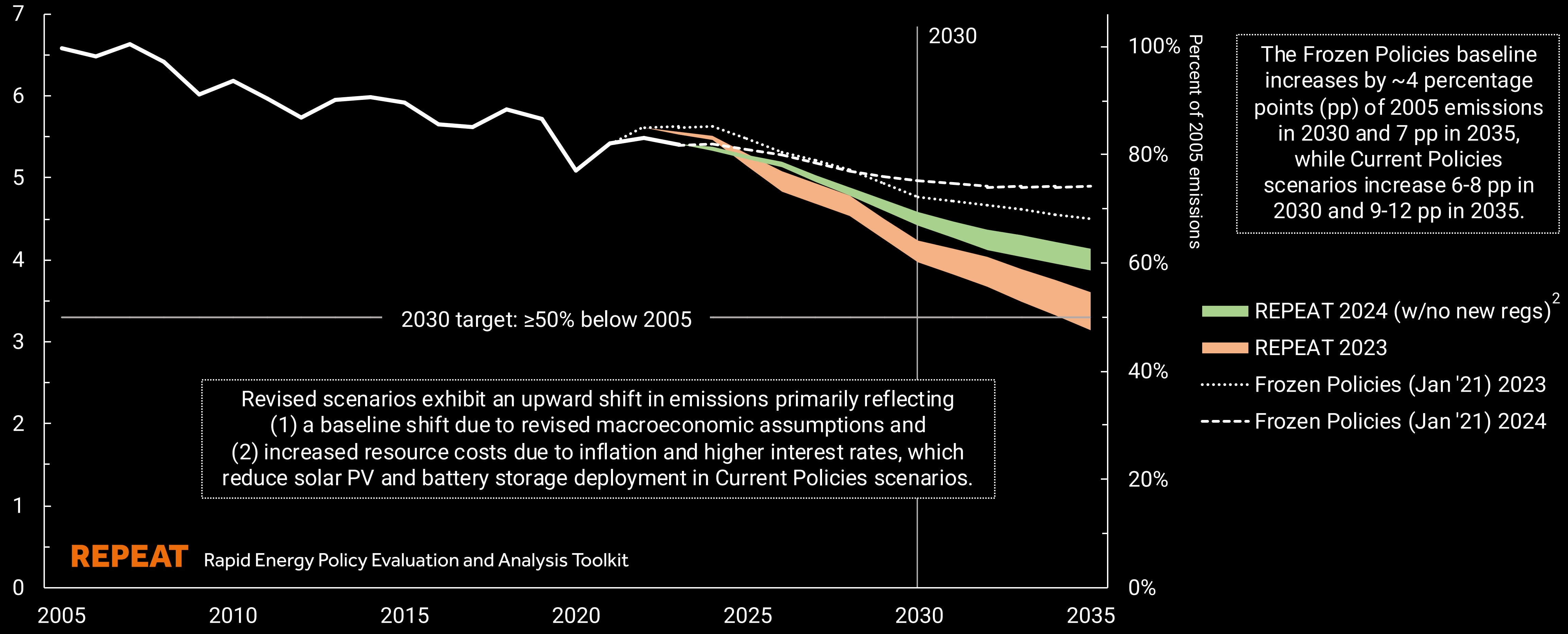
Historical and Modeled Net U.S. Greenhouse Gas Emissions from 2023 and 2024 REPEAT Project annual reports

billion metric tons CO_2-equivalent (Gt CO_2-e)[1]



1 – Historical emissions from EPA Inventory of Greenhouse Gas Emissions and Sinks. All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values should be regarded as approximate given uncertainty in future outcomes.**

2 - To present the most comparable cases, REPEAT Project 2023 Current Policies scenarios are compared to 2024 Current Policies without finalized Environmental Protection Agency regulations on oil & gas methane emissions, light and heavy vehicle tailpipe emissions and power plant greenhouse gas emissions, and Department of Energy appliance and lighting efficiency standards, as these regulations were not included in our 2023 scenarios (see REPEAT Project, "Climate Progress in the 117th Congress: The Impacts of the Inflation Reduction and and Infrastructure Investment and Jobs Act," July 2023.

Comparison to other modeling studies

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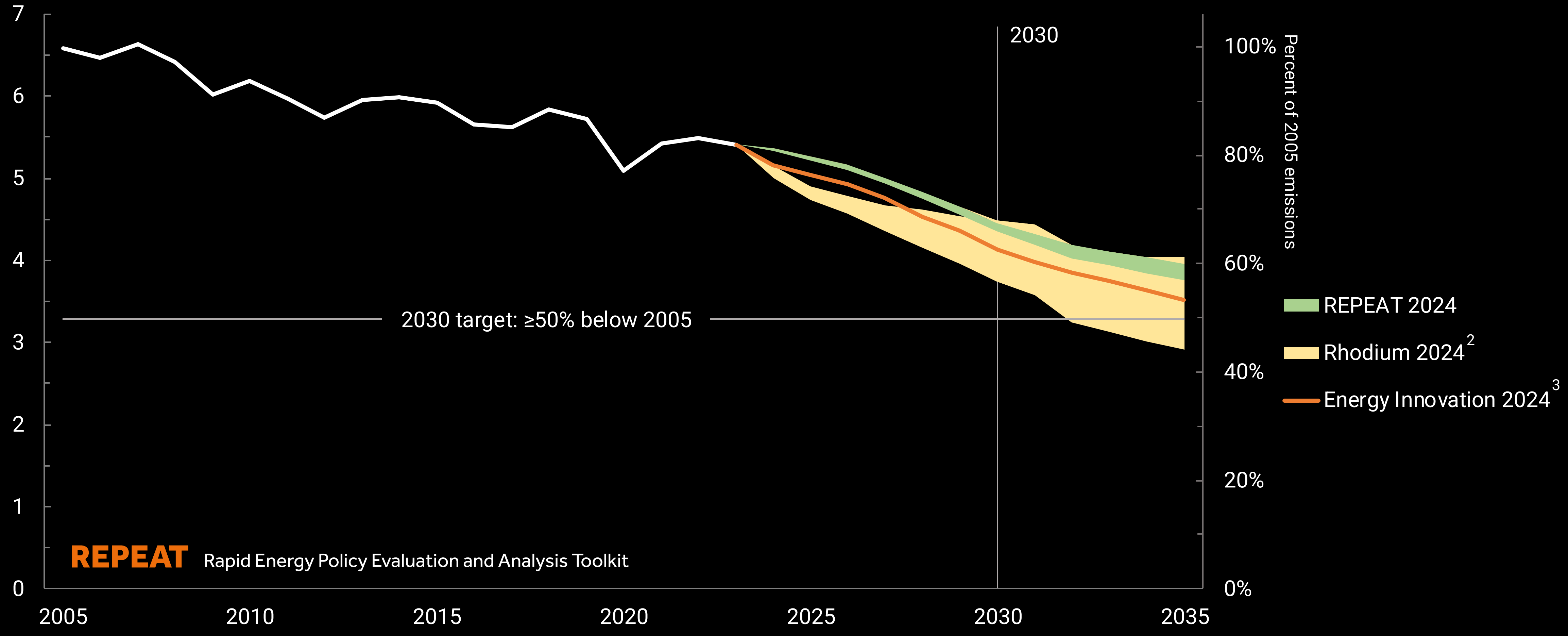
Historical and Modeled Net U.S. Greenhouse Gas Emissions from Three Modeling Studies

billion metric tons CO_2-equivalent (Gt CO_2-e)[1]



1 – Historical emissions from EPA Inventory of Greenhouse Gas Emissions and Sinks. All emissions are reported in CO_2-equivalent emissions calculations use IPCC AR4 100 year global warming potential consistent with the EPA inventory. **All values should be regarded as approximate given uncertainty in future outcomes.**

2 - Rhodium Group, "Taking Stock 2024: US Energy and Emissions Outlook," July 23, 2024. Note variation across Rhodium Group scenarios reflects varied assumptions about underlying macro-economic conditions and technology costs, while variation across REPEAT Project scenarios reflect variation in assumed policy impact (with consistent macro-economic and cost assumptions).

3 - Energy Innovation LLC, "The Second Half Of The Decisive Decade: Potential U.S. Pathways On Climate, Jobs, And Health," August 12, 2024.

About REPEAT Project

REPEAT Rapid Energy Policy Evaluation and Analysis Toolkit

REPEAT Project provides regular, timely and independent environmental and economic evaluation of federal energy and climate policies as they're proposed and enacted, offering a detailed look at the United States' evolving energy and climate policy environment and the country's progress on the path to net-zero greenhouse gas emissions.

Approach: we employ geospatial planning and analysis tools coupled with detailed macro-energy system optimization models to **rapidly evaluate federal policy and regulatory proposals at politically-relevant spatial resolutions** (e.g., state, county, and finer resolutions). This is a refinement of methods used in the Princeton *Net-Zero America* study.

Goal: provide independent, timely, and credible information and analysis for broad educational purposes, including as a resource available publicly for stakeholders, decision-makers, and the media.

Funding: funding for the REPEAT Project was provided by a grant from the Hewlett Foundation.

Impact: throughout the 117th Congress, REPEAT Project played a central role in informing debate, media coverage, and public understanding of the impacts of proposed and enacted legislation. The project continues to provide regular analysis of pending and finalized federal regulations, updates on progress towards climate goals, and other analysis at **repeatproject.org**

REPEAT Project is a joint project of the **Princeton University ZERO Lab** (Zero-carbon Energy Systems Research & Optimization Laboratory) and **Evolved Energy Research**.

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The REPEAT Project Team

REPEAT Rapid Energy Policy Evaluation and Analysis Toolkit

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Website development by Hyperobjekt

For more, see repeatproject.org/about

Statement of interests: Jesse D. Jenkins is part owner of DeSolve, LLC, which provides techno-economic analysis and decision support for clean energy technology ventures and investors. A list of clients can be found at https://www.linkedin.com/in/jessedjenkins. He serves on the advisory boards of Eavor Technologies Inc., a closed-loop geothermal technology company, Rondo Energy, a provider of high-temperature thermal energy storage and industrial decarbonization solutions, and Dig Energy, a developer of low-cost drilling solutions for geothermal heating and cooling, and he has an equity interest in both companies. He also serves as a technical advisor to MUUS Climate Partners and Energy Impact Partners, both investors in early-stage climate technology companies.

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