scout

U.S. DEPARTMENT OF ENERGY

2024 Scout Benchmark Scenario Guide

Aven Satre-Meloy[1], Jared Langevin[1], Chioke B. Harris[2], Handi Chandra Putra[1]

1 Lawrence Berkeley National Laboratory

2 National Renewable Energy Laboratory

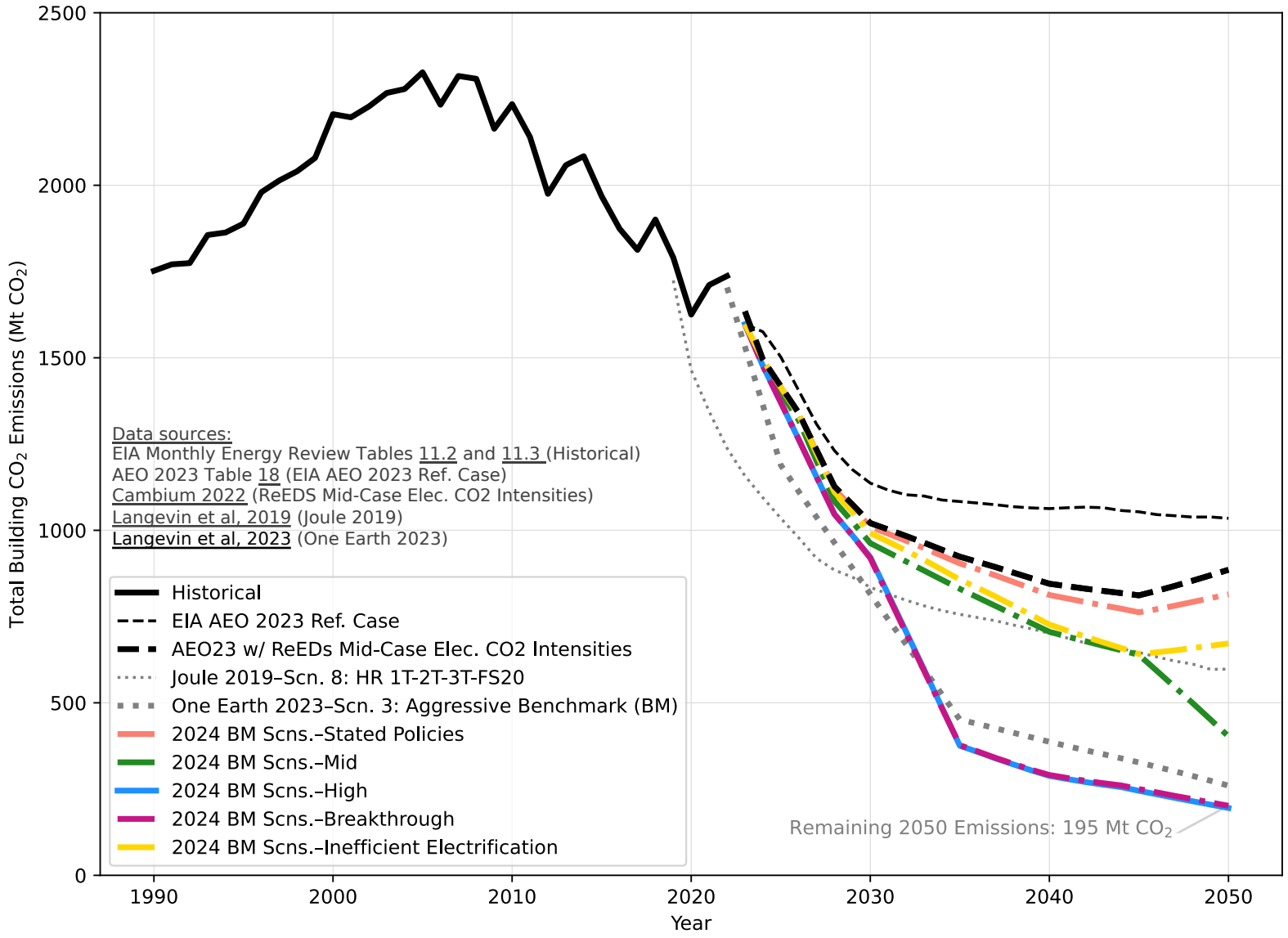
February 2024

Summary of 2024 Benchmark Scenario Assumptions

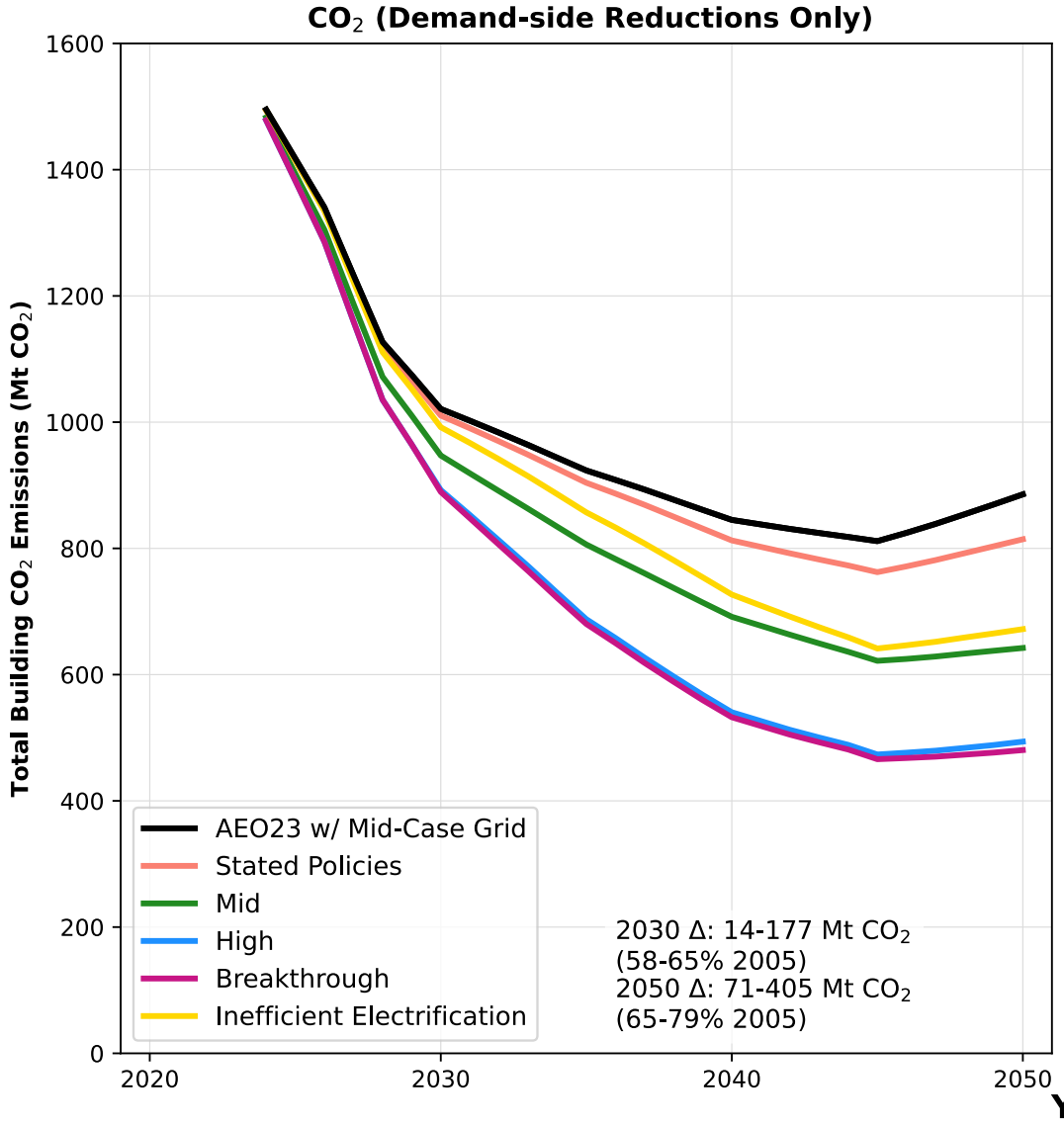
Consistent with capabilities of Scout v0.9.1, run via decarb-sa branch on Scout GitHub repository (accessed 01/31/24 and 02/07/24); refer to "Scenario_Execution" XLSX to reproduce scenario runs.

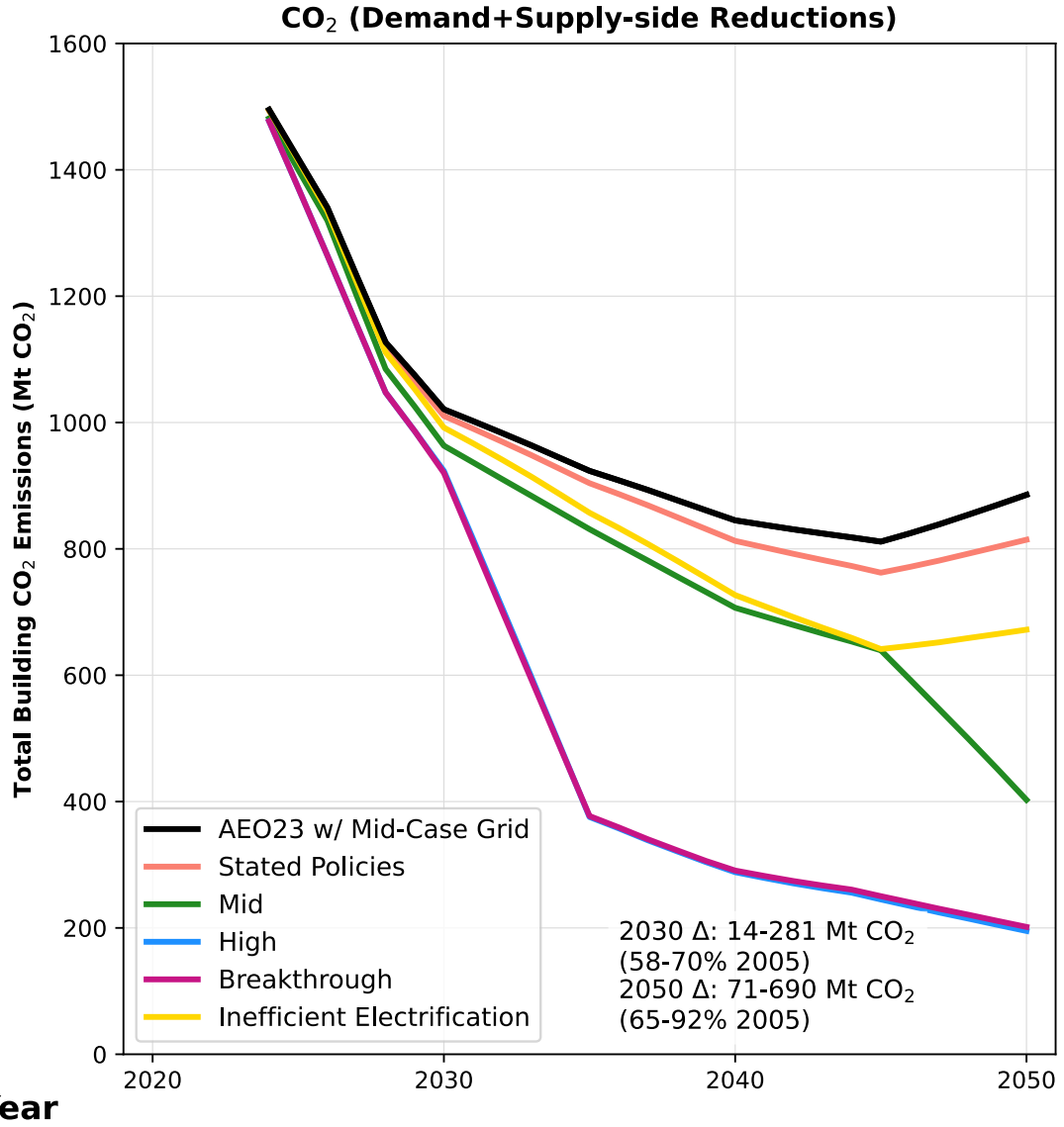
Scenario	Market-Available Technology Performance Range		Load Electrification		Early Retrofits	Power Grid
	Raise Floor	Raise Ceiling	Switching Rate	Efficiency Level		
Stated Policies: Buildings incentives and regulations (e.g., IRA) lead to modestly accelerated deployment of HPs/HPWHs but not other efficiency measures in the buildings sector. The power sector decarbonizes under a moderately aggressive scenario that reaches around 87% decarbonization by 2050 vs. 2005 levels.	BAU (AEO 2023 Reference Case)		Guidehouse Conservative (see slide 6 for details)	Switch to HPs	None	ReEDS DECARB Stated Policies
Mid: Policy makers rely mostly on market-based instruments to moderately increase deployment of efficient technology and fuel switching to heat pumps. The power sector decarbonizes under an aggressive scenario that reaches 97% decarbonization by 2050 vs. 2005 levels.	Moderate (elevated codes/stds. take effect in 2030)	BAU	Guidehouse Optimistic	Switch to HPs		ReEDS DECARB Mid
High: Policy makers use both regulations and market-based instruments to dramatically accelerate deployment of high efficiency technologies and fuel switching to heat pumps, though breakthrough buildings technologies do not materialize/enter the market. The power sector fully decarbonizes well before mid-century.	Aggressive (elevated codes/stds. take effect in 2025)		Guidehouse Most Aggressive		Elevated (see slide 8 for details)	ReEDS DECARB High
Breakthrough: Research and innovation breakthroughs lead to market availability of high-performance building technologies in 2030; these, coupled with accelerated deployment of high efficiency technologies and fuel switching to heat pumps, lead to aggressive buildings sector transformation. The power sector fully decarbonizes well before mid-century.		Aggressive (breakthrough tech. enters market in 2030)				
Inefficient Electrification Sensitivity: Policy makers use regulations and market-based instruments to encourage fuel switching but do not include provisions that require switching to efficient heat pumps, resulting in a substantial amount of switching to inefficient electric resistance heating and water heating technologies. The power sector decarbonizes under a moderately aggressive scenario that reaches around 87% decarbonization by 2050 vs. 2005 levels.	BAU		Guidehouse Most Aggressive	Switch to Resistance/HPs (53/47% split for res. heat; 82/18% res. WH; 55/45% com. heat; 94/6% com. WH)	None	ReEDS DECARB Stated Policies

Energy-Related Building CO_2: Historical and Projected Trends

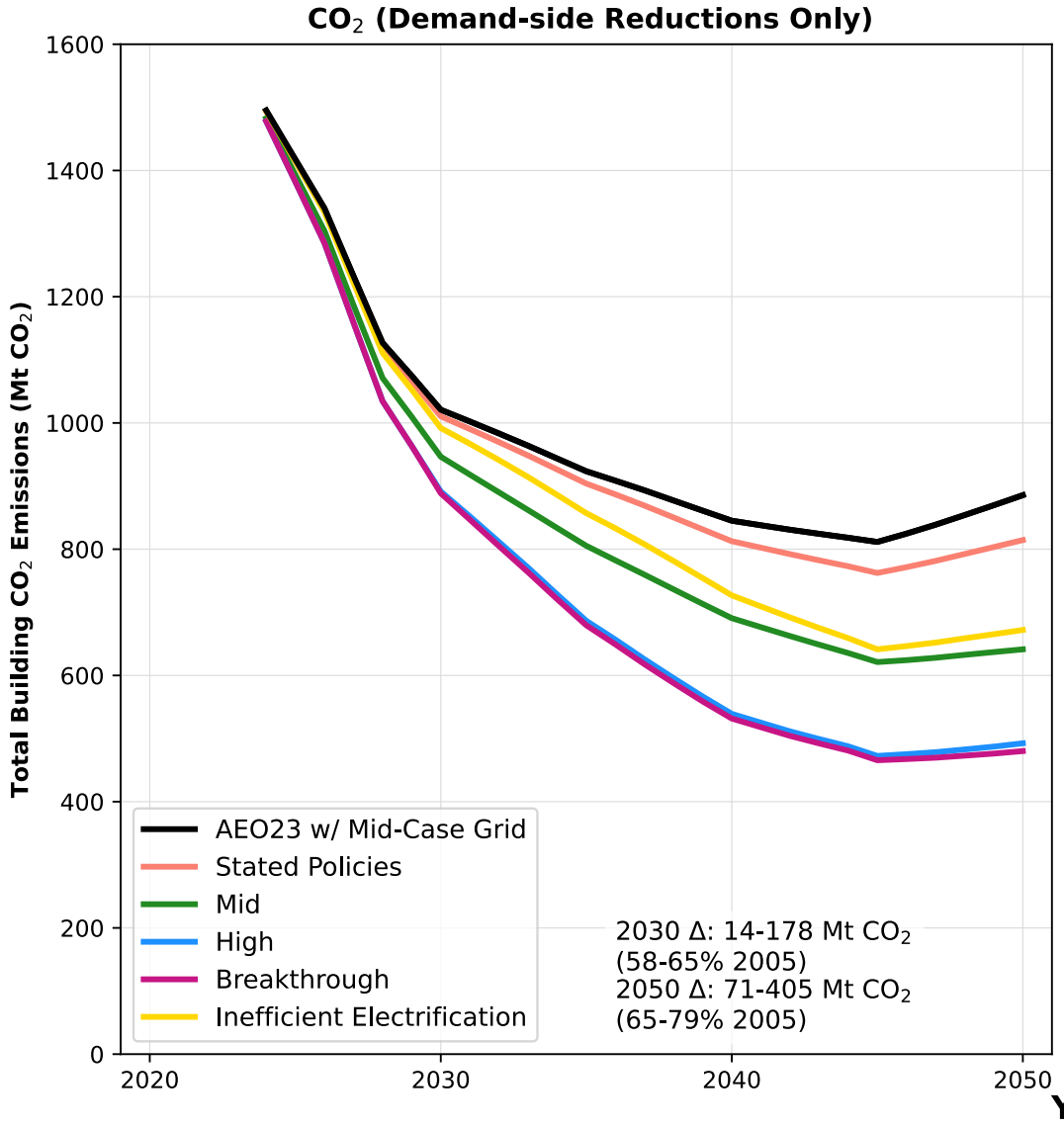


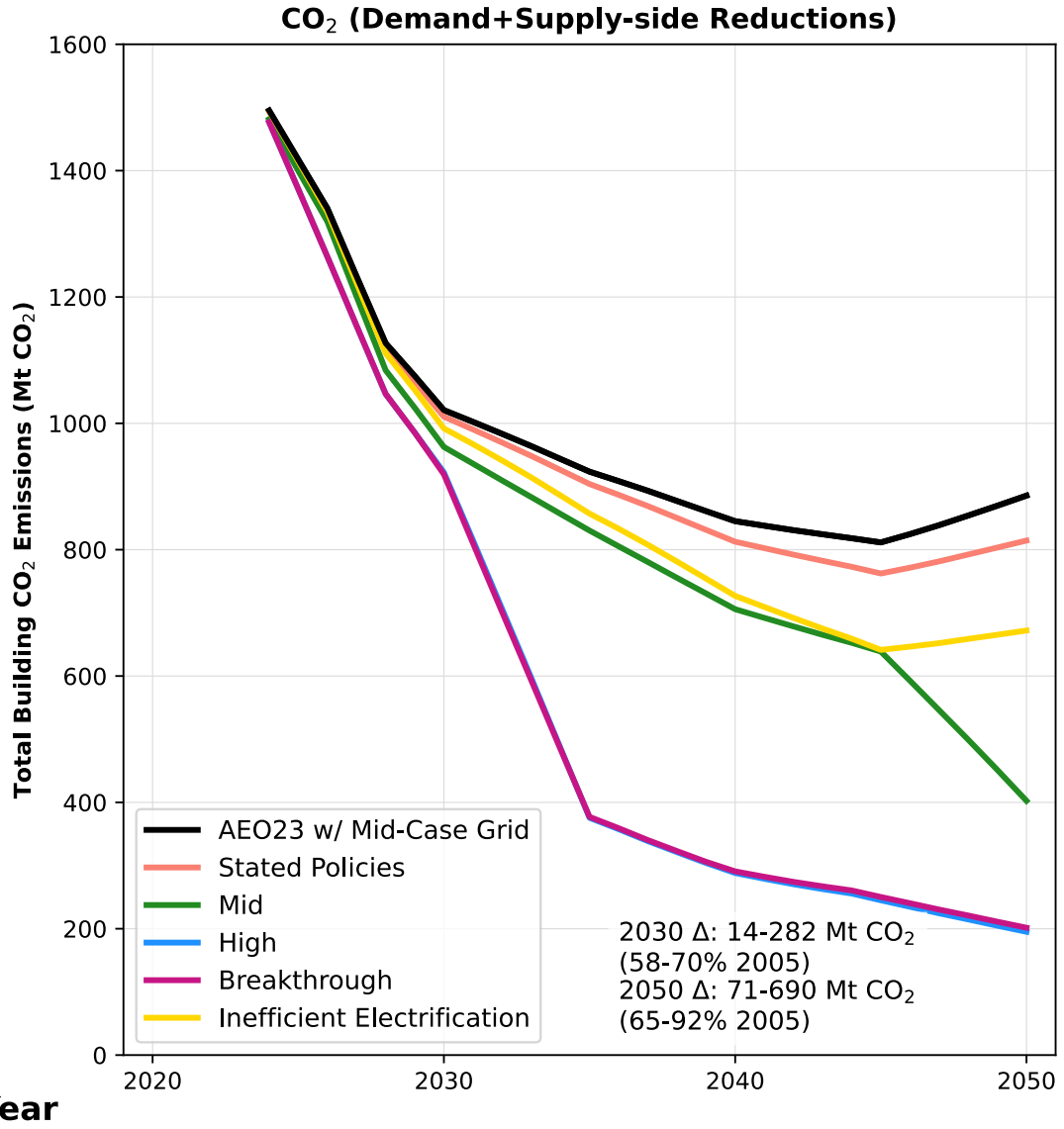
2024 Benchmark Scenario Energy-Related CO_2 Results



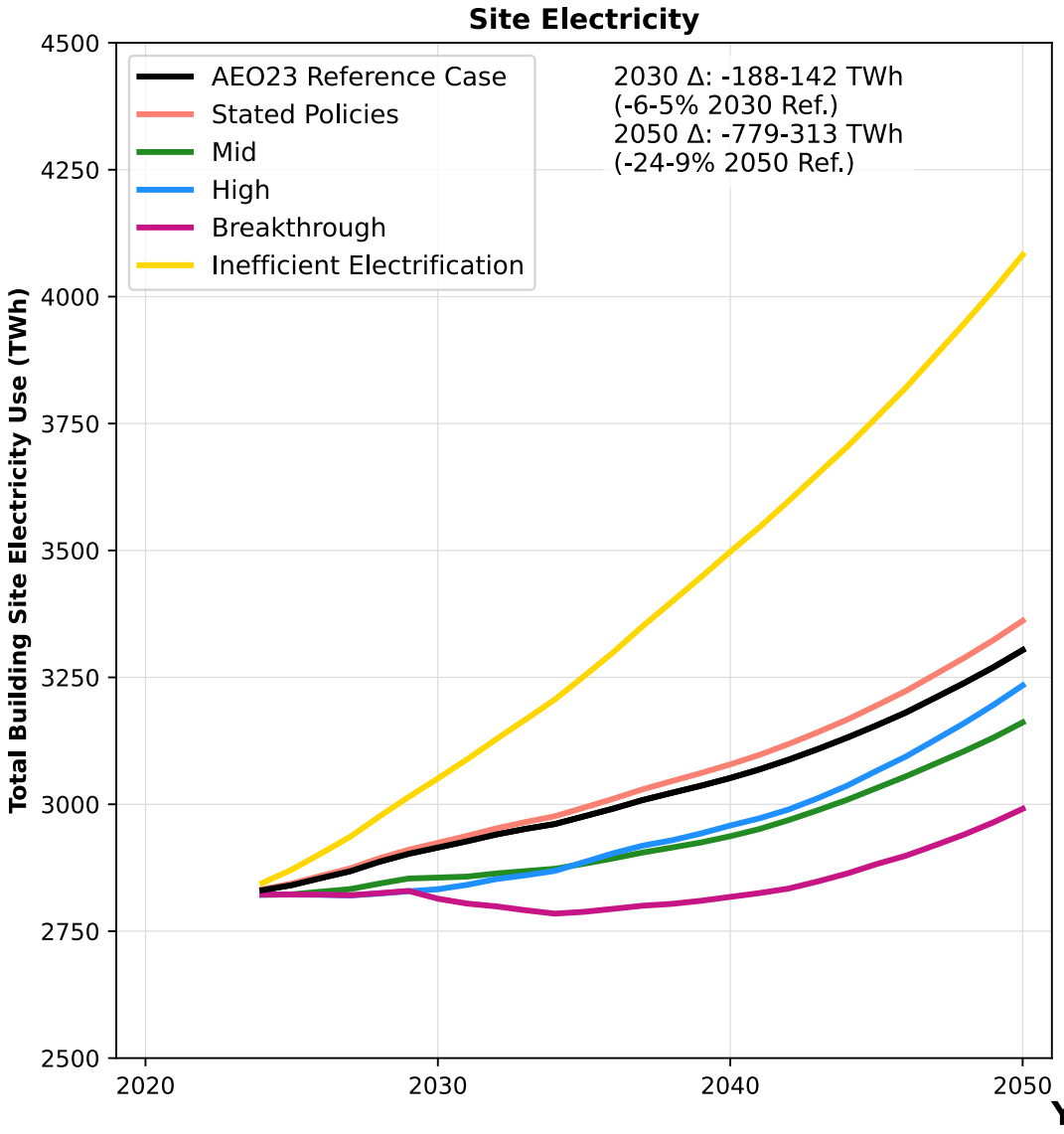


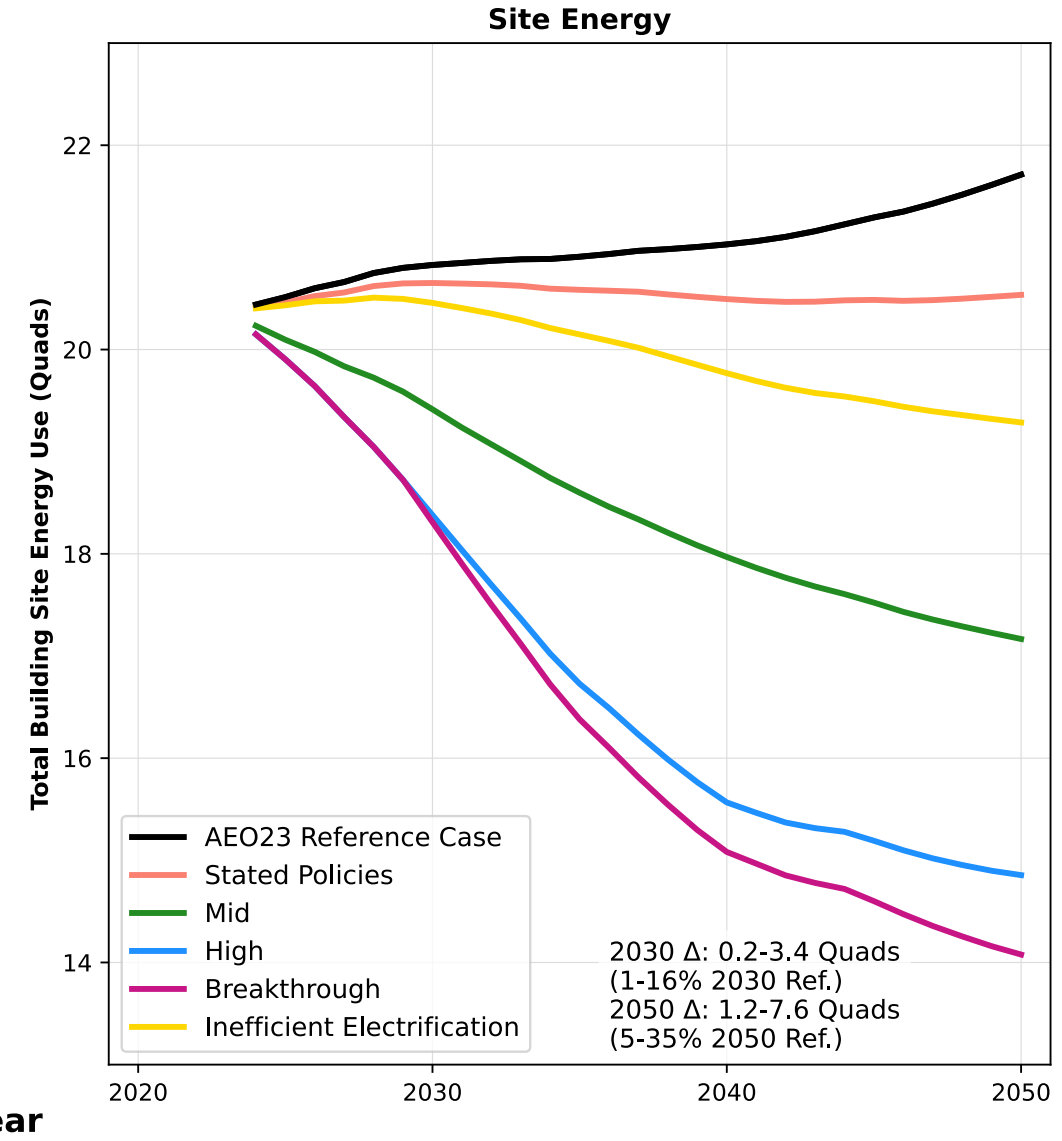
2024 Benchmark Scenario Energy-Related CO_2 Results





2024 Benchmark Scenario Site Electricity and Energy Results





Additional Scenario Details: Electrification Rates

Exogenous electrification rates are based on Guidehouse scenarios developed for the BTO E3 Initiative.

Increasing levels of :

- Federal / utility incentives
- State / local policy support
- Marketing support
- Certification development
- Product innovations

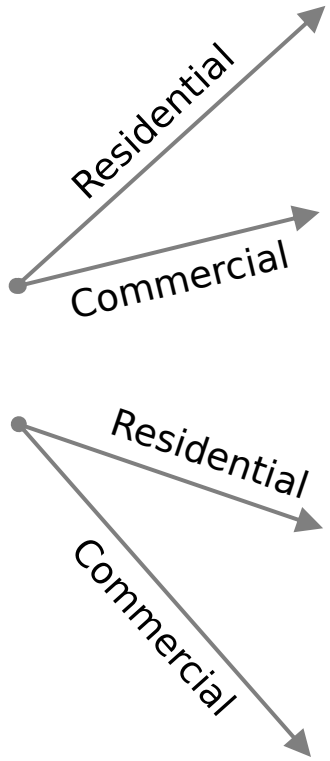
E3 Scenario	Federal / Utility Incentives	State / Local Restrictions	Product Innovations	Drivers (Key Differences Highlighted in BOLD)	Sector & End use		Res. SH	Res. WH	Com. SH	Com. WH
					2019 Heat Pump US Market Sales Shares		37%	1%	9%	0.10%
Conservative Scenario	Modest federal, few utilities	Few for NC, none for Existing	Low GWP refrigerants, grid interactive	• Moderate market transformation expansion by BTO, utility, and industry groups • Few utilities offer substantial incentives for electrification • Modest federal incentive for heat pump conversions (targets customers that already have attractive lifecycle cost savings, such as electric resistance, propane, and fuel oil) • Few state and local governments restrict natural gas for new construction	HP Sales Market Shares Targets	2030	45%	10%	15%	3%
						2050	61%	30%	27%	20%
Optimistic Scenario	Moderate, federal, more utilities	Some for NC, none for Existing	Affordable CCHPS /RTUs, 120V HPWHs	• **Large market transformation expansion** by BTO, utility, and industry groups • **More utilities offer substantial incentives for electrification** • **Moderate federal incentive** for heat pump conversions (targets customers that already have attractive lifecycle cost savings, such as electric resistance, propane, and fuel oil) • **Some state and local governments** restrict natural gas for new construction		2030	50%	20%	20%	5%
						2050	76%	60%	42%	30%
Aggressive Scenario	Large federal, more utilities	More for NC, some for Existing	Affordable CCHPS /RTUs, 120V HPWHs	• Large market transformation expansion by BTO, utility, and industry groups • More utilities offer substantial incentives for electrification • **Large federal incentive** for heat pump conversions (targets customers with more challenging conversions, as well as some environmentally focused gas customers) • **More state and local governments restrict natural gas for new construction, and provide significant incentives and/or restrictions for existing homes**		2030	63%*	40%*	25%	7%
						2050	85%	75%	66%	45%
Most Aggressive Scenario	Large federal, most utilities	Most for NC, most for Existing	Affordable CCHPS /RTUs, 120V HPWHs	• Large market transformation expansion by BTO, utility, and industry groups • **Most utilities offer substantial incentives for electrification** • Large federal incentive for heat pump conversions ((targets customers with more challenging conversions, as well as some environmentally focused gas customers) • **Most state and local governments restrict natural gas for new construction, and provide significant incentives and/or restrictions for existing homes**		2030	75%	50%	30%	10%
						2050	90%	85%	85%	50%

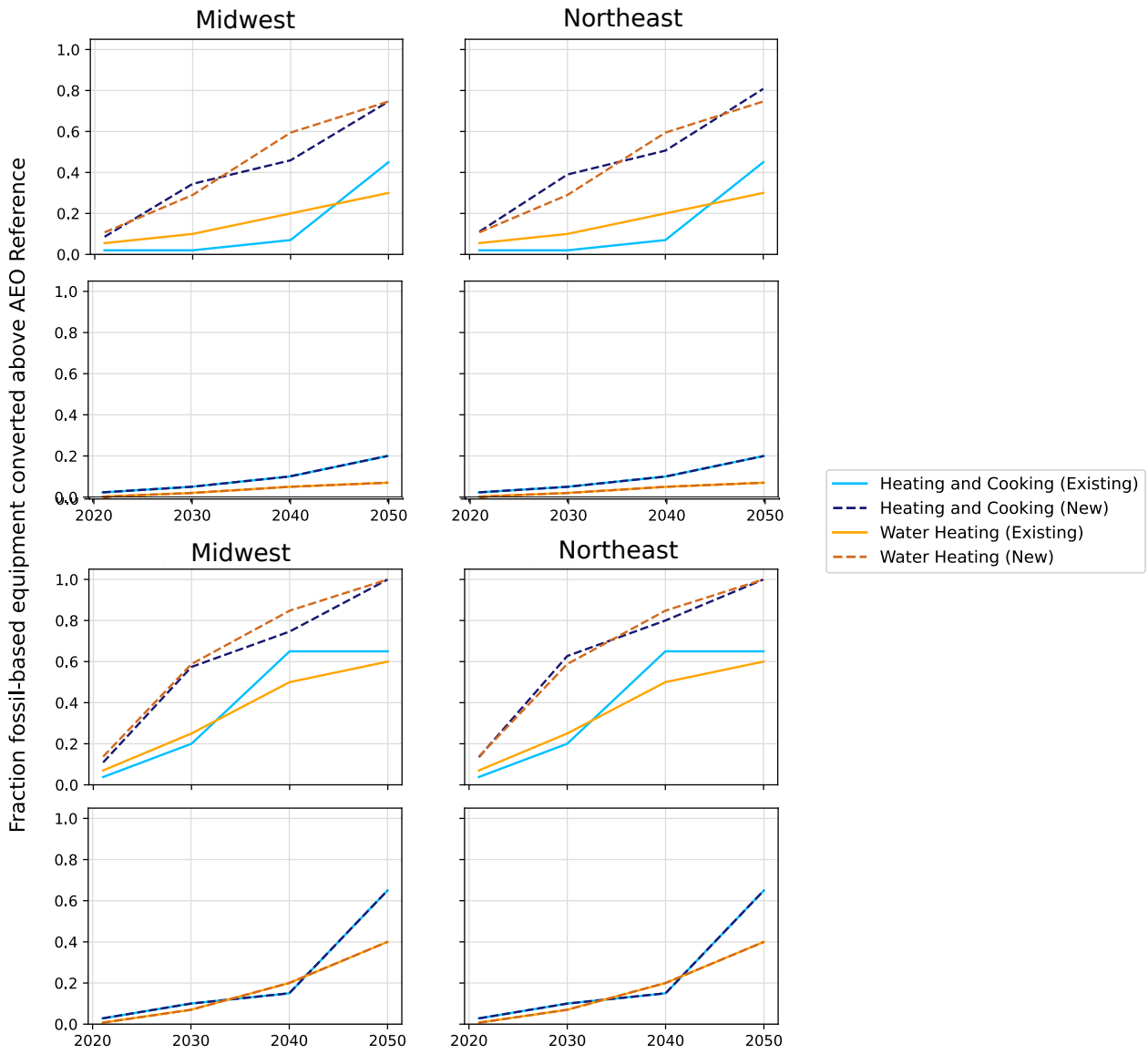
Additional Scenario Details: Electrification Rates (continued)

Exogenous electrification rates are resolved by building type/vintage, Census Region, and technology type. See supporting data available here.

Overall Heat Pump Sales Shares

	2030 Sales Market Share	2050 Sales Share
Conservative Scenario	27%	44%
Optimistic Scenario	34%	67%
Aggressive Scenario	50%	79%
Most Aggressive Scenario	61%	87%





Additional Scenario Details: Early Retrofit Rates

In the “High” and “Breakthrough” Scenarios, early retrofitting behavior is assumed (replacing existing equipment before end of useful life). Early retrofit rates are initialized based on data from the EIA Commercial Building Energy Consumption Survey (CBECS) and American Housing Survey (AHS) and are assumed to escalate linearly 4X by 2035 via policy interventions, as summarized below.

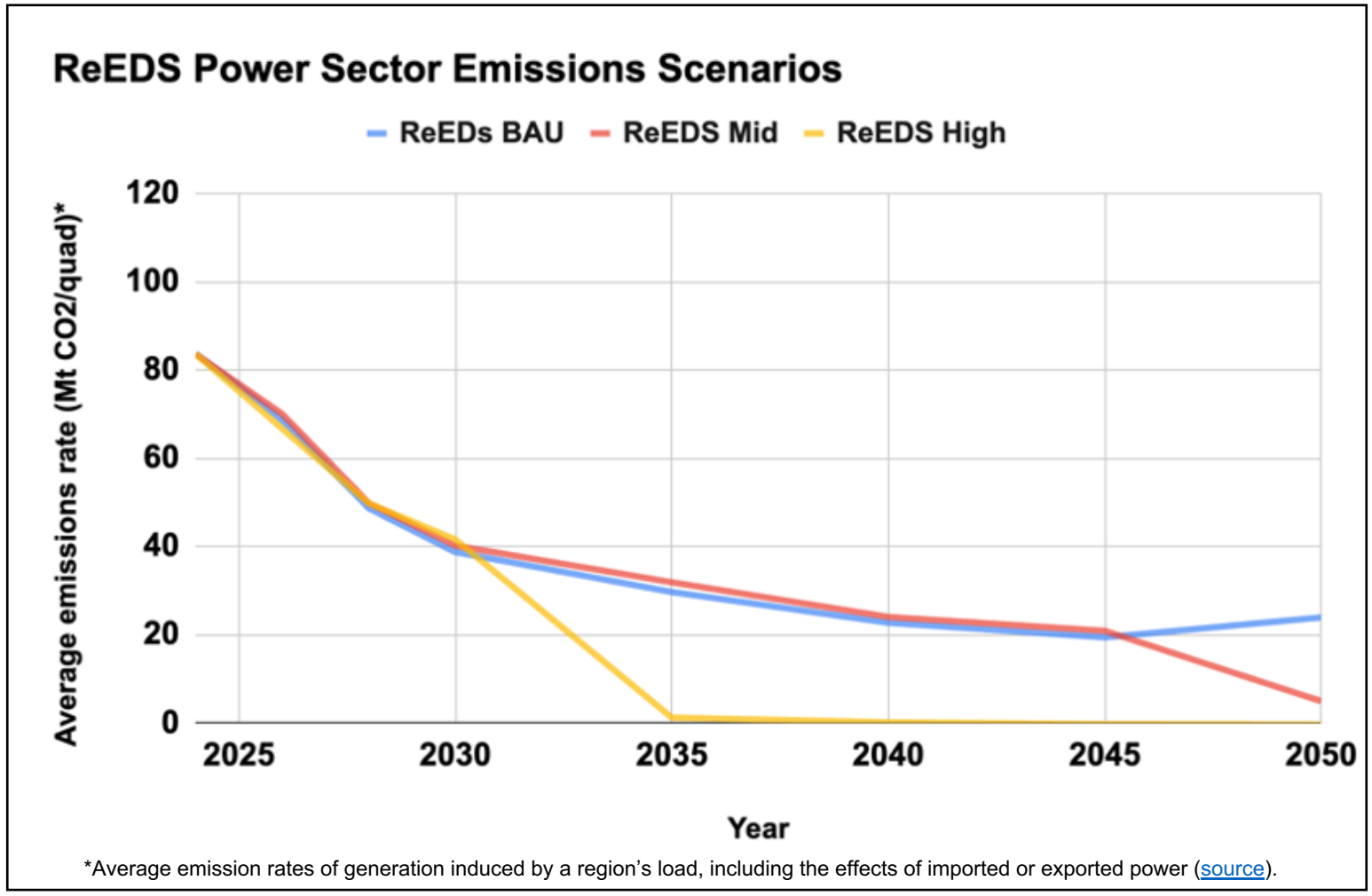
Building Type	Data source	Component retrofitted (year range)	Current annual early retrofit rate (%)	by 2035 (4X)
Commercial	CBECS 2012*	Lighting (2000-2008)	1.5	6
		HVAC (1990-2008)	0.9	3.6
		Roof (1990-2008)	0.6	2.4
		Windows (1990-2008)	0.3	1.2
		Insulation (1990-2008)	0.3	1.2
	Use com. HVAC	Water heating	0.9	3.6
	N/A	All other	0	0
Residential	AHS 2019**	HVAC (1990-2008)	0.5	2
		Roof (1990-2008)	0.27	1.08
		Windows (1990-2008)	0.23	0.92
		Insulation (1990-2008)	0.06	0.24
	Use res. HVAC	Water heating	0.5	2
	Use com. lighting	Lighting	1.5	6
	N/A	All other	0	0

*https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b1.php, see "Renovations in buildings constructed before 2008"

**https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=00000&s_year=2019&s_tablename=TABLE16&s_bygroup1=4&s_bygroup2=1&s_filtergroup1=1&s_filtergroup2=1, click "Get Table"

Additional Scenario Details: Power System Scenarios

NREL's ReEDS scenarios developed for the DECARB Initiative are used in these Scout scenarios to represent various cases of power system decarbonization and their respective annual average grid CO_2 emissions factors. The ReEDS tool has a publicly-available scenario viewer and data downloader (note: the DECARB grid scenario data are not yet publicly available).



*Average emission rates of generation induced by a region's load, including the effects of imported or exported power (source).