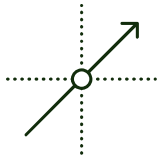
September 2024

OpenMinds 2024 ‘P50’ Outlook

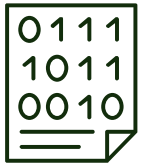
Energy & Climate Trajectory and Gaps to Close

OpenMinds

OpenMinds ‘P50’ Outlook Objectives



Develop a **non-biased view** of where we’re really heading on energy supply & consumption, power, and emissions



Quantify **what’s needed to close the gap** between our current energy mix and what’s needed to affordably and efficiently bend the curve

Provide an **annually-refreshed perspective to track** global & US progress against the Dual Challenge and to identify high-impact areas for improvement

OpenMinds ‘P50’ Outlook Scope and Contributors

2035 forecasts included in the ‘P50’ Outlook

	Global	US
Energy Demand	✓	✓
Supply Mix	✓	✓
Emissions	✓	✓

Developed and reviewed by industry leaders

MODEL CREATION

Intersect SM BAIN & COMPANY

Additional detail in appendix

Copenhagen Economics CE

EXPERT REVIEW

GE VERNOVA

CLEAN AIR TASK FORCE

tpi

SCF PARTNERS
HOUSTON | CALGARY | ABERDEEN | SINGAPORE

NEW ENERGY CAPITAL

How the Intersect Model Works

Outlook based on most cost-effective path, limited by real world constraints

Inputs

- Population Growth
- GDP
- Technology costs *(incl. commodity intensities)*
- Experience curves
- CO_2 intensity

Simulation Engine

STEP 1

Model is run as a **constrained optimization** to ensure sectors **decarbonize** based on the **most cost-effective path**

E X A M P L E **:** Decarbonization levers for transportation

- Switch Technology *e.g., ICE to EV*
- Improve Efficiency
- Lower demand

STEP 2

Demand = Supply

Model uses prices to reach **demand and supply equilibrium** across all sectors subject to input output matrix constraints

STEP 3

Forces consistency by ensuring changes in sector output and factor incomes still sum to GDP**.** Process repeats each year until decarbonization targets are met each year

Real World Constraints

- Impact of intermittency of renewables on grid stability
- Assume electricity is priced on basis of average cost
- Physical availability of agricultural land for biomass activities
- Pace of roll out, amount of VRE installed per year

Outputs

- Energy demand
- Energy supply mix
- Sales and total stock of EVs
- Electrification pace
- Carbon emissions

OpenMinds ‘P50’ Outlook Key Model Assumptions

PRELIMINARY

Key assumptions			2023	2030	2035
Energy and Electricity Demand	**GDP growth** (%)	***Global***	2.6	2.7	2.7
		USA	2.0	1.7	1.9
	Energy intensity[1]	***Global***	3.8	3.4	3.0
		USA	3.7	3.4	3.1
	EV sales penetration (% of new car sales)	***Global***	17	45	64
		USA	10	35	55
	Electricity demand from data centers and AI (TWh)	***Global***	400	1,060	1,230
		USA	117	351	406
Power Sector	**US Value-Adjusted Levelized Cost of Electricity** (VALCOE, $/MWh)	***Solar***	60	64	62
		Wind	64	71	77
	LCOE learning rate[2] (%)	***Solar***	20		
		Wind	15		
	Capacity factor (%)	***Solar***	18	19	20
		Wind[4]	35	38	40
	Battery storage intensity[3] (%)	***Global***	2	8	11
		USA	6	19	22

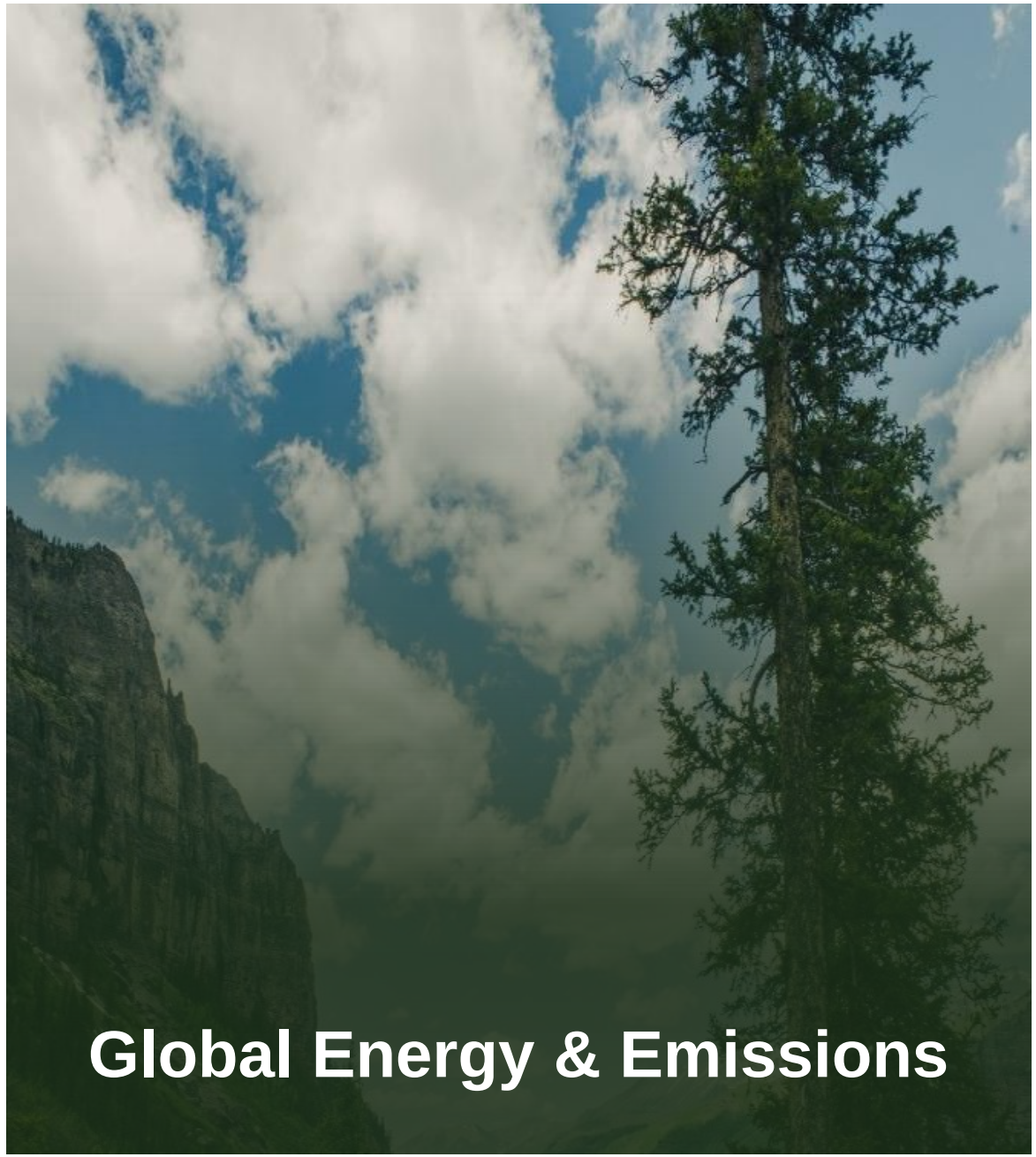
Questions answered by model

1 What is the outlook for **energy demand** and which sectors will drive growth?

2 How will the **energy mix** shift in coming years?

3 What does **emissions trajectory** look like through 2035?

Note: [1]Energy intensity shown in terms of total final consumption (EJ) per purchasing power parity (PPP) in trillion dollars (T$). [2]LCOE learning rate is the percentage decrease in LCOE for every doubling of installed capacity. [3]Battery storage intensity calculated as the total installed battery capacity as a % of total installed variable renewable energy (wind and solar) capacity. [4]Wind capacity factor provided as weighted averages across offshore and onshore
Source: IEA, Goldman Sachs, IRENA

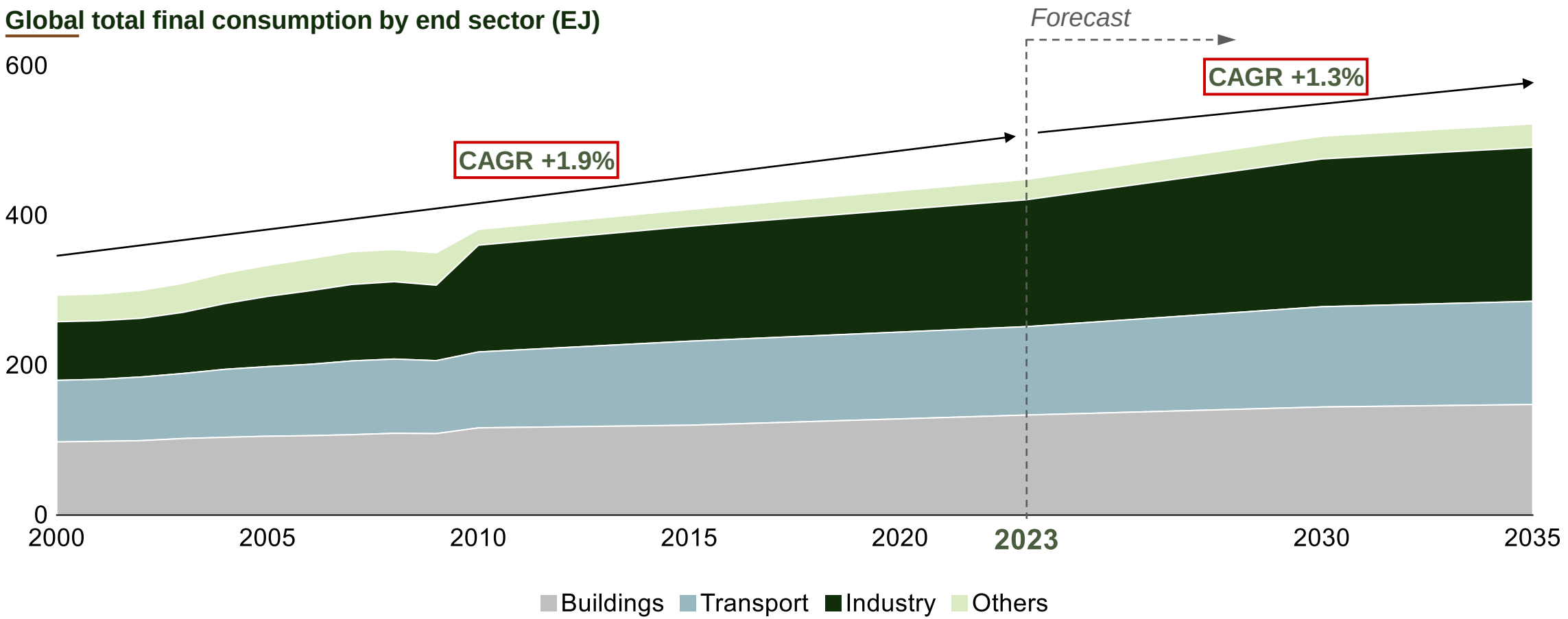


Global Energy & Emissions

US Energy & Emissions

Global Energy Demand is Expected to Rise Driven by Consumption Growth in Buildings and Industry Sectors

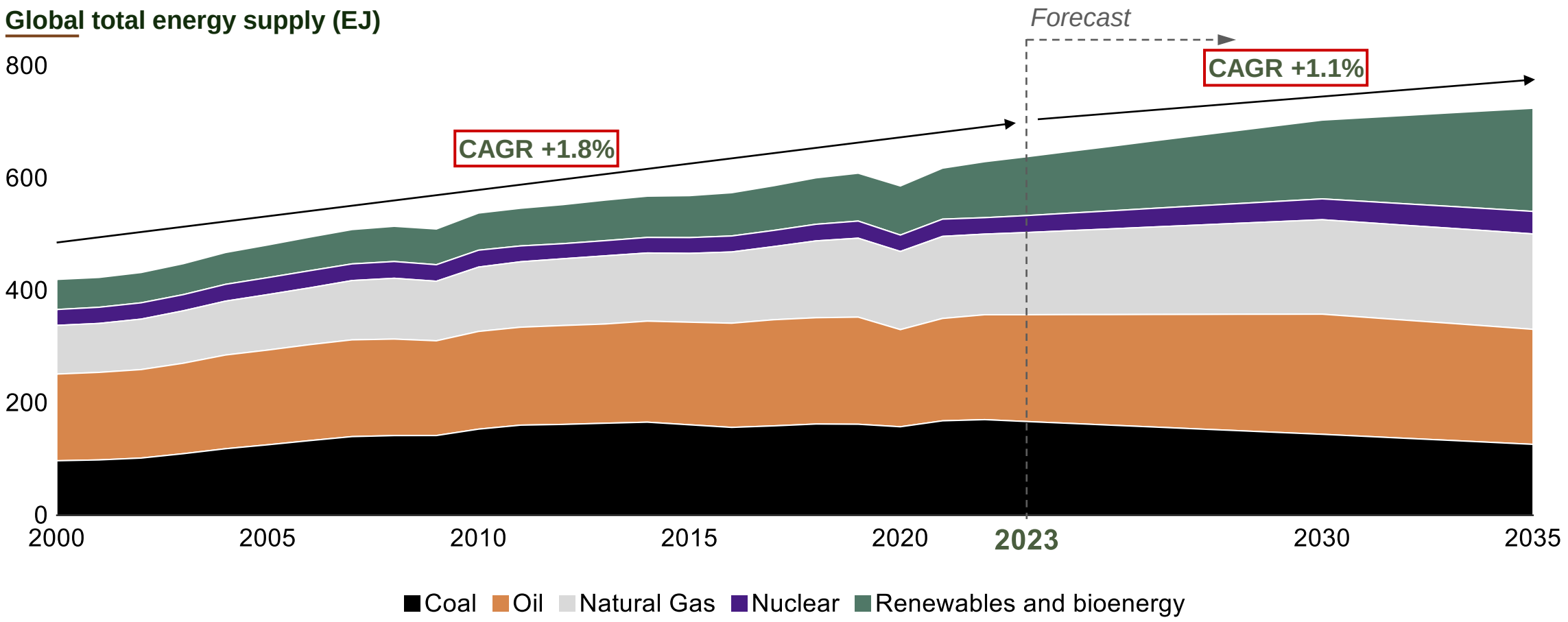
Global total final consumption by end sector (EJ)



Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

Renewables are Forecast to Continue to Phase Out Coal in Global Energy Supply Mix

PRELIMINARY

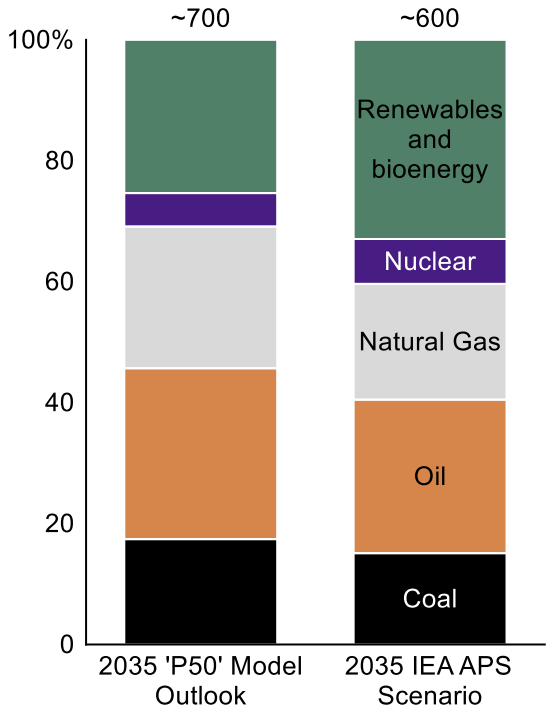


Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

Despite Rapid Growth in Low-Carbon Energy, it's Not Enough

/PRELIMINARY /ILLUSTRATIVE

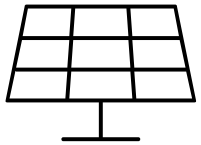
Forecasted Global Energy Supply (EJ)



Where We'll Land in 2035 if We Stay on 'P50' Path

Not enough renewables

Gap: 18 EJ

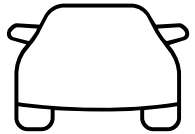


Enough solar to cover New Jersey

~70K more wind turbines

Overreliance on oil

Overage: 50 EJ

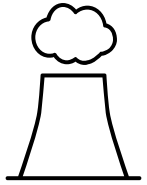


~13 million ICE vehicles

~8 billion barrels of oil

Underdeveloped nuclear

Gap: 5 EJ

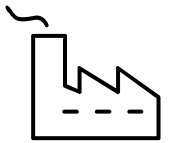


38 additional Vogtle power plants

~$1-2 trillion in capex

Too much gas & coal

Overage: 87 EJ



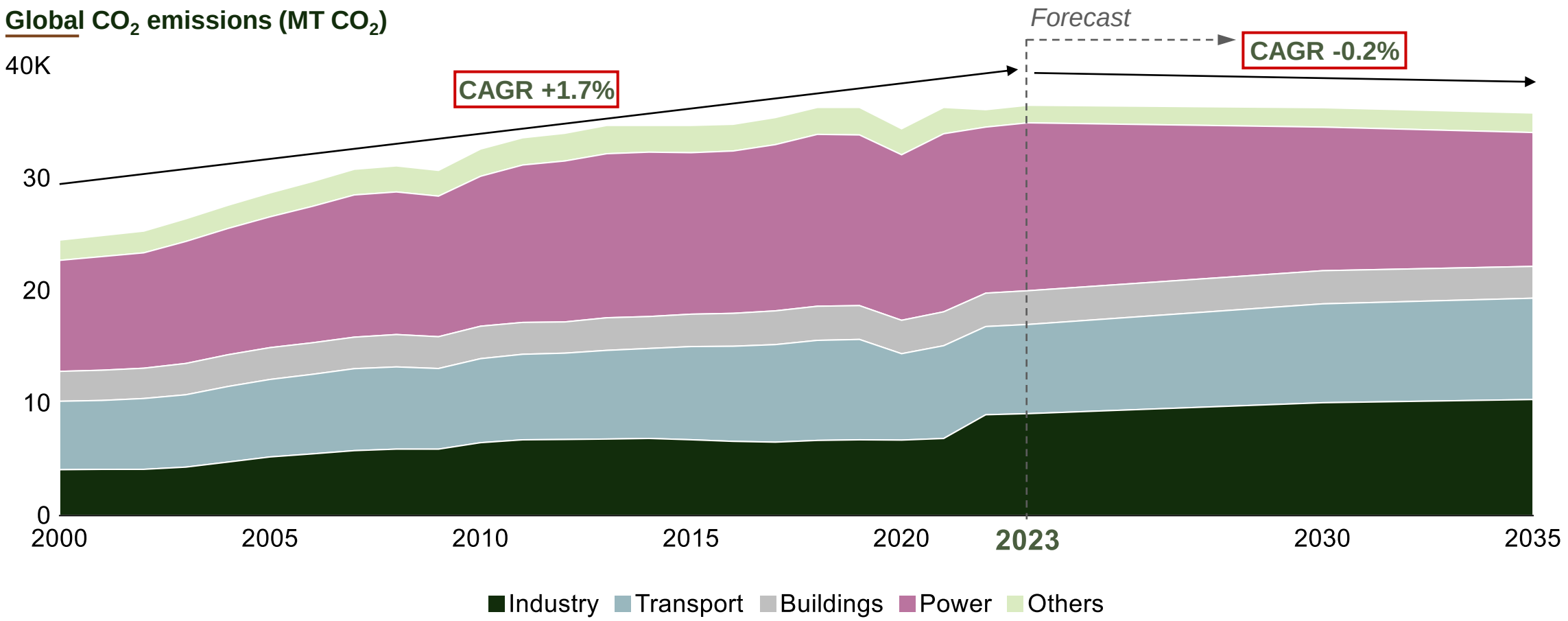
~50 trillion cubic feet of natural gas

~1 billion tons of coal

Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA

Developing Economies' Fossil Fuel-Powered Industrialization Offsets Developed Economies' Decarbonization

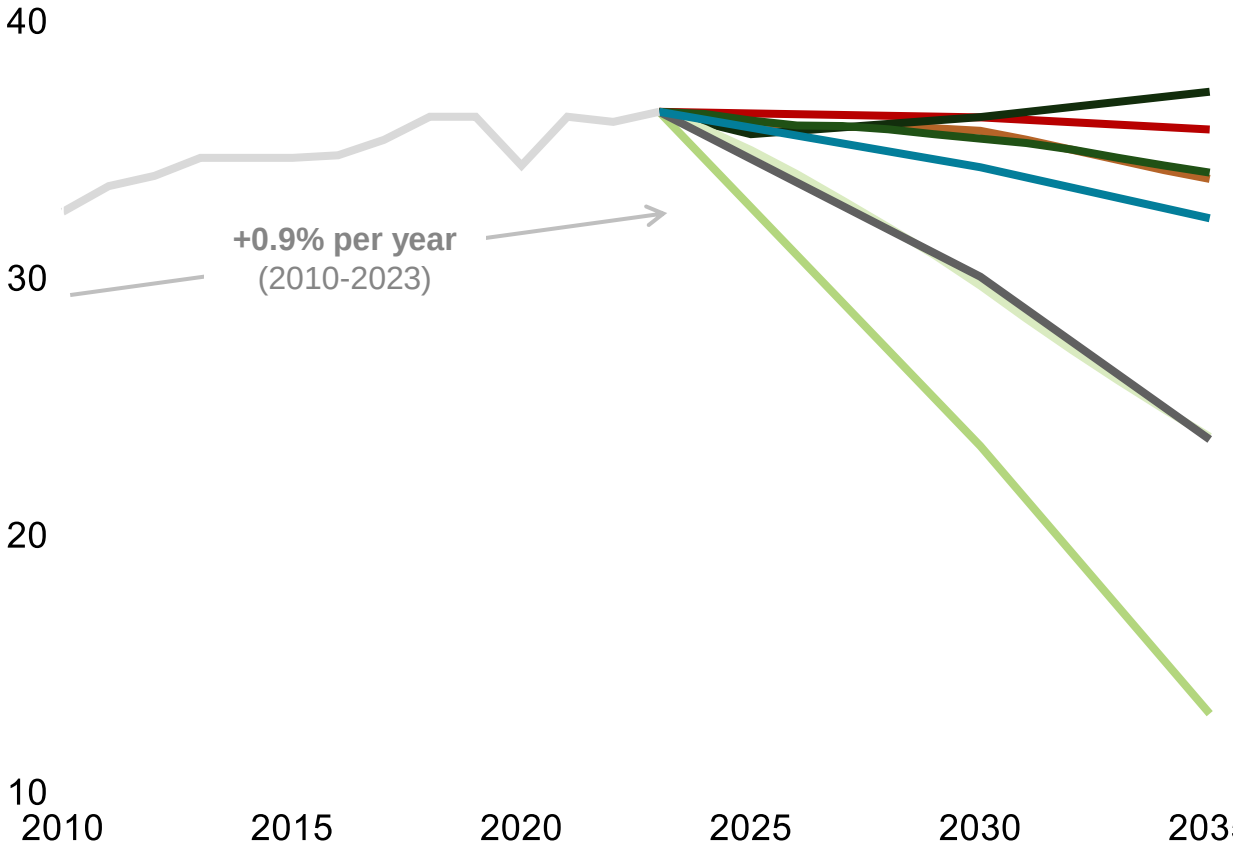
3 | EMISSIONS TRAJECTORY



Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

Global Carbon Emissions Likely to Decline Slightly by 2035

Global emissions by scenario (Gt CO_2)

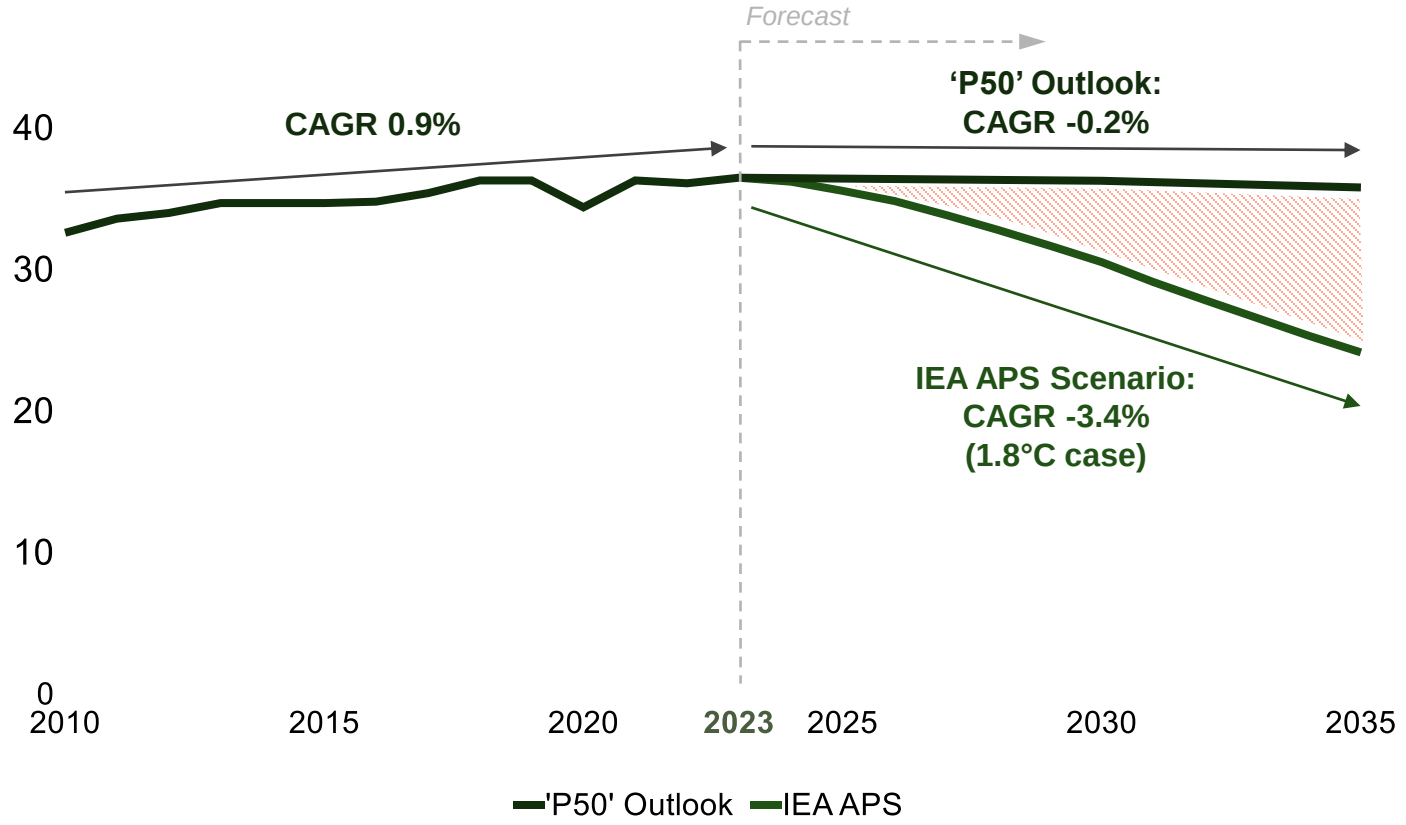


	Growth per year 2023-2035
Scenarios without significant policy or tech shifts	
EIA: International Energy Outlook 2023	+0.2%
OpenMinds 'P50' Outlook 2024	**(0.2%)**
ExxonMobil: 2023 Outlook for Energy	(0.6%)
BP: 2024 Energy Outlook	(0.6%)
IEA: Stated Policies Scenario (STEPS) 2023	(1.0%)
IEA: Announced Pledges Scenario (APS) 2023	(3.4%)
Scenarios with significant policy and tech shifts	
IEA: Sustainable Dev. Scenario (SDS) 2023	(3.5%)
IEA: Net Zero Emissions by 2050 (NZE)	(8.2%)

Source: BP Energy Outlook, 2021; ExxonMobil 2023 Outlook for Energy; International Energy Agency, World Energy Outlook 2023; EIA International Energy Outlook 2023

We’re Bending the Curve, but Still Have a Big Gap

Global CO_2 emissions (GT CO_2)



The gap through 2035

~66GT

Total global CO_2 emissions gap between the ‘P50’ Outlook and IEA APS scenario

-14%

Total global CO_2 emissions reduction needed to stay on track from ’23-’35

~$16T*

Total social cost of CO_2 emissions gap from ’23 to ’35

Note: *Value is presented in 2023 USD using 2% discount rate
Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023; Climate Action Tracker; EPA

Implications for Global Energy & Climate Outlook

Energy Demand...

is set to grow 15% by 2035, largely driven by developing economies

Oil Demand...

peaks in 2030, as the world passes a tipping point in EV adoption

Natural Gas Demand...

will grow in-line with total energy demand, maintaining its ~23% share through 2035

Renewable Energy...

share of energy mix is forecast to increase from ~15% to ~25% in 2035, as strong growth continues

Carbon Emissions...

will largely remain flat, decreasing ~0.2% p.a. to reach ~35 Gt in 2035

Differing Priorities...

in developing and developed world, with former focused on energy access, latter on climate change

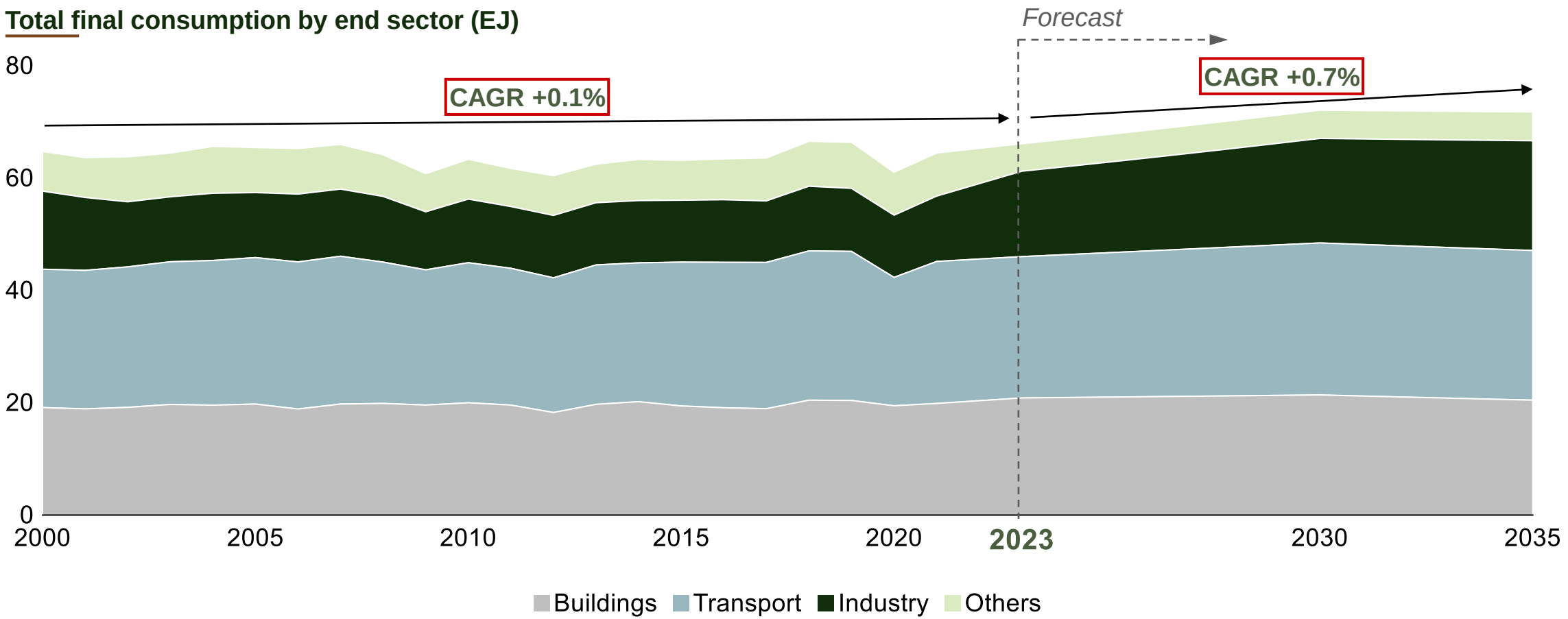
Global Energy & Emissions

US Energy & Emissions

In the US, Rising Energy Demand is Expected to be Mainly Driven by Transport and Industry Sectors

PRELIMINARY

Total final consumption by end sector (EJ)

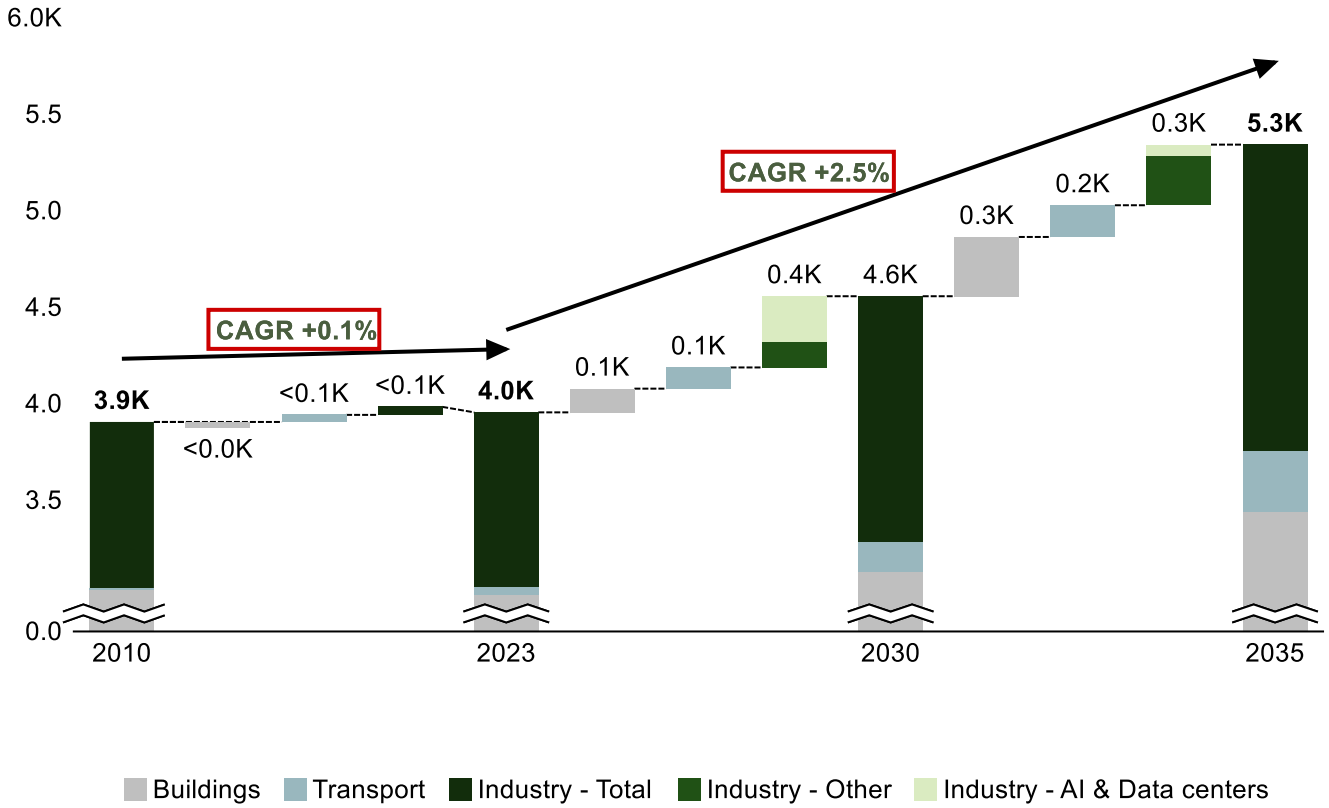


Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

Electricity Demand Expected to Grow by ~2.5% p.a., Driven by Data Centers, Increased AC Use, and EV Sales

PRELIMINARY

US electricity demand (2010A-2035F, TWh)



+35%

'23-'35 Growth in Total US Electricity Demand

~410 TWh

from Data Centers & AI by 2035

8% of total, 30% of incremental demand

~320 TWh

from EV Transport by 2035

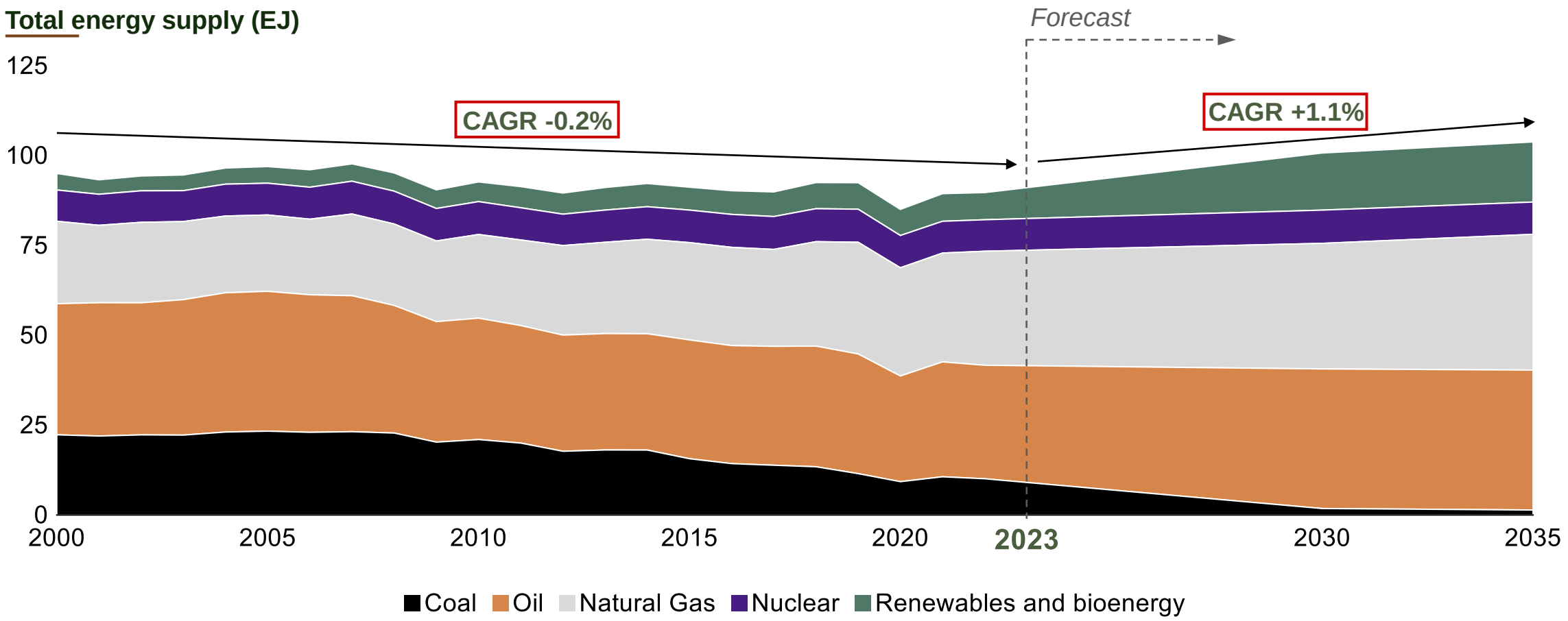
6% of total, 23% of incremental demand

Note: (1) "Buildings" only includes residential buildings; LDV = light-duty vehicles; ICE = internal combustion engine

Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; Goldman Sachs

The US is Projected to Rapidly Retire Coal as an Energy Source, Replacing it with Renewables and Natural Gas

PRELIMINARY

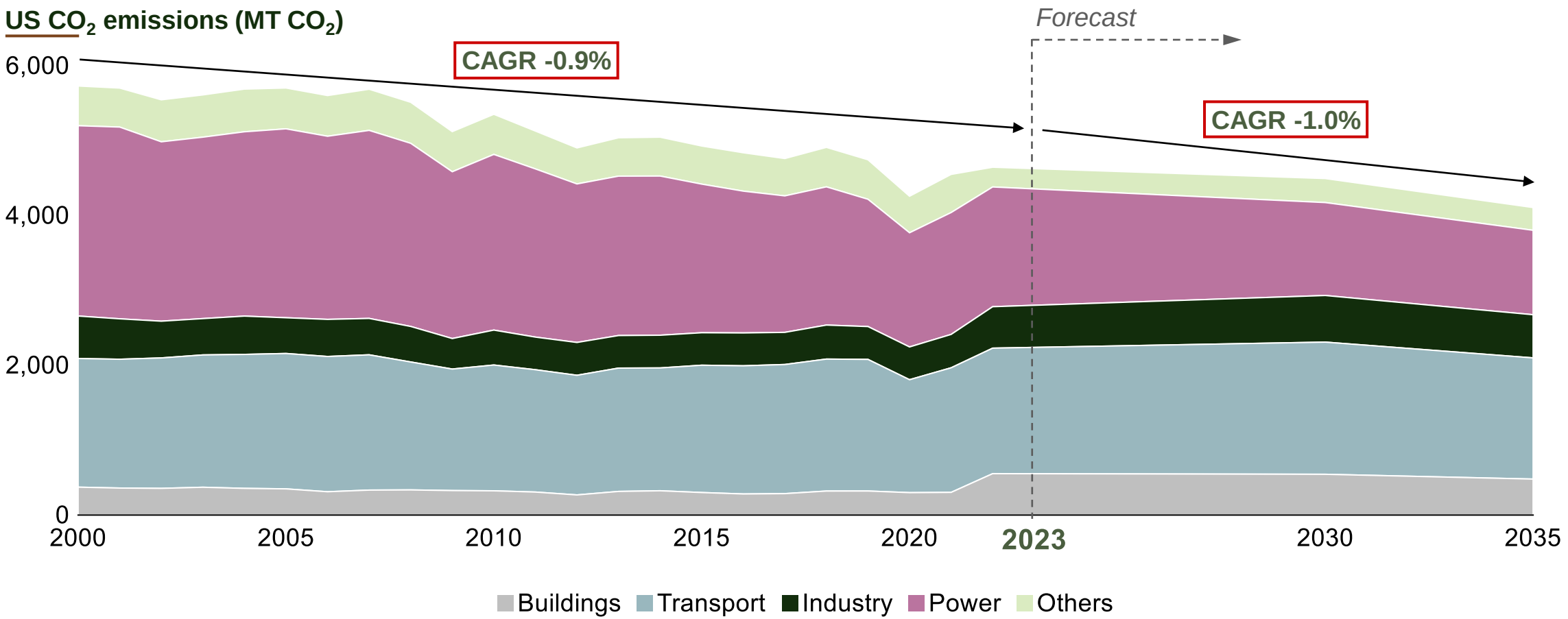


Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

US Power Generation's Continued Shift from Coal to Gas and Renewables Drives Lower Emissions

3 | EMISSIONS TRAJECTORY

PRELIMINARY



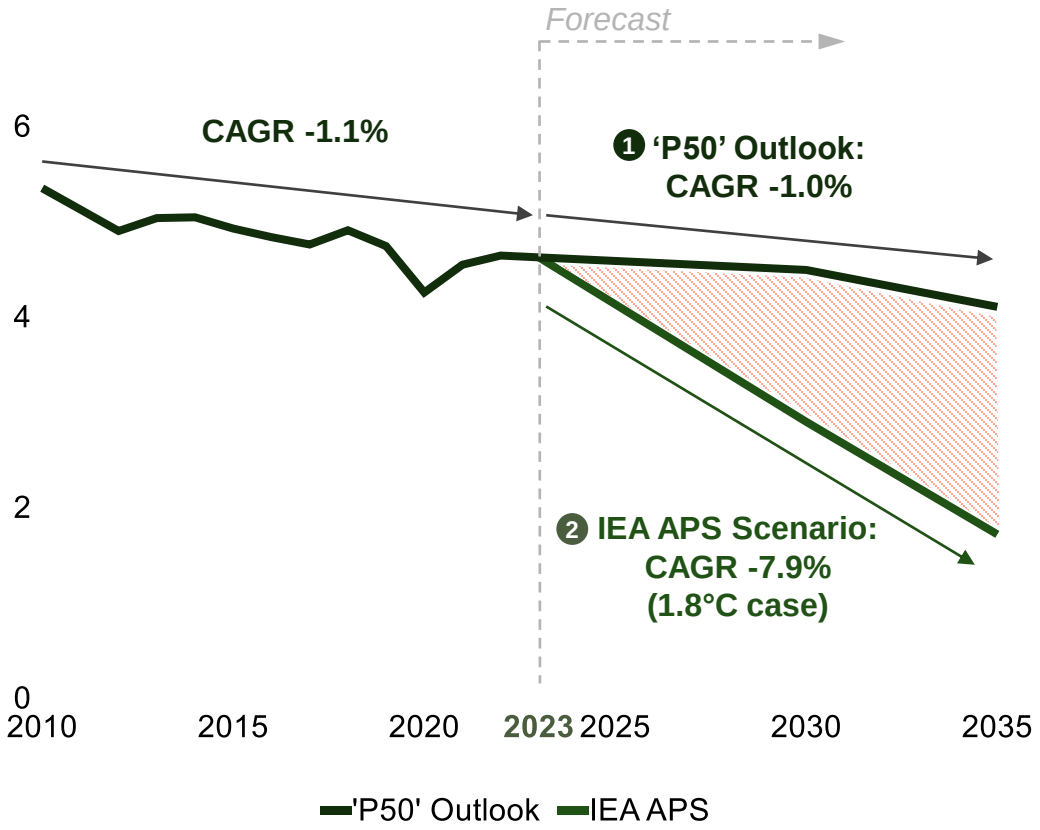
Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

Large Emissions Gap in the US Compared to 1.8°C Scenario Highlights Need For Rapid Low-Carbon Energy Expansion

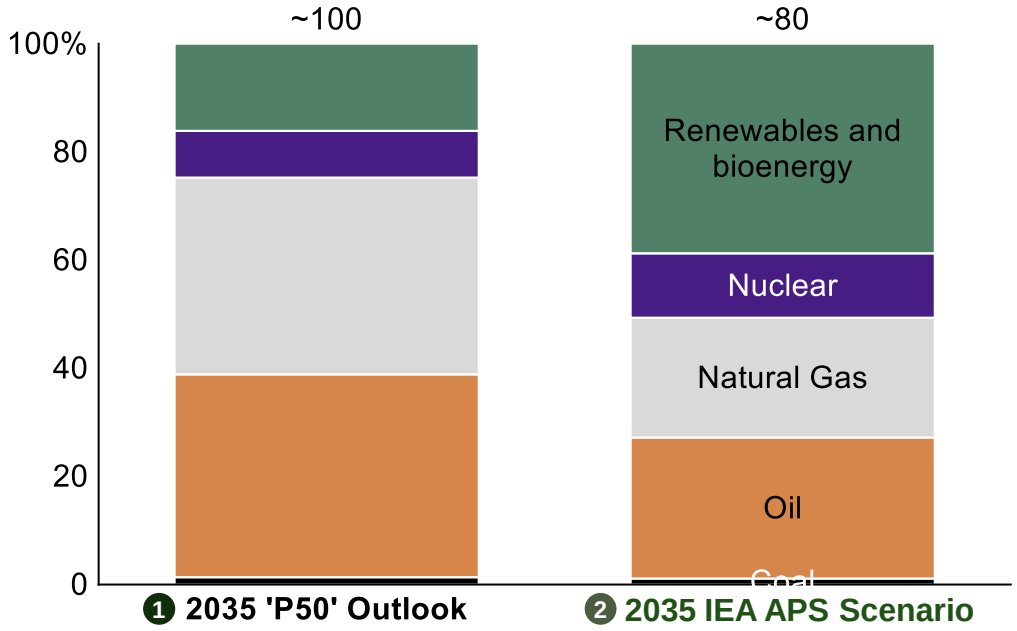
3 | EMISSIONS TRAJECTORY

/PRELIMINARY /ILLUSTRATIVE

US CO_2 emissions (GT CO_2)



Forecasted US Energy Supply (EJ)



Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023

What's Needed to Close the Gap in the US

Solutions we're progressing with current OpenMinds Impact Projects

Add More Firm and Low-Carbon Generation

- **Accelerate renewables**
- Scale geothermal and advance SMRs
- Deploy long-duration storage
- Firm with gas peakers

Remove Emissions from Current Energy System

- **Maximize methane abatement**
- **Advance CCS deployment**
- **Progress coal-to-X switching**

Expand Electric Transmission Infrastructure

- **Streamline permitting**
- **Enable interconnection**
- Upgrade existing assets

Increase Energy Efficiency and Electrification

- Make buildings more energy efficient
- Install heat pumps
- Improve fuel economy standards and EV adoption
- Electrify industrial processes

Identify and Develop a New Generation of Leaders

- **Equip, empower, and foster innovation**
- **Grow a strong network across climate and energy**

Implications for US Energy & Climate Outlook

Energy Demand...

is set to grow 9% by 2035, with booming electricity demand a key driver

Coal Power...

continues to decline, although recent plant retirement delays will slow mix shift

Natural Gas Demand...

will grow roughly in-line with total energy demand, maintaining its ~35% share through 2035

Renewable Energy...

is forecast to nearly double from ~9% of energy mix today to ~16% in 2035

Carbon Emissions...

will decrease by ~11% to reach ~4 Gt in 2035 (-1.0% p.a.)

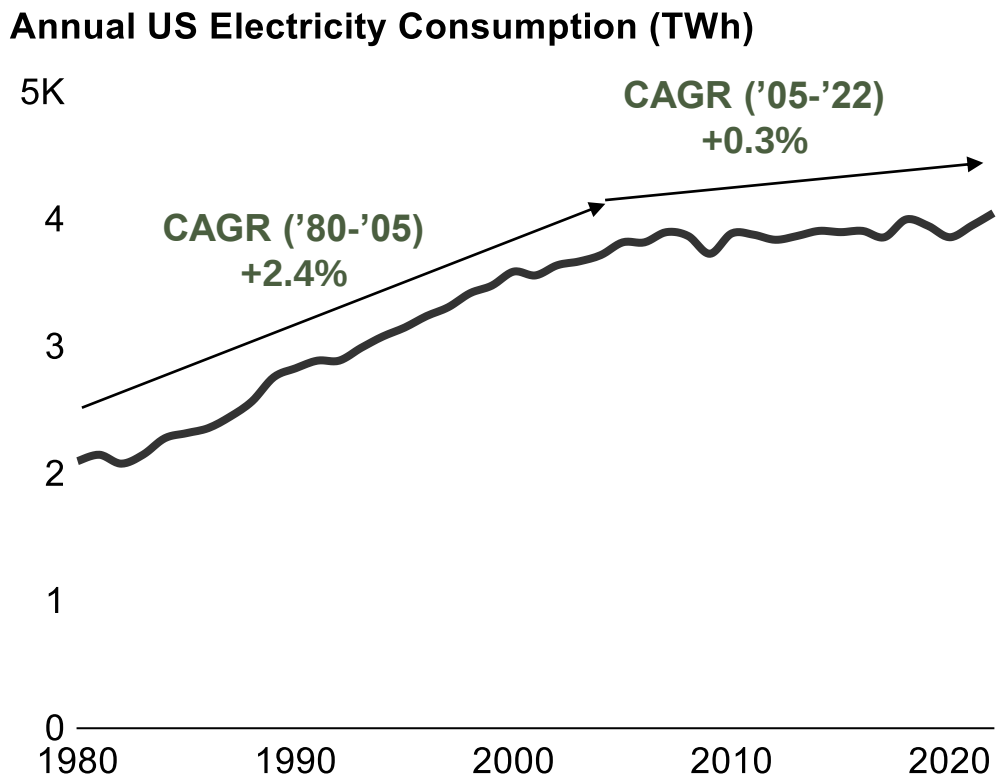
Energy Mix...

trajectory misaligned with 1.8°C forecast, requiring rapid implementation of solutions

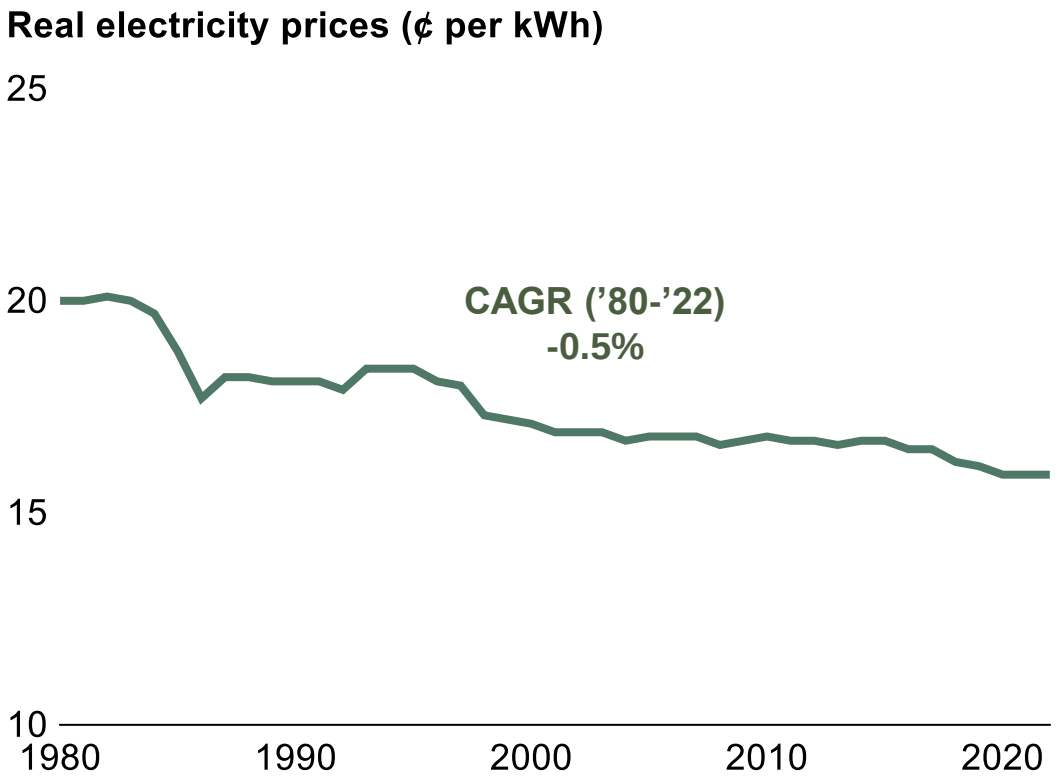
Appendix

Historically, US Electricity Consumption Has Increased as Real Prices Have Declined

Electricity consumption plateaued after long rise



Real electricity prices have trended down since 80s

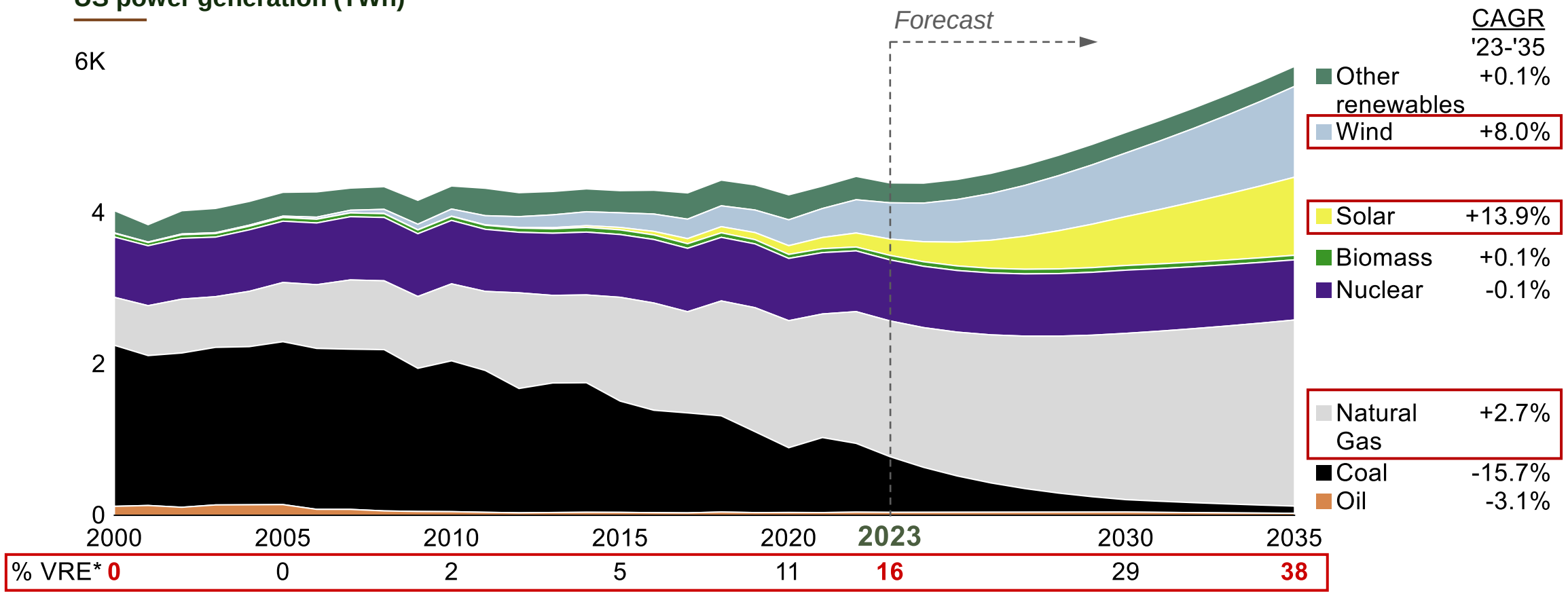


Source: EIA

Wind and Solar are Expected to Grow by ~3x and ~5x Respectively by 2035, While Coal is Replaced by Gas

PRELIMINARY

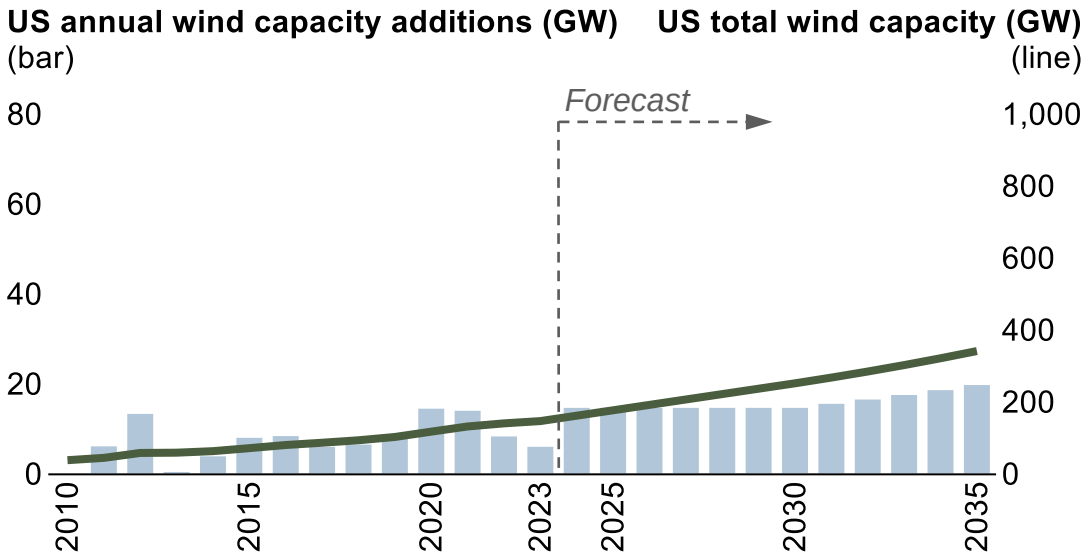
US power generation (TWh)



Note: (*) Variable renewable energy - includes percentage share of wind and solar combined; Other renewables include 'Hydropower'; IRA – Inflation Reduction Act
Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA

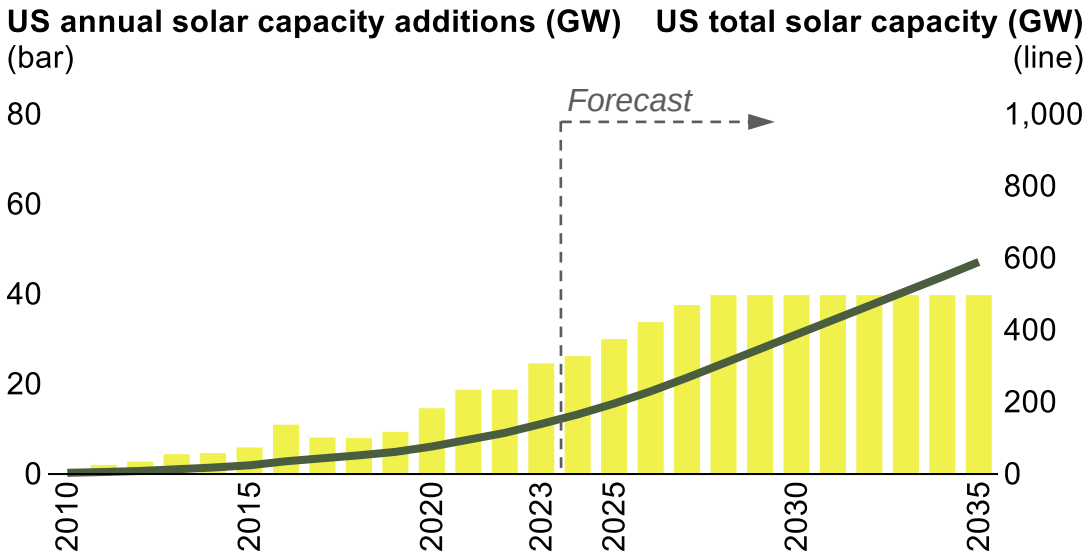
Solar Capacity Growth Will Continue to Outpace Wind

Wind capacity additions will flatline to 2030, before slowly accelerating



- Strong, but more moderate growth expected
- Elevated interest rates and increasing mix of costlier & longer-to-develop offshore wind drive deceleration

Solar capacity will more than double over the next five years

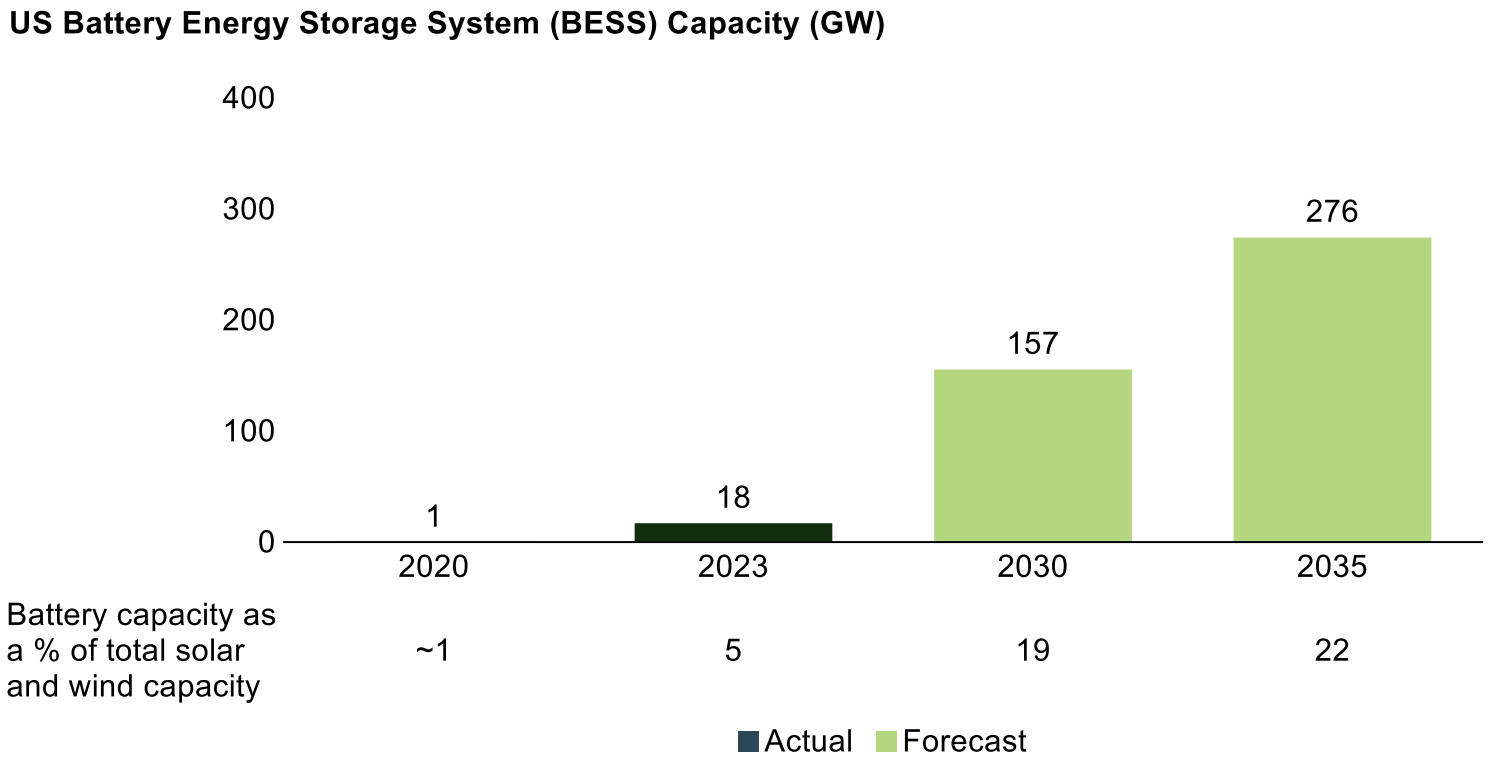


- Further cost reductions will continue to drive strong growth
- Growth beyond 2029 will level out due to US manufacturing capacity constraints (assumed to max out at 40 GW annually)

Source: Intersect$_{SM}$ Carbon and Energy Transition CGE Model, IEA WEO 2023

The US Will Rely Heavily on BESS to Manage Intermittency

BESS outlook shows strong growth off small base



- US is expected to have **similar share of renewables as other developed economies** by 2035
- Fragmented grid and nodal pricing are likely to cause **US to rely more on BESS** to manage intermittency
- **Forecast is highly uncertain,** dependent on extent to which other flexible supply and storage options are used (e.g., demand response, peak gas, hydrogen)

Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA WEO 2023; EIA

6 Macro Trends are Shaping the Utility and Power Sector

Data center load growth

Data center load growth primarily driven by **rapid expansion, development, and change in the AI and cloud computing spaces**

Manufacturing load growth

Key drivers of manufacturing load growth are largely regulatory and geopolitical, incentivizing **reshoring** of and **clean technology** investments in manufacturing

Decarbonization

Increasing focus on **emissions reduction** and need to incorporate more distributed renewable generating mix (e.g., rooftop solar)

Aging infrastructure & resiliency

Antiquated systems across the US increasingly **require repairs and upgrades** in addition to new transmission and distribution

Resource constraints

Competition for both skilled workers and material supplies are leading to a lack of resources to complete electricity investments in time to meet demand

Affordability

Increasing challenges to the rate base model with added focus on maintaining overall **customer affordability** in the face of increasing real price of electricity and increasing share of a smaller energy wallet