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Introduction

Contractor Team Overview

VERDANT

EVOLVED ENERGY RESEARCH

Mitchell Analytics

Overview of Contractor Team Presentation

- High-level overview of the tools and methodologies used in the Demand Scenarios Project
- Annual and hourly energy and greenhouse gas emissions results and trends through 2050 by scenario, fuel type, and sector
- Conclusions and key takeaways

Acronyms and Initialisms

BUGL – Burbank/Glendale Water and Power
CAISO – California Independent System Operator
CARB – California Air Resources Board
CC – Carbon Capture
CEC – California Energy Commission
CH_4 – Methane
CO_2 – Carbon Dioxide
CO_2e – Carbon Dioxide Equivalent
EAD – Energy Assessments Division
EER – Evolved Energy Research
EP – Energy Pathways
EPS – Enhanced Policy Scenario
GWP – Global Warming Potential
IEPR – Integrated Energy Policy Report
IID – Imperial Irrigation District
IPCC – Intergovernmental Panel on Climate Change
LADWP – Los Angeles Department of Water and Power
LD – Light-Duty (vehicles)
LCFS – Low-Carbon Fuel Standard
LPG – Liquified Petroleum Gas
H_2 – Hydrogen
MKRP – Mojave Kern River Pipeline
MMT – Million Metric Tons
MPG – Miles per Gallon
MPGe – Miles per Gallon Equivalent
NCNC – Northern California Non-CAISO Planning Area
N_2O – Nitrous Oxide
OGV – Ocean-Going Vessel
OOS – Out of State (aviation)
PGE – Pacific Gas and Electric
POU – Publicly-Owned Utility
SCE – Southern California Edison
SDGE – San Diego Gas and Electric
SLCPs – Short-Lived Climate Pollutants
TBtu – Trillion British Thermal Units
TE – Transportation Electrification
VMT – Vehicle Miles Traveled

Methodology

About Energy Pathways (EP)

- An advanced accounting framework that is used to develop economy-wide energy demand scenarios
- User-defined measures that change the composition of energy demand on a sub-sector level over time
- Used for a small subset of energy demand in these scenarios
  - Mostly fuels other than electricity and natural gas
  - About 10% of total statewide energy demand
  - Other demand developed by the CEC
- Additional electricity and natural gas script to integrate annual and hourly energy demand data provided by CEC Staff with EP results

Energy Pathways Detail

- For fuel/sector combinations developed using EP, model structure adapts to available data
- EP can use equipment stock rollover, projected service demand, or projected energy demand at the subsector level
- For the limited set of fuel/sector combinations that EP was used for in this analysis, projections were developed based on energy demand only from CEC provided drivers

Data-dependent analysis structures

Energy demand

- Track energy demand based on projections adjusted to the appropriate geographic scale and magnitude
- Can modify projections with revised driver inputs
- Examples: cement, agriculture

Stock with service or energy demand

- Track the stock rollover of technology stocks and new sales ensure the fleet can meet the required service demand or energy demand
- Examples: light duty trucks, res. water heating

Service with energy demand or efficiency

- Track service demand, either tracking projected energy demand or determining energy demand based on service efficiency
- Examples: aviation, iron & steel CO_2 capture

Multiple Scenarios from EP Customization

- Modified existing California geographic representation of each CEC planning area
- Incorporated CEC economic drivers of energy demand, including for industrial subsectors
- Calibrated model to previous demand scenario analysis
- Limited EP results to fuels and sectors not already addressed by CEC projections (see appendix for matrix of fuels/sectors using EP)
- Developed fuel switching and efficiency measures for ocean-going vessels and allocated minor transportation types (not previously disaggregated) to planning areas

Hourly Electricity Demand

- Verdant developed hourly profiles for POU planning areas where there were gaps in available CEC data
- EER developed a script to compile the numerous disparate hourly projections into a single projection
  - Hourly projections built from CEC and Verdant hourly projection files
  - Adjusts for planning area-specific losses
  - A number of TE subsectors are assumed to have flat hourly load profiles, and the script transforms the annual demand to flat hourly demand, including:
    - New aviation demand
    - Rail
    - Off-road transportation
    - Other new transportation electrification without a defined load shape

Limitations of Demand-Side Only Modeling

Because this is a demand-side only modeling effort, and these scenarios do not include energy supply, there are limitations to the results

- Energy amounts, types, and locations used to produce fuels for "retail" consumption are excluded in most cases
  - Energy consumption to generate electricity is excluded
  - Energy consumption to refine crude oil into imported petroleum products is excluded
  - Energy consumption to produce electrofuels and biofuels is excluded
- Some supply-side decarbonization measures not included in the analysis
  - Point-source carbon capture
  - Decarbonized fuel substitution for fossil fuels

Decarbonized Fuel Blending

- Decarbonized fuel supply not included in this demand-side analysis
  - Assumptions required for future decarbonization of fuel blends
- Scenarios assume today's level of gasoline, jet fuel, diesel, and natural gas decarbonization
  - Existing blending levels are calculated from the 2023 LCFS dashboard
  - Blending is held constant as a percent of total fuel demand through 2050
    - Because some fuels decline, the amount of decarbonized fuel consumed declines for some fuels (e.g., diesel fuel)

Bottom-Up Emissions Tool

- Excel spreadsheet using CARB fuel inventory emissions profiles to display all Demand scenarios
- Multiple Types of Emission Results
  - Statewide annual emissions in CO_2e from all fuels by sector and fuel type
  - Global warming impacts of fugitive methane and hydrogen
  - Display features that show 20-year and 100-year GWP timelines to help address SLCPs
  - Capability to assess multiple carbon emission reduction strategies (Fuel Blending, Hydrogen, CC)

Emission Factors Inputs

- Using real data to provide a robust forecast of future emissions profiles
  - Used CARB 2000-2021 Emissions Inventory data for CO_2, CH_4 and N_2O emissions profile as a function of energy consumption
  - CAISO projection of future electric power grid “Allowable Emissions” through 2050 used in the avoided cost calculator
  - Statewide grid average line loss values provided by CEC and projected through 2050
  - Inclusion of IPCC 2019 values of GWP values to produce CO_2e for trace gases (CH_4, N_2O and H_2)

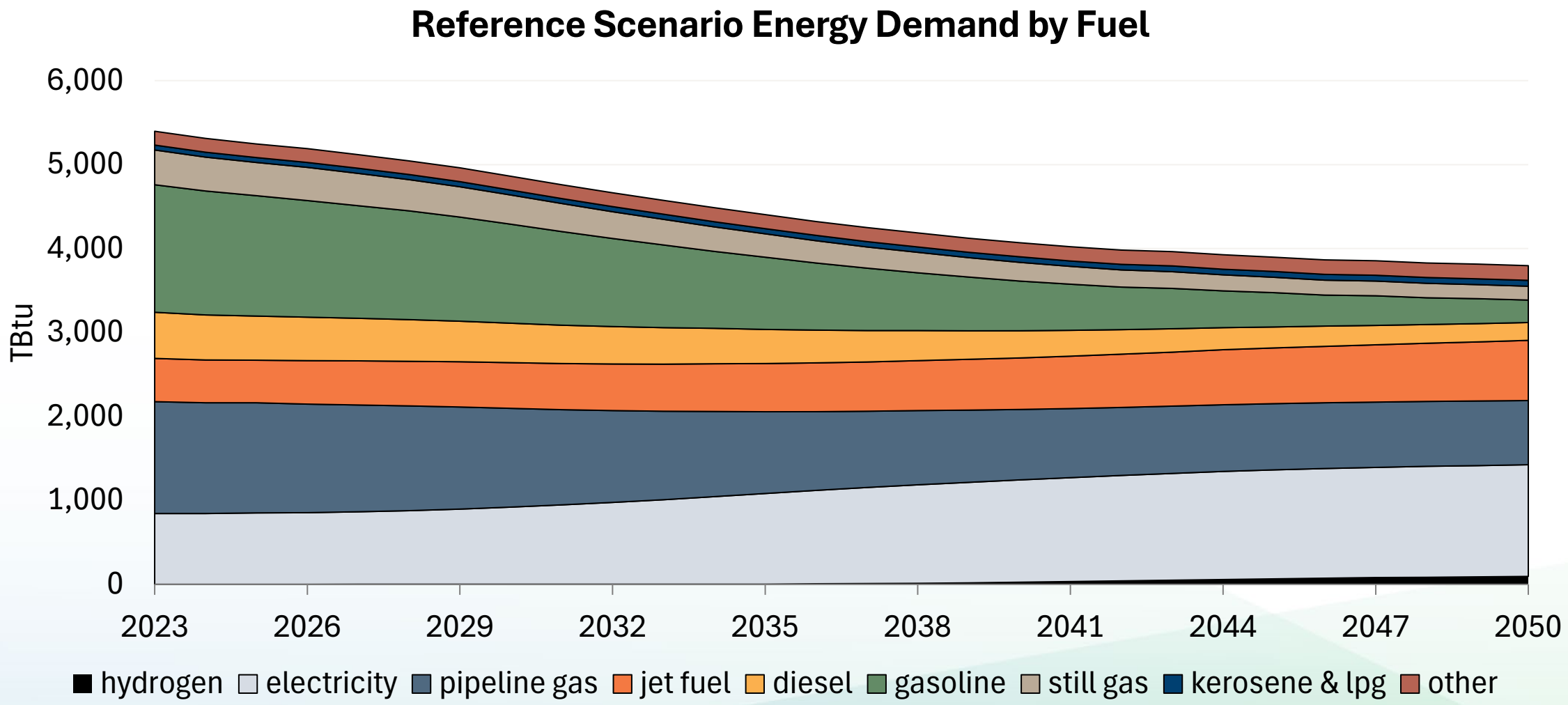
Results

Summary of Results Produced

- Annual energy demand by fuel type and sector for all CEC Planning Areas through 2050
- Annual emissions results by fuel type for various scenarios
- Hourly electricity results by Planning Area

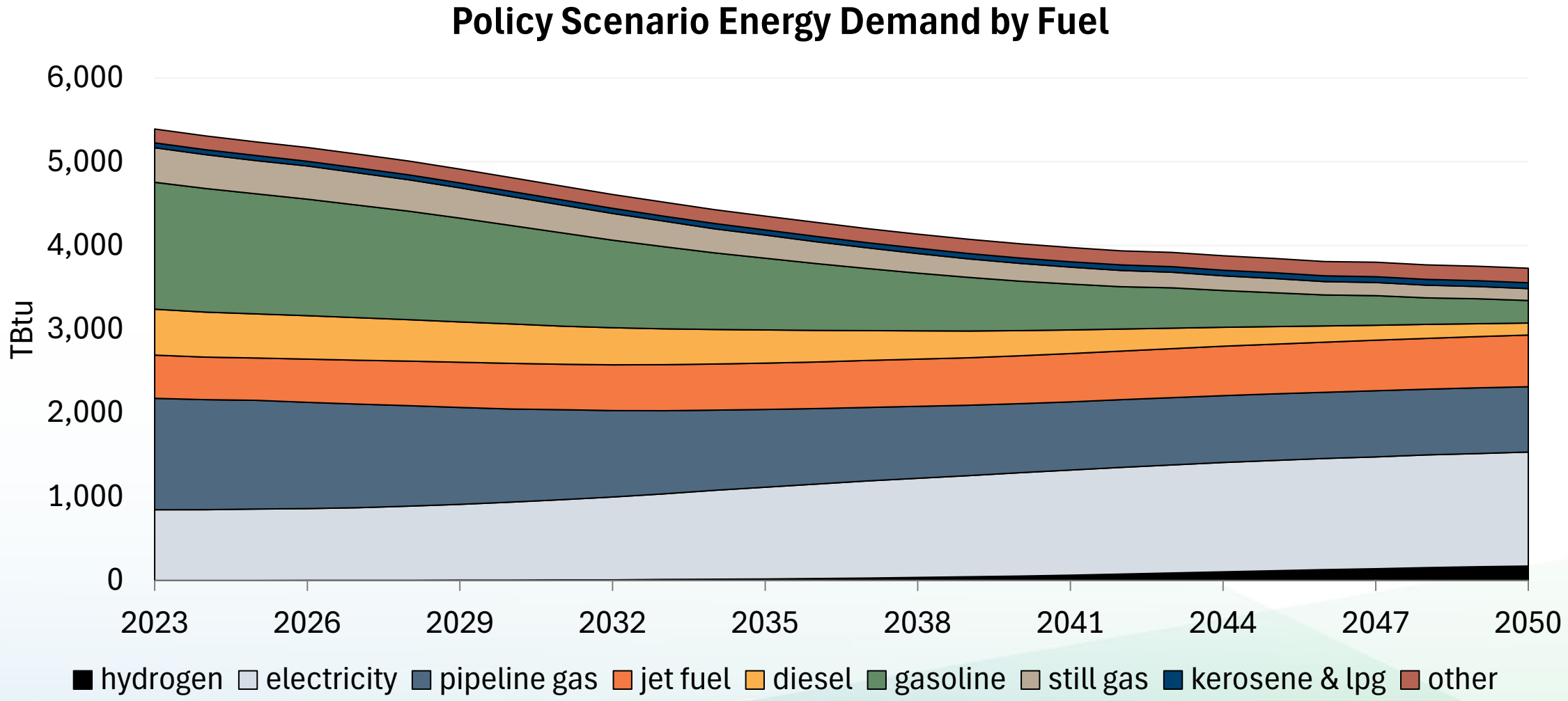
Annual Energy Results

Reference Scenario Statewide Energy Demand by Fuel



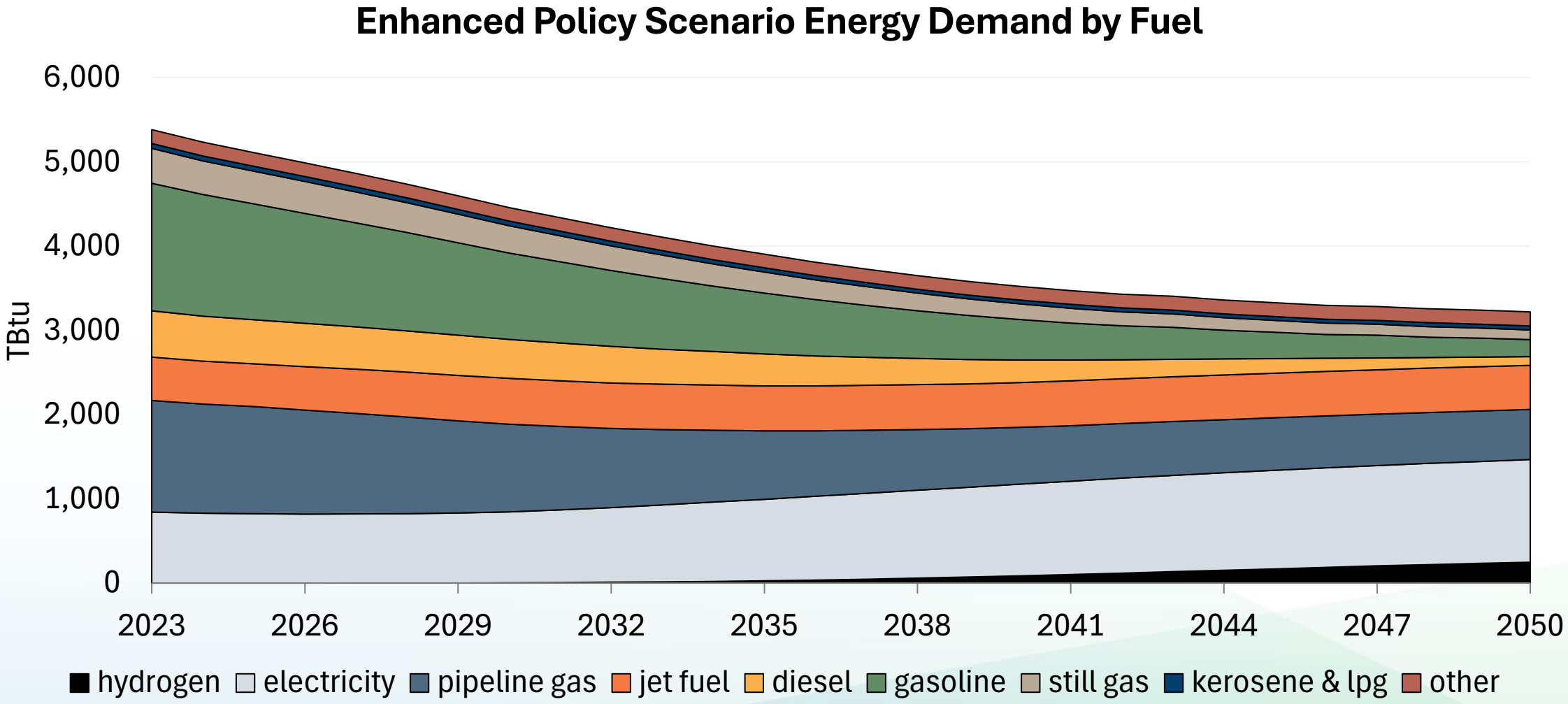
Source: Verdant, EER, CEC. Other includes biomass/wood, coal and steam

Policy Scenario Statewide Energy Demand by Fuel



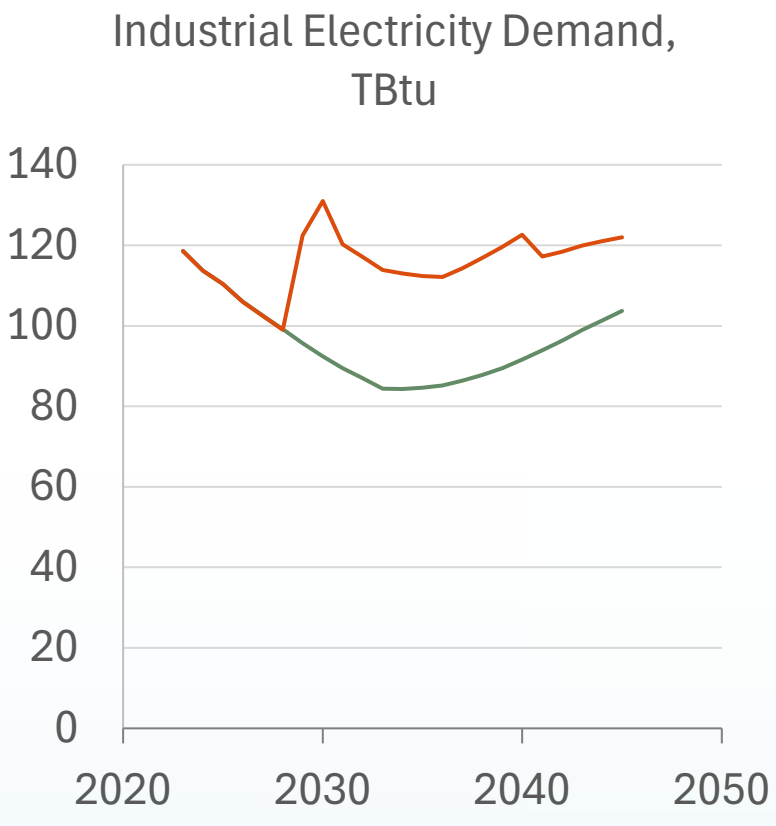
Source: Verdant, EER, CEC. Other includes biomass/wood, coal and steam

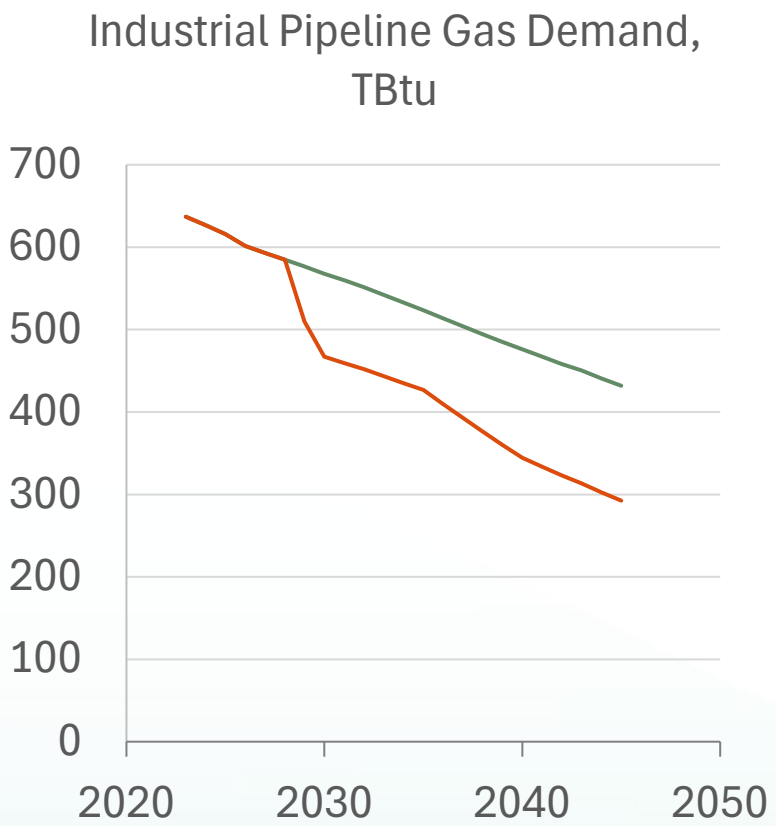
Enhanced Policy Scenario Energy Demand by Fuel

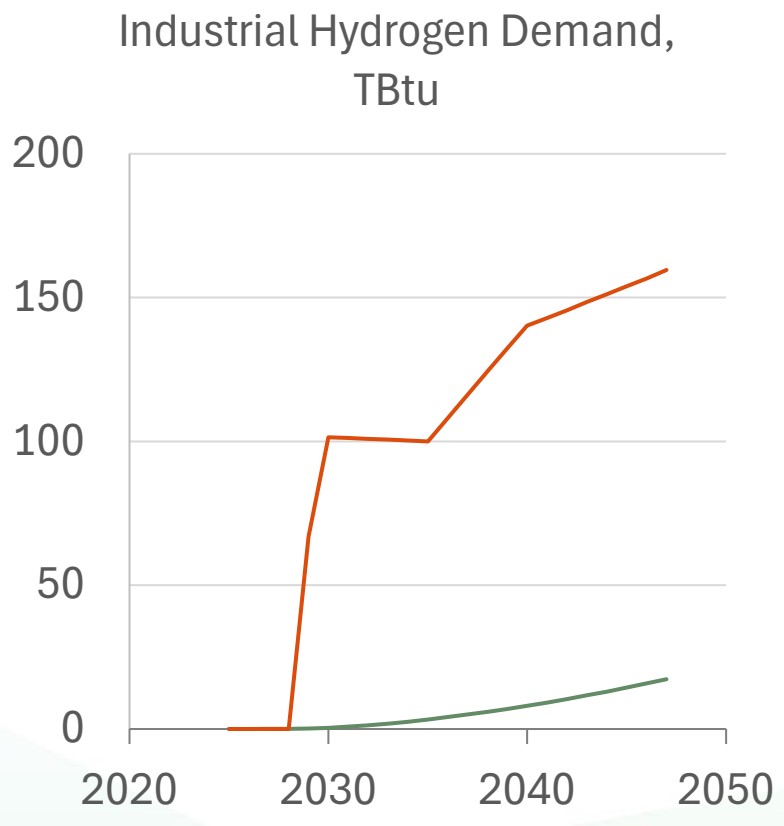


Source: Verdant, EER, CEC. Other includes biomass/wood, coal and steam

EPS Pipeline Hydrogen Sensitivity

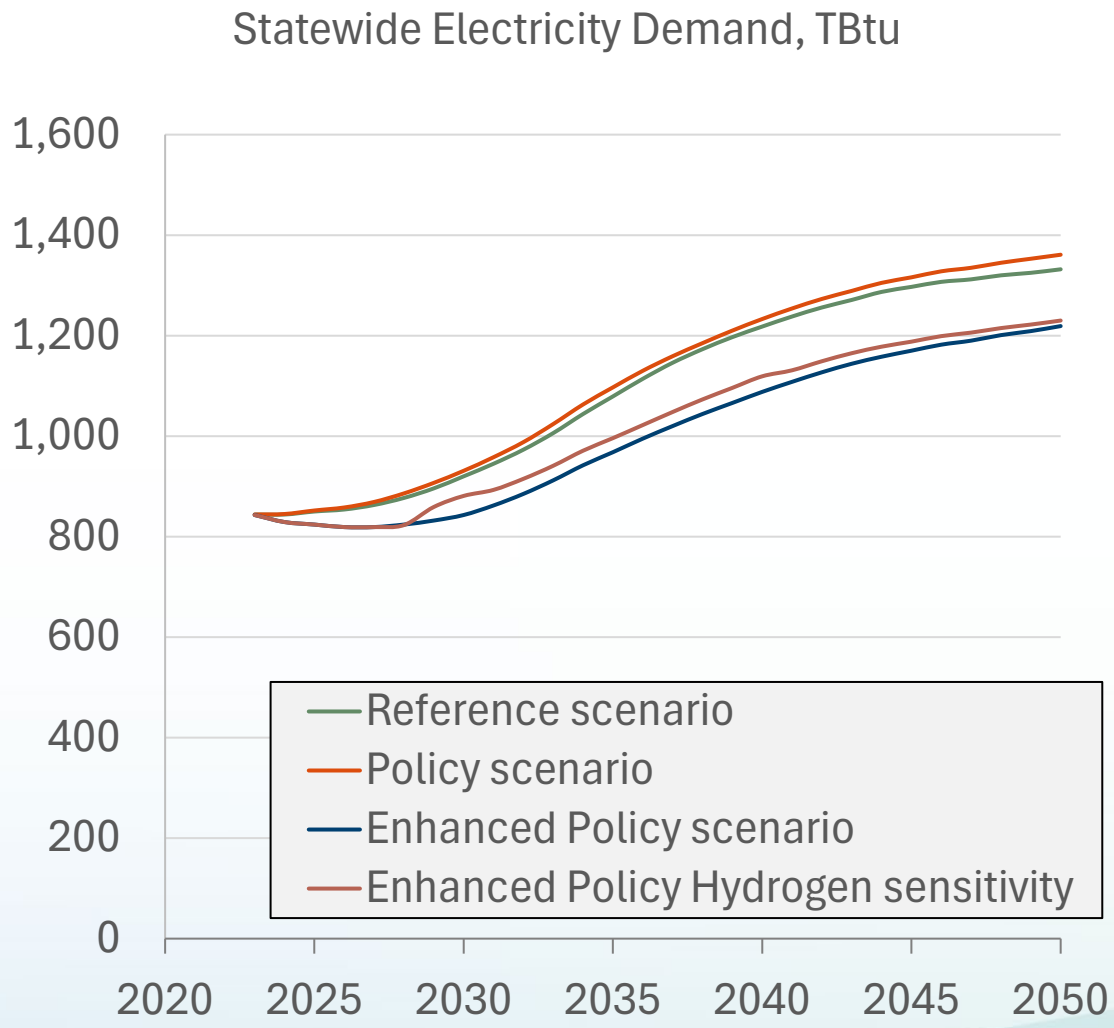


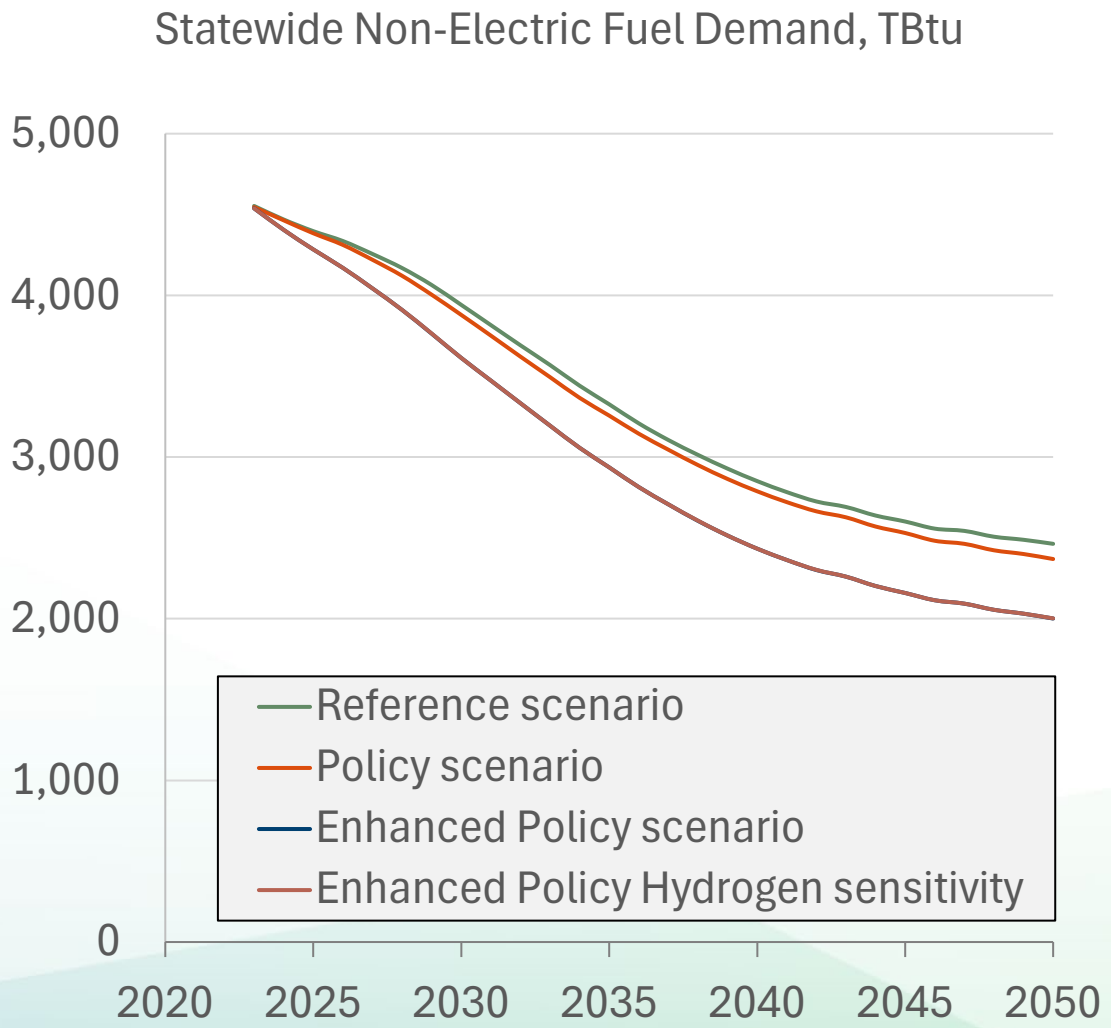




Source: Verdant, EER, CEC

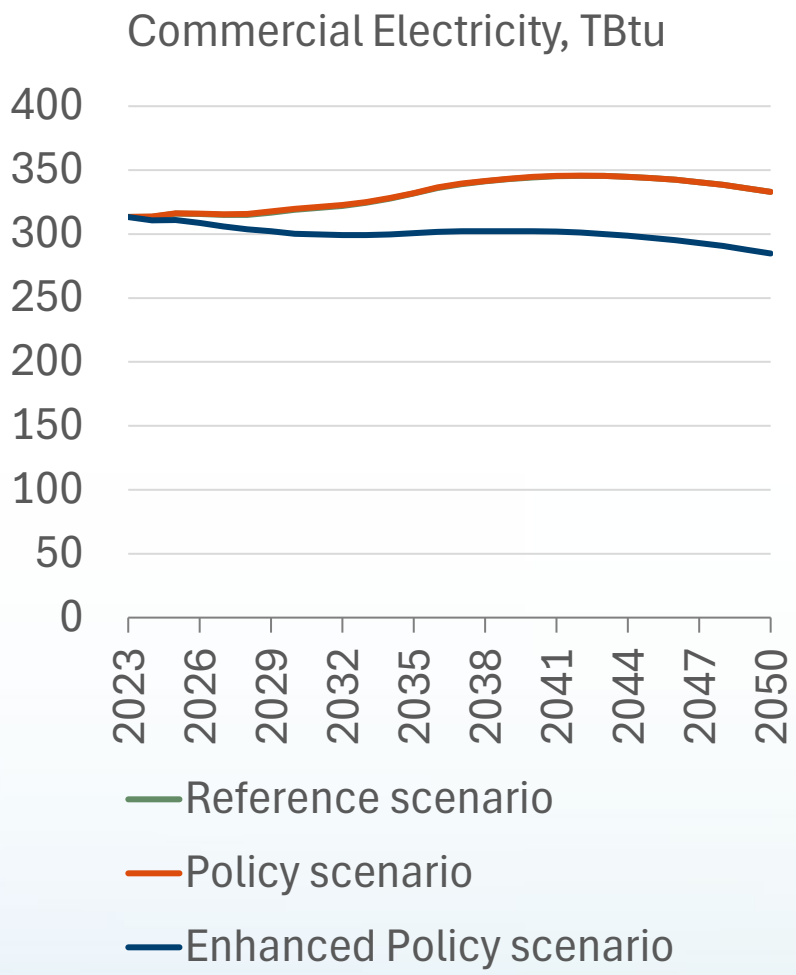
Annual Statewide Energy Demand

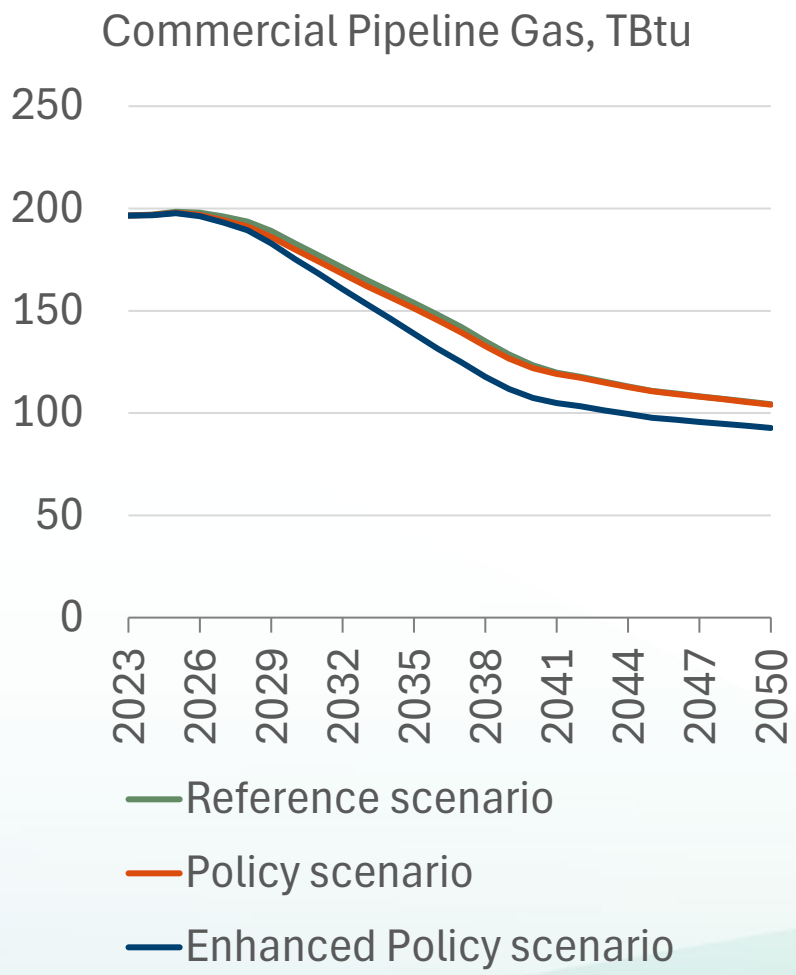


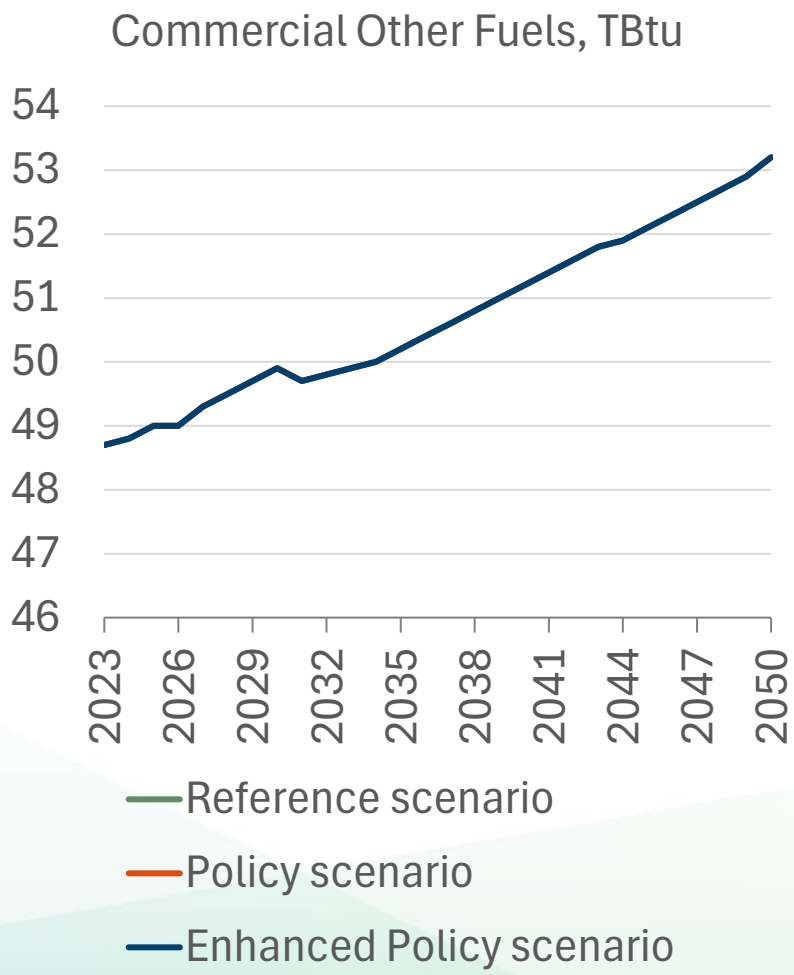


Source: Verdant, EER, CEC

Commercial Building Energy Demand

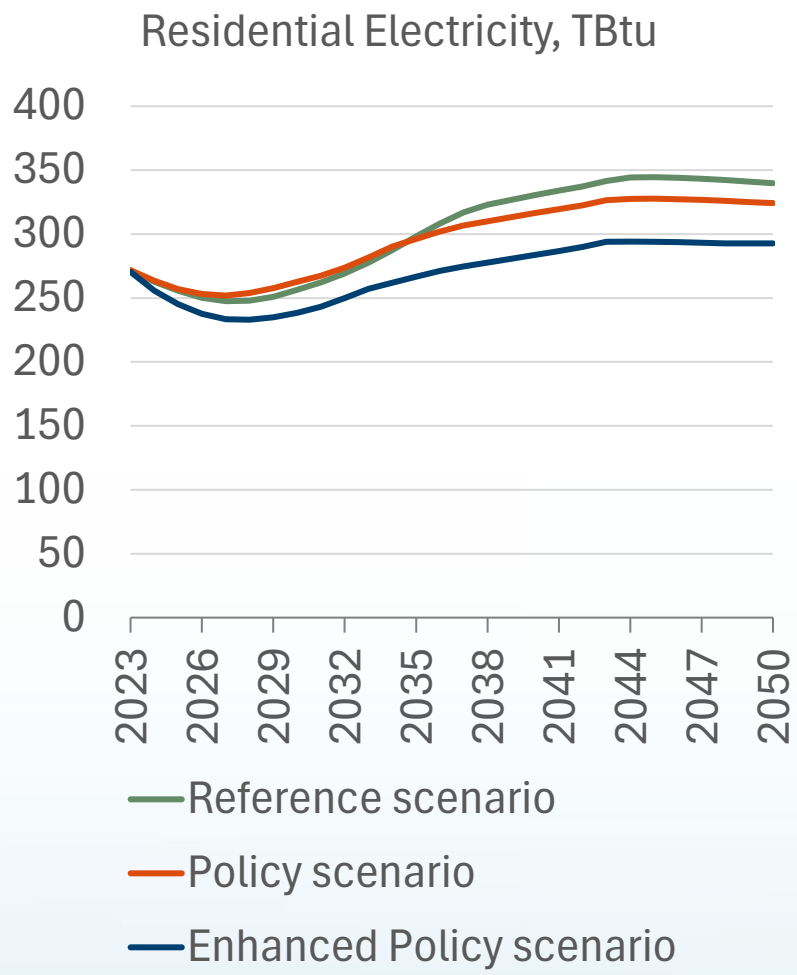


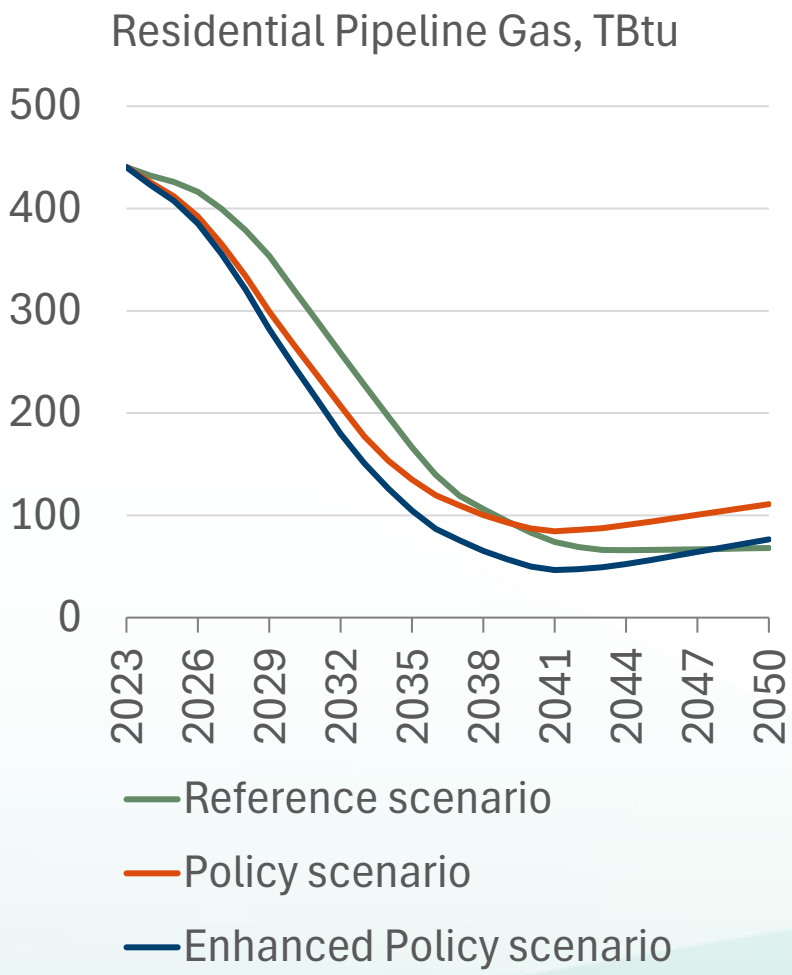


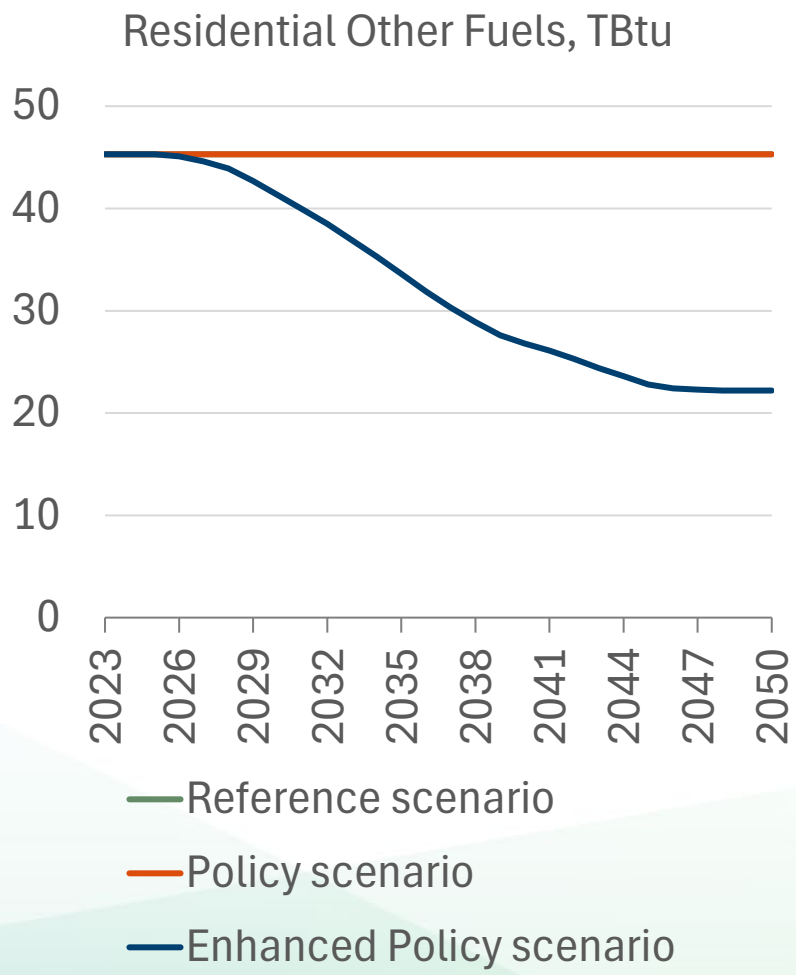


Source: Verdant, EER, CEC. Other includes biomass/wood, coal and steam

Residential Building Energy Demand

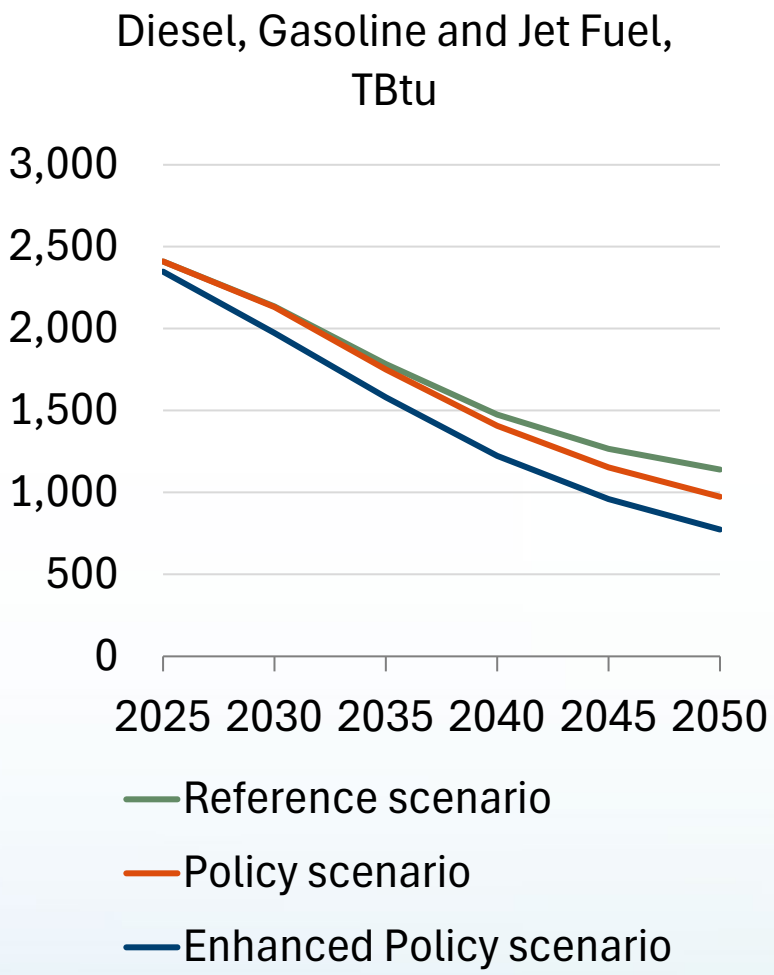


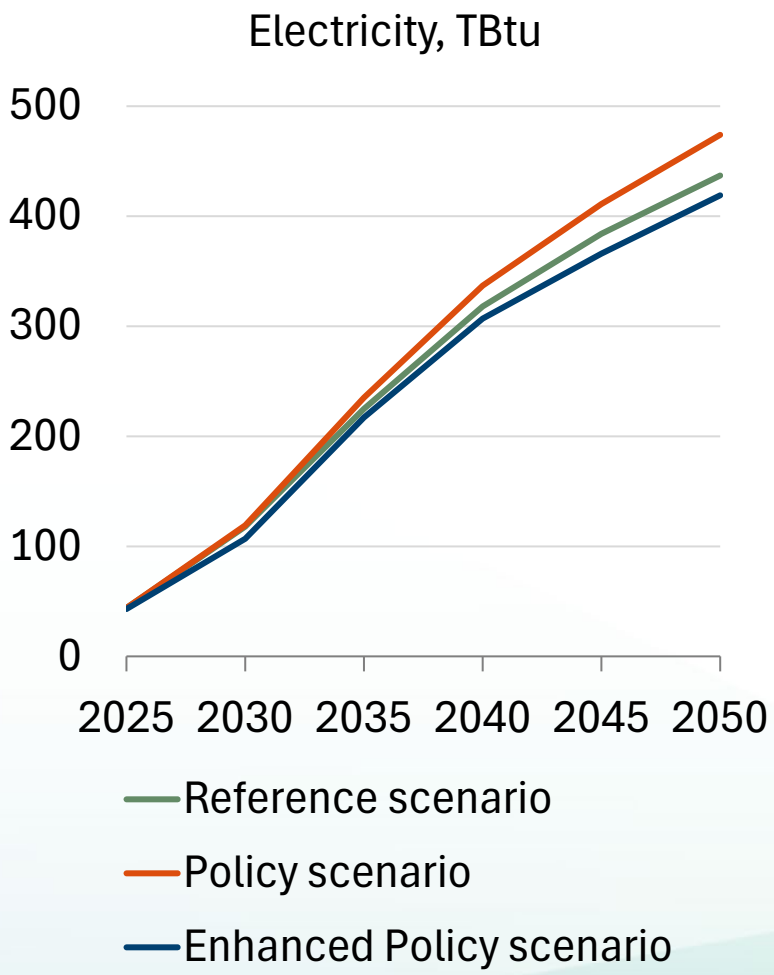


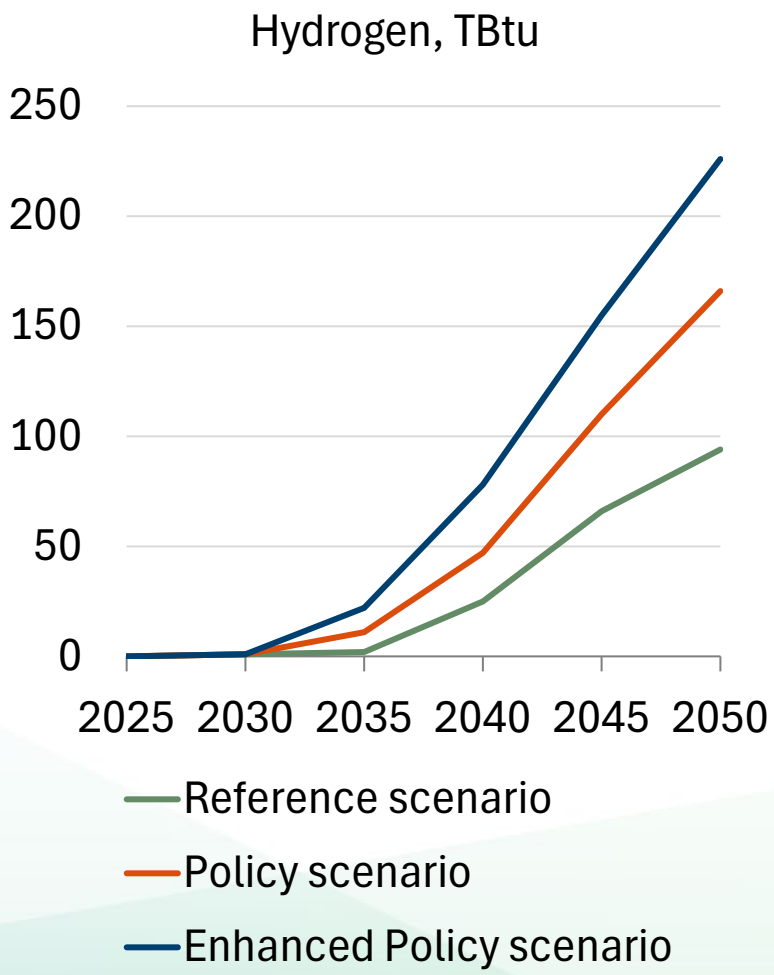


Source: Verdant, EER, CEC. Other includes biomass/wood, coal and steam

Transportation Energy Demand

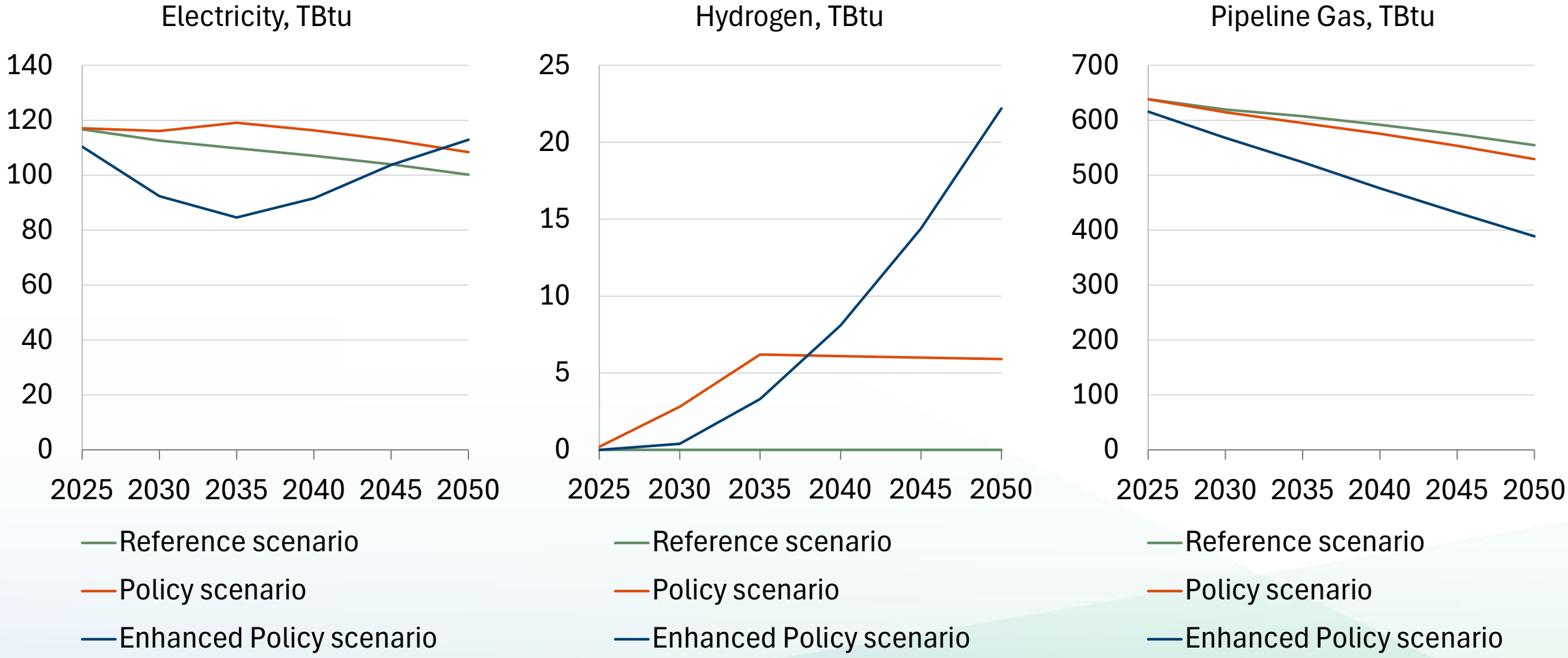






Source: Verdant, EER, CEC. Transportation natural gas demand is not pictured, does not vary by scenario

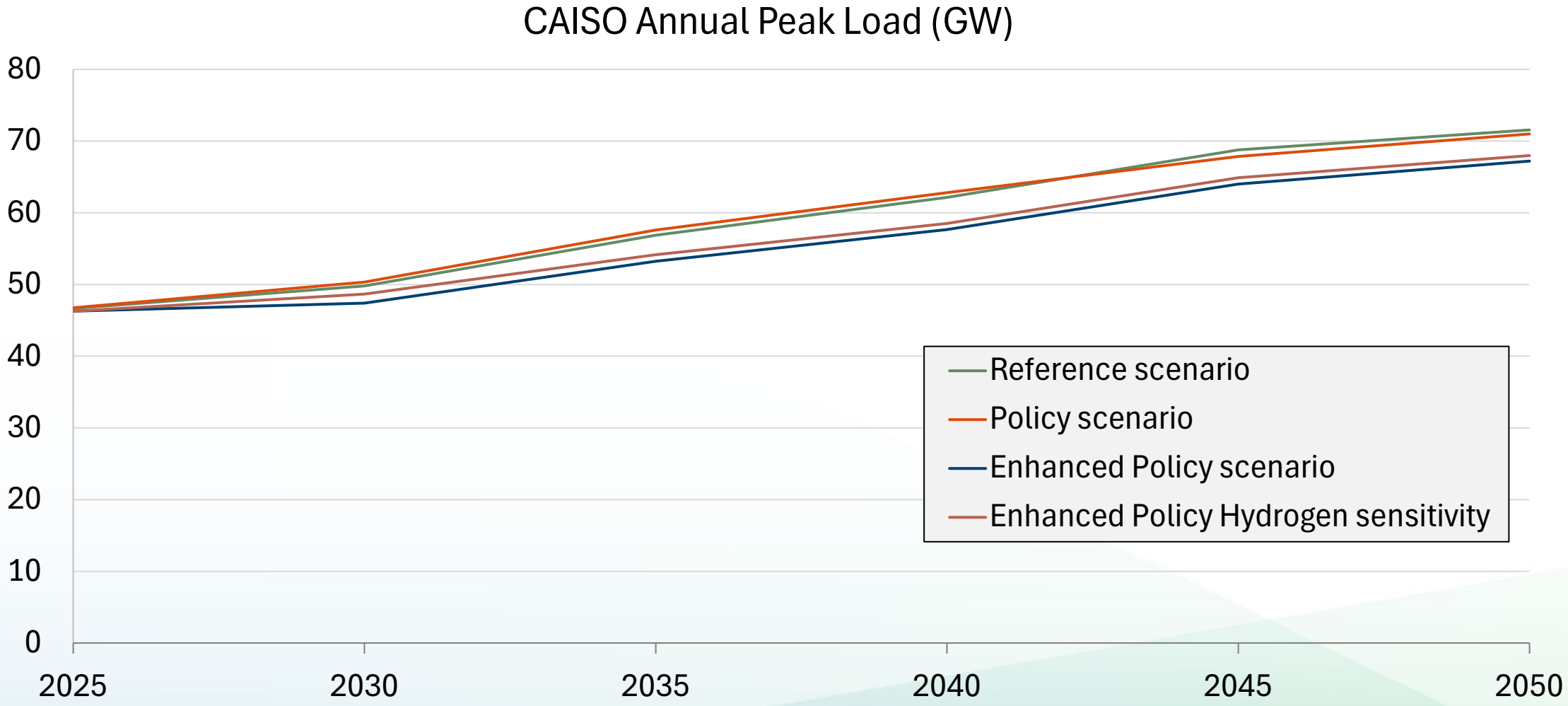
Industrial Energy Demand



Source: Verdant, EER, CEC. Other fuels not pictured: coal, diesel, gasoline, LPG, steam, still gas

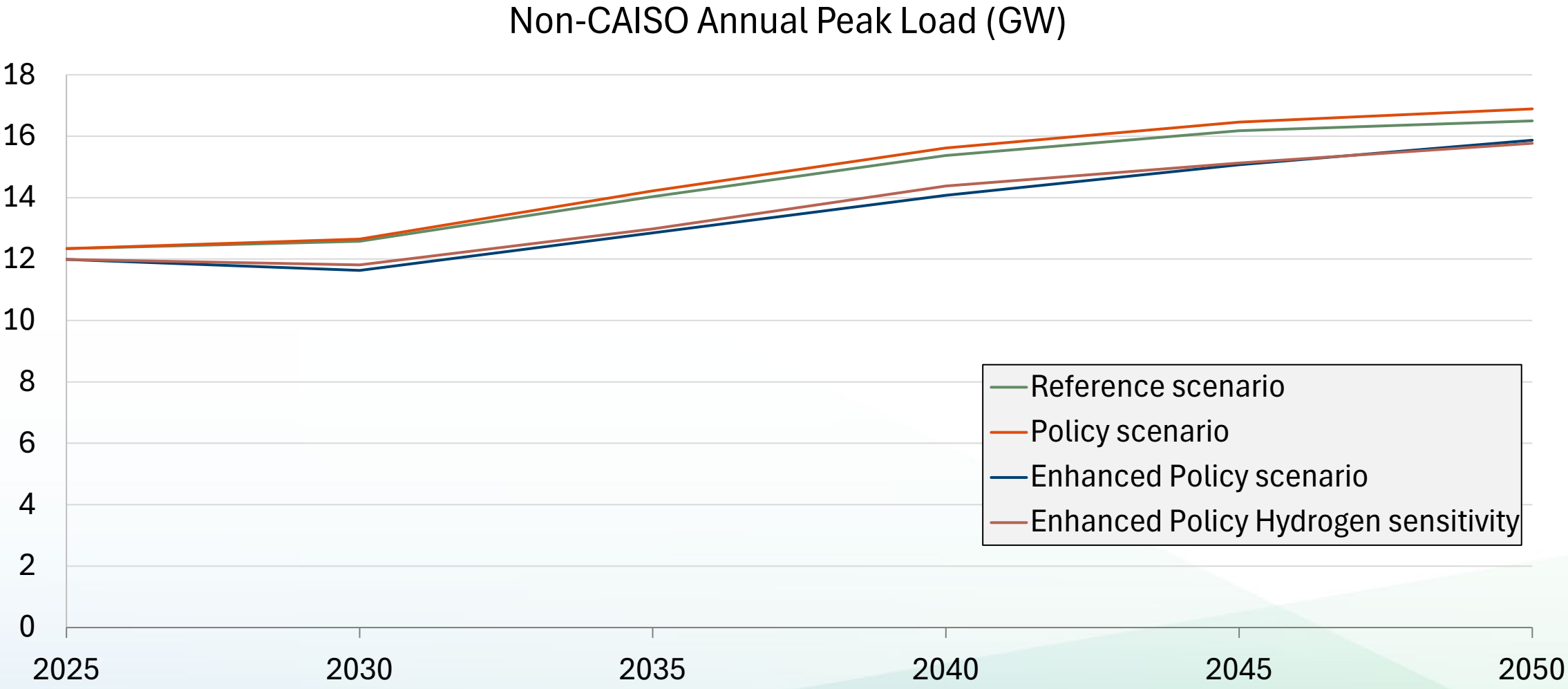
Hourly Electricity Results

Peak Electricity Demand (1 of 6)



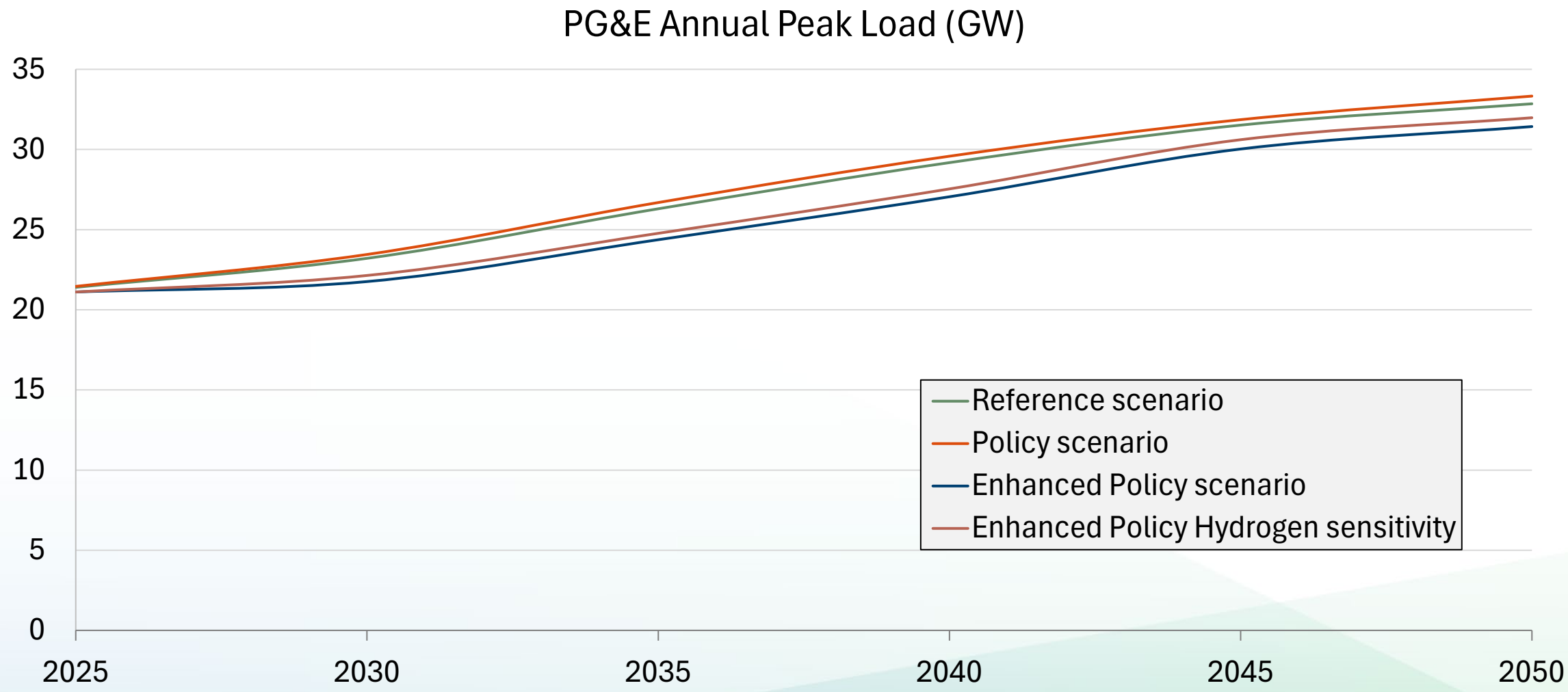
Source: Verdant, EER, CEC. Hourly electricity demand is net of behind the meter solar generation

Peak Electricity Demand (2 of 6)



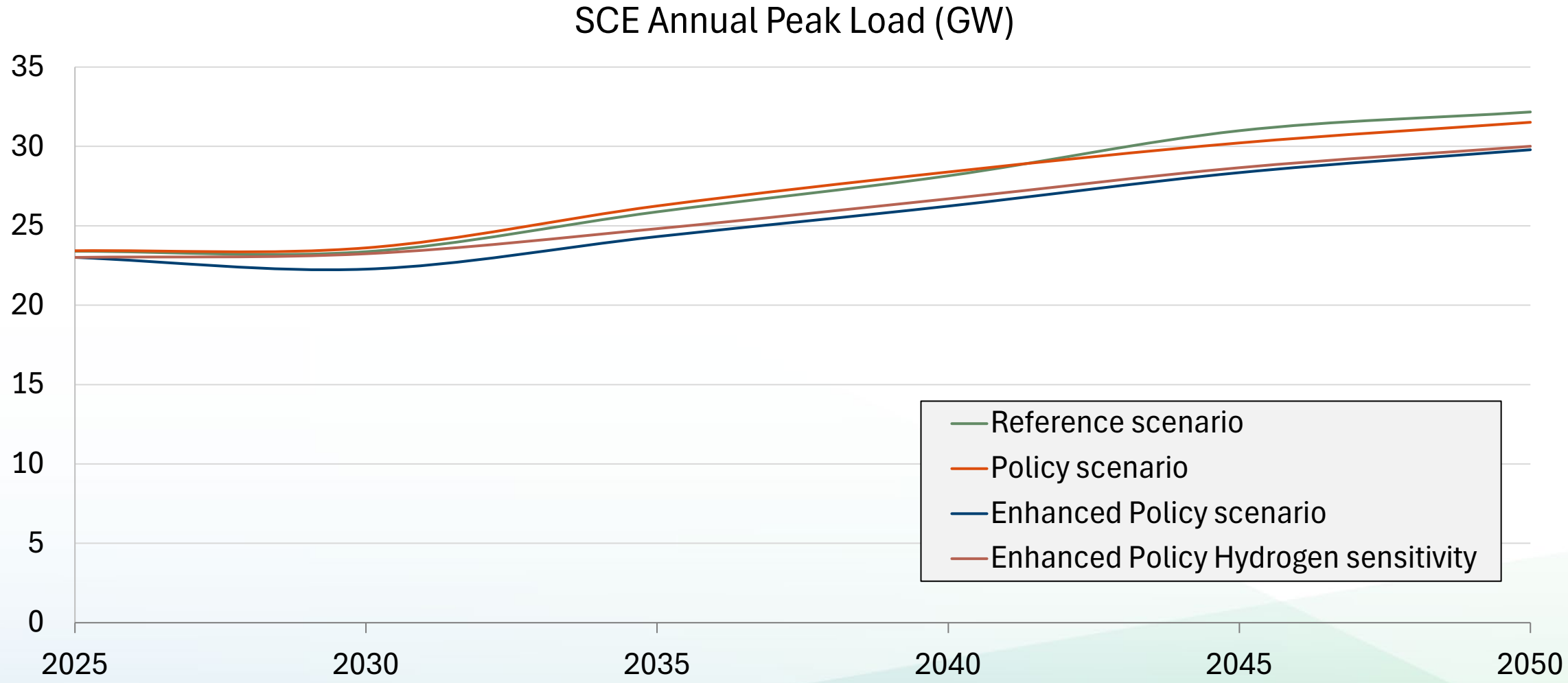
Source: Verdant, EER, CEC. Hourly electricity demand is net of behind the meter solar generation

Peak Electricity Demand (3 of 6)



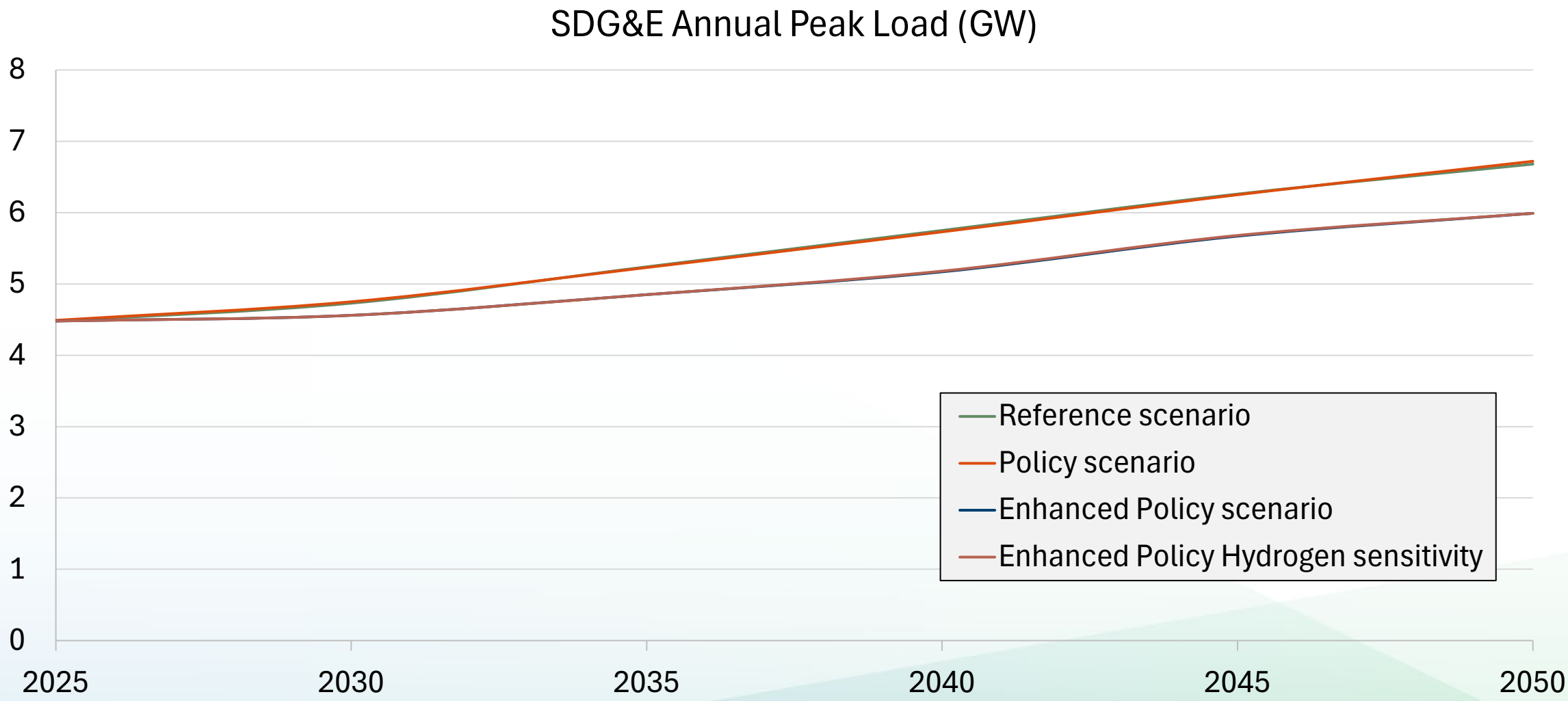
Source: Verdant, EER, CEC. Hourly electricity demand is net of behind the meter solar generation

Peak Electricity Demand (4 of 6)



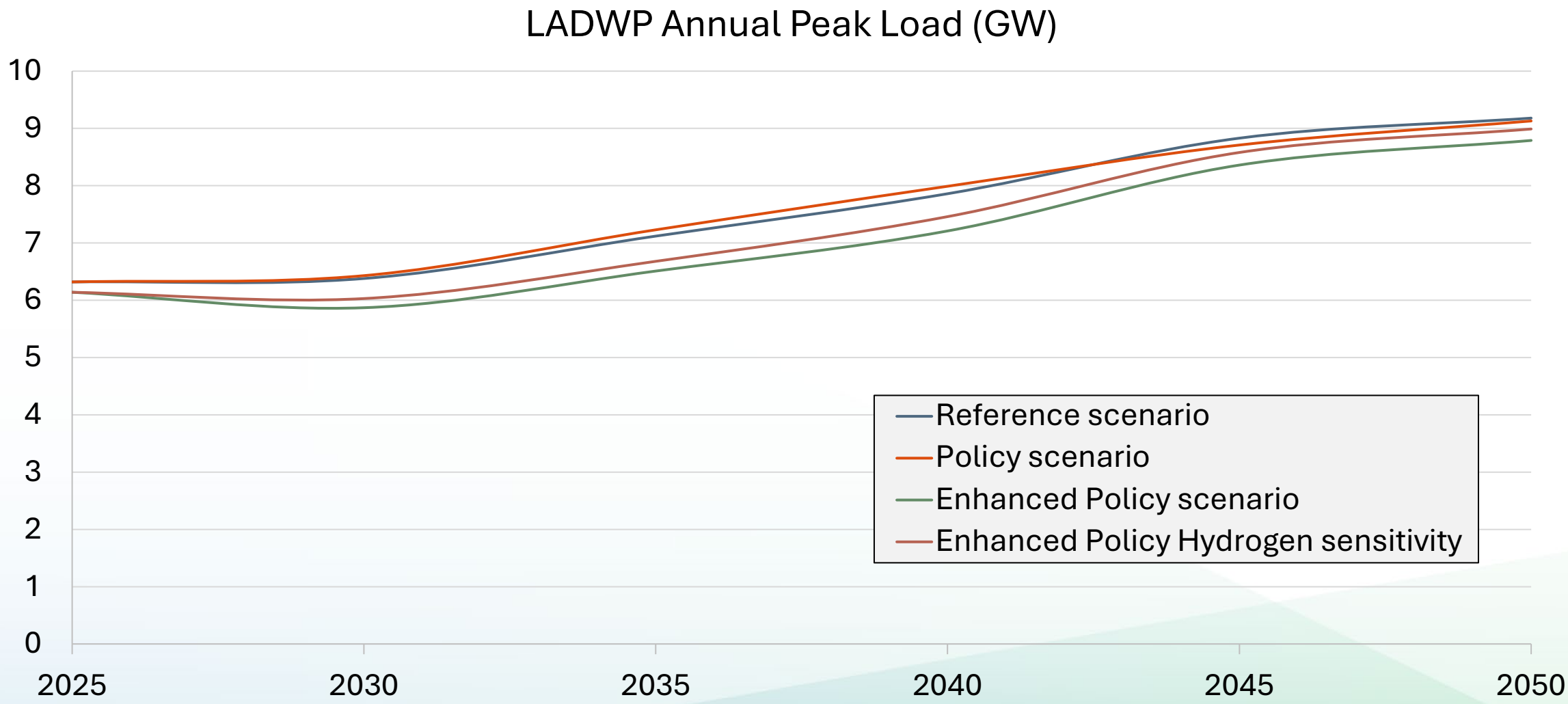
Source: Verdant, EER, CEC. Hourly electricity demand is net of behind the meter solar generation

Peak Electricity Demand (5 of 6)



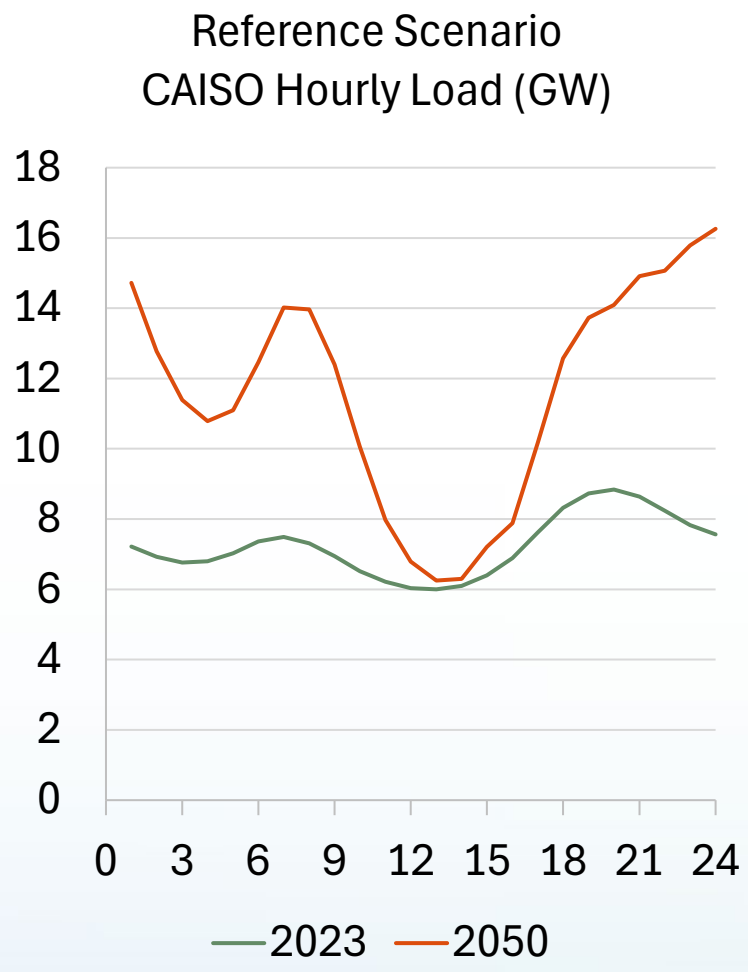
Source: Verdant, EER, CEC. Hourly electricity demand is net of behind the meter solar generation

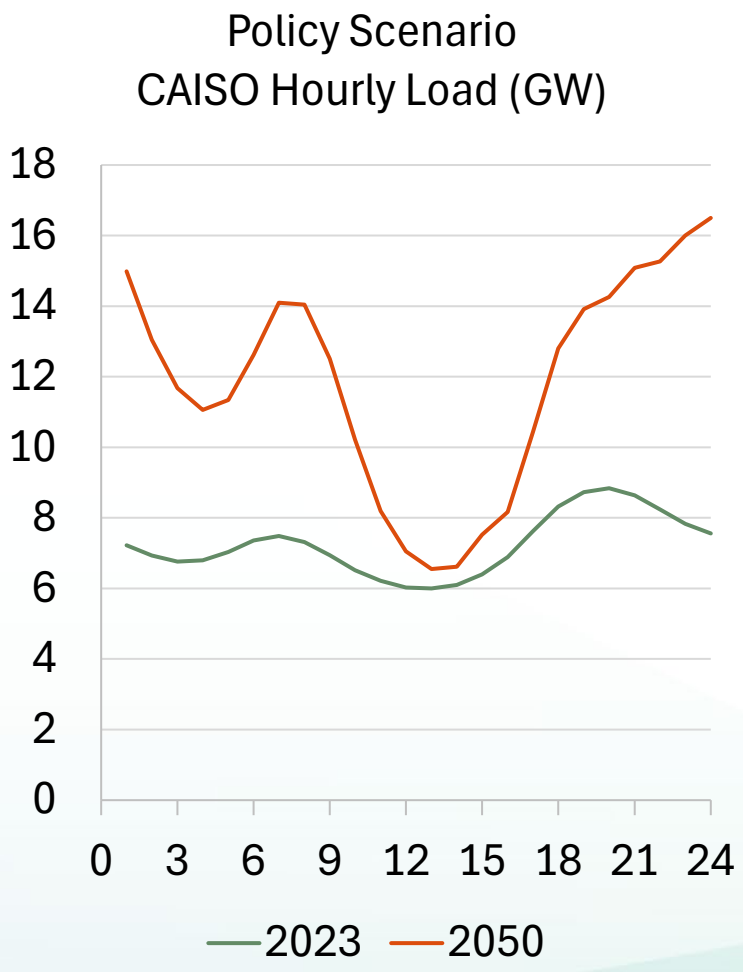
Peak Electricity Demand (6 of 6)

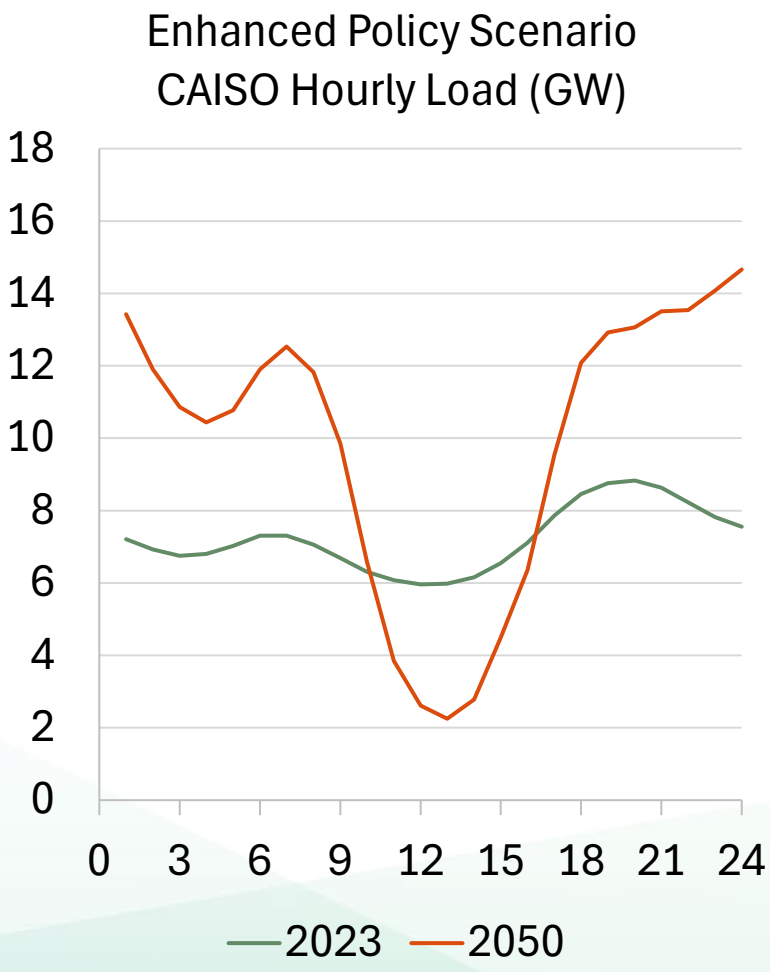


Source: Verdant, EER, CEC. Hourly electricity demand is net of behind the meter solar generation

Changing Electricity Demand Profiles, CAISO

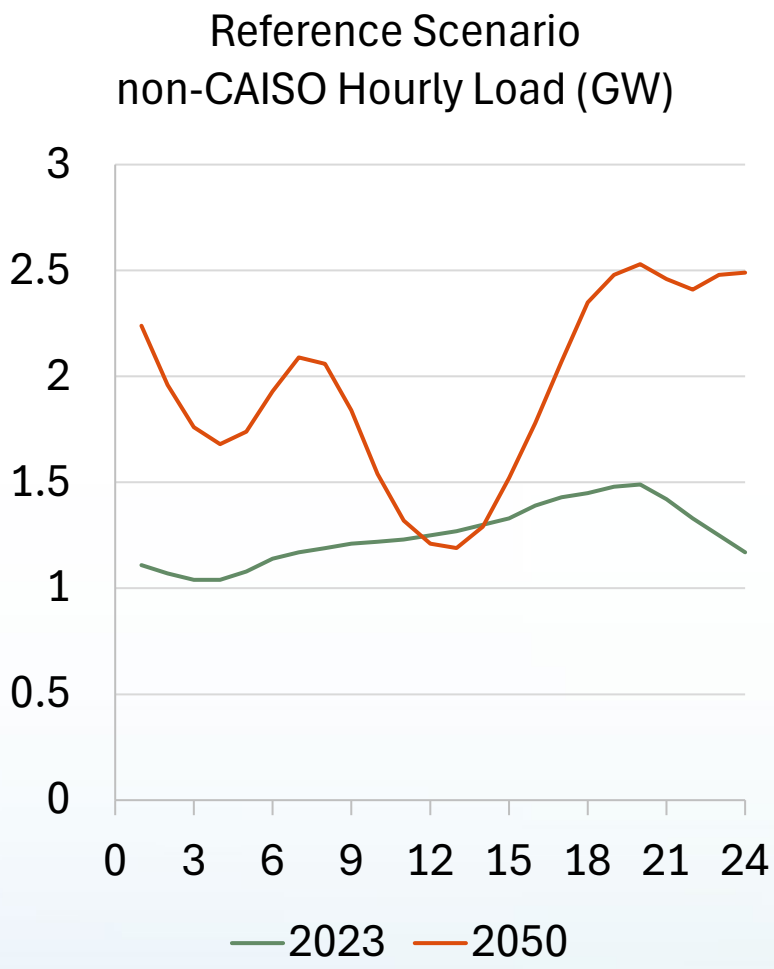


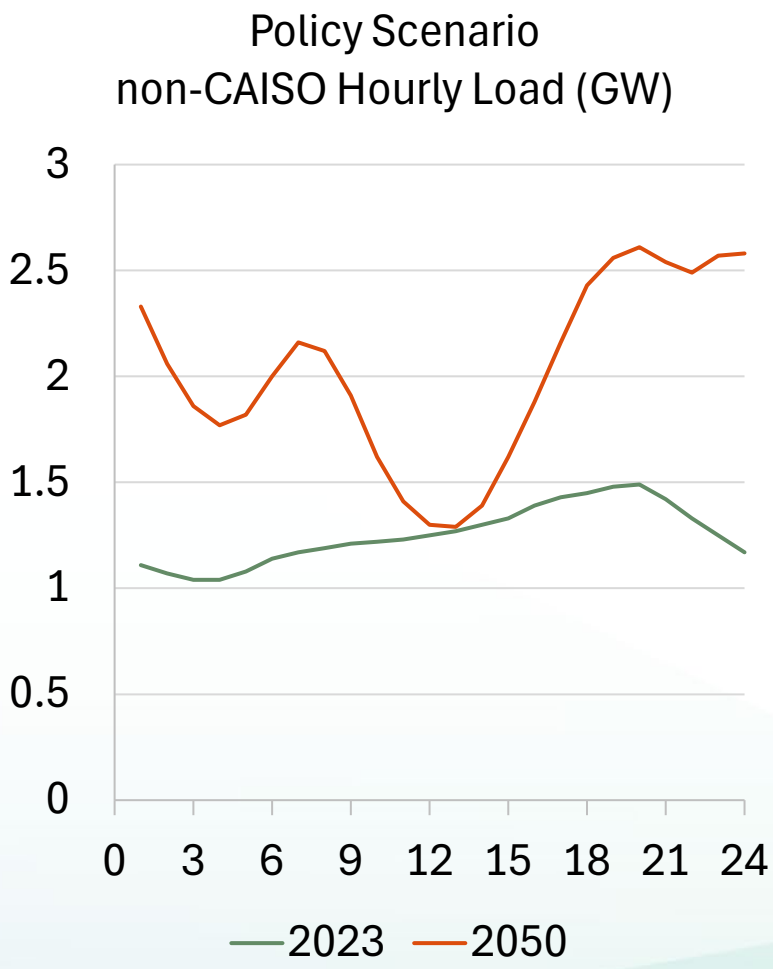


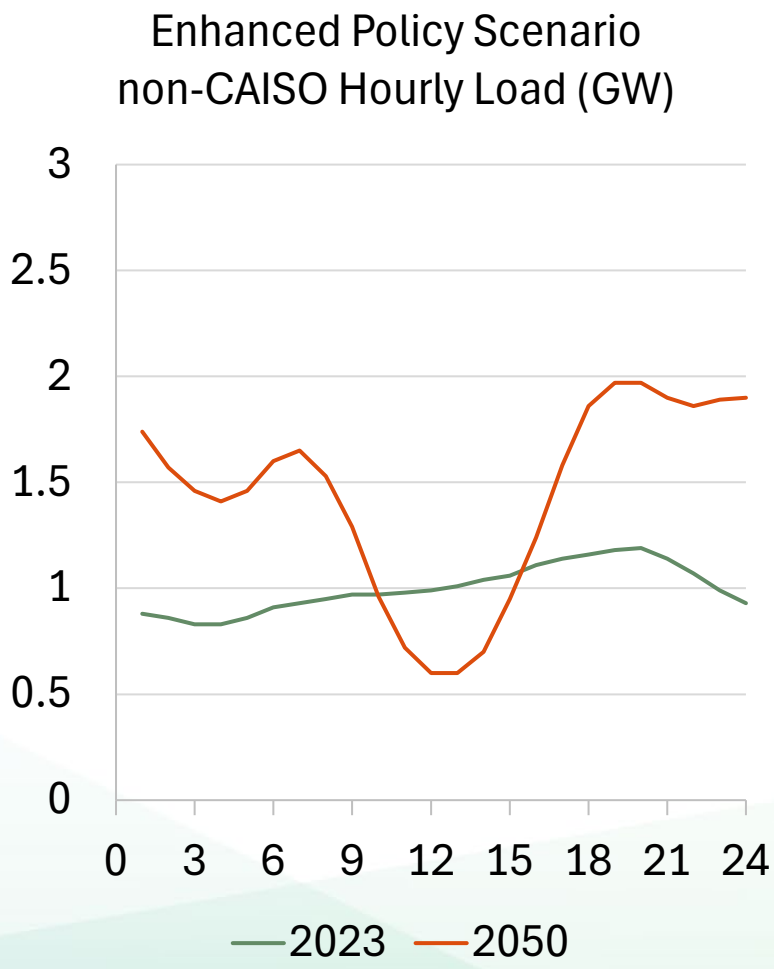


Source: Verdant, EER, CEC. Note: hourly electricity demand is net of behind the meter solar generation

Changing Electricity Demand Profiles, non-CAISO







Source: Verdant, EER, CEC. Note: hourly electricity demand is net of behind the meter solar generation

Seasonality of Electric Peak

Electric Planning Area	Reference Scenario	Policy Scenario	Enhanced Policy Scenario	Enhanced Policy H2 Sensitivity
BUGL	2043	2043	2043	2043
IID	n/a	n/a	n/a	n/a
LADWP	2042	2043	2040	2038
MKRP	n/a	n/a	n/a	n/a
NCNC	n/a	n/a	n/a	n/a
PGE	2045	n/a	2041	2040
SCE	2042	2043	2042	2042
SDGE	2044	n/a	2043	2043

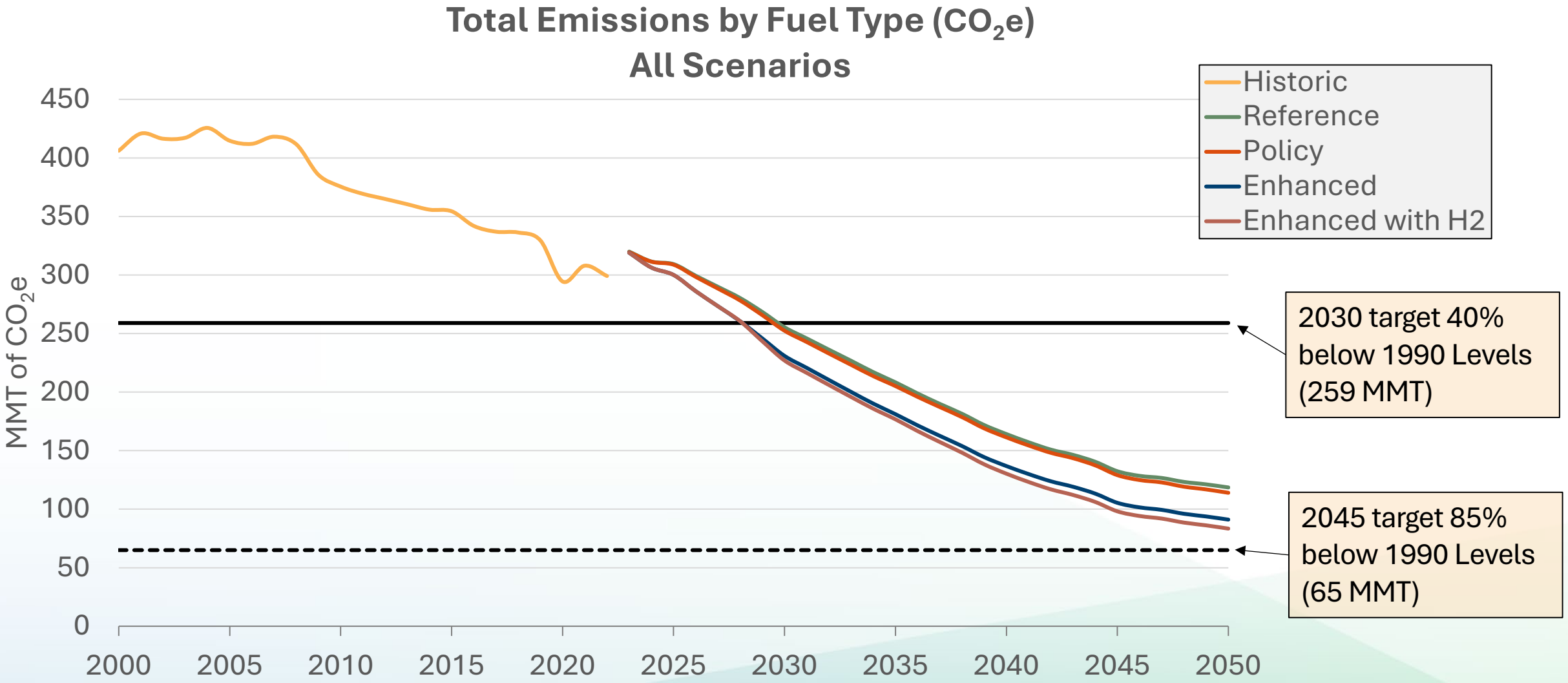
Source: Verdant, EER, CEC

Annual Emissions Results

Additional Limitations and Conventions

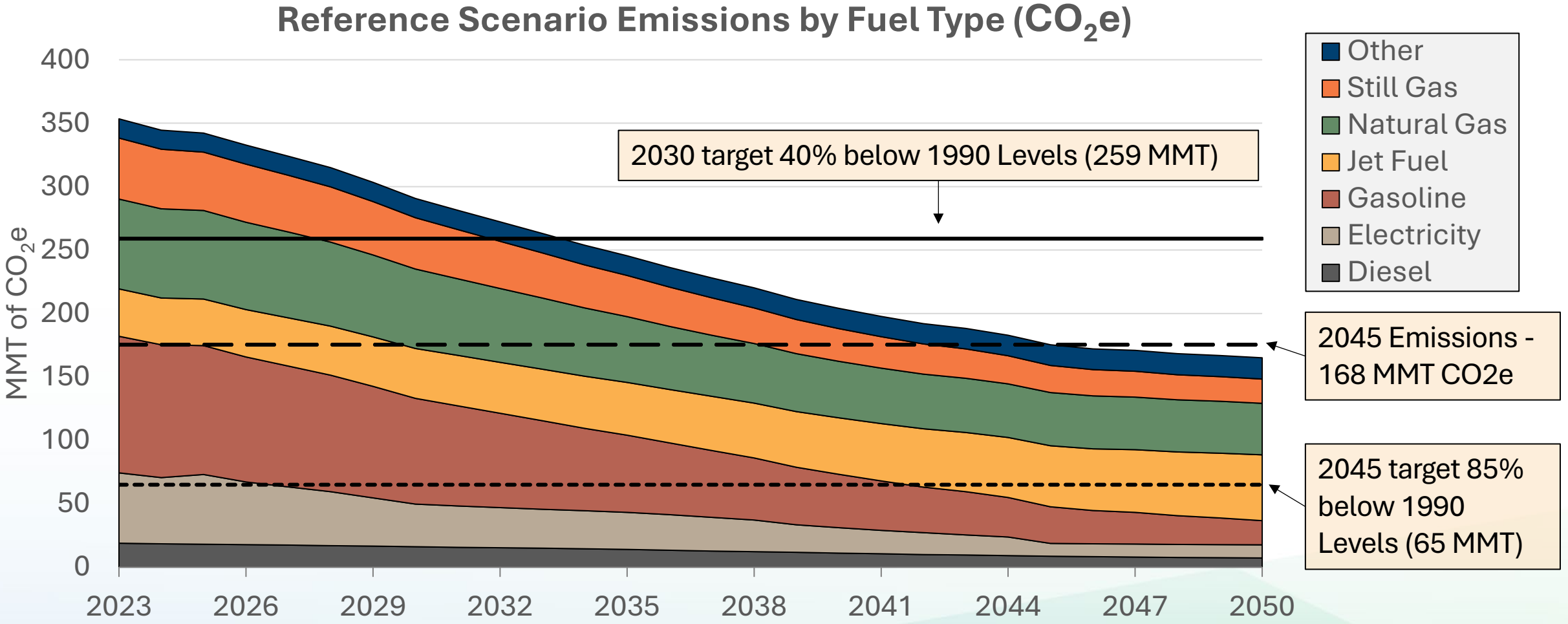
- Energy consumption GHG emissions only
- Natural and working lands GHG emissions not accounted for
- With the exception of the historical emissions comparison chart, all aviation energy GHG emissions are accounted for
  - In-State + Out-of-State flights

Comparison to Statewide Historic Emissions



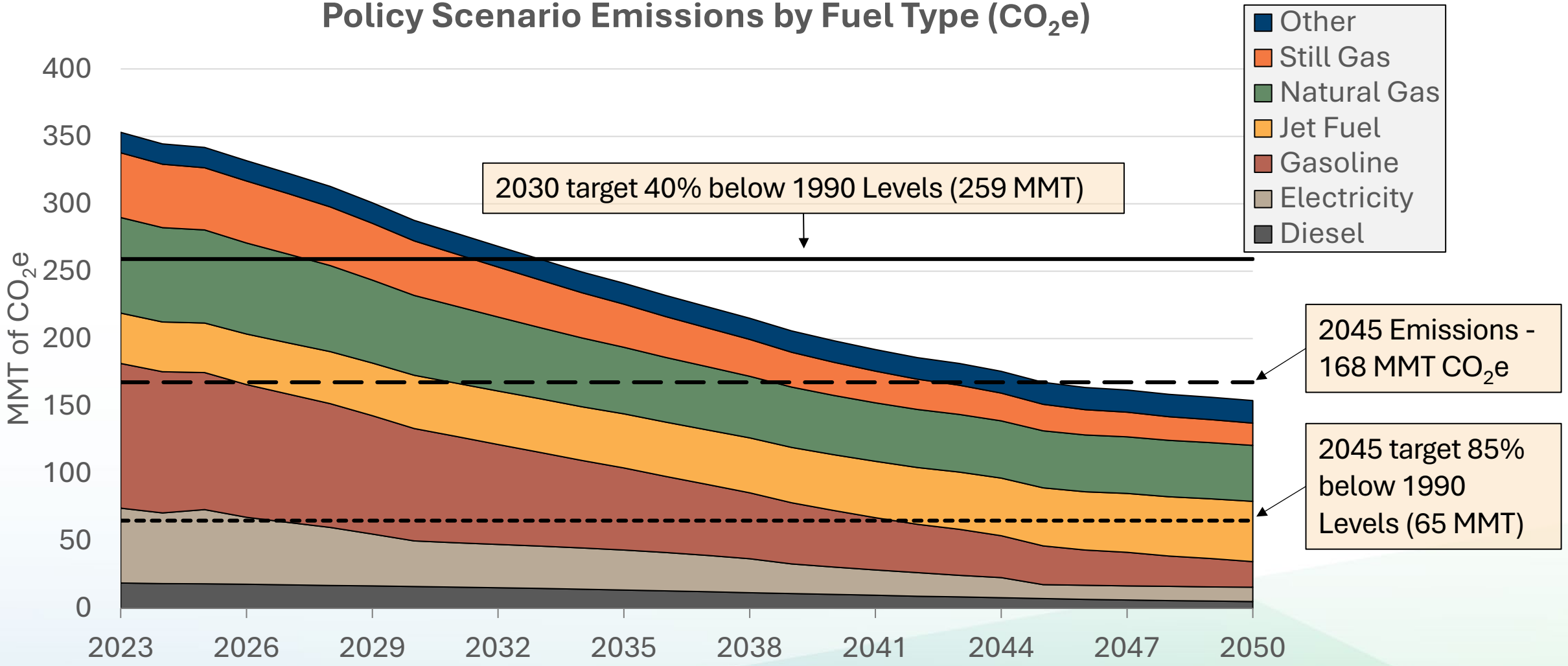
Source: Verdant, EER, CEC, JJMA

Reference Scenario Statewide Emissions By Fuel Type



Source: Verdant, EER, JJMA, CEC.
Other: Biomass/Wood, Coal, Coking Coal, Hydrogen, Kerosene Fuel, LPG, Residual Fuel Oil, Steam

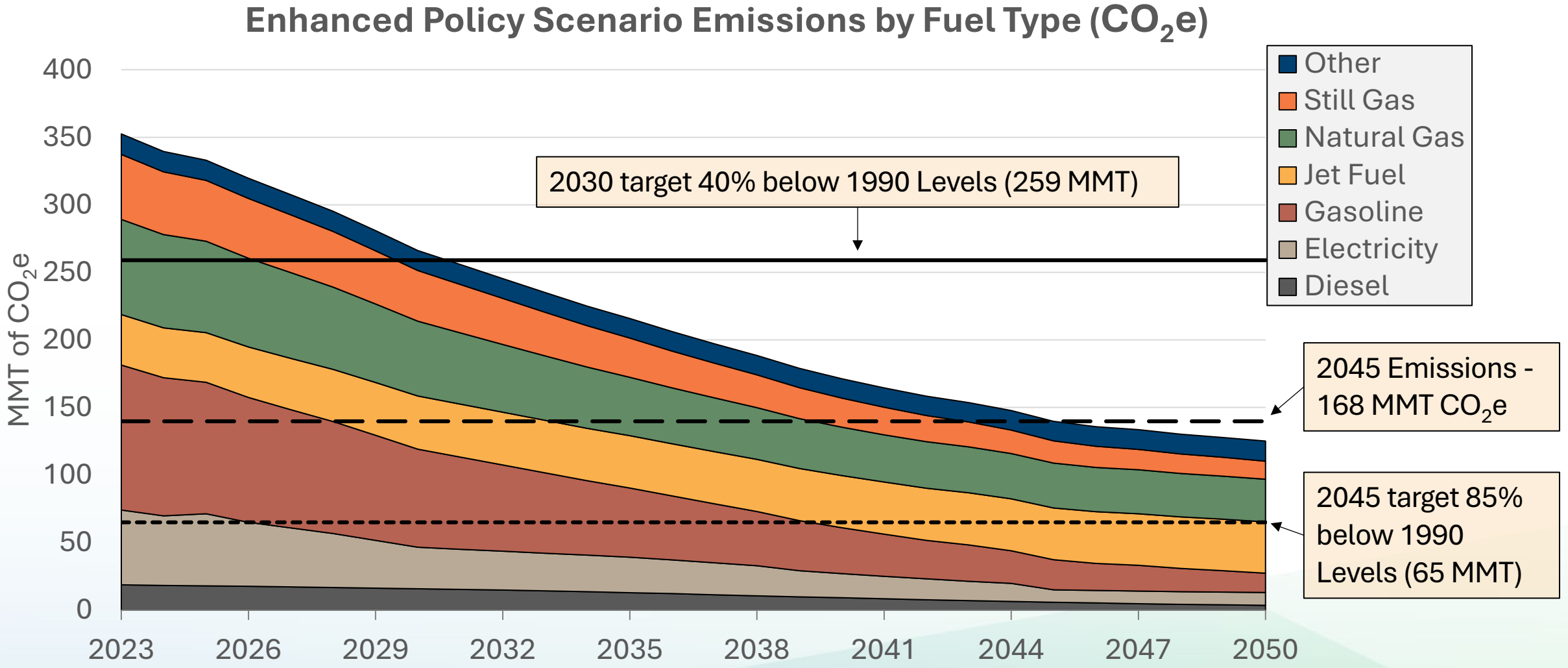
Policy Scenario Statewide Emissions By Fuel Type



Source: Verdant, EER, JJMA, CEC.

Other: Biomass/Wood, Coal, Coking Coal, Hydrogen, Kerosene Fuel, LPG, Residual Fuel Oil, Steam

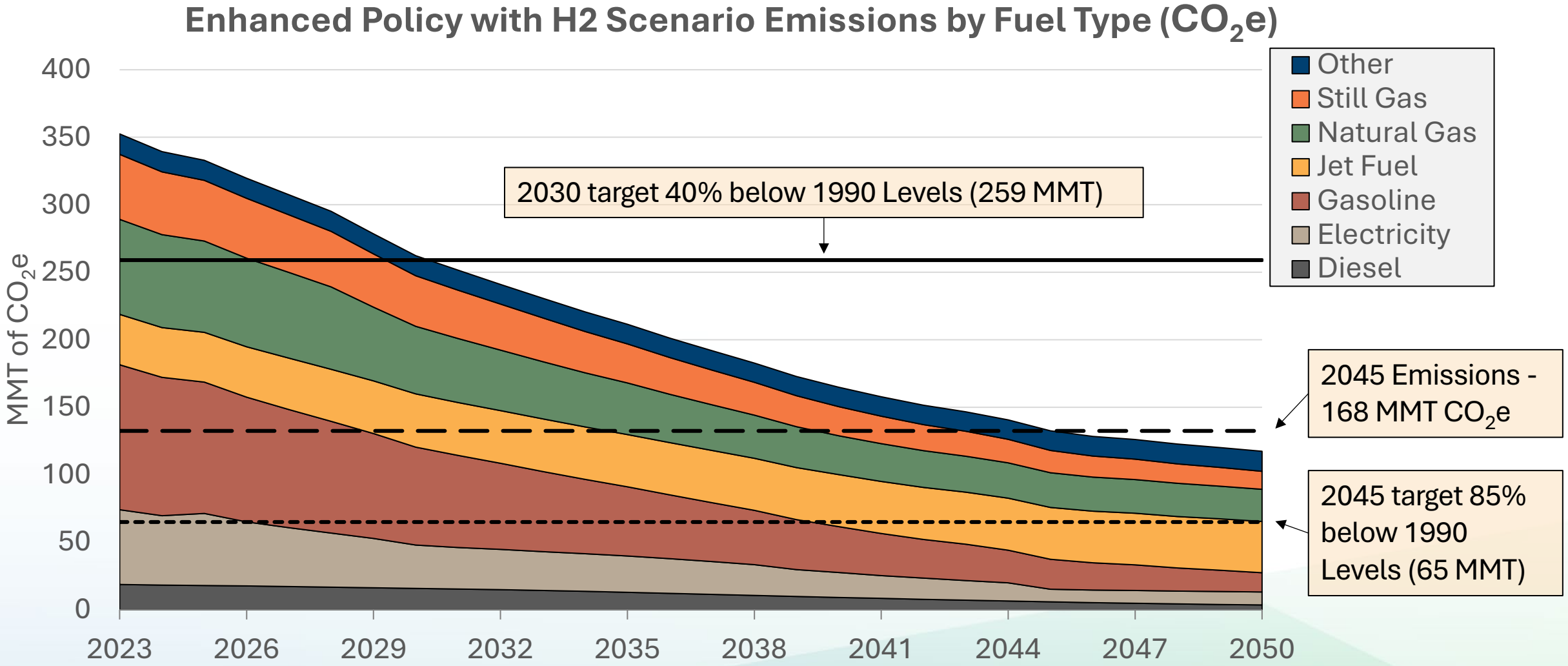
Enhanced Policy Scenario Statewide Emissions By Fuel type



Source: Verdant, EER, JJMA, CEC.

Other: Biomass/Wood, Coal, Coking Coal, Hydrogen, Kerosene Fuel, LPG, Residual Fuel Oil, Steam

Enhanced Policy Scenario H_2 Statewide Emissions By Fuel Type



Source: Verdant, EER, JJMA, CEC.

Other: Biomass/Wood, Coal, Coking Coal, Hydrogen, Kerosene Fuel, LPG, Residual Fuel Oil, Steam

Conclusions

Changing Energy Landscape

- In all demand scenarios, fuel switching increases California's electricity load and decreases demand for non-electric fuels through 2050 in all planning areas
  - The extent of this transformation depends on assumptions about how energy policies translate to changes in energy demand
- In many planning areas, growth in new types of electric load causes a transition from a summer to a winter electric peak
  - The timing of that transition depends on scenario assumption but is as early as 2038 under some conditions
- Increased electricity demand paired with increased behind-the-meter solar generation changes the hourly shape of electricity demand in California

Reaching Emissions Targets

- None of the demand scenarios achieves California's 2050 emissions targets under existing fuel blending conditions
- The Enhanced Policy scenario reflects ambitious levels of demand side energy efficiency and fuel switching, and still falls short of the 2045 target by about 75 MMT
- Supply-side decarbonization measures will be required to close this gap
  - Decarbonized electricity supply
  - Decarbonized fuel blending
  - Point-source carbon capture
  - Direct air capture
- Understanding how these different supply-side measures can best contribute to meeting California's emissions targets requires energy supply modeling that integrates the fuel supply and electricity supply sectors