THE ECONOMIC AND FISCAL IMPACTS OF CONNECTICUT'S GREENHOUSE GAS REDUCTION STRATEGIES

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Background

- By adopting of the Global Warming Solutions Act in 2008, Connecticut set a goal of reducing greenhouse gas (GHG) emissions by 80 percent below 2001 levels by 2050.
- Executive Order 46 in 2015 created the Governor's Council on Climate Change (GC3), which was tasked with examining the effectiveness of existing policies and regulations designed to reduce GHG emissions and identify new strategies to meet the state's 80 percent reduction goal.

Background

- The strategies to achieve this goal encompass:
  - a transition to zero-carbon vehicles,
  - building envelope improvements,
  - building energy management systems improvements including high-efficiency thermal systems, and
  - decarbonizing the electric grid with zero carbon resources such as solar photovoltaics (PV), wind, hydro, biomass and nuclear generation.

Background

- To inform the GC3's decision making, we examined the economic and environmental impacts of a consensus midterm (2030) GHG reduction target of 45 percent that includes:
- reductions from the individual transportation, building and electric utility sectors and all sources combined. These reductions are relative to a baseline, reference or BAU case.
- the economic analysis focuses on 2020 through 2030 because while we have simulation data to 2050, beyond 2030 there is significant uncertainty.

Transportation Sector

- Transportation accounted for about 35 percent of Connecticut's GHG emissions in 2014. Reducing GHGs from this sector represents a significant portion of the total that must be eliminated to reach the 2030 target of 45 percent below 2001 emissions.
- Strategies to achieve the needed reduction include the electrification of passenger vehicles and light trucks, short haul trucks, busses and commuter rail (not included in current economic analysis).
- Long-haul trucks, diesel freight locomotives, ferries and off-road construction equipment will need to transition to alternative fuels as well. We do not assume any changes to aircraft or watercraft fueling.

Transportation Sector

- We assume the GHG reductions are achieved with an estimated rate of electric passenger vehicle (EV) uptake and related changes in EV charger installation, electricity sales, retail gas station market exit and non-recurring gas station remediation.
- In addition, we assume there will be an increase in hydrogen-powered vehicles and their required filling stations.
- The Long-Range Energy Alternative Planning System (LEAP)[1] model provides the forecasts for EV deployment and fuel consumption (fossil reduction and electricity increase). Northeast States for Coordinated Air Use Management (NESCAUM) ran the LEAP model according to GC3 GHG reduction targets.

[1] See LEAP: Introduction, at https://www.energycommunity.org/default.asp?action=introduction.

Transportation Sector: EVs and Chargers

- We assume one-for-one displacement of conventional vehicles with EVs as the incentives remain and as prices and charging times fall and ranges increase.
- Charging stations in homes, businesses, shopping centers and public parking areas increase as EVs deploy.
- We assume there will be smaller growth in H_2 vehicles and fueling stations.
- Gas station revenues will decline and many will exit the market. As they leave, they incur a non-recurring cost of remediation (<u>not</u> regarded as net new investment).

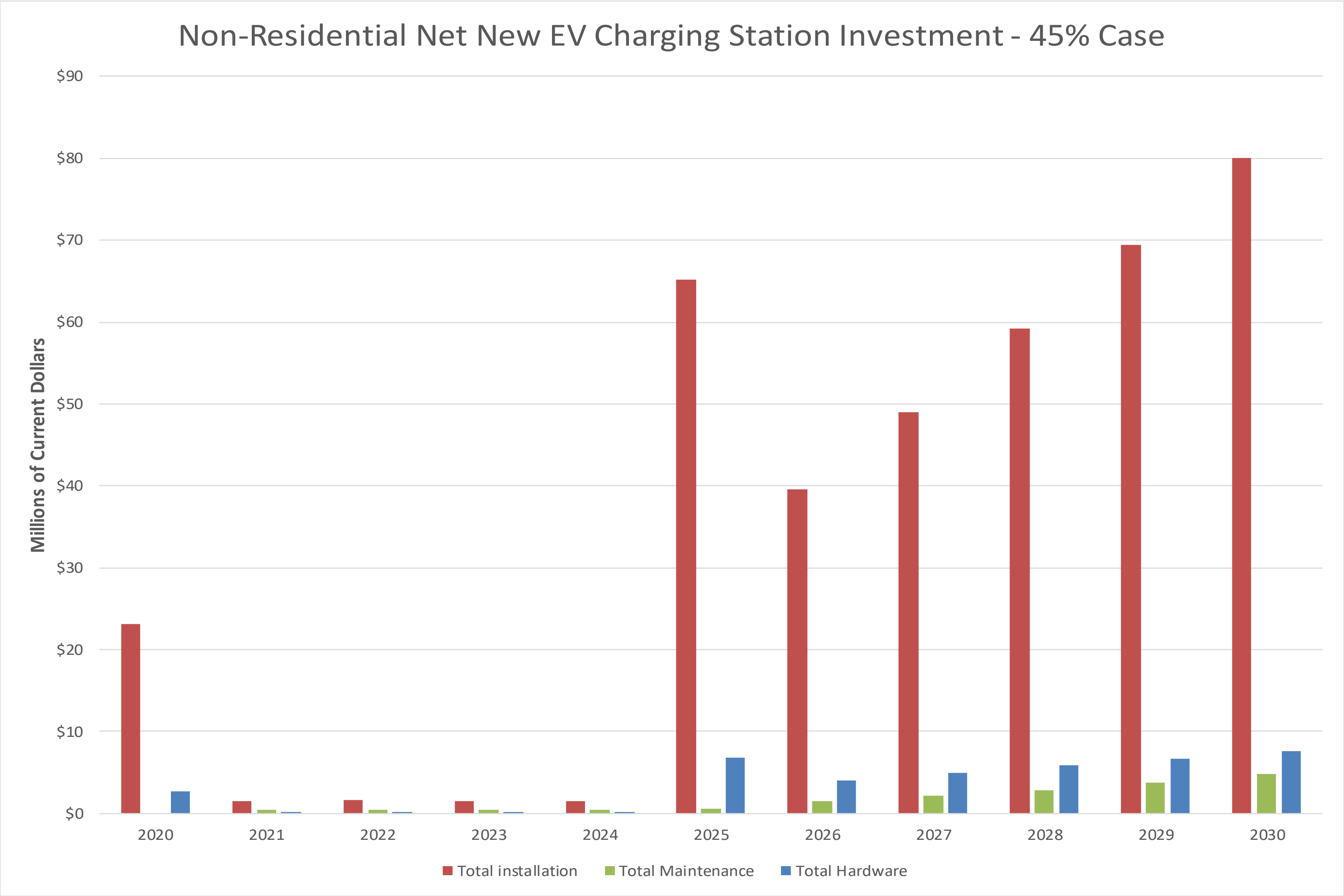
Transportation Sector: EVs and Chargers

- We assume the state will find alternative revenue sources to make up the fuel tax shortfall as fossil fuel consumption declines due to EV uptake. Per CONNDOT, we assume that gasoline-related federal funds to the state do not decrease and that there are a variety of state-level revenue generating strategies to offset the decline in state taxes derived from gasoline, diesel and natural gas sales.
- The fuel tax shortfall we use for economic impact arises from the differences between the reference case and the midterm target scenario assuming no changes in CONNDOT funding requirements.

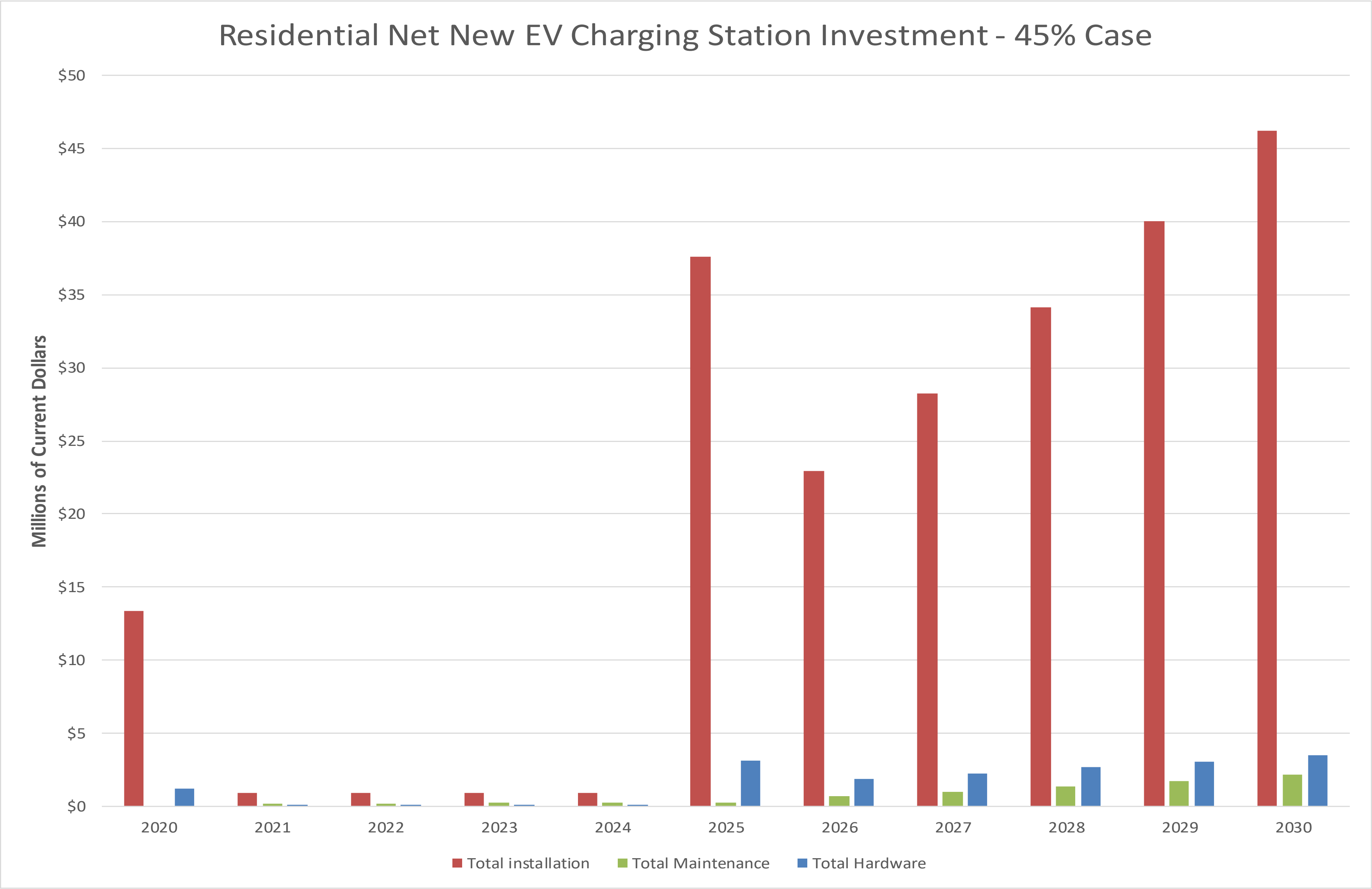
Transportation Sector: EVs and Chargers

- The health benefits of reduced SOx, NOx, and primary PM emissions improve the state's quality of life and productivity and reduce health care costs (reduced mortality and morbidity); however, the economic impacts of these benefits are not evaluated in this analysis.
- Further, we do not account for averted environmental costs and therefore to the extent that adaptation to climate change will generate new economic activity, our economic modeling results understate the economic benefit to the state.
- Switching from ICEs to EVs results in an increased demand for electricity. For the transportation GHG mitigation strategy, we assume that electricity sales increase commensurate with the needs of EV uptake.

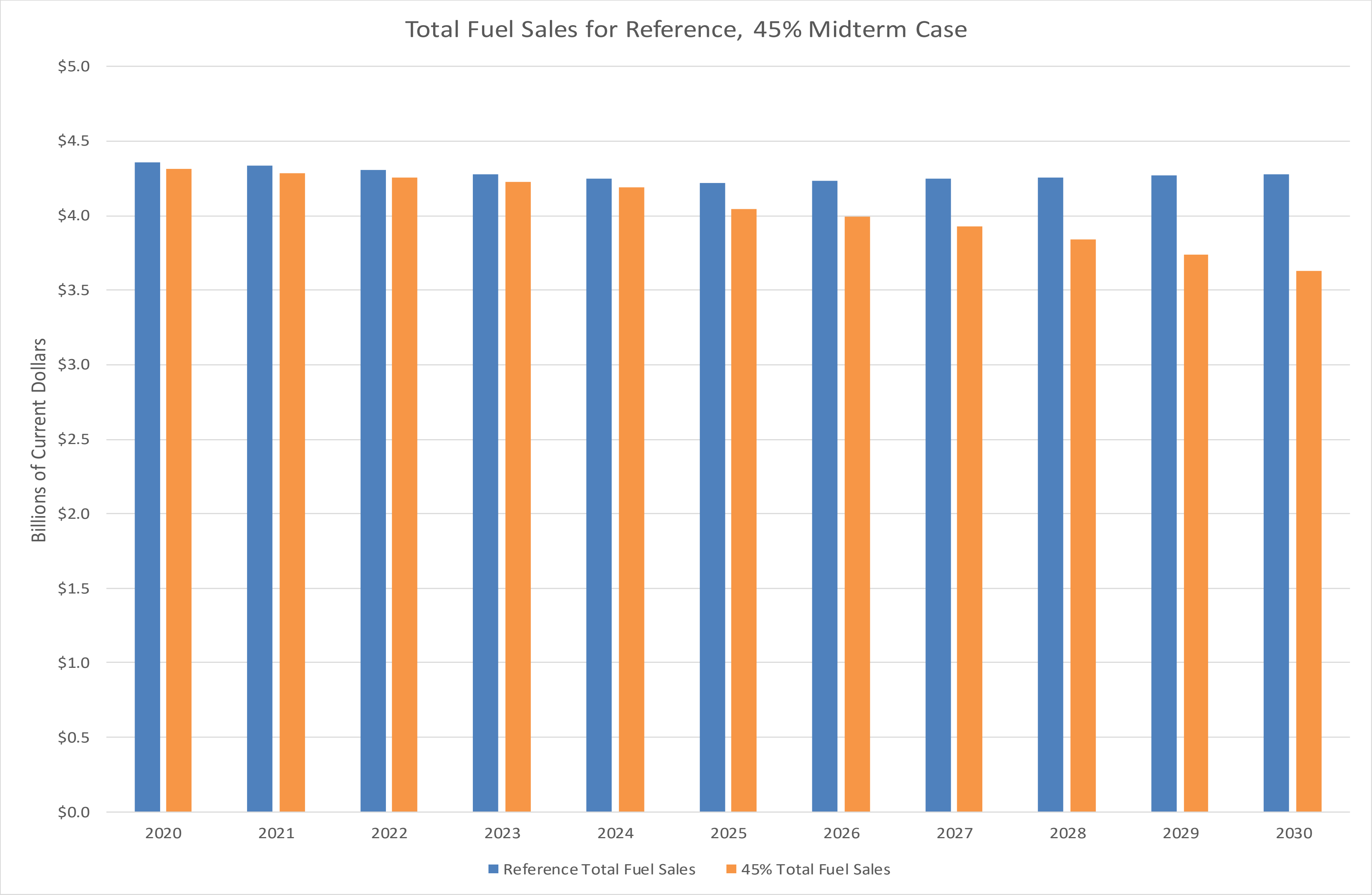
Transportation Sector: Chargers and H_2 Stations



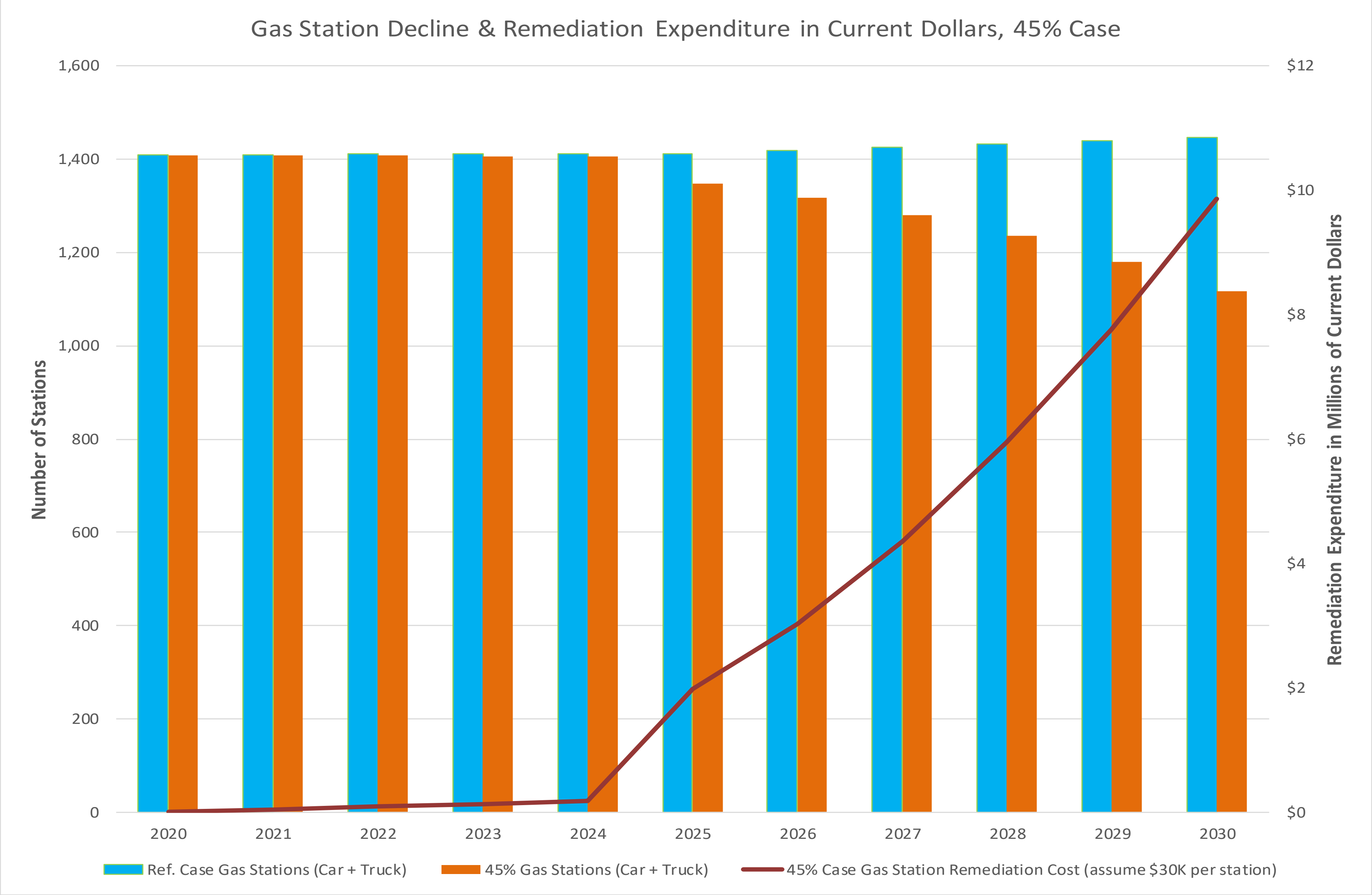
Transportation Sector: Chargers and H_2 Stations



Transportation Sector: Fuel Sales



Transportation Sector: Gas Stations & Remediation Cost

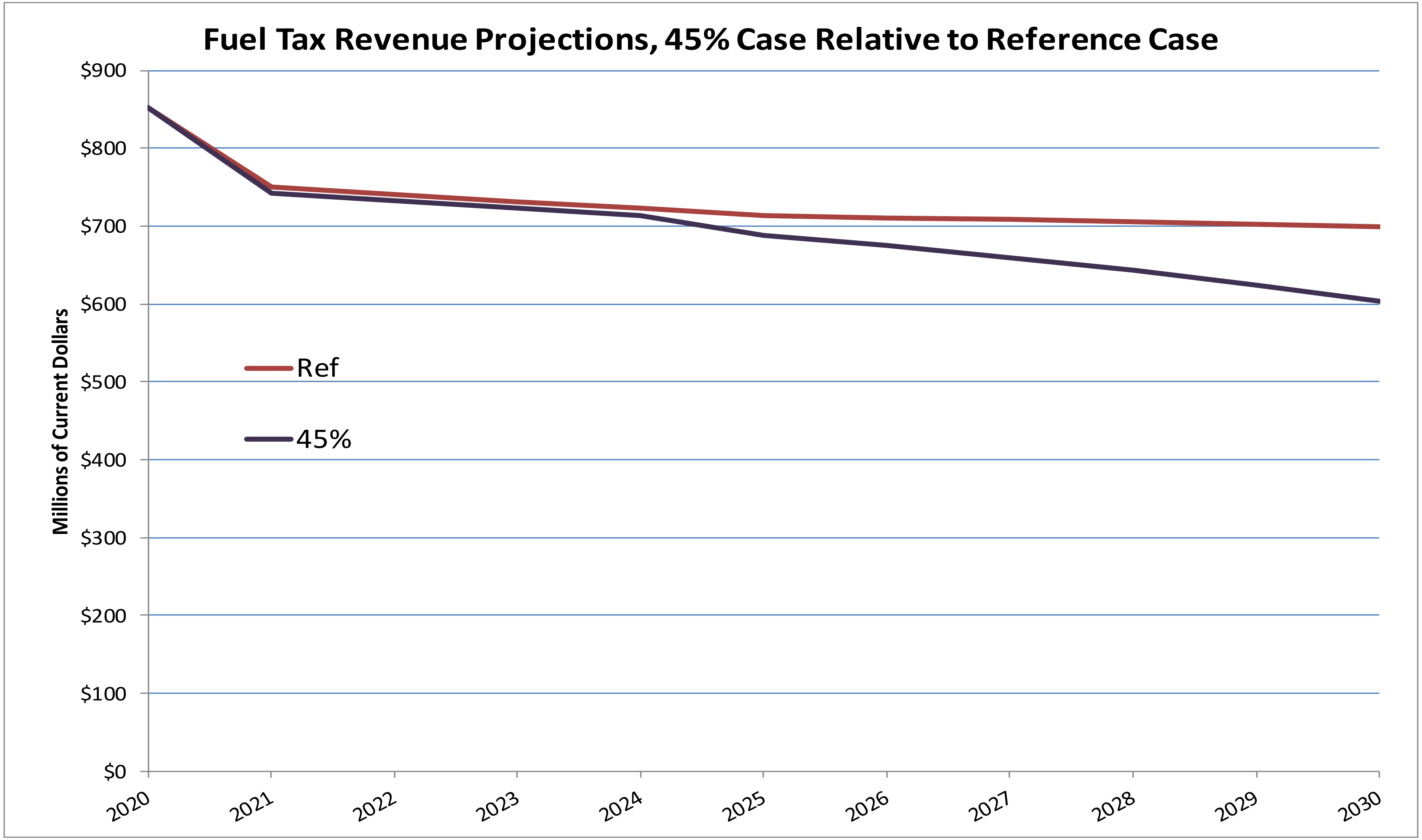


Transportation Sector: Fuel Tax Shortfall

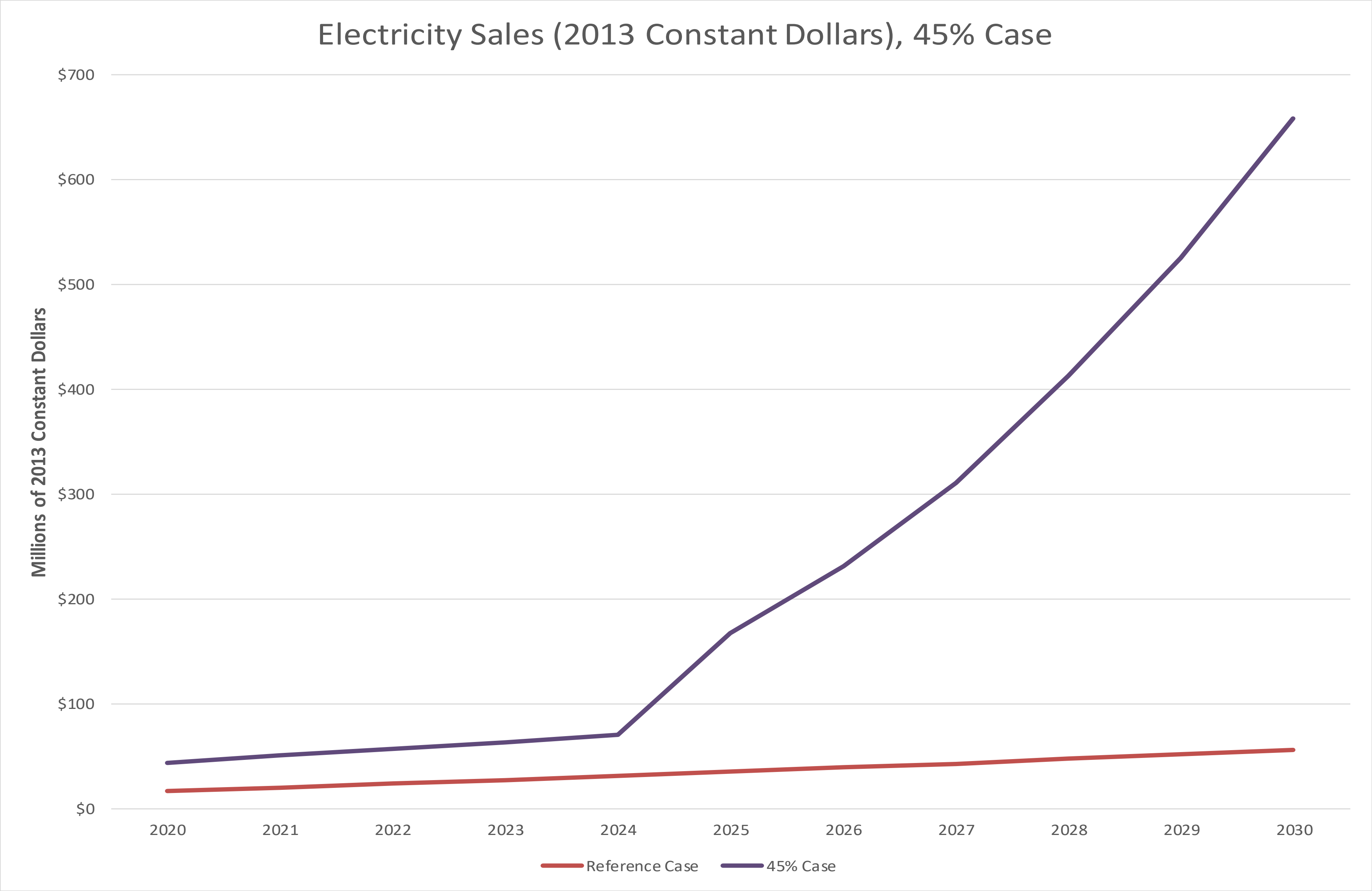
- We count the annual fuel sales tax revenue differences between the LEAP reference case and the 45% midterm case as they represent a shortfall that contributes to the economic and fiscal impact, because these differences arise from the GC3 GHG reduction strategies.

- Figure 6 shows the fuel tax revenue trajectories of the 45% midterm case relative to the reference case. The fuel tax shortfall in this case represents a reduction in state spending (service production) without state employment or compensation effects.

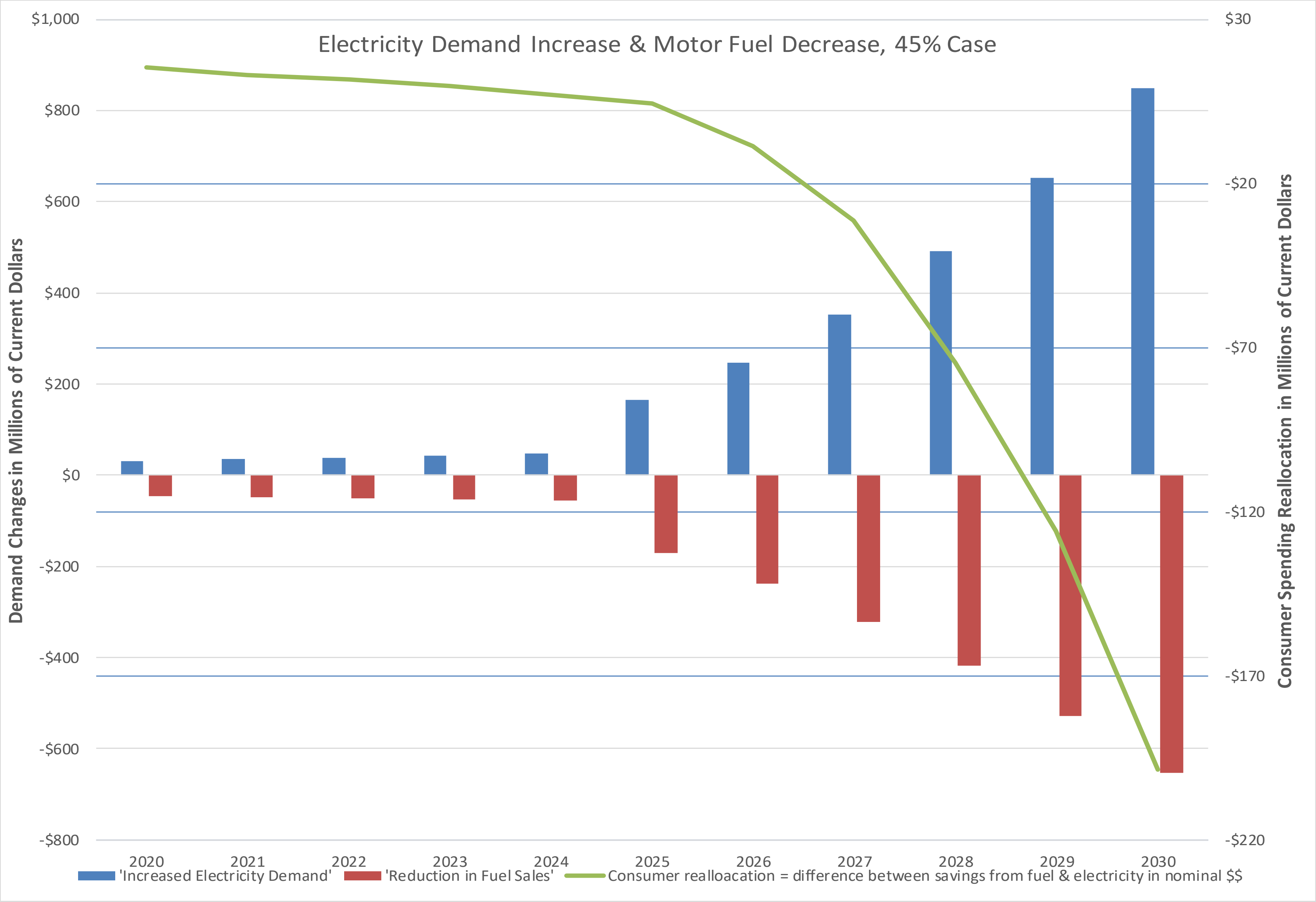
Transportation Sector: Fuel Tax Shortfall



Transportation Sector: New Electricity Sales



Transportation Sector: Electricity, Fuel Sales & Consumer Reallocation



Transportation Sector: REMI Results

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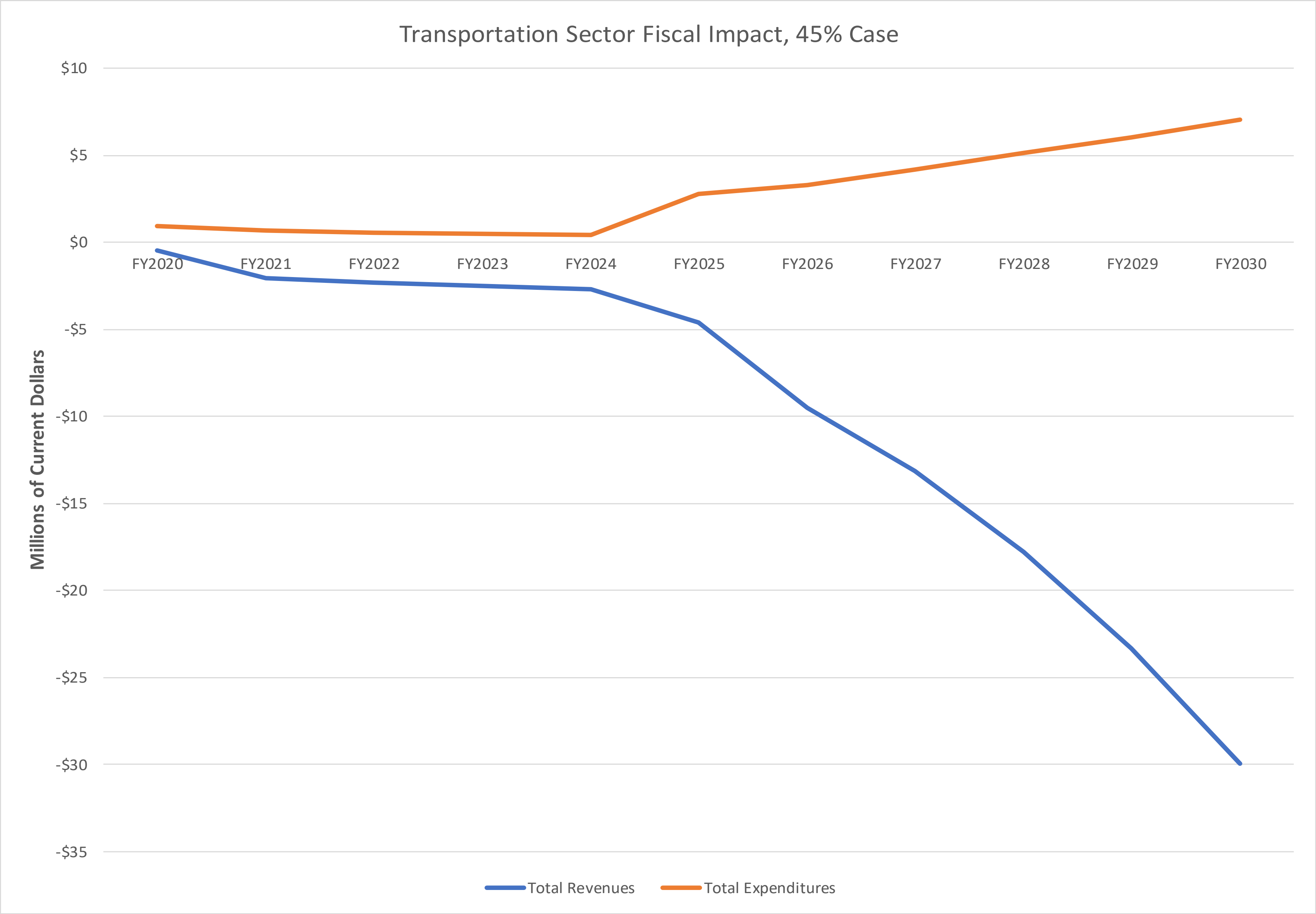


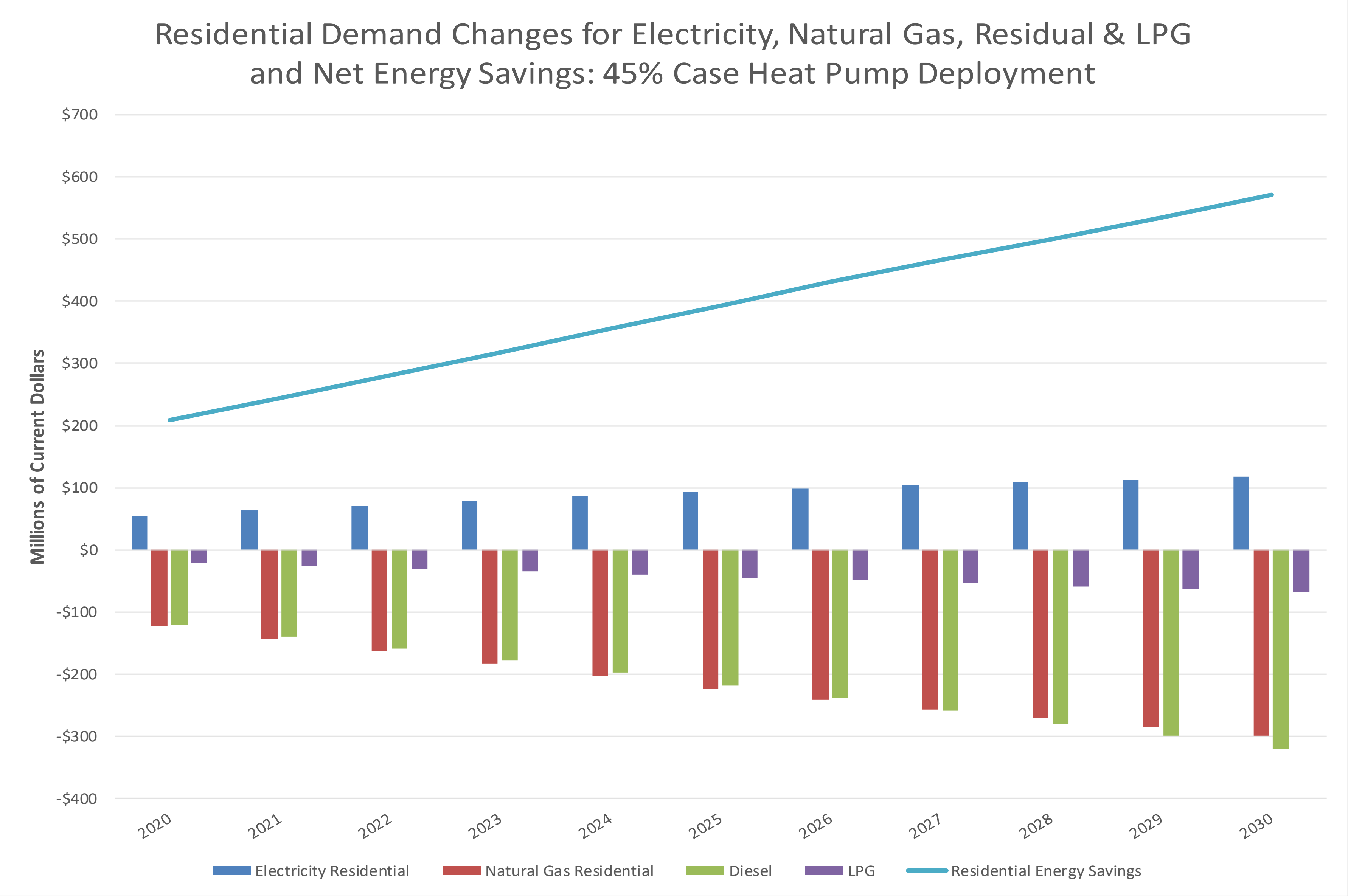
Buildings Sector

- Lighting, heating and cooling commercial, industrial and residential buildings account for about 33% of Connecticut's GHG emissions.
- Mitigation strategies include replacing existing oil- and gas-fired heating appliances with electric heat pumps that both heat and cool spaces more efficiently and will use electricity from renewable sources as they become available.
- In addition, building envelopes will become more efficient through installing increased insulation, weather-stripping, energy-efficient doors and windows and household appliances.
- Further, building energy management systems that control internal and external lighting will help reduce electricity demand. As a consequence of the deployment of these strategies, there will be less demand for heating oil and natural gas, and some suppliers of these and complementary products and services will exit the market. There will be a corresponding increase in the demand for electricity (offset by improvements in energy efficiency).

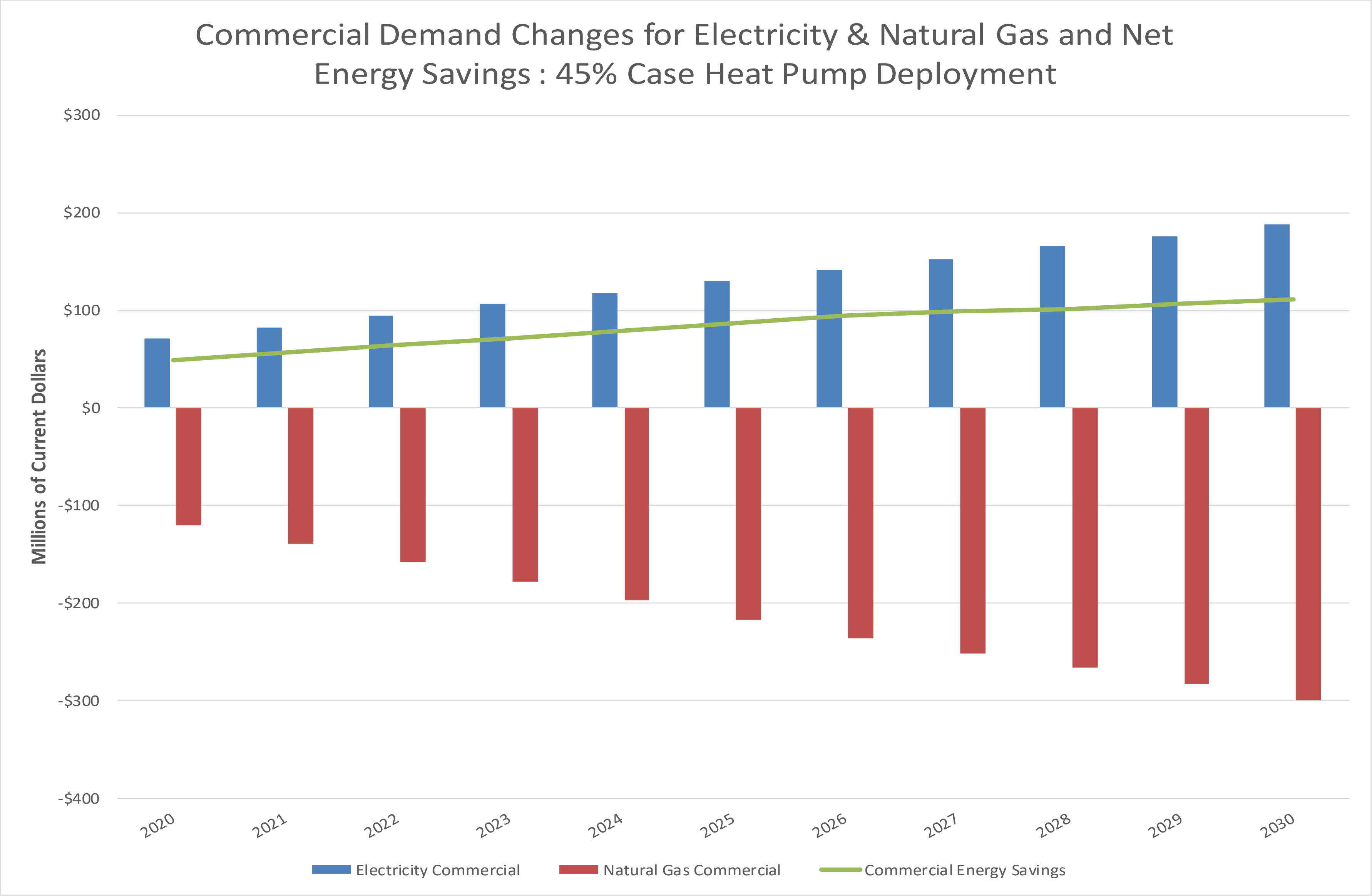
Buildings Sector: Assumptions

- We assume investment in electric heat pumps is net new and there is no state incentive to induce the switch from oil- and gas-fired heating appliances (there may be a federal tax credit for this purpose) and is entirely privately funded.
- The 45% midterm target scenario in LEAP separated the uptake of heat pumps for the residential and commercial sectors, which allows us to separate the changes in demand for different energy sources.
- We assume that commercial establishments and residential households increase their demand for electricity and reduce their demand for natural gas and fuel oil as heat pumps deploy.

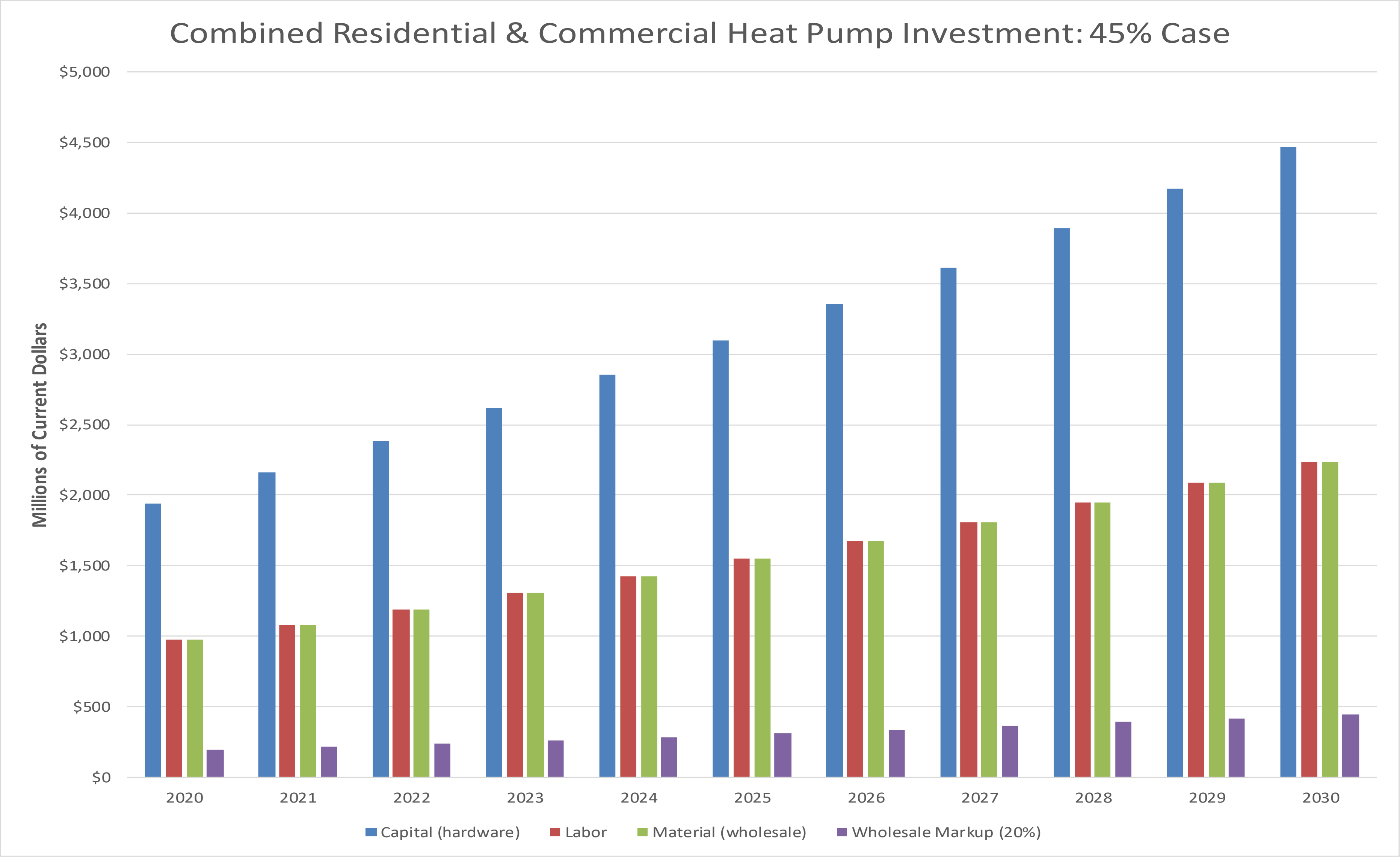
Buildings Sector: Demand Changes & Residential Savings



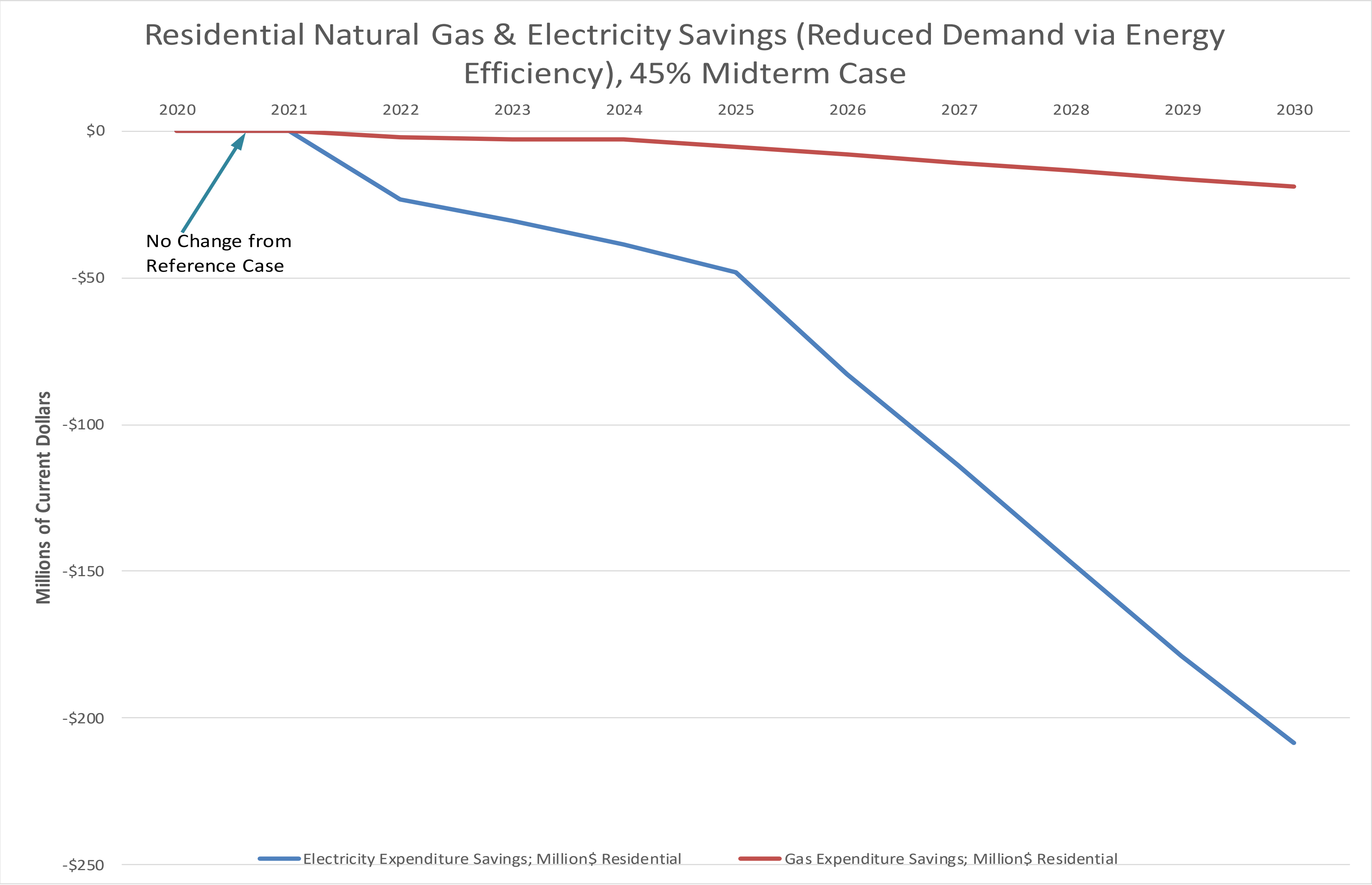
Buildings Sector: Demand Changes & Commercial Savings



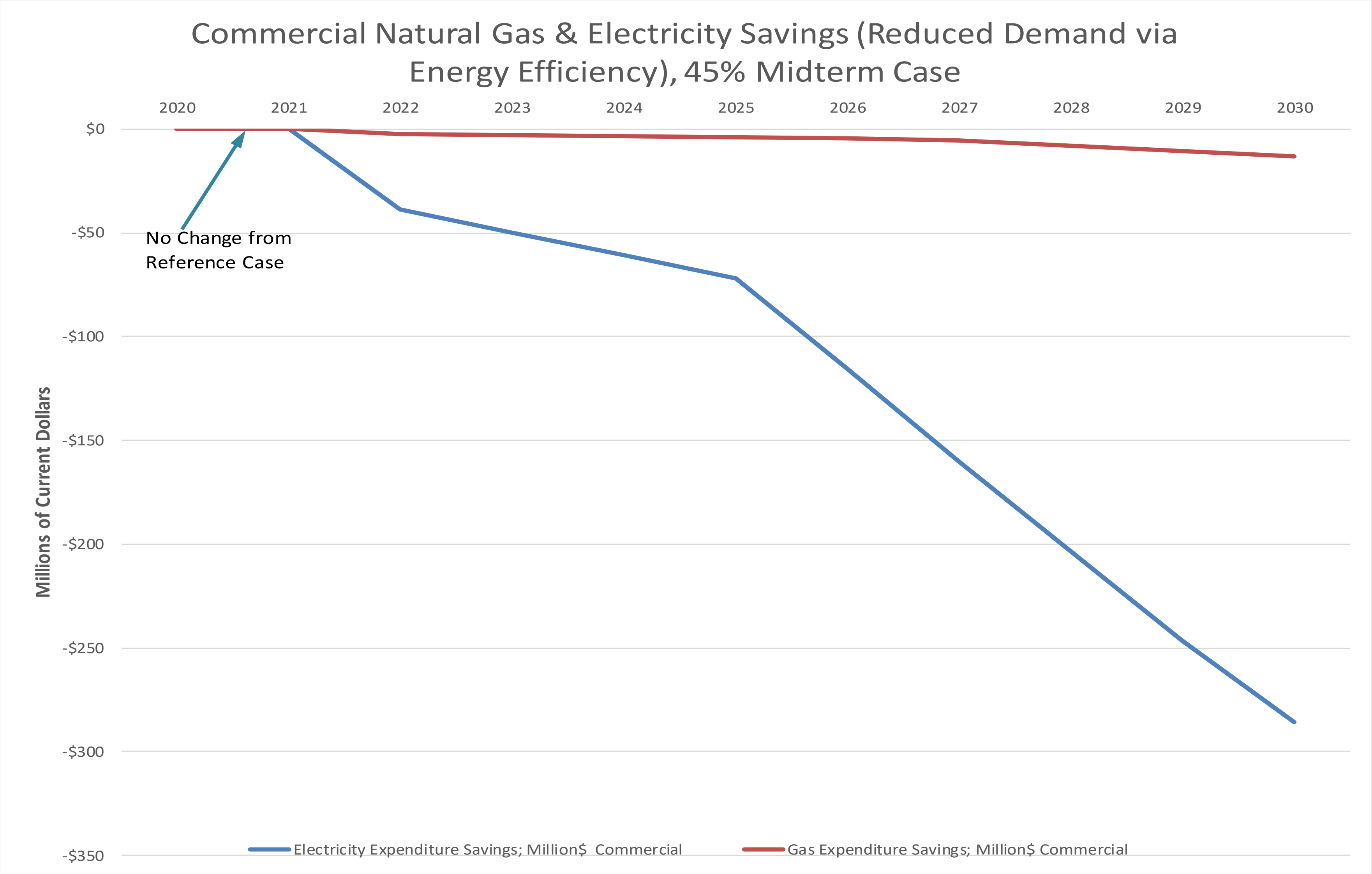
Buildings Sector: Commercial & Residential Investment



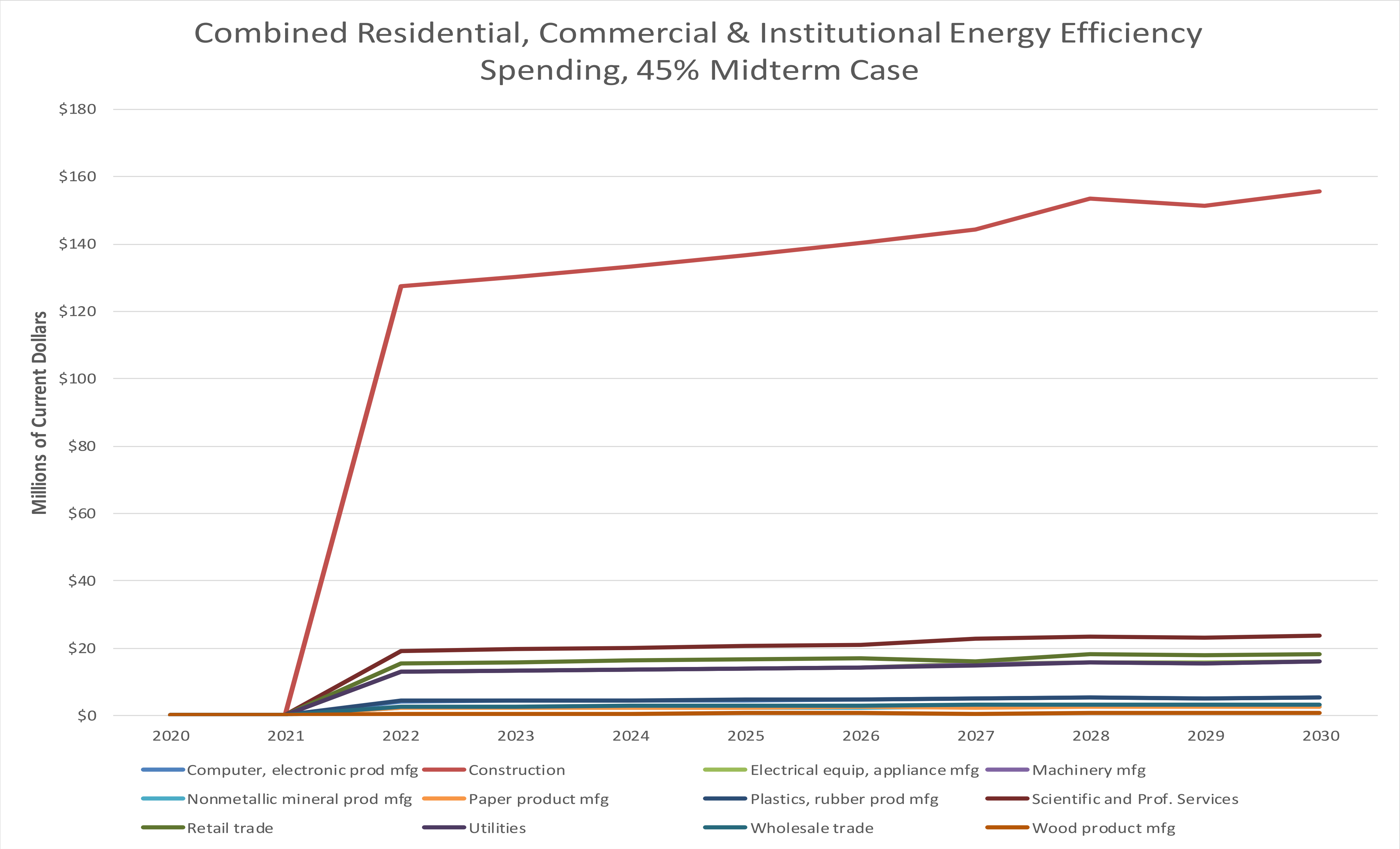
Buildings Sector: Residential Energy Efficiency Savings



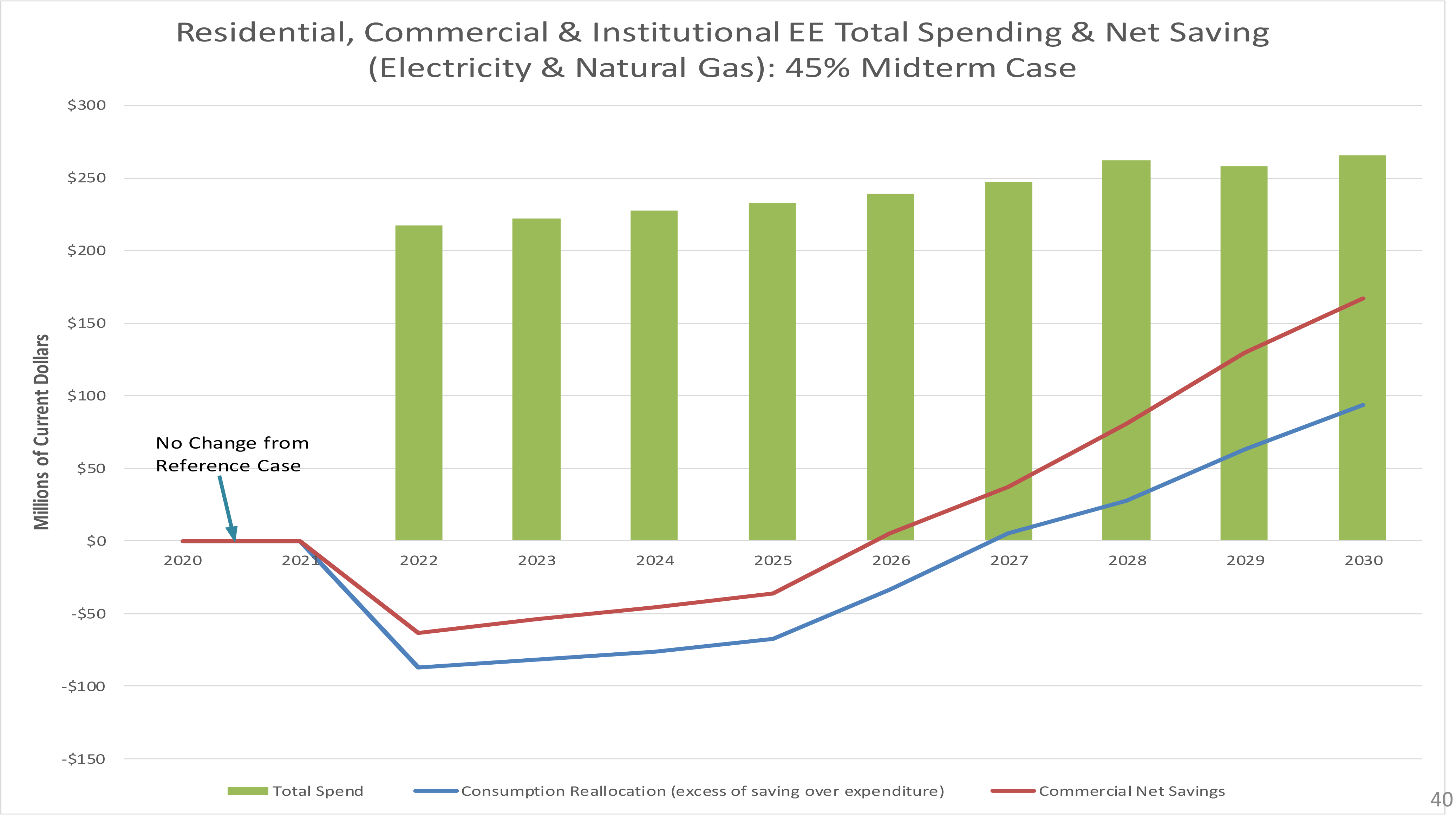
Buildings Sector: Commercial Energy Efficiency Savings



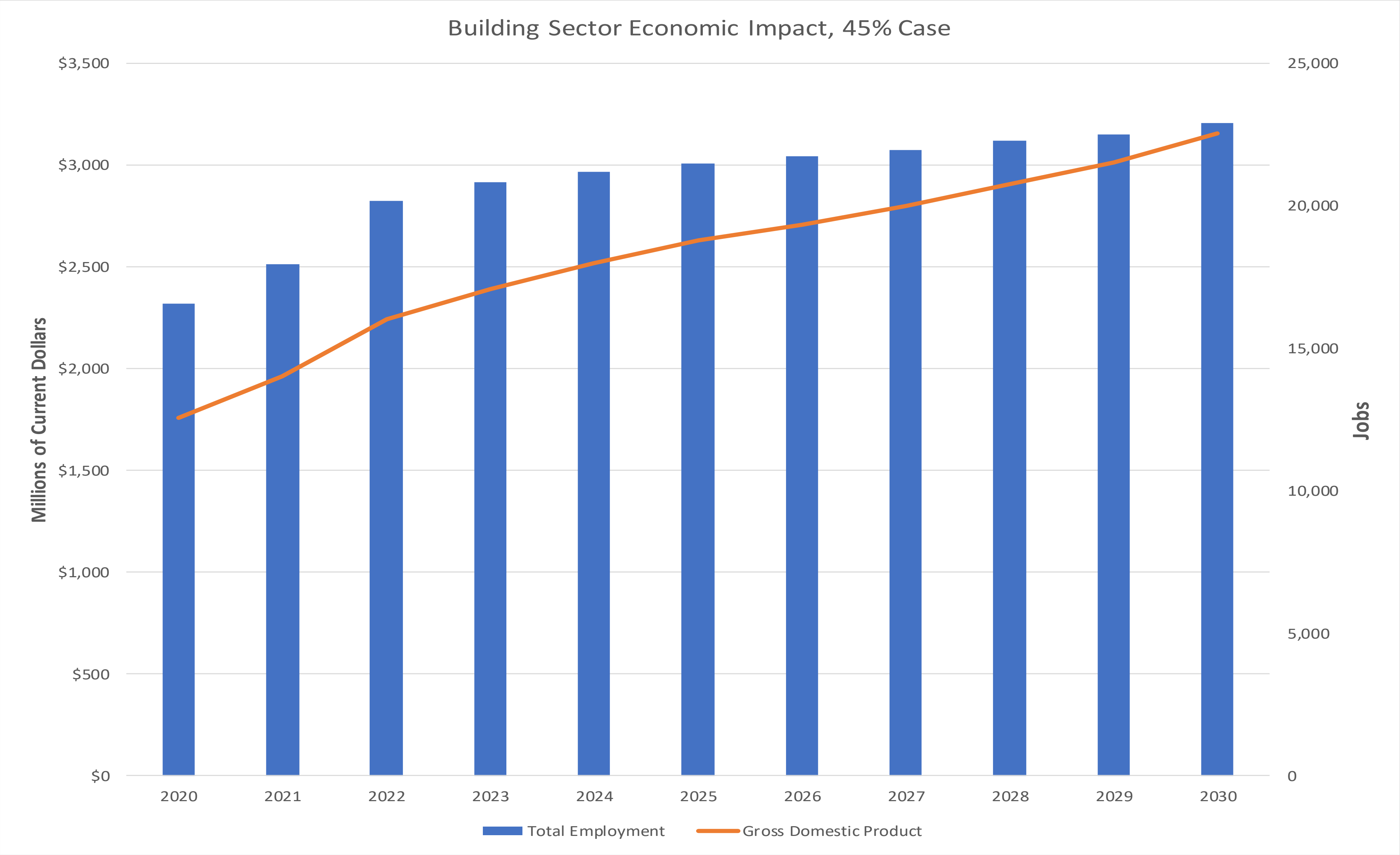
Buildings Sector: Combined Energy Efficiency Sector Spending



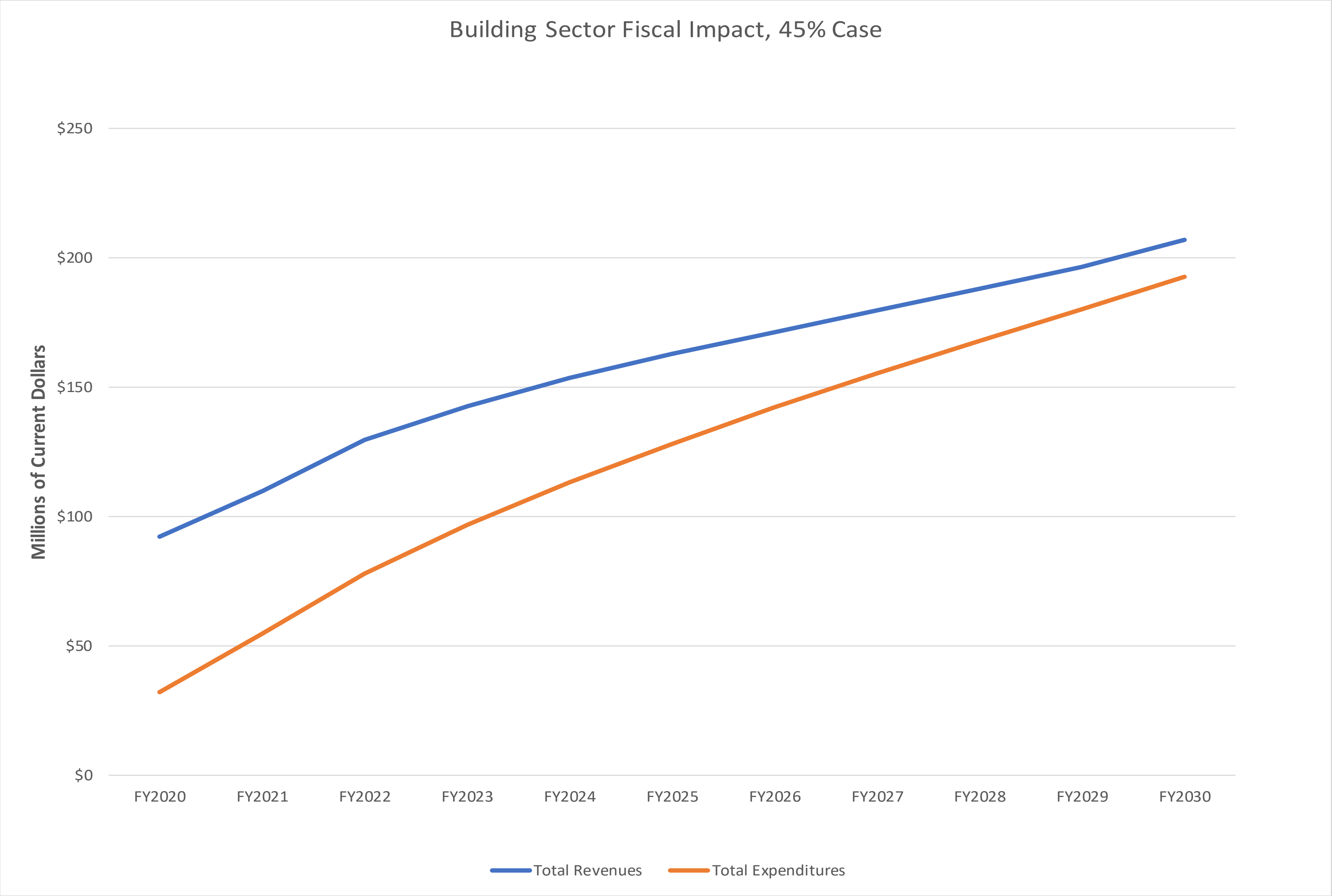
Buildings Sector: Combined Energy Efficiency Sector Saving & Spending



Buildings Sector: REMI Results



Buildings Sector: REMI Results



Electricity Sector: Assumptions

- The process to decarbonize the electric grid consists of utilities' switch to wind (on- and off-shore), solar, biomass and fuel cell electricity generation as well as households' and businesses' investment in behind-the-meter (BTM) solar.

- For modeling purposes, we assume grid-scale investment includes capital as well as fixed and variable operating and maintenance expenditure and we aggregate the total under investment for 'electrical transmission, distribution, and industrial apparatus' sector in the economic model.

Electricity Sector: Assumptions

- We assume grid-scale investment is financed with 20-year bonds earning a return to investment of 7%. A tranche of bonds is issued each year as new investment funds are needed to continue the buildout of wind, solar, biomass and fuel cells.
- Annual amortized grid-scale investment is offset by an annual increase in electricity costs to businesses and households. The average cost per kWh increase is roughly constant because each year the additional tranche of bonds to finance additional wind, solar, biomass and fuel cell capacity is spread over accumulating capacity.
- We assume households and businesses bear the increased costs of electricity without offsetting incentives because they recognize the importance of reducing GHG as a hedge against the costs of climate change. Similarly, we assume utilities undertake the investment in solar, wind, biomass, and fuel cells without offsetting incentives because they recognize the importance of reducing GHG as a hedge against the costs of climate change.

Electricity Sector: Assumptions

- We model household BTM investment as a household maintenance expenditure as we imagine the residential installation of solar comes from the household's budget for maintenance as it might for a new furnace or air-conditioning unit.
- We assume such expenditure may be financed by a home equity loan or one from the Green Bank. We assume businesses finance their solar installations through capital expenditure financed perhaps by borrowing in the capital market or from retained earnings.
- We model business BTM investment as occurring in the 'electrical equipment not-elsewhere-classified (nec)' sector.
- Other BTM financing options such as leasing exist as well.

Electricity Sector: Assumptions

- Households and businesses that install BTM solar realize a reduction in their electric bills that reduces revenue to the electric utilities. This in turn increases the rates of all users.
- We do not capture the increased rates accruing to all ratepayers as a result of the uptake of BTM solar because rates differ across classes of users and they have several choices of electricity suppliers whose rates differ.
- Further, the increased rates benefit BTM users because their credit is at the retail rate. The net effect of rate increases is difficult to allocate to different users and therefore to a net aggregate effect without additional research.
- Our modeling approach simply accounts for the reduction in the utilities' demand for natural gas as the buildout of BTM and grid-scale renewable generation proceeds. The reduction in natural gas demand offsets the utilities' investment in grid-scale renewable generation and BTM savings so there is no effective reduction in revenue to the utilities from BTM production (via net metering).
- We assume households spend their BTM savings on additional goods and services, while businesses invest their excess BTM savings in new plant and equipment.

Electricity Sector: Assumptions

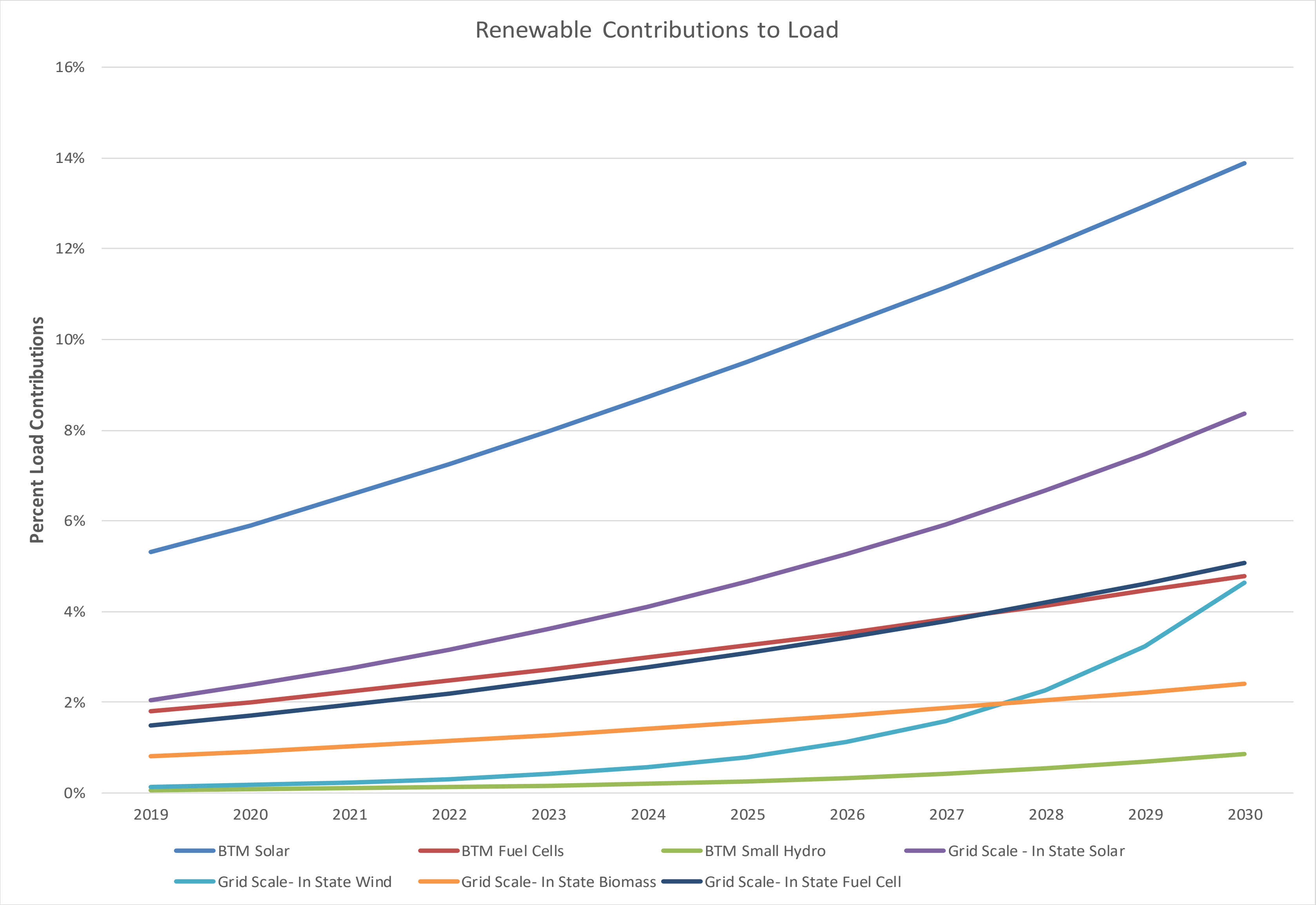
- Because we assume households borrow at very low rates or lease to obtain BTM solar, they spend their gross electricity savings on other goods and services even though their net BTM saving is negative from 2020 through 2026 inclusive and positive thereafter.
- This drives economic impact. Businesses realize a positive net saving from BTM investment from 2027 through 2030 and this is the amount that is additionally invested during that period and drives economic impact. Between 2020 and 2026 inclusive, we assume businesses invest in BTM solar with retained earnings or by going to the capital market to obtain needed funds.
- We assume the BTM savings businesses realize during the entire period pay down debt or replenish retained earnings (no economic impact); the excess savings from 2027 through 2030 constitutes additional investment (positive economic impact). This is because we assume businesses are more concerned with their balance sheets than are households and because we assume businesses behave as if they want to maximize profit and households (consumers) behave as if they want to maximize utility or wellbeing. Figure 20A shows the gross and net BTM savings for households and businesses.

Electricity Sector: Gross and Net BTM Savings for Households and Businesses

Electricity Sector: Assumptions

- Unlike the transportation and building sectors, there is no reference case to which to compare the 45% midterm target reductions in GHGs. The LEAP model uses a forecast of Connecticut's electricity load and the buildout of grid-scale renewable and BTM generation that satisfies an increasing portion of the projected load. We establish the expected load in 2019 as a base year by assuming it is the same as in 2020.
- DEEP provided the annual fractions of BTM solar, fuel cells and small hydro as well as grid-scale solar, wind, biomass and fuel cells that we assumed to contribute annually to the state's electricity load and reduce natural gas generation. The geometric mean growth rate of these contributions over the forecast period scales the 2020 percent contributions back to 2019.
- Figure 21 shows the percent contributions to the state's renewable portfolio from BTM and grid-scale generation sources including for the year 2019.
- Some of this data comes from https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf.

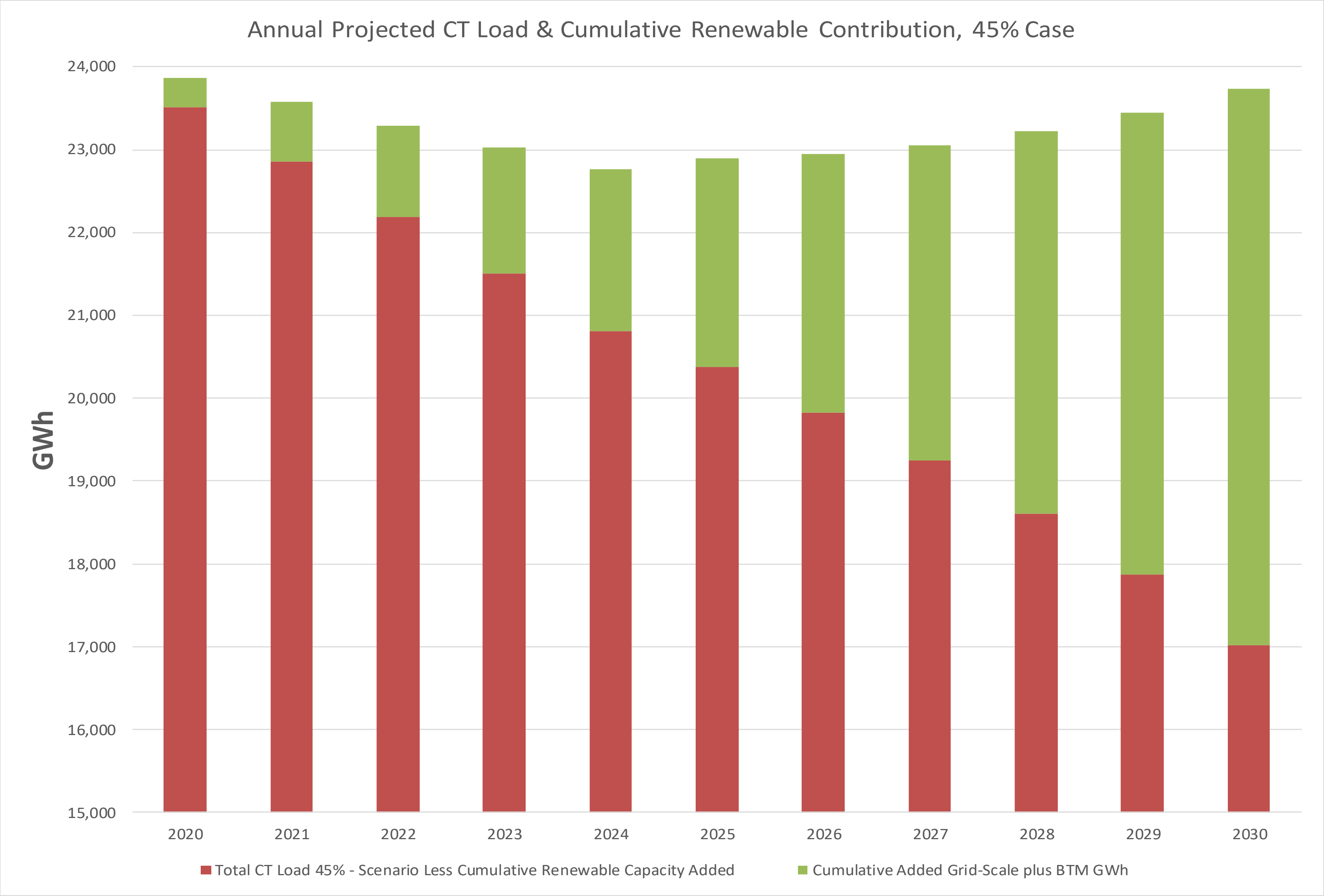
Electricity Sector: Renewable Contributions to Load



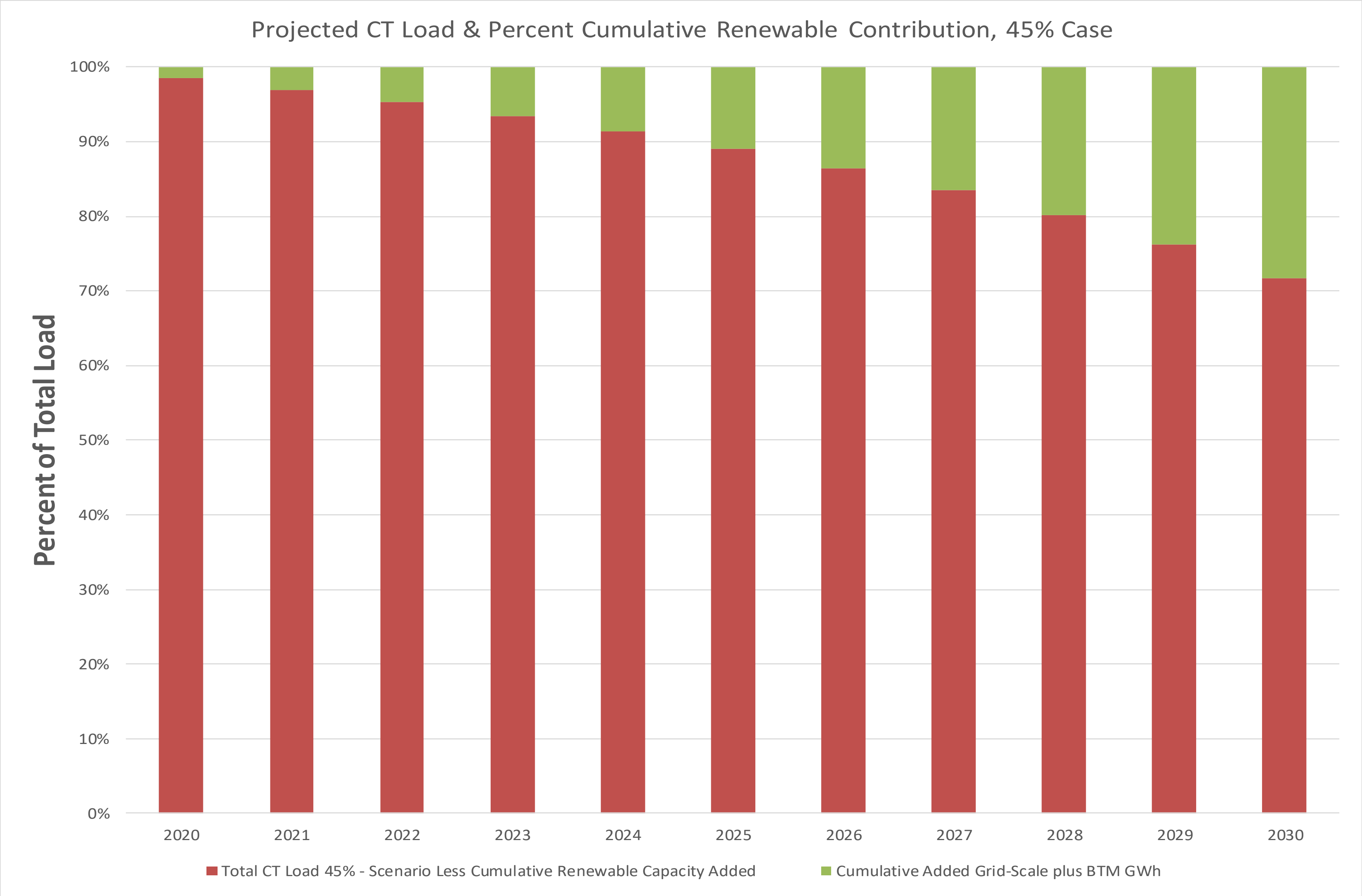
Electricity Sector: Assumptions

- Figure 23 shows the portion of the state's load satisfied by the accumulating new renewable sources. This is the actual effect of the 45% midterm target renewable buildout on the state's electricity load.

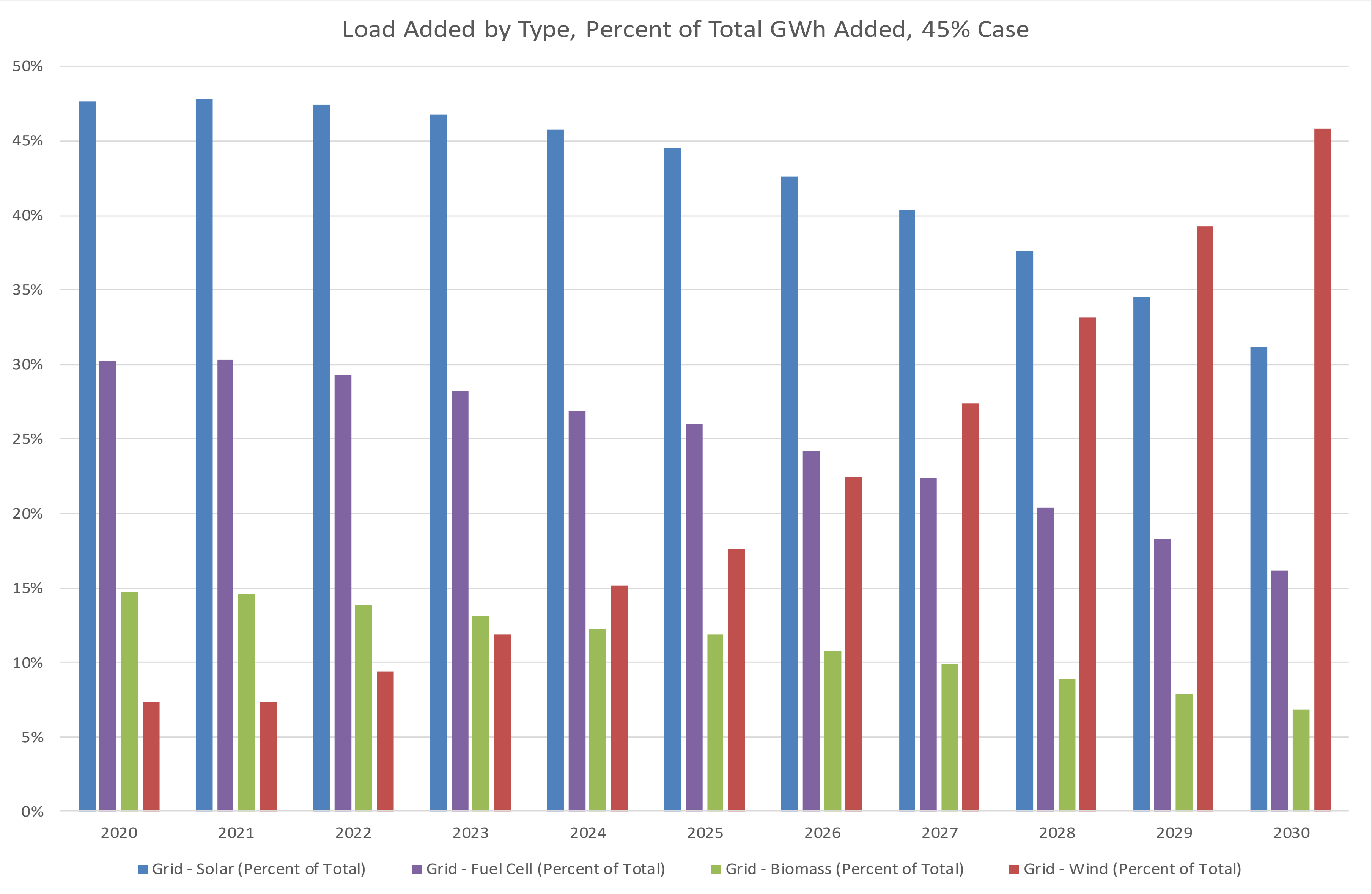
Electricity Sector: Assumptions



Electricity Sector: Assumptions



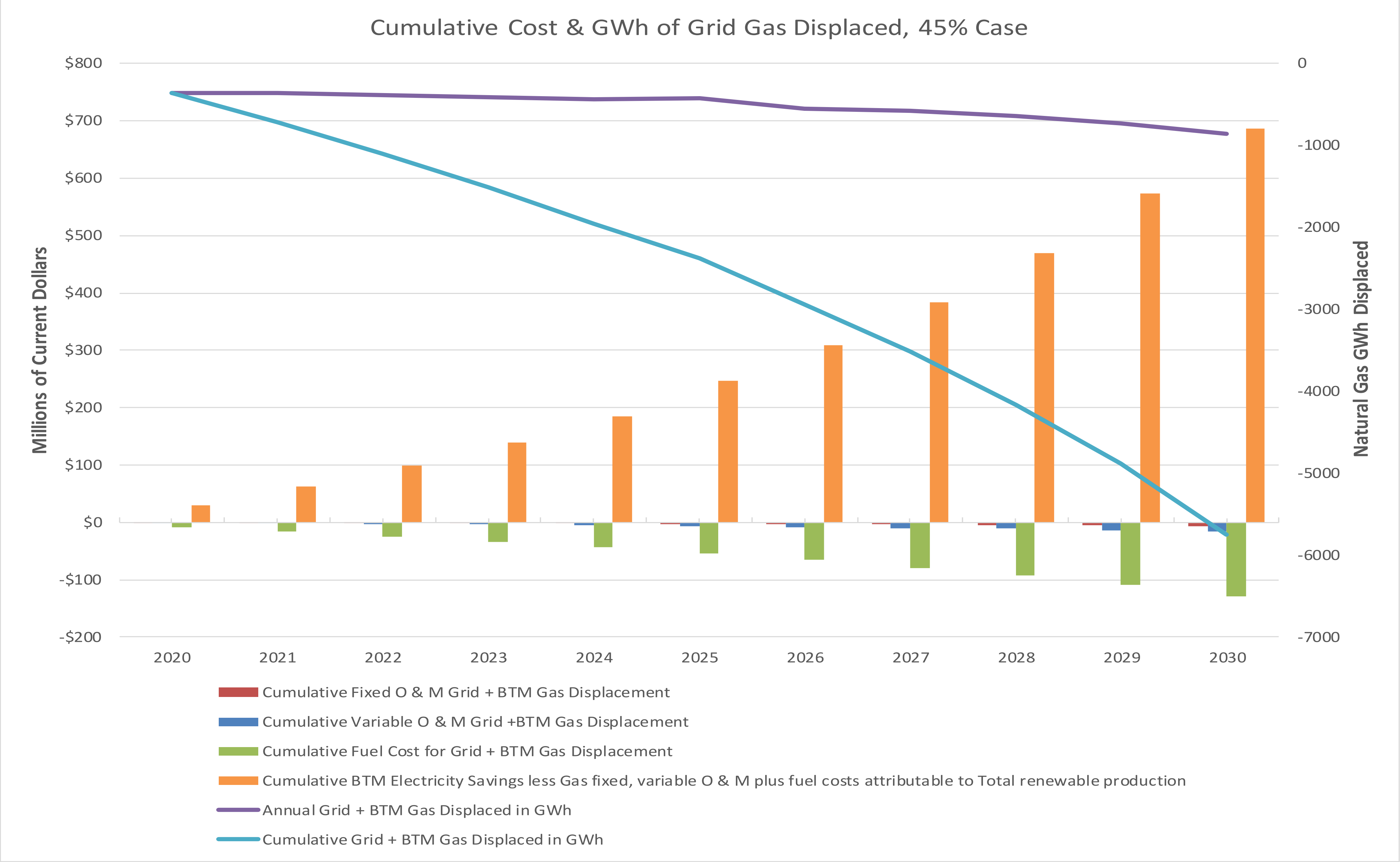
Electricity Sector: Assumptions



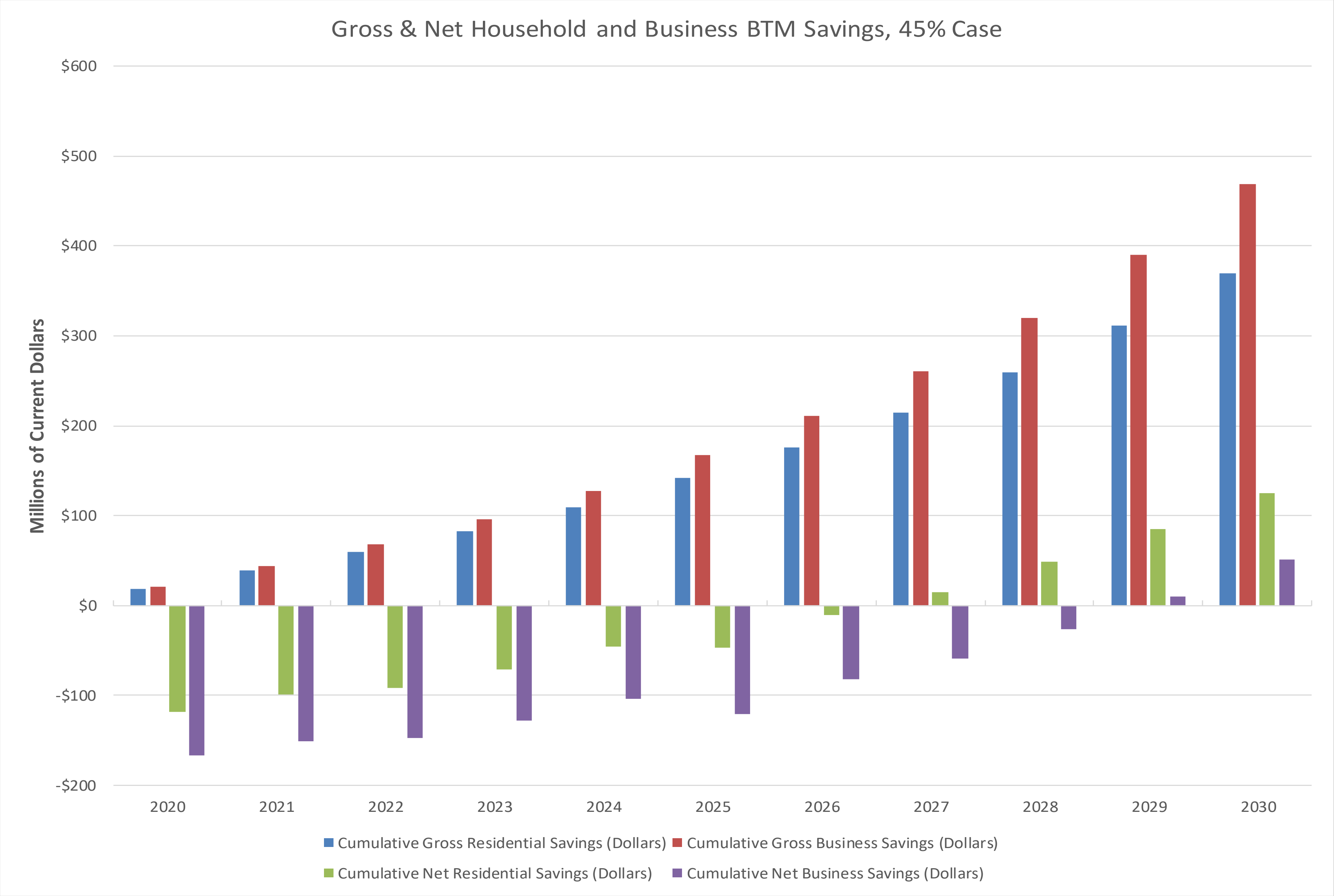
Electricity Sector: Assumptions

- We assume that as new renewable generation contributes to total load, it displaces natural gas. Figure 26 shows the cost savings to utilities in terms of (forgone) cumulative natural gas fixed and variable O & M and fuel costs (the sum of the negative bars). The natural gas cost savings to the utilities does not offset the lost revenue from BTM production and this counts as reduced revenue to the utilities.
- The positive bars in Figure 26 represent the net saving for households and businesses (their gross BTM savings less their capital, fixed and variable O & M and fuel costs). The lost revenue to utilities appears in Figure 27 and is the gross savings households and business realize from BTM production. For reference, the annual and cumulative GWh of natural gas displacement appears on the right-hand scale in Figure 26.

Electricity Sector: Assumptions



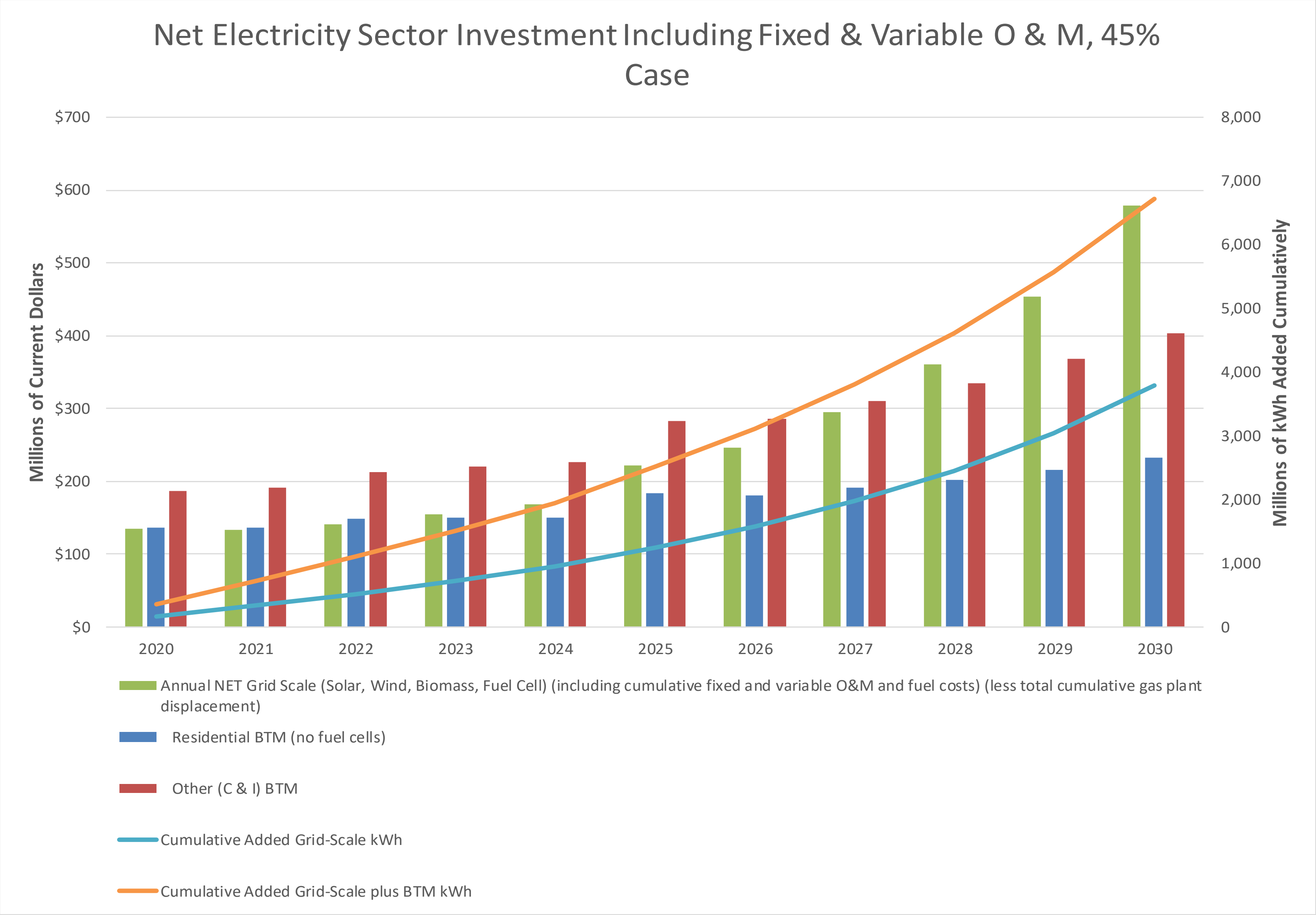
Electricity Sector: Assumptions



Electricity Sector: Assumptions

- We assume households borrow at very low rates or lease to obtain BTM solar (we assume households do not purchase fuel cells) and spend their gross BTM electricity savings on other goods and services even though their net BTM saving is negative from 2020 through 2026 and positive thereafter.
- We model household expenditure for solar and small hydro as household maintenance expenditure, which drives economic impact.
- Businesses realize a positive net saving from BTM investment in 2029 and 2030, which they invest during that period and contributes to economic impact.
- Between 2020 and 2028 inclusive, we assume businesses invest in BTM solar and fuel cells with retained earnings or by going to the capital market to obtain needed funds.

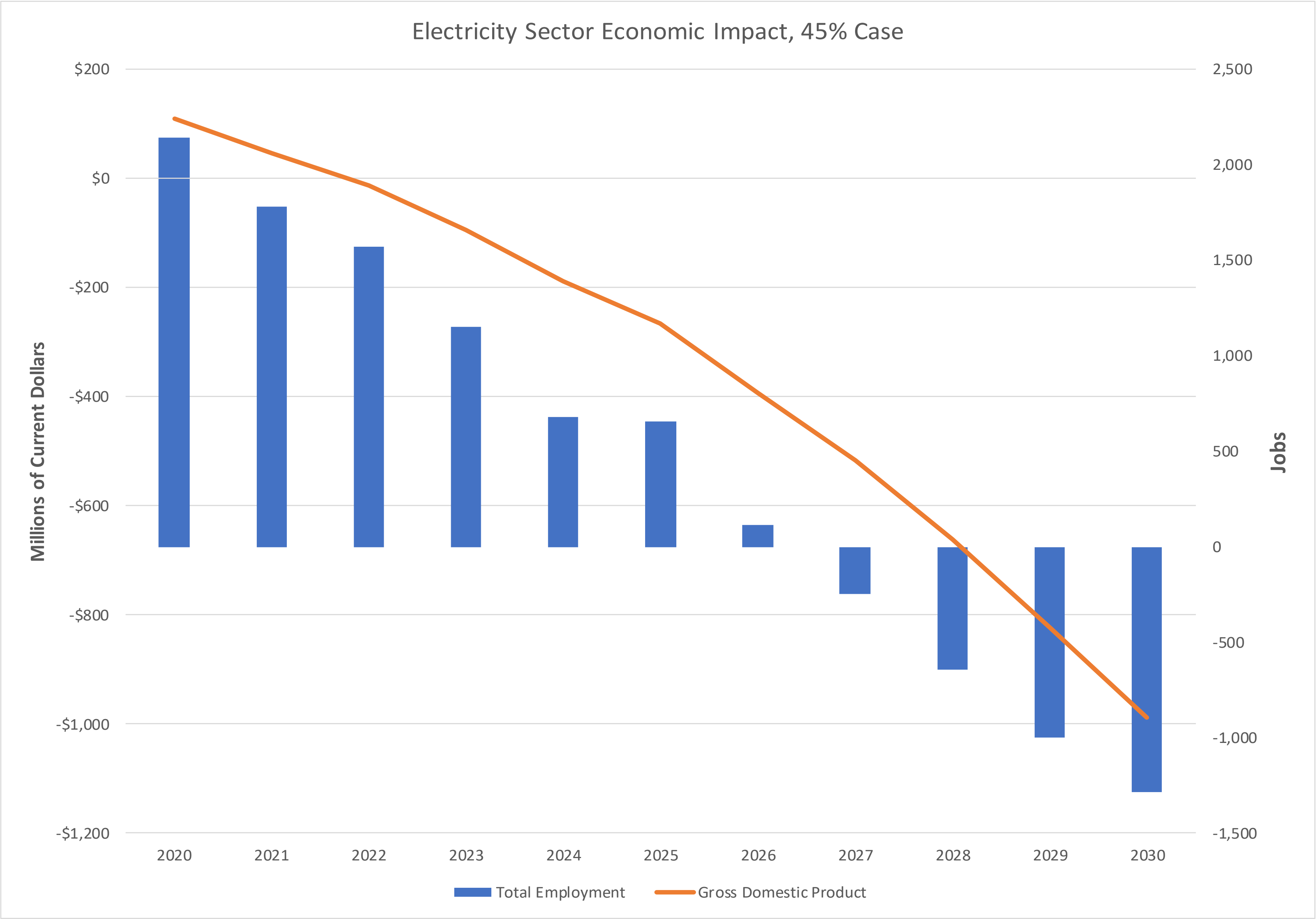
Electricity Sector: Assumptions



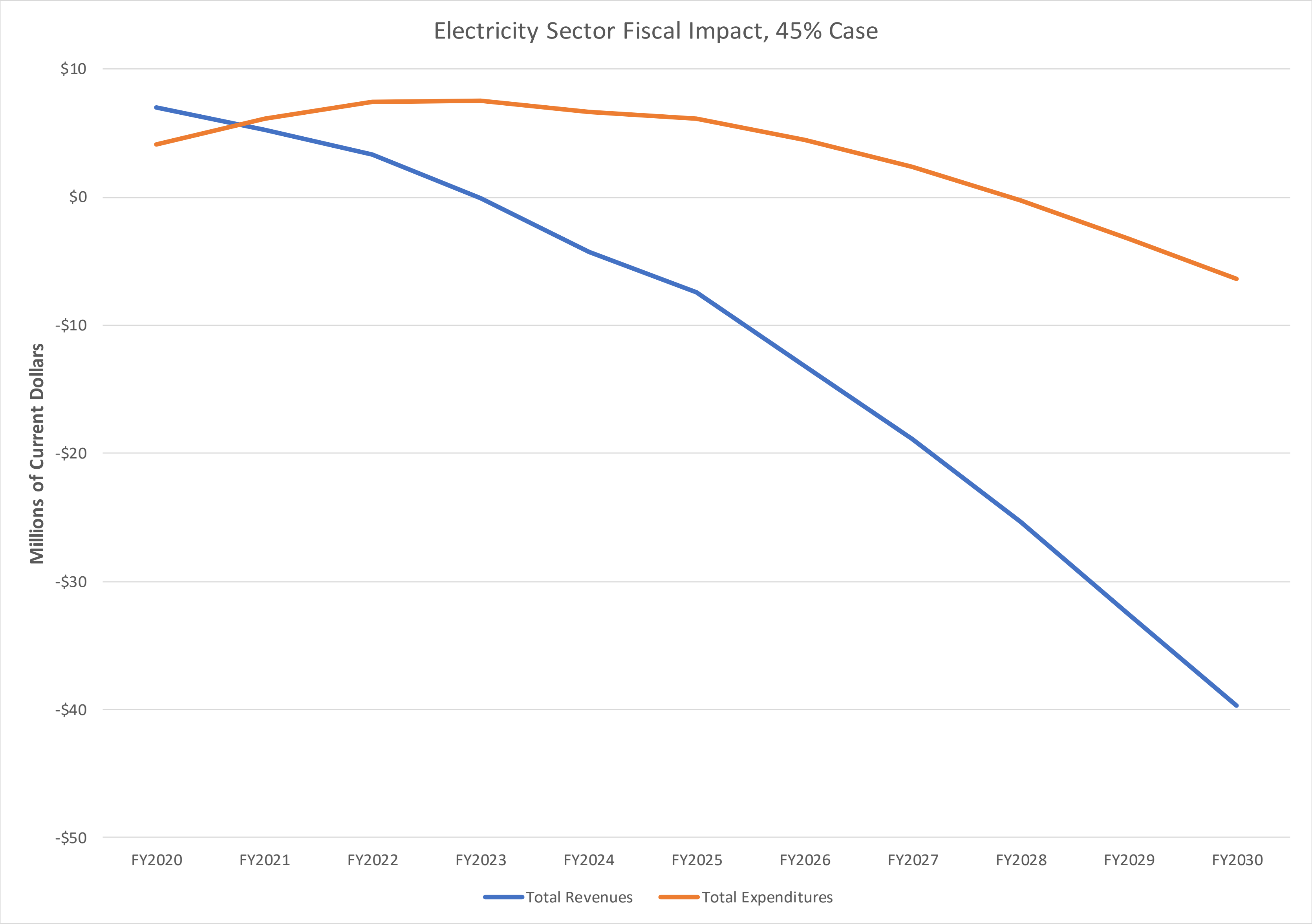
Electricity Sector: Assumptions

- We do not consider the decommissioning costs of fossil fuel or nuclear power plants as renewable sources displace them. These costs would likely be borne by investors and not affect rates beyond those necessary to build out the decarbonized grid.

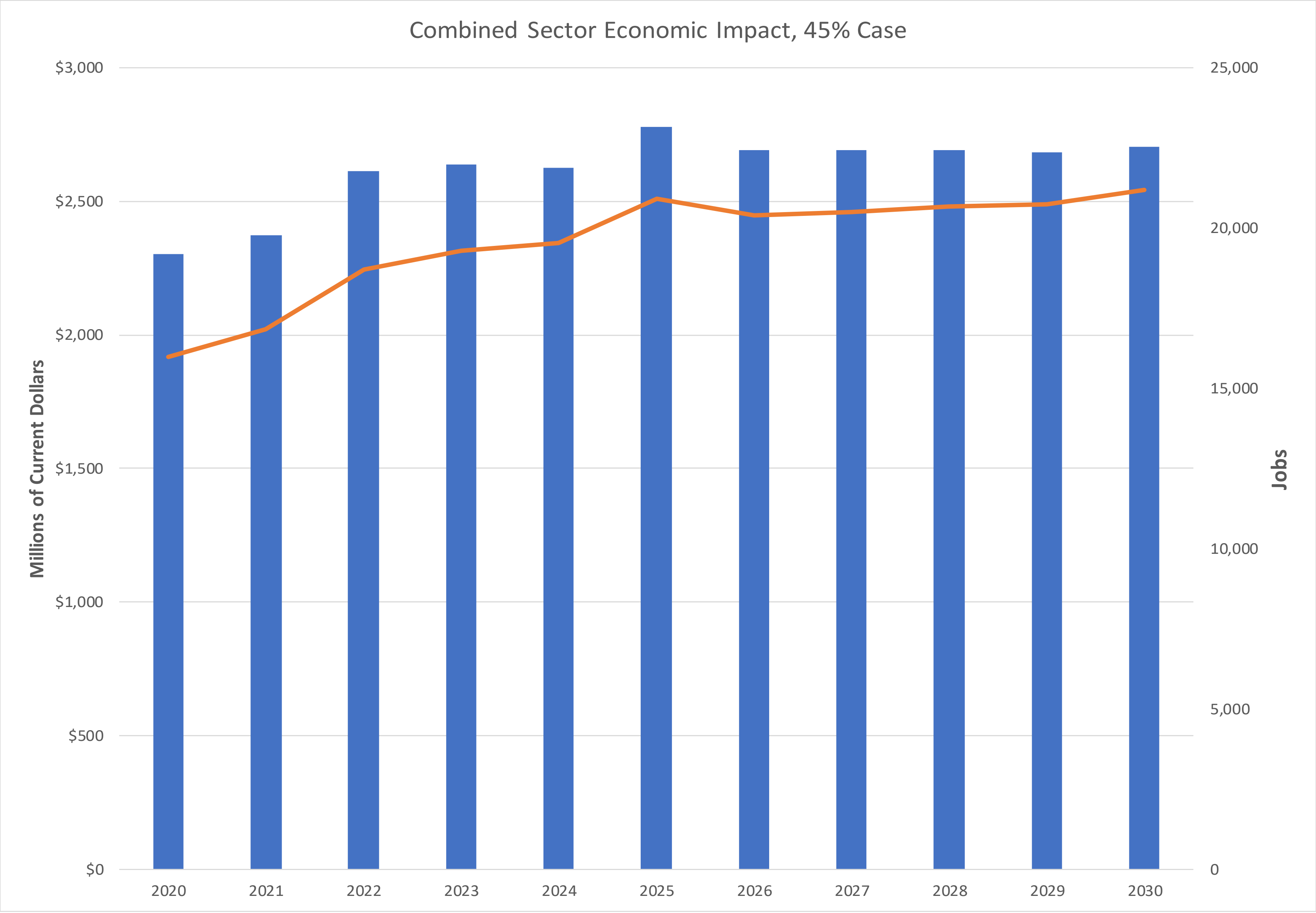
Electricity Sector: REMI Results



Electricity Sector: REMI Results



Combined Sectors: REMI Results



Combined Sectors: REMI Results

Combined Sectors: REMI Results

- Without incentives or accounting for policy costs or health and environmental co-benefits, the net economic and fiscal impacts of the combined sectors' GHG reduction strategies are summarized below.

Combined Sector Economic & Fiscal Impact (2020 – 2030)	
	45% Midterm Target
Economic or Fiscal Variable	Average Annual Change from Ref. Level & Percent
Total Employment (Jobs)	22,000, 0.9%
State GDP (billions current $)	$234, 0.62%
State Revenue (millions current $)	$136, 0.47%
State Expenditure (millions current $)	$128, 0.48%

Conclusions

- We assume Connecticut’s GHG reduction strategies occur in isolation (i.e., other states are not implementing their own GHG strategies) such that modeling the transition to a greener, healthier Connecticut economy occurs in the absence of similar changes in other states’ economies.
- When viewed in isolation, some households and businesses may migrate to lower cost regions in the modeling exercise, but such an inducement to move may diminish if all areas were similarly addressing the global problem of climate change.
- Recall, we have not modeled the health or other co-benefits from reducing GHG emissions that would positively affect these results or the costs of incentives or policies that are necessary to induce the transition envisioned in this analysis that would negatively affect these results. Until these offsetting effects are modeled, the results presented here are preliminary.

References

- Building a Low Carbon Future for CT, GHG Reduction Strategies and Recommendations (December 2018) https://www.ct.gov/deep/lib/deep/climatechange/publications/building_a_low_carbon_future_for_ct_gc3_recommendations.pdf.
- The Economic and Fiscal Impacts of Connecticut's Greenhouse Gas Reduction Strategies (December 2018) https://www.ct.gov/deep/lib/deep/climatechange/remi.pdf.