Maryland Building Decarbonization Study

Updates for the Mitigation Working Group

September 21, 2021

Energy+Environmental Economics

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Summary of Updates

+ **E3 has made the following updates to the analysis based on feedback from the Buildings Subgroup and MWG participants**
  - Updated the **electric efficiency assumptions** in the High Decarb Methane scenario assuming **extension of EMPOWER**
  - Halved the **gas revenue requirement growth rate after 2035**, to be consistent with GGRA assumption that **STRIDE** will complete by then
  - Adjusted the **optimistic RNG scenario** to reflect **competition from liquid fuels**
  - Estimated GHG emissions from **methane leakage** for each scenario
  - Corrected **an error in the electric system cost** estimate
  - Adjusted the **equipment cost** for the **High Electrification with Improved System Configuration** case to reflect larger tonnage for heat pumps
  - Included **climate impact** in the analysis

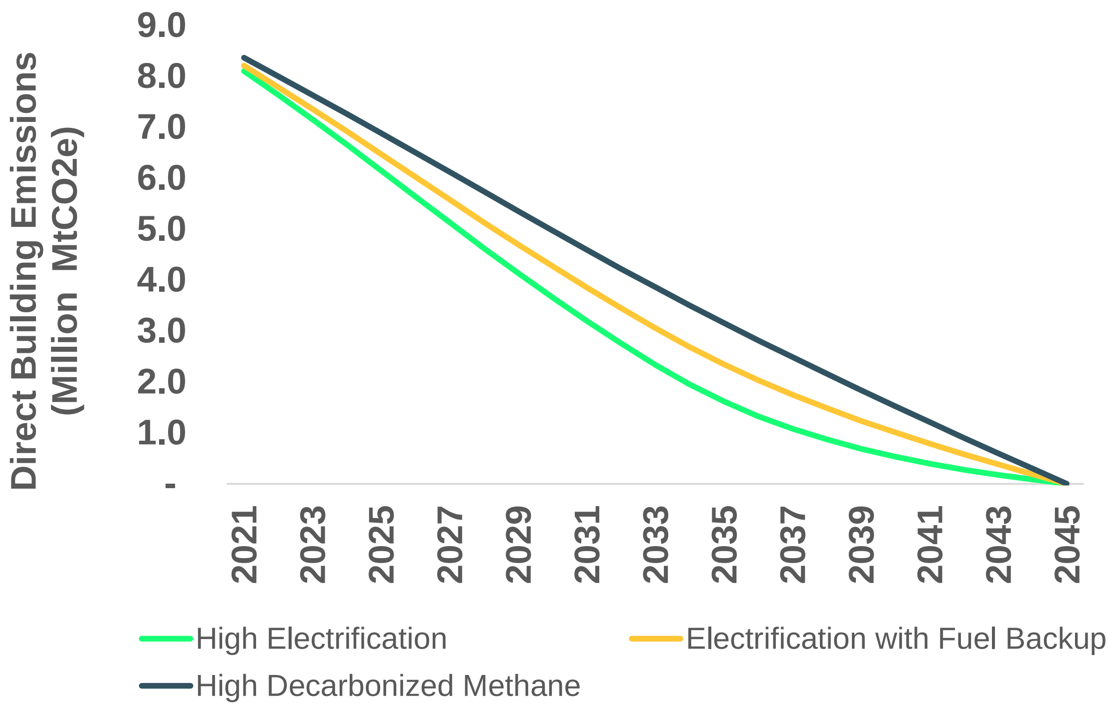
This study investigates opportunities for building decarbonization through 3 scenarios

+ E3 and MDE held a 4-hour workshop with the Buildings Ad-hoc Group, where we received feedback and input from stakeholders on scenario design that informed the selection of the following scenarios

Reference	High Electrification	Electrification with Fuel Backup	High Decarbonized Methane
+ Same as the Reference scenario in the GGRA analysis reflecting current policies + Buildings keep using existing devices with no electrification and little efficiency improvement + Building energy demand grows at 0.6%/yr, same as EIA's projected annual growth rate of Maryland households	+ Almost all buildings switch to ASHPs and GSHPs. Heating is supplied by electricity throughout the entire year + High efficiency through deep building retrofits	+ Existing buildings keep using fuels for heating and are supplied with a heat pump combined with existing furnace/boiler that serves as back up in the coldest hours of the year + All-electric for new construction	+ Buildings keep using fuels for heating while fossil fuels are gradually replaced by low-carbon renewable fuels. Some features: • RNG supplied by biomethane and synthetic natural gas • 7% hydrogen blend • High efficiency through deep building retrofits

All scenarios achieve zero direct building emissions by 2045

Direct building GHG emissions trajectory (MMtCO2e per year)

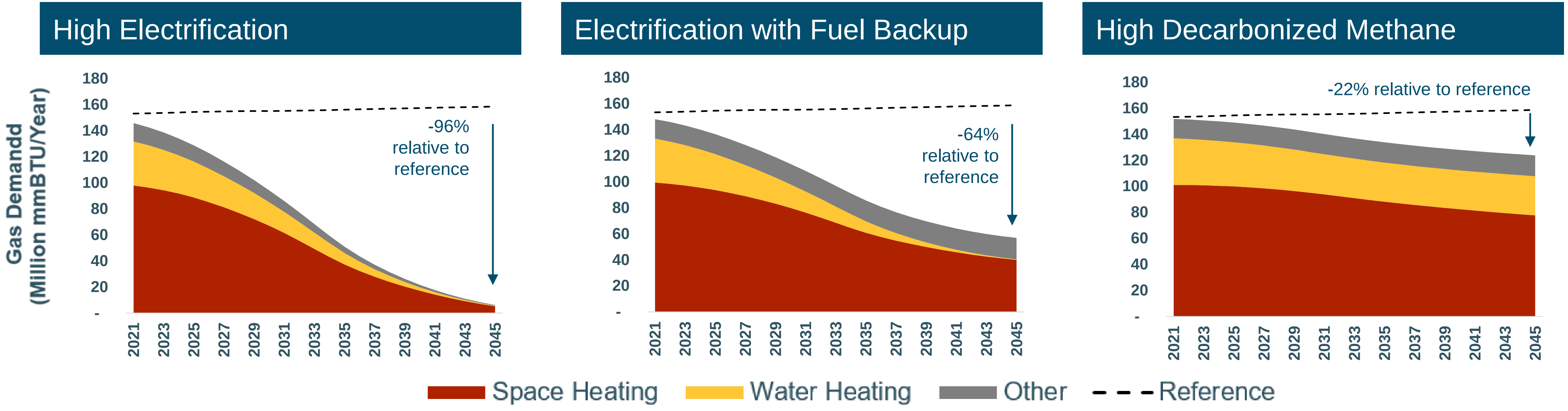


- Cumulative direct emissions and methane leakage from 2021 to 2045 add to 90 MMT CO2e in the High Electrification scenario, 103 MMT CO2e in the Electrification with Fuel Backup scenario, and 117 MMT CO2e in the High Decarbonized Methane scenario.
- CAVEAT: Cumulative emissions are subject to assumptions about timing of key policies and measures that drive the decarbonization trajectory; any comparisons among the scenarios should use caution.

+ **All scenarios achieve zero direct building emissions by 2045 through electrification, efficiency improvement and use of low-carbon fuels**
  - This is consistent with the MCCC-recommended economy-wide target of carbon neutrality by 2045
+ **Methane leakage from in-state gas pipelines may still contribute to indirect emissions**
  - Current emissions from methane leakage associated with building gas consumption are ~0.5 MMT CO2e
  - By 2045, methane leakage from each scenario is shown below, assuming that in-state pipeline leakage rate will decrease by 58% by 2045 relative to 2017 consistent with assumptions from the 2030 GGRA Plan
    - High Electrification - 0.02 MMT CO2e
    - Electrification with Fuel Backup - 0.09 MMT CO2e
    - High Decarbonized Methane - 0.19 MMT CO2e

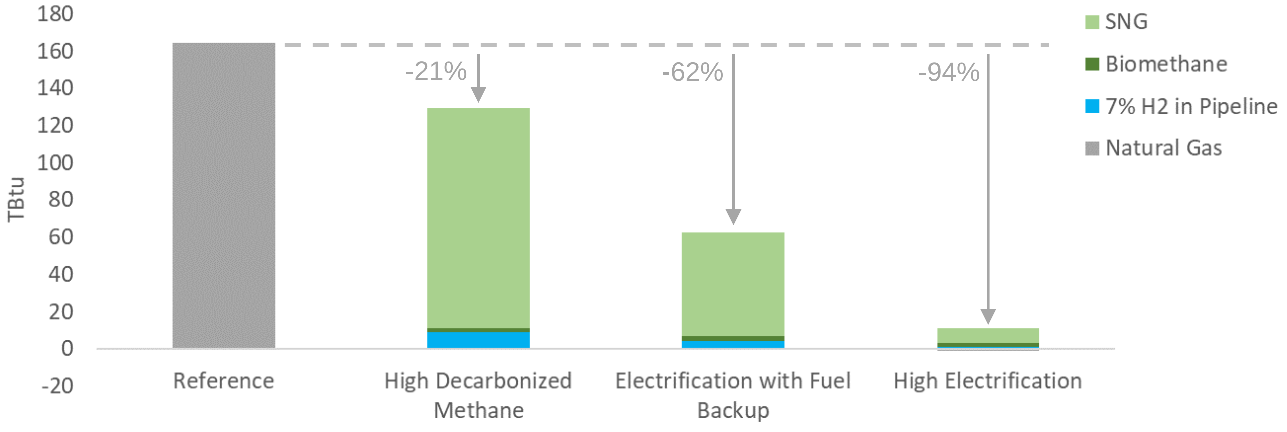
Natural gas demand declines in all scenarios due to energy efficiency gains and fuel switching offsetting growth

+ **Natural gas use in buildings is expected to decline in all scenarios due to energy efficiency gains offsetting growth in households, and this decline is accelerated in scenarios with significant building electrification**
  - **High Electrification** reduces gas demand by 96% by 2045 due to aggressive electrification of all building end-uses
  - **Electrification with Fuel Backup scenario** has lower reduction in gas demand by 2045 at 64%, as most customers adopt dual-fuel heat pumps that use gas with gas as a backup heating source during coldest hours of the year
  - **High Decarbonized Methane** scenario results in a 22% reduction in gas demand by 2045 due to efficient gas appliance adoption and building shell improvements

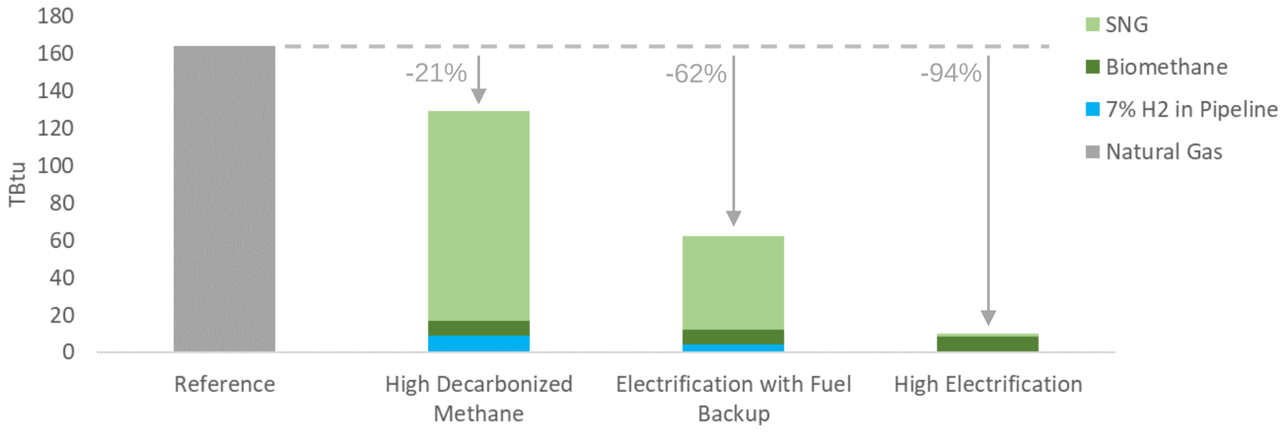


Gas composition transitions to RNG

Gas commodity blend in 2045 (Conservative)



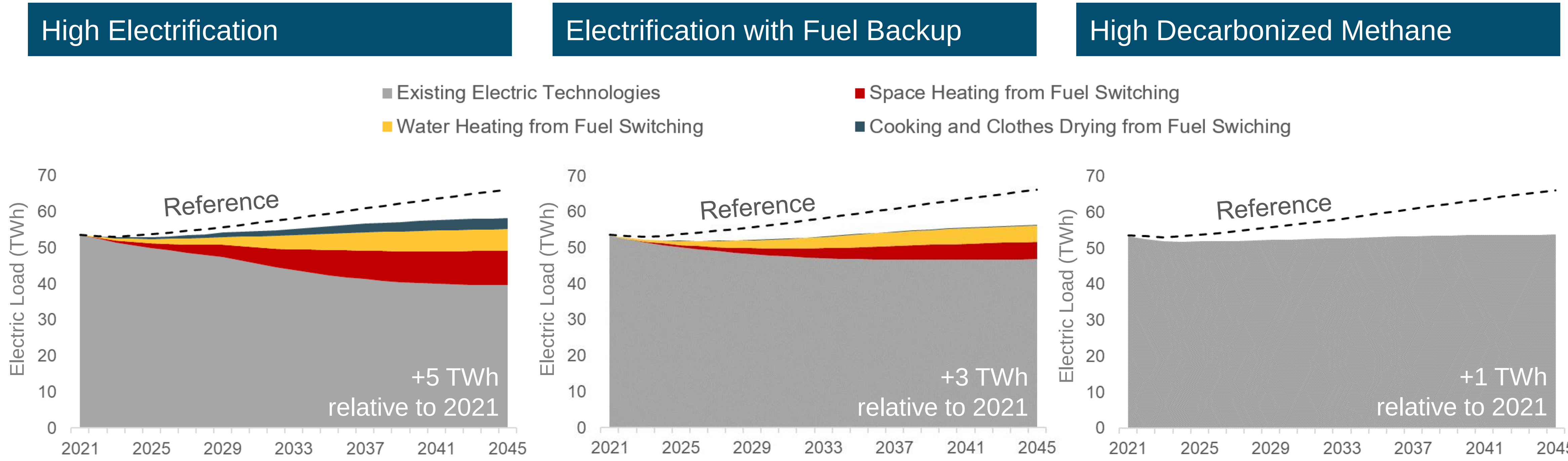
Gas commodity blend in 2045 (Optimistic)



- **By 2045, all building scenarios have 100% blend of RNG in the remaining gas demand**
  - This helps all scenarios reach zero direct building emissions target by 2045
  - Hydrogen blend in pipeline is assumed in all scenarios where it makes economic sense, up to 7% in energy content (20% in volume) which is the maximum current natural gas pipelines can take without significant modification
- **In a conservative RNG scenario where biomass supply is limited, SNG is the main source of low-carbon gas in all scenarios**
- **In an optimistic RNG scenario, SNG is still needed across all scenarios due to the limit in biomass supply**

Electricity demand in all scenarios are lower than Reference due to energy efficiency gains

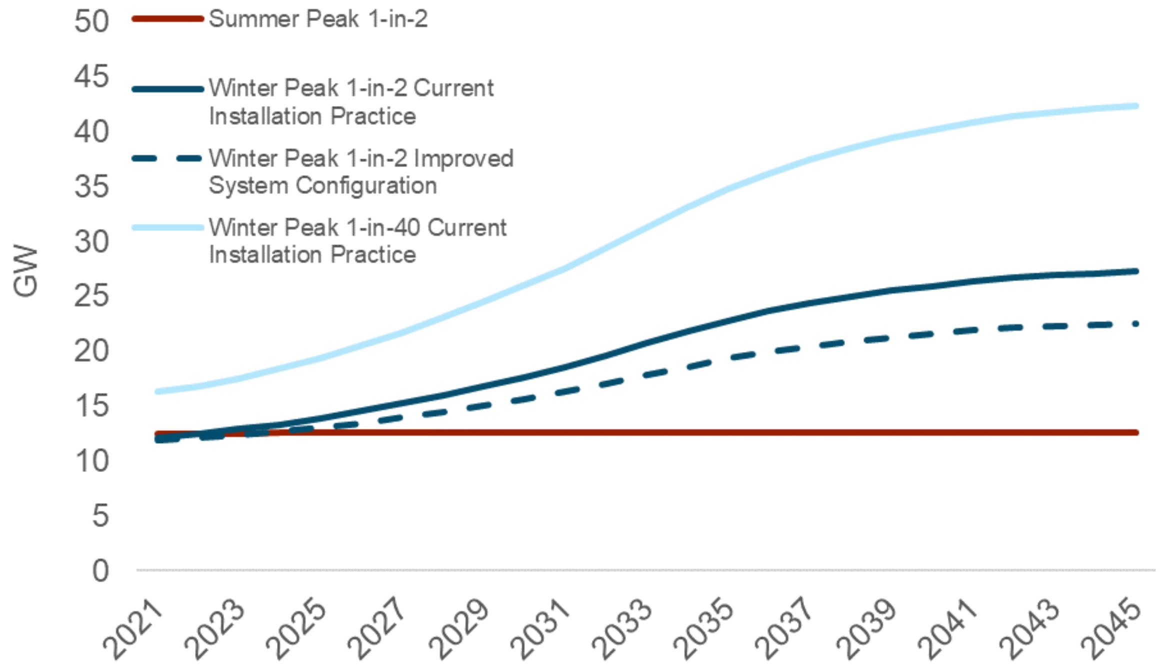
- **Electricity demand increases in all scenarios due to growth in households**
  - **High Electrification** scenario has the highest load growth among the three scenarios due to new space heating, water heating and other loads as a result of fuel switching
- **Compared to Reference, all scenarios have lower electricity demand due to energy efficiency gains**
  - **High Electrification** scenario also has the largest reduction in existing loads due to higher levels of efficiency from building shell improvement and efficient electric device adoption



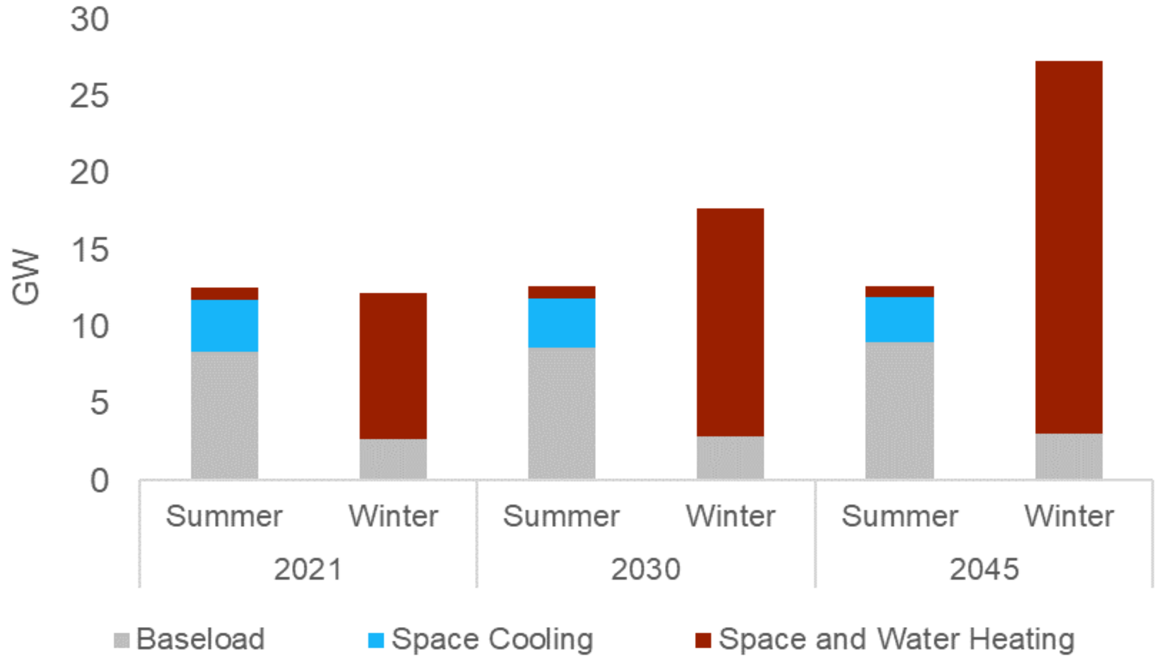
Winter peak load is expected to grow by 15 GW by 2045 in the High Electrification scenario

- **In the High Electrification scenario, Maryland's electricity system is expected to become winter peaking in the near future, and will more than double the current system peak by 2045**
  - Switching to heat pumps from electric resistance heating, which is currently used in about 25% of Maryland households, has a much smaller impact on peak heating load than on annual total heating loads

Peak Load Projection 2021-2045
High Electrification



Contribution to 1-in-2 System Peak by Sector
High Electrification – Current Installation Practice



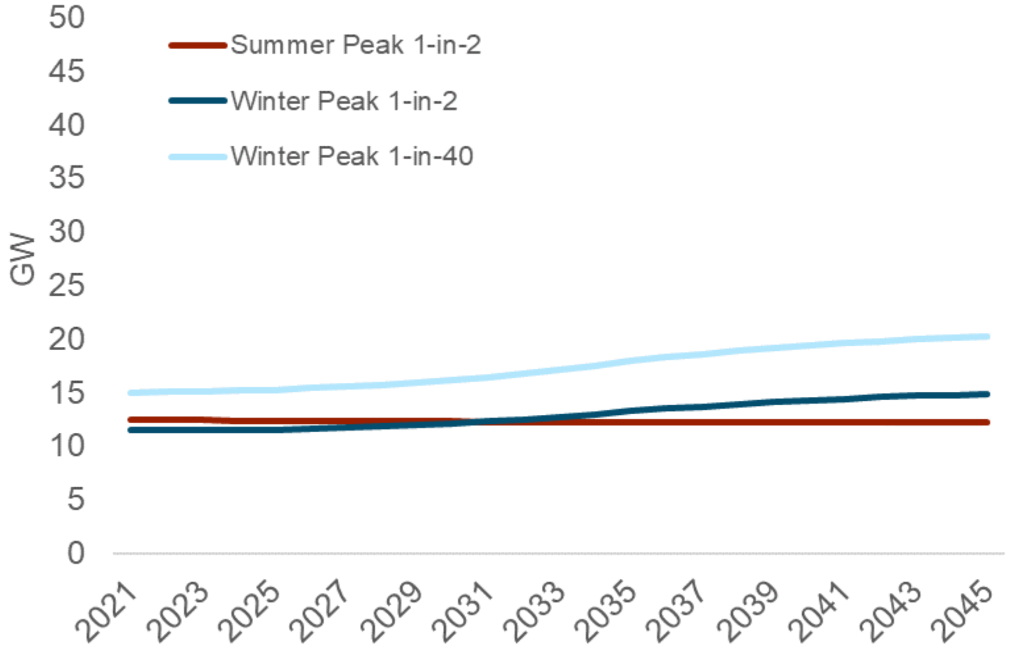
*In 2045, the 1-in-10 and 1-in-40 summer peak is 0.5 GW higher than the 1-in-2 peak

Sources & assumptions: Coincident peak load is based on a modeled hourly load for MD. The projected hourly load is calculated using incremental load in 2050 modeled from PATHWAYS and end-use shapes from RESHAPE based on 2017 weather added to the 2017 historical load.

Electrification with Fuel Backup scenario has much smaller winter peak load growth

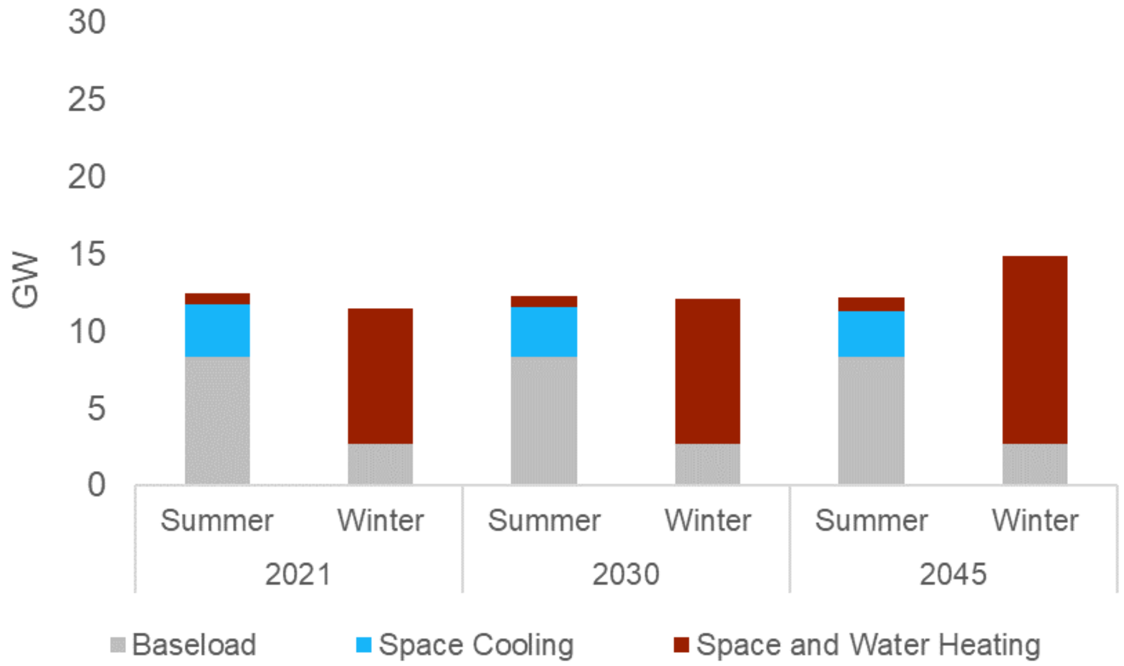
- Compared to the High Electrification scenario, Maryland's electricity system becomes winter peaking about a decade later
- Peak load growth is also significantly smaller, ~2 GW by 2045 compared to the current system peak

Peak Load Projection 2021-2045
Electrification with Fuel Backup



*In 2045, the 1-in-10 and 1-in-40 summer peak is 0.5 GW higher than the 1-in-2 peak

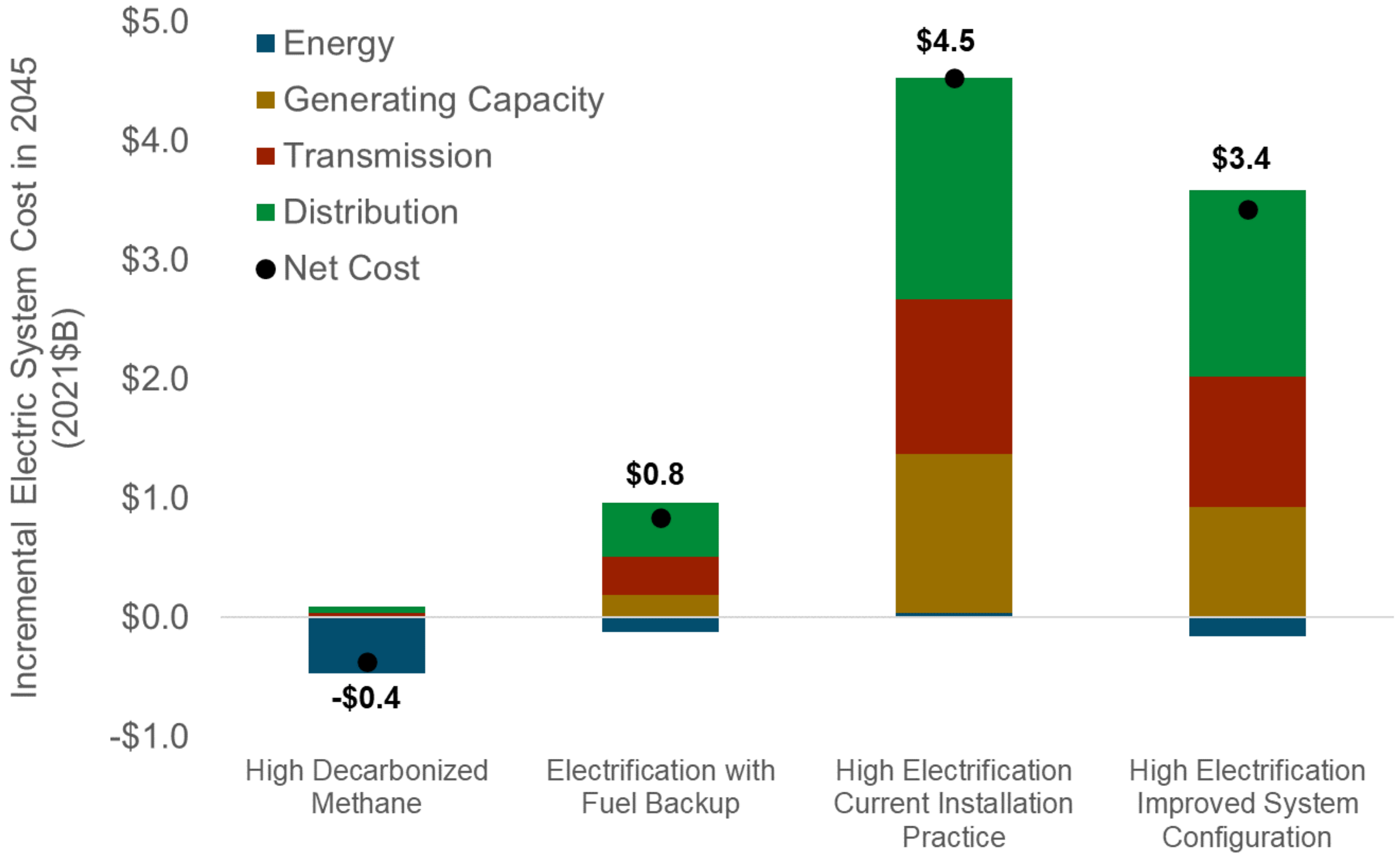
Contribution to 1-in-2 System Peak by Sector
Electrification with Fuel Backup



Sources & assumptions: Coincident peak load is based on a modeled hourly load for MD. The projected hourly load is calculated using incremental load in 2050 modeled from PATHWAYS and end-use shapes from RESHAPE based on 2017 weather added to the 2017 historical load.

Meeting electric loads in the High Electrification scenario requires around $3-4 billion of annual incremental system costs

Annual Incremental Electric System Costs relative to Reference in 2045 (2021$ Billions per year)

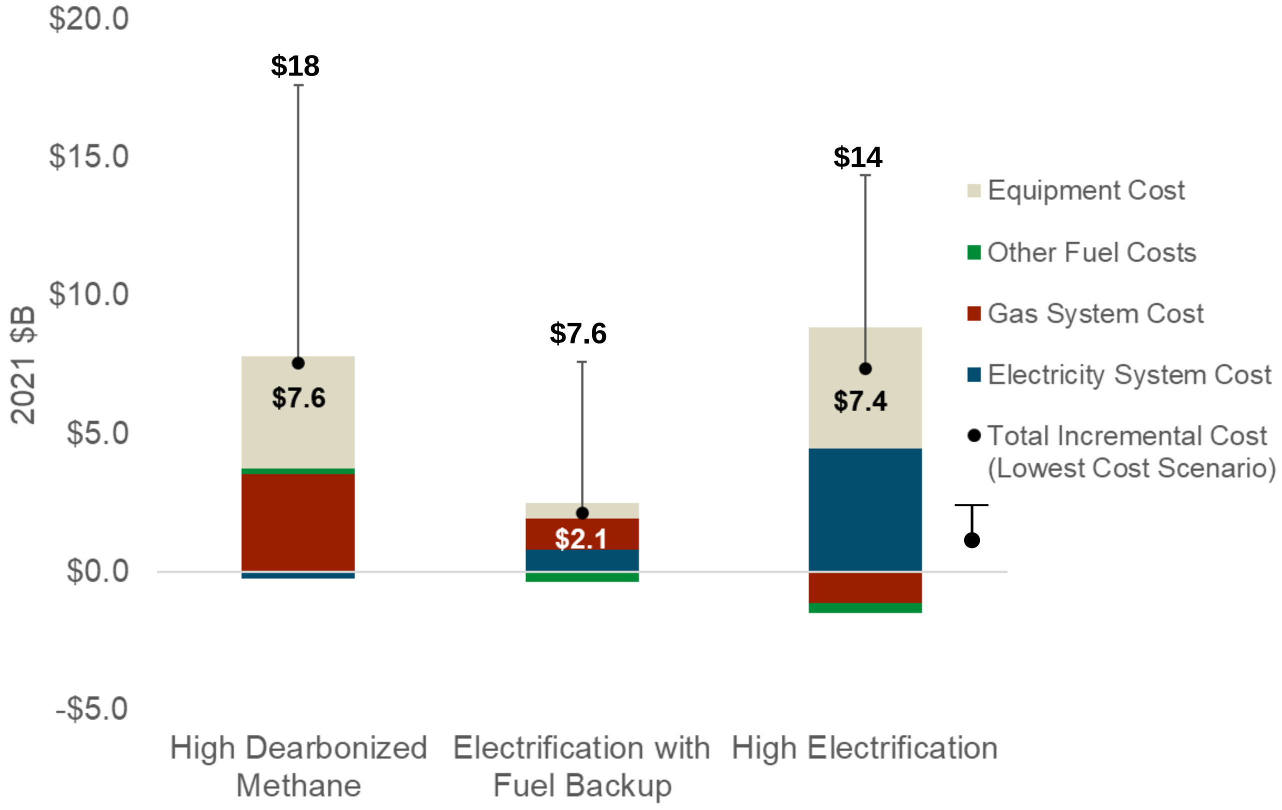


- **High levels of electrification significantly increase electricity system costs, mainly for meeting peak capacity needs.**
  - Improving system installation practices would result in less increase in electric system costs, only ~75% of that in the High Electrification scenario
- **Pairing ASHPs with fuel systems can save more than 80% of the incremental costs, mainly by avoiding T&D infrastructure and generating capacities**
  - System costs in the Electrification with Fuel Back Up scenario are $0.8 billion in 2045 compared to $4.5 billion for the High Electrification scenario

Sources & assumptions: Details of the electric sector cost assumptions are documented in the Appendix. T&D costs are high-level assumption reflecting new investment in lines. This captures the high-level investment requirement in the High Electrification Scenario given the magnitude of the peak impact from electrification. Further analysis is needed to explore near term opportunities for using headroom in existing T&D infrastructure and for expanding existing lines, which are likely going to be less expensive.

Electrification with Fuel Backup scenario is expected to be the relatively low-cost and low-risk among the three scenarios

Incremental Total Resource Costs for Buildings (2045) ($2021 Billions per year)



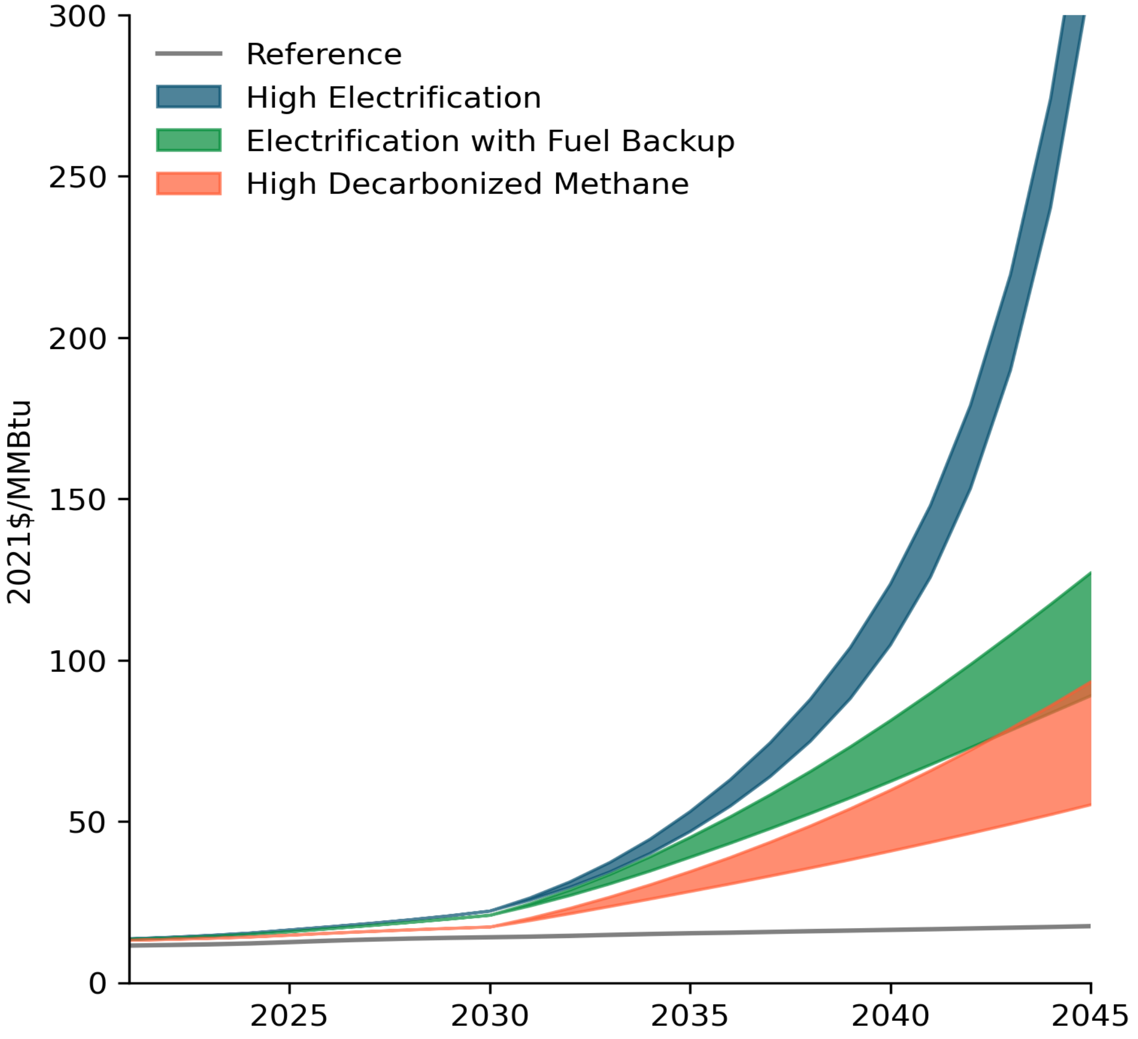
Total cost range reflects assumptions regarding fuel costs, equipment cost, and heat pump installation practices

- **Building sector costs show large variation across scenarios depending on:**
  - Gas fuel costs (optimistic/conservative supply curve)
  - Equipment costs (mainly building shell upgrade costs)
  - Installation practice for electric heating systems
- **A hybrid scenario could potentially "hedge" for this uncertainty given its lower overall costs and narrow cost ranges**

Sources & assumptions: These charts show incremental resource costs of the scenarios compared to the reference scenario. Climate impact is included in the total resource costs results, but not yet in other results.

Gas rates increase significantly across all scenarios

Residential gas rates (2021$/MMBtu)



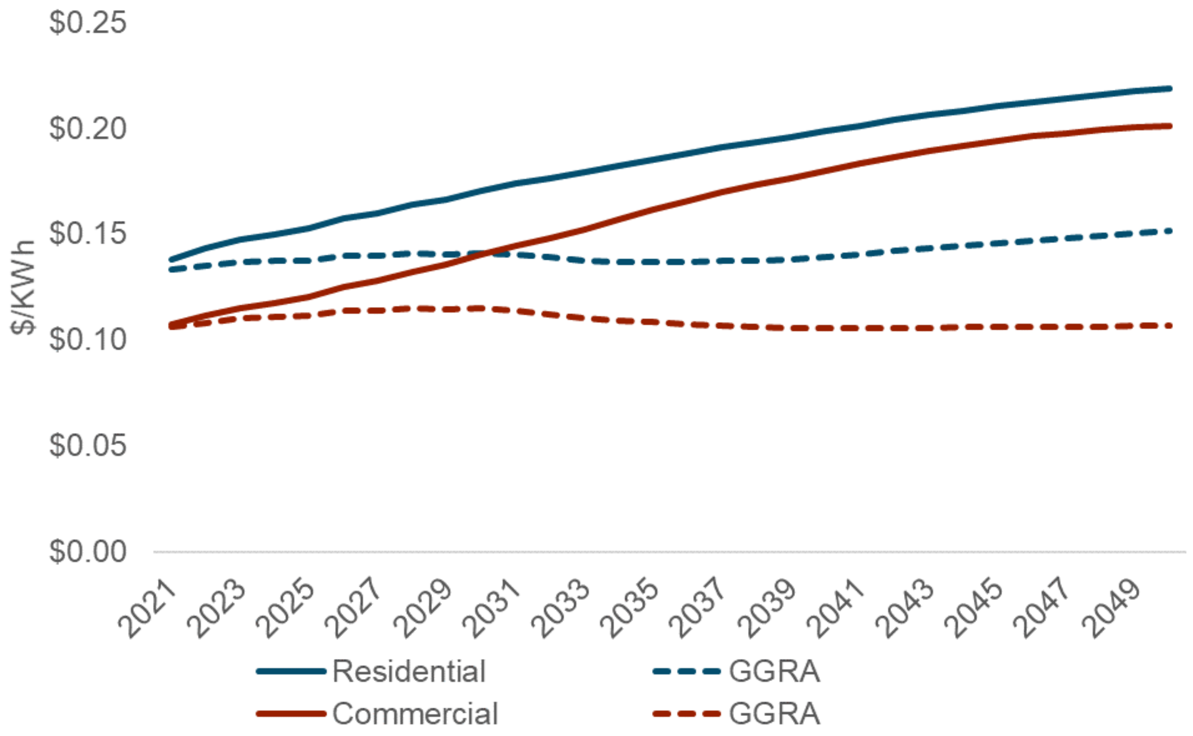
- **High Electrification scenario** experiences a rapid rate increase driven by declining throughput despite lower total delivery and commodity costs
- Rate increases in the **High Decarbonized Methane scenario** are driven primarily by the commodity cost for zero carbon fuel
- **Electrification with Fuel Backup scenario** has higher gas rates than the High Decarbonized Methane scenario, due to its lower throughput and the resulting higher per MMBtu delivery cost

*Range shown in figure reflects the commodity cost forecast uncertainty

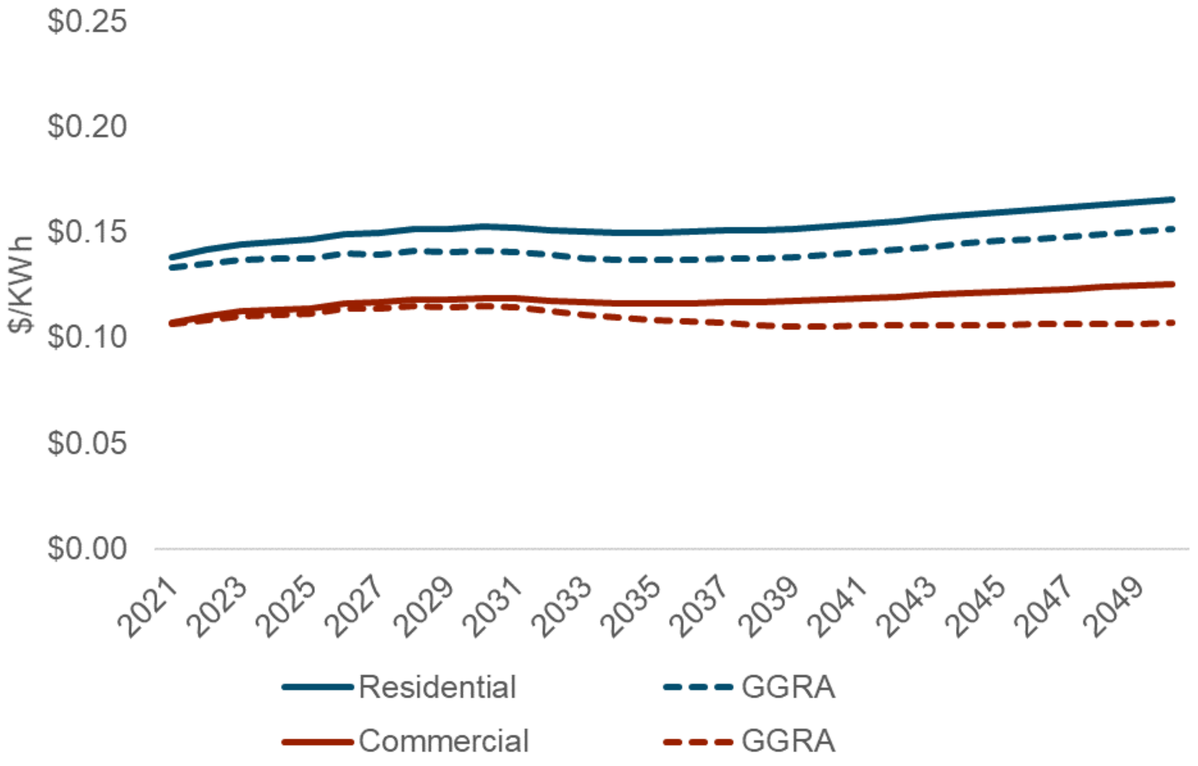
High Electrification scenario shows a more rapid electric rate increase compared to Electrification with Fuel Backup

+ **The Electrification + Fuel Backup scenario is projected to have a lower rate increase because it has a smaller load factor and manages to avoid the expensive peak capacity investment.**

Electric rates in the High Electrification Scenario (2021$/kWh)

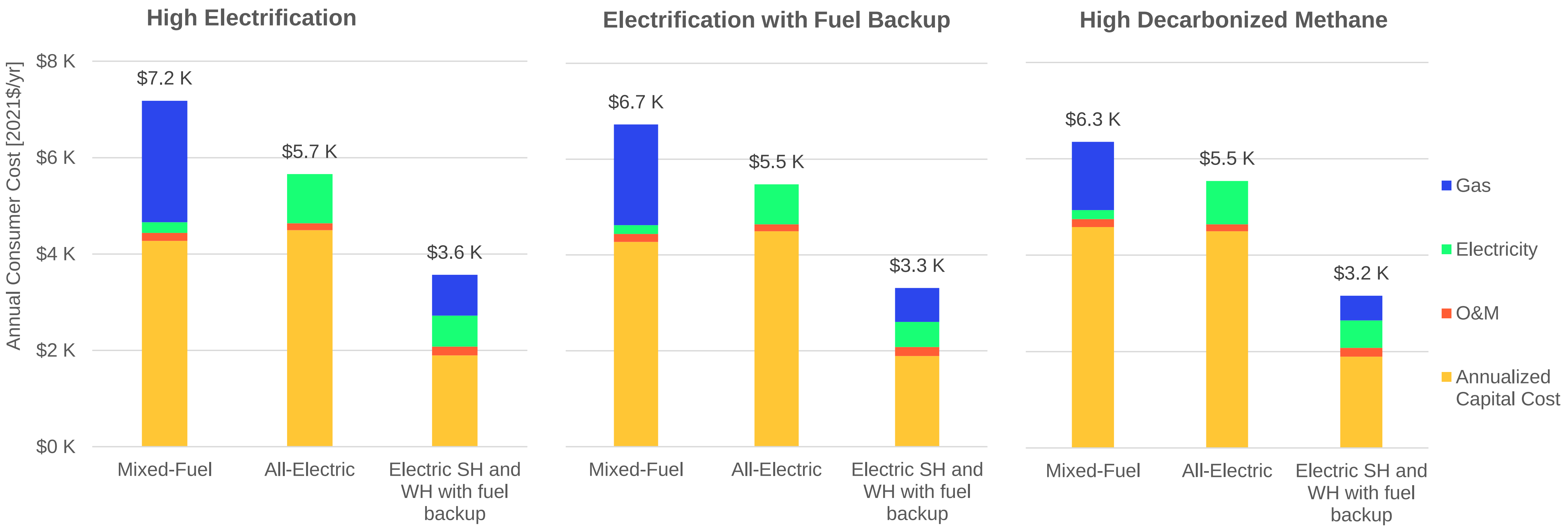


Electric rates in the Electrification + Fuel Back-up Scenario (2021$/kWh)



Electrifying heating with fuel backup is expected to be the least expensive option when both capital and operating costs are considered

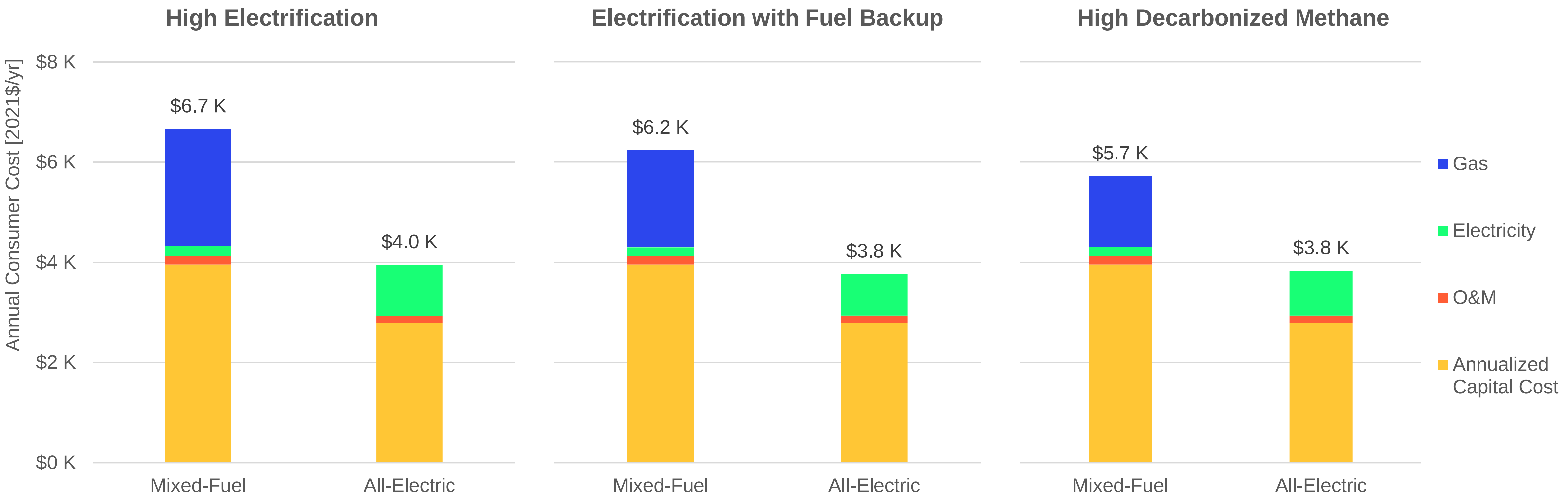
+ **"Hybrid" customers can save money by utilizing their existing fuel-based heating equipment to provide backup heating during coldest hours of a year, and by not having to upgrade building shells**



* Gas costs, electricity costs, and equipment costs are based on 2035 rates; Gas costs represent "optimistic" rate scenario ("conservative" gas scenario has 4% higher total cost for mixed-fuel)

All-electric design is expected to be the less expensive option

+ **All-electric new construction is cheaper than mixed-fuel new construction for single-family residential homes across all decarbonization scenarios due to both lower capital (with avoided gas connection) and operating costs**



* Gas costs, electricity costs, and equipment costs are based on 2035 rates; Gas costs represent "optimistic" rate scenario ("conservative" gas scenario has 6% higher total cost for mixed-fuel)

Summary of key findings

Reducing direct building emissions to zero is feasible in all scenarios, but requires technology commercialization and accelerated implementation.

Electrification with Fuel Backup shows lowest overall costs while also reducing reliance on technologies that have not yet been widely commercialized or that are uncertain in their scalability

- **High Decarbonized Methane** requires large quantities of zero-carbon fuels, resulting in high incremental fuel costs with significant cost uncertainty depending on the commercialization of RNG
- **High Electrification** causes a Summer to Winter peak-shift and significant increase in peak electricity demand, resulting in high incremental electricity system costs

Consumers in **retrofit buildings** can save costs by employing a **dual-fuel heating system** with heat pumps providing majority of the heating need and fuel system providing backup during the coldest hours

All-electric new construction is found to be less expensive for consumers considering all costs including equipment and fuel costs compared to mixed-fuel new construction that uses fuels for heating

Achieving the Electrification with Fuel Backup scenario would require careful policy design that incentivizes consumers to employ dual-fuel heating systems

Costs of gas increase in all scenarios as a result of zero-carbon fuels and higher delivery costs (due to lower gas demand in the electrification scenarios); emphasis on mitigating the energy burden with customers **‘staying behind’** is important.