An Assessment of Electrification Impacts on the Maryland Electric Grid

PREPARED BY

Sanem Sergici
Akhilesh Ramakrishnan
Kate Peters
Ryan Hledik
J. Michael Hagerty
Ethan Snyder
Julia Olszewski
Hazel Ethier

PREPARED FOR

The Maryland Public Service Commission

WITH SUPPORT FROM

Applied Energy Group and
Mondre Energy

DECEMBER 19, 2023

Brattle

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STATE OF MARYLAND

PUBLIC SERVICE COMMISSION

December 29, 2023

President Bill Ferguson
H-107 State House
100 State Circle
Annapolis, MD 21401

Speaker Adrienne Jones
H-101 State House
100 State Circle
Annapolis, MD 21401

RE: Compliance with Sect. 10 of the Climate Solutions Now Act of 2022

Dear President Ferguson and Speaker Jones:

Section 10 of the Climate Solutions Now Act of 2022 (CSNA) requires the Public Service Commission (Commission) to complete a general system planning study to assess the capacity of each gas and electric company's distribution systems to successfully serve customers under a managed transition to a highly electrified building sector. The CSNA set Maryland on a course to achieve net zero greenhouse gas (GHG) emissions by 2045, and 60% GHG reduction by 2031 relative to 2006 levels. The Act includes provisions for extensive changes to various sectors including transportation, electricity, buildings, and agriculture. Further, the Act set the following requirements for this study:

- use a projection of average growth in system peak demand between 2021 and 2031 to assess the overall impact on each gas and electric distribution system
- compare future electric distribution system peak and energy demand load growth to historic rates
- consider the impacts of energy efficiency and conservation and electric load flexibility
- consider the capacity of the existing distribution systems and projected electric distribution system improvements and expansions to serve existing electric loads and projected electric load growth
- assess the effects of shifts in seasonal system gas and electric loads

The Maryland's Climate Pathway Report[1] demonstrates how Maryland can meet its ambitious climate goals of 60% reduction of greenhouse gas emissions by 2031 relative to 2006 levels, and attain a net-zero economy by 2045, all while realizing health and economic benefits

[1] *See* www.marylandsclimatepathway.com

WILLIAM DONALD SCHAEFER TOWER □ 6 ST. PAUL STREET □ BALTIMORE, MARYLAND 21202-6806

410-767-8000 □ Toll Free: 1-800-492-0474 □ FAX: 410-333-6495

MDRS: 1-800-735-2258 (TTY/Voice) □ Website: www.psc.state.md.us

for Marylanders, including improved air quality, new jobs, and household cost savings. This study modeled electrification scenarios that would result in direct building heating emissions reductions consistent with Maryland's Climate Pathway report.

The results indicate that the aggregate Maryland electric systems would see load growth rates in the range of 0.6–2.1% per year through 2031 with high electrification, assuming utility energy efficiency plans consistent with the Climate Solutions Now Act and existing utility demand response plans. This increase in load growth is accompanied by a 31–32% reduction in building sector gas demand by 2031 in high electrification scenarios. The Maryland electric distribution system, which is currently summer peaking, would switch to winter peaking around 2026–2027. Furthermore, additional energy efficiency and load flexibility measures could result in significant mitigation of load growth by 2031 to −0.2–1.2% per year. Historically, there was significant Maryland system load growth in the 1980s of 4.9% per year and more moderate growth of 1.2–1.5% from 1990–2010 while load declined between 2010–2020. These results show that peak load growth through 2031 with high electrification of the building sector will be comparable to or less than the growth rate the Maryland system has seen over the past 40 years.

This study provides system-level load growth projections to enable policymakers to understand and benchmark the impacts of different building decarbonization scenarios through 2031. While the study concludes that high levels of electrification can be handled by Maryland electric systems through 2031, consistent or lower than historical levels of Maryland load growth, the study does not quantify the costs and benefits of each scenario. Each scenario would result in several costs, including equipment installation and maintenance costs borne by building owners and grid investment and demand-side management program costs borne by utilities and utility ratepayers. Each scenario would also create several benefits, including fuel savings, avoided natural gas infrastructure investments, reduced societal impacts of GHG emissions, and reduced health impacts of air pollution.

It is also important to note that, while this study provides a utility system-level view of load growth trajectory under different scenarios, this study is not a substitute for more granular, locational distribution planning studies that could be conducted by the utilities. Through these studies, utilities will be able to plan specific upgrades to the distribution system based on the loading of existing equipment and forecasted customer adoption of various technologies.

Sincerely,

Frederick H. Hoover
Chair

cc: Chair Brian Feldman, Education, Energy and the Environment Committee
Chair C.T. Wilson, Economic Matters Committee
Chair Marc Korman, Environment and Transportation Committee
Eric Leudtke, Chief Legislative Officer

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ACKNOWLEDGMENTS

The authors would like to thank the members of the Electrification Study Working Group for participating in a collaborative process and making important contributions to the development of this study.

The authors would also like to extend their special thanks to Mr. John Borkoski, Senior Advisor with the Maryland Public Service Commission, for his excellent leadership and management of the working group process.

The authors would like to acknowledge excellent analytical and data support they received from the study partners Eli Morris and Kenneth Walter (Applied Energy Group) and Judith Mondre and Steven Miller (Mondre Energy).

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Key Takeaways

The Maryland's Climate Pathway Report demonstrates how Maryland can meet its ambitious climate goals of 60% reduction of greenhouse gas emissions by 2031 relative to 2006 levels, and attain a net-zero economy by 2045, all while realizing health and economic benefits for Marylanders, including improved air quality, new jobs, and household cost savings. This ***study modeled electrification scenarios that would result in direct building heating emissions reductions consistent with Maryland's Climate Pathway*** report.

The results indicate that the aggregate Maryland electric systems would see ***load growth rates in the range of 0.6–2.1% per year through 2031 with high electrification, assuming utility energy efficiency plans consistent with the Climate Solutions Now Act*** and existing utility demand response plans. This increase in load growth is accompanied by a ***31–32% reduction in building sector gas demand by 2031*** in high electrification scenarios. The Maryland electric distribution system, which is currently summer peaking, would switch to winter peaking around 2026–2027. Furthermore, ***additional energy efficiency and load flexibility measures could result in significant mitigation of load growth by 2031 to −0.2–1.2% per year***.

Historically, there was significant Maryland system load growth in the 1980s of 4.9% per year and more moderate growth of 1.2–1.5% from 1990–2010, while load declined between 2010–2020. These results show that ***peak load growth through 2031 with high electrification of the building sector will be comparable to or less than the growth rate the Maryland system has seen*** over the past 40 years.

Executive Summary

The Climate Solutions Now Act (CSNA),[1] passed into law in 2022, set Maryland on a course to achieve net zero greenhouse gas (GHG) emissions by 2045. In support of this goal, the Act stated the intent for Maryland to move toward electrification of the building sector, and directed the Maryland Public Service Commission ("PSC" or "Commission") to conduct a study "assessing the capacity of each company's gas and electric distribution systems to successfully serve customers under a managed transition to a highly electrified building sector." This study was developed to address the CSNA's directive to study the impacts of this transition through 2031.

This study assessed three high electrification scenarios that would result in reductions of direct greenhouse gas emissions from the building sector consistent with a pathway to meet the economy-wide goal of 60% reduction in emissions by 2031 relative to a 2006 baseline. These scenarios assume rapid electrification of the building sector, leading to 31–32% reduction of natural gas consumption and 27–28% reduction in liquid fuel (oil and propane) consumption in buildings by 2031 relative to 2022. All three scenarios also assume achievement of other key state decarbonization policies, including energy efficiency targets, the Renewable Portfolio Standard for electricity supply, the Advanced Clean Cars and Advanced Clean Trucks standards for vehicle sales, and the Building Energy Performance Standards for large buildings.

In a scenario where buildings electrify space and water heating primarily using less efficient heat pumps with resistive backup, results indicate that the aggregate Maryland electric system would see annual peak load growth of 2.1% through 2031. While these less efficient heat pumps are the most commonly used technology today, more efficient cold-climate heat pumps are commercially available and growing in market share.

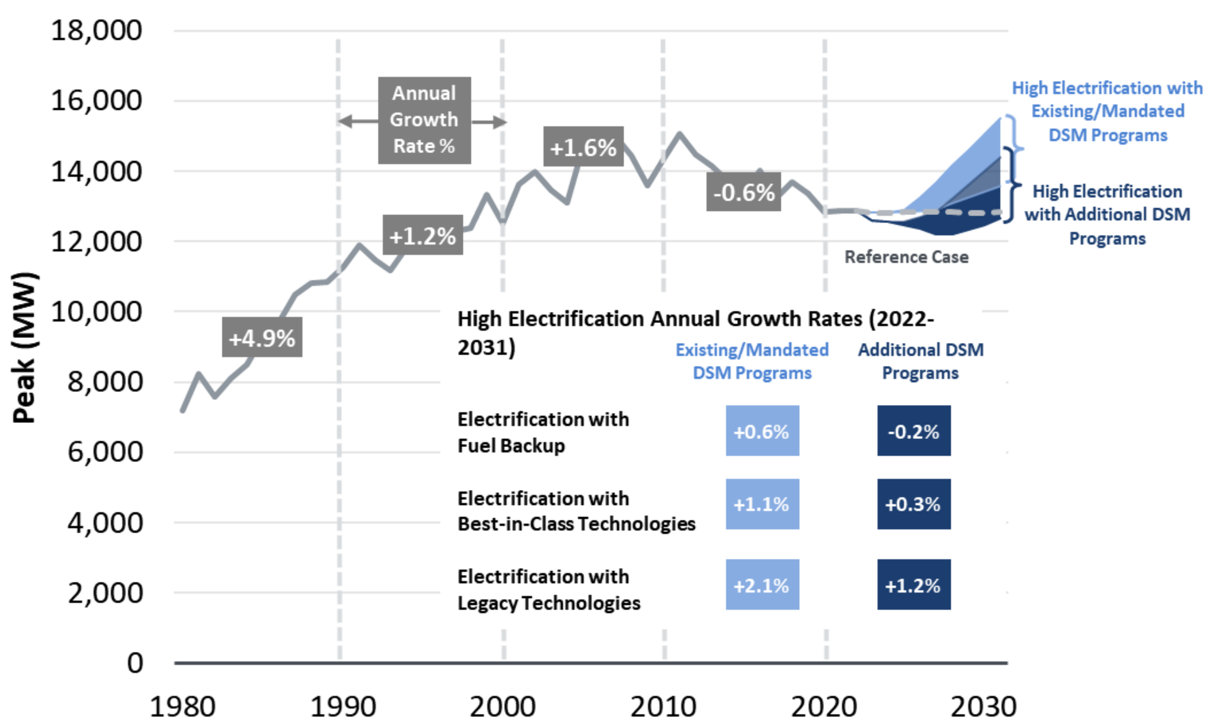
In a scenario where buildings electrify primarily using best-in-class cold climate heat pumps, the study projects an annual peak load growth of 1.1% through 2031. Cold-climate heat pumps can be sized to operate without backup and remain relatively efficient even at very low temperatures.

1 Climate Solutions Now Act of 2022, Md. S.B. 528 (2022).

A “hybrid solution” to decarbonize buildings could consist of heat pumps operating for the majority of the year, with existing fossil fuel combustion equipment maintained as backup to operate during the coldest hours of the year. In a scenario where most buildings maintain and use their existing combustion equipment during the coldest hours, the study projects an annual peak load growth of 0.6% through 2031.

This projected range of 0.6–2.1% annual load growth assumes that utilities only implement demand-side management (energy efficiency and load flexibility) programs to mandated minimum levels. The study finds that load growth in high electrification scenarios can be further mitigated to −0.2 to 1.2% per year if utilities pursue additional demand-side management programs. Additional load flexibility programs could include managed EV charging, battery demand response, smart thermostat and smart water heater load control programs, and time-varying electricity rates.

FIGURE 1: HISTORICAL AND PROJECTED MARYLAND ANNUAL LOAD GROWTH



Sources and Notes: Maryland system peak loads are based on the total coincident peak of the six in-scope utilities. Historical load is backcasted using the 2022 peak load and the weighted average historical annual load growth of each utility. Historical growth rates are sourced from utility data if available or PJM zonal data for the corresponding zone. Projected load growth rates are based on utility load forecasts submitted for the 2022–2031 Ten Year Plan and Brattle modeling of the impacts of energy efficiency, behind-the-meter solar, load flexibility, transportation electrification, and building electrification.

Historically, there was significant load growth of 4.9% per year in Maryland in the 1980s and more moderate growth of 1.2 to 1.6% per year from 1990 to 2010. These historical load growth rates are indicators that the Maryland distribution utilities have successfully expanded capacity at growth rates comparable to or even higher than those projected in this study. Further, load declined between 2010 and 2020, implying that on average, existing utility distribution systems have capacity headroom to serve some load growth before system expansion would be required again.

This study provides system-level load growth projections to enable policymakers to understand and benchmark the impacts of different building decarbonization scenarios through 2031. While the study concludes that load growth through 2031 with high levels of electrification will be consistent or lower than historical levels of Maryland load growth, the study does not quantify the costs and benefits of electrification scenarios modeled. Each scenario would result in several costs, including equipment installation and maintenance costs borne by building owners and grid investment and demand-side management program costs borne by utilities and utility customers. Each scenario would also create several benefits, including fuel savings, avoided natural gas infrastructure investments, reduced societal impacts of greenhouse gas emissions, and reduced health impacts of air pollution.

It is also important to note that, while this study provides a utility system-level view of load growth trajectory under different scenarios, it does not identify exactly the timing, location, and magnitude of utility distribution system upgrades that may be needed. It is plausible that electrification may be concentrated on the parts of the distribution network with limited headroom for some of the in-scope utilities, and that these distribution assets will need more immediate upgrades than others. Therefore, this study is not a substitute for more granular, locational distribution planning studies that could be conducted by the utilities. Through these studies, utilities will be able to plan specific upgrades to the distribution system based on the loading of existing equipment and forecasted customer adoption of various technologies.

I. Introduction

The Climate Solutions Now Act (CSNA) set Maryland on a course to achieve net zero greenhouse gas (GHG) emissions by 2045, and 60% GHG reduction by 2031 relative to 2006 levels. The Act includes provisions for extensive changes to various sectors including transportation, electricity, buildings, and agriculture. Among provisions related to the buildings sector, the Act stated the intent for the State to “move toward broader electrification of both existing buildings and new construction,” and directed the Maryland Public Service Commission (“PSC” or “Commission”) to conduct this study to assess the electric and gas distribution system impacts of a managed transition to a highly electrified building sector. Further, the Act set the following requirements for this study:

- Use a projection of average growth in system peak demand between 2021 and 2031 to assess the overall impact on each gas and electric distribution system;
- Compare future electric distribution system peak and energy demand load growth to historic rates;
- Consider the impacts of energy efficiency and conservation and electric load flexibility;
- Consider the capacity of the existing distribution systems and projected electric distribution system improvements and expansions to serve existing electric loads and projected electric load growth; and
- Assess the effects of shifts in seasonal system gas and electric loads.

The Commission convened the Electrification Study Working Group to advise on the study, and engaged The Brattle Group to conduct the study, with assistance from Applied Energy Group and Mondre Energy. This Executive Summary Report outlines the framework and key findings of the study. Further details on the analytical methodology, assumptions, inputs, data sources, and results are provided in the accompanying Technical Appendix.

A. Scope of This Study

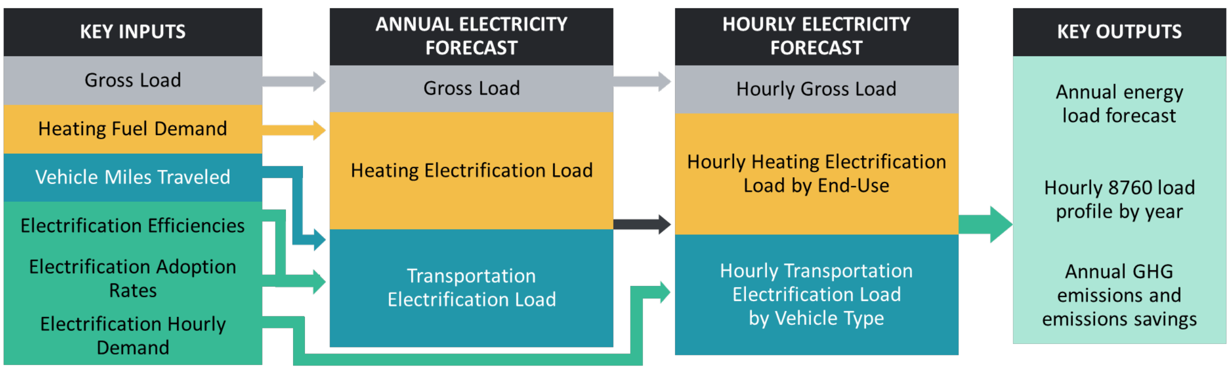
Per CSNA directives, the main objective of the study is to model the impact of building electrification on system average load growth for in-scope gas and electric utilities.

In-Scope Electric Utilities: Baltimore Gas and Electric (BGE), Choptank Electric, Delmarva Power (DPL), Pepco, Potomac Edison, Southern Maryland Electric Cooperative (SMECO)

In-Scope Natural Gas Utilities: Baltimore Gas and Electric (BGE), Columbia Gas of Maryland, Washington Gas Light (WGL) Maryland

Each in-scope utility system was modeled **using Brattle's Decarbonization, Electrification, and Economic Planning (DEEP) Model**. The model provides in-depth projections of electric load based on input scenarios detailing the uptake over time of heat pumps, electric vehicles, distributed energy resources (DERs), energy efficiency, and load flexibility. The model also quantifies changes to fossil fuel demand, including changes to natural gas, fuel oil, propane, and motor gasoline consumption, and associated direct GHG emissions.

FIGURE 2: BRATTLE'S DEEP MODEL FRAMEWORK



Sources and Notes: The DEEP model was calibrated to each in-scope utility system. It included a detailed characterization of each system in terms of the forecasted growth of non-electrification related loads; the existing number of types of equipment used by customers for heating, cooling, transportation, and distributed generation; and energy demand associated with each of these end uses. The model then produces hourly electric loads associated with each end use and appliance type through 2031, using assumptions on appliance efficiencies, usage, and the evolution of the fuel mix over time as customers adopt new technologies.

The DEEP model was used to project the impacts of stakeholder-defined scenarios centered on different possible rates of electrification and demand-side management (DSM). The modeled scenarios are described in Section II.

The projections of hourly electricity load through 2031 for each electric utility in each scenario are used to assess the impacts of a highly electrified building sector. The results are used to identify the rate of utility system average peak load growth as well as the timing of changes to summer and winter loads. Projected load growth rates are then compared to historical load growth rates managed by each utility from 1980–2020 to provide a benchmark for the severity of load impacts. Finally, the geographical overlap of each electric utility with each gas utility service territory is used to project changes to each gas utility's demand in each scenario.

Several proposed, ongoing, or recently concluded studies, proceedings, and rulemakings were used to inform the framework as well as assumptions used in this study. Key sources of information include the following:

The Maryland Department of Environment (MDE) Climate Pathway Study[2] is used primarily to inform this study on the GHG reduction contribution required from the building sector in order for Maryland as a whole to meet the 60% by 2031 GHG reduction goal.

The Maryland GHG Abatement Study[3] was completed in 2023 as part of EmPOWER Maryland ("EmPOWER") proceedings, and is used to inform this study on the existing mix of heating and cooling equipment types used by customers in each utility service territory.

EmPOWER 2024–2026 Program Cycle Utility Filings[4] were submitted by each EmPOWER utility in August 2023, and are used to inform this study on the expected electricity savings from energy efficiency programs.

The Maryland Renewable Portfolio Standard (RPS) Study[5] is an ongoing study being conducted by the Power Plant Research Program, and is used to inform this study on the capacity of behind-the-meter solar and storage resources that can be expected to be installed through 2031.

The Advanced Clean Cars (ACC) II Rule[6] was adopted by MDE in 2023 and requires vehicle manufacturers to gradually increase the zero-emission vehicle (ZEV) share of their total car sales to 100% by 2035. This study uses the Rule's annual targets to inform growth in EV sales.

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2 Kennedy, Kathleen M. et al. "Maryland's Climate Pathway." Center for Global Sustainability, University of Maryland, June 2023. https://cgs.umd.edu/sites/default/files/2023-09/file_final_Maryland%27s Climate Pathway Report.pdf

3 Applied Energy Group (AEG) EmPOWER Maryland. "2024–2029 Greenhouse Gas Abatement Potential Study Final Report." Case No. 9648 ML #300751, Potomac Electric Power Company filed, on January 06, 2023.

4 Maryland EmPOWER Utilities, Maryland Department of Housing, and Community Development (DHCD). "The 2024-2026 EmPOWER Maryland Program." Case No. 9705, ML #303381, June 7, 2023. https://webpsc.psc.state.md.us/DMS/case/9705

5 Maryland Department of Natural Resources. "Maryland 100% Study." https://dnr.maryland.gov/pprp/Pages/maryland-100percent-study.aspx

6 Maryland Department of the Environment. "Advanced Clean Cars II." https://mde.maryland.gov/programs/air/MobileSources/Pages/Clean-Energy-and-Cars.aspx#:~:text=%E2%80%8BWhat%20is%20Advanced%E2%80%8B%E2%80%8B%20Clean%20Cars%20II&text=By%20adopting%20ACC%20II%20in,to%20reduce%20smog%2Dforming%20emissions.

The Advanced Clean Trucks (ACT) Rule[7] is similar to the ACC II Rule and requires vehicle manufacturers to gradually increase the ZEV share of their total medium/heavy duty vehicle sales by 2035 to 55% of Class 2b—3 truck sales, 75% of Class 4—8 straight truck sales, and 40% of truck tractor sales. The Advanced Clean Trucks Act, passed in 2023, directed MDE to adopt the ACT Rule. This study uses the Rule's annual targets to inform growth in EV sales.

The Building Energy Performance Standard (BEPS)[8] is proposed by MDE under the directive of the CSNA to require buildings over 35,000 sq. ft. to net-zero direct GHG emissions by 2040. This study uses the requirements of the BEPS to inform the assumed rate of electrification of buildings over 35,000 sq. ft.

B. Related Matters Outside the Scope of this Study

The transition to a highly electrified building sector is complex and multifaceted. Each facet merits detailed study during the process of policy development and implementation. This study is intended to inform policymakers regarding one facet of the transition—the impacts on electricity and natural gas demand through 2031.

This study does not address other important transition issues, including but not limited to:

- Cost-effectiveness of building electrification;
- The technical feasibility and commercial availability of electrification technologies for various types of customers;
- Locational distribution system upgrades that may be needed to support new load;
- Locational non-wire solutions that may defer distribution system upgrades;
- Potential decommissioning of parts of the gas delivery system as customers electrify;
- Regulatory mechanisms to sustainably manage gas utilities as gas throughput declines;
- Environmental justice and equity to ensure that disadvantaged communities are not left behind in the transition.

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7 Maryland Department of the Environment. "Facts about Adoption of COMAR 26.11.43 Advanced Clean Trucks Program." June 12, 2023. https://mde.maryland.gov/programs/regulations/air/Documents/Hearings/2023 ACT Fact Sheet.pdf

8 Maryland Department of the Environment. "Building Energy Performance Standards." https://mde.maryland.gov/programs/air/ClimateChange/Pages/BEPS.aspx

II. Study Scenarios

A. Scenario Definitions

TABLE 1: SCENARIO DEFINITIONS

	Decarbonization Policy Goals Not Pursued		Pursuit of Policy Goals through Hybrid Solutions		Pursuit of Policy Goals through Zero Direct Emissions Solutions	
	Reference	**Low Electrification Scenario[1]**	**Mid Electrification Scenario[1]**	**High Electrification with Fuel Backup Scenario**	**High Electrification with Best-in-Class Technologies Scenario**	**High Electrification with Legacy Technologies Scenario**
Description	"Reference" for load impacts of other scenarios. Defined as the state of the world as implied by each utility's current load forecast.	Limited incremental electrification. Assumes policy goals are not met.	Mix of electrification and continued use of fuels.	High electrification with retention of existing fossil fuel equipment for backup.	Fossil fuel equipment is phased out through policy. Customers quickly adopt more advanced, efficient electric technologies.	Fossil fuel equipment is phased out through policy. Customers are slower to adopt more advanced, efficient electric technologies.
Buildings	**Fuel mix held flat** from 2022.	**Limited incremental electrification** (majority of existing gas and fossil customers do not adopt heat pumps).	**Fossil fuel equipment sales continue beyond 2030;** some customers switch to heat pumps.	By 2030, all new equipment sales are HPs. **Almost all existing customers retain their fossil fueled equipment as backup.**	By 2030, all new equipment sales are HPs.[2] **Most HPs are highly efficient ccASHPs.[3]**	By 2030, all new equipment sales are HPs.[2] **Most HPs are less efficient ASHP+resistance backup.**
Distributed Energy Resources	Distributed Energy Resources (DER) growth in line with RPS mandate.					
Transportation	Based on EIA projections.	3-year delay relative to ACC II and ACT.	Achievement of Advanced Clean Cars II (ACC II) and Advanced Clean Trucks (ACT) regulations.			
Demand-Side Management	For each scenario, we run two DSM cases: 1. **Existing/Mandated DSM Programs Only** 2. **Additional DSM Programs (i.e., new programs and growth of existing programs)**					

1 The Low and Medium Electrification Scenarios were modeled in this study but are not discussed in this report, as they are inconsistent with a pathway to meeting the state's climate goals. 2 With some exceptions for the hardest-to-electrify cases (we assume around 5% of sales will be exempt from the policy and remain as fossil fuel equipment sales); 3 ccASHP = cold climate air-source heat pump, ASHP = air-source heat pump.

Per the CSNA directive to study a “managed transition to a highly electrified building sector,” the three scenarios discussed in this report assume high electrification of space and water heating in residential and commercial buildings. The study included modeling of two other scenarios—Low Electrification and Medium Electrification—that did not result in GHG emission reductions sufficient to meet Maryland’s climate goals. Those scenarios are not discussed in this report. Assumptions and results related to those two scenarios are provided in the Technical Appendix. All of the scenarios, inputs, assumptions, and data sources were developed with close collaboration and review from stakeholders in the Electrification Study Working Group.

In this study’s high electrification scenarios, high electrification is defined as a transition to all new heating equipment sales being heat pumps by 2030, with very limited exceptions. While this is an ambitious trajectory, it is consistent with the pace of decarbonization required to meet Maryland’s climate goals, for at least three reasons:

- Due to the long lifetime of heating equipment (15–25 years), new equipment installed in 2030 will likely still be in operation in 2045, and therefore must be zero-emission in order for Maryland to meet its goal of net-zero emissions by 2045
- MDE’s Climate Pathway Study identified that a 35% reduction of building sector emissions by 2031 relative to 2006 would be required for the state to meet the economy-wide goal of 60% emission reduction by 2031, relative to 2006. This is in parallel to decarbonization of other key sectors like electricity, transportation, and industry.
- Further, the MDE Climate Pathway Study showed that a zero-emission appliance standard for space and water heating by 2030 would result in the building sector emission reductions needed to meet the 2031 and 2045 climate goals.

As a result, all three high electrification scenarios modeled in this study were benchmarked against the Climate Pathway Study to ensure consistency with meeting Maryland’s 2031 climate goal.

Electrification at such a pace likely requires policies to incentivize and/or require customer adoption of zero-emission technologies. Regulations to achieve this transition to zero-emission heating can take many forms. For example, the Building Energy Performance Standard proposed by MDE would penalize large buildings over 35,000 square feet for emissions above a cap that declines over time. Similar zero-emission standards could be implemented for smaller buildings, as envisioned in MDE’s Climate Pathway Study, to accelerate the transition of residential and small commercial buildings.

While all three high electrification scenarios in this study assume a similar pace of building electrification, the key distinction between the scenarios is in the primary configuration or type of heat pumps used to electrify buildings. The study considers three heating electrification scenarios:

Electrification with Fuel Backup: In this scenario, most customers currently heating with fossil fuels are assumed to maintain their fossil fuel equipment for use during the coldest hours of the year, even after adopting a heat pump. The advantage of this solution is that peak electric heating loads, which occur during the coldest hours, can be mitigated by switching to fossil fueled heat, while limiting emissions by operating heat pumps in all other hours. However, it requires maintenance (and eventually, replacement) of two sets of heating equipment, in addition to ongoing maintenance and investment in fossil fuel infrastructure.

Electrification with Best-in-Class Technologies: In this scenario, most customers are assumed to adopt highly efficient cold-climate air-source heat pumps (ccASHPs). Modern cold-climate heat pumps operate at relatively high efficiencies even at very cold temperatures and can be sized to meet peak heating demands without inefficient resistive heating backup. This scenario also assumes a higher penetration of ground source heat pumps (GSHPs) than the other two scenarios.

Electrification with Legacy Technologies: In this scenario, most customers are assumed to adopt lower efficiency air source heat pumps (ASHPs), with resistive heating backup elements to serve heating demands during the coldest hours. These systems may be cheaper than newer, more efficient heat pumps, but add significant electric load due to their low efficiency at very cold temperatures.

Table 1 summarizes the study scenarios based on the key changes modeled within the building sector, transportation sector, distributed energy resources (DERs), and demand-side management (DSM). All of the modeled scenarios build from the Reference Case, which is defined primarily using the 2022–2031 load forecasts provided by each utility in the 2022–2031 Ten Year Plan of Electric Companies in Maryland.[9] The Reference Case assumes no change to the fuel mix of the building sector and very limited transportation electrification, and is

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[9] Public Service Commission of Maryland. "Ten-Year Plan (2022-2031) of Electric Companies in Maryland." https://www.psc.state.md.us/wp-content/uploads/2022-2031-Ten-Year-Plan-Final.pdf. Some adjustments were made to the utility forecasts to align all 6 in-scope utilities' EV and DER assumptions in the Reference Case.

intended to capture load growth from factors unrelated to decarbonization, such as economic growth and population migration.

In order to isolate the impacts of different building electrification scenarios, the other key modeled sectors, transportation and DERs, were held constant across the electrification scenarios. All three high electrification scenarios assume vehicle sales follow the trajectories set by the Advanced Clean Cars II[10] and Advanced Clean Trucks[11] rules, which require vehicle manufacturers to gradually increase their fraction of zero-emission vehicle sales. The Advanced Clean Cars II rule requires 100% zero-emission light duty vehicle (LDV) sales by 2035, and the Advanced Clean Trucks rule requires 40–75% zero-emission sales across different medium/heavy duty vehicle (MHDV) classes by 2035. All three scenarios also assume DER capacity grows in line with the trajectory modeled by the Maryland RPS Study. Recent trends in distributed solar adoption suggest that rates of adoption are on track for RPS compliance.

Demand-side management through energy efficiency and load flexibility programs can be highly effective at mitigating load growth. To assess the impact of DSM, the study considers two DSM cases for each scenario:

Existing/Mandated DSM: This case assumes annual energy efficiency savings consistent with utility plans that meet the minimum requirements set forth by the CSNA. It assumes only existing utility demand response programs continue through 2031. The modeling in this case assumes that both mandated energy efficiency and existing demand response programs are already factored into utility load forecasts, and therefore does not adjust forecasts further for DSM.

Additional DSM: This case assumes significant additional energy efficiency, consistent with deployment of all cost-effective energy efficiency measures. It also assumes the introduction of new load flexibility programs, such as managed EV charging, and enrollment and participation of an ambitious but plausible fraction of customers in these programs.

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10 California Air Resource Board. "Advanced Clean Cars II." https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii

11 "Final Regulation Order: Advanced Clean Trucks Regulation." https://ww2.arb.ca.gov/sites/default/files/2023-06/ACT-1963.pdf

B. Customer Adoption of Technologies by 2031

The study models the turnover of equipment stock in the transportation and building sectors as customers replace their existing equipment at the end of its average useful lifetime. Based on the definitions of each of the three scenarios, the mix of new equipment sales is assumed to change over time to reflect fuel-switching. However, the long lifetime of transportation and heating equipment means changes in the mix of new equipment sales take many years to lead to significant changes in the mix of the total installed stock of equipment. For example, an appliance having an average lifetime of 20 years implies that only 5% of customers replace their equipment in a given year. Table 2 through Table 5 summarize the assumed mix of new equipment sales and resulting changes to total installed equipment stock in 2031. Aggregate Maryland level figures are summarized here, and detailed utility level inputs and data sources are provided in the Technical Appendix.

TABLE 2: RESIDENTIAL SPACE AND WATER HEATING NEW SALES AND STOCK PROJECTIONS

	2022	2031							
	Current	Reference		Fuel Backup		Best Tech.		Legacy Tech.	
	Penetration	Sales	Stocks	Sales	Stocks	Sales	Stocks	Sales	Stocks
Residential Space Heating									
Gas	43%	43%	43%	3%	29%	3%	29%	3%	29%
Liquid Fuel	8%	8%	8%	1%	6%	1%	6%	1%	6%
ASHP + Fuel	5%	5%	5%	43%	18%	0%	3%	0%	3%
Electric Resistance	22%	22%	22%	0%	14%	0%	14%	0%	14%
ASHP + Resistance	17%	17%	17%	32%	22%	0%	11%	57%	32%
ccASHP	3%	3%	3%	16%	8%	82%	31%	29%	12%
GSHP	2%	2%	2%	5%	3%	14%	7%	10%	5%
Residential Water Heating									
Gas	35%	35%	35%	4%	20%	4%	20%	4%	20%
Liquid Fuel	3%	3%	3%	0%	2%	0%	2%	0%	2%
Resistance	55%	55%	55%	25%	48%	5%	29%	25%	48%
Heat Pump	6%	6%	6%	70%	30%	91%	49%	70%	30%

Sources and Notes: “Best Tech.” refers to the Electrification with Best-in-Class Technologies Scenario and “Legacy Tech.” refers to the Electrification with Legacy Technologies Scenario. The Reference Case assumes customers replace their existing space and water-heating equipment with the same technology at the end of its lifetime, meaning the installed mix of equipment in 2031 is identical to today. All three High Electrification Scenarios assume heat pump sales grow rapidly to meet a zero-emission standard for new space and water heating equipment sales by 2030, similar to modeling by MDE in the Climate Pathway Report. Delivered fuel and standalone gas equipment sales fall to almost zero, assuming regulations allow limited exceptions. The scenarios differ in terms of the mix of heat pump configurations adopted by customers. Sales and stocks are expressed as % of households.

TABLE 3: COMMERCIAL SPACE AND WATER HEATING NEW SALES AND STOCK PROJECTIONS

	2022	2031							
	Current	Reference		Fuel Backup		Best Tech.		Legacy Tech.	
	Penetration	Sales	Stocks	Sales	Stocks	Sales	Stocks	Sales	Stocks
Commercial Space Heating									
Gas	50%	50%	50%	3%	32%	3%	32%	3%	32%
Liquid Fuel	6%	6%	6%	1%	4%	1%	4%	1%	4%
ASHP + Fuel	0%	0%	0%	45%	17%	8%	3%	8%	3%
Electric Resistance	33%	33%	33%	1%	21%	1%	21%	1%	21%
ASHP + Resistance	10%	10%	10%	31%	18%	0%	6%	53%	27%
ccASHP	0%	0%	0%	15%	6%	74%	29%	26%	10%
GSHP	1%	1%	1%	5%	2%	13%	6%	9%	4%
Commercial Water Heating									
Gas	33%	33%	33%	3%	21%	3%	21%	3%	21%
Liquid Fuel	1%	1%	1%	0%	1%	0%	1%	0%	1%
Resistance	60%	60%	60%	15%	44%	4%	37%	15%	44%
Heat Pump	6%	6%	6%	81%	34%	93%	41%	81%	34%

Sources and Notes: "Best Tech." refers to the Electrification with Best-in-Class Technologies Scenario and "Legacy Tech." refers to the Electrification with Legacy Technologies Scenario. The Reference Case assumes customers replace their existing space and water heating equipment with the same technology at the end of its lifetime, meaning the installed mix of equipment in 2031 is identical to today. In the three High Electrification Scenarios, commercial buildings electrification is assumed to progress at a different pace for small commercial buildings (which are not covered by the BEPS) and large commercial buildings (which are covered by the BEPS). Smaller commercial buildings are assumed to follow a similar trajectory to residential buildings, with heat pump sales growing rapidly to meet a zero-emission standard for new space and water heating equipment sales by 2030, similar to modeling by MDE in the Climate Pathway Report. Delivered fuel and standalone gas equipment sales fall to almost zero, assuming regulations allow limited exceptions. Larger commercial buildings are assumed to electrify at a pace sufficient to comply with the BEPS based on modeling in the Climate Pathway Report. Sales and stocks are expressed as % of commercial square feet.

TABLE 4: ELECTRIC VEHICLE NEW SALES AND STOCK PROJECTIONS

	2022	2031			
	Current	Reference		High Electrification	
	Penetration	Sales	Stocks	Sales	Stocks
Electric Vehicles					
LDV	1%	20%	8%	76%	23%
Class 2B-3	0%	0%	0%	35%	8%
Class 4-8	0%	0%	0%	55%	13%
Class 7-8 Tractor	0%	0%	0%	35%	8%
School Bus	1%	0%	1%	55%	13%

Sources and Notes: The Reference Case assumes very limited growth in transportation electrification, consistent with the EIA's Annual Energy Outlook. All three High Electrification Scenarios assume the same level of transportation electrification, consistent with meeting the requirements of the Advanced Clean Cars and Advanced Clean Trucks regulations that have been adopted in Maryland. Sales and stocks are expressed as % of vehicles.

TABLE 5: MARYLAND BEHIND-THE-METER DISTRIBUTED ENERGY RESOURCE FORECASTS (MW)

	2022	2031
Solar	1,204	2,290
Storage	40	518

Sources and Notes: All three High Electrification Scenarios and the Reference Case assume the same level of growth of distributed energy resources (DERs) in line with RPS achievement as projected in the PPRP RPS Study.[12] Behind-the-meter storage in the Existing/Mandated DSM Program Cases does not affect peak load, since no utilities currently have battery storage demand response programs. The Additional DSM Programs Cases assume that utilities use BTM storage to manage peak load through demand response programs described below.

C. Demand Side Management (DSM)

Within each scenario, the study models two different portfolios of DSM programs to study the potential load mitigation impacts of additional DSM.

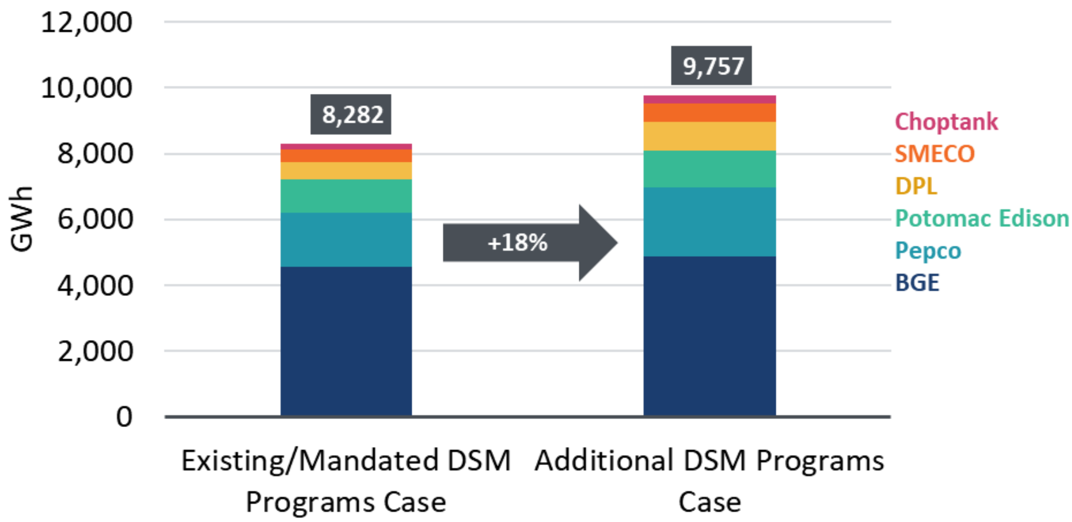
1. Energy Efficiency

Energy Efficiency assumptions are based on the EmPOWER 2024–2026[13] program cycle plans filed by utilities in August 2023. The Existing/Mandated DSM Programs Case assumes utilities achieve the "2023 Scenario" level of Energy Efficiency from these filed plans, which is based on achievement of minimum statutory requirements. The Additional DSM Programs Case assumes utilities adopt EE programs consistent with their filed "Maximum Achievable Scenarios," defined as the set of programs and measures that result in maximum cost-effective savings. Annual savings from 2027 to 2031 were assumed to be the same as 2026 savings. By 2031, Maryland-wide Energy Efficiency savings are 18% higher in the Additional DSM Programs case than the Existing/Mandated case.

12 Maryland Department of Natural Resources. "Maryland 100% Study." https://dnr.maryland.gov/pprp/Pages/maryland-100percent-study.aspx

13 Maryland Public Service Commission. "Energy Efficiency and EmPOWER Maryland." https://www.psc.state.md.us/electricity/empower-maryland/

FIGURE 3: ANNUAL ENERGY EFFICIENCY SAVINGS (GWH) IN 2031



Sources and Notes: The figure shows the 2031 savings from energy efficiency programs for the Existing/Mandated and Additional DSM Programs Cases. Program savings are sourced from EmPOWER 2024–2026 filed plans, which provide one case aligned with minimum mandates and another case aligned with maximum achievable cost-effective savings. Annual savings from 2027–2031 are assumed to be the same as in 2026. Adjustments were made to remove heating and cooling programs from energy efficiency portfolios, as these measures are modeled separately in this study.

2. Load Flexibility

The Existing/Mandated DSM Programs Case assumes utilities continue existing load flexibility programs at the same participation levels through 2031. The Additional DSM Programs Case assumes increased participation in existing programs and the deployment of new load flexibility programs using BTM storage, managed electric vehicle charging, expanded time-varying rates, and others described in Table 6.

TABLE 6: LOAD FLEXIBILITY PROGRAMS AND 2031 PARTICIPATION (% OF ELIGIBLE CUSTOMERS)

Program	Description	Existing Participation[14]	Additional Case Participation
Residential			
Time-of-use (TOU)	Time varying pricing signals, consistent with proposed utility rates	0%	15%
Peak time rebate (PTR)	Residential customers reduce load during called event hours	BGE, Pepco, DPL: 90% SMECO, Choptank, Potomac Edison: 0%	90%
Smart thermostat	Customers reduce cooling or heating load by adjusting thermostats during utility called events (<20/yr)	Summer: BGE (28%); Pepco (38%); DPL (20%); SMECO, Choptank, Potomac Edison (0%) Winter: 0% for all utilities	Summer (~+25%pt from existing): BGE (55%); Pepco (65%); DPL (45%); SMECO, Choptank, Potomac Edison (25%) Winter: 25% for all utilities
Smart water heating	Customers shift heat water during off peak hours on a frequent (daily) basis	0%	30%
Commercial			
Smart thermostat	Small commercial customers reduce cooling or heating load by adjusting thermostats during utility called events (<20/yr)	0%[15]	25%
Automated demand response (DR) – HVAC	Automated control of customer heating and cooling demand. Only applicable to large (Covered) customers	0%	10%
Interruptible tariff	Large customers (Covered) reduce load during called events. Events are infrequent (<10/yr)	0%	15%
Additional Programs			
Managed electric vehicle charging	Customers are incentivized to charge in off peak hours and shift EV load out of daily peak periods	0%	30% (all vehicle classes)
Behind-the-meter battery storage	Utilities can call on batteries to charge and discharge during event hours (70 events/yr). Assume only a portion of BTM storage capacity from the PPRP study enrolls in utility programs	0%	30% of BTM storage capacity

Sources and Notes: The Existing/Mandated DSM case assumes utilities continue to operate existing load flexibility programs at current participation levels. These existing programs are comprised mainly of smart thermostats and time-varying rates. The Additional Case participation assumes increasing participation in existing programs, in addition to the introduction new programs. These participation rates were informed by a review[16] of comparable programs deployed in other jurisdictions, representing aggressive but achievable enrollment.

III. Key Results

The Brattle Group's DEEP Model[17] was used to evaluate the impacts of each electrification scenario on fossil fuel consumption, electricity demand, and emissions at the utility system level. This section summarizes key results for the three high electrification scenarios at the aggregated Maryland level and then highlights differences between utility regions. The Low and Medium Electrification scenarios are not discussed as they are inconsistent with achievement of Maryland's GHG goals. Detailed annual results by utility for all modeled scenarios are available in the Technical Appendix.

A. Reductions in Fossil Fuel Consumption

Electrification of the building sector results in significant reductions in liquid fuel (fuel oil and propane) and natural gas consumption. Figure 4 shows that the modeled rate of electrification would reduce fossil fuel consumption for space and water heating by 31–32% relative to 2022.

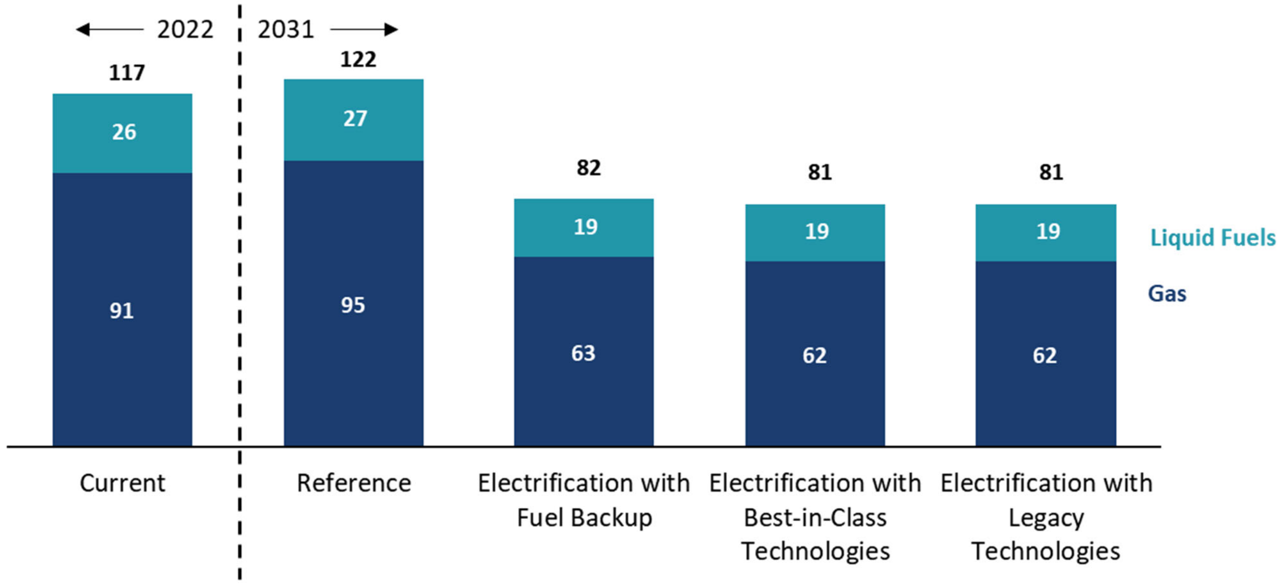
[14] Participation assumptions for existing load flexibility programs are sourced from utility EmPOWER filings. Maryland Public Service Commission. "Energy Efficiency and EmPOWER Maryland." https://www.psc.state.md.us/electricity/empower-maryland/

[15] Pepco and DPL have commercial smart thermostat programs, but participation is negligible.

[16] National Roadmap for Grid Interactive Efficient Buildings, The Brattle Group

[17] Modeling methodology and detailed assumptions and inputs are provided in the Technical Appendix.

FIGURE 4: FOSSIL FUEL CONSUMPTION FOR SPACE AND WATER HEATING IN MARYLAND
Million MMBTU per Year

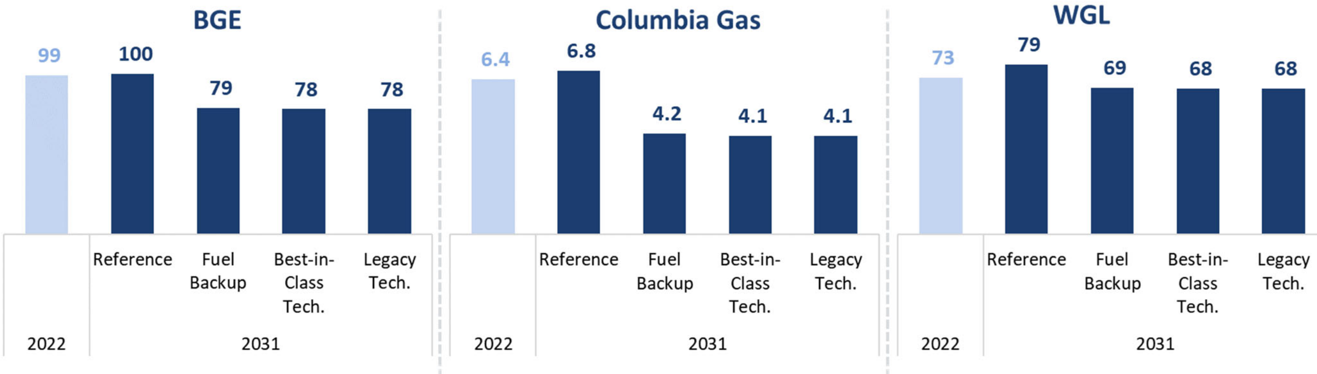


Sources and Notes: 2022 consumption of liquid fuels and natural gas are based on EmPOWER GHG abatement study data. The Reference Case is based on customer growth and the assumption that the percentage of customers using each fuels remains unchanged. The Electrification scenarios are based on the modeled shift of customers to heat pumps over time.

There are only minor differences in fossil fuel consumption across electrification scenarios as all three scenarios model a switch to 100% heat pump sales (when a customer installs a new heating unit) by 2030. The Fuel Backup scenario has slightly higher fuel consumption as heat pump customers continue to serve roughly 7% of their annual heating demand by operating their fossil fuel equipment in the 170 coldest hours of the year.

The 31-32% reduction in natural gas consumption for space and water heating end uses translates to a 19% reduction in total gas delivered in 2031 by the Maryland gas utilities relative to the Reference Case.

FIGURE 5: TOTAL NATURAL GAS DEMAND, BY UTILITY
Million MMBTU



Sources and Notes: "Best-in-Class Tech." refers to the Electrification with Best-in-Class Technologies Scenario and "Legacy Tech." refers to the Electrification with Legacy Technologies Scenario. 2022 and Reference Case 2031– natural gas demand are based on each utility's load forecast. Since WGL's forecast ends in 2027, Reference Case 2031 load was projected by Brattle based on WGL's forecasted 2020–2027 load growth rate. 2031 natural gas demand in the Electrification scenarios is based on the modeled reduction in gas usage for space and water heating relative to Reference. None of the other end uses of natural gas (e.g., industrial) are assumed to change in this study.

B. Reductions in GHG Emissions

The MDE Climate Pathway Study identified a pathway to achieving Maryland's 2031 climate goal that involves a 30% reduction in direct emissions from space and water heating in buildings from 2022 levels. Table 7 shows that each of the three modeled electrification scenarios approximately meet this 30% direct emission reduction target. The Fuel Backup scenario involves marginally higher emissions than the other two scenarios due to the direct emissions of the fossil fuel equipment used to provide backup during the coldest hours of the year.

Because this study is focused on the building sector, it does not attempt to repeat the economy-wide emissions modeling completed in the MDE Climate Pathway Study. Instead, this study benchmarks space and water heating emissions to the MDE study to ensure that the modeled building sector pathway is consistent with a broader economy-wide pathway to meeting Maryland's climate goal. Sectors that are outside the scope of this study, such as electricity generation and industry, must decarbonize at the pace modeled in MDE's study for the economy-wide goal to be achieved.

TABLE 7: DIRECT EMISSIONS FROM SPACE AND WATER HEATING EQUIPMENT (MILLION METRIC TONS OF CO_2E)

	2022	2031		
	Current	**High Electrification** *with Fuel Backup*	**High Electrification** *with Best-in-Class Technologies*	**High Electrification** *with Legacy Technologies*
Natural Gas	4.83	3.35	3.28	3.28
Liquid Fuels	1.99	1.44	1.43	1.43
Total Emissions	6.82	4.80	4.71	4.71
% Change	**–**	**−29.6%**	**−30.9%**	**−30.9%**

Sources and Notes: Emissions are estimated based on projected 2022 and 2031 consumption of each type of fossil fuel and the GHG emission rates of each fuel.

C. Electricity Demand

The study projects growth in seasonal and peak electricity loads through modeling of hourly load for each in-scope electric utility through 2031. The load forecasts submitted by each utility as part of the 2022–2031 Ten Year Plan (TYP) serve as the starting point for these projections. The utility load forecasts capture load growth associated with non-electrification related factors, such as customer growth and economic growth. Some utilities also account for the impacts of behind the meter (BTM) solar adoption and transportation electrification in their TYP load forecast. In order to align the assumptions of each utility's load forecast in this study's Reference Case, two adjustments were made to utility TYP load forecasts:

- **BTM Solar Adjustment:** Several utilities did not account for BTM solar at all in their load forecasts. To align assumptions, an adjustment is made to each utility's TYP load forecast so that the Reference Case reflects the level of solar adoption projected by the RPS Study. For all utilities except BGE this adjustment reduces projected load growth relative to the TYP. BGE already includes significant solar adoption impacts in its load forecast, so this adjustment is negligible for BGE's Reference Case.
- **Electric Vehicle Adjustment:** Some utilities did not account for electric vehicles at all in their forecasts and others assume significant adoption. To align assumptions, the electric vehicle component of each utility's TYP load forecast is adjusted so that the Reference Case reflects the level of sales growth projected by the Energy Information Administration.

TABLE 8: COMPARISON OF THIS STUDY'S REFERENCE CASE TO UTILITY TEN-YEAR PLANS (2022-2031)

	Annual Average Sales Growth Rate	Annual Average Peak Load Growth Rate
Ten Year Plan	0.10%	0.25%
Reference Case	−0.10%	−0.02%

Sources and Notes: This table shows the aggregate Maryland growth rates based on the weighted average of in-scope utilities. A utility-specific comparison is provided in the Technical Appendix.

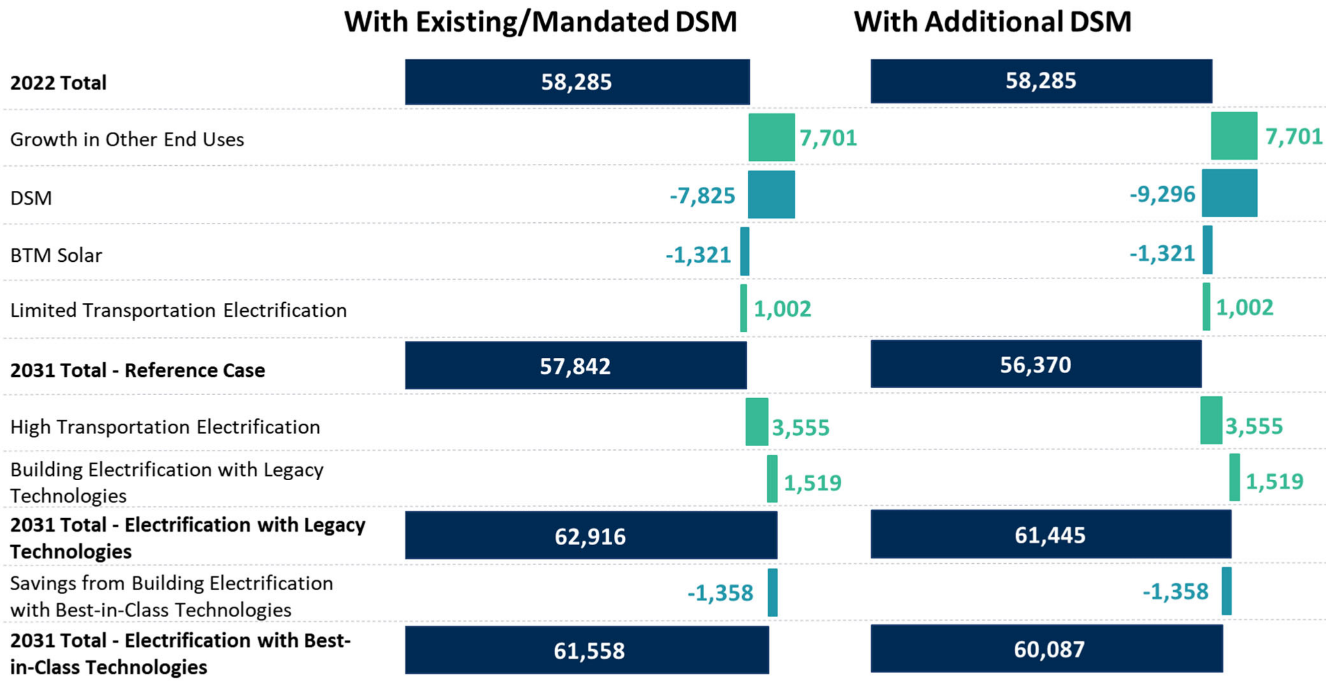
Electrification can have differing impacts on annual electricity sales and on peak load. Both metrics are important for planning purposes. Annual electricity sales are used as the basis for setting customer rates, and sufficient energy must be procured to meet customer demands. Higher electricity sales can drive electricity rates down, as costs are spread over a greater base of sales. Peak electricity loads drive grid investment, as each component of the distribution system must be sized to ensure reliability at peak load conditions. Higher peak loads can necessitate grid upgrades if existing parts of the grid do not have sufficient capacity, and associated costs would drive electricity rates up. This study quantifies the impacts of electrification on both sales and peak load, both at the system level.

1. Impact on Annual Electricity Sales

The Reference Case shows that with limited transportation electrification and no building electrification, the aggregate electric sales in Maryland would be flat (growth rate of −0.10% per year). As shown in Figure 6, flat electricity sales in the Reference Case are the result of growth being offset by mandated DSM programs and BTM solar adoption. Under the High Electrification with Fuel Backup and High Electrification with Legacy Technologies scenarios, sales would grow at 0.9% per year through 2031. The sales growth in these two scenarios is similar because the only difference between them is the use of backup fossil fuel equipment in a few hours of the year. Though this has a significant impact on peak load, it has a negligible impact on total electricity sales. In the Electrification with Best-in-Class Technologies scenario, the adoption of more efficient cold-climate heat pumps reduces the energy consumption for space and water heat, resulting in a slightly lower sales growth rate of 0.6% per year.

Expansion of DSM programs would mitigate some of the sales growth shown in the Existing/Mandated DSM Case. Figure 6 shows that the modeled additional DSM measures would result in annual energy savings of an additional 1,471 GWh by 2031. This would reduce the projected range of sales growth in the High Electrification Scenarios to 0.3-0.6% per year.

FIGURE 6: PROJECTED CHANGES IN MARYLAND ANNUAL ELECTRICITY SALES BETWEEN 2022 AND 2031

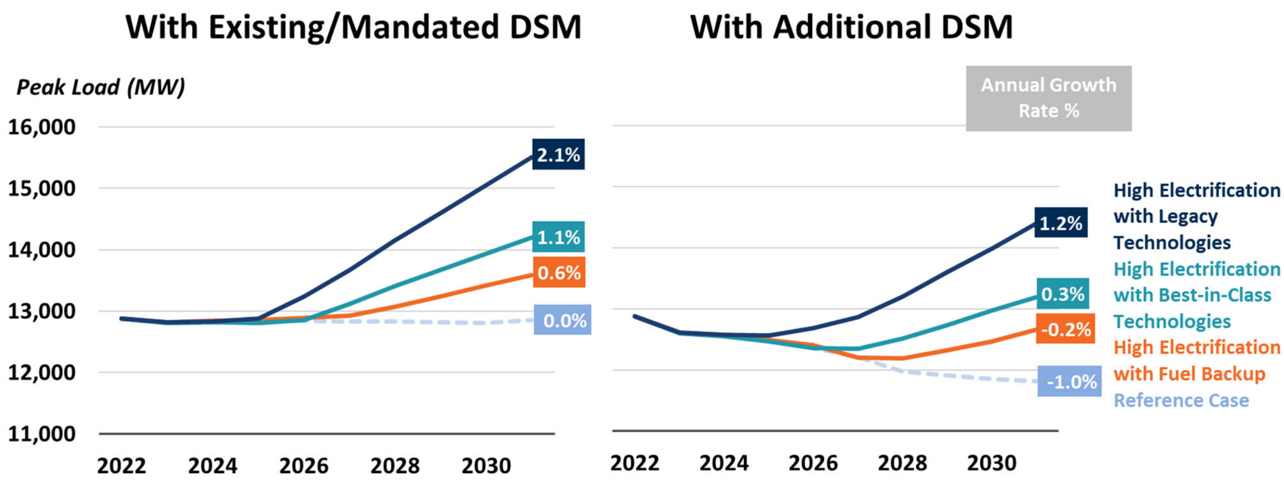


Sources and Notes: 2022 and 2031 Reference Case Sales Growth reflects utility load forecasts submitted as part of the 2022–2031 Ten Year Plan, with minor adjustments. The 2031 sales projection for the Electrification with Fuel Backup Scenario is the same as the Electrification with Legacy Technologies Scenario. DSM impacts are based on utility filings in the 2024–2026 EmPOWER program cycle. BTM solar, transportation, and building electrification impacts are based on Brattle modeling.

2. Impacts on Peak Load

In the Reference Case, which has limited transportation electrification and no building electrification, the aggregate Maryland system would remain summer-peaking, with negligible growth (−0.02% per year) through 2031. Under the High Electrification scenarios, the Maryland system would shift from summer-peaking to winter-peaking around 2026–2027, and load growth through 2031 would range from 0.6% to 2.1% per year with Existing/Mandated DSM programs, as shown in Figure 7.

FIGURE 7: PROJECTED AGGREGATE MARYLAND SYSTEM PEAK LOAD IN ELECTRIFICATION SCENARIOS



Sources and Notes: Reference Case reflects utility load forecasts submitted as part of the 2022–2031 Ten Year Plan, with minor adjustments. The Electrification Scenarios are projections based on Brattle modeling of the impacts of transportation and building electrification. Modeled additional DSM programs, which consist of cost-effective energy efficiency measures and a portfolio of load flexibility programs, would result in significant load mitigation relative to a case where only existing and mandated programs are deployed.

Peak loads in all three High Electrification scenarios occur around the coldest times of the year and are driven by electric heating loads. The Electrification with Legacy Technologies Scenario has the highest load growth of 2.1% per year. Peak loads in this scenario are driven by the use of relatively inefficient resistive heating that is assumed to supplement heat pumps when temperatures are below 22 F. The Electrification with Best-in-Class Technologies Scenario has significantly lower load growth of 1.1% per year. In this scenario, customer adoption of ccASHPs and GSHPs, both of which can be configured to operate without resistive backup, results in lower heating loads in the coldest hours of the year compared to legacy heat pumps. The Electrification with Fuel Backup Scenario results in the lowest load growth of 0.6% per year, as customers with existing fossil fuel heating are assumed to maintain their equipment and operate it during the coldest hours of the year when temperatures are below 20 F. This mitigates the highest potential electric heating peak loads, and shifts the peak load to less severe winter days.

Expansion of DSM programs would mitigate some of the peak load growth shown in the Existing/Mandated DSM Case. With Additional DSM, Figure 7 shows that in the High Electrification Scenarios, load growth through 2031 would range from −0.2% to 1.2%, which is significantly lower than the 0.6–2.1% growth rate projected with only existing/mandated DSM programs.

The portfolio of additional energy efficiency measures reduces load at various times of the day from various end uses, and has a small impact in the morning hours when the winter peak occurs. Load flexibility programs are more effective at mitigating peak loads by flattening the load shape relative to unmanaged load. This is achieved through various means, including preheating using smart thermostats, deferring water heating, and discharging behind-the-meter batteries.

As the timing of peak load shifts to mornings of the coldest days in winter, factors other than electric heating have less influence on the peak. BTM solar, which generates more energy in the summer and at mid-day, provides negligible load reduction during winter mornings. Electric vehicles, which tend to charge in the evenings and at night, do not significantly add to morning loads.

D. Utility-Specific Differences

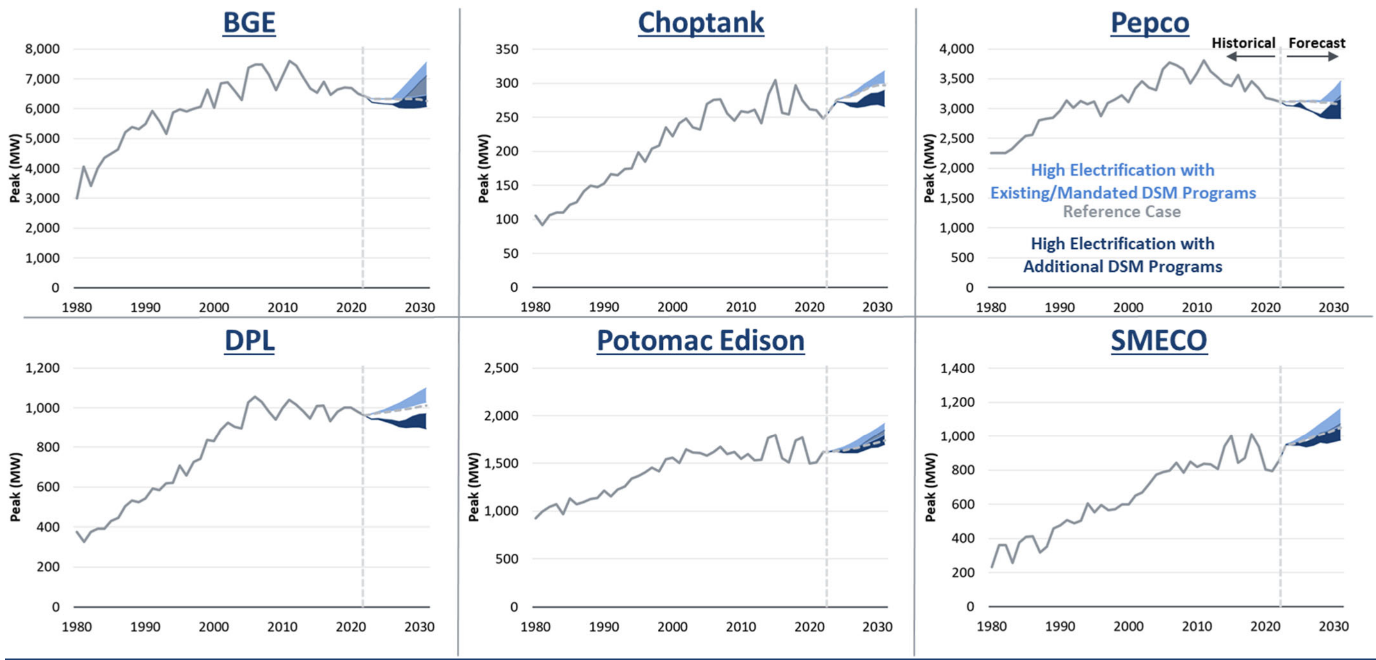
Each utility system and service territory may have unique characteristics in terms of its size, customer types, customer preferences, weather, regional economic growth, customer programs, and planning standards. While there are many factors that differ between the six in-scope electric utilities, two particularly important factors cause meaningful divergence in results.

Reference Case Forecast: The Reference Case forecasts indicate how much load growth each utility can expect with limited transportation electrification and no building electrification. There is significant divergence of Reference Case load forecasts between utilities. BGE and Pepco have load declining at rates of −0.27% and −0.16% per year respectively through 2031. On the other hand, Choptank, DPL, Potomac Edison, and SMECO have load growth of 0.56–2.30% per year through 2031. It follows that the utilities that already expect higher load growth in the Reference Case are also projected to have higher load growth in the High Electrification Scenarios.

Current Penetration of Electric Heating: The Maryland system as a whole peaks in the summer because the two largest utilities, BGE and Pepco, are summer-peaking. BGE and Pepco are summer-peaking because there is significant penetration of the natural gas delivery systems in their service territories, and fewer customers currently use electricity for heating. This implies the BGE and Pepco systems, currently sized for higher summer peaks, have some headroom for winter peak load growth before electric heating starts driving annual peaks. In contrast, DPL, Potomac Edison, and SMECO have more limited overlap with gas delivery service territories, and many more of their customers already use electricity for heating. Therefore, they are currently winter-peaking systems.

Figure 8 presents historical and projected in-scope utility system peak loads through 2031.

FIGURE 8: HISTORICAL AND PROJECTED UTILITY SYSTEM PEAK LOADS



	Reference	*Fuel Backup*		*High Electrification with Best-in-Class Technologies*		*Legacy Technologies*	
		Exst/Mandate DSM	Add. DSM	Exst/Mandate DSM	Add. DSM	Exst/Mandate DSM	Add. DSM
BGE	-0.3%	0.1%	-0.6%	0.8%	0.2%	1.8%	1.2%
Pepco	-0.2%	0.2%	-1.1%	0.2%	-0.6%	1.2%	0.4%
Potomac Edison	0.8%	1.2%	0.7%	1.2%	0.6%	1.9%	1.5%
DPL	0.6%	0.8%	-0.8%	0.8%	-0.7%	1.5%	0.1%
SMECO	2.3%	2.6%	1.6%	2.4%	1.5%	3.5%	2.6%
Choptank	2.0%	2.3%	1.3%	2.2%	0.8%	2.8%	1.8%

Sources and Notes: "Exst/Mandate DSM" refers to the Existing/Mandated DSM Programs cases and "Add. DSM" refers to the Additional DSM Programs cases. Historical load is sourced from utility data if available or backcasted from PJM zonal data for the corresponding zone if utility data is unavailable. Projected load growth rates are based on utility load forecasts submitted for the 2022–2031 Ten Year Plan and Brattle modeling of the impacts of energy efficiency, behind-the-meter solar, load flexibility, transportation electrification, and building electrification.

Finally, historical load growth trends suggest that the implications of projected load growth may vary across utilities. BGE and Pepco experienced their highest historical peak loads in 2011 and then saw load decline significantly from 2011 to 2022. Their load declines were significant enough that their projected 2031 peak loads in the highest load case of this study (Electrification with Legacy Technologies) is lower than their peak loads were in 2011. BGE's and Pepco's load declines from 2011–2022 suggest that their distribution systems likely have headroom to support some load growth, *on average*. However, it is possible for load growth to be concentrated in specific areas and still necessitate grid upgrades. The other four utilities saw flat or less significant load declines in the 2010s. Therefore, their projected 2031 peak loads in some high electrification scenarios are higher than their historical highest peak loads.

TABLE 9: COMPARISON OF HIGHEST PROJECTED PEAK LOAD TO HIGHEST HISTORICAL PEAK LOAD (MW)

Utility	Highest Projected 2031 Peak Load with Electrification	Highest Historical Peak Load (1980 -2022)
BGE	7,561	7,608
Pepco	3,460	3,806
Potomac Edison	1,921	1,798
DPL	1,100	1,056
SMECO	1,162	1,011
Choptank	318	305

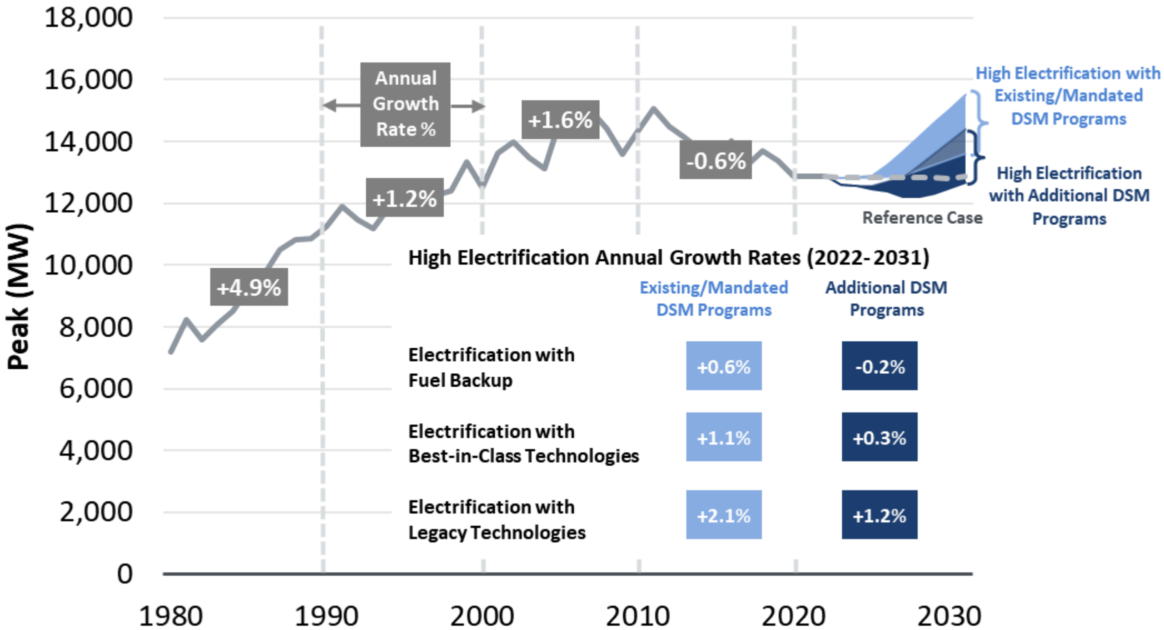
Sources and Notes: Historical load is sourced from utility data where available. Where utility data was unavailable, PJM historical growth rates for the corresponding zones were used to backcast 2022 peak load. Highest projected 2031 peak load with electrification refers to the Electrification with Legacy Technologies Scenario.

IV. Conclusion

The Maryland's Climate Pathway report demonstrates how Maryland can meet its ambitious climate goals of 60% reduction of greenhouse gas emissions by 2031 relative to 2006 levels, and attain a net-zero economy by 2045, all while realizing health and economic benefits for Marylanders, including improved air quality, new jobs, and household cost savings. This study modeled electrification scenarios that would result in direct building heating emissions reductions consistent with Maryland's Climate Pathway report. The results indicate that the aggregate Maryland electric systems would see growth rates in the range of 0.6–2.1% per year through 2031 with high electrification assuming utility energy efficiency plans consistent with the Climate Solutions Now Act and existing utility demand response plans. This increase in load growth is accompanied by a reduction in gas demand by about 20% by 2031 for high electrification scenarios. The Maryland electric distribution system, which is currently summer peaking, would switch to winter peaking around 2026–2027. Furthermore, additional energy efficiency and load flexibility measures could result in significant mitigation of load growth by 2031 to −0.2-1.2% compound annual growth per year.

Maryland electric utilities managed a peak growth rate of 4.9% per year in the 1980s, when there was rapid adoption of air conditioning. 1990–2010 saw more moderate load growth of 1.2–1.6%, and load declined in the 2010s during a period of large gains in energy efficiency. While the load growth caused by electrification would represent a paradigm shift in Maryland compared to the load declines of the past decade, even the highest projected growth rate of 2.1% per year is not extraordinary relative to growth served by the Maryland utilities in the past.

FIGURE 9: HISTORICAL AND PROJECTED ANNUAL LOAD GROWTH BY DECADE



Sources and Notes: Aggregate Maryland system load growth rates are based on the weighted average peak load growth of the in-scope utilities. Historical load growth rates are from utility provided forecasts when available or PJM zonal historic data for the corresponding zone. Projected load growth rates are based on utility load forecasts submitted for the 2022–2031 Ten Year Plan and Brattle modeling of the impacts of energy efficiency, behind-the-meter solar, load flexibility, transportation electrification, and building electrification.

This study projects utility system level average load growth rates through 2031. The modest system average load growth rates do not necessarily imply that distribution upgrades needed to support electrification will be insignificant. Distribution system planning is necessarily locational, and pockets of concentrated load growth may necessitate upgrades in some locations. A locational analysis of existing distribution system capacity and projected customer adoption of different technologies would be needed to identify specific areas that may require distribution upgrades. Nevertheless, the load declines of the past decade imply that on average, there is headroom on distribution systems to serve near-term load growth. In addition, the results show that deploying a portfolio of energy efficiency and load flexibility measures can lead to significant mitigation of load growth, even with high electrification. This combination of factors suggests that the transition to a highly electrified building sector in Maryland is manageable through 2031.

AUTHORS

Dr. Sanem Sergici |Principal | Boston

Sanem's practice focuses on regulatory and planning matters related to innovative rate design, electrification, distributed energy resources, and grid modernization. Sanem led numerous studies in these areas that were instrumental in regulatory approvals of grid modernization investments and integrated resource plans. She received her PhD in Applied Economics from Northeastern University in the fields of applied econometrics and industrial organization. She received her M.A. in Economics from Northeastern University, and B.S. in Economics from Middle East Technical University (METU), Ankara, Turkey.

sanem.sergici@brattle.com

Akhilesh Ramakrishnan |Managing Energy Associate | Chicago

Akhilesh specializes in policy analysis, regulatory economics, and strategic planning related to the demand side of the electricity sector. He has supported clients on a range of topics including economic analyses of electrification, rate design, resource planning, load flexibility, and value of solar. Prior to joining Brattle, he developed business strategy and policy for Exelon's electric and gas utility businesses. He received his M.S. in Mechanical Engineering from Columbia University, with a concentration in Energy Systems. He received his B.S. in Electrical Engineering from SRM University, India.

akhilesh.ramakrishnan@brattle.com

Kate Peters | Energy Research Associate | New York

Kate focuses her research on resource planning in decarbonized electric markets and economic analysis of distributed energy resources. She has supported utilities, renewable developers, research organizations, technology companies, and other private sector clients in a variety of energy regulatory and strategy engagements. Kate received her B.A. in Environmental Economics from Middlebury College.

kate.peters@brattle.com

Ryan Hledik| Principal | San Francisco

Ryan's consulting practice is focused on regulatory and planning matters related to emerging energy technologies and policies. His research on the "grid edge" has been cited in federal and state regulatory decisions, as well as by Forbes, National Geographic, The New York Times, Vox, and The Washington Post. Ryan received his M.S. in Management Science and Engineering from Stanford University, with a concentration in Energy Economics and Policy. He received his B.S. in Applied Science from the University of Pennsylvania, with minors in Economics and Mathematics.

ryan.hledik@brattle.com

J. Michael Hagerty | Principal | Washington, DC

Michael specializes in the economic analysis of new technologies and resources across the power sector supply chain, including transportation and heating electrification, distributed solar resources, and transmission system upgrades. He assists electric utilities, renewable developers, transmission developers, and RTOs in understanding and preparing for a shifting market and policy landscape. Michael received his M.S. in Technology and Policy at Massachusetts Institute of Technology, and B.S. in Chemical Engineering from the University of Notre Dame.

michael.hagerty@brattle.com

Ethan Snyder and Julia Olszewski are Senior Energy Analysts, and Hazel Ethier is an Energy Analyst with The Brattle Group.

Technical Appendix

An Assessment of Electrification Impacts on the Maryland Electric Grid

TECHNICAL APPENDIX TO THE REPORT

Brattle

Table of Contents

1 – Study Scope and Scenario Design

Purpose of the Electrification Study

Senate Bill 528 ("SB528" or "The Climate Solutions Now Act of 2022" or CSNA) requires Maryland to reduce GHG emissions by 60% from 2006 levels by 2031 and achieve net-zero GHG emissions by 2045.

SB528 directed the PSC to conduct this study "*assessing the capacity of each company's gas and electric distribution systems to successfully serve customers under a managed transition to a highly electrified building sector.*"

In addition, SB528 set the following requirements for this study:

- *use a projection of average growth in system peak demand between 2021 and 2031 to assess the overall impact on each gas and electric distribution system*
- *compare future electric distribution system peak and energy demand load growth to historic rates*
- *consider the impacts of energy efficiency and conservation and electric load flexibility*
- *consider the capacity of the existing distribution systems and projected electric distribution system improvements and expansions to serve existing electric loads and projected electric load growth*
- *assess the effects of shifts in seasonal system gas and electric loads*

Our scenario design is focused on meeting the requirements for this study as stated in the CSNA

Climate Solutions Now Act of 2022, Md. S.B. 528 (2022)

What is In Scope

- For each in-scope utility system, in depth modeling of electric load, including hourly load impacts by end use and appliance type for transportation and buildings sectors through 2031
- Calibration of end uses in each sector to each utility's baseline, i.e., representing the mix of uses and equipment penetration that exists today based on the best available data
  - Distributed Energy Resources (DERs), energy efficiency, load flexibility, vehicles, heat pumps, hot water etc.
  - Rely on EmPOWER GHG abatement study, the PPRP 100% RPS Study and the MDE Pathway study
- Analysis of historical electric and/or gas demand trends for each in-scope utility
- Model six study scenarios and the implied incremental electrification additional to what is already included in utility baseline forecasts
- Track reductions in consumption of natural gas and other fossil fuels as electrification adoption increases
- Model the impacts of electric load mitigation measures (energy efficiency and load flexibility)
- Track the impacts (peak demand, annual energy, emissions) of increased electricity demand due to electrification and reductions in transportation and heating fuel demand on Maryland GHG emissions

1 The MDE Pathway study modeled Maryland's economy-wide decarbonization pathway to achieving the climate goals set by the CSNA (https://cgs.umd.edu/sites/default/files/2023-09/file_final_Maryland%27s Climate Pathway Report.pdf)

What is NOT in Scope

- Cost of each scenario and mitigation option
- Recommendations on specific utility distribution/delivery investment plans
- Questions and modeling efforts pertaining to the future of the gas delivery systems
- Regulatory and business models for electric and gas utilities
- Impact on electric and gas systems beyond 2031

Scenario Matrix

	Decarbonization Policy Goals not Pursued		Pursuit of Policy Goals through Hybrid Solutions		Pursuit of Policy Goals through Zero Direct Emissions Solutions	
	S.0	**S.1**	**S.2A**	**S.2B**	**S.3A**	**S.3B**
	Reference	Low Electrification	Mid Electrification	High Electrification with Fuel Backup	High Electrification with Best-in-Class Technologies	High Electrification with Legacy Technologies
Description	"Reference" for load impacts of other scenarios. Defined as the state of the world as implied by each utility's current load forecast.	Limited incremental electrification. Assumes policy goals are not met.	Mix of electrification and continued use of fuels.	High electrification with retention of existing fossil fuel equipment for backup.	Fossil fuel equipment is phased out through policy. Customers quickly adopt more advanced, efficient electric technologies.	Fossil fuel equipment is phased out through policy. Customers are slower to adopt more advanced, efficient electric technologies.
Buildings	**Fuel mix held flat** from 2022.	**Limited incremental electrification** (majority of existing gas and fossil customers do not adopt heat pumps by 2031).	**Fossil fuel equipment sales continue beyond 2030;** some customers switch to heat pumps.	By 2030, all new equipment sales are HPs. **Almost all existing customers retain their fossil fueled equipment as backup.**	By 2030, all new equipment sales are HPs[1]. **Most HPs are highly efficient ccASHPs.**	By 2030, all new equipment sales are HPs[1]. **Most HPs are less efficient ASHP+resistance backup.**
DERs	Distributed Energy Resources (DER) growth in line with RPS mandate.					
Transportation	Based on EIA projections.	3-year delay relative to ACC II and ACT.	Achievement of Advanced Clean Cars II (ACC II) and Advanced Clean Trucks (ACT) regulations.			
Demand Side Management (DSM)	For each scenario, we run two DSM cases with a range of Energy Efficiency (EE) and Load Flexibility programs: **1) Existing/Mandated DSM Programs Only** **2) Additional DSM Programs (i.e., new programs and growth of existing programs)**					

1 With some exceptions for the hardest-to-electrify cases (we assume at least 5% of sales will be exempt from the policy and remain as fossil fuel equipment sales)
ccASHP = cold climate air-source heat pump, ASHP = air-source heat pump, HP = heat pump

Goals and Design of Adoption Curves for Each Scenario

For each scenario, we model the evolution of heating and transportation equipment penetration in MD based on:

- The best available data on existing equipment penetration as the starting point
- Annual sales adoption curves for each equipment type through the end of the study period or beyond
- Typical pace of equipment stock turnover; we do not model accelerated replacements

What the adoption curves are:

- The adoption curves are formulated as S-shaped curves representing the share of annual new equipment sales for each modeled equipment type
- They are designed to enable us to study plausible future states of the world that fulfill the study's goal of evaluating the grid impacts of a "highly electrified building sector" in the context of MD's 2031 and 2045 climate goals
- They are informed (qualitatively) by the relative economics and policies related to different fuels and equipment types. E.g., ground source heat pump adoption may be low due to the high upfront cost; IRA incentives may accelerate heat pump adoption

What the adoption curves are not:

- They are not forecasts; they are "what-if" scenarios
- **They are not an endorsement of the technical feasibility or cost-effectiveness of a certain technology/solution**

Benchmarking to the 60x31 Decarbonization Goal

While the scope of this study is focused on quantifying the electric load impacts of high electrification of the building sector, it was important to benchmark resulting emission reductions to Maryland's decarbonization goals

- This benchmarking is necessarily imperfect due to differing studies, models, and data sources and the fact that the state's goals apply to the entire economy, not specific sectors such as buildings
- This study quantifies the reduction in fossil fuel consumption and associated direct emissions resulting from the electrification of residential and commercial space and water heating, but not the electric grid emissions impacts
- This study is not an economy-wide decarbonization study, and therefore does not model changes to components of the Maryland economy outside of transportation and buildings
- To benchmark this study's building electrification scenarios to the State's decarbonization goals, we calibrate emission reductions in the modeled sector of interest (building heating) to the emission reductions in MDE's economy-wide Climate Pathways Scenario for those particular end uses
- All three high electrification scenarios (S.3A, S.3B, S.2B) result in direct building heating emissions reductions consistent with MDE's Climate Pathways modeling, implying the 60x31 economy-wide goal can be met if other sectors also decarbonize according to MDE's Climate Pathways modeling. Two of these scenarios (S.3A, S.3B) pursue zero direct emissions solutions while S.2B pursues hybrid solutions with customers maintaining their fossil equipment as backup
- Other scenarios (S.0, S.1, S.2A) result in less direct building heating emissions reductions than MDE's Climate Pathways modeling, implying that unless other sectors of the economy decarbonize faster than MDE's modeled pathway, the 60x31 economy-wide goal will not be met

2 – Load Modeling Methodology and Assumptions

Goals of the Modeling Approach

- Incorporate the load impacts of sectors/technologies relevant to this study (EE, DERs, electrification, load flexibility)
- Account for future changes in load not modeled in this study
- Avoid double counting any end uses that may be modeled in both this study and the utility load forecasts
- Maintain consistency across utilities and with other state studies to the extent possible

Approach to Scenario Load Modeling (I)

1 Disaggregate Utility Load Forecasts

Isolate end uses that will be modeled in this study (EE, DERs, heating, cooling, transportation)

Utility Load Forecasts

Annual forecasts Net of DSM from MD Ten Year Plan.

+

Scenario-Related Components in Utility Forecast

- Energy Efficiency (+)
- DER Impact (+)
- Transportation (-)
- Heating and Cooling (-)

Gross up utility forecasts by these end uses to avoid double counting in scenario modeling

=

Gross Load Forecast

= Utility Load Forecast + Scenario Related Components

2 Model Electricity Demand in Each Scenario

Model scenario-based electrification for building and transportation sectors to assess load impacts

Scenario-Related Load Impacts:

- Building heating and cooling
- Transportation
- Distributed Energy Resources (DERs)
- Energy Efficiency
- Load Flexibility

Gross Load Forecast

Hourly Scenario Load

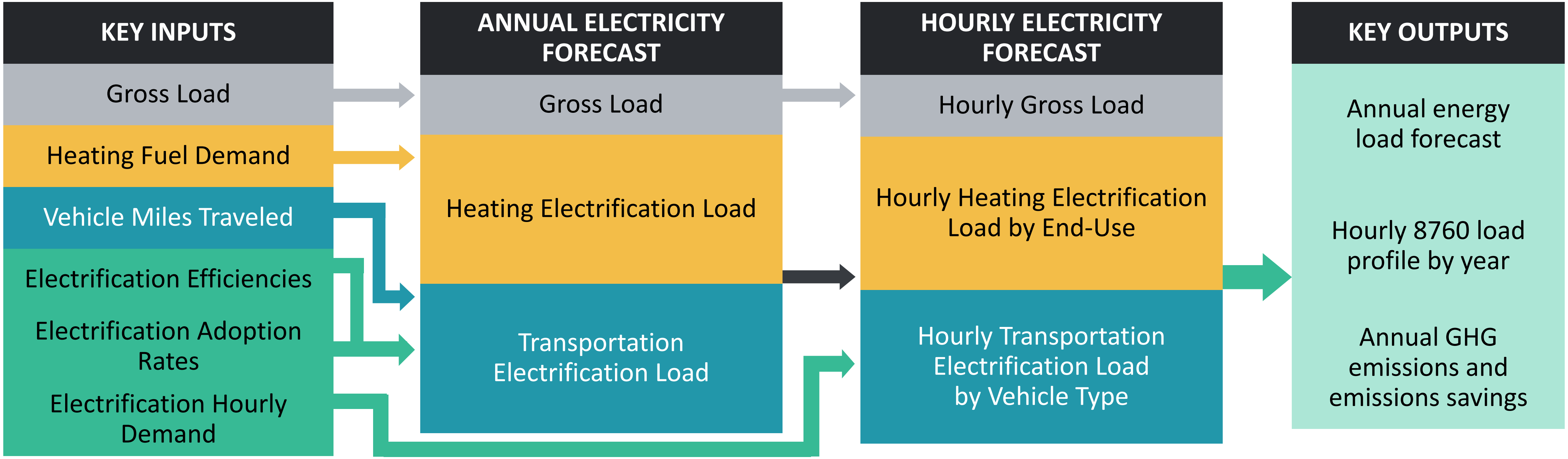
Sum of load components

= Same for all scenarios

= Varies by scenario and year

Approach to Scenario Load Modeling (II)

We rely on Brattle's Decarbonization, Electrification, & Economic Planning ("DEEP") Model to conduct the analyses of electric and gas load impacts of the six study scenarios



2019 Weather Year

The hourly load shape and temperature-related modeling use historical 2019 data

- 2019 was a non-extreme weather year that was close to the historical 30-year average high, low, and average temperatures
- Hourly load is built up from the 2019 actual hour load shape; the net load shape changes over time as projected electrification, DER, and load flexibility impacts take effect
- We use temperature data from a weather station in each utility region to capture regional differences

Baltimore Temperature Stats (1993-2022)

Metric	Degrees F
50/50 Low	8
90/10 Low	1
Lowest Low (ocurred in 1994)	-5
2019 Low Temp (Used in Study)	6

Baltimore Temperature (1993-2022)

	High Temperature	Low Temperature	Average Temperature
1993	100	9	55
1994	101	-5	56
1995	102	5	57
1996	94	-1	54
1997	101	1	55
1998	99	9	57
1999	102	7	56
2000	95	7	54
2001	98	14	56
2002	100	6	56
2003	93	5	54
2004	92	6	55
2005	96	9	56
2006	100	12	57
2007	102	8	56
2008	96	8	56
2009	94	2	55
2010	105	8	57
2011	106	8	58
2012	104	13	59
2013	97	11	56
2014	96	3	54
2015	97	1	56
2016	100	8	57
2017	98	8	57
2018	99	1	57
2019	**100**	**6**	**58**
2020	100	19	59
2021	99	19	59
2022	99	6	58
Average (1993-2022)	**99**	**8**	**56**

1994 = lowest low

2019 = model year

Source: NOAA

3 – Building Sector Assumptions and Inputs

Modeled Building and Equipment Types

Sector	Modeled Building Types	Space Heating Equipment Types	Water Heating Equipment Types
Residential	Single Family	• Fuel Oil furnace/boiler • Gas furnace/boiler • Gas heat pump • Other Fuels (propane, wood, etc.) • Electric resistance • Cold Climate air-source heat pump (ASHP) • ASHP + Resistance Backup • ASHP + Existing Fuel as Backup • GSHP	• Propane • Fuel Oil • Avg. Efficiency Gas • Efficient Gas • Electric Resistance • Electric Heat Pump
	Multifamily[2]		
Non-Residential	Exempt Commercial[1]		
	Covered Commercial[2]		

1 "Exempt" category includes: all buildings under 25k sq. ft., buildings 25k-35k sq. ft. outside Montgomery county, and any building types exempt from the Building Energy Performance Standards (BEPS).
2 "Covered" category includes buildings over 25k sq. ft. in Montgomery county or over 35k in the rest of MD, except exempt building types. "Covered Commercial" includes some residential multifamily building types.

Detail on Modeled Electric Heating Equipment

Modeled Equipment Types	Description
Electric Resistance Heaters	Some customers are currently heated by 100% resistive heat. This equipment is significantly less efficient than heat pumps and significant load reductions can be achieved by replacing them with heat pumps.
Cold Climate Air Source Heat Pump (ccASHP)	Standalone cold climate heat pumps sized to meet customers' peak heating load. No backup resistive heat.
ASHP + Resistance Backup	Less efficient and smaller heat pump. Resistive heating supplements the heat pump at temperatures below 22F.
ASHP + Fuel Backup	Less efficient and smaller heat pump. Their existing fossil fuel equipment is maintained. The heat pump is assumed to supply 100% of the heat above 20F and the fossil equipment supplies 100% of the heat below 20F.
Ground Source Heat Pump (GSHP)	Standalone ground source heat pumps sized to meet customers' peak heating load.

Calibrating to Maryland's Existing Fuel Mix

The starting point for equipment penetration was based on the best available data from previous MD studies, with some adjustments to account for newer information.

- Current saturation of residential space and water heating equipment informed primarily by Verdant's September 2022 survey for the GHG potential study.
- Current saturation of commercial space and water heating equipment informed by EIA CBECS 2018
- The Heat Pump Subgroup conducted a survey of contractors about the mix of heat pump configurations they installed or serviced in the past 12 months in Maryland. We used the results to inform more granular assumptions on heat pump configurations:
  - **12%** of existing homes with heat pumps qualify as cold-climate ASHP
  - **69%** of homes with heat pumps operate with electric resistance backup
  - **10%** of homes with heat pumps operate with gas backup
  - **9%** of homes with heat pumps operate with fuel backup
- Though the contractor survey was limited to the residential sector, we assume the same mix of heat pump configurations for the commercial sector due to lack of other data sources
- Our adoption curves (for annual new sales) use the existing equipment saturation proportions as the starting point. E.g., since ~30% of homes currently use heat pumps, we assume 30% of 2023 new equipment sales are heat pumps (this is likely a conservative assumption as heat pump sales have been growing).

Existing Fuel Mix by Utility

Existing Fuel Mix (2022)

	BGE	Choptank	DPL	PEPCO	Potomac Edison	SMECO	BGE	Choptank	DPL	PEPCO	Potomac Edison	SMECO
	Residential Water Heating						**Commercial Water Heating**					
Electric Heat Pump	5%	6%	6%	4%	9%	15%	5%	8%	8%	5%	7%	7%
Electric Resistance	52%	71%	71%	43%	73%	63%	56%	91%	89%	58%	75%	72%
Fossil	43%	23%	23%	52%	18%	23%	39%	1%	3%	37%	18%	21%
	Residential Space Heating						**Commercial Space Heating**					
ccASHP	3%	5%	5%	2%	3%	5%	0%	0%	0%	0%	0%	0%
GSHP	2%	2%	2%	1%	3%	6%	1%	1%	1%	1%	1%	1%
ASHP + Resistance	16%	27%	27%	12%	20%	26%	9%	23%	23%	8%	17%	15%
ASHP + Fuel Hybrids	4%	7%	7%	4%	5%	7%	0%	0%	0%	0%	0%	0%
Electric Resistance	20%	25%	25%	17%	31%	26%	28%	75%	72%	27%	55%	55%
Fossil	54%	34%	34%	63%	38%	30%	62%	1%	5%	64%	27%	30%

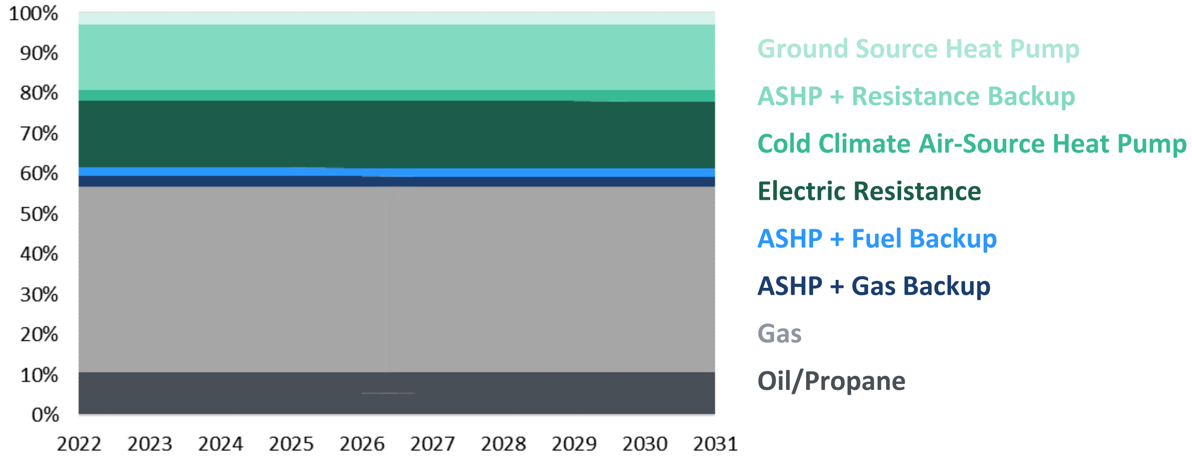
Note: Utility totals may not sum to 100% due to rounding. ccASHP = cold climate air source heat pump, ASHP = air source heat pump, GSHP = ground source heat pump
Data sources noted in previous slide.

Residential Space Heating Adoption Curves – All MD – S.0 and S.1

Adoption Curves (% of new sales)

Description

S.0: Reference

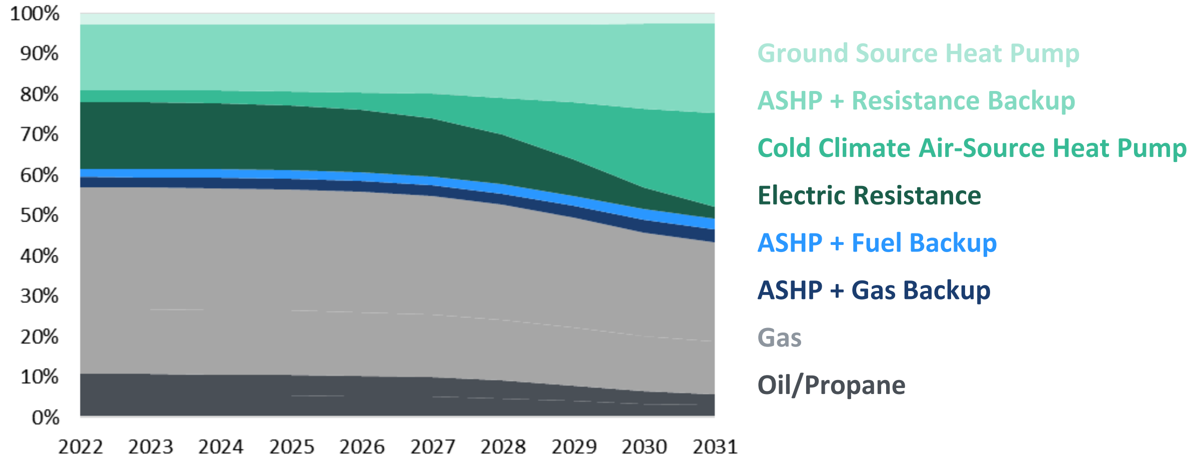


Assumes no fuel switching:

- At the end of equipment lifetimes stock is replaced by new equipment of the same type
- Aligned with EmPOWER GHG study BAU case

Leads to 2031 fuel mix the same as today's mix.

S.1: Low Electrification



Very slow change in fuel mix:

- Delivered fuel equipment sales fall by almost 50% by 2031
- Gas equipment sales fall by 20% by 2031
- Electric heating equipment sales are 48% ccASHP, 44% ASHP+resistance, 5% GSHP, and 3% Electric Resistance

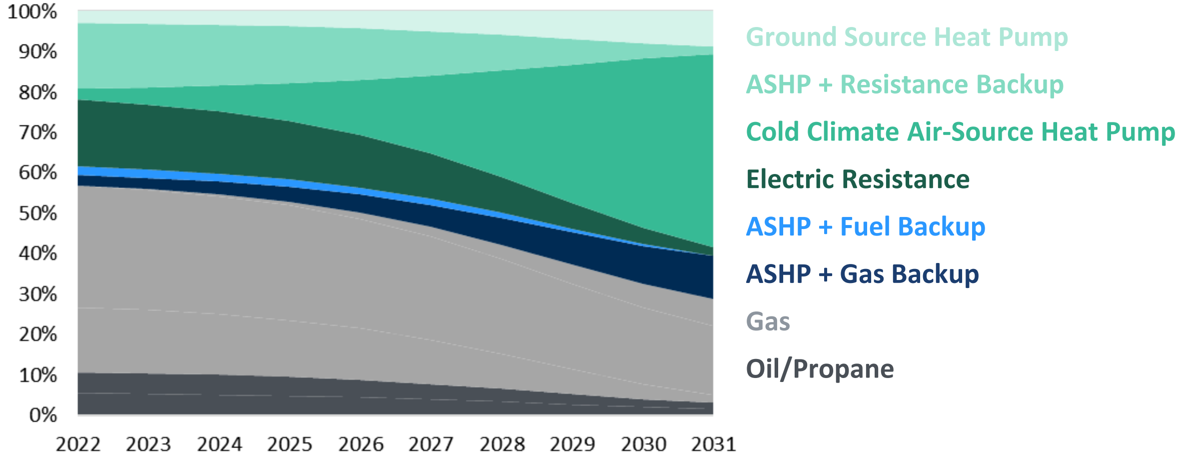
Leads to 2031 mix similar to today's mix.

Residential SH Adoption Curves – all MD – S.2

Adoption Curves (% of new sales)

Description

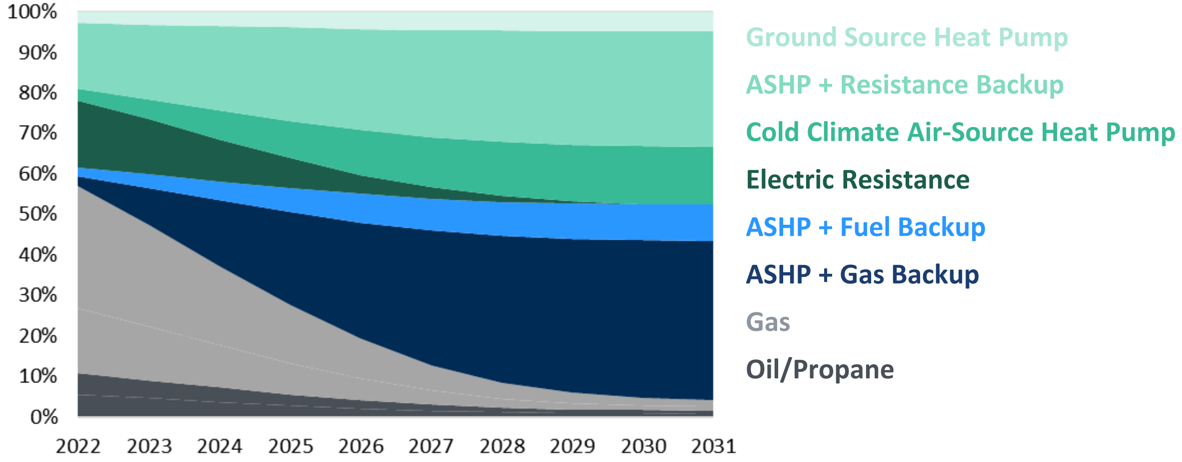
S.2A:
Mid Electrification



Heat pumps sales grow but fuel equipment sales continue beyond 2031:

- Delivered fuel equipment sales fall 70% by 2031
- Gas equipment sales fall 40% by 2031
- Full electric heating equipment sales are 85% ccASHP, 15% GSHP

S.2B:
High Electrification with Fuel Backup



Most new equipment sales are HPs by 2030*:

- At end of equipment life, 85% of existing fossil fuel customers add ASHPs and keep their fossil equipment (gas, oil, or propane) for backup
- Full electric heating equipment sales are 30% ccASHP, 60% ASHP+resistance, 10% GSHP

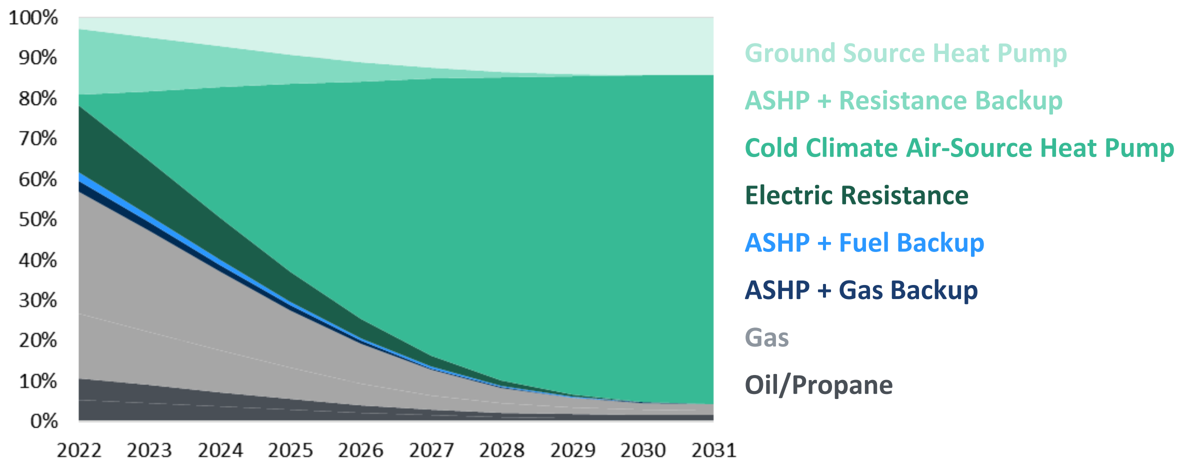
*Note: Delivered fuel and standalone gas equipment sales fall to almost zero (we assume a small amount because the regulation is likely to allow some exceptions)

Residential SH Adoption Curves – all MD – S.3

Adoption Curves (% of new sales)

Description

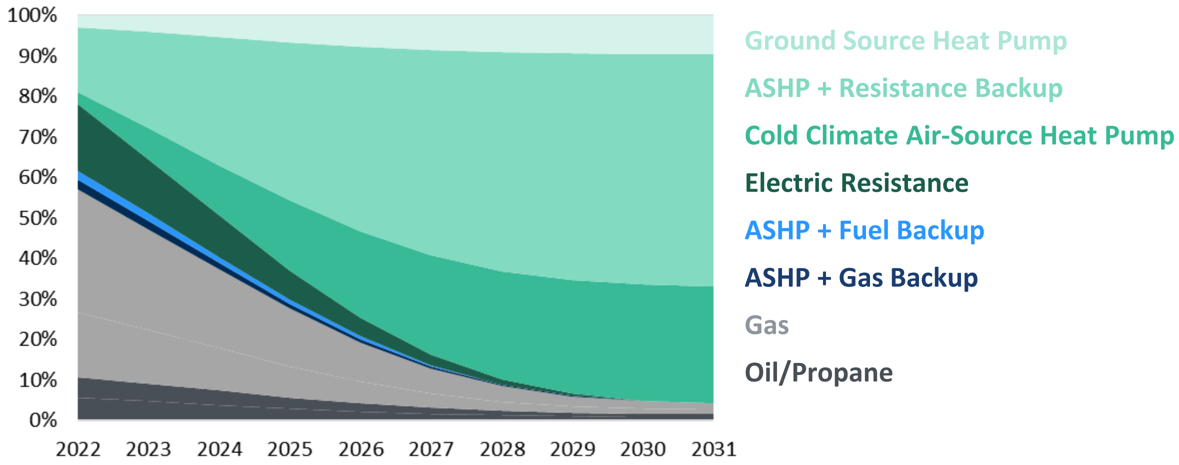
S.3A: High Electrification Best-in-Class Technologies



All fossil fuel equipment sales fall to zero by 2030:

- Fully electric sales are 85% ccASHP and 15% GSHP
- ASHP+resistance sales fall to zero because ccASHPs are more efficient and widely available (in this scenario per definition)
- Delivered fuel and standalone gas equipment sales fall to almost zero (we assume a small amount because the regulation is likely to allow some exceptions)

S.3B: High Electrification with Legacy Technologies



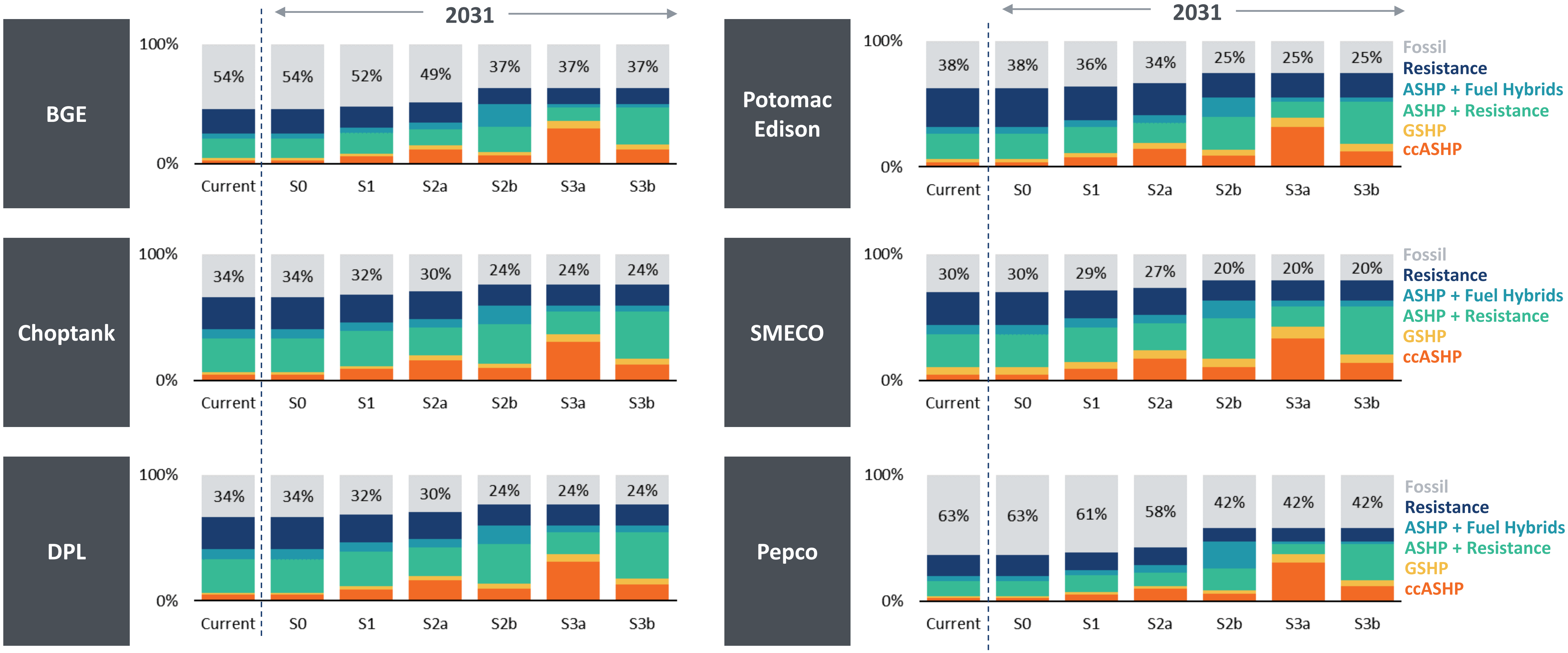
All fossil fuel equipment sales fall to zero by 2030:

- Fully electric sales are 30% ccASHP, 60% ASHP+resistance, 10% GSHP
- Delivered fuel and standalone gas equipment sales fall to almost zero (we assume a small amount because the regulation is likely to allow some exceptions)

Scenarios - Residential Space Heating Stock

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Space Heating Equipment Penetration, *% of residential customers*



Fossil = gas, oil, propane equipment; ASHP = air source heat pumps; GSHP = ground source heat pumps; ccASHP = cold climate air source heat pumps
Water heating equipment penetrations are provided in the appendices.

Scenarios - Commercial Space Heating Stock

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

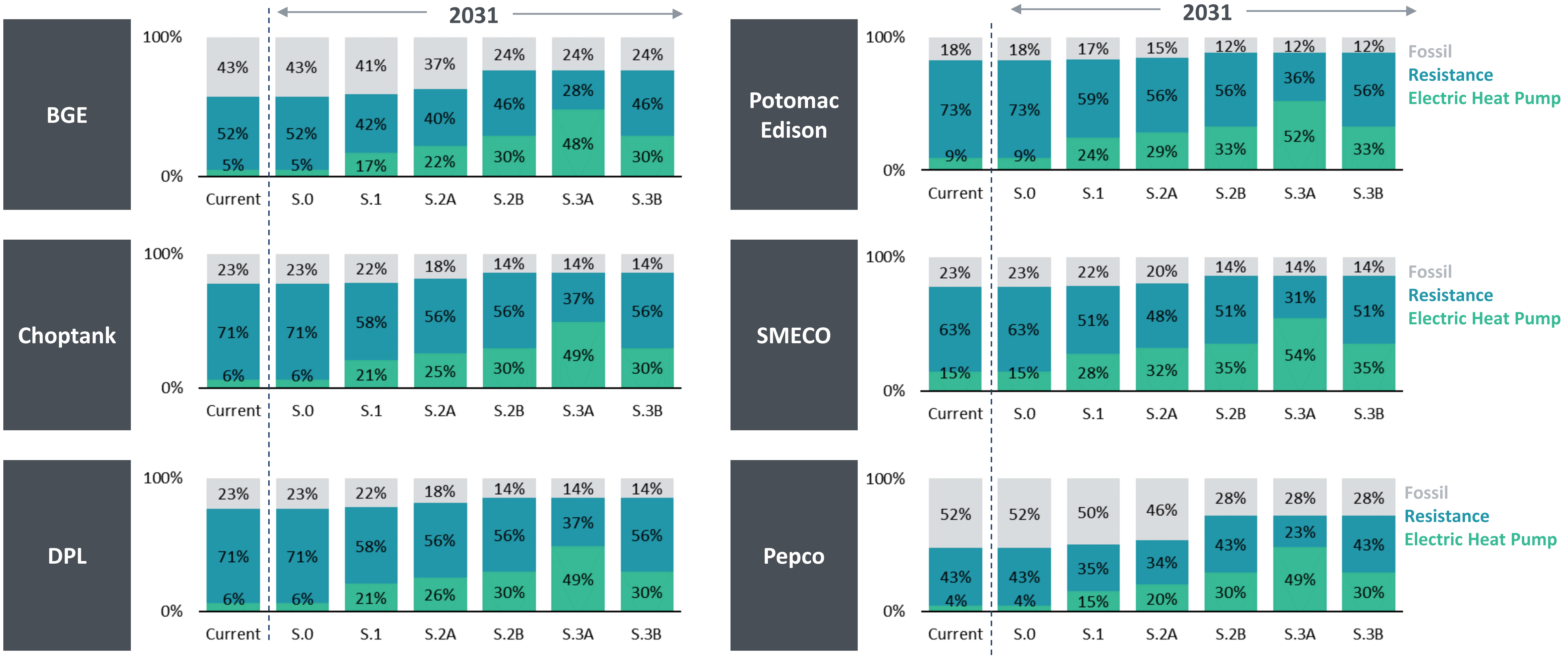
Space Heating Equipment Penetration, *% of heated floor area*

Fossil = gas, oil, propane equipment; ASHP = air source heat pumps; GSHP = ground source heat pumps; ccASHP = cold climate air source heat pumps
Water heating equipment penetrations are provided in the appendices.

Scenarios - Residential Water Heating

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Water Heating Equipment Penetration, *% of residential customers*



Fossil = gas and oil.

Scenarios - Commercial Water Heating

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Water Heating Equipment Penetration, *% of floor area*

Fossil = gas and oil.

Utility Customer Forecasts

Utility-Level Customer Count and Square Footage Forecast											
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2022- 2031 CAGR
Residential Single-Family Home Customer Count											
BGE	870,886	875,307	879,491	883,719	888,108	892,711	897,418	902,176	906,904	911,240	0.5%
DPL	112,398	112,775	113,209	113,627	114,036	114,446	114,857	115,270	115,684	116,101	0.4%
Pepco	374,346	377,753	381,060	384,385	387,664	390,971	394,306	397,671	401,063	404,485	0.9%
PE	191,453	194,068	196,766	199,382	201,961	204,500	206,967	209,387	211,773	214,126	1.3%
Chop	30,709	30,889	31,069	31,186	31,271	31,358	31,452	31,556	31,673	31,795	0.4%
SMECO	127,036	131,428	133,208	135,069	137,254	139,359	141,463	143,648	145,914	147,532	1.7%
Total	**1,706,829**	**1,722,219**	**1,734,803**	**1,747,367**	**1,760,293**	**1,773,344**	**1,786,463**	**1,799,708**	**1,813,011**	**1,825,279**	**0.7%**
Residential Multi-Family Home Customer Count											
BGE	329,406	331,078	332,660	334,259	335,919	337,661	339,441	341,241	343,029	344,669	0.5%
DPL	69,630	69,864	70,133	70,392	70,645	70,899	71,154	71,410	71,667	71,924	0.4%
Pepco	169,639	171,182	172,681	174,187	175,673	177,172	178,684	180,208	181,746	183,296	0.9%
PE	59,568	60,381	61,221	62,035	62,837	63,627	64,395	65,148	65,890	66,622	1.3%
Chop	19,024	19,135	19,247	19,319	19,373	19,427	19,485	19,549	19,621	19,697	0.4%
SMECO	29,937	30,972	31,392	31,831	32,346	32,841	33,337	33,852	34,386	34,768	1.7%
Total	**677,204**	**682,613**	**687,334**	**692,024**	**696,793**	**701,627**	**706,495**	**711,408**	**716,339**	**720,976**	**0.7%**
Commercial Covered Square Footage (Thousands)											
BGE	706,336	710,437	713,966	717,495	721,023	724,552	728,081	731,610	735,139	738,667	0.5%
DPL	57,405	57,680	57,958	58,217	58,467	58,720	58,973	59,228	59,482	59,739	0.4%
Pepco	322,740	325,566	327,714	329,869	331,811	333,760	335,721	337,695	339,676	341,676	0.6%
PE	92,812	96,860	96,860	96,860	96,860	96,860	96,860	96,860	96,860	96,860	0.5%
Chop	39,762	39,994	40,227	40,375	40,488	40,601	40,721	40,855	41,011	41,166	0.4%
SMECO	40,108	40,415	40,696	41,054	41,361	41,616	41,898	42,179	42,460	42,664	0.7%
Total	**1,259,163**	**1,270,951**	**1,277,421**	**1,283,869**	**1,290,011**	**1,296,109**	**1,302,253**	**1,308,426**	**1,314,627**	**1,320,773**	**0.5%**
Commercial Exempt Square Footage (Thousands)											
BGE	332,969	334,902	336,565	338,229	339,892	341,556	343,219	344,883	346,546	348,210	0.5%
DPL	70,620	70,958	71,301	71,619	71,927	72,238	72,549	72,862	73,176	73,492	0.4%
Pepco	122,154	123,224	124,037	124,853	125,588	126,325	127,068	127,815	128,565	129,322	0.6%
PE	78,331	81,748	81,748	81,748	81,748	81,748	81,748	81,748	81,748	81,748	0.5%
Chop	86,593	87,097	87,605	87,928	88,174	88,420	88,681	88,973	89,311	89,650	0.4%
SMECO	48,735	49,108	49,450	49,884	50,257	50,568	50,909	51,251	51,593	51,841	0.7%
Total	**739,403**	**747,037**	**750,705**	**754,261**	**757,586**	**760,855**	**764,175**	**767,533**	**770,939**	**774,262**	**0.5%**

Sources and notes: Utility provided customer forecasts, Ten Year Plan (November 2022), GHG EmPOWER study surveys, and CBECs 2018. "Covered" refers to buildings covered by the BEPS and Montgomery county regulations (large buildings); "Exempt" refers to buildings exempt from the regulations (smaller buildings).

Service Demand per Customer

Service demand per customer refers to the amount of usable energy required by customers for each end use (regardless of the fuel/equipment it comes from).

Building Service Demand (Annual MMBtu/residential customer or Btu/commercial sq ft)

	BGE	DPL	Choptank	Pepco	Potomac Edison	SMECO
Single Family Space Heat	52.1	62.3	62.3	52.7	49.2	51.7
Single Family Water Heat	8.2	8.9	8.9	7.8	8.8	8.8
Single Family Cooling	41.9	46.1	46.1	40.0	42.3	48.7
Multi Family Space Heat	13.1	12.9	12.9	23.0	18.8	18.2
Multi Family Water Heat	7.1	7.1	7.1	7.1	7.3	7.9
Multi Family Cooling	15.5	14.5	14.5	13.4	19.4	26.6
Covered Space Heat	31,052	31,428	29,835	33,396	30,991	28,454
Covered Water Heat	4,330	4,634	4,887	4,472	4,460	5,150
Covered Cooling	55,110	56,413	54,460	53,640	54,390	53,131
Exempt Space Heat	30,234	35,658	36,924	30,960	34,076	32,798
Exempt Water Heat	4,396	4,972	4,618	3,977	4,603	4,867
Exempt Cooling	52,427	53,458	52,032	51,805	52,011	52,205

Sourced from Verdant survey and utility customer data from EmPOWER GHG Potential Study. “Covered” refers to buildings covered by the BEPS and Montgomery county regulations (large buildings); “Exempt” refers to buildings exempt from the regulations (smaller buildings).

Equipment Efficiencies and Useful Lifetimes

Residential Sector Equipment Efficiencies

	2022 New Installs	2031 New Installs	2022-2031 CAGR	Equipment Lifetimes
Space Heating				
Fuel Oil	0.83	0.83	0.00%	20
Avg. Efficiency Gas	0.80	0.80	0.00%	20
Efficient Gas	0.95	0.95	0.00%	20
Gas Heat Pump	1.30	1.30	0.00%	20
Electric Resistance	0.98	0.98	0.00%	20
Cold Climate Air-Source Heat Pump (ASHP)	N/A	N/A	3.24%	20
ASHP + Resistance Backup	N/A	N/A	2.26%	20
ASHP + Gas Hybrid System	N/A	N/A	2.26%	20
ASHP Hybrid, Other Fuels	N/A	N/A	2.26%	20
Ground-Source Heat Pump	3.64	4.23	1.70%	20
Propane	0.83	0.83	0.00%	20
Cooling				
ASHP	4.48	4.75	0.64%	20
GSHP	5.07	5.07	0.00%	20
Central AC	4.13	4.25	0.30%	20
Water Heating				
Fuel Oil	0.64	0.64	0.00%	15
Avg. Efficiency Gas	0.61	0.61	0.00%	15
Efficient Gas	0.83	0.83	0.00%	15
Electric Resistance	0.92	0.92	0.00%	15
Electric Heat Pump	3.30	3.79	1.55%	15
Propane	0.64	0.64	0.00%	15

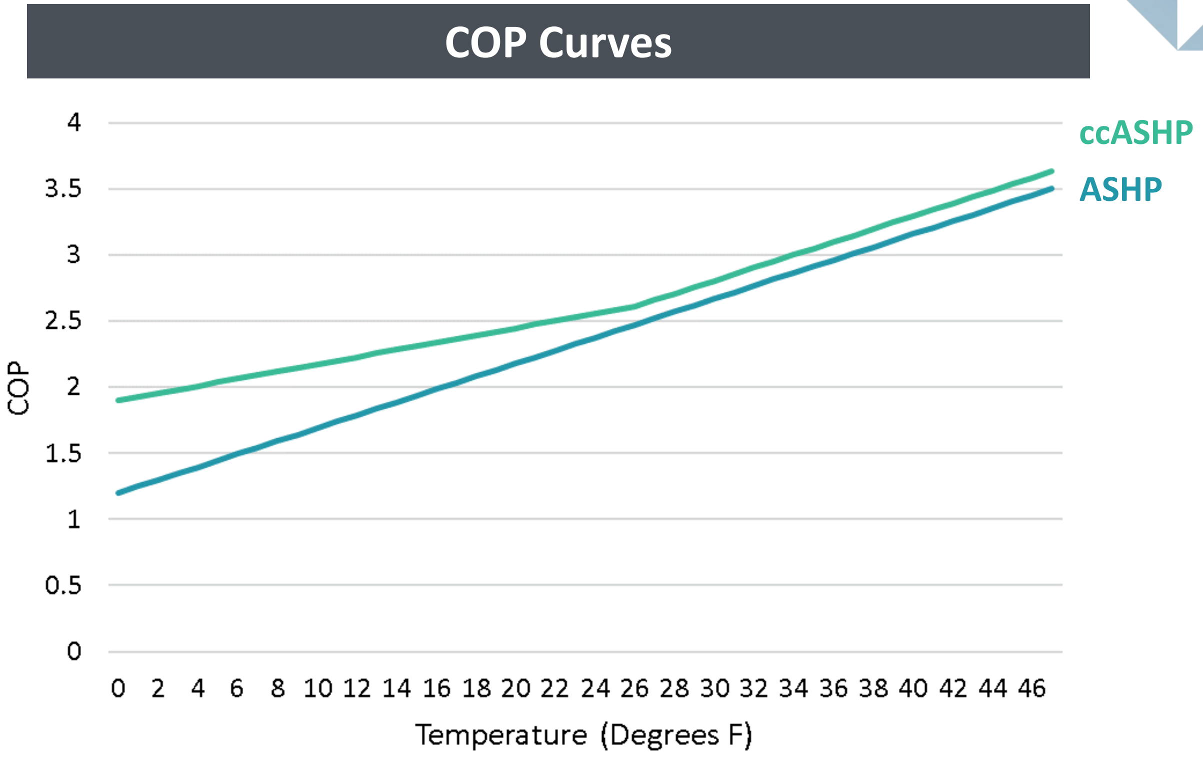
Commercial Sector Equipment Efficiencies

	2022 New Installs	2031 New Installs	2022-2031 CAGR	Equipment Lifetimes
Space Heating				
Fuel Oil	0.82	0.82	0.00%	16
Avg. Efficiency Gas	0.81	0.81	0.00%	16
Efficient Gas	0.95	0.95	0.00%	16
Gas Heat Pump	1.30	1.30	0.00%	16
Electric Resistance	0.98	0.98	0.00%	16
Cold Climate Air-Source Heat Pump (ASHP)	N/A	N/A	2.26%	16
ASHP + Resistance Backup	N/A	N/A	0.65%	16
ASHP + Gas Hybrid System	N/A	N/A	0.65%	16
ASHP Hybrid, Other Fuels	N/A	N/A	0.65%	16
Ground-Source Heat Pump	3.44	4.00	1.70%	16
Propane	0.82	0.82	0.00%	16
Cooling				
ASHP + Resistance Backup	4.10	4.10	0.00%	16
ASHP + Gas Hybrid System	3.55	3.55	0.00%	16
ASHP Hybrid, Other Fuels	4.19	4.23	0.10%	16
Ground-Source Heat Pump	4.98	4.98	0.00%	16
Water Heating				
Fuel Oil	0.80	0.80	0.00%	16
Avg. Efficiency Gas	0.80	0.80	0.00%	16
Efficient Gas	0.94	0.94	0.00%	16
Electric Resistance	0.98	0.98	0.00%	16
Electric Heat Pump	3.90	4.19	0.80%	16
Propane	0.80	0.80	0.00%	16

Sources and notes: For heat pump technologies, annual COP is a function of hourly COP that is modeled based on hourly temperature. Efficiency improves each year with the CAGR. EIA - Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case and NREL EFS

Heating Load Modeling: Hourly Heat Pump COPs

- **ASHP:** Coefficient of Performance (COP) modeled as a function of hourly temperature based on input COP vs. temperature curves. See chart for COP assumptions for standard ASHP and cold-climate ASHP (ccASHP)
- **ASHP with fossil backup:** ASHP serves 100% of heating load in hours above cut-in temperature (20 degrees F). All heating demand below cut-in temperature is served exclusively by fossil source. Fossil backup COP does not vary with temperature
- **ASHP with resistance backup:** Resistive heat supplements the ASHP below cut-in temperature (22 degrees F), at COP of 1. ASHP continues to operate.
- **Ground Source Heat Pump:** COP does not vary with hourly temperature



Sources for COP and cut-in temperature: Gibb, *et. al*, Coming in from the cold: Heat Pump efficiency at low temperatures; Goodman GSH13 Split System Heat Pump Product Specifications. ASHP curve based on NEEP Standards. Chart shows Brattle interpolation of the point ratings provided in the sources.

Electric Load Impacts of Fuel Switching

As customers switch fuel types, their electric peak impact varies based on a few key factors:

- **Current fuel**: Customers that currently heat with fossil fuels add electric load after fuel-switching. Customers that already have electric heat reduce load when adopting heat pumps due to the higher efficiency.
- **Customer size** Larger customers have higher heating demands. Data shows that oil and natural gas customers, on average, have much larger homes than electric resistance heating customers.
- **Adopted electric equipment** impacts are highest for fuel-switching to electric resistance and lowest for customers that switch to GSHP (this study does not model any switching to resistance).

Impact of Fuel Switching on Electric Load (non-coincident peak)

Varies by current fuel and new equipment type

Current Fuel Type	Customer Size	Per-Customer Electrification Peak Impact (kW)				
		Electric Resistance	ASHP + Resistance Backup	Cold-Climate Heat Pump (ccASHP)	ASHP + Fossil Backup	Ground-Source Heat Pump (GSHP)
Liquid Fuels	Some of the largest customers currently heat their homes with liquid fuels. When these customers electrify, they have the largest electric impacts. (85.6 MMBTu/customer-yr heating service demand)	12.02	8.84	5.75	5.12	3.23
Natural Gas	The majority of residential customers heat their homes with natural gas and have average annual heating service demands of 59.1 MMBTu/customer-yr	8.34	6.13	3.99	3.53	2.24
Electric Resistance	Homes that currently use electric resistive heating tend to be smaller. Resistive heat being replaced by heat pumps reduces load. (25.1 MMBTu/customer-yr heating service demand)	--	-0.93	-1.84	-2.03	-2.58

Notes: Peak impacts shown are for single family homes in BGE. Other utility impacts vary slightly based on differences in customer heating demands. Impacts shown are the non-coincident peaks of the heating equipment only. ASHP + fossil backup has no electric peak impact during the coldest hours of the year, when it relies fully on backup equipment to heat the home.

4 – Transportation Sector Assumptions and Inputs

Calibrating to MD's Current EV Stock

The starting point for EV penetration is based on the best available data from public data sources

- LDV EV stock from MD DOT MVA Electric Vehicle Registration Data; allocated utilities based on zip code mapping
- MHDV starting stock based on the Maryland Open Data Portal registration data
  - Majority of existing MHDV EVs are electric school buses and passenger buses
- We assume all 91 existing EV school buses are in Pepco service territory
  - 86 school buses are currently in operation at 5 Montgomery County Public School Bus Depots. Montgomery County covers three utilities (mainly served by PEPCO)
  - An additional 240 buses are to be added by the end of the 2024-2025 school year
- We assume all 20 existing EV passenger buses are in BGE service territory
  - 7 battery electric buses deployed in early 2023 through MDOT MTA's first pilot ZEB program, at MTA Kirk Avenue Bus Division (served by BGE)

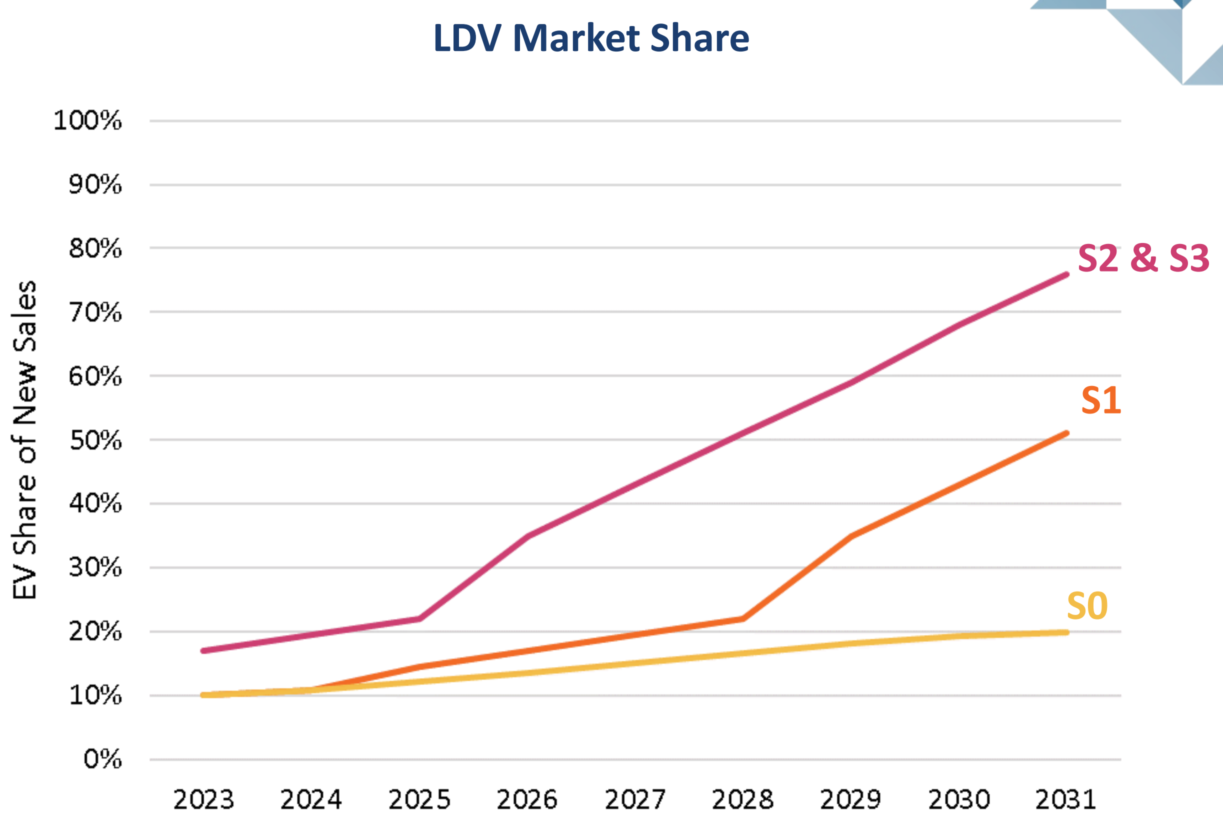
Assumed Electric Vehicle Starting Stock by Utility

	BGE	DPL	PEPCO	PE	Choptank	SMECO	In-Scope MD
LDV-BEV	18,394	1,103	13,950	4,211	301	1,735	39,694
LDV-PHEV	9,476	568	7,186	2,169	155	894	20,448
Class 2b-3 Light Truck	-	-	-	-	-	-	-
Class 4-8 Truck	20	-	-	-	-	-	20
Class 7-8 Tractor Trailer	2	-	-	-	-	-	2
School Bus	-	-	91	-	-	-	91
Total LDV	**27,870**	**1,671**	**21,136**	**6,380**	**456**	**2,629**	**60,142**
Total MHDV	**22**	**-**	**91**	**-**	**-**	**-**	**113**

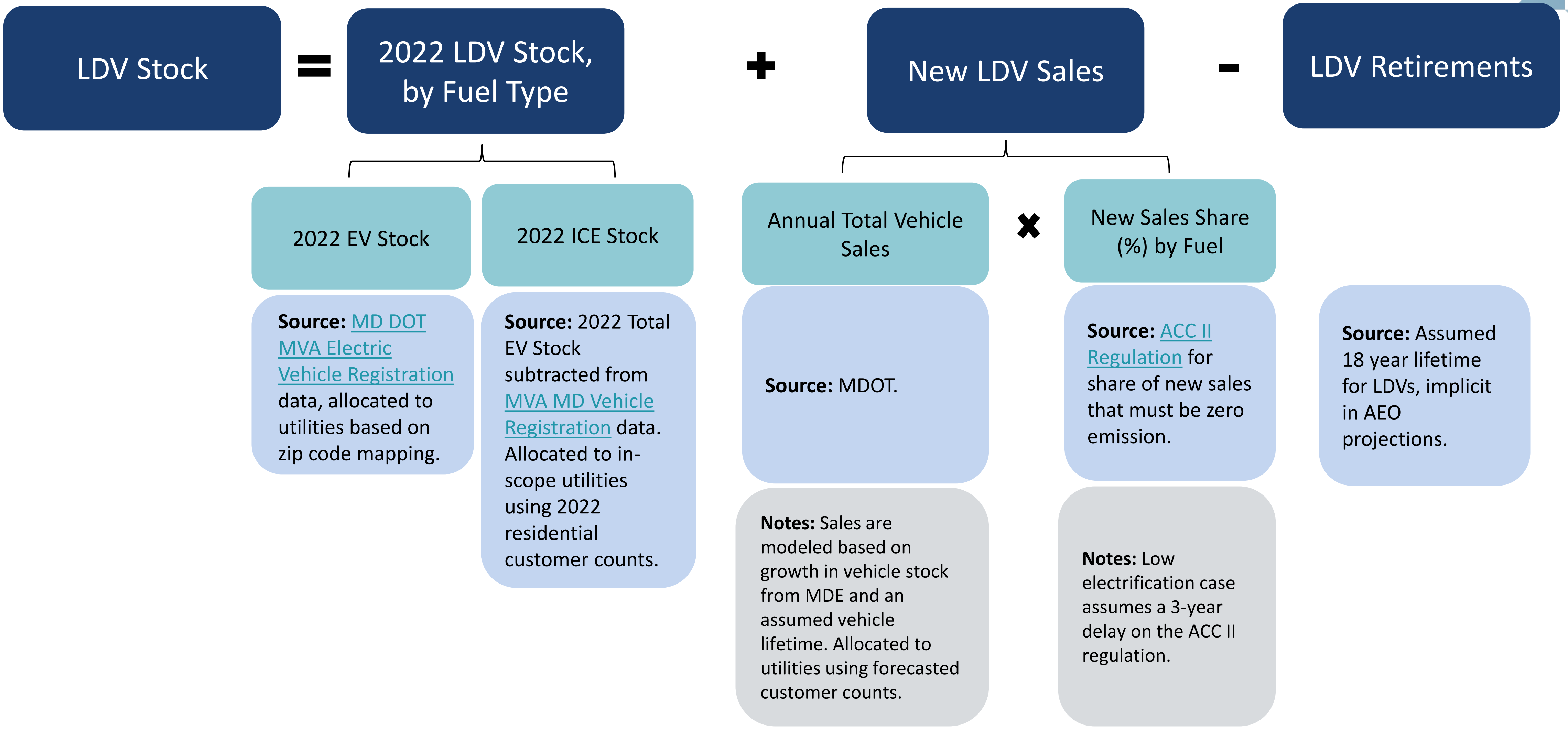
LDV Adoption Curves

Because the scope of the study is more focused on studying the electrification of the building sector, we keep the same EV adoption curve in all S.2 and S.3 scenarios

- **S.2 and S.3 (Decarb. Scenarios):** Assume the standards set in the Advanced Clean Cars II (ACC II) regulation are met
  - 76% EV share of new sales by 2031
  - 1.0M EV LDVs on the road by 2031, or 22% of vehicles
- **S.1 (Low Electrification):** Based on annual EV sales growth rate from EIA Annual Energy Outlook for 2023-2025; assumes the ACC II standards are met with a 3-year delay for 2026-2031
  - 51% EV share of new sales by 2031
- **S.0 (Reference):** Based on annual EV sales growth rate from EIA Annual Energy Outlook 2023



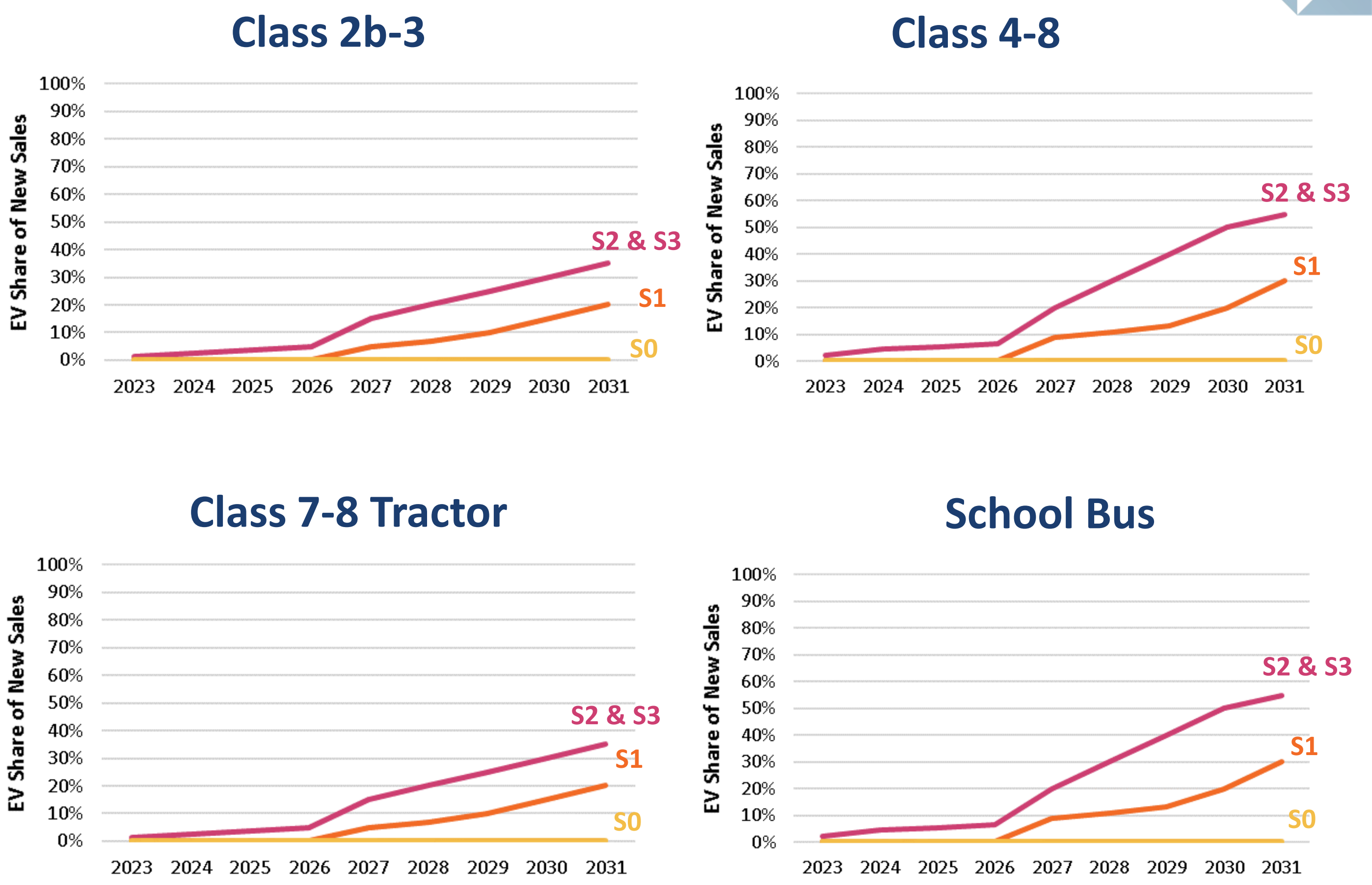
LDV Adoption Modeling Methodology and Data Sources



MHDV Adoption Curves

Because the scope of the study is more focused on studying the electrification of the building sector, we keep the same EV adoption curve in all S.2 and S.3 scenarios

- **S.2 and S.3 (Decarb. Scenarios):** Assumes the standards set in the Advanced Clean Trucks (ACT) regulation are met
  - 35% to 55% EV share of new sales by 2031 (varies by vehicle class)
  - Because MD's adoption of the ACT only starts in 2027, we set 2024-2026 EV penetration at half the level prescribed in the ACT. 2023 is interpolated between 2022 actuals and projected 2024
- **S.1 (Low Electrification):** Assumes the ACT standards are met with a 3-year delay
  - 20-30% EV share of new sales by 2031
- **S.0 (Reference):** Based on annual EV sales growth rate from EIA Annual Energy Outlook 2023



MHDV Adoption Modeling Methodology and Data Sources

MHDV Stock = 2022 MHDV Stock, by Fuel Type & Class + New MHDV Sales by Class - MHDV Retirements by Class

2022 MHDV Stock, by Fuel Type & Class:

- 2022 EV Stock
  - **Source:** MDOT Electric Vehicle Registrations by Classification.
  - **Notes:** We allocate all existing electric school bus stock to PEPCO and all electric transit bus and tractor stock to BGE, due to news announcements.
- 2022 ICE Stock
  - **Source:** MDOT.
  - **Notes:** MHDV stock taken directly from MDOT dataset. Maryland-level data scaled to utility-level based on county level diesel consumption.

New MHDV Sales by Class = Annual Total Vehicle Sales × New Sales Share (%) by Fuel

- Annual Total Vehicle Sales
  - **Source:** MDOT.
  - **Notes:** Sales are modeled based on growth in vehicle stock from MDOT and an assumed vehicle lifetime.
- New Sales Share (%) by Fuel
  - **Source:** Advanced Clean Trucks Act starting in 2027.
  - **Notes:** Low electrification case assumes a 3-year delay on the ACT regulation.

MHDV Retirements by Class

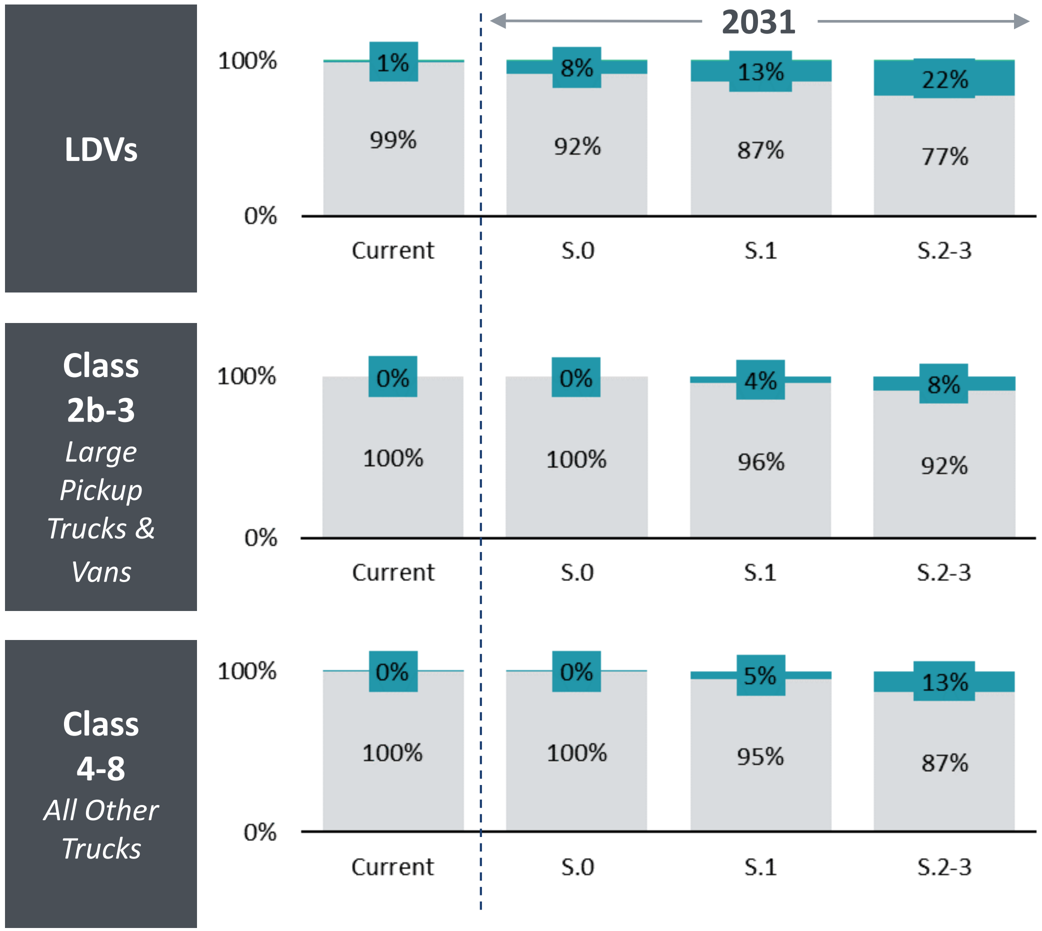
- **Assumption:** 18 year lifetime. No advanced retirements

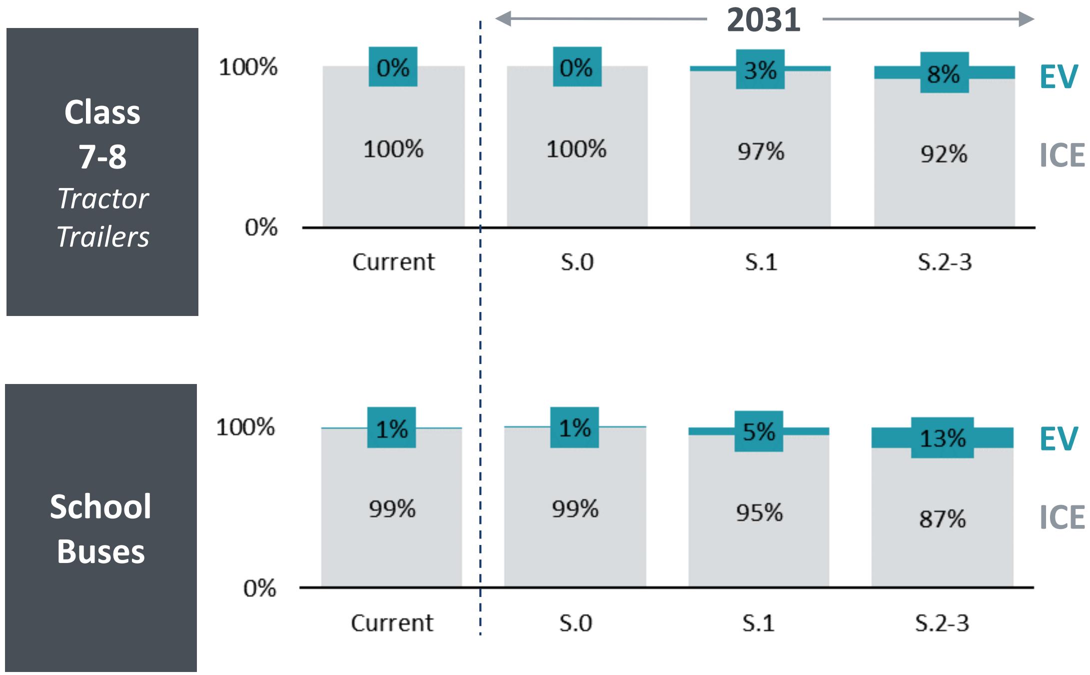
EV Penetration Scenarios - Statewide

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Electric Vehicle Penetration by Weight Class, *% of on-road vehicles*

Charts show state level data – inter-utility variation is negligible





LDV = light-duty vehicle, EV = electric vehicle, ICE = internal combustion engine

EV Penetration Scenarios by Utility

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Electric Vehicle Stock by Weight Class, *# of on-road electric vehicles*

2031 Electric Vehicle Stock						
Vehicle Class	BGE	Choptank	DPL	PEPCO	Potomac Edison	SMECO
S.0						
LDV	203,868	8,058	29,414	98,425	44,695	28,045
Class 2b-3	161	4	24	80	49	14
Class 4-8	82	2	11	36	22	6
Class 7-8	18	0	3	9	5	2
School Bus	6	0	1	48	2	1
S.1						
LDV	325,850	13,070	47,713	155,237	71,722	45,545
Class 2b-3	4,145	103	610	2,045	1,254	367
Class 4-8	3,347	83	491	1,647	1,010	295
Class 7-8	550	14	81	271	166	49
School Bus	270	7	40	179	82	24
S.2 - S.3						
LDV	560,459	22,735	82,995	263,910	123,144	78,692
Class 2b-3	9,802	243	1,442	4,836	2,966	867
Class 4-8	8,525	211	1,253	4,201	2,576	753
Class 7-8	1,306	32	192	644	395	116
School Bus	688	17	101	385	208	61

Vehicle miles traveled (VMT) Forecast

Electric vehicle load impacts are quantified based on stock forecasts and annual VMTs

- VMT forecasts based on MDOT forecast
- LDV VMTs are allocated to utilities based on residential customer counts
- MHDV VMTs are allocated to utilities based on county shares of state diesel fuel sales and county-to-utility mapping

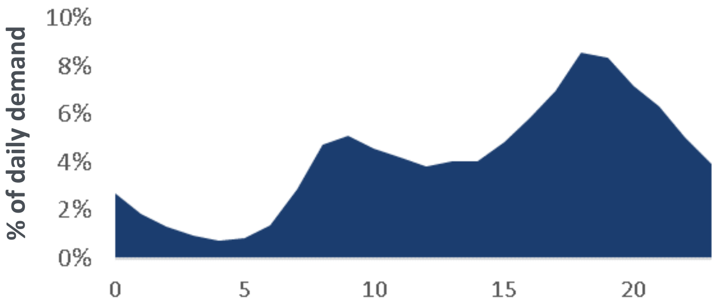
Projected VMT in Maryland by Vehicle Category (million miles)

Vehicle Category	2022 VMT (million miles)	2031 VMT (million miles)	CAGR (%)
Light-Duty Vehicles	47,959	52,009	0.90%
Class 2b-3 Light Truck	2,861	3,159	0.98%
Class 4-8 Truck	1,796	1,975	0.94%
Class 7-8 Tractor Trailer	2,310	2,541	0.95%
School Bus	220	239	0.85%

Sources and Notes:
MDOT-provided VMT forecast.

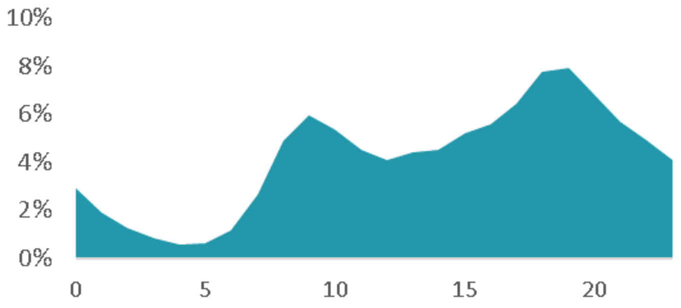
Electric Vehicle Load Shapes

LDV-BEV



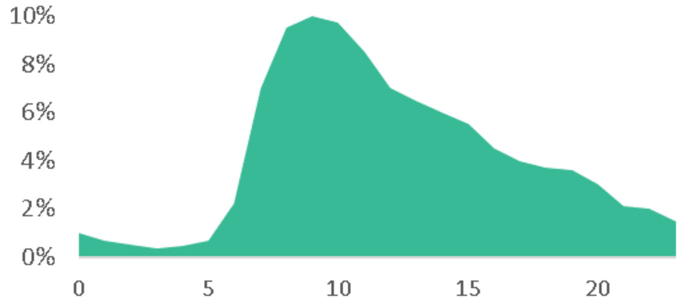
Source: EVI Pro-Lite

LDV-PHEV



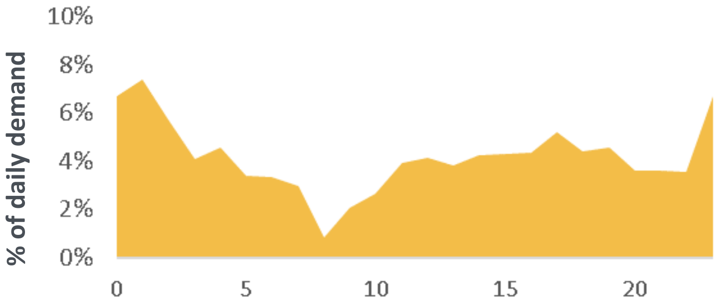
Source: EVI Pro-Lite

Class 2b-3



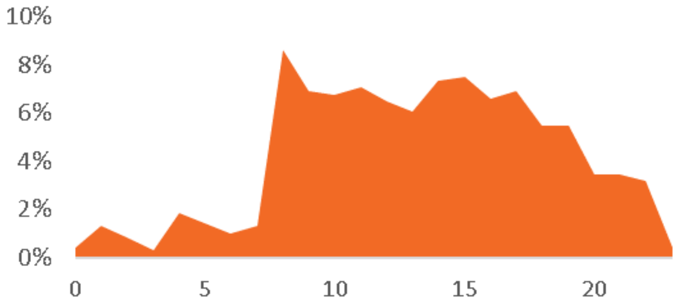
Source: California Load Shapes Report
Notes: We assume the commercial LDV load shape is representative of this vehicle class.

Class 4-8 Truck



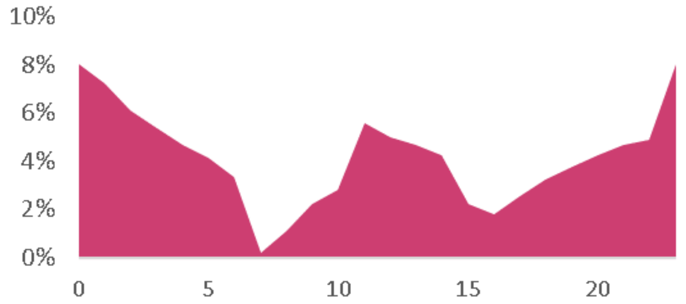
Source: 2023 ICCT Report
Notes: The profile is an aggregated profile of all class 4-8 trucks. The ICCT report utilized the HEVI-LOAD tool which is the same tool used in the California reports.

Class 7-8 Tractor Trailer



Source: 2021 California Report
Notes: Specifically, the tractor-trailer load shape is used for this category.

School Bus



Source: 2021 California Report
Notes: Specifically, the school bus load shape is utilized.

Profiles show natural charging profiles, without any utility TOU or programs to incentivize off peak charging.

5 – Distributed Energy Resources and Demand Side Management Inputs

Distributed Energy Resource Penetration

Distributed (i.e., behind-the-meter) solar and storage growth in all scenarios is based on results from the Power Plant Research Program (PPRP) 100% RPS Study BAU Case

- The current capacity is also sourced from the PPRP study for consistency
- We use the same solar projection in all scenarios, including Reference and Low Electrification, because the RPS achievement trajectory is consistent with the level of annual solar adoption already occurring
- BAU and High EE and load flexibility cases have the same BTM solar and storage assumptions
  - Storage capacity in the BAU case does not impact load since none of the utilities currently have a storage DR program
  - Only a portion of distributed storage is assumed to participate in utility programs based on achievable program participation

Distributed Solar Capacity by Utility (MW)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
All Scenarios										
BGE	610	650	692	736	804	875	947	1,022	1,099	1,159
DPL	71	76	81	86	94	103	111	120	129	136
Potomac	118	126	134	143	156	170	184	198	213	225
PEPCO	306	326	348	369	404	439	476	513	552	582
SMECO	78	83	88	94	103	112	121	130	140	148
Choptank	21	22	24	25	28	30	33	35	38	40
MD Total	**1,204**	**1,285**	**1,368**	**1,453**	**1,589**	**1,728**	**1,872**	**2,020**	**2,172**	**2,290**

Distributed Storage Capacity by Utility (MW)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
All Scenarios										
BGE	20	23	27	30	37	219	238	259	260	262
DPL	2	3	3	4	4	26	28	30	31	31
Potomac	4	5	5	6	7	42	46	50	51	51
PEPCO	10	12	14	15	19	110	119	130	131	132
SMECO	3	3	3	4	5	28	30	33	33	33
Choptank	1	1	1	1	1	8	8	9	9	9
MD Total	**40**	**46**	**54**	**59**	**73**	**432**	**469**	**511**	**514**	**518**

Source: 100% RPS Study

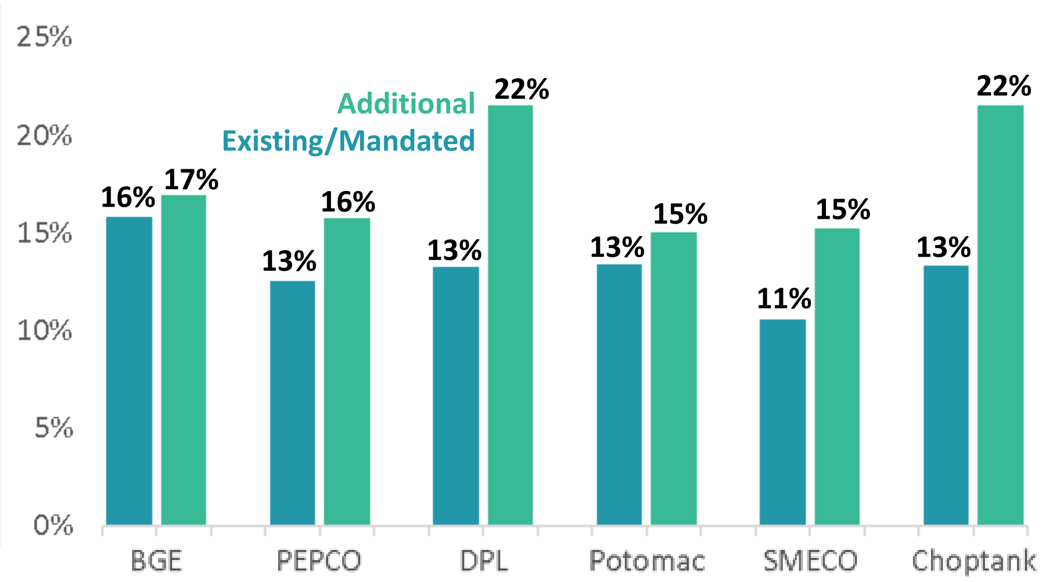
Energy Efficiency Assumptions

Energy efficiency assumptions are based on the EmPOWER 2024-2026 program cycle plans filed by the utilities in August

- **Existing/Mandated DSM Programs Case:** We map the BAU Case to utilities' filed "2023 Scenario", which was defined based on current EE programs and current statutory requirements
- **Additional DSM Programs Case:** We map the High Case to utilities' filed "Maximum Achievable Scenario", which was defined as the set of programs and measures that result in maximum savings at a higher spending level
- We remove all heating and cooling related programs from EE accounting as efficiency improvements for those end uses are accounted for within our model
- We assume Choptank EE deployment is comparable to DPL's as Choptank is not an EmPOWER utility

Energy Efficiency Assumptions

2031 EE as % of 2022 Actual Consumption



Source: August 1st, 2023 utility filings in Case No. 9705

Load Flexibility Participation Assumptions

Electric utilities can reduce electrification peak load growth impacts by deploying load flexibility programs:

- Existing/Mandated DSM Programs Case assumes existing load flexibility programs continue, without growth
- Existing utility load flexibility impacts are accounted for in Ten Year Plan forecasts sourced from utilities
- Additional DSM Programs Case assumes growth in existing program participation and deployment of new Demand Response (DR) programs, representing advanced but achievable deployment
- Additional DSM Programs Case participation ramps up from current levels (low for most utility programs) to end state participation by 2031, following S-curve adoption
- Program impact assumptions are based on existing MD programs and pilot data when applicable, or data from other jurisdictions, tailored to MD customer characteristics. See following slides for more information

Load Flexibility Participation Assumptions

Additional DSM Programs Case participation ramps up from current levels (low for most utility programs) to end state participation by 2031, following S-curve adoption

Program	Description	Existing Participation	Additional Case Participation
Residential			
Time-of-use (TOU)	Time varying pricing signals, consistent with proposed utility rates	0%	15%
Peak time rebate (PTR)	Residential customers reduce load during called event hours	BGE, Pepco, DPL: 90% (assume limited use of the program and that impacts are not reflected in utility forecasts) SMECO, Choptank, Potomac Edison: 0%	90%
Smart thermostat	Customers reduce cooling or heating load by adjusting thermostats during utility called events (<20/yr)	Summer: BGE (28%, 342,000 customers); Pepco (38%, 206,012 customers); DPL (20%, 33,844 customers); SMECO, Choptank, Potomac Edison (0%) Winter: 0% for all utilities	Summer (~+25%pt from existing): BGE (55%); Pepco (65%); DPL (45%); SMECO, Choptank, Potomac Edison (25%) Winter: 25% for all utilities
Smart water heating	Customers shift heat water during off peak hours on a frequent (daily) basis	0%	30%
Commercial			
Smart thermostat	Small commercial customers reduce cooling or heating load by adjusting thermostats during utility called events (<20/yr)	0%*	25%
Automated demand response (DR) – HVAC	Automated control of customer heating and cooling demand. Only applicable to large (Covered) customers	0%	10%
Interruptible tariff	Large customers (Covered) reduce load during called events. Events are infrequent (<10/yr)	0%	15%
Additional Programs			
Managed electric vehicle charging	Customers are incentivized to charge in off peak hours and shift EV load out of daily peak periods	0%	30% (all vehicle classes)
Behind-the-meter battery storage	Utilities can call on batteries to charge and discharge during event hours (70 events/yr). Assume only a portion of BTM storage capacity from the PPRP study enrolls in utility programs	0%	30% of BTM storage capacity

*Note: Pepco and DPL have commercial smart thermostat programs, but participation is negligible. Participation expressed as % of eligible customers.

Load Flexibility Program Impact Assumptions

Program impacts are modeled on a per-participant basis. See following slides for assumption justifications

Program	% of Load Shifted	# of Hrs Shifted from	# of Hrs Shifted to
Residential			
Time-of-use (TOU)	10% (summer); 5% (winter)	5 (summer); 3 (winter)	7 (summer); 8 (winter)
Peak time rebate (PTR)	5%	3	5
Smart thermostat	60% (cooling); 20% (heat pump space heating); 40% (electric resistance space heating)	3	6
Smart water heating	Modeled by shifting water heating load out of system peak windows. Maximum impact is 50% of hourly water heating load shifted out of peak hours	8	16
Commercial			
Smart thermostat	20% (cooling); 5% (heat pump space heating); 10% (electric resistance space heating)	3	6
Automated demand response (DR) – HVAC	60% (cooling); 15% (heat pump space heating); 30% (electric resistance space heating)	3	6
Interruptible tariff	20%	3	0
Additional Programs			
Managed electric vehicle charging	Modeled by shifting charging load out of system peak windows. Maximum impact is 50% of hourly vehicle charging load (on average, across all vehicles) shifted out of peak hours	6	18
Behind-the-meter battery storage	Impacts modeled at aggregate level. Maximum per customer impact is per customer battery storage capacity	4	7

Notes: '% of Load Shifted' refers to the percent of applicable end use load that is curtailed during each load flexibility event.

Load Flexibility Sources Considered

Program impacts are based on MD programs and pilot data when applicable, or data from other jurisdictions, tailored to MD customer characteristics

Program	Sources Considered
Residential	
Time-of-use (TOU)	Impacts based on Maryland PC44 Time of Use Pilots: End-of-Pilot Evaluation
Peak time rebate (PTR)	Impacts based on Brattle's database of time-varying pricing offerings, Arcturus 3.0
Smart thermostat	Impacts based on Brattle review of third-party reports analyzing thermostat DR operations: CenterPoint, Cadmus (2022); Indianapolis Power & Light, Cadmus (2020); KCP&L, Navigant (2017); PGE 2017/2018 electric BYOT program; Michigan electric DR potential study; ACEE study of DR for electric baseboard heating in Quebec; Pepco DR Electrification Study (FC 1167)
Smart water heating	Assumptions for grid interactive water heating and static timed water heating are derived from studies, for example, Ryan Hledik, Judy Chang, and Roger Lueken. "The Hidden Battery: Opportunities in Electric Water Heating." January 2016
Commercial	
Smart thermostat	Impacts based on Brattle review of third-party reports analyzing thermostat DR operations: CenterPoint, Cadmus (2022); Indianapolis Power & Light, Cadmus (2020); KCP&L, Navigant (2017)
Automated demand response (DR) – HVAC	The potential for C&I customers to provide around-the-clock load flexibility was primarily derived from data supporting a 2017 statewide assessment of DR potential in California, a 2013 LBNL study of DR capability, and electricity load patterns representative of C&I buildings developed by the U.S. Department of Energy
Interruptible tariff	Impacts based Brattle analysis of FERC data on utility DR programs in other jurisdictions
Additional Programs	
Managed electric vehicle charging	The ability to curtail charging load is guided by a review of utility EV charging DR pilots, including managed charging programs at several California utilities (PG&E, SDG&E, SCE, and SMUD) and United Energy in Australia
Behind-the-meter battery storage	Impacts based on full dispatch of behind-the-meter battery with assumed average capacity of 5 kW / 15 kWh

6 – Emissions and Gas Consumption Results

Calibrating Emissions to MDE Climate Pathway

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

2031 Maryland[1] Total Fuel Consumption and Emissions from Building Sector Space and Water Heating

		S.0	S.1	S.2A	S.2B	S.3A	S.3B	MDE Climate Pathway
Fuel Consumption *Million MMBTU*	**Gas**	94.9	91.5	80.8	63.1	61.7	61.7	76.4
	Liquid Fuels	27.2	25.5	22.1	19.1	18.9	18.9	14.6
	Total Fossil	122.1	116.9	102.9	**82.2**	**80.6**	**80.6**	**90.9**
	2022-2031 % Change	4.2%	-0.2%	-12.2%	**-29.8%**	**-31.2%**	**-31.2%**	**-30.1%**
Direct Emissions *Million Metric Tons CO_2e*	**Gas**	5.05	4.87	4.30	3.35	3.28	3.28	4.06
	Liquid Fuels	2.05	1.92	1.67	**1.44**	**1.43**	**1.43**	**1.01**
	Total Fossil	7.10	6.79	5.97	**4.80**	**4.71**	**4.71**	**5.07**
	2022-2031 % Change	4.1%	-0.5%	-12.5%	**-29.6%**	**-31.0%**	**-31.0%**	**-30.0%**

The High Electrification and Hybrid with Fuel Backup scenarios roughly match the MDE Climate Pathway's emission reductions from space and water heating.

Note: Tables include fuel and emissions from direct fossil fuel consumption for residential and commercial space and water heating. Total fossil liquids were modeled separately as oil and propane, and combined in tables above for comparison with MDE categories. MDE data is based on consumption by end use, customer type, and fuel type. Emissions are calculated from fuel consumption based on emission factors based on 20-year global warming potential from EPA (consistent with MDE's modeling).

1 Does not include out-of-scope utilities

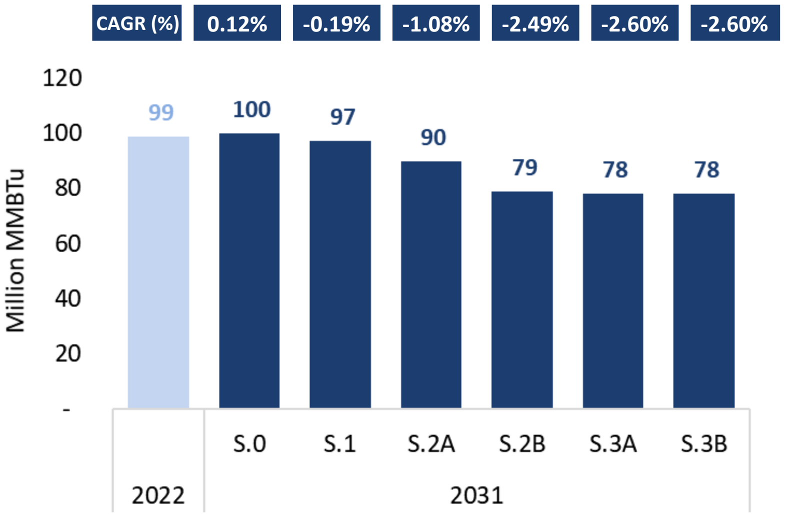
Gas Demand Impacts by Utility

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

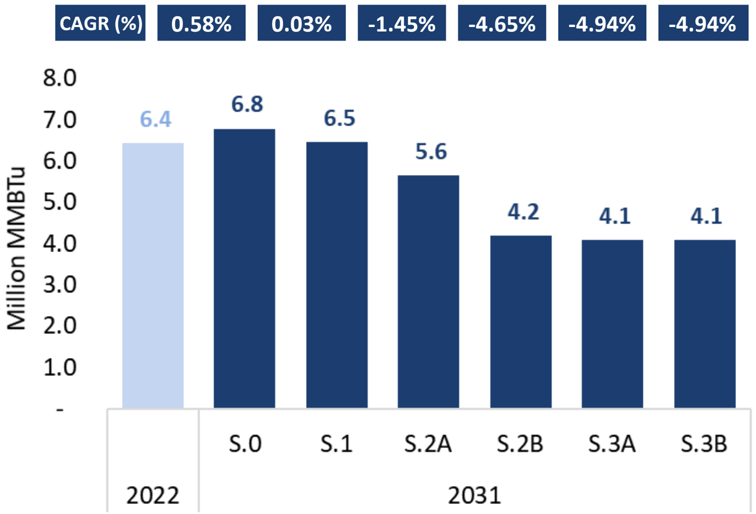
2022-2031 Annual Total Gas Demand by Scenario and Utility

Gas demand will decrease significantly in the high electrification scenarios

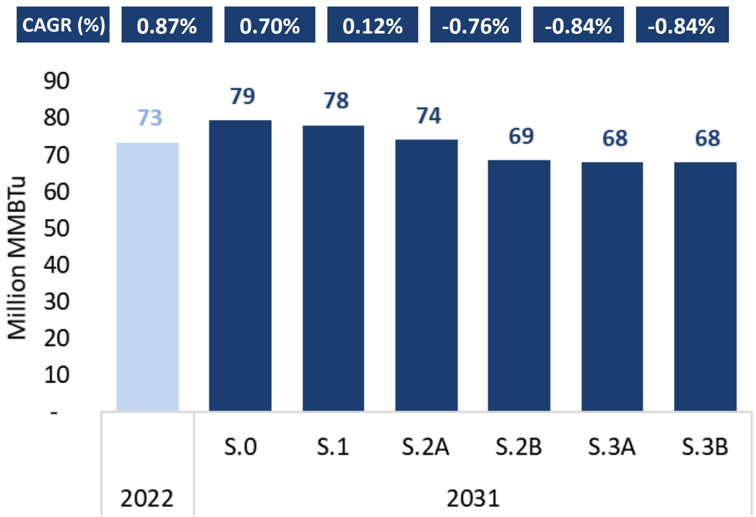
Total BGE Gas Demand



Total Columbia Gas Demand



Total WGL Gas Demand



Notes: 2022 and S.0 2031 natural gas demand are based on each utility's load forecast. Since WGL's forecast ends in 2027, Reference Case 2031 load was projected by Brattle based on WGL's forecasted 2020-27 load growth rate. 2031 natural gas demand in other scenarios is based on the modeled reduction in gas usage for space and water heating relative to S.0. None of the other end uses of natural gas (e.g., industrial) are assumed to change in this study.

7 – Existing/Mandated DSM Programs Case Results

Insights from Existing/Mandated DSM Programs Case Results

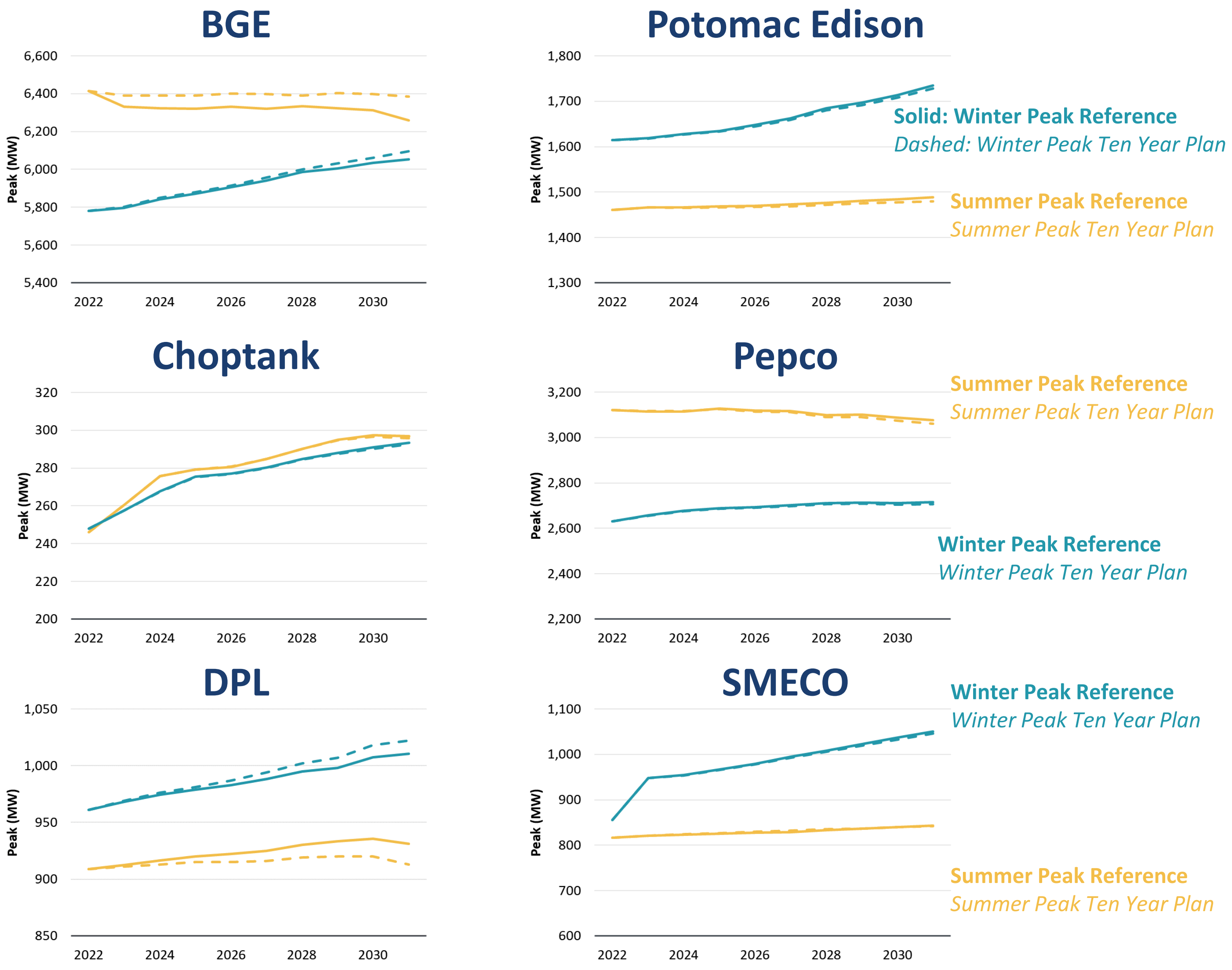
- There is a high degree of variation between utilities even in the **Reference Scenario**, which is based on utility Ten Year Plans and contain no assumed building electrification
  - We aligned utilities' EV and BTM solar forecasts, but did not make any other adjustments
  - **CAGRs range from -0.27% (BGE) to 2.30% (SMECO)** under the Reference case for 2022-2031 peak load growth
- **High Electrification with Legacy Tech (S.3B)** results in the highest load growth across utilities, as expected
  - **CAGRs range from 1.15% (Pepco) to 3.45% (SMECO)**
- **High Electrification with Best-in-Class Tech (S.3A)**, where most electrification was assumed to occur with cold climate heat pumps, shows significantly lower load growth than S.3B
  - **CAGRs range from 0.24% (Pepco) to 2.39% (SMECO)**
  - Note that these CAGRs show very limited additional load growth relative to what is already in the Reference scenario
  - This is due to the assumption that resistance heater sales (including resistance backup) will fall to zero by 2030; cold climate heat pumps are twice as efficient as resistance heat at 5F
- All summer peaking utilities **switch to winter peaking** by 2030 in S.3B
- **The Hybrid scenarios (S.2A and S.2B)** have significantly lower load growth than S.3B, but show negligible load differences (if any) relative to S.3A

Note: Business-as-Usual (BAU) energy efficiency (EE) and load flexibility assumes current EE and DR program impacts, consistent with utility forecasts

Utility Ten Year Plans and Reference Scenario

We develop the Reference Scenario for this study from the 2022 Ten Year Plan filings

- Because each utility had different assumptions in their Ten Year Plan load forecasts, we made adjustments to align the utility forecasts for the Reference Scenario
  - Distributed solar forecasts adjusted to be consistent with RPS achievement trajectory (and PPRP study) across utilities
  - EV forecasts adjusted to follow the EIA Annual Energy Outlook trajectory and align all utility forecasts in the reference scenario; largest impact on BGE because we assume EIA growth, which is less aggressive than their Ten Year Plan assumptions
- Other than the above changes implemented to create a consistent comparison case, the Reference Scenario is the same as the Ten Year Plan forecasts
  - Pepco and BGE forecast a slight peak decline by 2031
  - Choptank and SMECO model >1.0% annual peak growth through 2031



Note: Choptank is not forecasted in Ten Year Plan and is instead compared to the utility-provided forecast. Chart axes differ across utilities and do not start a zero. In the charts above, Ten Year Plan forecasts are represented as dashed lines and solid lines are the Reference Case in this study. Summer peaks are shown in yellow and winter peaks in blue.

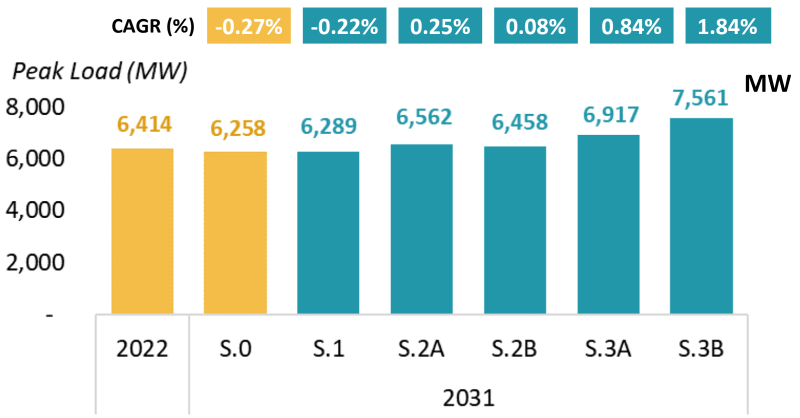
Summary of Results by Utility and Scenario

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

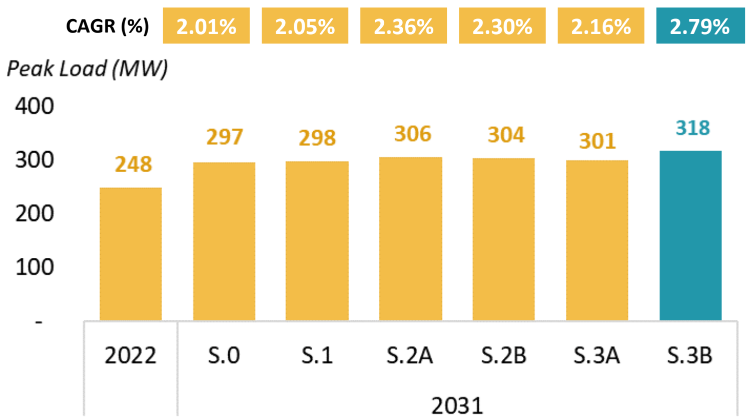
2022-2031 Peak Load Growth by Scenario

*Utilities that are currently **summer peaking** become **winter peaking** in some scenarios, with **Existing/Mandated DSM***

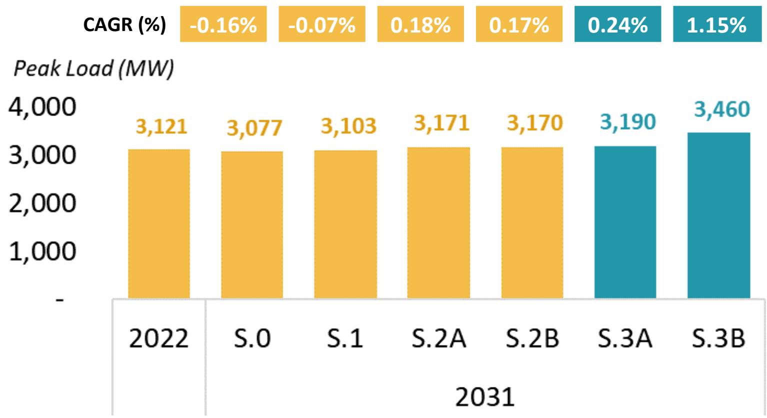
BGE



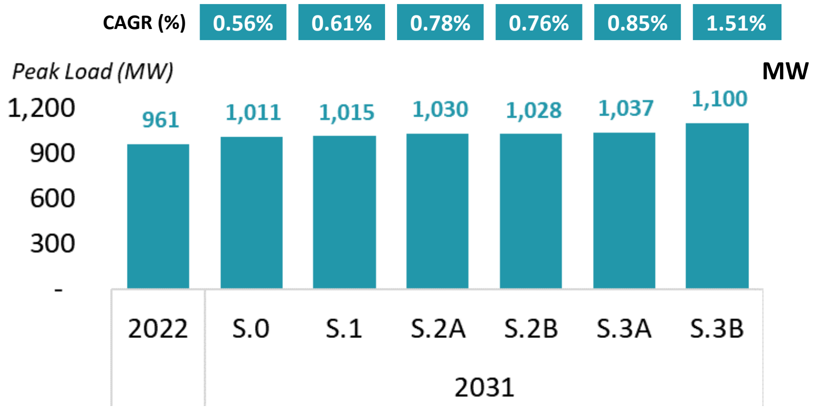
Choptank



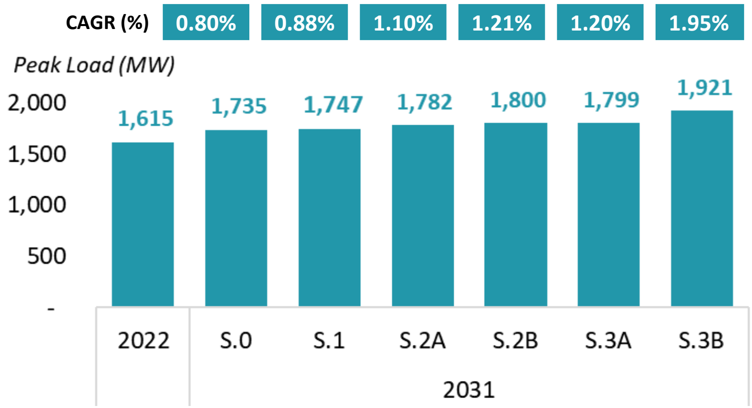
Pepco



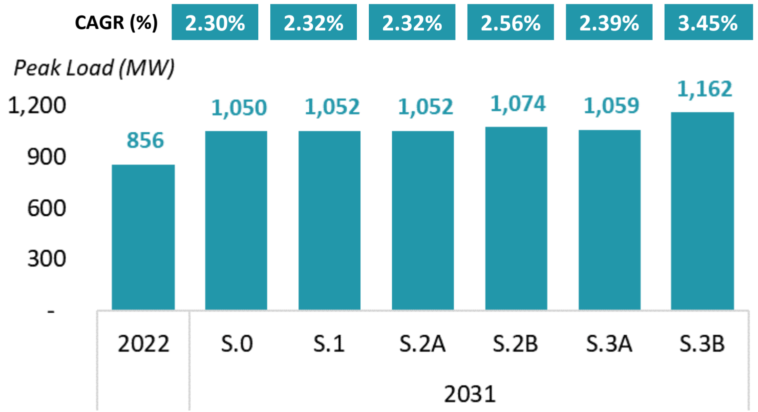
DPL



Potomac Edison

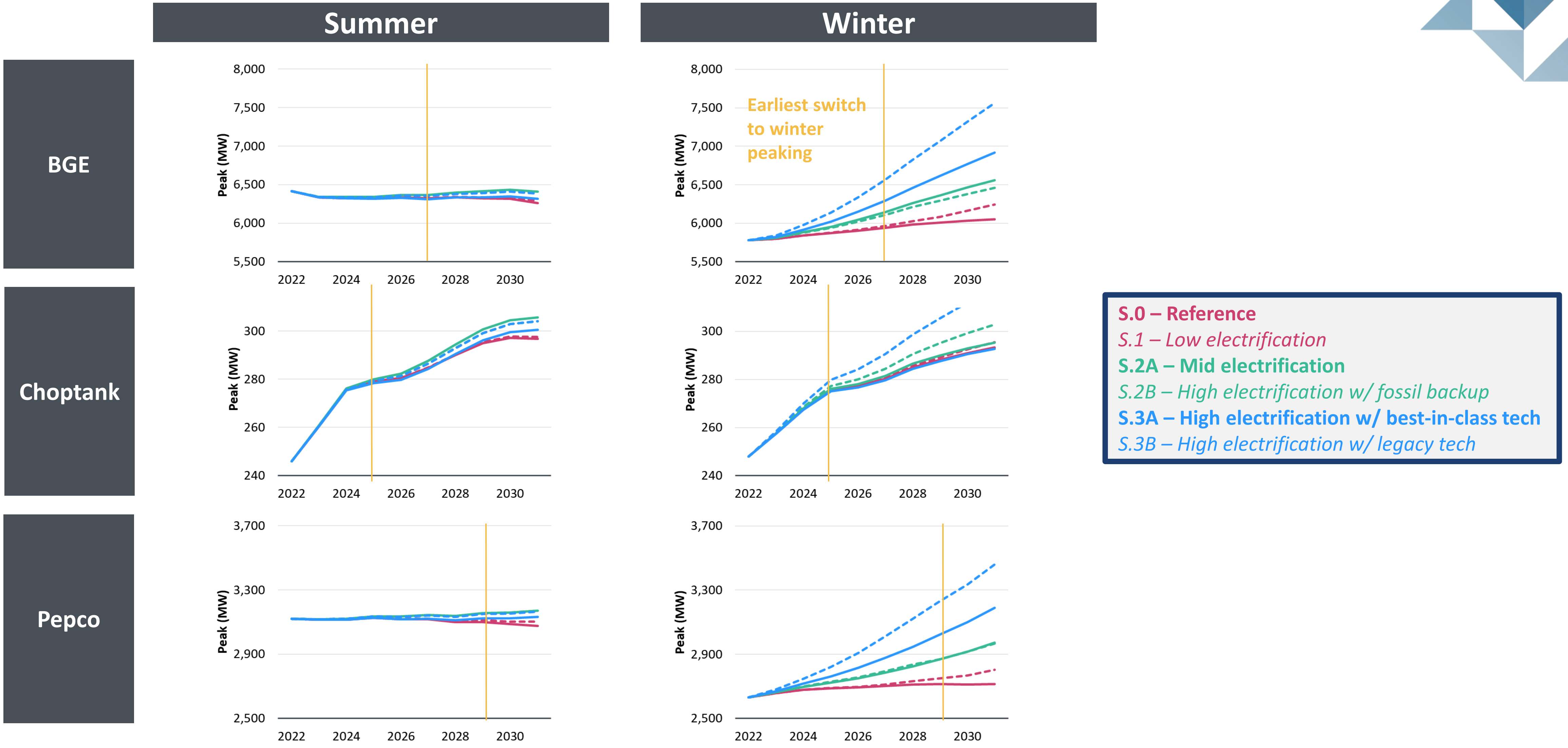


SMECO



Notes: Y-axis scales differ across charts. 2022 peak load is sourced from 2022 Ten Year Plan or utilities directly.

Summer and Winter Load Growth



Vertical axis scale differs across charts.

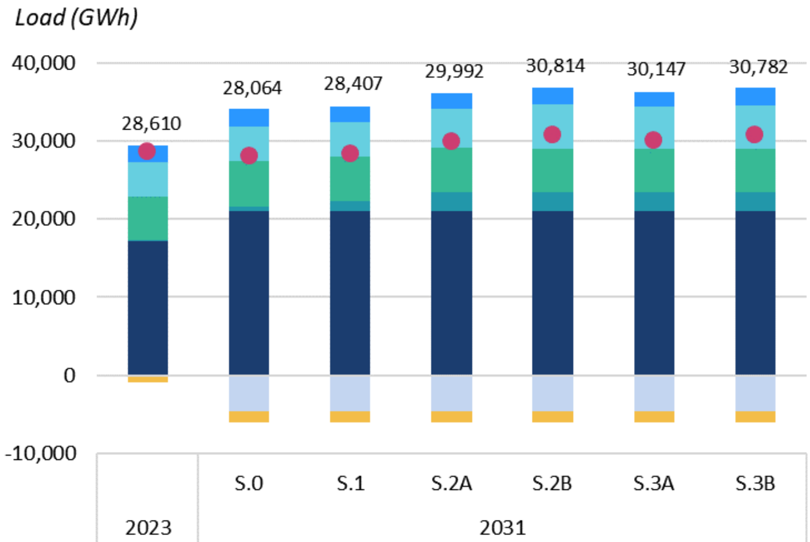
Annual Energy Consumption by End Use

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

2023-2031 Annual Electricity Consumption by End Use, *GWh*

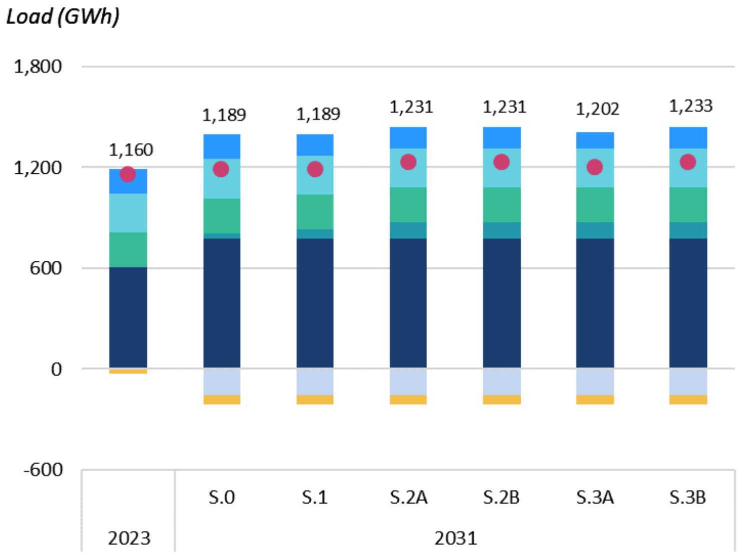
BGE

CAGR	-0.24%	-0.09%	0.59%	0.93%	0.66%	0.92%



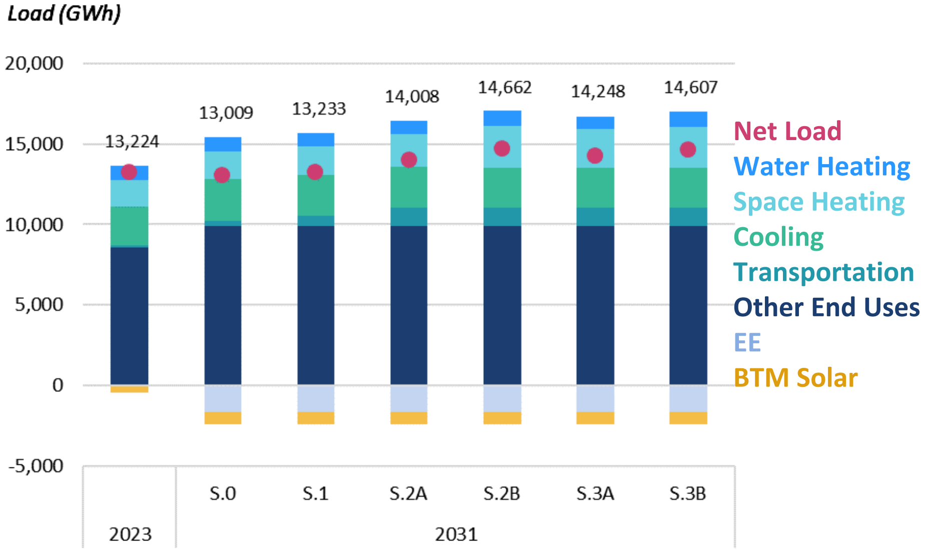
Choptank

CAGR	0.31%	0.31%	0.75%	0.74%	0.45%	0.76%



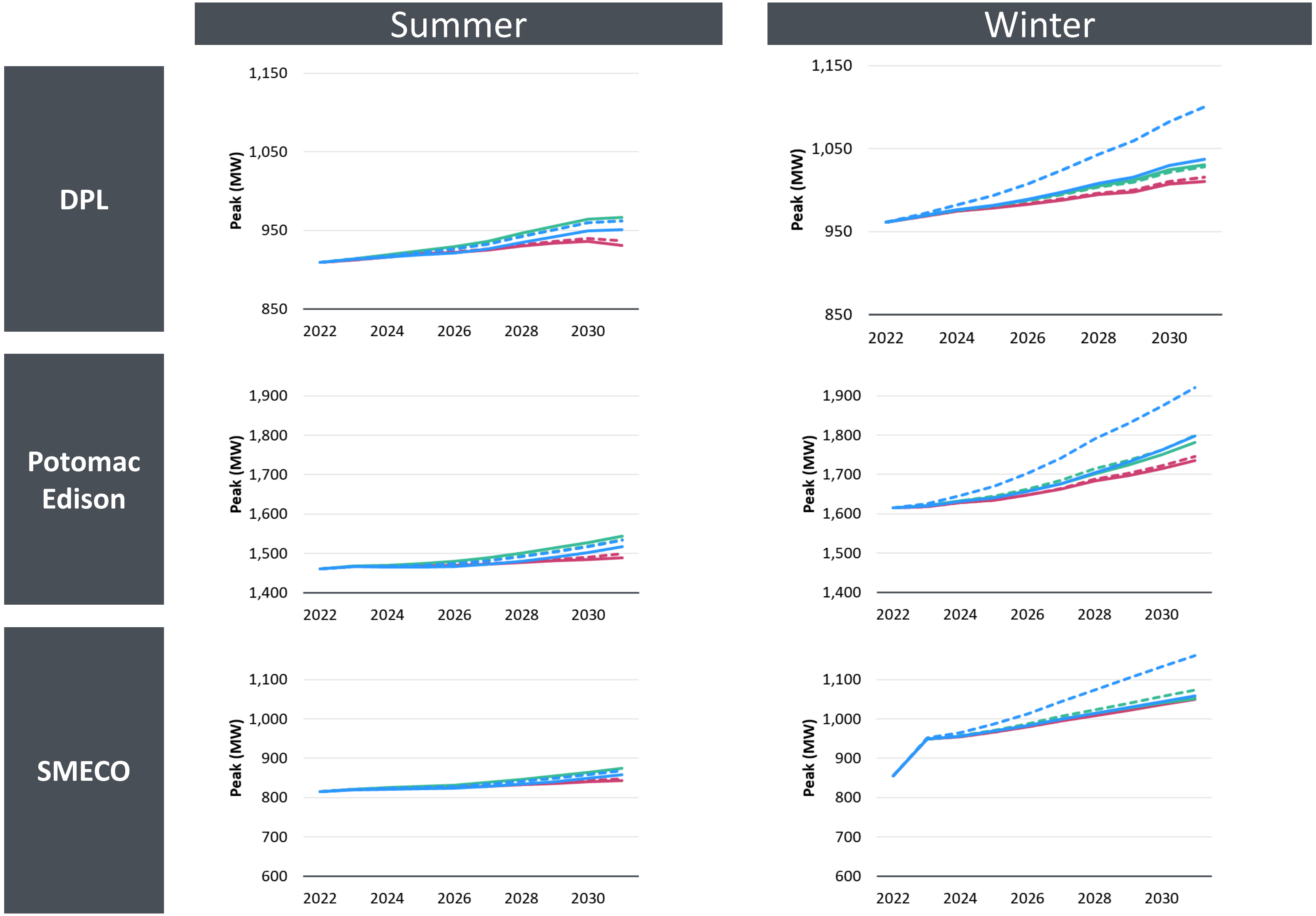
Pepco

CAGR	-0.20%	0.01%	0.72%	1.30%	0.94%	1.25%



Notes: Vertical axis scale differs across charts.

Summer and Winter Load Growth



S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

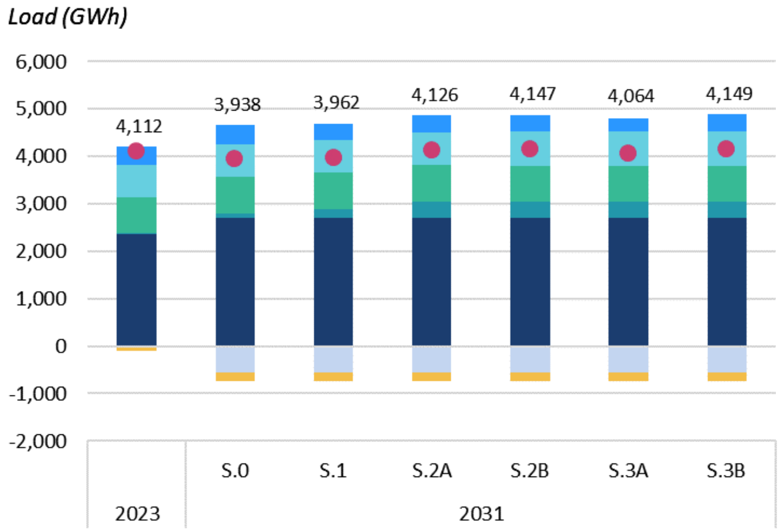
Note: In the Ten Year Plan, SMECO forecasts a 92 MW increase in winter peak load from 2022 to 2023. Vertical axis scale differs across charts.

Total Annual Energy

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

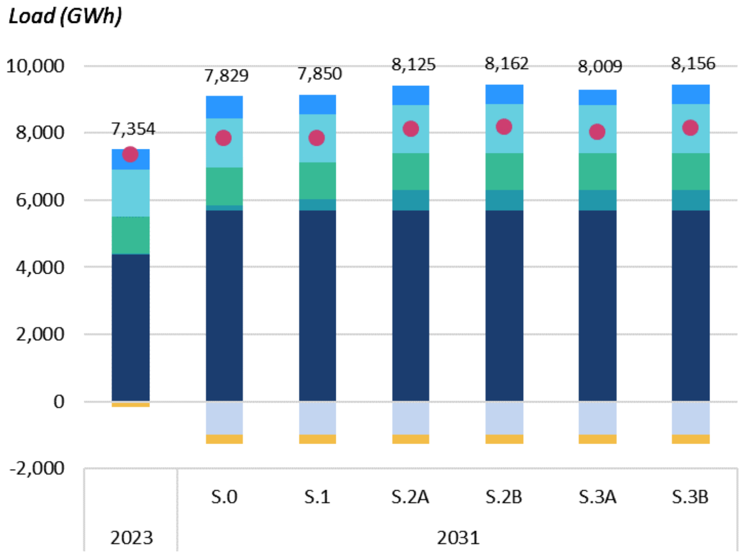
DPL

CAGR	-0.54%	-0.46%	0.04%	0.10%	-0.15%	0.11%



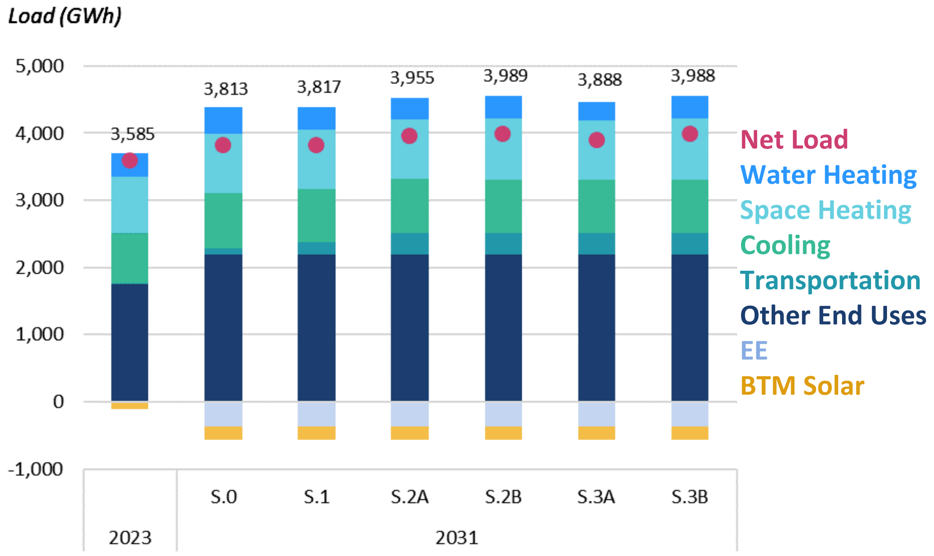
Potomac Edison

CAGR	0.79%	0.82%	1.25%	1.31%	1.07%	1.30%



SMECO

CAGR	0.78%	0.79%	1.24%	1.35%	1.02%	1.34%



Notes: Vertical axis scale differs across charts.

8 – Additional DSM Programs Case Results

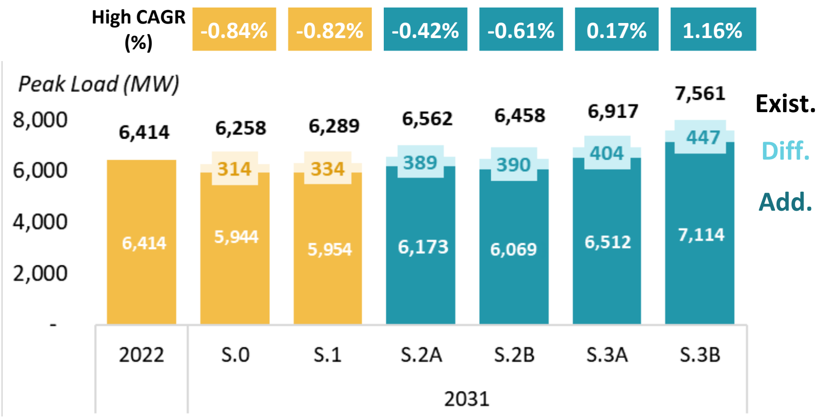
Summary of Results by Utility and Scenario

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

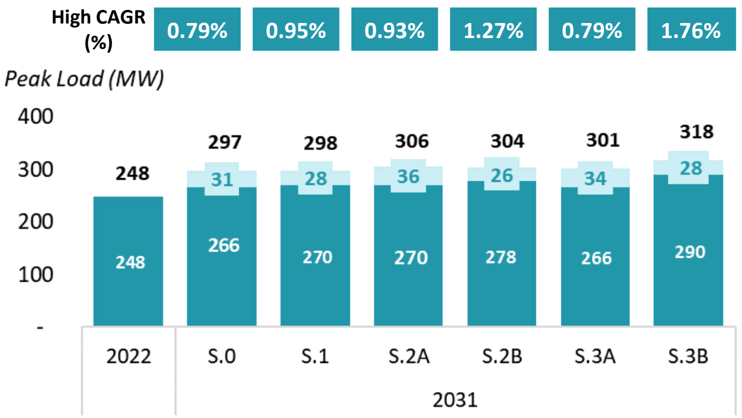
2022-2031 Peak Load Growth by Scenario

*Utilities see less **summer** and **winter** peak load growth with **Additional DSM** than in the Existing/Mandated DSM Cases*

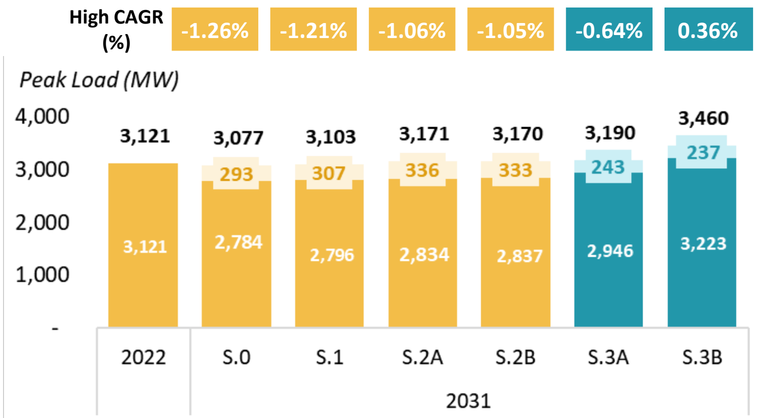
BGE



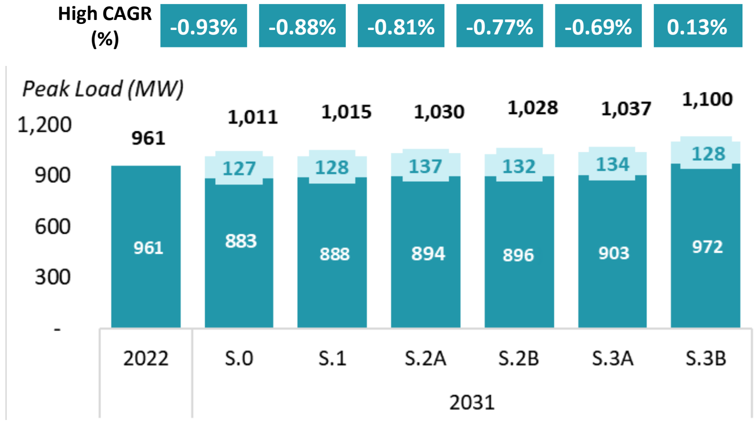
Choptank



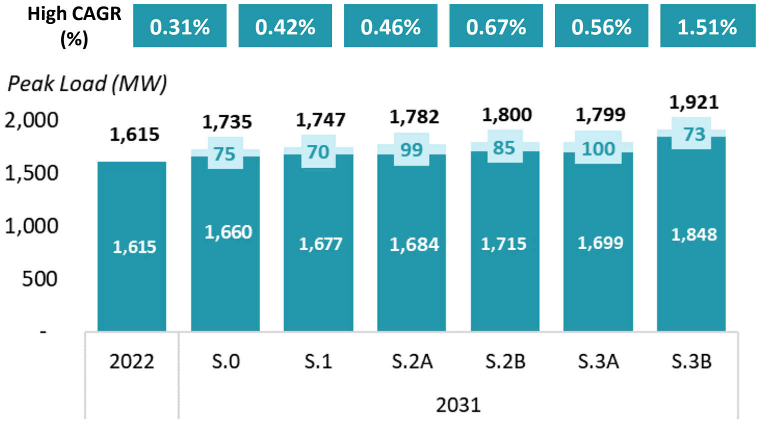
Pepco



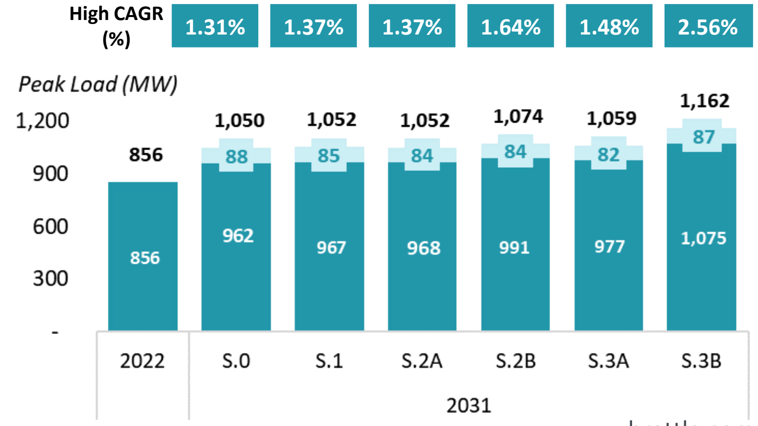
DPL



Potomac Edison



SMECO



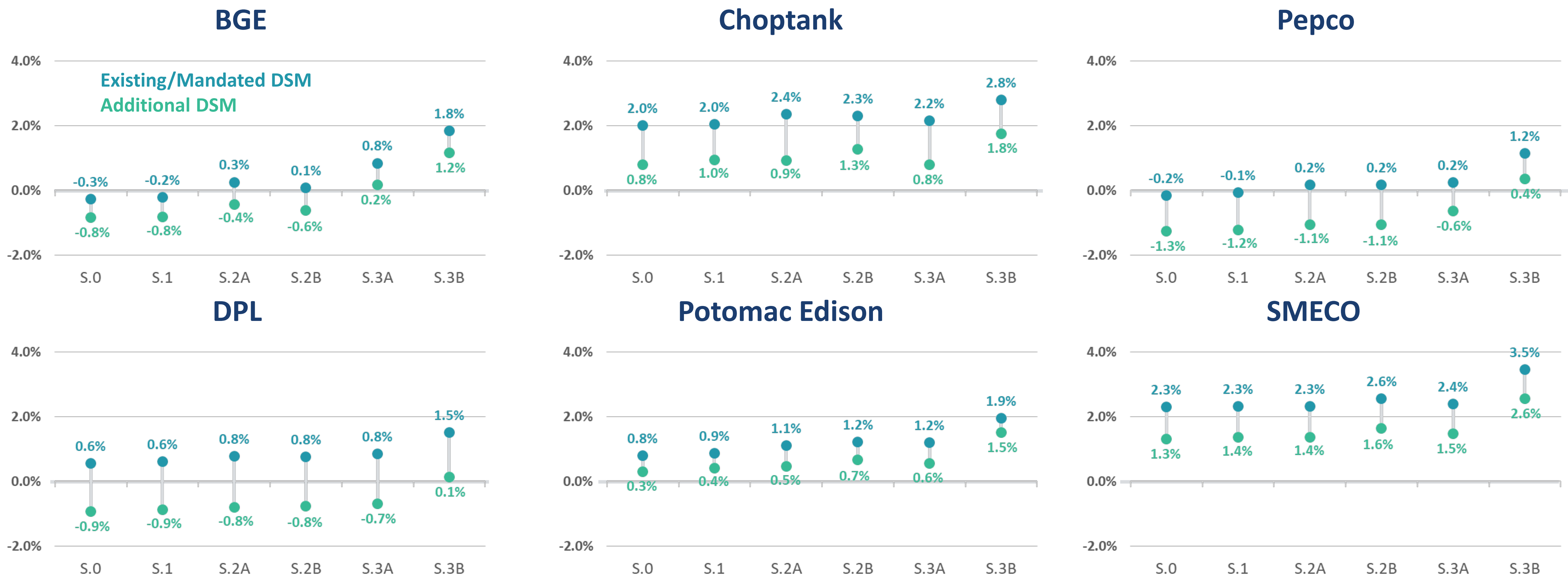
Notes: Y-axis scales differ across charts. 2022 peak load is sourced from 2022 Ten Year Plan or utilities directly. The light bars ("Diff.") are the difference between the Existing/Mandated DSM case and the Additional DSM case, and represent the impact of the Additional DSM programs.

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Load Growth Results – Existing/Mandated vs. Additional DSM

2022-2031 Compound Annual Peak Load Growth Rate (CAGR) by Scenario and Utility

*With **Existing/Mandated** and **Additional** Demand Side Management*

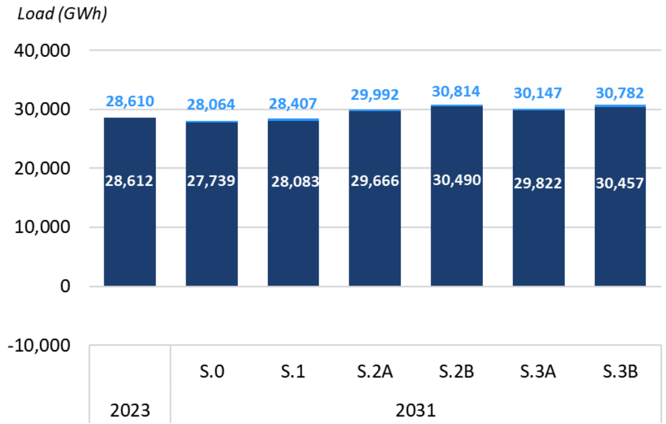


Sales Growth Results – Existing/Mandated vs. Additional DSM

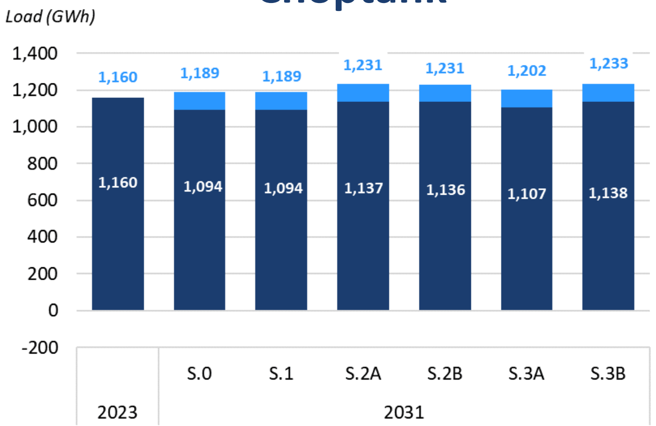
S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

2023-2031 Annual Electricity Consumption by Scenario and Utility

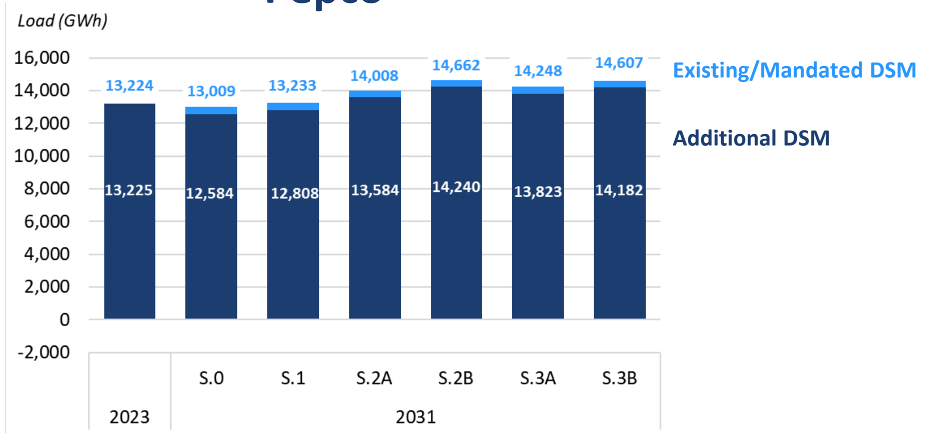
BGE



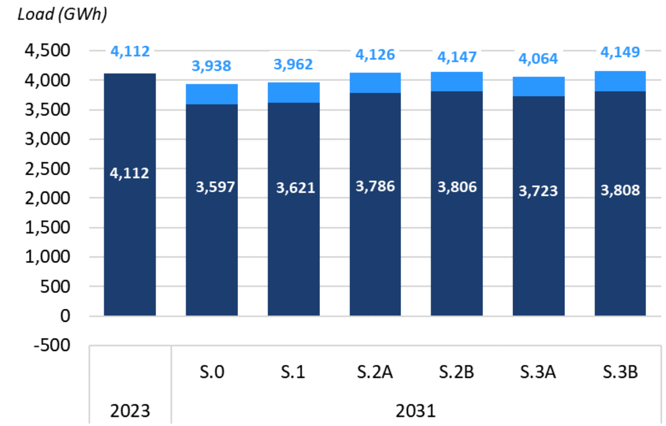
Choptank



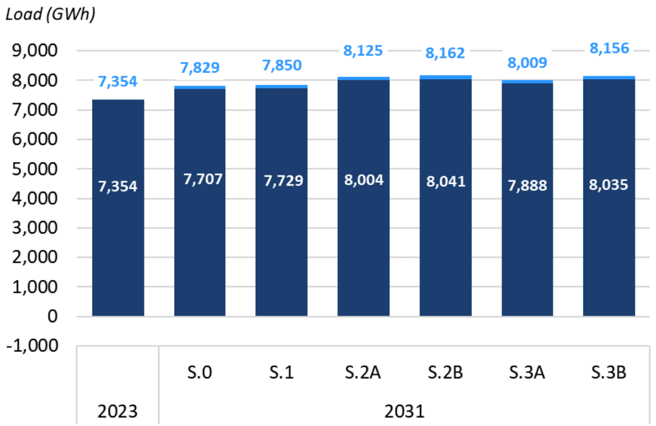
Pepco



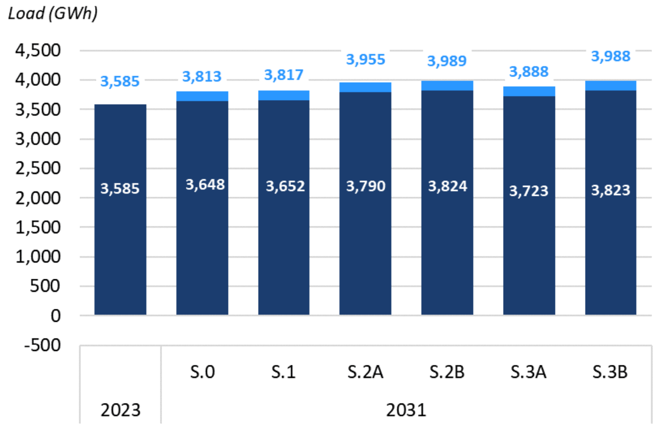
DPL



Potomac Edison



SMECO



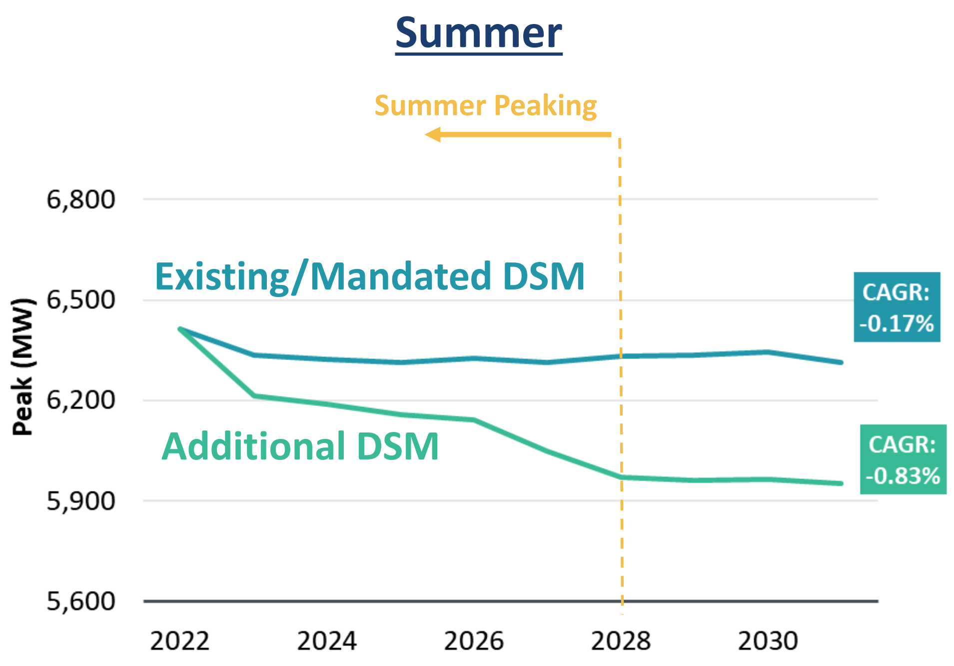
Notes: Vertical axis scale differs across charts.

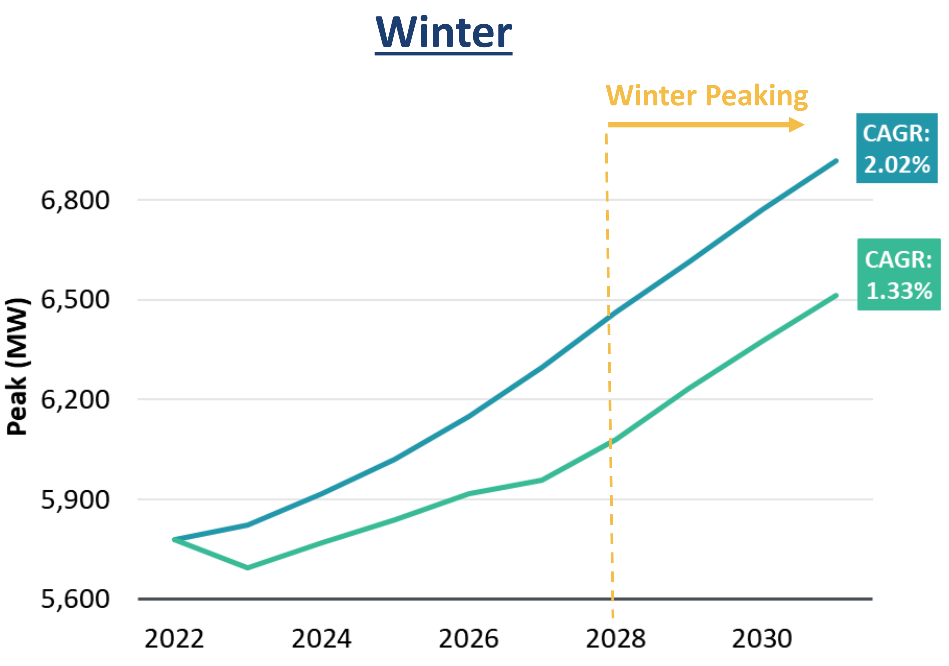
Impact of EE and Load Flexibility – BGE S.3A

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

BGE Summer and Winter Peak Loads with Existing/Mandated and Additional DSM

High Electrification with Best-in-Class Technologies Scenario (S.3A)





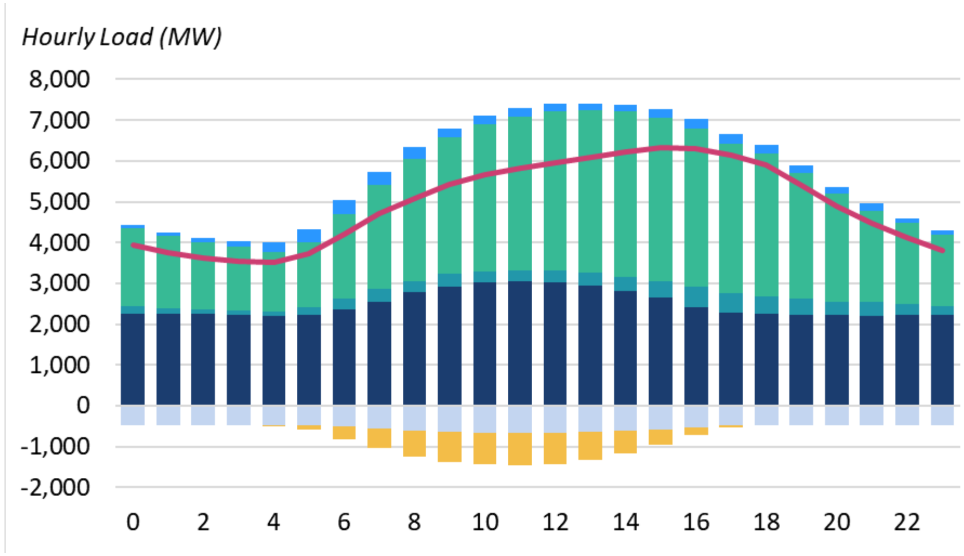
Note: BAU and High scenarios switch from Summer to Winter peaking in 2028

DSM on Summer Peak Day – BGE S.3A

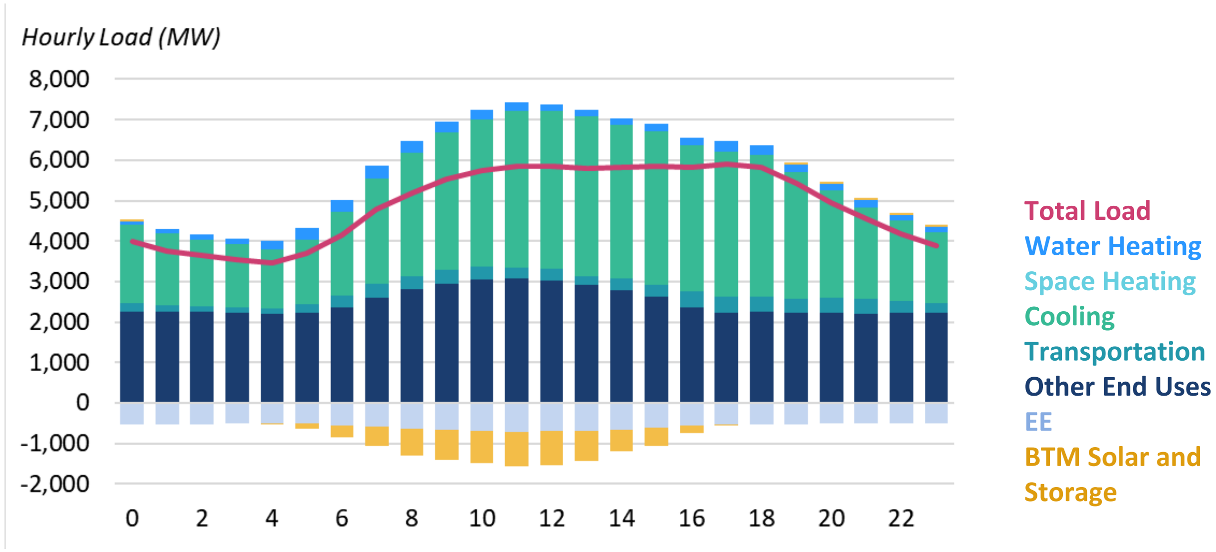
Hourly Load by End Use on 2031 Summer Peak Day, *MW*

Additional DSM Programs flatten load shape relative to Existing/Mandated DSM Programs Case and shifts peak hour

Existing/Mandated DSM Programs



Additional DSM Programs

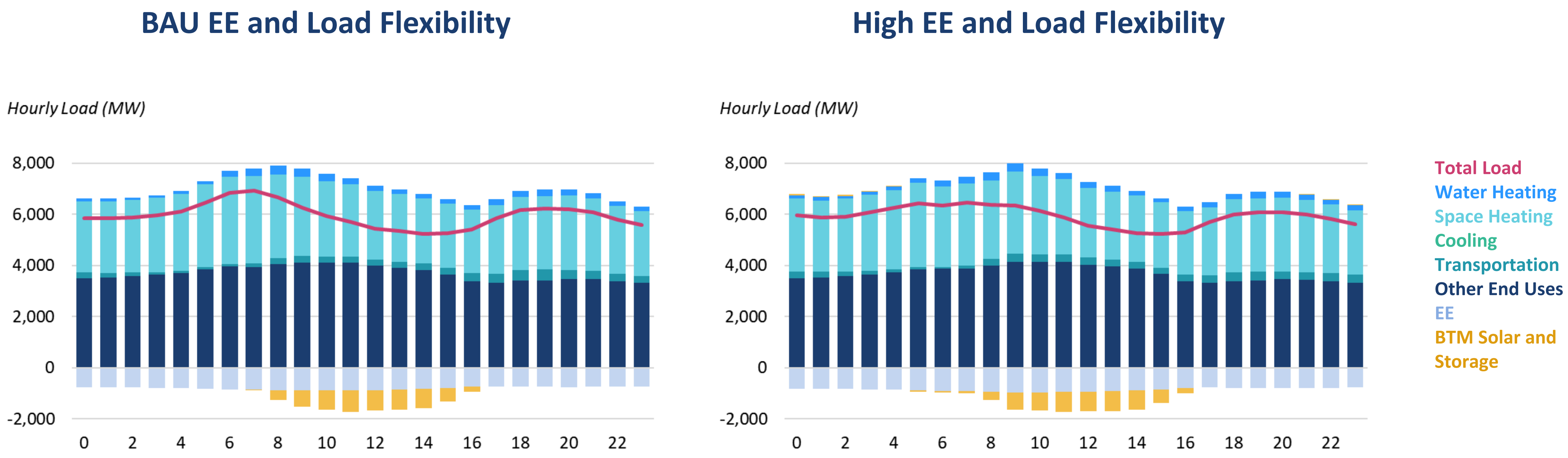


Notes: Load flexibility impacts are reflected within their respective end use (e.g EV managed charging program impacts Transportation load). All hours are hour beginning.

DSM on Winter Peak Day – BGE S.3A

Hourly Load by End Use on 2031 Winter Peak Day, *MW*

Additional DSM Programs flatten load shape relative to Existing/Mandated DSM Programs Case and reduce peak



Notes: Load flexibility impacts are reflected within their respective end use (e.g EV managed charging program impacts Transportation load). All hours are hour beginning.

9 – Conclusion

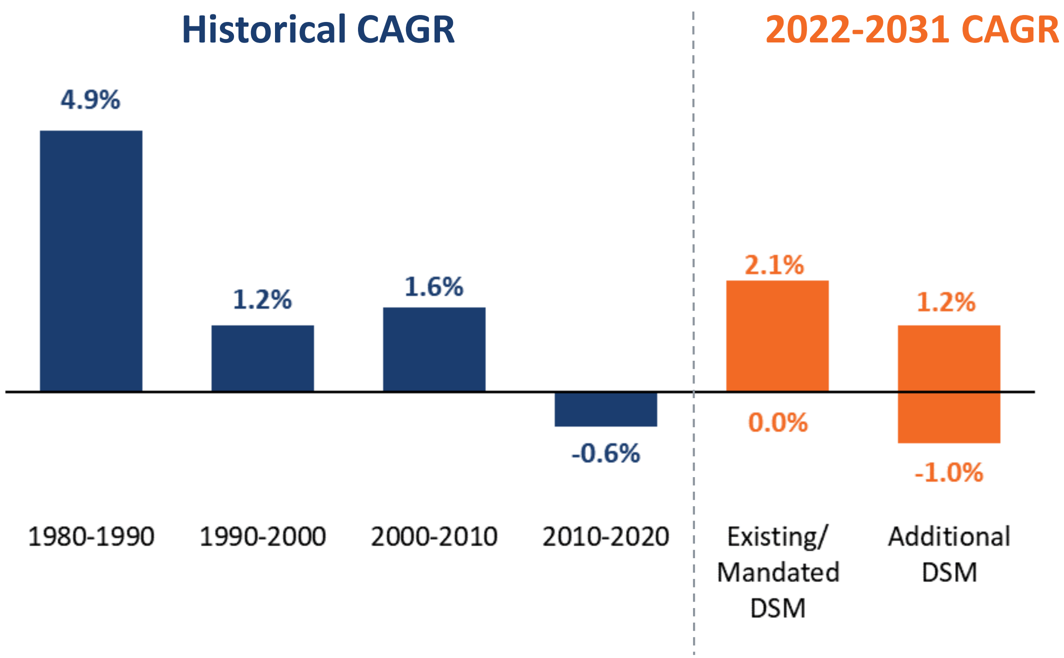
Maryland-Wide Historical Peak Growth Rates

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Results show that peak load growth through 2031 with high electrification of the building sector will be comparable to or less than the Maryland system has seen over the past 40 years.

- Historically, there was significant load growth in the 1980s of 4.9% per year and more moderate growth of 1.2-1.5% from 1990-2010. Load declined between 2010-2020.
- High Electrification with Legacy Tech (S.3B) with Existing/Mandated DSM would have the highest growth rate of 2.1% per year
  - Additional DSM programs would reduce this to 1.2% per year
- High Electrification with Best-in-Class tech (S.3A) with Existing/Mandated DSM would have a growth rate of 1.1% per year
  - Additional DSM would reduce this to 0.3% per year
- The lower ends of the ranges are the Reference, Low Electrification, and Mid Electrification Scenarios, which do not include a highly electrified building sector

Maryland Historical and Forecasted Growth Rates

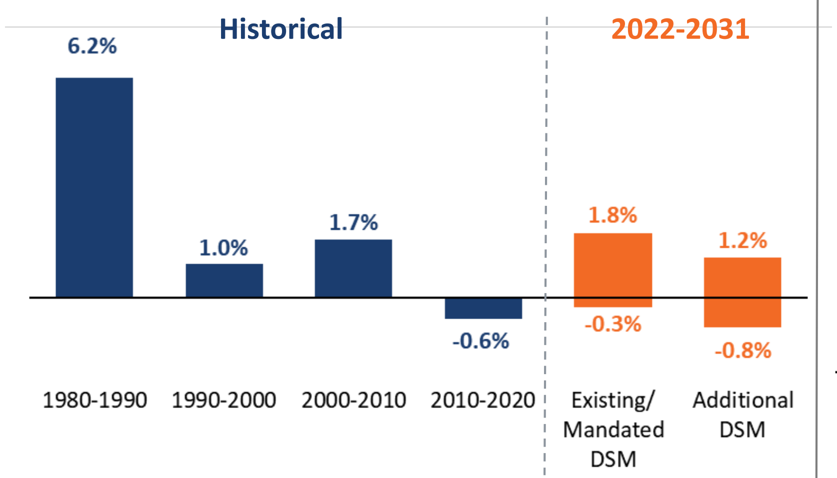


Notes: Historical load growth calculated based on load weighted average for Maryland utility historical peak load. Historical peak load provided by utilities where applicable, otherwise CAGRs from respective PJM LDA historical peaks. Only accounts for in-scope Maryland utilities. Forecasted load growth rates show range of CAGRs for all scenarios modeled.

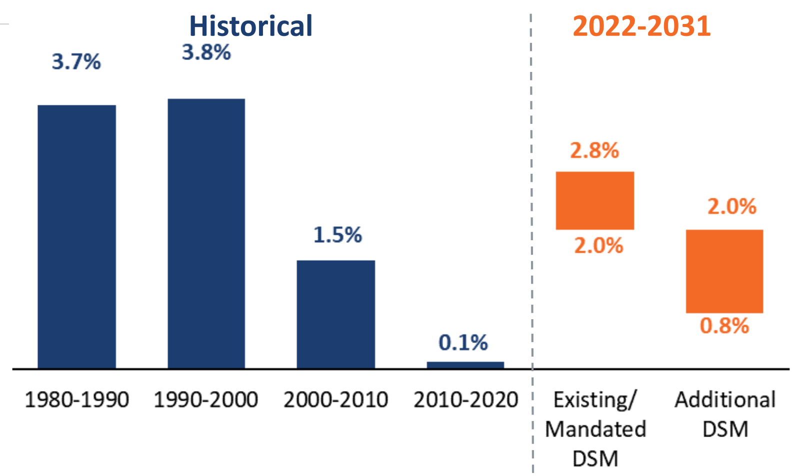
CONCLUSION

Historical Growth Rates by Utility

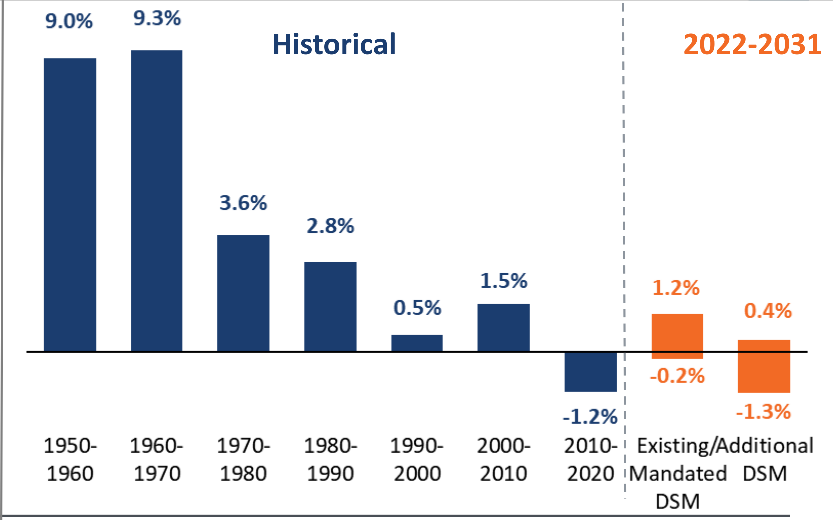
BGE



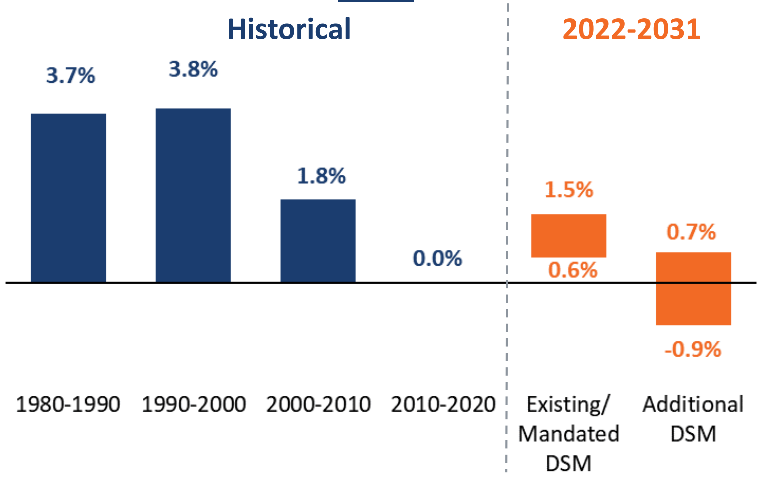
Choptank



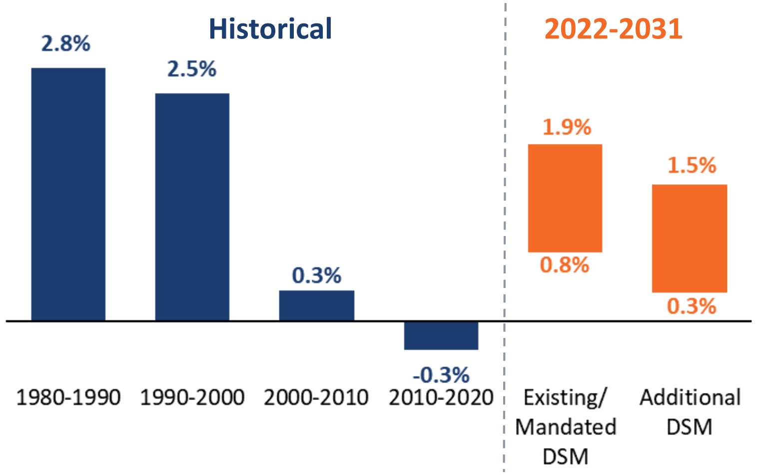
Pepco



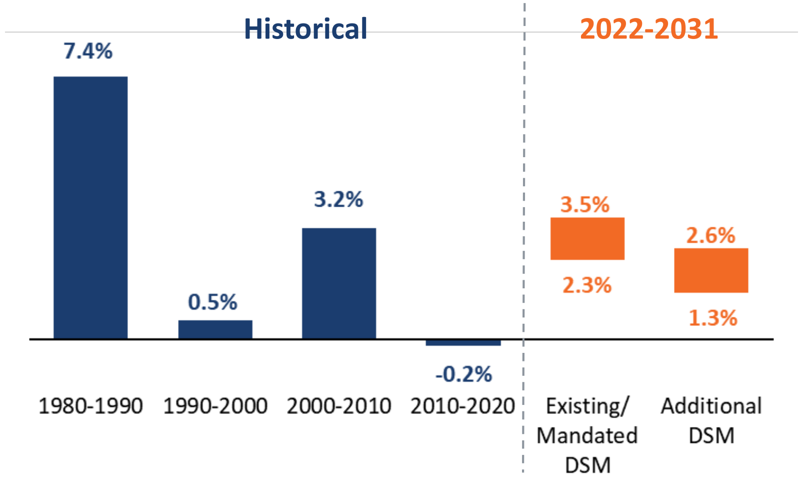
DPL



Potomac Edison



SMECO



Notes: Vertical axis scale differs across charts. Historical peak load provided by utilities where applicable. Otherwise, CAGRs sourced from respective PJM LDAs. Forecasted load growth rates show range of CAGRs for all scenarios.

Historical Growth by Utility

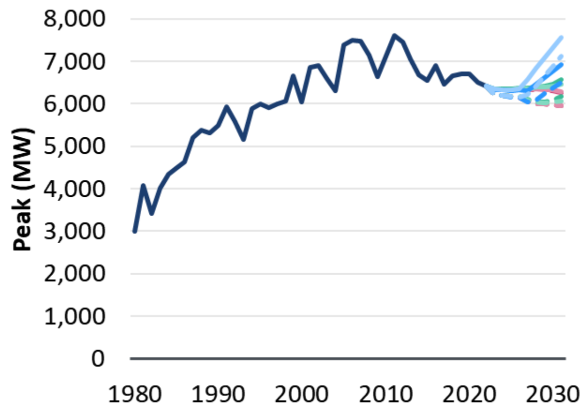
S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

Solid = Existing/Mandated DSM
Dashed = Additional DSM

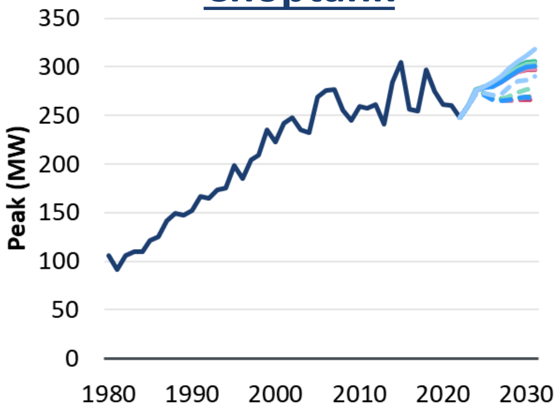
Historical and Projected Peak Loads by Utility

Historical loads are from utility data and/or from PJM load growth data for the utility's load zone

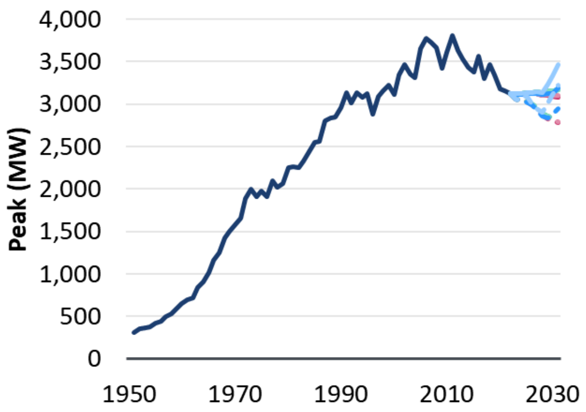
BGE



Choptank



Pepco



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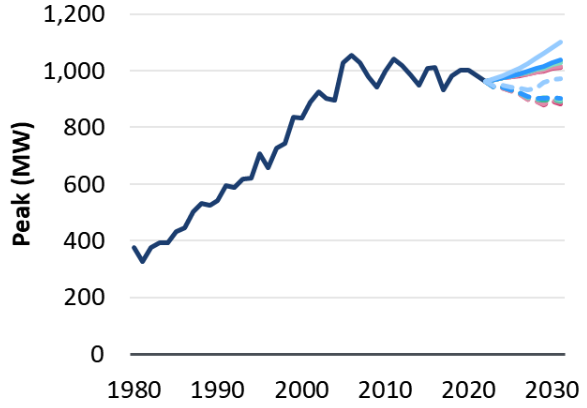
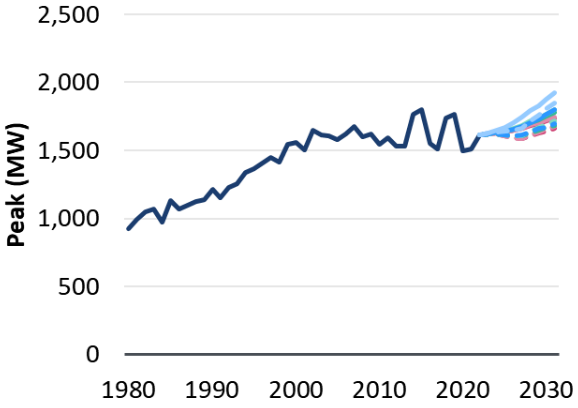
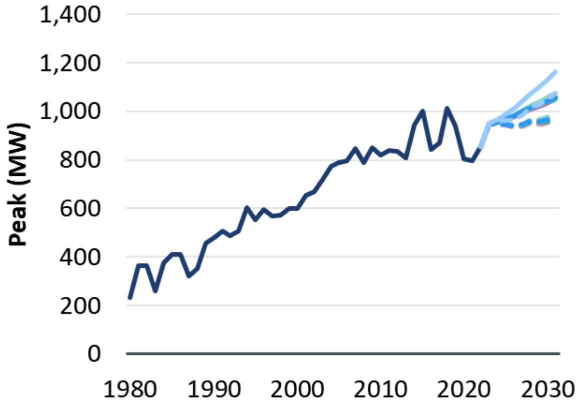


Potomac Edison



SMECO



Sources for historical load: 1) BGE: PJM load zone data 2) Choptank: Utility data 2010-2022, PJM growth rate for load zone 1980-2010 3) Pepco: Utility growth rate data 1950 – 2022 4) DPL: Utility growth rate data 1999-2022, PJM growth rate for load zone 1980-1999 5) Potomac Edison: Utility data 2009-2022, PJM growth rate for load zone 1980-2009 6) SMECO: Utility data 1993-2022, PJM growth rate for load zone 1980-1993.

Recap of Results for Maryland System

S.0 – Reference
S.1 – Low electrification
S.2A – Mid electrification
S.2B – High electrification w/ fossil backup
S.3A – High electrification w/ best-in-class tech
S.3B – High electrification w/ legacy tech

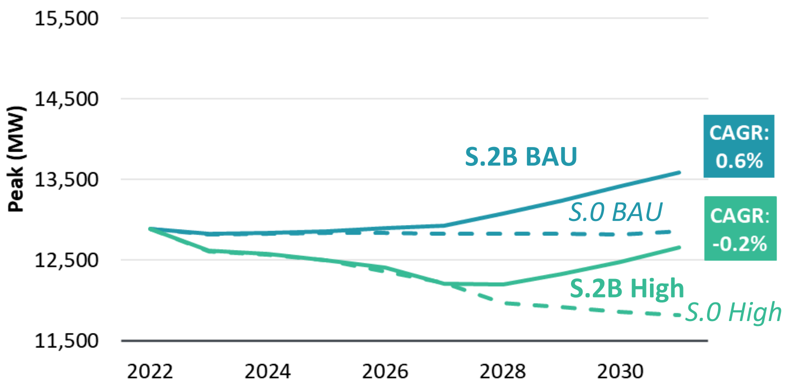
Results show that in the High Electrification Scenarios, the aggregate Maryland system would see 0.6%-2.1% annual growth with Existing/Mandated DSM.

- The High Electrification Scenarios result in direct building heating emissions reductions consistent with MDE's Climate Pathway to meet the 60x31 goal
- The Maryland system, which is currently summer peaking, would switch to winter peaking around 2026-2027
- BGE and Pepco, the largest utilities, see limited load growth because they have significant headroom between the winter and summer peaks and because they forecast limited growth from non-electrification drivers like economic growth
- Pursuing policies to incentivize efficient electrification over legacy technologies (S.3A vs. S.3B) could result in significant mitigation of load growth
- A hybrid approach with fossil backup would also result in electric load mitigation, but would require continued direct emissions from buildings
- High electrification scenarios reduce gas demand from buildings by 31-32% and total gas utility deliveries by about 20%
- Additional demand side management programs could result in significant further mitigation of load growth in every scenario

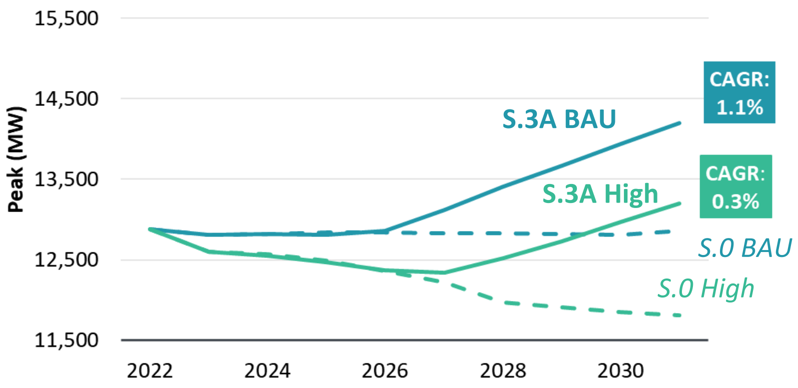
Maryland[1] System Peak Load

*With **Existing/Mandated** and **Additional DSM** Energy Efficiency and Load Flexibility*

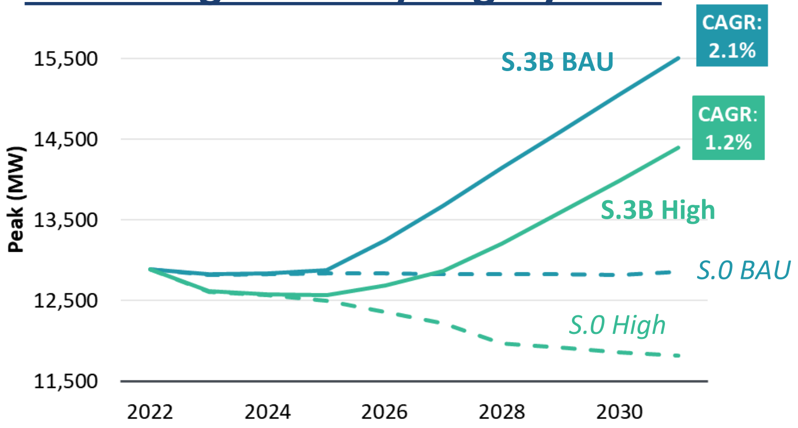
S.2B – Hybrid with Fuel Backup



S.3A – High Elec. w/ Best-in-Class Tech



S.3B – High Elec. w/ Legacy Tech



1 Does not include out-of-scope utilities

Electrification Study Report Q&A

Q. Why did the Commission perform an electrification study?

A. The electrification study was performed in compliance with Sect. 10 of the Climate Solutions Now Act of 2022 (CSNA), which requires the Public Service Commission to complete a general system planning study to assess the capacity of each gas and electric company's distribution systems to successfully serve customers under a managed transition to a highly electrified building sector. The CSNA set Maryland on a course to achieve net zero greenhouse gas (GHG) emissions by 2045, and 60% GHG reduction by 2031 relative to 2006 levels. The Act includes provisions for extensive changes to various sectors including transportation, electricity, buildings, and agriculture. Further, the Act set the following requirements for this study:

- use a projection of average growth in system peak demand between 2021 and 2031 to assess the overall impact on each gas and electric distribution system
- compare future electric distribution system peak and energy demand load growth to historic rates
- consider the impacts of energy efficiency and conservation and electric load flexibility
- consider the capacity of the existing distribution systems and projected electric distribution system improvements and expansions to serve existing electric loads and projected electric load growth
- assess the effects of shifts in seasonal system gas and electric loads

Q. What did the Commission's electrification study conclude?

A. The study modeled electrification scenarios that would result in direct building heating emissions reductions consistent with Maryland's Climate Pathway report. The results indicate that the aggregate Maryland electric systems would see load growth rates in the range of 0.6–2.1% per year through 2031 with high electrification, assuming utility energy efficiency plans consistent with the Climate Solutions Now Act and existing utility demand response plans. This increase in load growth is accompanied by a 31–32% reduction in building sector gas demand by 2031 in high electrification scenarios. The Maryland electric distribution system, which is currently summer peaking, would switch to winter peaking around 2026–2027. Furthermore, additional energy efficiency and load flexibility measures could result in significant mitigation of load growth by 2031 to −0.2–1.2% per year. Historically, there was significant Maryland system load growth in the 1980s of 4.9% per year and more moderate growth of 1.2–1.5% from 1990–2010, while load declined between 2010–2020. These results show that peak load growth through 2031 with high electrification of the building sector will be comparable to or less than the growth rate the Maryland system has seen over the past 40 years.

Q. Why did the Commission only perform an electrification study through 2031?

A. The CSNA requires the Public Service Commission to use a projection of average growth in system peak demand between 2021 and 2031 to assess the overall impact on each gas and electric distribution system. The Maryland's Climate Pathway Report demonstrates how Maryland can meet its ambitious climate goals of 60% reduction of greenhouse gas emissions by 2031 relative to 2006 levels, and attain a net-zero economy by 2045.

Q. Why were grid impacts developed based on system-level load growth results, as opposed to a more granular grid study that identifies local investment needs?

A. The electrification study scope does not require a granular distribution system planning study and therefore, does not identify local investment needs. In addition, this type of granular study would require significantly more time and investment to develop. The electrification study final report is similar to other reports that the Brattle Group has authored in the past where system-level load growth results are intended to provide one reasonable benchmark by which to determine whether the system load growth in a high electrification scenario will be within the range of growth utilities have accommodated in the past.

Utilities will need to develop their own "bottom-up" distribution impact studies to identify which parts of the grid will experience more immediate growth, and develop plans accordingly, including a consideration of non-wires alternatives. It is important to note that, while this electrification study provides a utility system-level view of load growth trajectory under different scenarios, this study is not a substitute for more granular, locational distribution planning studies that could be conducted by the utilities. Through these studies, utilities will be able to plan specific upgrades to the distribution system based on the loading of existing equipment and forecasted customer adoption of various technologies.

Q. What types of considerations are outside of the electrification study scope?

A. The transition to a highly electrified building sector is complex and multifaceted. Each facet merits detailed study during the process of policy development and implementation. This study is intended to inform policymakers regarding one facet of the transition—the impacts on electricity and natural gas demand through 2031. This study does <u>not</u> address several important transition issues, including but not limited to:

- Cost-effectiveness of building electrification;
  - *Note: Each scenario would result in several costs, including equipment installation and maintenance costs borne by building owners and grid investment and demand-side management program costs borne by utilities and utility ratepayers. Each scenario would also create several benefits, including fuel savings, avoided natural gas infrastructure investments, reduced societal impacts of GHG emissions, and reduced health impacts of air pollution. These types of considerations would require significantly more time and investment to evaluate*.
- The technical feasibility and commercial availability of electrification technologies for various types of customers;
- Locational distribution system upgrades that may be needed to support new load and locational non-wire solutions that may defer distribution system upgrades;
- Potential decommissioning of parts of the gas delivery system as customers electrify;
- Regulatory mechanisms to sustainably manage gas utilities as gas throughput declines;
- Environmental justice and equity to ensure that disadvantaged communities are not left behind in the transition.

Q. What does this electrification study mean for the future of electrification in Maryland?

A. The scope of this study was to pursue "what-if" scenarios to provide information for policy makers to make decisions about the future of electrification which could include further incentives to accelerate different types of heat pump adoption, additional load flexibility and energy efficiency measures, and building electrification standards, among other things.

Q. What does this study mean for the future of gas planning and electric distribution planning in Maryland?

A. Successful gas and electric distribution planning depends on gas and electric demand forecasting as a first step. A key question moving forward is how will utilities provide transparency, accommodate stakeholder involvement and build consensus on the assumptions used to develop their investment plans? Electrification pathways affect gas forecasts and gas near-term and long-term plans will also impact electric distribution forecasts. There is currently a docketed case (Case No. 9665) and Commission workgroup established for electric distribution system planning that must consider these questions. There is also a newly docketed case (Case No. 9707) where gas system planning will be considered.

Q. What EmPOWER assumptions were used for the study?

A. In Case No. 9648 for EmPOWER, the utilities filed 2024–2026 Program Proposals. In Order No. 90549, the Commission required the utilities to develop three scenarios that resulted in increasing GHG savings while still meeting the energy efficiency goals required by law:

- 2023 Scenario - Utility required to meet the energy efficiency goals as required by law as cheaply as possible.
- Middle Scenario - Between the 2023 and maximum scenario that reduces GHG above the 2023 scenario but is cognizant of funding constraints. Must meet energy efficiency goals in law.
- Maximum Achievable Scenario - Utility required to meet the energy efficiency goals while trying to meet the potential studies maximum achievable and was intended to include programs and measures that would bring maximum savings when spending is unconstrained.

Energy efficiency assumptions in the electrification study are based on the EmPOWER 2024–2026 program cycle plans filed by utilities in August 2023. The existing/mandated Demand Side Management Programs case assumes utilities achieve the “2023 Scenario” level of energy efficiency from these filed plans, which is based on achievement of minimum statutory requirements.