Modeling the Benefits of Energy Storage in Maryland

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EXECUTIVE SUMMARY

For decades, Maryland has relied heavily on fossil fuels to meet its electricity demands. Now, Maryland has passed legislation to encourage the state to rapidly decarbonize and transition to renewable energy. In 2022, Maryland adopted one of the nation's most ambitious climate change laws to date, requiring a 60 percent GHG reduction by 2031 and net-zero emissions by 2045. In addition, Maryland has a Renewable Portfolio Standard that requires 50 percent clean electricity sales by 2030. Meeting these ambitious goals will likely require the construction of energy storage facilities that will help to ensure clean wind and solar generation is available in the hours when demand is high and renewable supply is otherwise low.

Synapse was hired by the American Clean Power Association to better understand the potential benefits of procuring increased amounts of energy storage resources as an alternative to gas-fired capacity in Maryland over the next decade. Synapse conducted a rigorous, independent analysis of Maryland's electric power sector, accounting for market dynamics in PJM and the incentives related to the recently passed *Inflation Reduction Act of 2022* (IRA).[1] Using a state-of-the-art electric sector model, we examined Maryland's electric system at a detailed level from 2023 through 2033 under two different futures.

First, in the "Continued Gas Dependence" case, the model relies on existing gas-fired resources in Maryland, as well as a combination of new gas, solar, and wind generation. This scenario functioned as a reference case, and new energy storage resources were not allowed to build. Conversely, in the "Increased Energy Storage" scenario, the model was allowed to optimize Maryland's electric system using a combination of existing resources and new renewable generators. In this scenario, new fossil-fuel resources were not allowed to build.

By conducting scenario analysis of two different visions of the future, we compared an accelerated clean energy future to one which continues to rely on fossil fuels instead of storage. Our results showed that a future with increased energy storage substantially cuts greenhouse gas emissions, meets energy and capacity needs, and provides electricity reliably without increasing rates.

We find:

- **It is economic for Maryland to build over 3.6 GW of storage by 2033.** The Increased Energy Storage scenario builds 3.6 GW of storage in Maryland by 2033, with an average of over 400 MW built each year starting in 2025 (see Figure ES-1). This storage is largely built in the Pepco and BGE service territories. It facilitates the construction of over 16 GW of solar and wind in Maryland.

[1] H.R.5376 - Inflation Reduction Act of 2022. Public Law No: 117-169 (08/16/2022)

- **IRA tax credits help make renewables and storage more favorable compared to new and existing fossil resources.** The model builds renewables in excess of what is required to meet RPS requirements in PJM, the large mid-Atlantic regional transmission organization that serves Maryland. In the Increased Energy Storage scenario, the model chooses to build twice as much solar in Maryland than in the case with no new storage. This suggests that increased amounts of batteries can facilitate more renewables.

- **System and ratepayer costs are marginally lower in the Increased Energy Storage scenario relative to the Continued Gas Dependence case.** We observed that energy costs are roughly $2 per MWh lower due to higher penetrations of storage and renewables by 2033, while capacity costs are roughly equal in both scenarios. Deploying this level of storage would lower residential electric bills by about $1 per month, compared to an alternative that is more dependent on gas.

- **CO_2 emissions are reduced by over 90 percent in the Increased Energy Storage scenario.** As shown in Figure ES-2, the Increased Energy Storage scenario reduces Maryland's emissions by 93 percent by 2033 relative to 2023 levels, while the Continued Gas Dependence scenario reduces Maryland's emissions by 23 percent over the same time period. Over the 10-year modeling period, the Increased Energy Storage scenario releases 47 percent less CO_2 than the Gas Dependence scenario, when counting emissions associated with Maryland's in-state generation.

Figure ES-1. Cumulative Maryland storage capacity additions under the Increased Energy Storage scenario

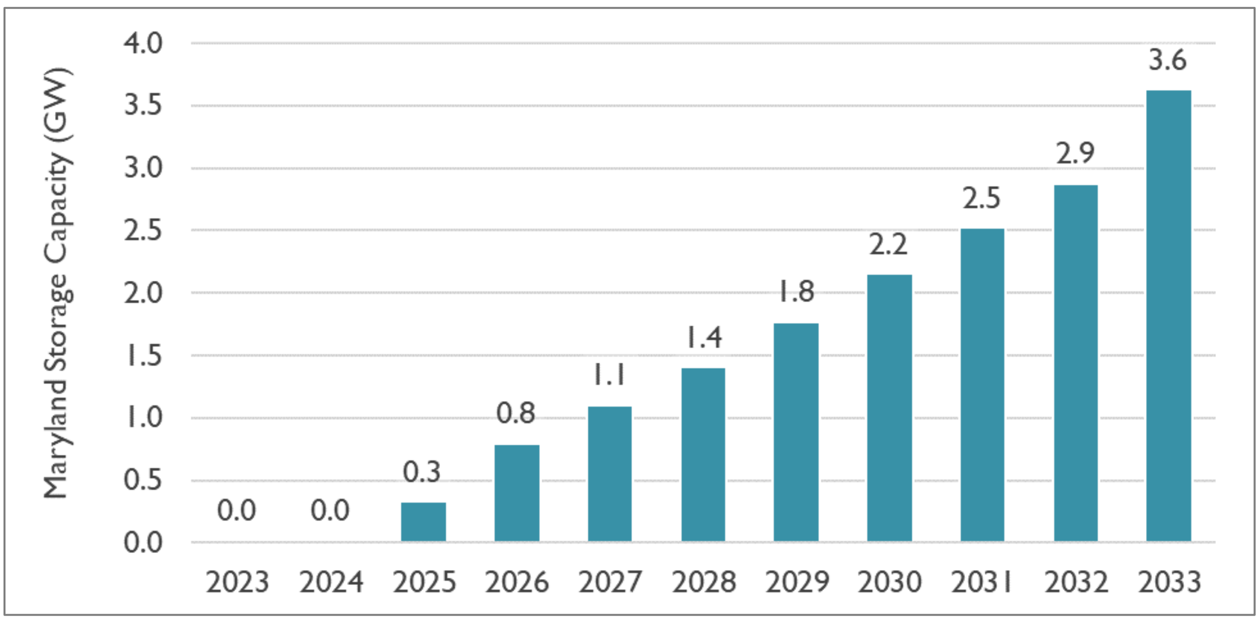
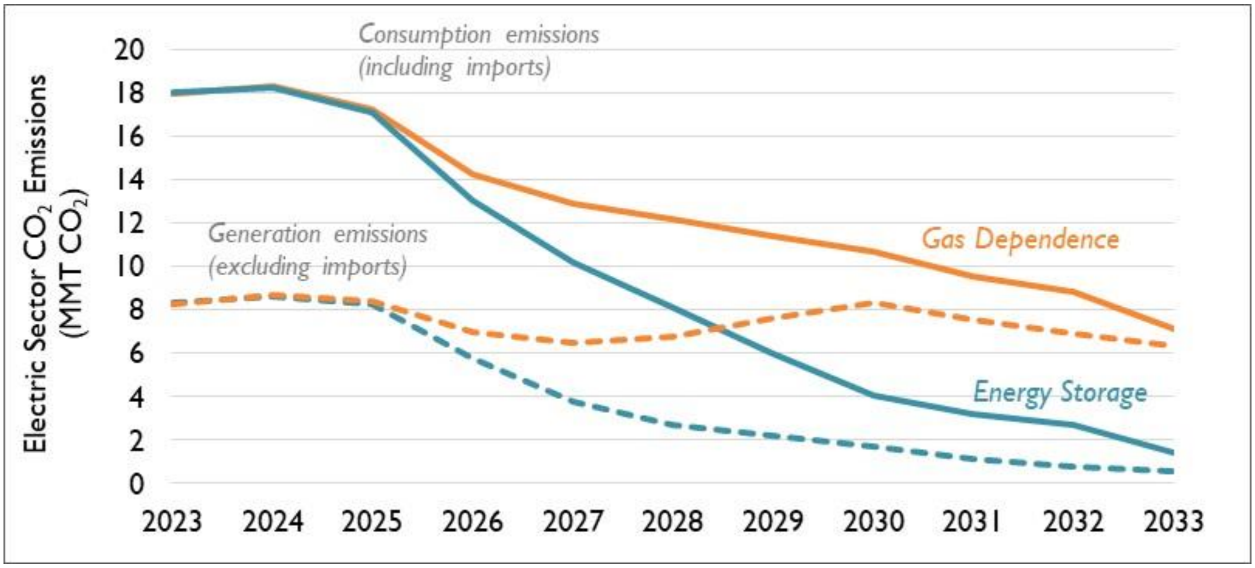


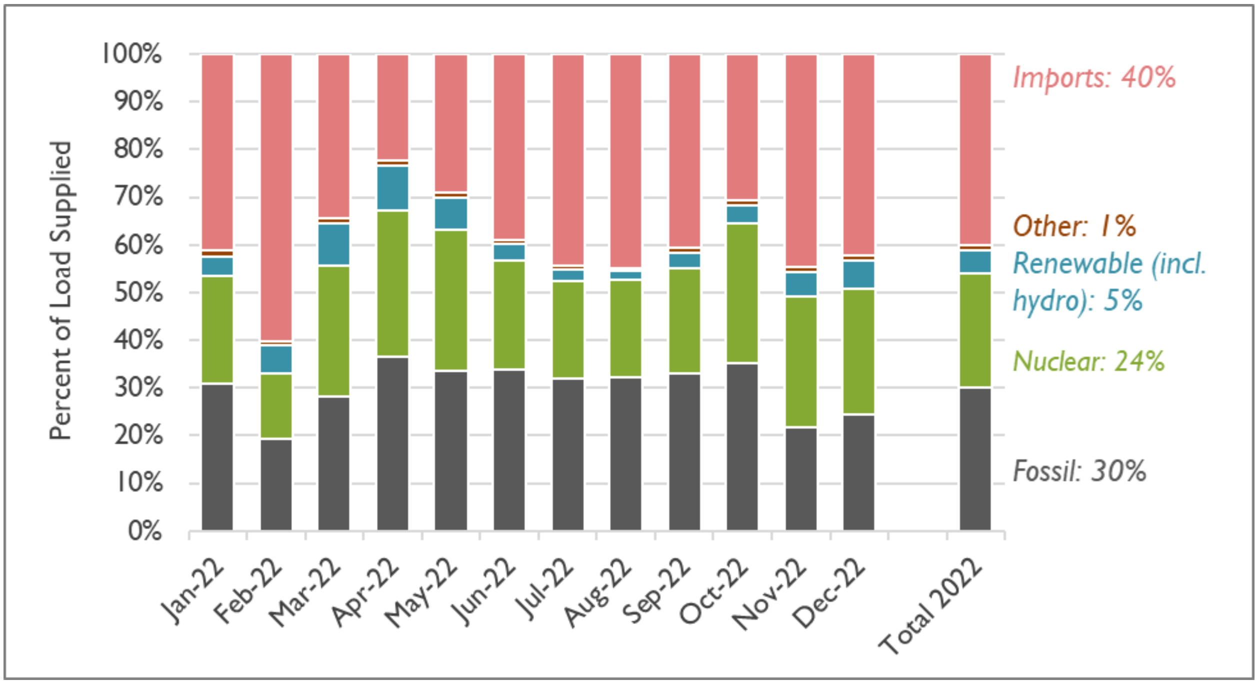
Figure ES-2. Maryland's emissions trajectory under the Increased Energy Storage and Continued Gas Dependence scenarios



1. BACKGROUND

For decades, Maryland has relied heavily on fossil fuels to meet its electricity demands. In 2022, fossil fuels accounted for half of Maryland's electricity generation. At the same time, Maryland has committed to ambitious greenhouse gas (GHG) emissions reduction targets that will be difficult to achieve without shifting its focus to zero-carbon energy sources like renewables. Meeting these ambitious GHG reductions will likely require the construction of energy storage facilities that will help to ensure clean wind and solar generation is available in the hours when demand is high and renewable supply is otherwise low. Energy storage resources will also help to ensure that Maryland's costs of meeting its clean electricity supply remain reasonable and are not dependent on volatile pricing of fossil fuels like coal and gas, which in 2022 constituted about one-third of Maryland's electricity demand as shown in Figure 1.

Figure 1. Percent of Maryland's load served by resource type in 2022



Source: US Energy Information Administration.

In 2022, Maryland adopted one of the nation's most ambitious climate change laws to date, requiring a 60 percent GHG reduction by 2031 and net-zero emissions by 2045.[2] In addition, Maryland has a Renewable Portfolio Standard that requires 50 percent clean electricity sales by 2030.[3]

To achieve these ambitious climate goals, Maryland will need to accelerate in-state renewable energy generation and reduce electric sector emissions. Maryland has already approved over 2,000 MW of offshore wind projects and is considering expanding its commitment to 8.5 GW of offshore wind by 2031.[4, 5] The expanded tax credits in the IRA will enable further economic procurement of solar and wind. The IRA also offers an additional ten percent tax credit adder for projects located in areas designated as energy communities, which will likely include the majority of the Maryland panhandle. [6, 7, 8] Storage will be key to unlocking the value of renewables by providing flexibility to the grid and enabling operators to store energy and dispatch it at times of peak demand.

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[2] Climate Solutions Now Act of 2022. Article II, Section 17(b) of the Maryland Constitution - Chapter 38. (2022) Available at: https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/sb0528?ys=2022RS

[3] Clean Energy Jobs. Article II, Section 17(c) of the Maryland Constitution - Chapter 757. (2019) Available at: https://mgaleg.maryland.gov/2019RS/bills/sb/sb0516E.pdf

[4] Maryland Energy Administration. "Offshore Wind Energy in Maryland." Available at: https://energy.maryland.gov/Pages/Info/renewable/offshorewind.aspx

[5] Witte, Brian. "Maryland bill aims to expand commitment to offshore wind." *Associate Press*. March 7, 2023.Available at: https://apnews.com/article/offshore-wind-environment-d186a46333591ffec18b9c5fc64fc329

[6] Resources for the Future. 2022. "What is an Energy Community?" Available at: https://www.resources.org/common-resources/what-is-an-energy-community/

[7] Ibid.

[8] Vibrant Clean Energy LLC. 2022. *Analyzing the Inflation Reduction Act Definitions of Low-Income and Energy Communities.* Available at: https://www.vibrantcleanenergy.com/wp-content/uploads/2022/09/IRA_EC+LIC_VCE-Analysis.pdf

2. METHODOLOGY

To assess the impacts of energy storage in Maryland, Synapse used EnCompass, an industry-standard electric power planning model, to project capacity builds and energy dispatch in PJM over the next decade. Developed by Anchor Power Solutions, EnCompass is a single, fully integrated power system platform that allows for utility-scale generation planning and operations analysis. It is widely used by utilities across the country for IRP planning.[9] Synapse populated the model using the EnCompass *National Database*, created by Horizons Energy, and supplemented this dataset with additional publicly available information to provide further detail on power plant characteristics, resource costs, and fuel prices. EnCompass was used to produce outputs related to generation, capacity, emissions, and system costs, based on least-cost optimization. Detailed input assumptions are given in Appendix A.

To quantify the impacts of each scenario on ratepayers, we conducted a rate and bill impact analysis using a combination of historical data and EnCompass modeling results. Synapse relied on data from the U.S. Energy Information Administration to determine information on historical sales, customers, and revenues across sectors, which we then used to calculate cost and load allocation.[10] We also used this data to estimate the portion of historical revenues associated with electric supply versus other components such as delivery and administrative fees. We then combined this information with modeled energy and capacity prices to calculate projected system costs in 2033. Energy and capacity costs were included as changes to the supply portion of the bill, and we assumed rate impacts related to other factors such as energy efficiency, distributed generation, and renewable energy credits were consistent across the two scenarios and constant over time.

[9] For more information on EnCompass, its users, and capabilities, see: https://anchor-power.com/encompass-power-planning-software/

[10] US Energy Information Administration. Annual Electric Power Industry Report, Form EIA-861 detailed data files. October 6, 2022.

3. MODELED SCENARIOS

Table 1 describes the scenarios modeled in this study and the primary differences between them. Our two scenarios were:

- Continued Gas Dependence: Models a status-quo approach to Maryland's electric sector. This scenario reflects the continued maintenance and expansion of gas-fired resources in Maryland and does not allow any energy storage to build in the state.
- Increased Energy Storage: Requires that Maryland install at least 2.5 GW of battery energy storage by 2033 and does not allow any new gas resources to be built in the state.

For both scenarios, we modeled the entire PJM region first to properly account for energy and capacity market dynamics before locking in non-Maryland capacity builds to appropriately isolate the impacts of the scenario differences on Maryland. We performed a sensitivity analysis on both scenarios to determine the effect of higher, more volatile gas prices throughout the study period.

Both scenarios modeled in this analysis utilize the same set of inputs described in Appendix A.

Table 1. Key scenario differences

	Continued Gas Dependence	Increased Energy Storage	High Gas Price Sensitivity (applied to both scenarios)
Gas Capacity Builds	No restriction on gas builds	No new gas resources can be built in Maryland	No new resource builds are permitted; this sensitivity only analyzes resource operation and dispatch
Renewables Capacity Builds	No constraints except to meet state RPS		
Storage Builds	No new storage resources can be built in Maryland	At least 2.5 GW of storage to be built by 2033	
Gas Prices	Short-term: NYMEX Mid- and Long-term: AEO 2022 Reference case		Short-term: NYMEX Mid- and Long-term: AEO 2022 Low Oil and Gas Supply case

4. RESULTS

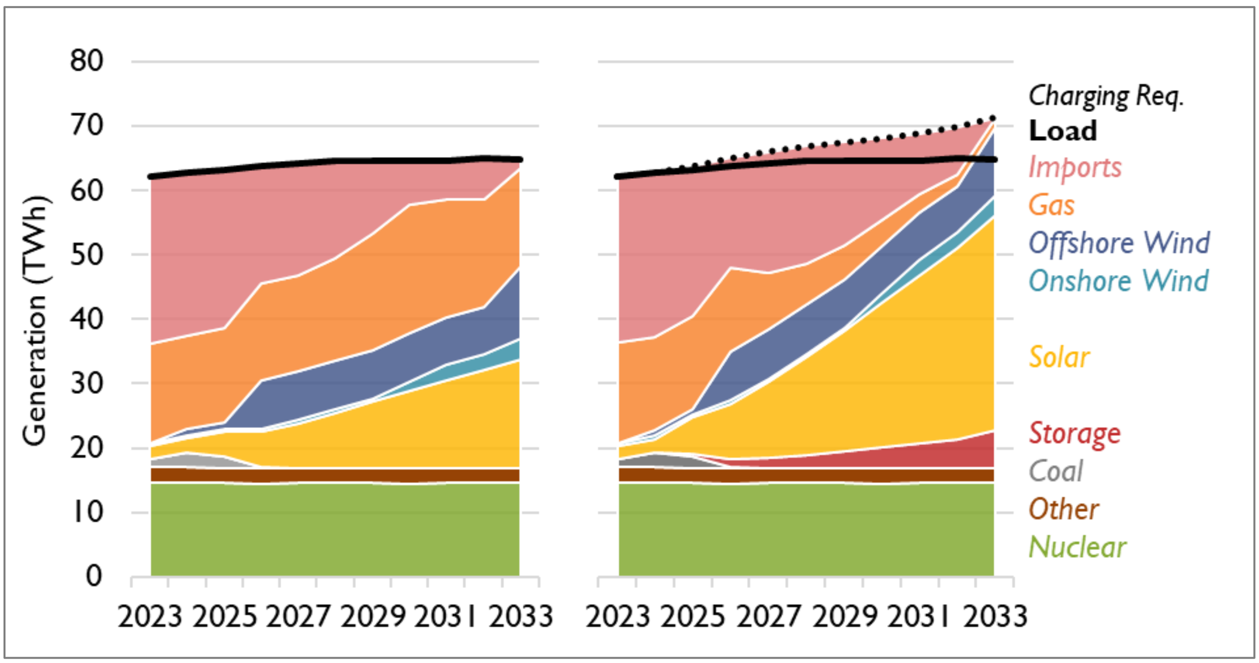
Our modeling suggests that decisions regarding storage buildout will have major implications on Maryland's future energy mix and emissions. The following chapter describes the results of our scenario analysis.

4.1. Annual load and generation

In the Increased Energy Storage scenario, we observe 3.6 GW of energy storage built in-state by 2033. By focusing on procuring energy storage rather than gas-fired resources, Maryland is likely to see a significant buildout of new clean energy, especially solar (see Figure 2). Under the Increased Energy Storage scenario in-state solar generation is projected to serve 51 percent of Maryland's load by 2033. Wind generation is projected to increase to 22 percent of load by 2033, largely driven by new offshore wind projects. By the end of the study period, we find that 97 percent of Maryland's electricity load is served by non-fossil resources. Maryland shifts from importing almost half of its electricity today to importing only 15 percent to meet demand (inclusive of battery charging requirements) by 2033. Adding 3.6 GW of energy storage by 2033 results in 6.4 GWh of charging requirements—about 10 percent of Maryland's customer demand.

In contrast, under the Continued Gas Dependence scenario we observe that gas still serves nearly a quarter of the load in Maryland in 2033. Compared to the Increased Energy Storage scenario, the Continued Gas Dependence scenario results in comparable amounts of wind generation by 2033. However solar generation is much lower, at only 26 percent of demand by 2033.

Figure 2. Generation and load under the Gas Dependence (left) and Increased Energy Storage (right) scenarios

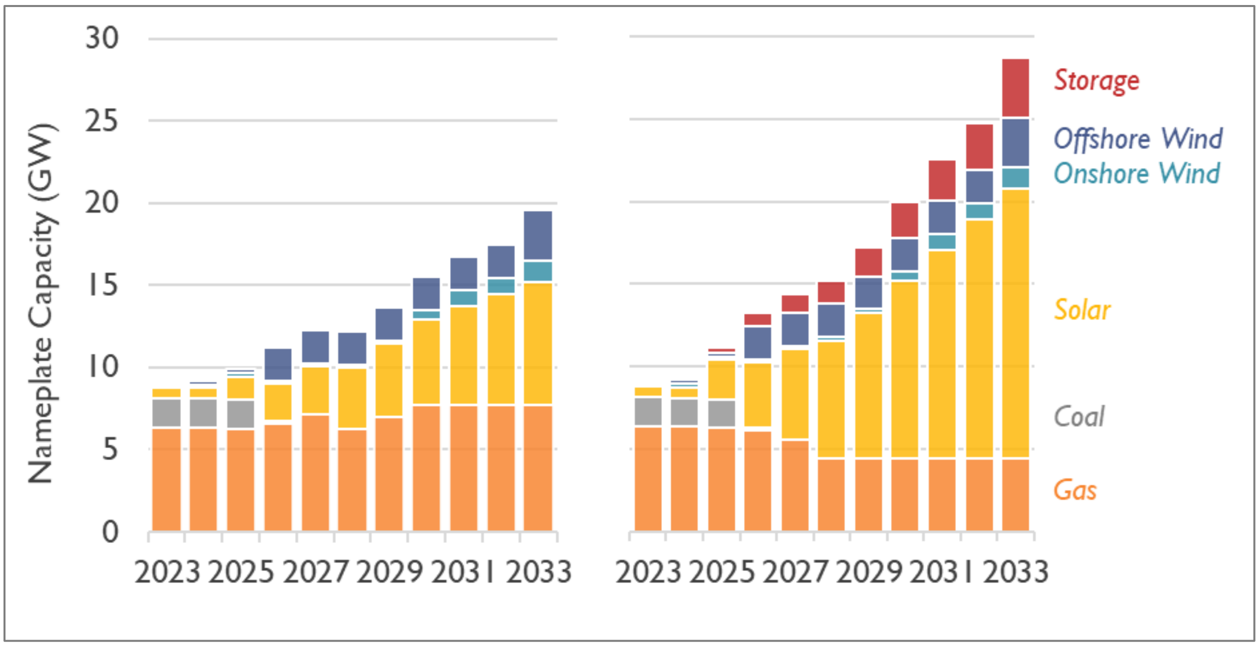


4.2. Capacity changes

As described above, the Increased Energy Storage scenario results in 3.6 GW of new energy storage constructed in Maryland, which facilitates 16.4 GW of solar being built in-state by 2033 (see Figure 3). This scenario results in an average addition of 400 MW of new storage and about 1.7 GW of solar per year. This scenario builds about 1 GW of onshore wind in western Maryland, along with 2.1 GW of offshore wind, including the US Wind and Ørsted offshore wind projects.[11] Lastly, under the Increased Energy Storage scenario, we find that all coal in Maryland is retired by 2027, with 2 GW of gas retiring and no new gas resources being built, consistent with scenario constraints.

Under the Continued Gas Dependence scenario, coal retirements and new wind builds are similar to those observed in the Increased Energy Storage scenario. All coal in Maryland retires by 2027, and wind builds are identical between cases. Notably however, this scenario builds less than half as much solar across the study horizon, totaling only 7.5 GW by 2033. This scenario projects a net addition of 2.8 GW of gas capacity (inclusive of some retirements of older gas turbine plants). No new storage is built under this scenario, consistent with scenario constraints.

Figure 3. Capacity changes under the Gas Dependence (left) and Increased Energy Storage (right) scenarios

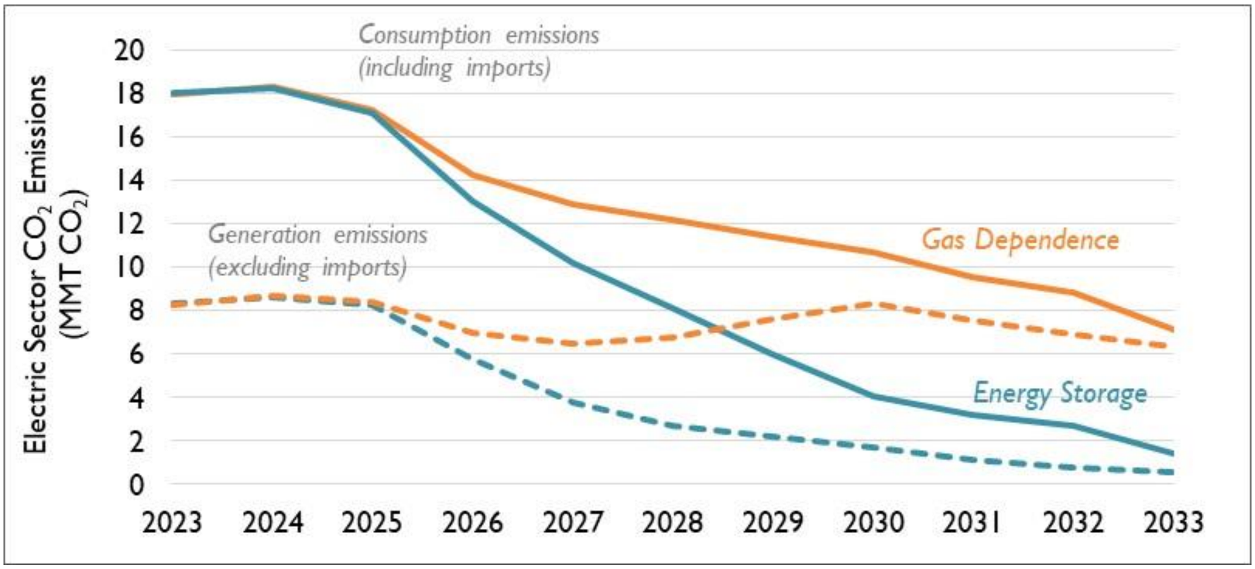


[11] For more information about these projects, see *Offshore Wind Projects in Maryland.* Offshore Wind Maryland. Available at: https://offshorewindmaryland.org/offshore-wind-projects-in-md/

4.3. CO_2 emissions

The Increased Energy Storage scenario results in significant GHG emissions reductions, relative to the Gas Dependence scenario (see Figure 4). When accounting for only emissions produced inside Maryland, the Energy Storage scenario reduces Maryland emissions by 93 percent relative to 2023, whereas the Gas Dependence scenario only reduces emissions by 23 percent. After accounting for imports, the Energy Storage scenario reduces emissions by 97 percent by 2033, and the Gas Dependence scenario reduces emissions by 65 percent by 2033. Emissions reductions from 2025 through 2027 are mainly driven by coal retirements in both scenarios, as well as planned offshore wind projects. In general, growing demand leads to increased gas capacity in the Gas Dependence scenario, whereas in the Energy Storage scenario, additional solar is built to meet this demand. This leads to lower emissions in the Energy Storage scenario because a greater quantity of generation is coming from renewable energy.

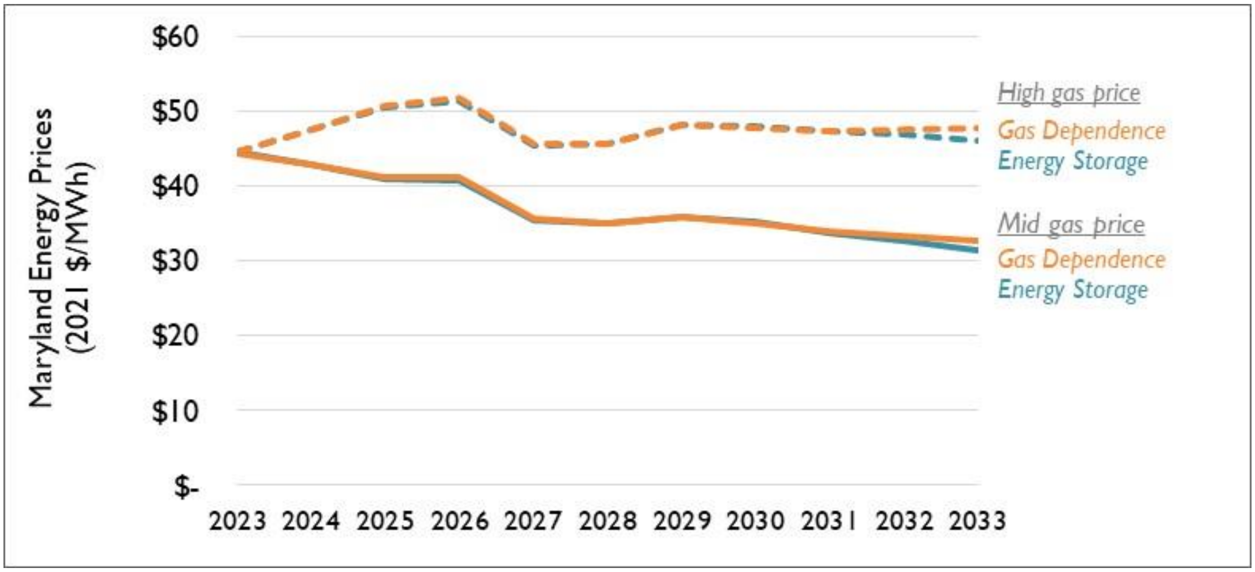
Figure 4. Emissions associated with energy consumption in Maryland



4.4. System costs

Energy costs are similar across both scenarios because gas plants, imported energy, and energy storage resources are the marginal resources in most hours of the year in both cases (see Figure 5). Energy prices in the Gas Dependence and Energy Storage scenario are within five percent of each other throughout the study time horizon for both the main case and the high gas price sensitivity. However, by 2033, energy prices in the Increased Energy Storage case are four percent lower as a result of more zero operating-cost renewables shifting the energy market clearing point down the supply curve. In the high gas price sensitivity in 2033, higher gas prices drive energy prices 46 percent higher than scenarios with medium gas prices.

Figure 5. Load-weighted locational marginal energy prices in Maryland



Equivalent effects are at play in the capacity market, where new gas plants are the marginal capacity resource in both scenarios. Although new gas plants can't be built in Maryland under the Energy Storage scenario, they are still built in nearby states, which Maryland shares a capacity market with. This activity outside of Maryland causes capacity prices to be very similar in the two scenarios, with 2033 prices in the Gas Dependence scenario only one percent higher than prices in the Energy Storage scenario, as shown in Table 2. Capacity prices in both scenarios are around eight percent lower under the high gas price sensitivity, compared to the medium gas price cases. Because high gas prices drive energy prices higher, new fossil plants can earn more money from the energy market and require less revenue and lower prices from the capacity market.

Table 2. 2033 Maryland capacity prices, 2021 $ per MW-day

	Main Scenario	High Gas Price Sensitivity
Continued Gas Dependence	$222	$206
Increased Energy Storage	$222	$204

Upon summing up the total costs associated with Maryland's energy and capacity requirements, we find that the Increased Energy Storage scenario results in net system cost savings of approximately $74 million in 2033, compared to the Gas Dependence scenario. Under the high gas price sensitivity, the Increased Energy Storage scenario results in net system cost savings to Maryland of roughly $100 million in 2033 due to lower observed energy costs.

4.5. Rate and bill impacts

By 2033, ratepayer rates and bills are roughly equivalent in both scenarios and are similar to the present day. In the final year of our analysis, residential electric rates in the Increased Energy Storage scenario are 1.1 percent lower than those under the Gas Dependence Scenario. For a residential electric customer in Maryland, this translates to an average bill savings of $1.28 per month, shown in Table 3.

Table 3. Historical and projected residential electric rates and bills

	2023 Historical	2033 Modeled	
		Energy Storage	Gas Dependence
Residential Rates (2021 $/kWh)	$0.131	$0.130	$0.131
Residential Bills (2021 $ per month)	$116	$115	$116

5. CONCLUSION

Our results indicate that it is economic for Maryland to build over 3.6 GW of storage by 2033. In general, IRA tax credits make renewables and storage more favorable, compared to new and existing fossil resources. Our Increased Energy Storage scenario shows that transitioning to renewables and storage, instead of continuing to rely on fossil fuels, can lower residential electric bills by about $1 per month compared to an alternative that is more dependent on gas. By pursuing additional installations of energy storage over the next decade, Maryland can reduce its in-state, electric sector greenhouse gas emissions by 93 percent by 2033, relative to 2023 levels, while saving millions in system energy costs.

Appendix A. Detailed Modeling Inputs and Assumptions

		Gas Dependence	Increased Storage
Storage parameters	Utility-scale battery storage	No new builds allowed	4-, 6-, and 8-hour storage allowed beginning in 2025 Prices based on NREL's 2022 ATB
	Long-duration storage	Not modeled, unlikely to have high penetration in the timeframe being modeled	Same as "Gas Dependence"
	Distributed battery storage	Follows PJM 2023 Load Forecast. Starts at 20 MW in 2023 and increases to 586 MW by 2033 for all of PJM	Same as "Gas Dependence"
Storage ELCC	4-hr storage	From PJM December 2022 Report. 94% in 2023, increasing to 100% in 2033	Same as "Gas Dependence"
	6-hr and 8-hr storage	From PJM December 2022 Report. Close to 100% across study period	Same as "Gas Dependence"
Modeling parameters	Topology	All of PJM, with Maryland's zones broken out separately	Same as "Gas Dependence"
	Modeling horizon	2023-2033	Same as "Gas Dependence"
	Temporal detail	Typical peak/off-peak day (2 days per month, 24 days total per year) with 6 intervals per day for capacity expansion 365 days with 12 intervals per day for production cost	Same as "Gas Dependence"
	Optimization period	Full-period optimization ("perfect foresight") for capacity expansion. No optimization for production cost	Same as "Gas Dependence"
Load	Energy efficiency	Follows PJM Load Forecast	Same as "Gas Dependence"
	DG Solar	Removed from PJM Load Forecast and modeled on the supply-side	Same as "Gas Dependence"
New conventional resources *(costs and tax credits, when allowed)*	Conventional gas	Allowed beginning in 2025, prices based on AEO 2022	Not allowed to build
	Gas with CCS	Not currently modeled	Same as "Gas Dependence"
	Coal with CCS	Not currently modeled	Same as "Gas Dependence"
	Adv. nuclear reactors / SMRs	Not currently modeled	Same as "Gas Dependence"
New utility-scale clean energy resources *(costs and tax credits, when allowed)*	Utility-scale solar	Allowed beginning in 2025, prices based on NREL's 2022 ATB; includes options for both PTC ($25/MWh) and ITC (30%)	Same as "Gas Dependence"
	Onshore wind	Allowed beginning in 2025, prices based on NREL's 2022 ATB;	Same as "Gas Dependence"

		Gas Dependence	Increased Storage
		includes options for both PTC ($25/MWh) and ITC (30%)	
New distributed clean energy resources *(costs and tax credits, when allowed)*	Distributed solar	Follows PJM 2023 Load Forecast. *(8 GW in 2023, 22 GW by 2033 for PJM)*	Same as "Gas Dependence"
	Conventional demand response	From PJM: 7 GW by 2033	Same as "Gas Dependence"
	Flexible load	None	Same as "Gas Dependence"
Fuel costs	Gas	NYMEX in short term, AEO 2022 Reference case in mid- to long-term	Same as "Gas Dependence"
	Coal	NDB default	Same as "Gas Dependence"
Existing fossil and nuclear and allowed retirements	Coal and gas	All plants currently listed as having an announced retirement retire on that date. Plants are allowed to retire endogenously beginning in 2025	Same as "Gas Dependence"
	Nuclear	Plants assumed to receive license extensions; IRA tax credits are assumed to prevent nuclear plants from retiring	Same as "Gas Dependence"
Transmission	Within Maryland	Modeling constraints between BGE and PEPCO	Same as "Gas Dependence"
	With regions adjacent to Maryland	Modeling constraints between SWMAAC, EMAAC, and APS	Same as "Gas Dependence"
Reserve margins	System	PJM Reserve margin and VRR curve	Same as "Gas Dependence"
Renewable capacity contributions (ELCC)	Solar	From PJM December 2022 Report. 50% in 2023, decreasing to 10% in 2033	Same as "Gas Dependence"
	Wind	From PJM December 2022 Report. 15% in 2023, decreasing to 11% in 2033	Same as "Gas Dependence"