Maryland PATHWAYS

Sensitivity Scenarios

June 21, 2021

Energy+Environmental Economics

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Agenda

+ **Background**

+ **Sensitivity Scenario Narrative and GHG Emissions Results**

+ **Optimistic Sensitivity – assumptions and results**

+ **Pessimistic Sensitivity – assumptions and results**

+ **Summary**

Background

+ **In early 2021, MDE released the 2030 GGRA Plan**

  • The Plan achieves 49% reduction in statewide gross greenhouse gas emissions from 2006 levels by 2030 (54% reduction in net GHG emissions)

+ **MDE further designed two sensitivity scenarios based on the 2030 GGRA Plan, reflecting different levels of potential federal actions**

+ **Today's presentation focuses on E3's modeling of Maryland's GHG emissions projection under the two sensitivity scenarios using the PATHWAYS model**

MD Net GHG Emissions Results for the 2030 GGRA Plan
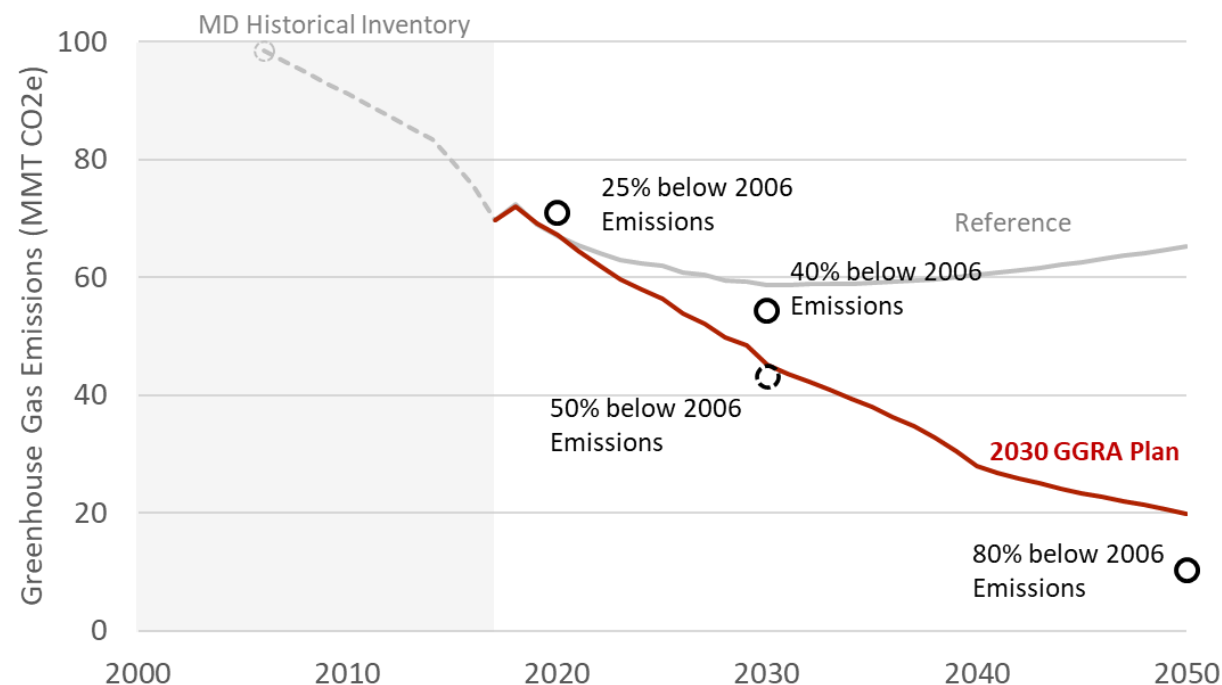
Total Net GHG Emissions by Scenario

+ The **Optimistic Sensitivity** reflects additional federal investment in green buildings, electric vehicles, low-carbon electricity, biofuels, and agricultural management practices.

  - It achieves 54% reduction below 2006 GHG emissions by 2030 and 84% by 2050 *on a gross emissions basis*

+ The **Pessimistic Sensitivity** reflects lack of federal actions that result in slower pace of electrification and efficiency improvement, as well as early retirement of Calvert Cliffs nuclear power plant in 2023

  - It achieves 41% reduction by 2030 *on a gross emissions basis*

MD Net GHG Emissions Results
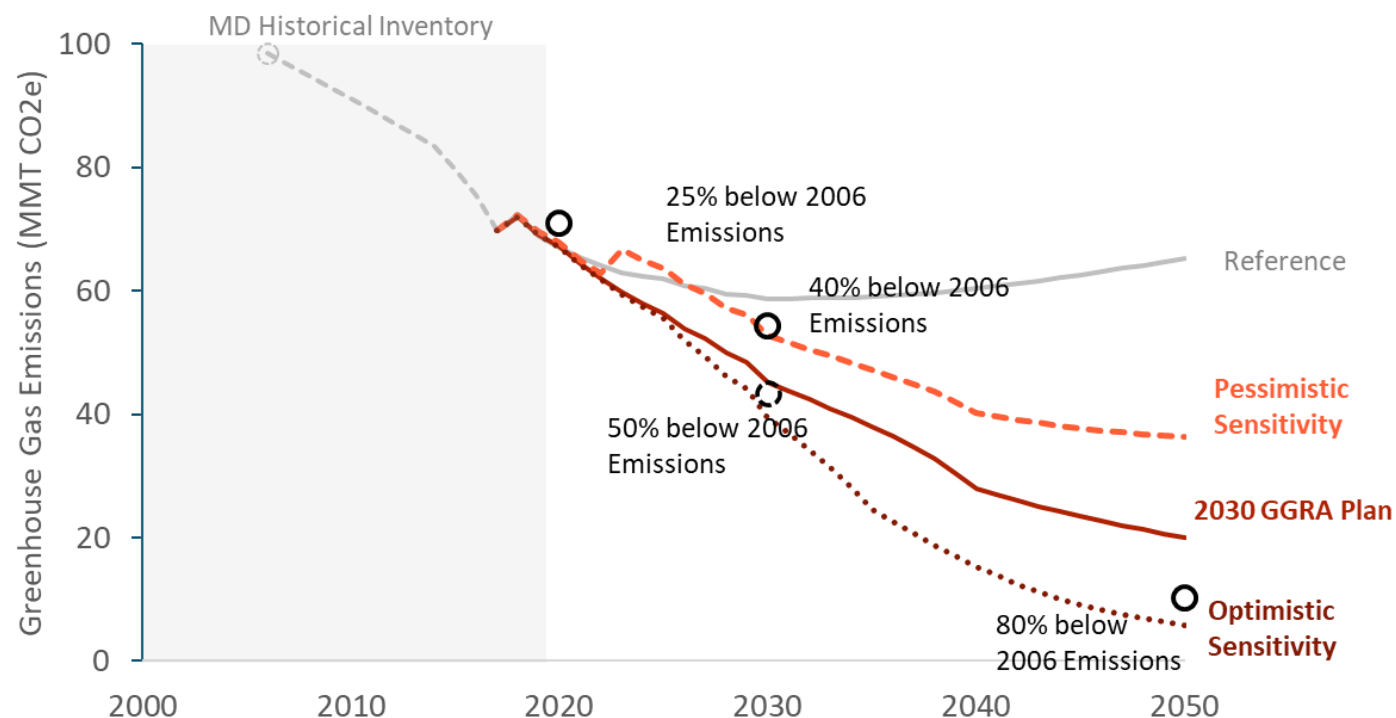
Notes:
- The goal of 50% reduction by 2030 is not required by the GGRA law, but it is what the state pursues in the recently released 2030 GGRA Plan.
- GGRA accounting measures reductions on a gross emissions basis. If accounting is done on a net basis (e.g. emissions measured net of land sinks) in line with the Biden Administration targets, net GHG emissions are reduced by 46% and 60% in 2030 relative to 2006 from the pessimistic and optimistic sensitivities respectively.

Optimistic Sensitivity
Assumptions and Results

Energy+Environmental Economics

+ Buildings

- Additional EmPOWER achievements in efficiency reflecting federal investment in retrofits and green buildings for pursuing broader energy efficiency and building decarbonization goals
  - 100% high efficiency electric sales by 2030
  - Improved building shells for all new construction and 50% of retrofit buildings by 2030
  - Aggressive building electrification achieving same levels of building electrification in 2030 GGRA Plan 5 years earlier

+ Transportation

- 100% ZEV LDV sales by 2035, and 100% ZEV MHDV sales by 2045, similar to California's ZEV mandate and reflecting federal investment in electric vehicles

+ Electricity Generation

- Nationwide 100% carbon-free electricity by 2035 as in Biden's proposed infrastructure plan
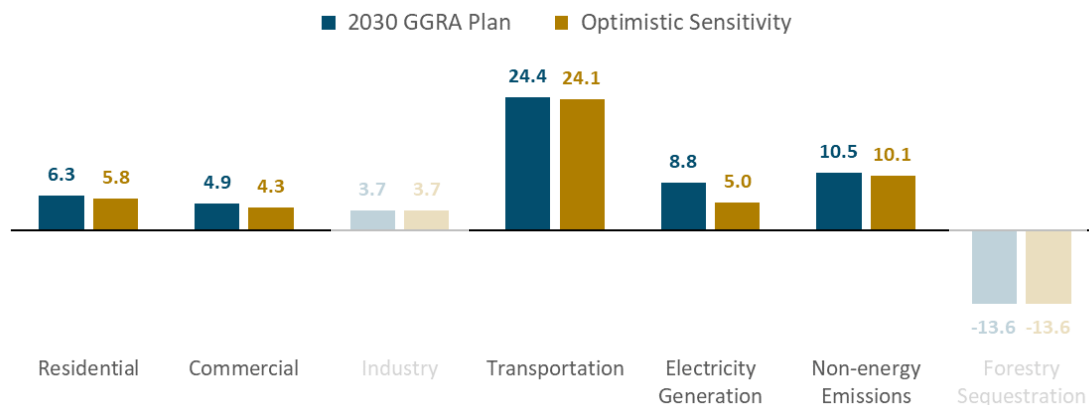
+ Other

- Advanced sustainable biofuels blended into diesel and natural gas reflecting federal investment in bioenergy development
  - 86% blend of bio-diesel with fossil-based diesel and fuel oil, reducing emissions mainly in industry and medium-and-heavy-duty transportation
  - 13% blend of bio-gas with natural gas, reducing emissions mainly in buildings and industry
- Federal incentives for improving agricultural management practices
- 10% of cement industrial emissions are reduced through carbon capture and storage by 2030 reflecting federal incentives for carbon removal technologies
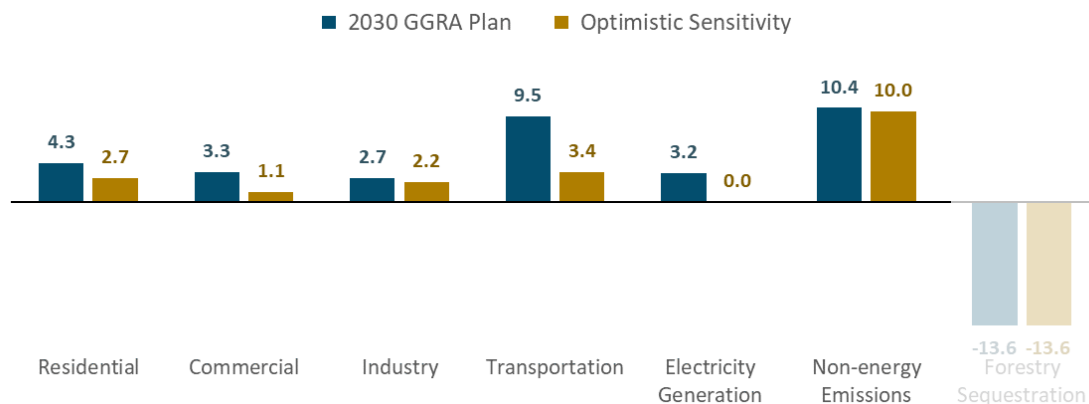
2030 GHG Emissions (MMT CO2e)

2030 GGRA Plan · **Optimistic Sensitivity**

	2030 GGRA Plan	Optimistic Sensitivity
Residential	6.3	5.8
Commercial	4.9	4.3
Industry	3.7	3.7
Transportation	24.4	24.1
Electricity Generation	8.8	5.0
Non-energy Emissions	10.5	10.1
Forestry Sequestration	-13.6	-13.6

2050 GHG Emissions (MMT CO2e)

2030 GGRA Plan · **Optimistic Sensitivity**

	2030 GGRA Plan	Optimistic Sensitivity
Residential	4.3	2.7
Commercial	3.3	1.1
Industry	2.7	2.2
Transportation	9.5	3.4
Electricity Generation	3.2	0.0
Non-energy Emissions	10.4	10.0
Forestry Sequestration	-13.6	-13.6

+ **In the near term**, lower GHG emissions in the Optimistic Sensitivity than in the 2030 GGRA plan is mainly attributed to **lower-carbon electricity generation** to achieve nationwide carbon-free electricity by 2035

+ **In the long term**, **aggressive electrification and efficiency measures**, together with the blend of **low-carbon advanced biofuels** with fossil fuels, <u>further</u> lower GHG emissions in the Optimistic Sensitivity
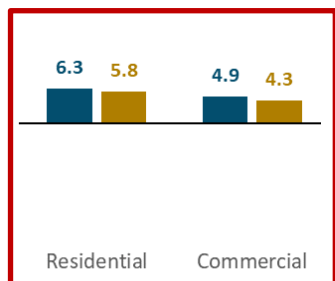
Total Net GHG Emissions (MMT CO2e)

	2030 GGRA Plan	Optimistic Sensitivity
2030	45.1	39.4
2050	19.9	5.9

2030 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

6.3 5.8   4.9 4.3

Residential   Commercial

2050 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

4.3 2.7   3.3 1.1

Residential   Commercial
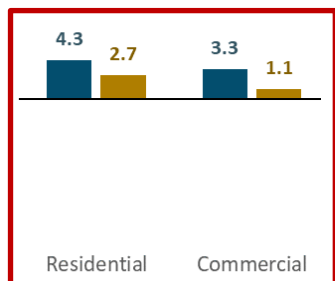
+ Building electrification adoption increases at a faster pace in the optimistic sensitivity

+ Residential electric appliance sales reach 50% by 2025, five years earlier than in the 2030 GGRA Plan; similarly, commercial electric sales reach 30% by 2025

+ The faster adoption trajectory is consistent with the MCCC-recommended target for building electrification

Residential Space Heaters (Sales Share)

Other Devices

2030 GGRA Plan

Electric Heat Pumps
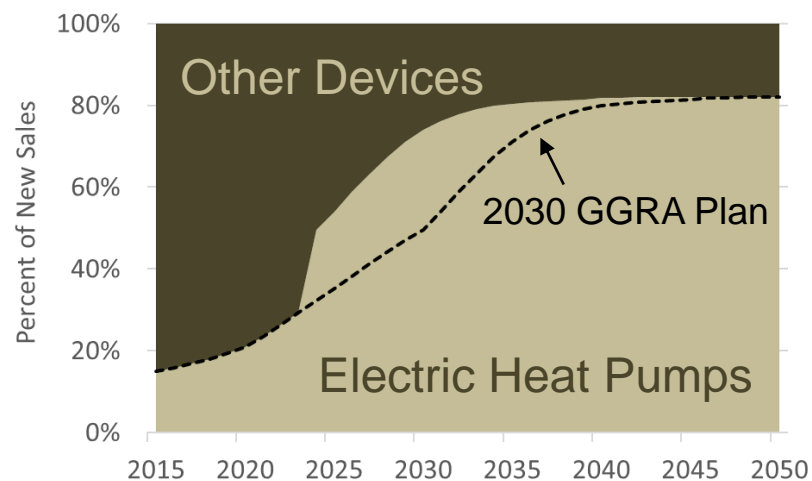
Residential Space Heaters (Total Stock)
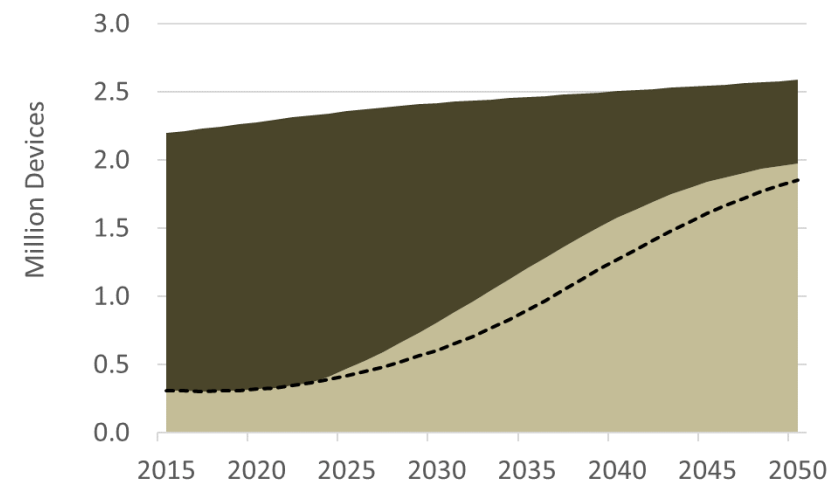
2030 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

24.4   24.1

Transportation

2050 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

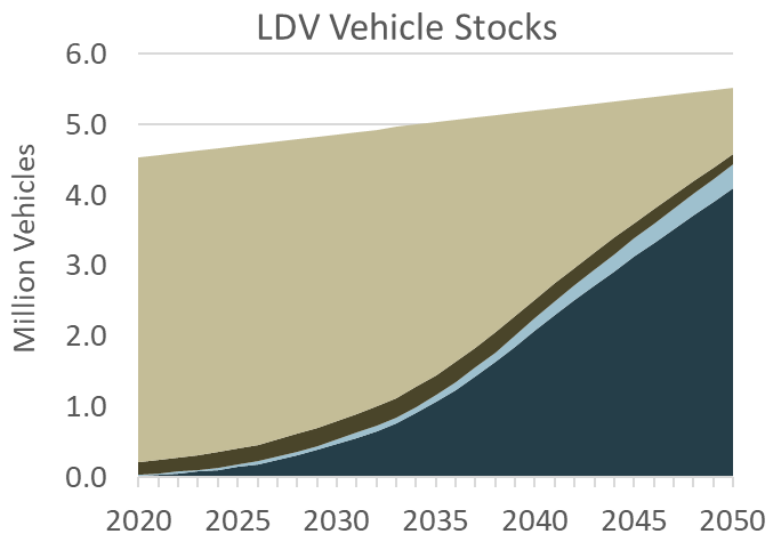9.5   3.4

Transportation
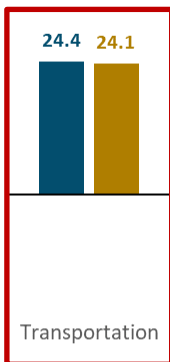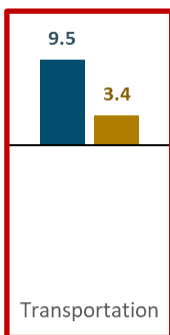
+ ZEV LDVs sales in the Optimistic Sensitivity reaches 100% by 2035, achieving beyond the ZEV Mandate goal as in the 2030 GGRA Plan
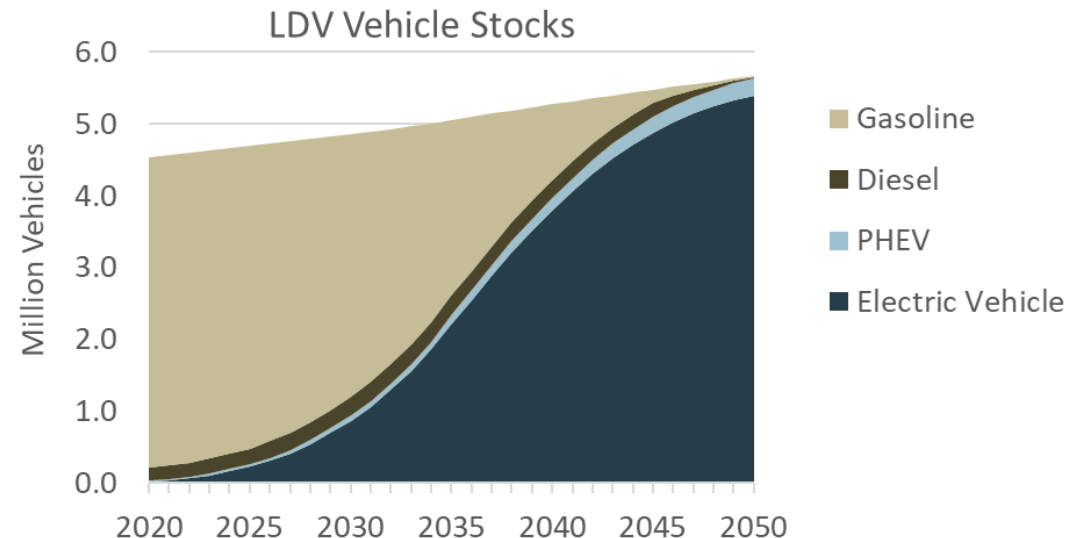
- **~400,000 more ZEV LDVs by 2030 and 1 million more by 2050**

2030 GGRA Plan

LDV Vehicle Stocks

Thousand	2025	2030	2050
BEV	140k	470k	4,100k
PHEV	40k	70k	300k
Total ZEV	180k	540k	4,400k

Optimistic Sensitivity
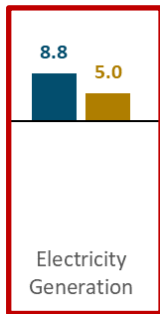
LDV Vehicle Stocks

■ Gasoline
■ Diesel
■ PHEV
■ Electric Vehicle

Thousand	2025	2030	2050
BEV	220k	860k	5,400k
PHEV	35k	80k	240k
Total ZEV	255k	930k	5,640k

2030 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

8.8   5.0

Electricity Generation

2050 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

3.2   0.0

Electricity Generation
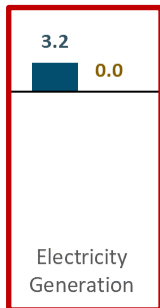
+ The Optimistic Sensitivity assumes national carbon-free electricity by 2035

- **In-state natural gas generation is all phased out by 2035, five years ahead of the CARES requirement in the 2030 GGRA Plan**

- **All imports are carbon-free by 2035**

- **(In the 2030 GGRA Plan, imports still have associated emission as only RGGI states in the PJM reach carbon-free electricity generation by 2040)**
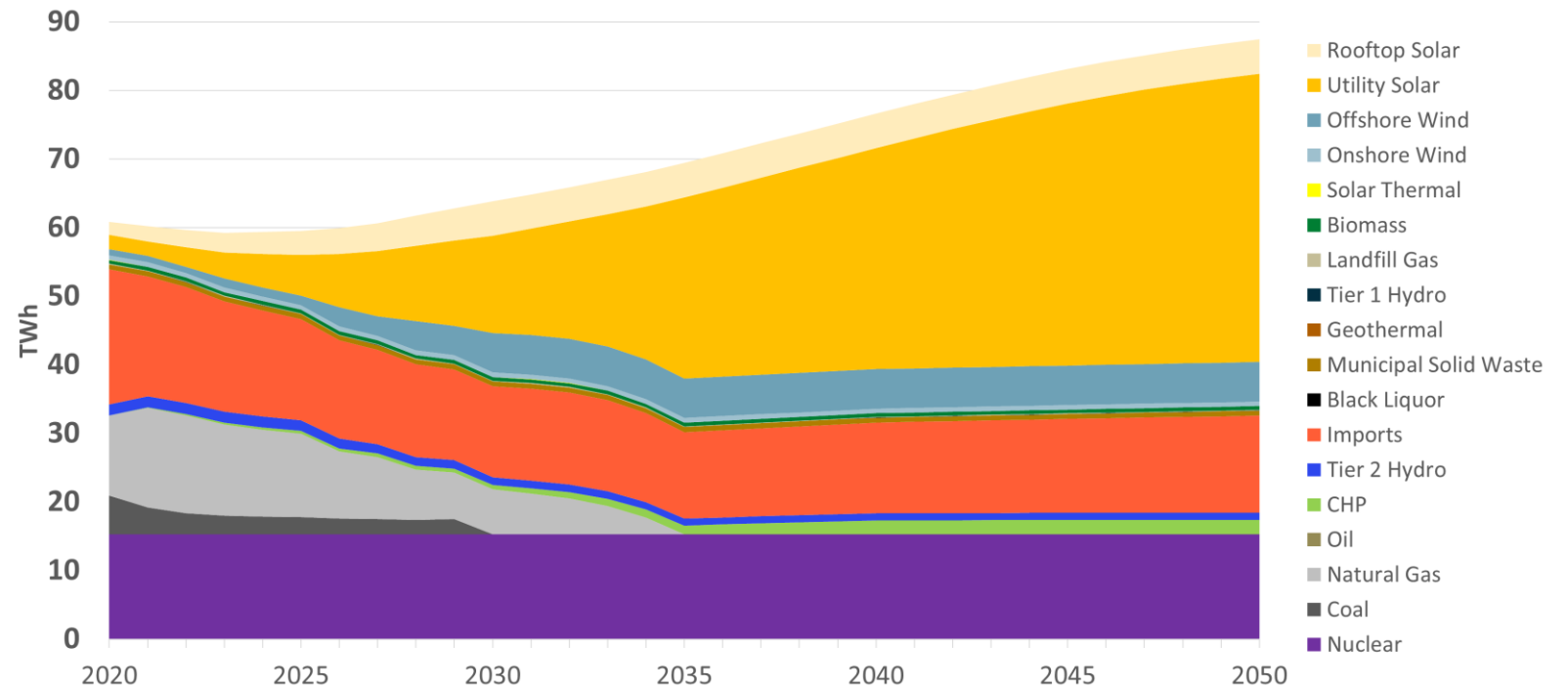
Legend:
- Rooftop Solar
- Utility Solar
- Offshore Wind
- Onshore Wind
- Solar Thermal
- Biomass
- Landfill Gas
- Tier 1 Hydro
- Geothermal
- Municipal Solid Waste
- Black Liquor
- Imports
- Tier 2 Hydro
- CHP
- Oil
- Natural Gas
- Coal
- Nuclear

Pessimistic Sensitivity
Assumptions and Results

Energy+Environmental Economics

+ Electricity Generation

- Calvert Cliffs Retirement in 2023

+ Transportation

- Half of LDV and MHDV electrification levels achieved in 2030 GGRA Plan

- Federal SAFE standards reflecting reduced vehicle efficiency improvement until 2025 and flat thereafter
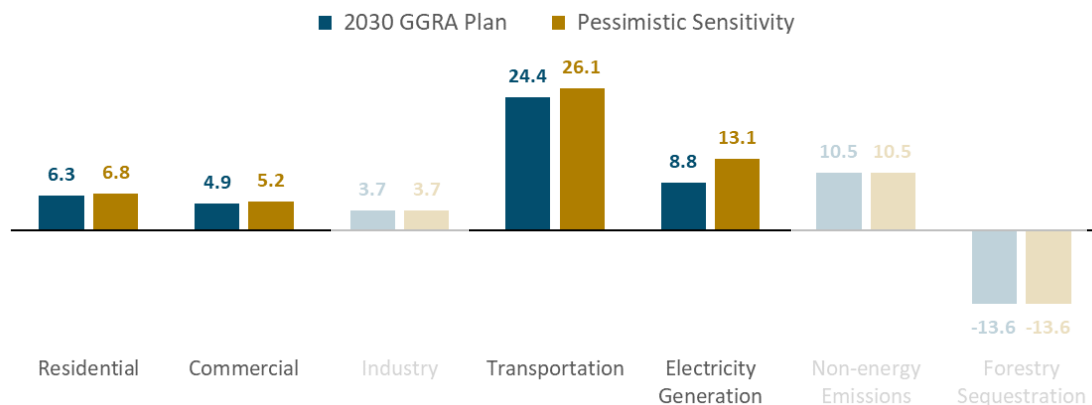
+ Buildings

- Half of building efficiency and electrification levels as achieved in the 2030 GGRA Plan
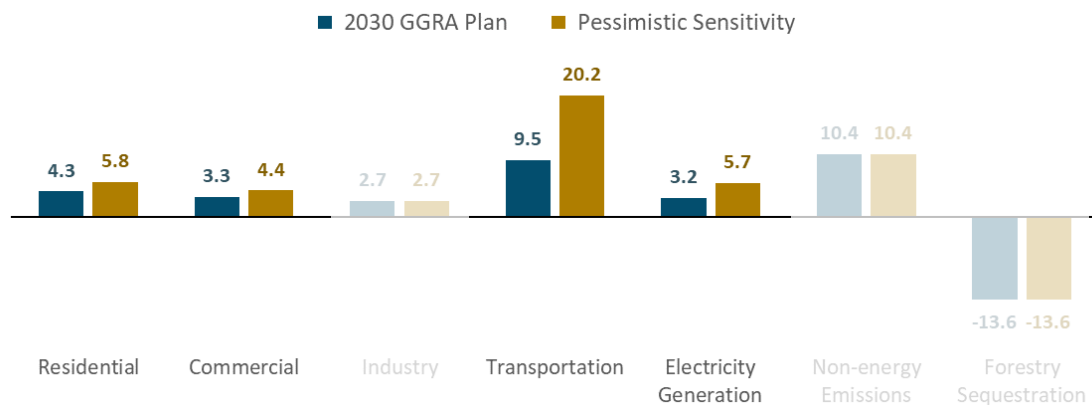
2030 GHG Emissions

■ 2030 GGRA Plan   ■ Pessimistic Sensitivity

6.3 6.8	4.9 5.2	3.7 3.7	24.4 26.1	8.8 13.1	10.5 10.5	-13.6 -13.6
Residential	Commercial	Industry	Transportation	Electricity Generation	Non-energy Emissions	Forestry Sequestration

2050 GHG Emissions

■ 2030 GGRA Plan   ■ Pessimistic Sensitivity

4.3 5.8	3.3 4.4	2.7 2.7	9.5 20.2	3.2 5.7	10.4 10.4	-13.6 -13.6
Residential	Commercial	Industry	Transportation	Electricity Generation	Non-energy Emissions	Forestry Sequestration

+ **In the near term**, higher GHG emissions in the Pessimistic Sensitivity compared to 2030 GGRA plan is mainly attributed to **the early retirement of Calvert Cliffs by 2023** and **reduced vehicle efficiency improvement**

+ **In the long term**, significantly reduced levels of **building electrification, efficiency improvement and zero-emission vehicle adoption** further increases GHG emissions in the Pessimistic Sensitivity
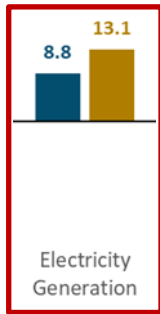
Total Net GHG Emissions (MMT CO2e)

	2030 GGRA Plan	Pessimistic Sensitivity
2030	45.1	52.8
2050	19.9	36.3

2030 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

8.8   13.1

Electricity Generation

2050 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

3.2   5.7

Electricity Generation

+ The Pessimistic Sensitivity assumes early retirement of Calvert Cliffs nuclear plant by 2023

- • **The gap from nuclear retirement is met by imports, which has associated carbon emissions and contributes to increase in electricity GHG emissions**

Legend:
- Rooftop Solar
- Utility Solar
- Offshore Wind
- Onshore Wind
- Solar Thermal
- Biomass
- Landfill Gas
- Tier 1 Hydro
- Geothermal
- Municipal Solid Waste
- Black Liquor
- Imports
- Tier 2 Hydro
- CHP
- Oil
- Natural Gas
- Coal
- Nuclear
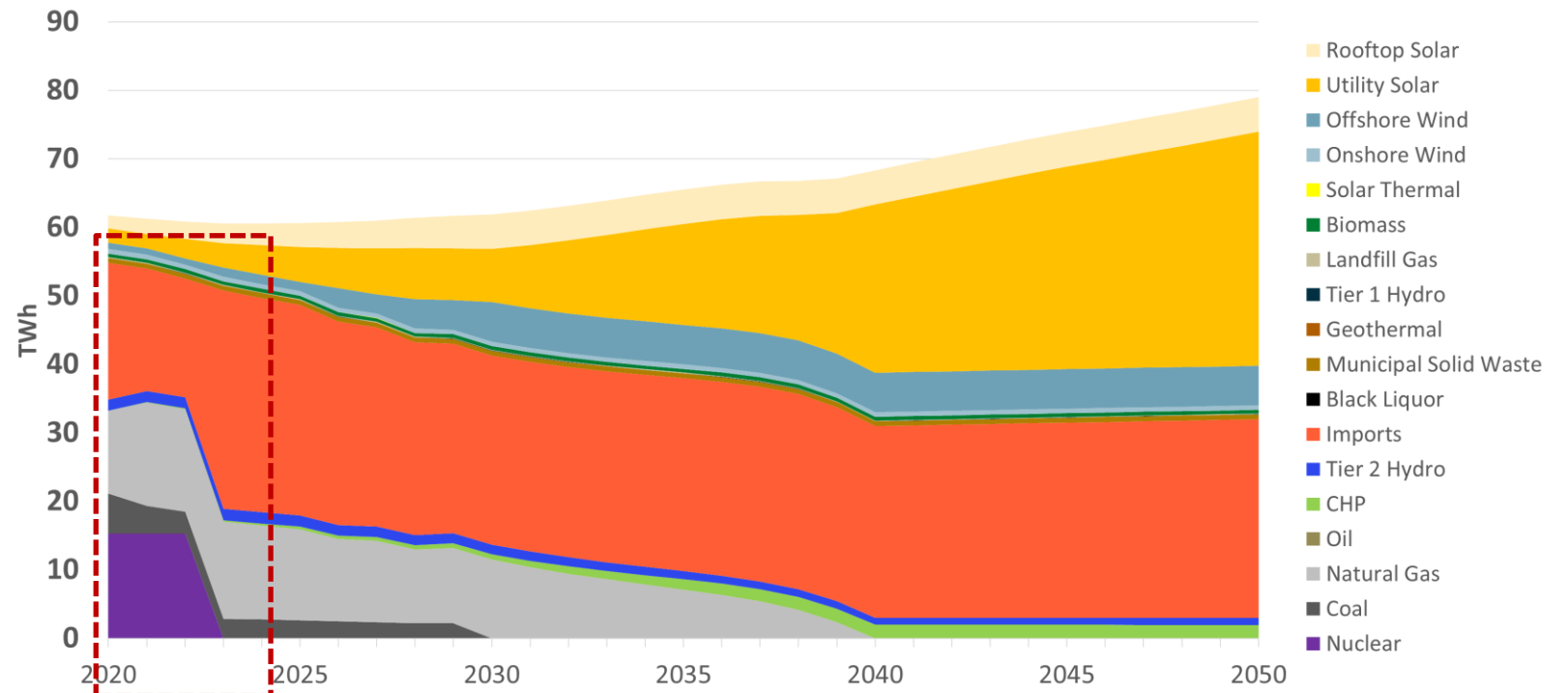
+ The **Optimistic Sensitivity** shows that **additional federal investment in electrification, nationwide clean electricity and sustainable low-carbon fuels** can help Maryland achieve deeper GHG emission reductions both in the near term (beyond 50% by 2030) and in the long term (beyond 80% by 2050)

+ The **Pessimistic Sensitivity** shows that **Maryland may still achieve the 2030 GGRA target even with the retirement of Calvert Cliffs**; however **reduced level of electrification and efficiency improvement** due to lack of federal action may keep the state from achieving any long-term GHG reduction goals commensurate to what other states are committed to
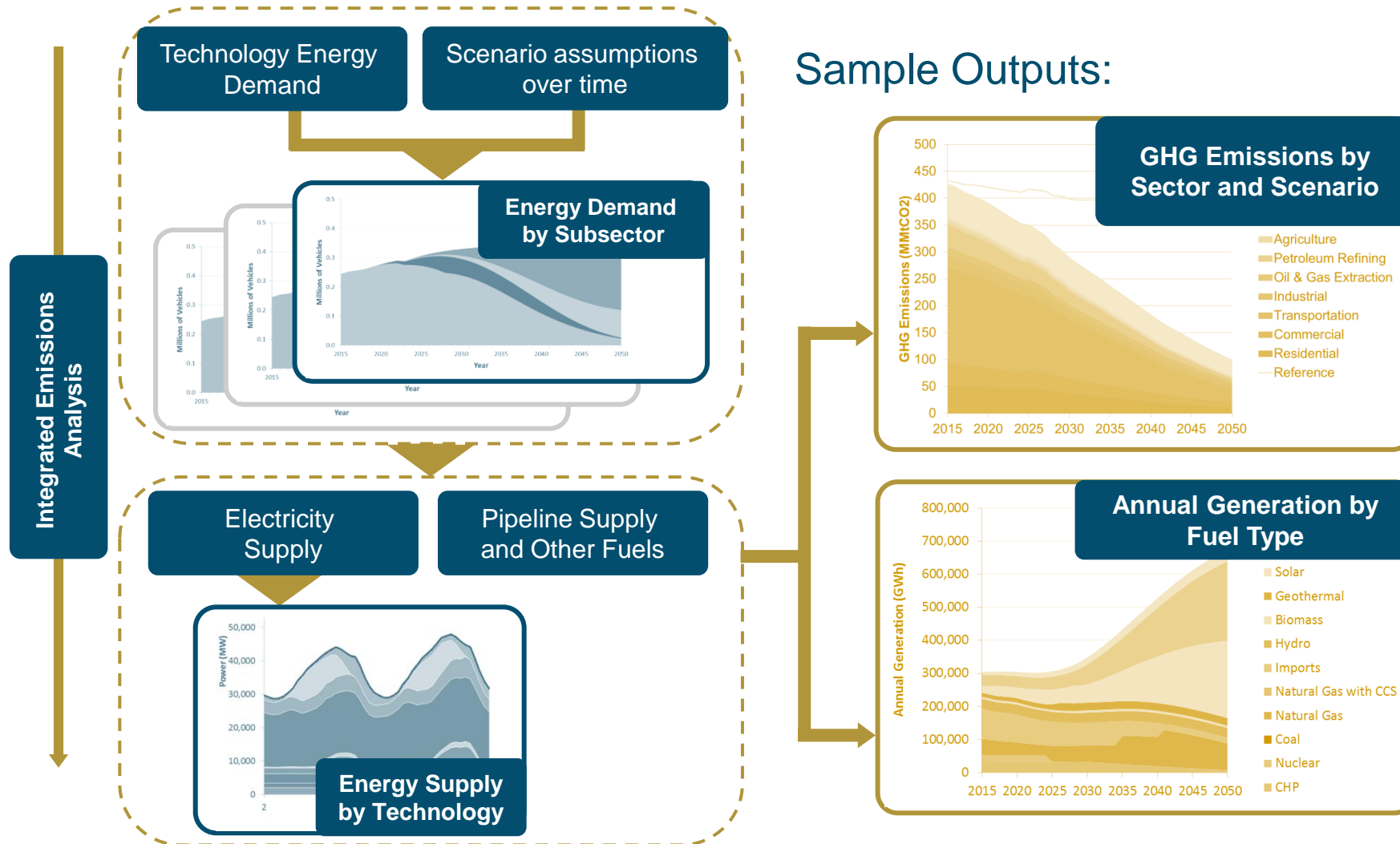
Appendix

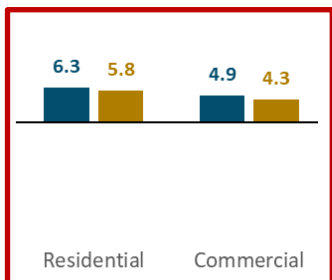Energy+Environmental Economics

PATHWAYS Modeling Framework

Sample Outputs:
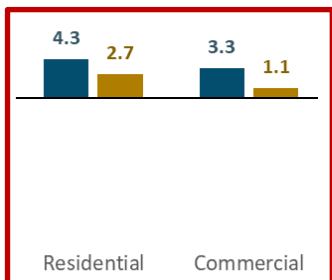
Building Energy Efficiency - Optimistic Sensitivity

2030 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

	Residential	Commercial
2030 GGRA Plan	6.3	4.9
Optimistic Sensitivity	5.8	4.3

2050 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

	Residential	Commercial
2030 GGRA Plan	4.3	3.3
Optimistic Sensitivity	2.7	1.1

+ The Optimistic Sensitivity assumes higher levels of building shell improvement in retrofit buildings

- In the 2030 GGRA Plan, same level of efficient shell adoption happens in retrofit buildings as in new constructions in 2030, as retrofit buildings are projected to account for 80% of the total sales in 2030

- The Optimistic Sensitivity doubles the level of efficient shell adoptions in retrofit buildings

Sales Share (%)	2030 GGRA Plan	Optimistic Sensitivity
New Construction	100%	100%
Retrofit Buildings	25% (same amount of adoption as in new constructions)	50%

+ In addition, the Optimistic Sensitivity also assumes higher adoption of efficient electric appliance reflecting renewed and more aggressive EMPOWER program

- 100% of efficient electric appliance sales by 2030 vs. 50% by 2030 in the 2030 GGRA Plan
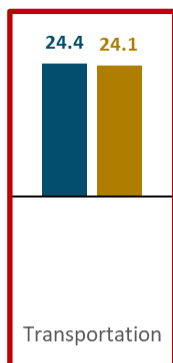
2030 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

24.4   24.1

Transportation

## 2050 GHG Emissions

■ 2030 GGRA Plan   ■ Optimistic Sensitivity

9.5

3.4

Transportation

+ ZEV MHDVs sales in the Optimistic Sensitivity reaches 100% by 2045, five years ahead of the ZEV Truck Mandate goal as in the 2030 GGRA Plan

- **ZEV MHDV fleet reaches 158,000 by 2050, ~10% more than in the 2030 GGRA Plan**

Medium and Heavy-duty Vehicle Stock

Thousand Vehicles

.... Optimistic Sensitivity

—— 2030 GGRA Plan

Year
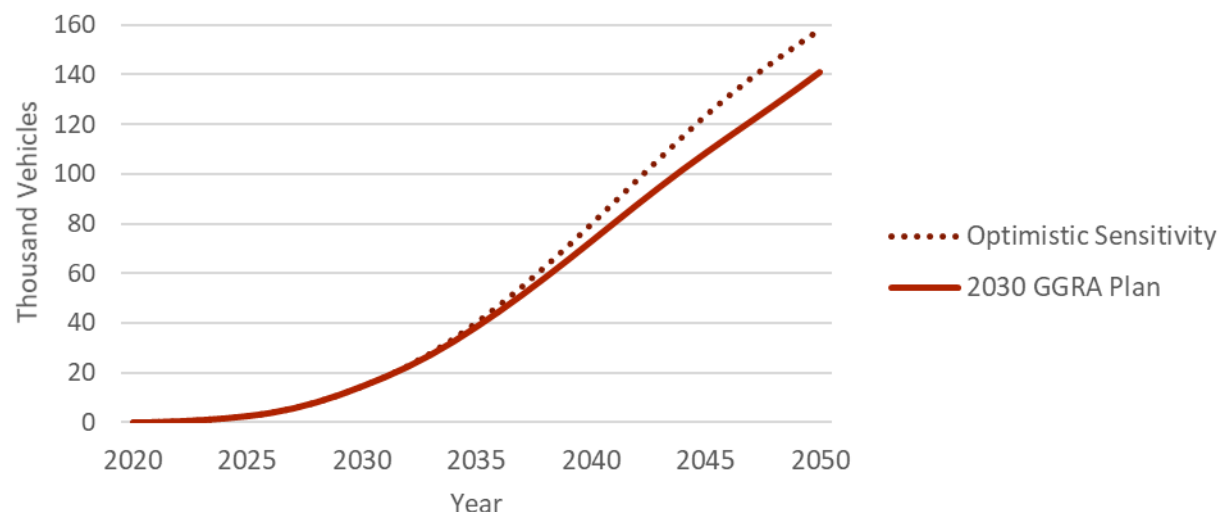
	2025	2030	2050
2030 GGRA Plan	3k	14k	141k
Optimistic Sensitivity	3k	14k	158k

Sensitivity Scenarios
Policies and Measures

|	2030 GGRA Plan	Optimistic Sensitivity	Pessimistic Sensitivity
Clean Electricity Standard	75% Clean and Energy Standard (CARES) by 2030, 100% by 2040; carveout for in-state clean energy resources reaching 10% by 2030 and 30% by 2040	Nationwide 100% carbon-free electricity by 2035 (Biden's proposed infrastructure plan)	Same as 2030 GGRA Plan
Nuclear power	Assume Calvert Cliffs is relicensed in 2034/2036 at end of license		Calvert Cliffs Retirement in 2023 with imports filling the gap
Energy Efficiency	Continued EmPOWER for efficiency in buildings *(50% high efficiency electric sales by 2030, 25% for natural gas appliance sales)*	Additional EmPOWER achievements in efficiency reflecting federal investment in building retrofits for pursuing broader energy efficiency goals *(100% high efficiency electric sales by 2030)*	Half of efficiency achieved in 2030 GGRA Plan
Building Code	Improved building shells for all new construction and 25% of retrofit buildings by 2030	Improved building shells for all new construction and 50% of retrofit buildings by 2030 reflecting federal investment in green buildings	Same as 2030 GGRA Plan
Electrification of buildings	High levels of building electrification reflecting reformed EmPOWER program *(heat pumps sales increase to 50% by 2030 and 80% by 2040)*	Achieving same levels of building electrification in 2030 GGRA Plan 5 years earlier reflecting federal investment in building retrofits *(heat pumps sales increase to 50% by 2025 and 80% by 2035)*	Half of electrification levels achieved in 2030 GGRA Plan

Sensitivity Scenarios
Policies and Measures (cont'd)

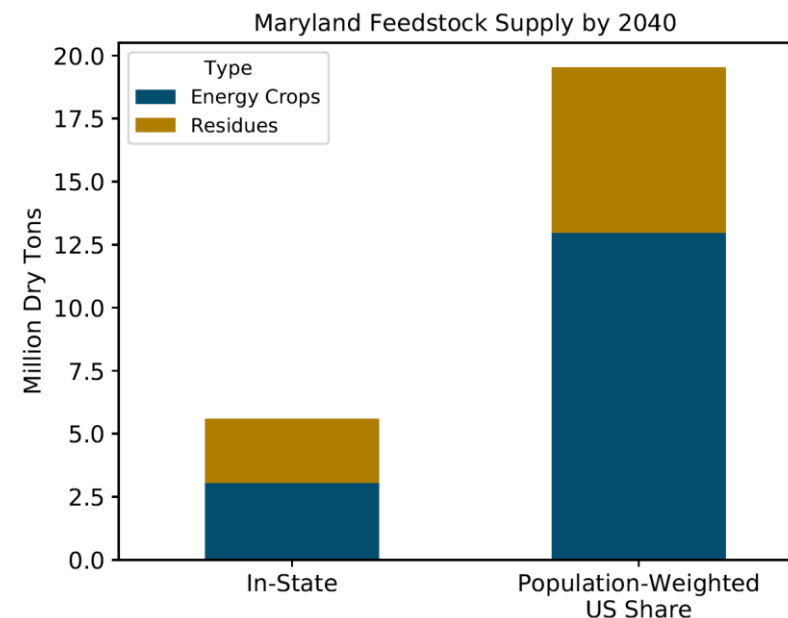|	2030 GGRA Plan	Optimistic Sensitivity	Pessimistic Sensitivity
Fuel Economy Standards	Extension of Federal CAFE standards for LDVs through 2030	Same as 2030 GGRA Plan	Federal SAFE standards reflecting reduced vehicle efficiency improvement until 2025 and flat thereafter
Zero Emission Vehicles	Increased sales of ZEV LDVs after 2025 and aggressive sales after 2030; aggressive sales of ZEV MHDVs to meet the ZEV Truck Mandate	100% ZEV LDV sales by 2035, and 100% ZEV MHDV sales by 2045, reflecting federal investment in electric vehicles	Half of LDV and MHDV electrification levels achieved in 2030 GGRA Plan
Biofuels	Existing ethanol and biodiesel blends, but no assumed increase	Advanced sustainable biofuels blended into diesel and natural gas reflecting federal investment in bioenergy development	Same as 2030 GGRA Plan
Other (fossil fuel industry, industrial processes, agriculture, etc.)	Forest management and healthy soils conservation practices; reduced methane emissions from natural gas transmission and distribution.	More aggressive measures in enteric fermentation & manure management reflecting federal incentives for improving agricultural management practices; 10% of cement industrial emissions are reduced through carbon capture and storage by 2030 reflecting federal incentives for carbon removal technologies	Same as 2030 GGRA Plan

Biomass Feedstock Potential

National Feedstock Supply by 2040
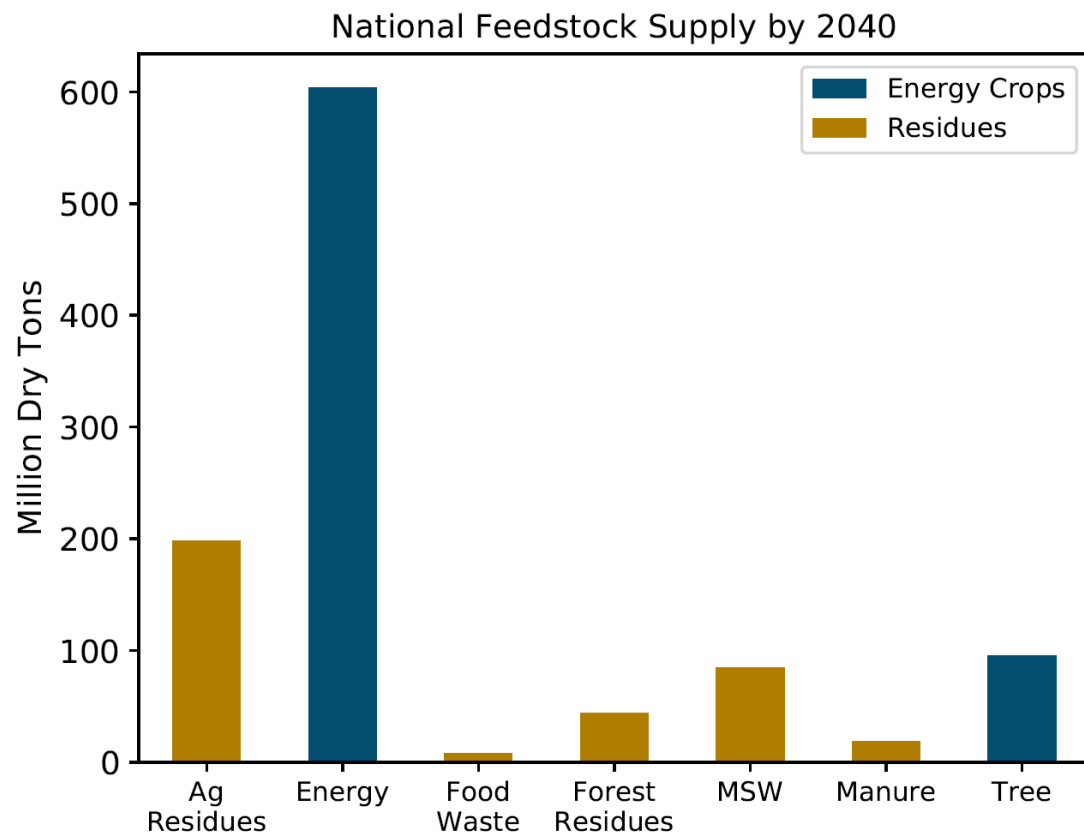
Source: DOE, 2016. Billion Ton Update

Maryland Feedstock Supply by 2040

+ Maryland has limited in-state biomass resource potential

+ Using the population-weighted share of the US supply, MD has access to more than 3x the in-state potential

+ Energy crops increase available supply, but can be controversial due to land-use concerns

+ Optimistic Sensitivity assumes that Maryland has access to the population-weighted share of all "Residues" feedstock categories