



Maryland
Department of
the Environment

GGRA Modeling Update

This presentation does not represent any state policy positions nor does it represent a proposed state climate plan. This is simply the first of several model runs that examine different scenarios to be used to guide the state in developing a climate plan. These materials are informational only and should not be used for any other purpose.



Energy+Environmental Economics

+ Maryland Pathways Policy Scenario 1

September 18th, 2018

Tory Clark, Managing Consultant

Doug Allen, Managing Consultant

Sharad Bharadwaj, Consultant

Amber Mahone, Director

Sneller Price, Senior Partner



Policy Scenario 1 Measures

- + Philosophy: Continuation or Extension of current programs**
- + Includes:**
 - Continued effort for energy efficiency in buildings
 - Additional ZEV sales for light-duty transit
 - Reduction in vehicle-miles traveled and other MDOT measures
 - 50% RPS by 2030 (HB1435/SB0732)
 - Smart Growth (75% compact development goal)
 - Additional acreage in forest management and healthy soils conservation practices



Policy Scenario 1 Measures

Light Duty ZEV Adoption and VMT Reduction

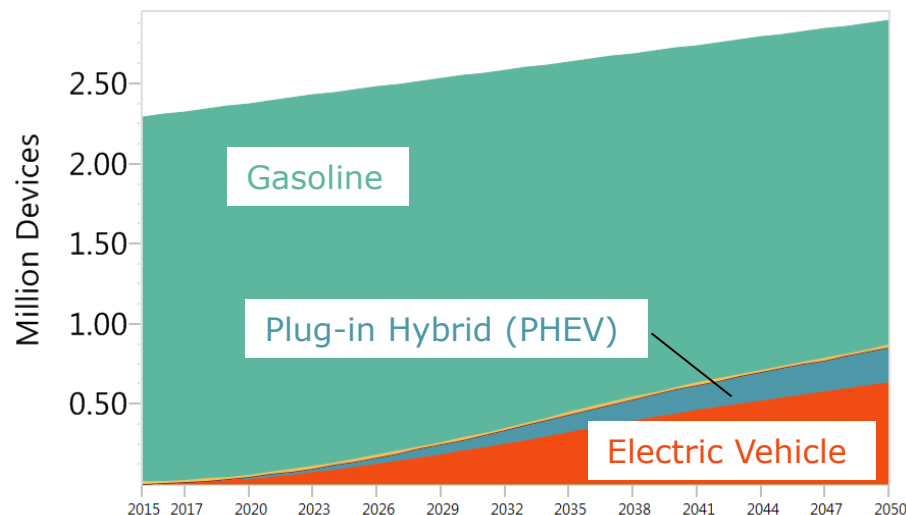
Increased Sales of ZEVs

- + New sales of EVs and PHEVs increase to 35% by 2050
- + 270,000 ZEVs by 2025, 530,000 ZEVs by 2030, 1,400,000 ZEVs by 2050

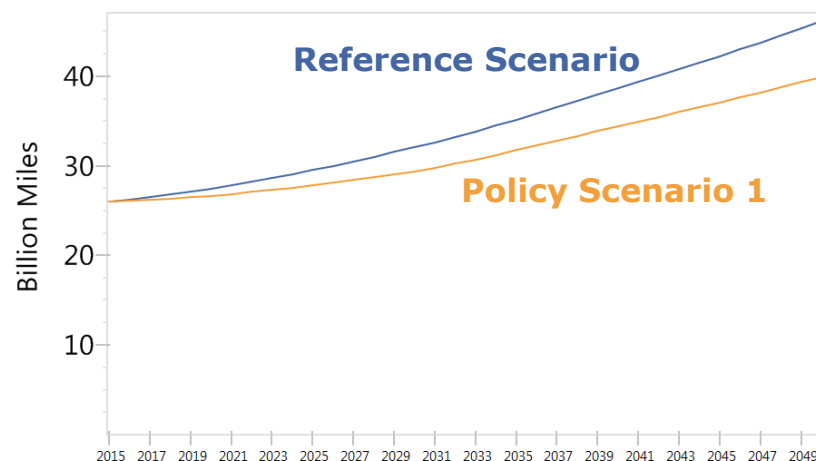
Reduction in VMT

- + Reduction of annual vehicle-miles traveled from 1.7% to 1.4% (2018 MPO Plans & Programs)
- + Further reduction in LDV VMT due to smart transit measures (e.g. compact development, transportation demand management, public and intercity transit)

LDA Vehicle Stocks



VMT by Scenario





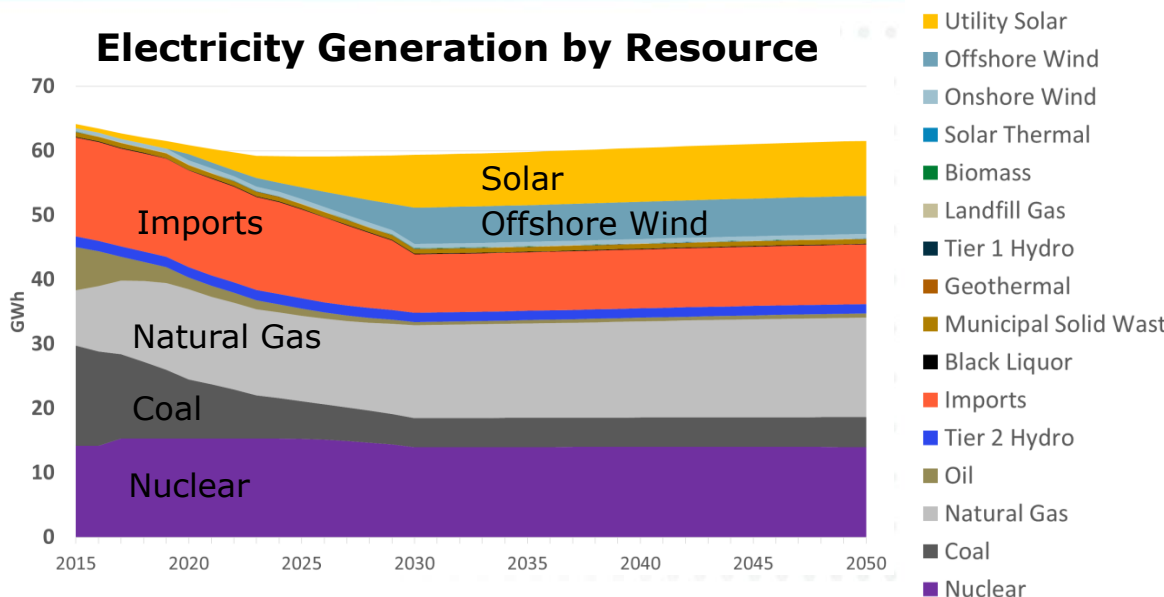
Policy Scenario 1 Measures Increased Renewable Generation

50% RPS by 2030 (HB1435/SB0732)

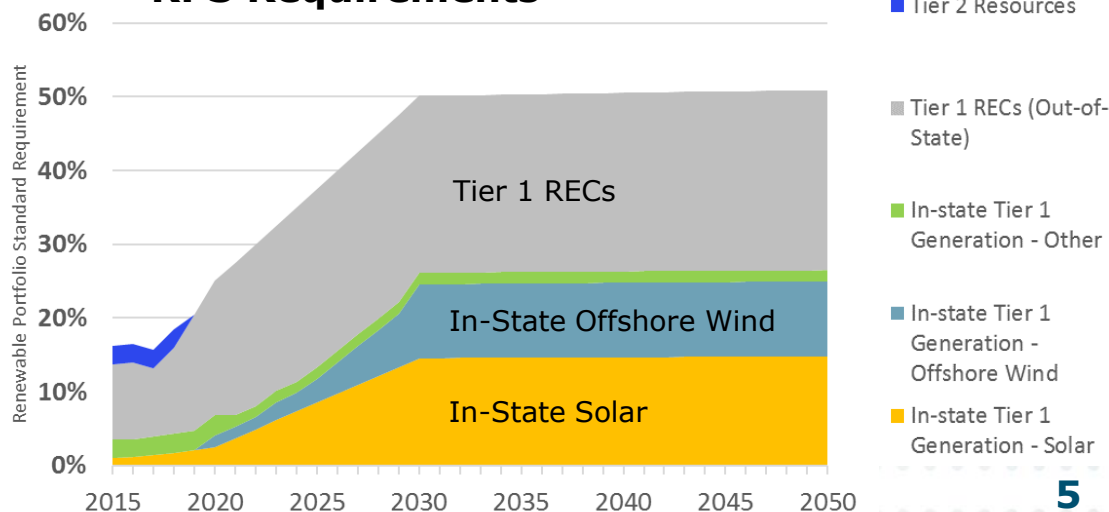
+ 25% RPS in 2020, 50% RPS in 2030, with solar (14.5%) and offshore wind (10%) carveouts

+ Achieves solar (14.5%) and offshore wind (10%) carveouts, decreases proportion of RPS met by out-of-state RECs relative to 25% RPS

Electricity Generation by Resource

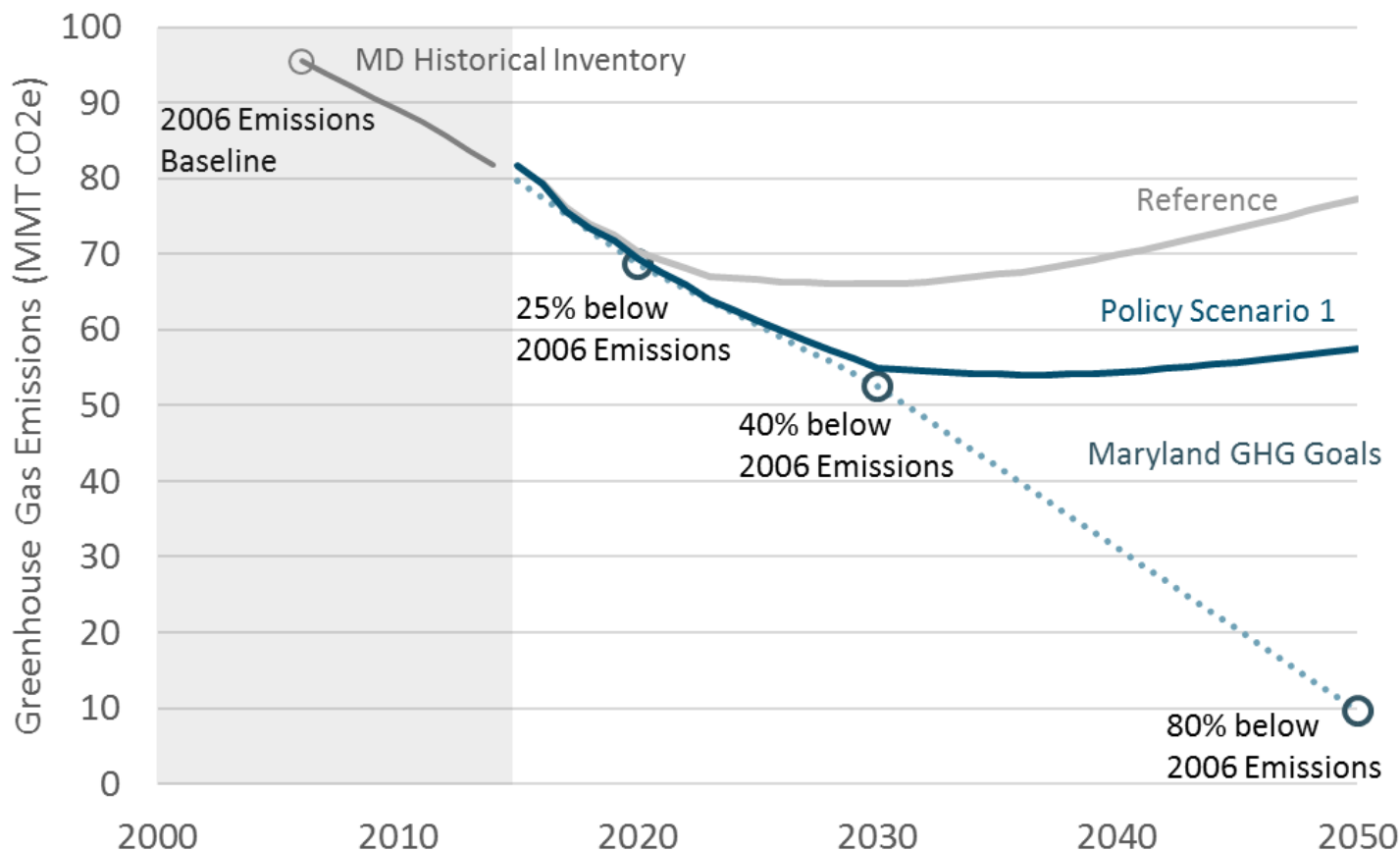


RPS Requirements





Policy Scenario 1 total GHG emissions

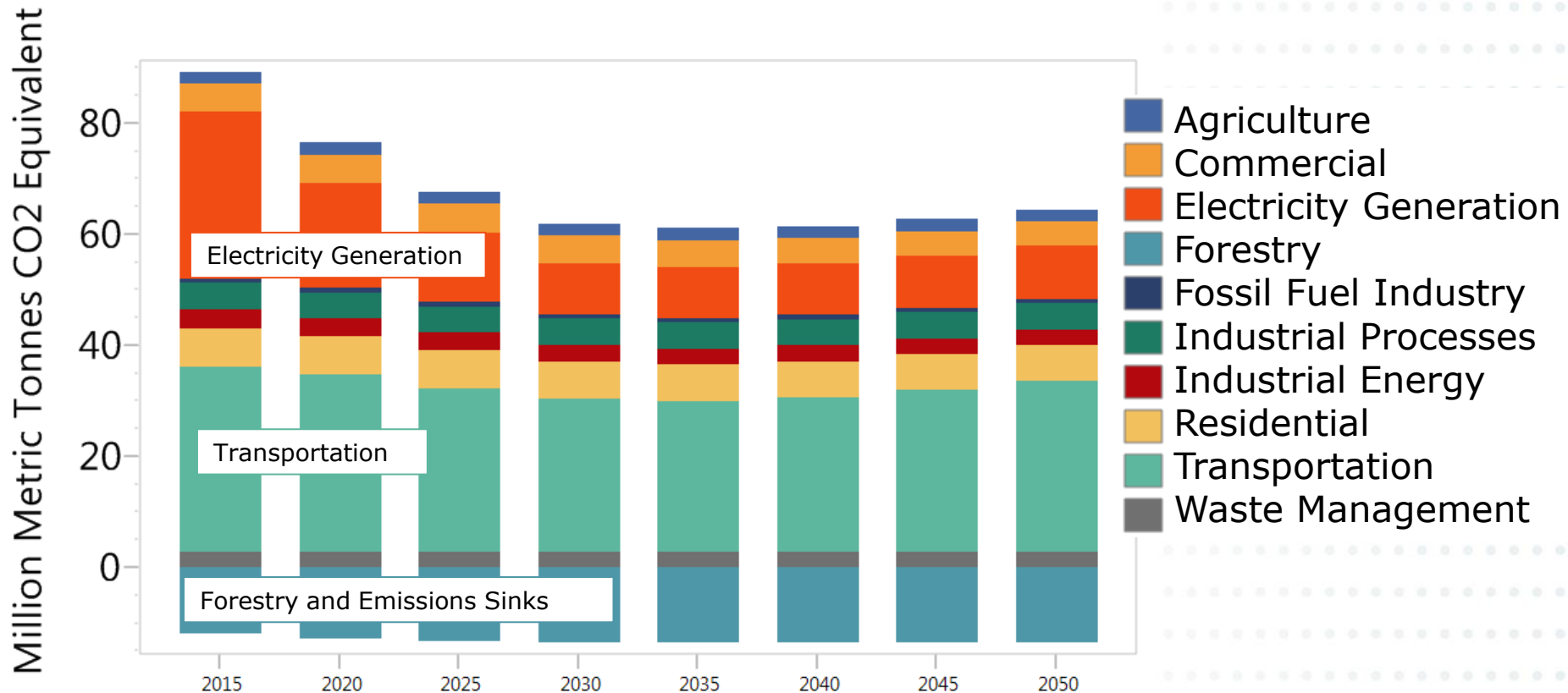


Gap in 2020: 0.7 MMT (1% above goal)
Gap in 2030: 2.4 MMT (5% above goal)
Gap in 2050: 47.8 MMT



Policy Scenario 1

Total emissions by sector

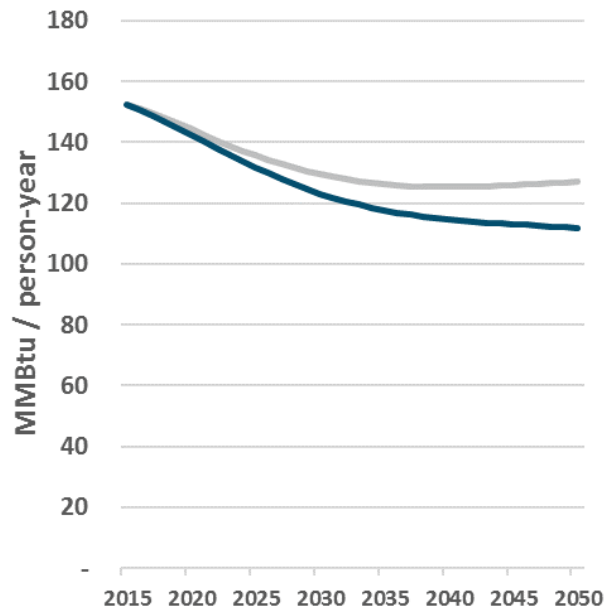




Key Metrics: 3 Pillars of Decarbonization

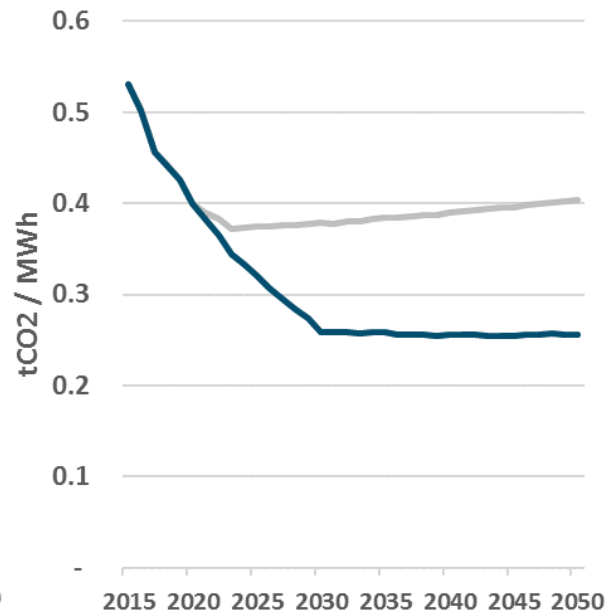
(1) Energy Efficiency

[Energy Consumption per person]



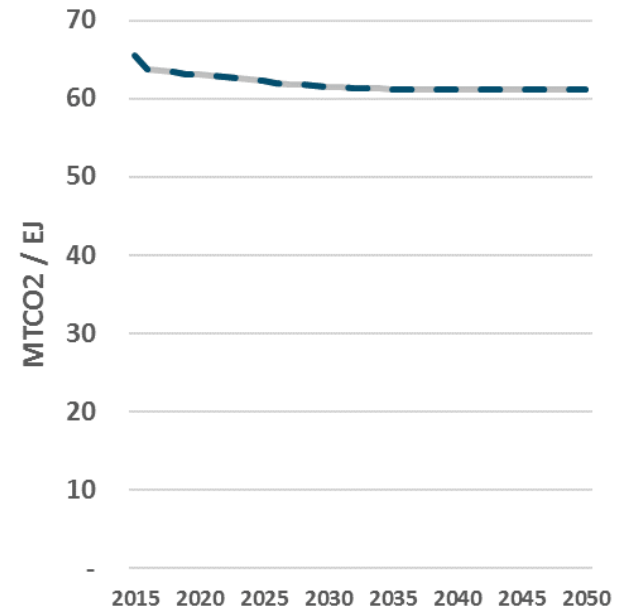
(2) Clean Electricity

[Metric ton/MWh]



(3) Clean Liquid and Gaseous Fuels

[Million Metric tonnes / EJ]



Reference Scenario
Policy Scenario 1



How to close the gap: 2030

2.6 MMT CO₂e needed in 2030

Methane capture
and flaring

Refrigerant F-gas
mitigation

Electrification of
water heating

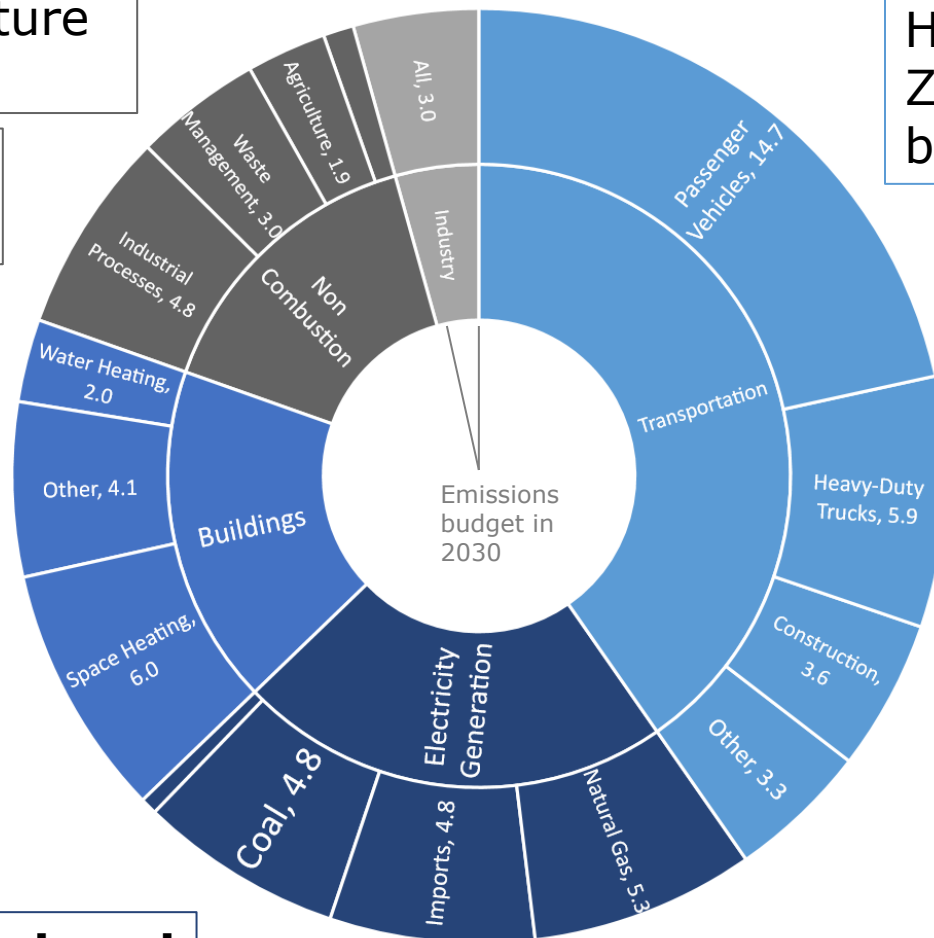
Electrification of
space heating

**Additional coal
retirements**

**Update RPS
REC accounting**

Higher rate of
ZEV Sales
before 2030

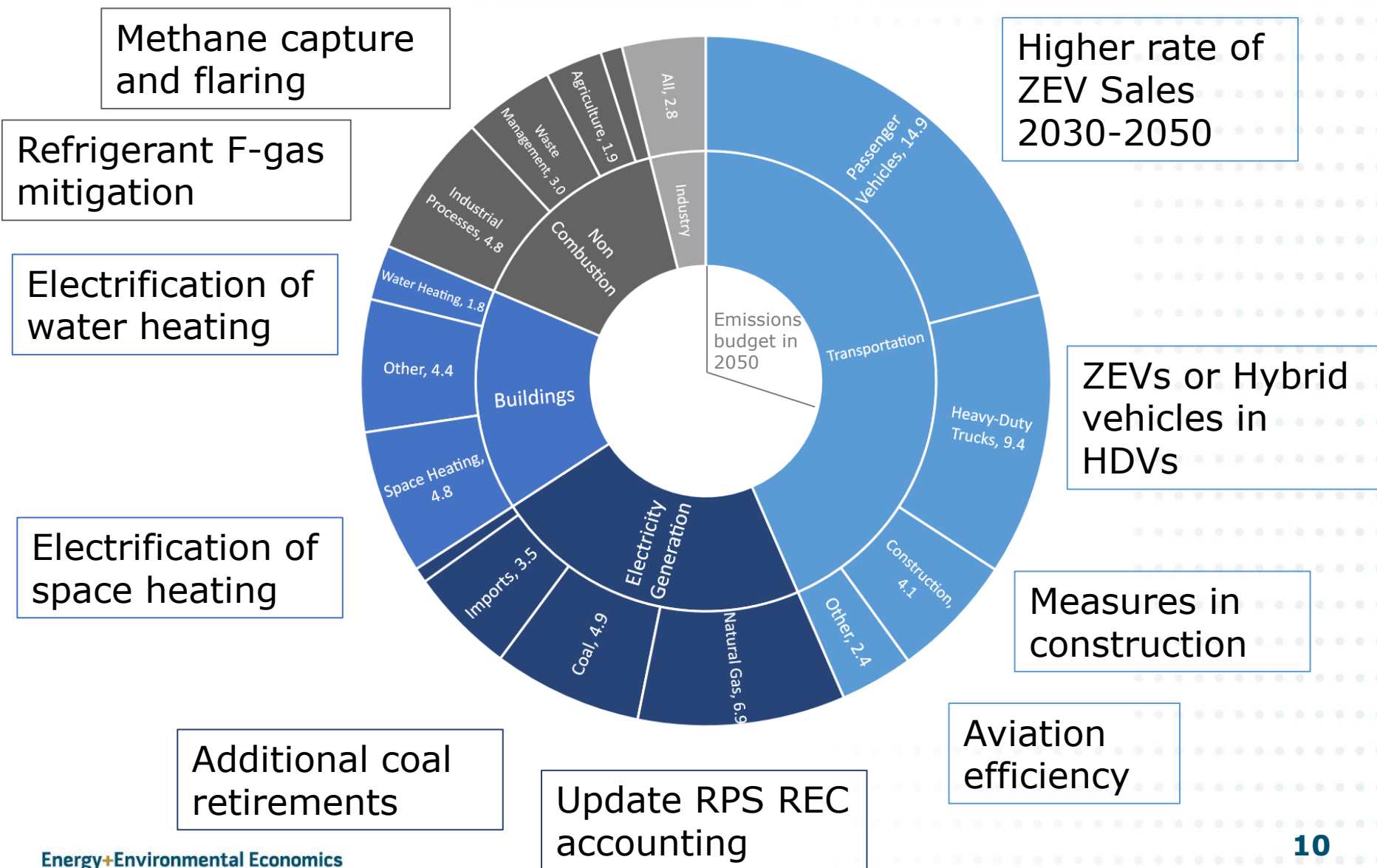
ZEVs or Hybrid
vehicles in
HDVs





How to close the gap: 2050

47.6 MMT CO₂e needed in 2050





Potential measures to close emissions gap

+ 2030

- Coal retirements
- Update RPS REC accounting/procurement to include emissions credit for renewable generation (~5 MMT CO₂e in 2030 and 2050)

+ 2050

- Increased effort across all sectors – goal in 2050 is ~20MMT gross emissions
 - Deeper reductions in electricity generation
 - Increased transportation and building electrification
 - Approach to construction emissions
 - Advanced biofuels for drop-in liquid and gaseous fuels
 - *NB: Some measures required to reach 2050 will require near-term actions based on economic life of equipment*



Energy+Environmental Economics

Thank You!

Energy and Environmental Economics, Inc. (E3)

101 Montgomery Street, Suite 1600

San Francisco, CA 94104

Tel 415-391-5100

Web <http://www.ethree.com>



Energy+Environmental Economics

APPENDIX



K I L O W A T T H O U R S

SINGLE-STATOR WATTHOUR METER

TYPE AB1 S.

200 CL 240 V 3 W 60 Hz TA 30

MADE
IN



Reference Policies

+ Electricity Generation

- Upcoming Coal facility retirements
- 25% RPS by 2020
- RGGI 2030 cap
- Relicense Calvert Cliffs Nuclear Facility*

+ Transportation

- CAFÉ Standards by 2025
- Zero Emission Vehicle Mandate

+ Buildings

- EmPOWER efficiency goals
- DHCD Low Income EE Program*
- MEA Woodstoves Program*

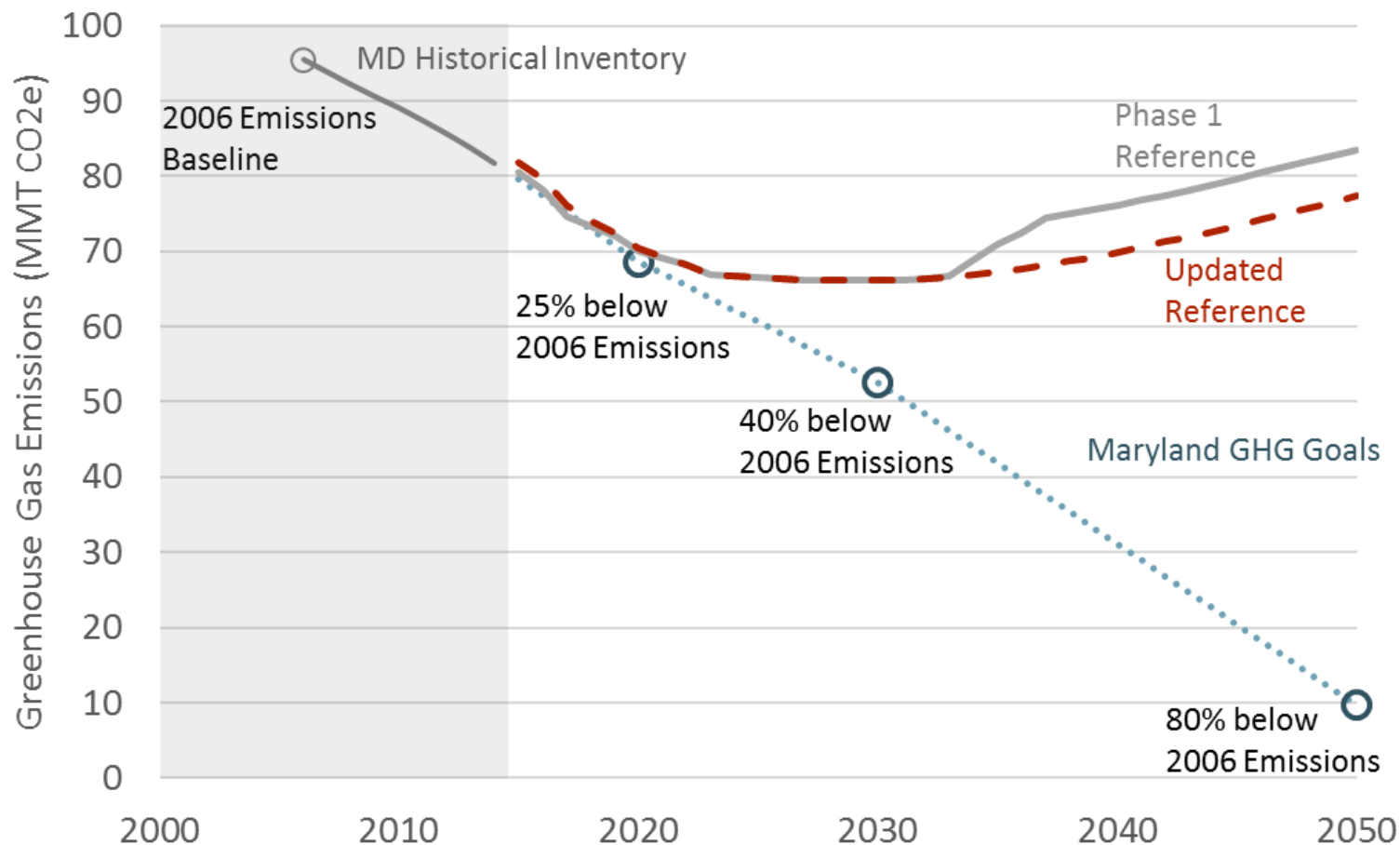
+ Other

- Updated Forest Management and healthy soils sequestration projections*

*Updated from 2/1/2018 results



Updated Reference Scenario



Gap in 2020: 1.7 MMT (2% above goal)
Gap in 2030: 13.6 MMT (26% above goal)



Policy Measures Energy Efficiency

Reference Scenario

- + EmPOWER annual savings targets, 2018-2023
 - 50% efficient sales of new electric appliances
 - 5% residential behavioral conservation
 - 10% reduction in “other” electricity use
 - Distribution system optimization

Policy Scenario 1

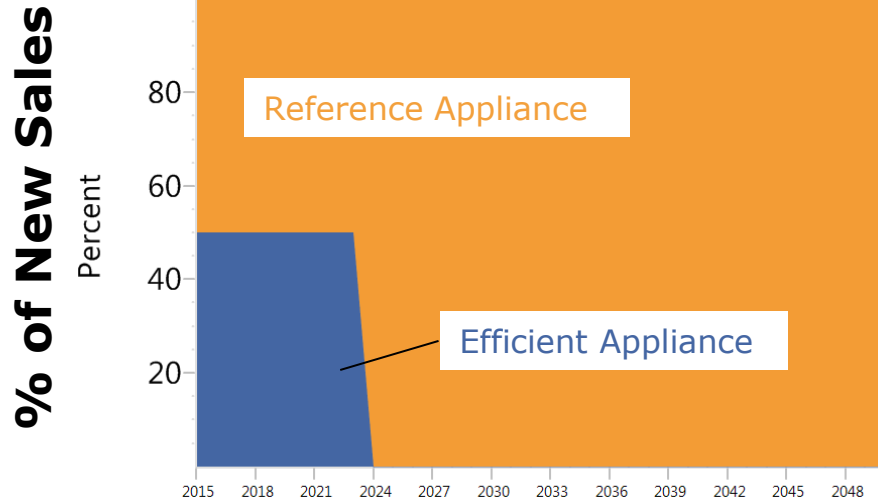
- + Continue EmPOWER Investment, 2024-2050
 - 50% efficient sales of new electric appliances (25% for natural gas)
 - 10% residential and commercial behavioral conservation by 2050
 - 20% reduction in “other” electricity use by 2050 (10% for natural gas)
 - Distribution system optimization (no change from Reference)
 - Moderate building electrification (15% of NG SH sales replaced with heat pumps by 2050)



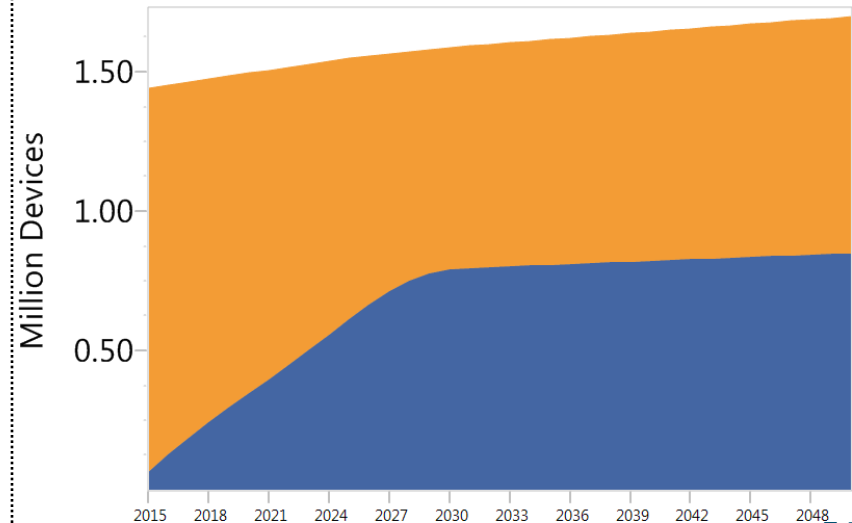
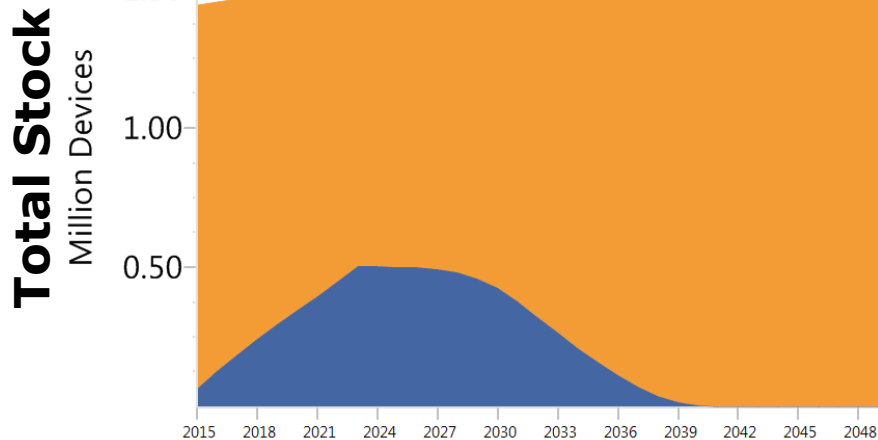
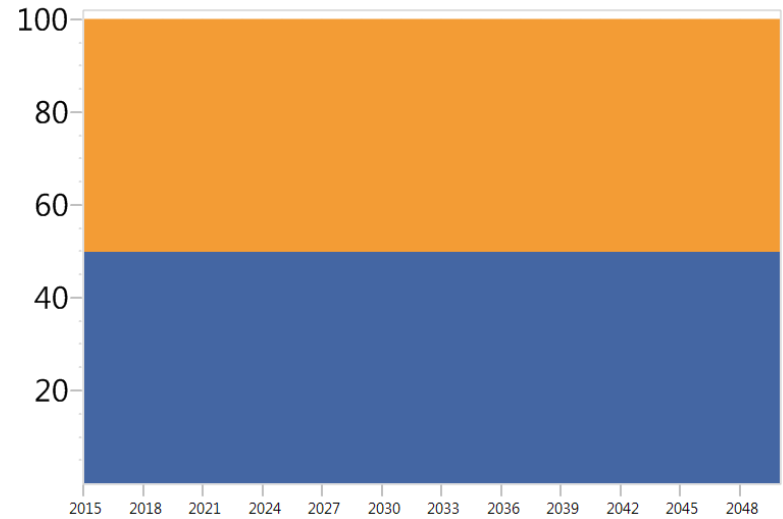
Building Efficiency

Residential Appliance example

Reference Scenario



Policy Scenario 1





Policy Measures Light Duty ZEV Adoption

Reference Scenario

- + 20% of new sales are ZEVs by 2030
 - 5% PHEV sales by 2030
 - 15% EV sales by 2030
- + 270,000 ZEVs by 2025,
530,000 ZEVs by 2030,
1,100,000 ZEVs by 2050

Policy Scenario 1

- + 35% of new sales are ZEVs by 2050
 - 9% PHEV sales by 2050
 - 26% EV sales by 2050
- + 270,000 ZEVs by 2025,
530,000 ZEVs by 2030,
1,400,000 ZEVs by 2050

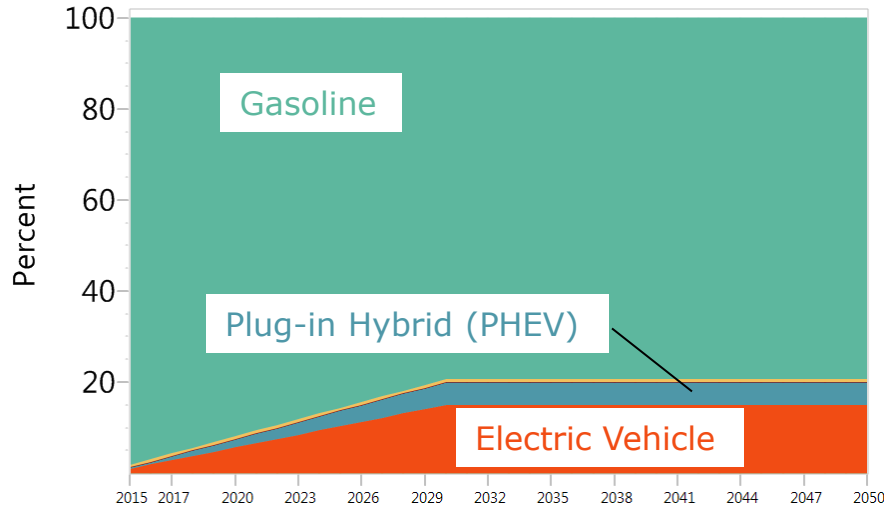


New Sales and Stocks

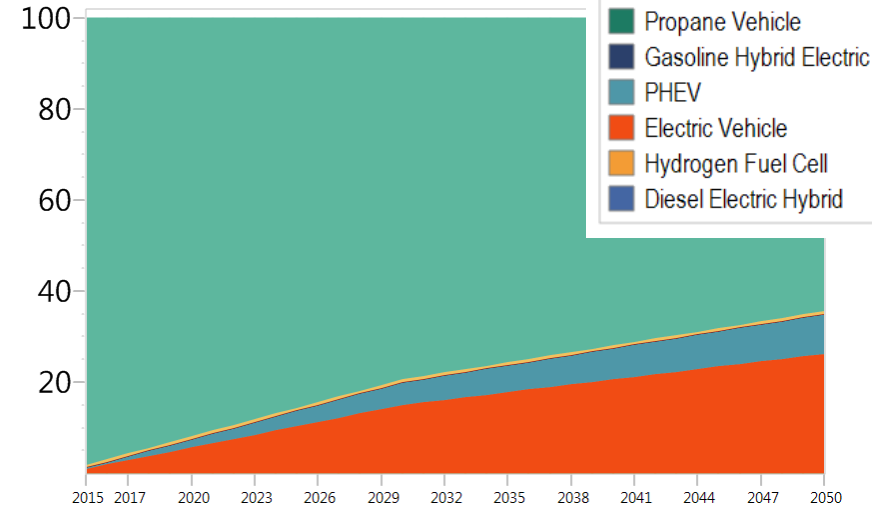
Light Duty Auto example

Reference Scenario

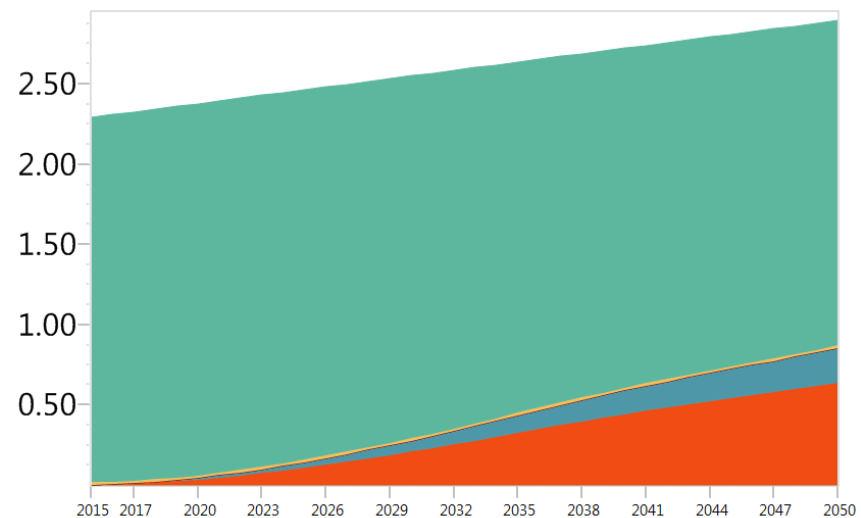
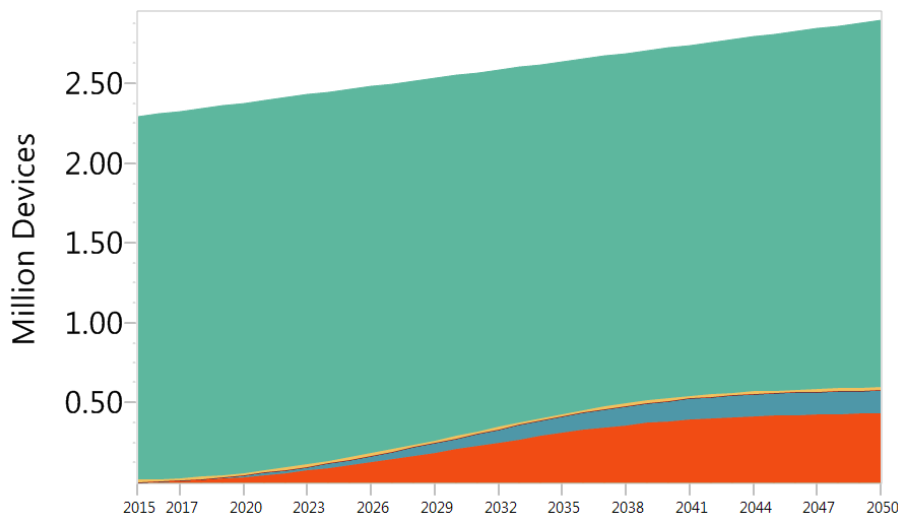
% of New Sales



Policy Scenario 1



Total Vehicle Stock





Policy Measures Vehicle Miles Traveled

Reference Scenario

- + Projected 1.7% annual growth in total on-road vehicle miles traveled (VMT)

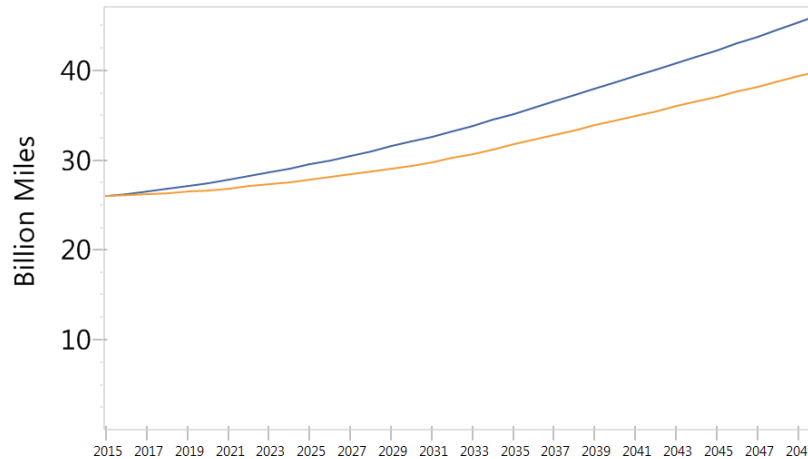
Policy Scenario 1

- + Reduction of annual VMT growth to 1.4% (2018 MPO Plans & Programs)
- + Reduction in LDV VMT due to Smart Transit measures (e.g. compact dev., TDM, public & intercity transit)
- + Reduction in HDV VMT due to National Gateway and MTA rail projects
- + Various MDOT fuel savings (CHART, Airport shuttle buses, electronic tolling)



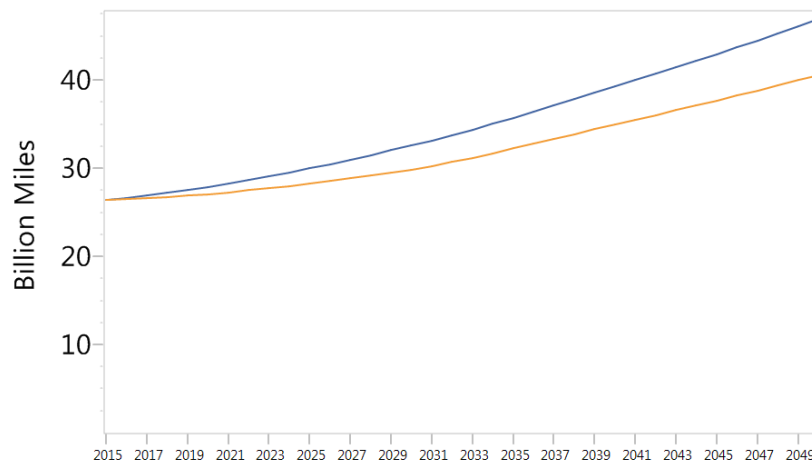
Vehicle Miles Traveled by Scenario

Light Duty Autos

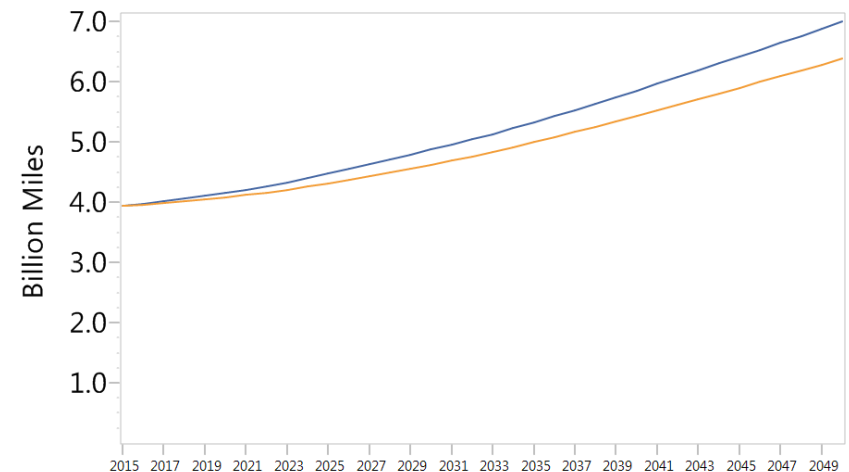


— **Reference Scenario**
— **Policy Scenario 1**

Light Duty Trucks



Heavy Duty Trucks





Policy Measures RPS and RGGI

Reference Scenario

- + 25% RPS by 2020
- + RGGI
 - 30% cap reduction 2020-2030

Policy Scenario 1

- + 50% RPS by 2030
(HB1435/SB0732)
- + RGGI
 - 30% cap reduction 2020-2030 (no change from reference)

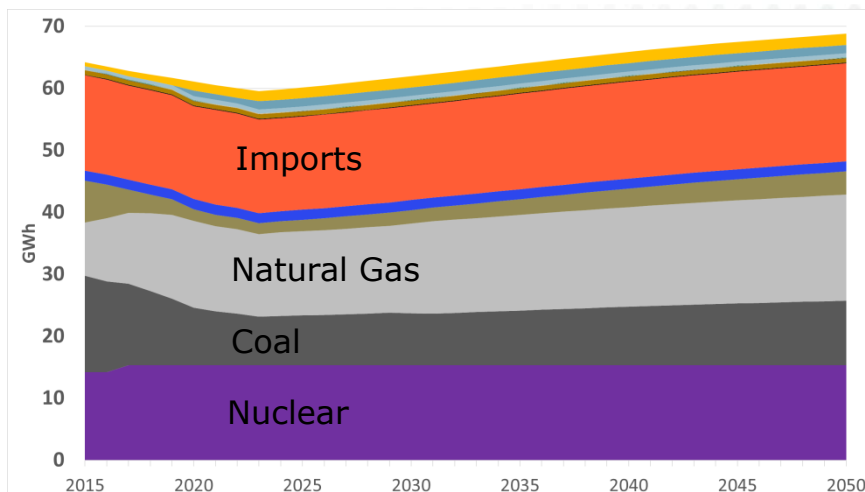


Electricity Generation by Resource Type

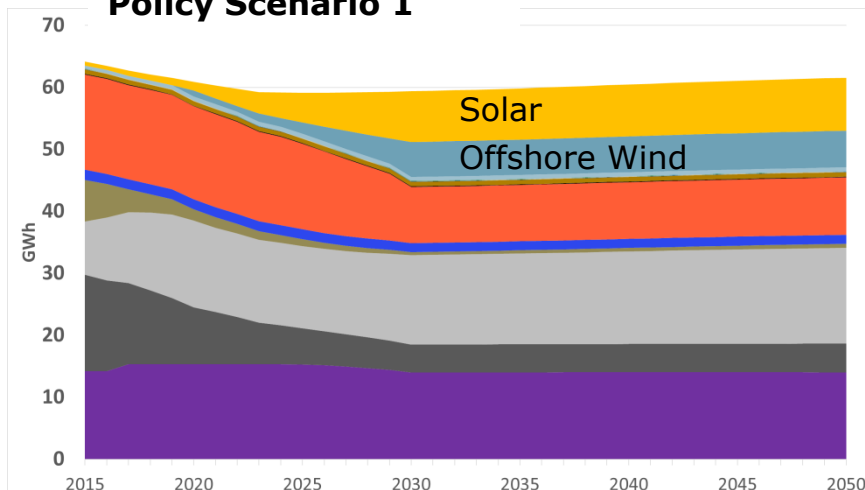
+ Reference Scenario reaches 25% RPS in 2020, increased load growth after 2023 due to end of EmPOWER

+ Mitigation Scenario reaches 25% RPS in 2020, 50% RPS in 2030, with solar (14.5%) and offshore wind (10%) carveouts

Reference Scenario



Policy Scenario 1



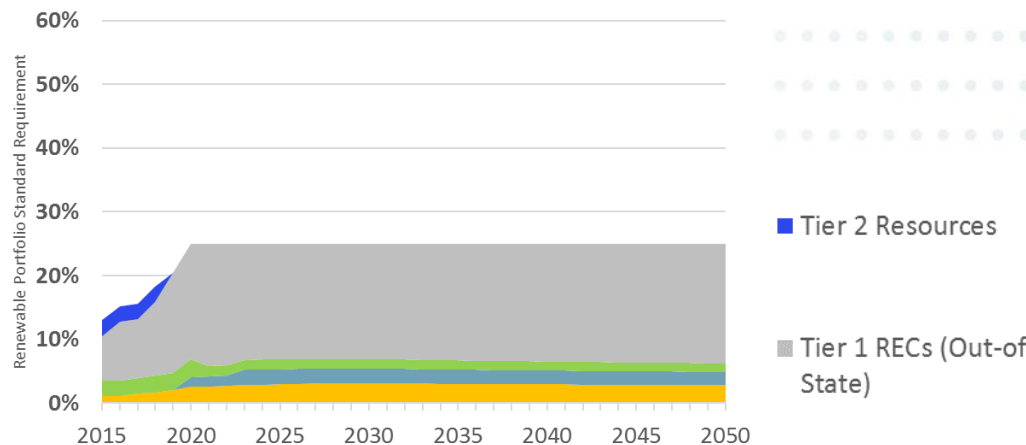


RPS Requirements

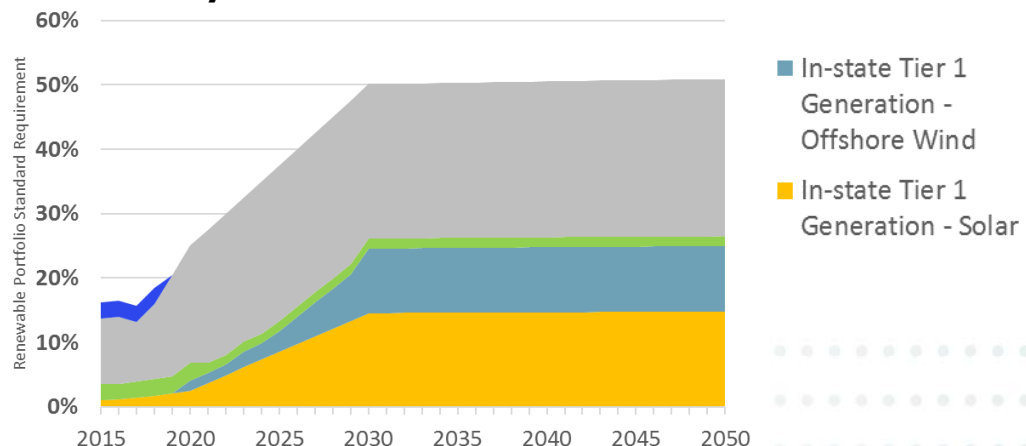
+ Reference Scenario achieves 2.5% solar carveout, supplements with wind RECs from out-of-state

+ Policy Scenario 1 achieves solar (14.5%) and offshore wind (10%) carveouts, decreases proportion of RPS met by out-of-state RECs

Reference Scenario



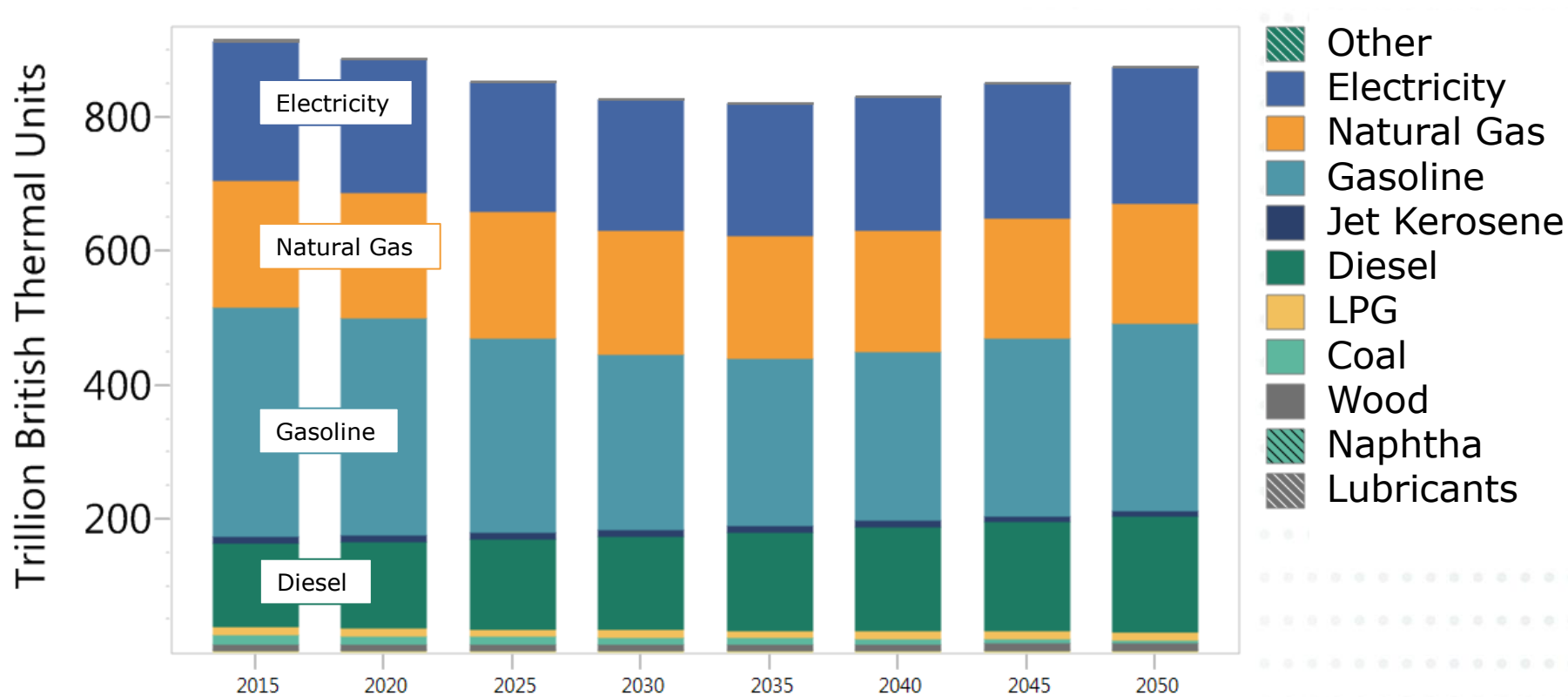
Policy Scenario 1





Policy Scenario 1

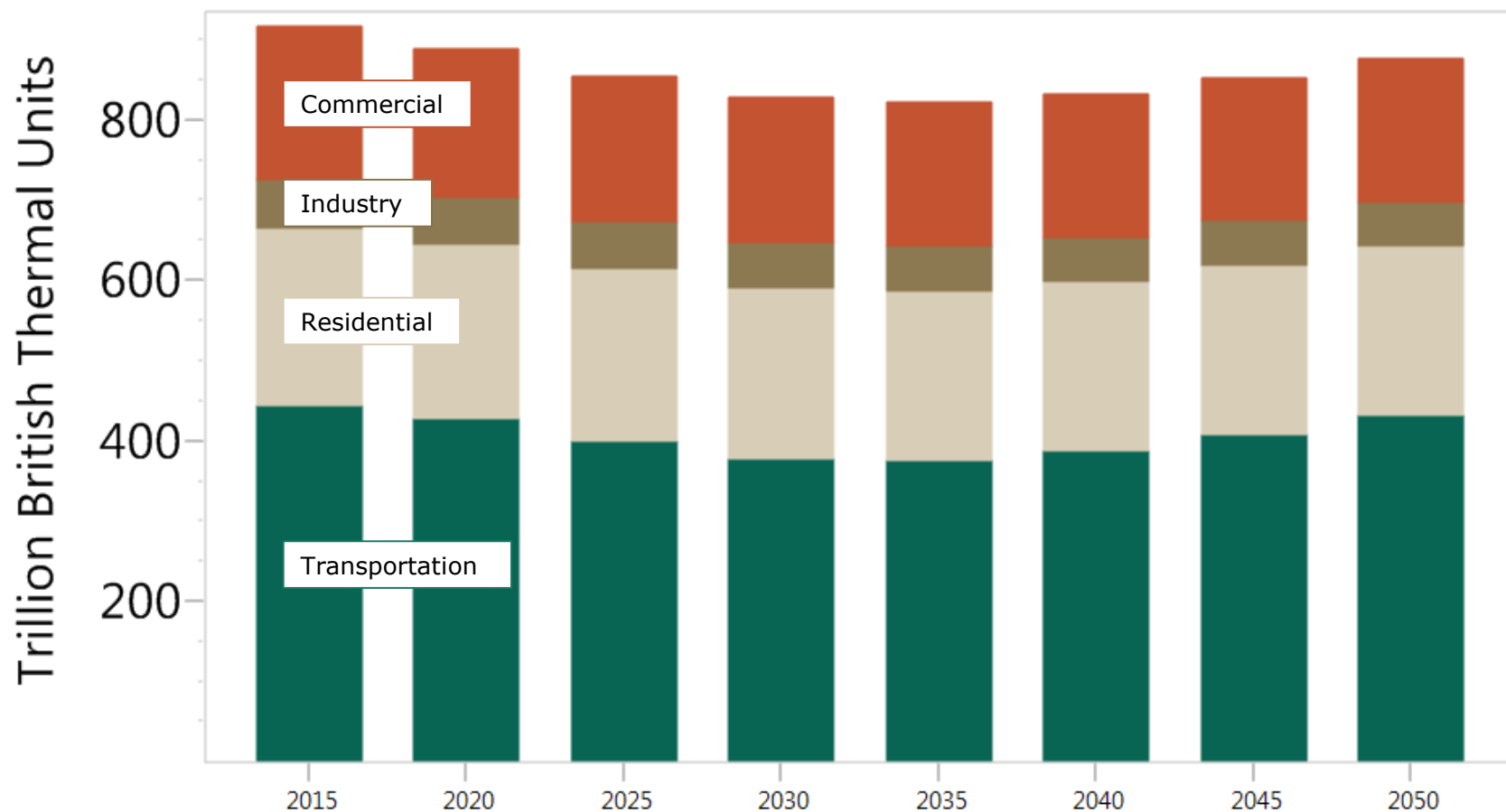
Total energy by fuel





Policy Scenario 1

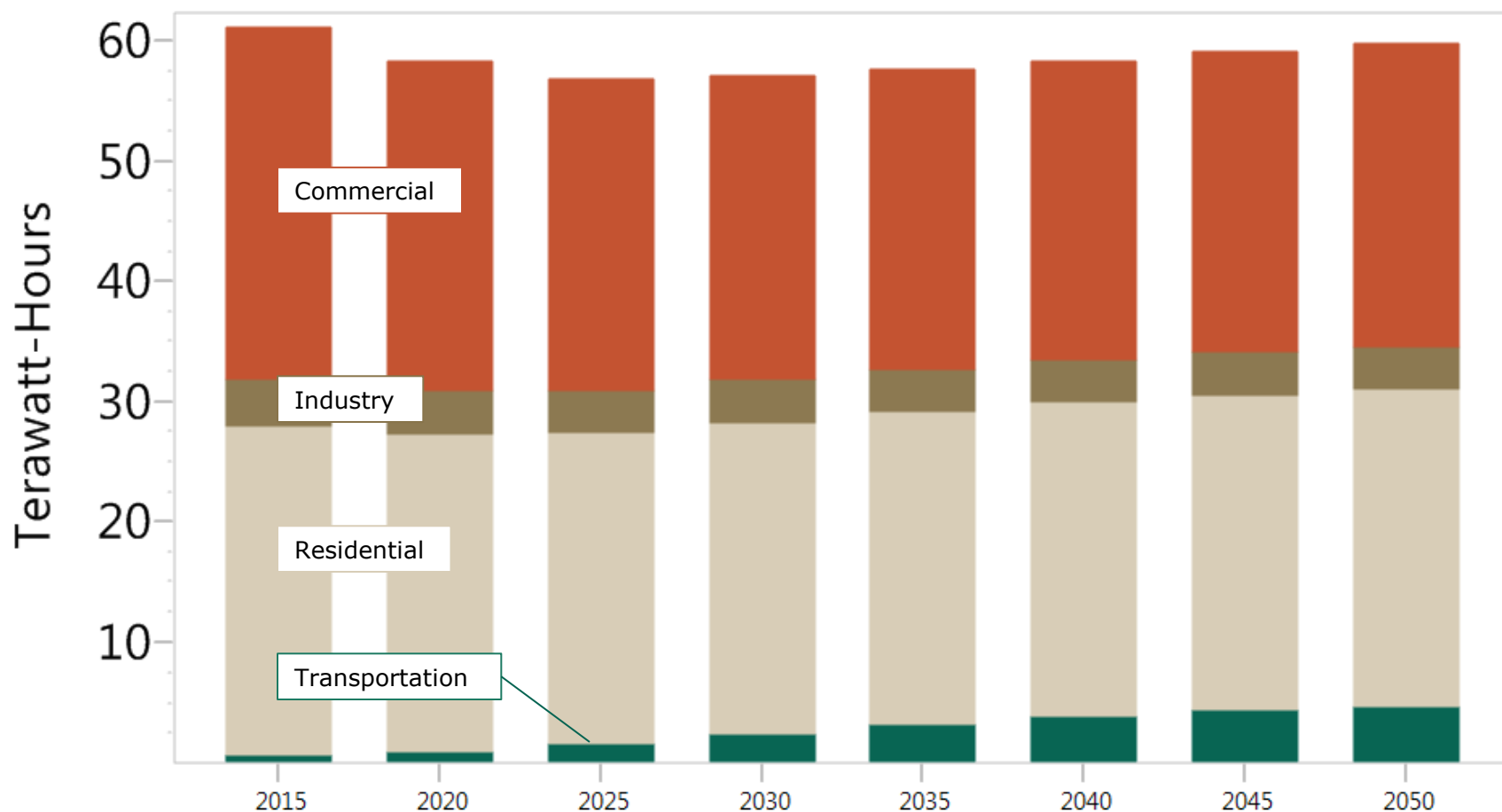
Total energy by sector





Policy Scenario 1

Electricity Use by Sector

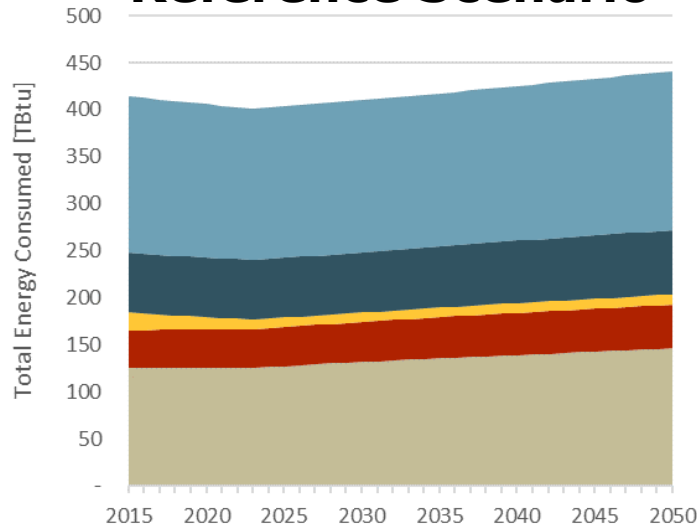




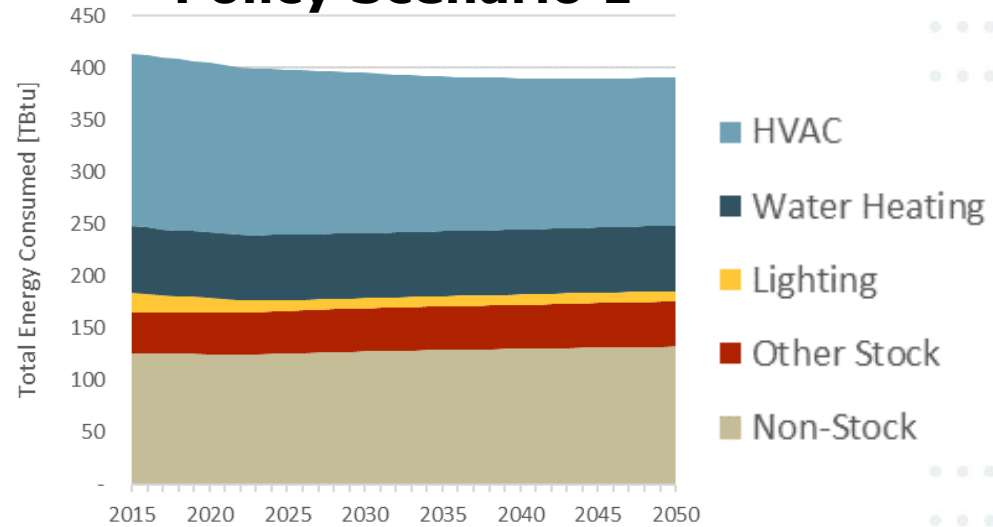
Building Energy Consumption Policy Scenario 1 vs. Reference

All Fuels

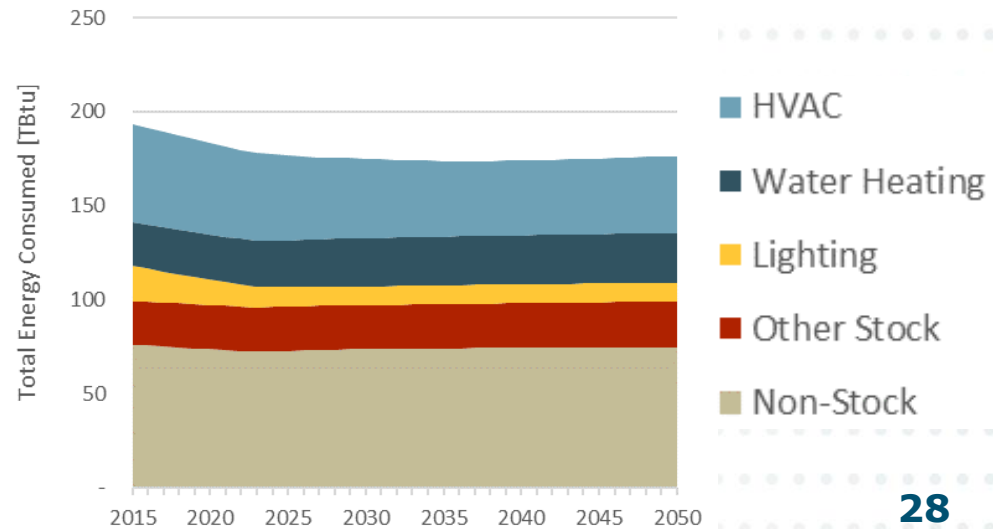
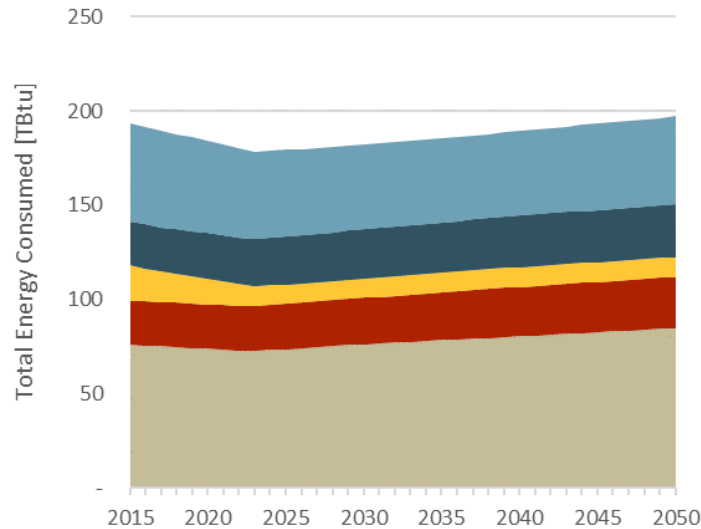
Reference Scenario



Policy Scenario 1

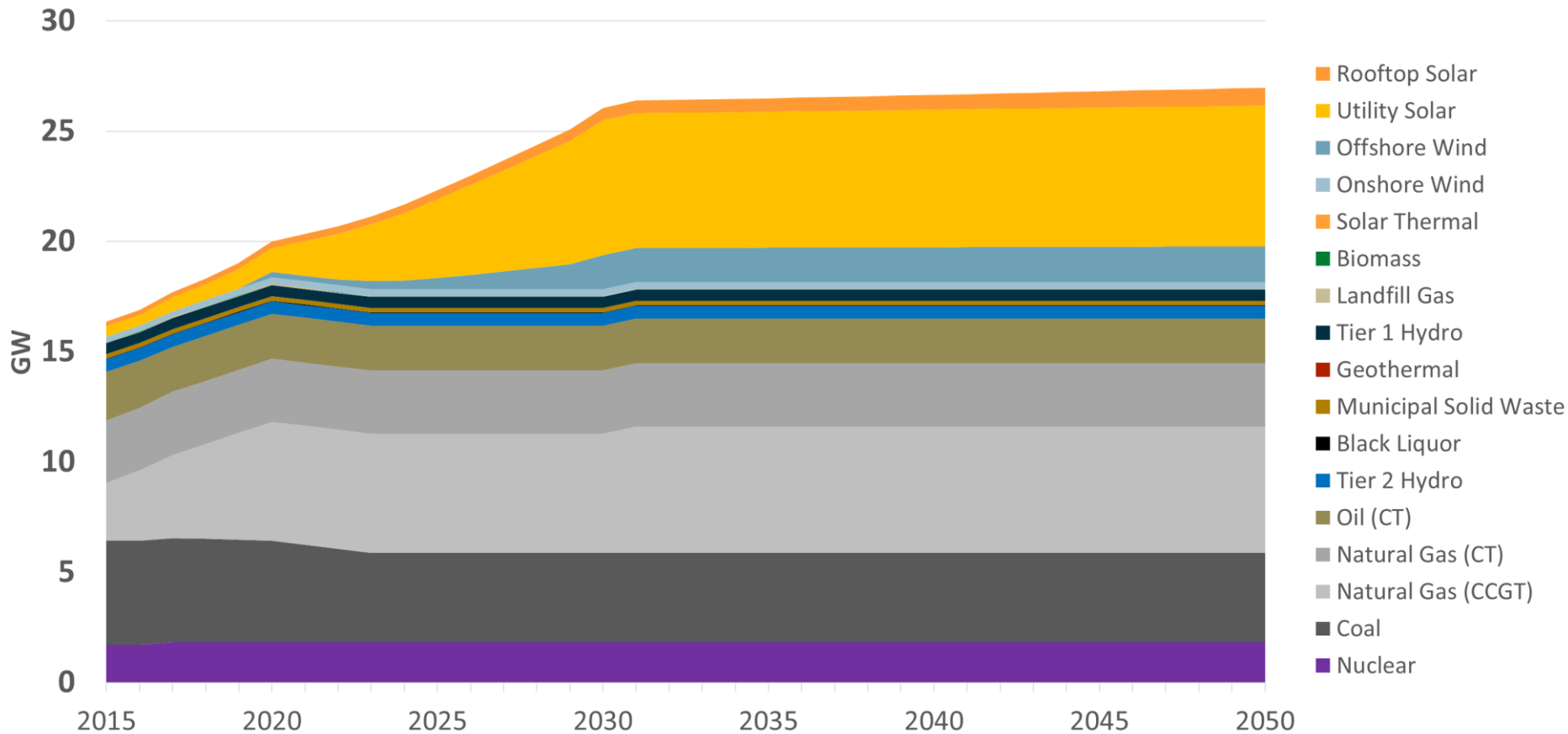


Electricity





Policy Scenario 1 In-State Electric Generating Capacity





Key Drivers 2015-2050

Sector	Key Driver	Compound annual growth rate [%]	Data Source
Residential	Households	0.73-0.53%	Maryland Department of Planning (varies over time)
Commercial	Households	0.73-0.53%	Maryland Department of Planning (varies over time)
Industry	Energy growth	Varies by fuel	EIA AEO
On Road Transportation	VMT	1.7%	Maryland DOT
Off Road Transportation	Energy growth	Varies by fuel	EIA AEO
Electricity generation	Electric load growth	0.5% average 2015-2050	Built up from Pathways demands in Buildings, Industry, Transportation



Scenario Assumptions

Reference Scenario

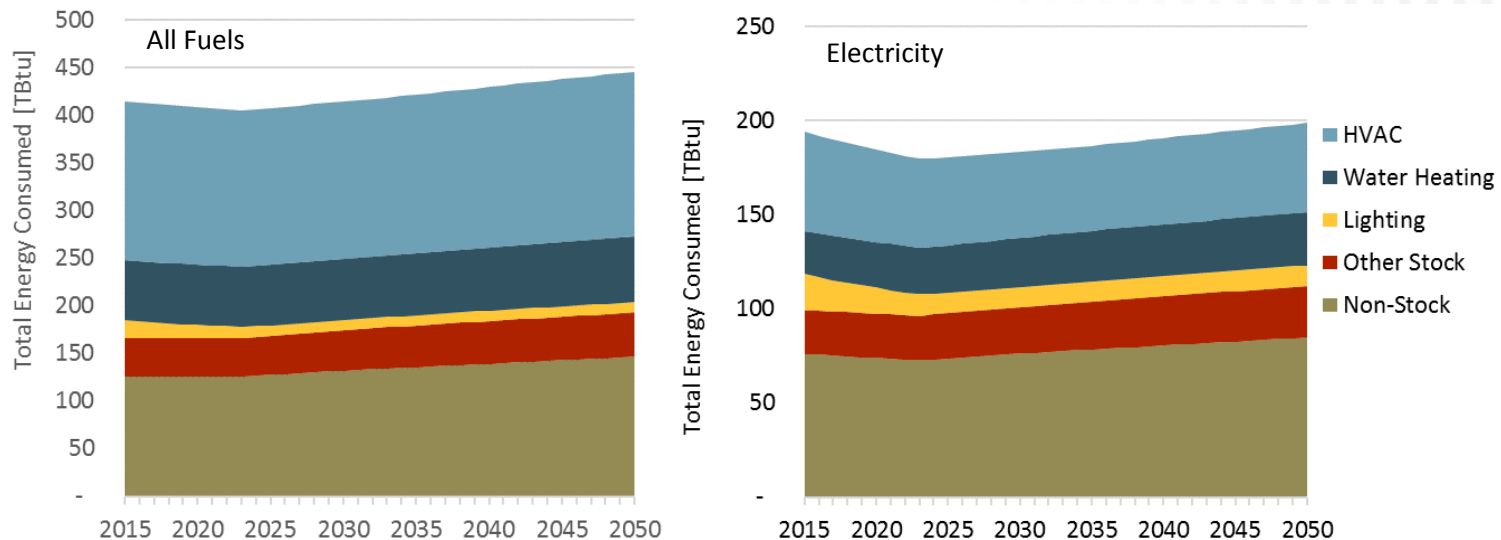
	Reference Scenario (Existing Policies)
Renewable Portfolio Standard	25% RPS by 2020
RGGI	30% cap reduction from 2020 to 2030
Nuclear power	Assume Calvert Cliffs is relicensed in 2034/2036 at end of license
Existing coal power plants	IPM planned retirements (670 MW of coal by 2023)
Rooftop PV	Moderate growth from current levels of 200 MW (2% a year; 400 MW in 2050)
Energy Efficiency (Res., Com. & Industrial)	Calibrated to EmPOWER filing targets 50% of electric appliance sales are high-efficiency 2015-2023, 5% residential behavioral conservation by 2030, 10% reduction below baseline for electricity in non-stock sectors by 2050
Electrification of buildings (e.g. NG furnace to heat pumps)	None
Transportation	Federal CAFÉ standards for LDVs by 2026, Meets ZEV mandate by 2025 (270,000 ZEVs)
Other transportation sectors (e.g. aviation)	AEO 2017 reference scenario growth rates by fuel
Industrial energy use	AEO 2017 reference scenario growth rates by fuel
Biofuels	Existing ethanol and biodiesel blends, but no assumed increase
Other (fossil fuel industry, industrial processes, agriculture, waste management, forestry)	Assume held constant at MDE 2014 GHG Inventory levels, with specific projections for forest management and healthy soils



A mix of building efficiency measures meet EmPOWER goals in the Reference Scenario

- + **50% sales of new electric devices efficient devices for all stock (e.g. EnergyStar) by from 2015-2023**
- + **5% behavioral conservation in residential lighting, space heating, water heating (reduction in energy services demand)**
- + **10% below Baseline counterfactual for non-stock electricity use**
- + **Distribution system optimization**

Total Energy Consumption by End-Use Sector, Reference Scenario

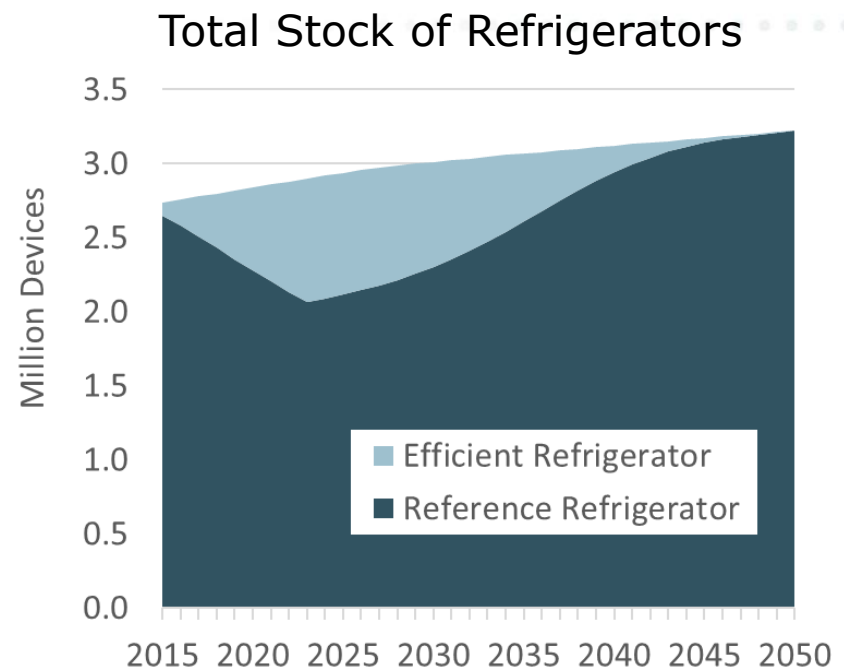
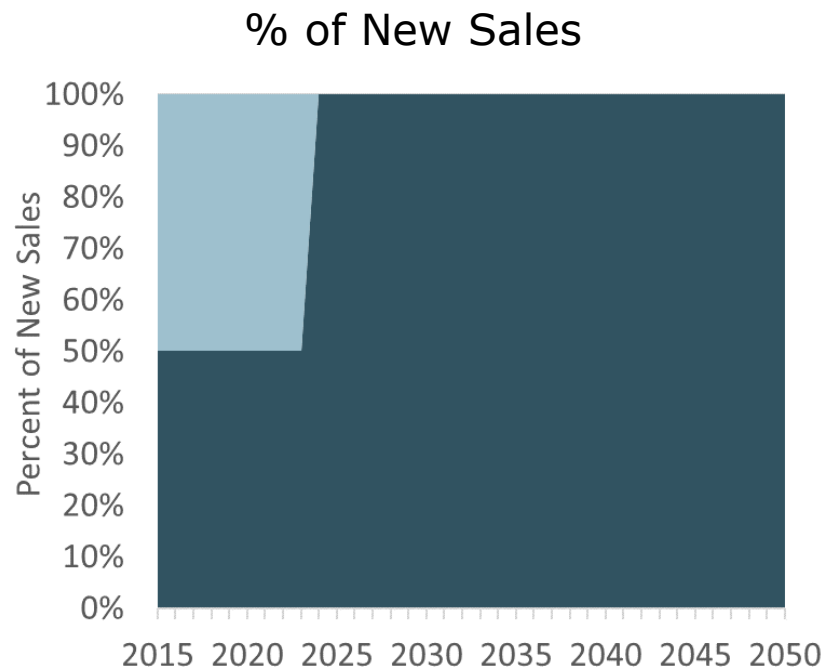




Stock Rollover Example

Residential Refrigeration, Reference Scenario

- + **EmPOWER goals represent increased sales of more efficient devices in residential and commercial buildings in 2015-2023**
- + **In 2024, when current regulations expire, sales go back to 2014 sales levels**





Scenario Assumptions

Policy Scenario 1

	Policy Scenario 1 (updates from Reference in Bold)
Renewable Portfolio Standard	50% RPS by 2030
RGGI	30% cap reduction from 2020 to 2030
Nuclear power	Assume Calvert Cliffs is relicensed in 2034/2036 at end of license
Existing coal power plants	IPM planned retirements (670 MW of coal by 2023)
Rooftop PV	Doubling of reference levels (800 MW in 2050)
Energy Efficiency (Res., Com. & Industrial)	50% of electric appliance sales are high-efficiency 2015-2050 (25% for natural gas), 10% residential behavioral conservation by 2050, 20% reduction below baseline for electricity in non-stock sectors by 2050 (10% for natural gas)
Electrification of buildings (e.g. NG furnace to heat pumps)	Moderate electrification – increase of 15% in electric heat pump sales by 2050 (replacing natural gas furnaces and boiler sales)
Transportation	Federal CAFÉ standards for LDVs by 2026, Meets ZEV mandate by 2025 (270,000 ZEVs), increases to 1.4 Million ZEVs by 2050
Other transportation sectors (e.g. aviation)	AEO 2017 reference scenario growth rates by fuel
Industrial energy use	AEO 2017 reference scenario growth rates by fuel
Biofuels	Existing ethanol and biodiesel blends, but no assumed increase
Other (fossil fuel industry, industrial processes, agriculture, waste management, forestry)	Forest management and Healthy soils sequestration



Scenario Assumptions – Transportation Measures

Strategy	Description	2030 VMT Reduction	VMT type	2030 Gas reduction (g)	2030 Diesel reduction (g)
2018 MPO Plans & Programs yield lower annual VMT growth (1.4%/yr)	Modeled VMT and emissions outcomes (through MOVES2014a) from implementation of MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.	3,158,758,638	On-road fleet		
EV/PHEV sales grow to 15%/5% by 2025	EV market share analysis within reference case already assumes 15%/5% sales growth by 2030.			-	
On-Road Technology (CHART, Traveler Information)	A range of increase in coverage shall be assumed based on a low and high deployment scenario. Under on the books scenario, 35% of urban unrestricted access roadways and 15% of rural restricted access roadways are assumed to be included under CHART's coverage.			16,165,665	1,326,297
Freight and Freight Rail Programs (National Gateway and MTA rail projects including new locomotive technologies)	Implementation of the CSX National Gateway provides new capacity and eliminates bottlenecks for access to the Port of Baltimore and across MD for rail access westward toward PA and OH and south toward VA and NC.	26,431,915	HDV only		
Public Transportation (new capacity, improved operations/ frequency, BRT)	This strategy includes projects designed to increase public transit capacity, improve operations and frequency, and new BRT corridors. Projects include dedicated bus lanes/TSP, bus rapid transit (US 29), and MARC service/capacity improvements.	84,137,696	LDV only		
Public Transportation (fleet replacement / technology)	This strategy includes MTA planned fleet replacement to Clean Diesel and WMATA planned fleet replacement based on current replacement strategy.				2,367,995
Intercity Transportation Initiatives (Amtrak NE Corridor, Intercity bus)	Northeast corridor analysis - Assumption of growth in annual ridership by 2030 for Amtrak consistent with addressing growing demand. Assume primarily SOGR investments only through 2030.	47,806,157	LDV only		
Transportation Demand Management	The following programs are included for consideration towards reduction in VMT: Commuter Connections Transportation Emission Reduction Measures (MWCOG), Guaranteed Ride Home, Employer Outreach , Integrated Rideshare, Commuter Operations and Ridesharing Center, Telework Assistance, Mass Marketing, MTA Transportation Emission Reduction Measures, MTA College Pass, MTA Commuter Choice Maryland Pass, Transit Store in Baltimore	486,499,923	LDV only		
Pricing Initiatives (Electronic Tolling)	Ongoing Conversion to All-Electronic Tolling			2,241,454	209,554
Bicycle and Pedestrian Strategies (Provision of non-motorized infrastructure including sidewalks and bike lanes)	Assumes VMT reductions due to availability of Bike/Ped facility lane miles (assuming connectivity is maintained and incrementally added to the existing network). Trend of VMT reductions based on data available for 2015, 2017 and 2025 for Bike/Ped facility lane miles.	79,504,966	LDV only		
Land-Use and Location Efficiency	MDP projection of 75% compact development for 10% of development / redevelopment through 2030. Compact development is assumed to reduce VMT by 30% relative to standard density / mix development. This strategy partially captures MDOT/MDP commitment to TOD.	979,733,809	LDV only		
Drayage Track Replacements	Emission benefit of estimated 600 total dray trucks replaced through 2030.				590,523
BWI Airport parking shuttle bus replacements	Emission benefit of replacing 50 diesel buses with clean diesel buses and CNG buses for expansion.				150,000



Translating PATHWAYS costs to REMI

+ E3 has prepared a simple Revenue Requirement calculator to estimate sectoral impacts over time

- Rates have three components: Transmission, Distribution, and Generation
 - Transmission component increases based on long-run peak demand growth projections from PJM (0.4% per 2018 load forecast report)
 - Distribution component grows with load
 - Generation component layers incremental costs of renewables and RECs onto existing average energy rates

+ REC prices are separated into 3 categories

- Solar RECs
- Offshore Wind RECs
- Other Tier 1 RECs



REC Price Assumptions and Calculations

+ Solar REC prices

- Use existing data until 2016 (from the Renewable Energy Portfolio Standard Report) and escalate to the long-run cap on the Tier 1 Solar Alternative Compliance Penalty (\$22.50) as specified in Senate Bill 732 §7-705(b)(2)(i)(1)(G)

+ OREC Prices

- Based on 2016 prices for non-solar RECs in Maryland, escalate to the price agreed to by Skipjack Offshore Energy in PSC Order 88192 by 2022
- From 2022 to 2030, OREC prices escalate at 1.5% until 2030, approximately reaching the cap price of \$130/MWh described in Senate Bill 732 §7-704.1(e)(1)(iii)(3)

+ Other RECs

- Prices for remaining RECs are taken from the Integrated Planning Model results prepared by ICF for the Regional Greenhouse Gas Initiative



Strategies for Deep Decarbonization



Energy efficiency & conservation

Conventional Efficiency

- Codes and Standards
- Switching to efficient devices
- Building shell improvements

Conservation

- Behavioral conservation
- Smart growth



Electrification

Buildings

- Space heating
- Water heating

Transportation

- Electric vehicles (BEV and PHEV)
- Public transportation
- Ports

Industry

- Boilers
- Process heat



Low carbon electricity

Renewables

- Solar (utility-scale and distributed)
- Wind (offshore and onshore)
- Hydro
- Geothermal

Zero-carbon

- Nuclear
- CCS (and BECCS)

Grid Integration



Low carbon fuels

Biofuels

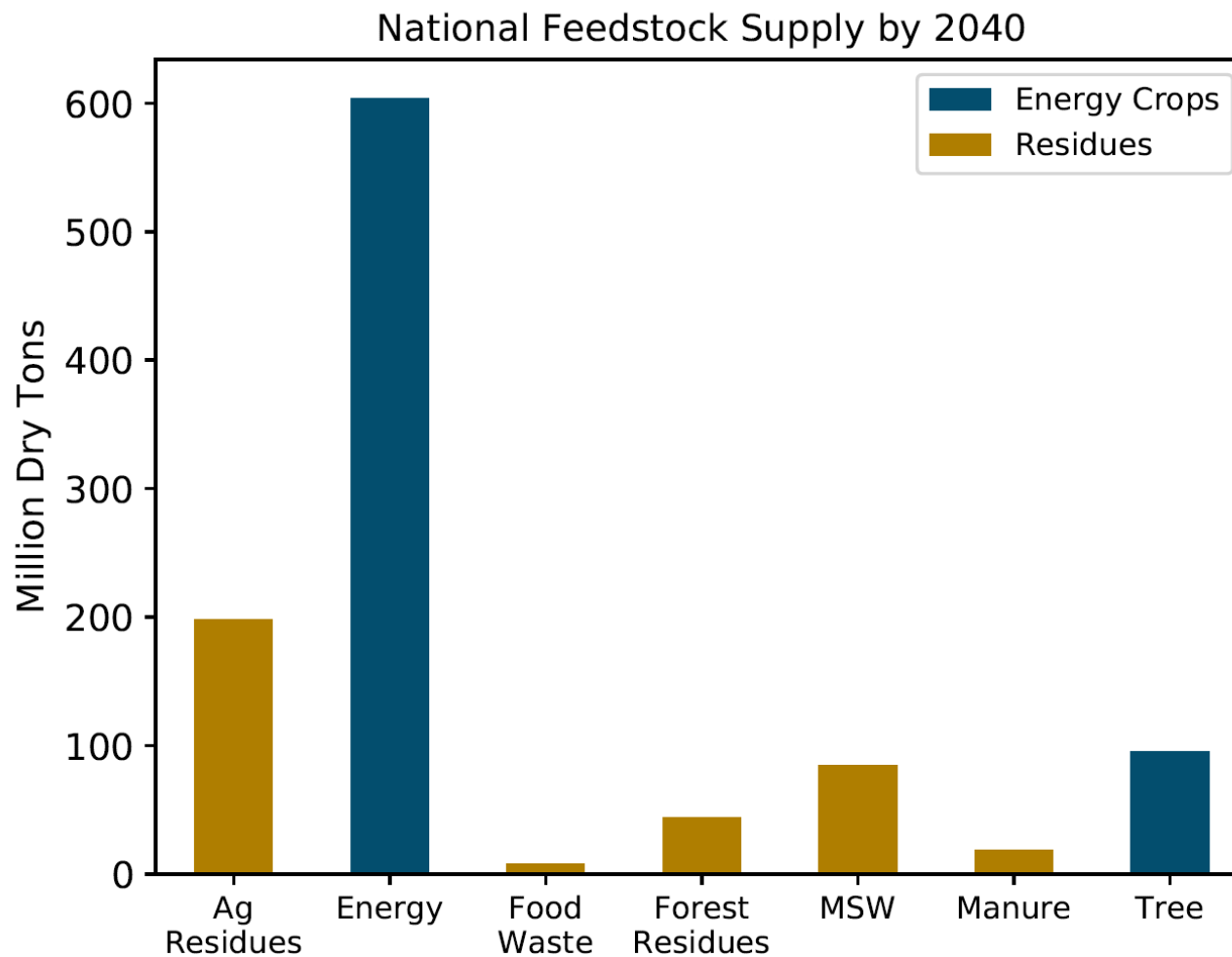
- Renewable natural gas
- Renewable oil products (diesel, gasoline, jet kerosene)

Hydrogen

- Blending into pipeline
- Heavy-duty vehicles
- Stationary fuel cells



Biomass Feedstock Potential

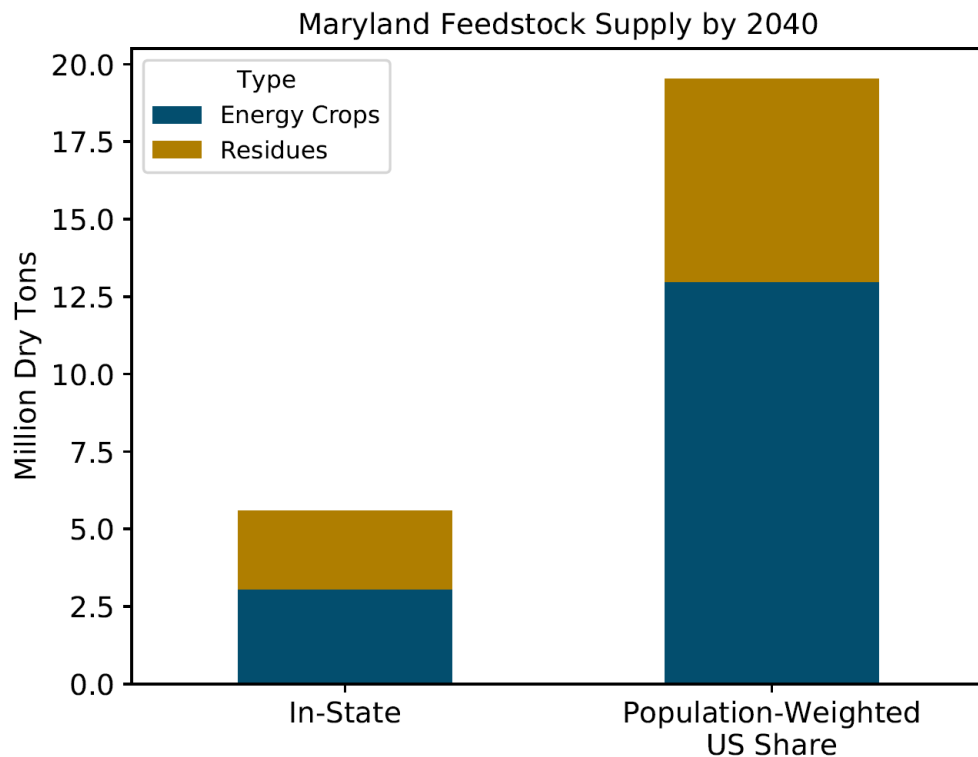


Source: DOE, 2016. Billion Ton Update



Maryland Biomass Feedstocks

- + **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**





Biofuel GHG Abatement Potential

- + Using the MD-share of the US supply, Maryland can reduce up to 6-16 MMT CO₂e, depending on use of energy crops

