



**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.

Mitigation Working Group  
August 30, 2018



# + Maryland Pathways Policy Scenario 1

August 30<sup>th</sup>, 2018

*Tory Clark, Managing Consultant*

*Doug Allen, Managing Consultant*

*Sharad Bharadwaj, Consultant*

*Amber Mahone, Director*

*Snuller Price, Senior Partner*



# 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\*

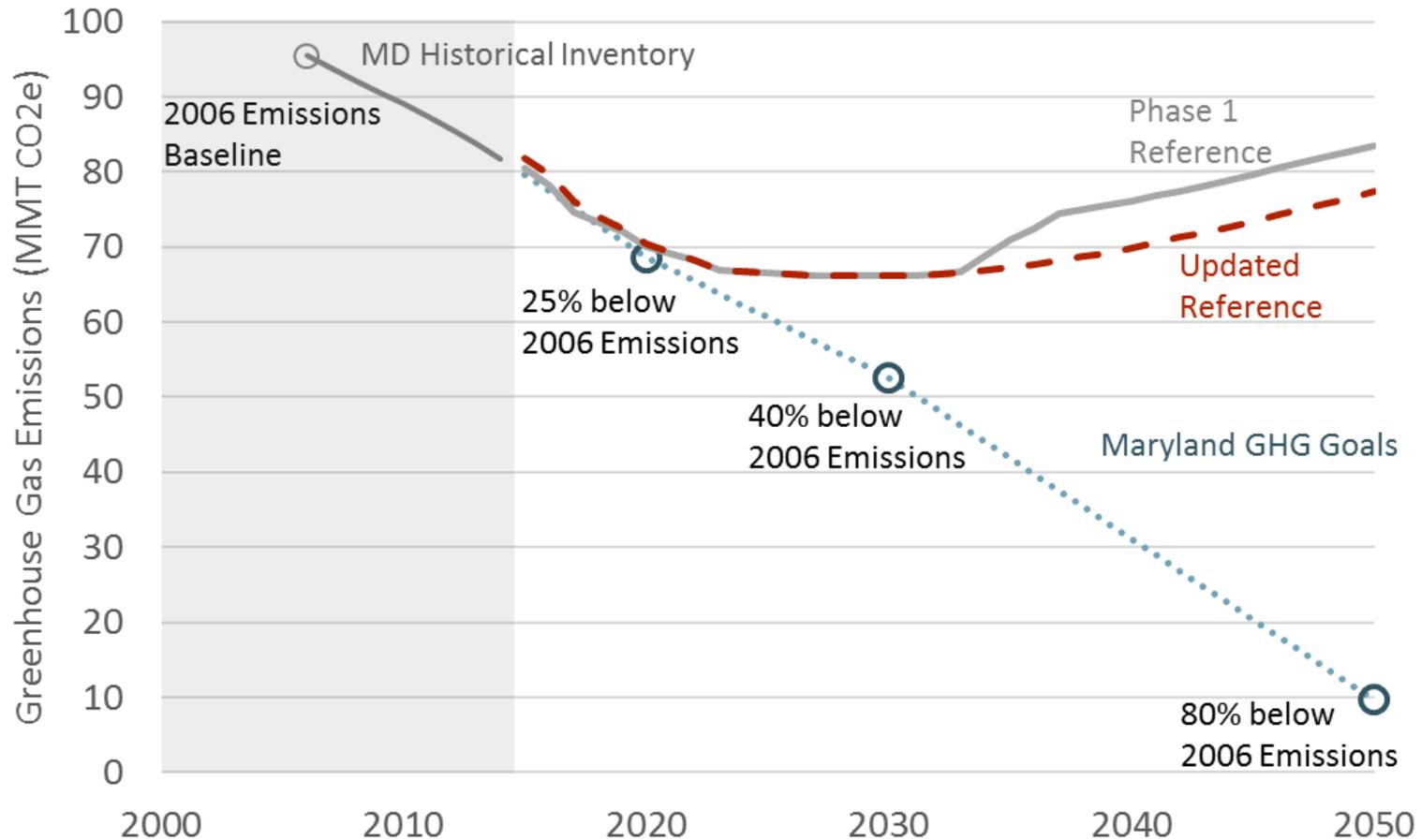
## + Other

- 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 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 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

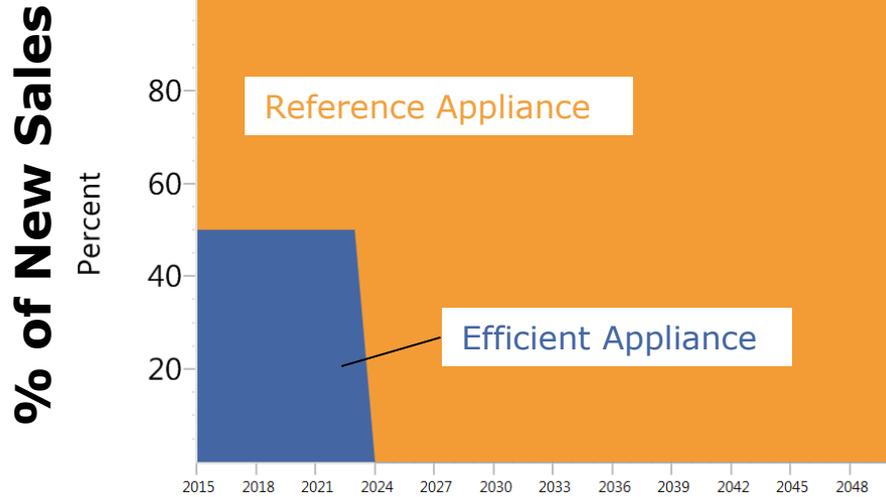
- + Continue EmPOWER Investment, 2024-2050
  - 50% efficient sales of new electric appliances (25% for natural gas)
  - 10% residential and commercial behavioral conservation by 2050
  - 20% reduction in “other” electricity use by 2050 (10% for natural gas)
  - Distribution system optimization (no change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



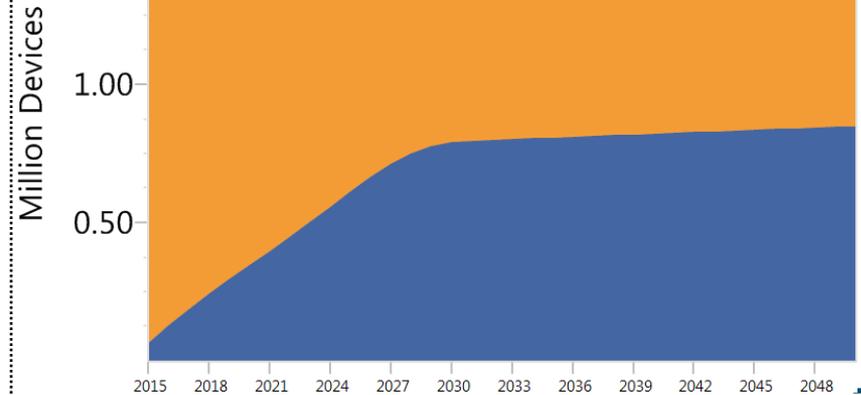
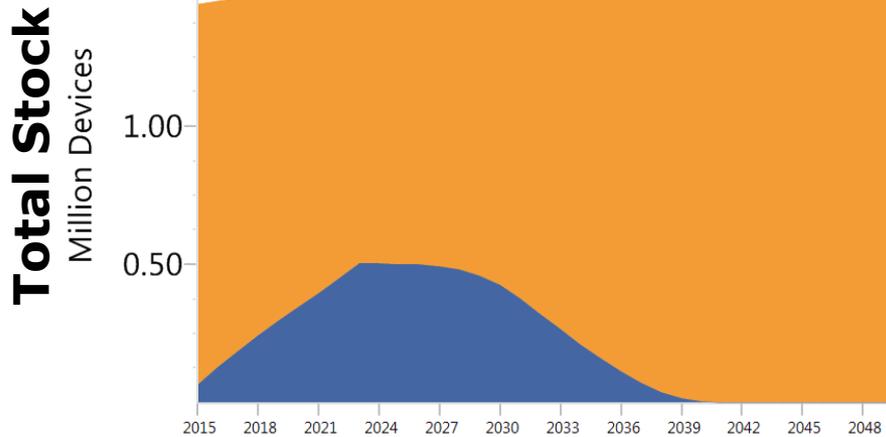
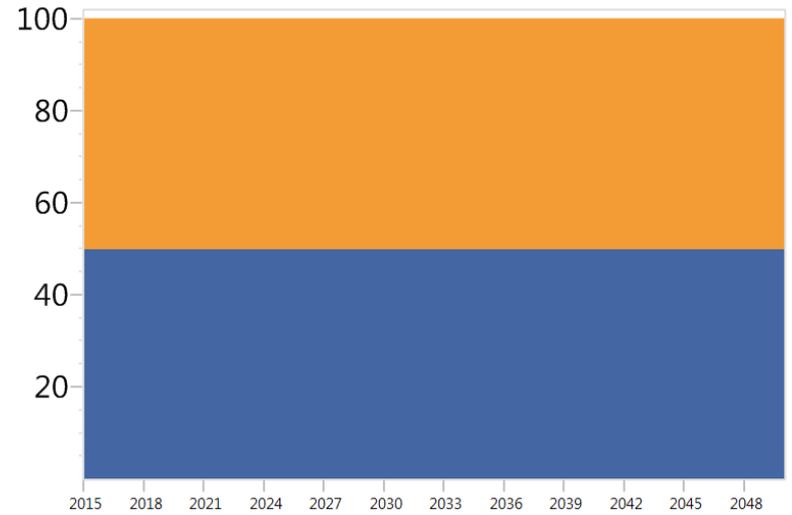
# Building Efficiency

## 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

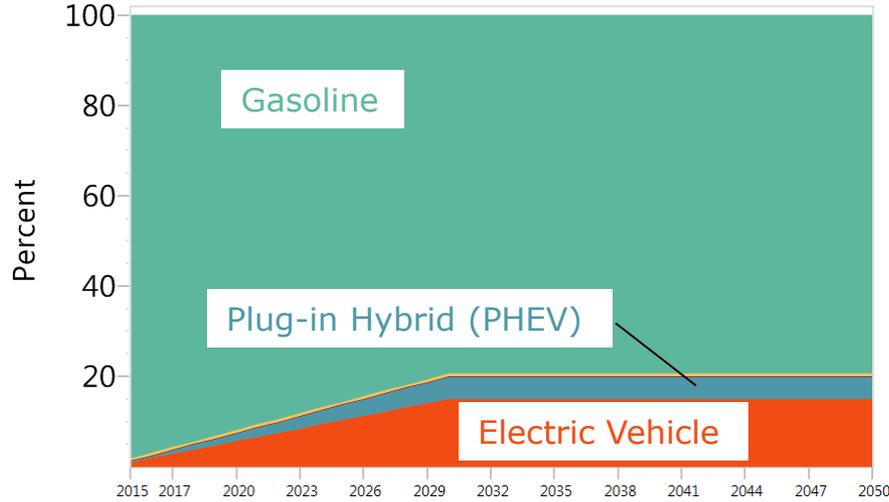


# New Sales and Stocks

## Light Duty Auto example

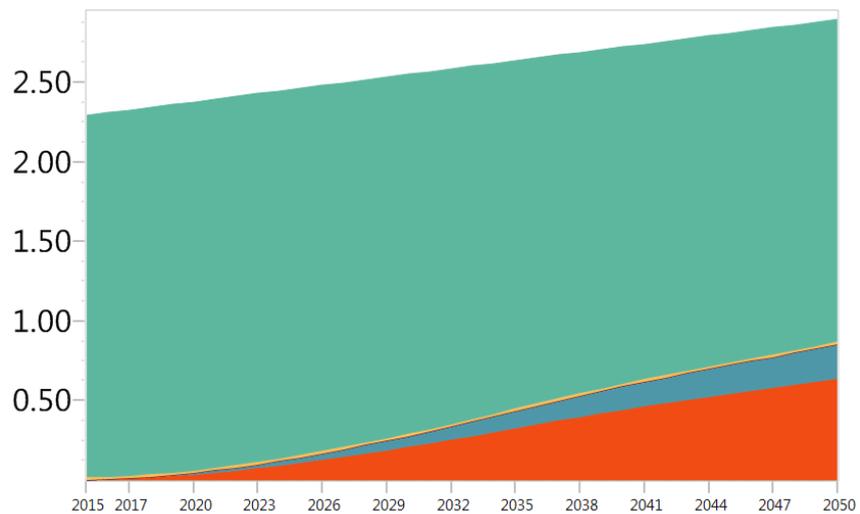
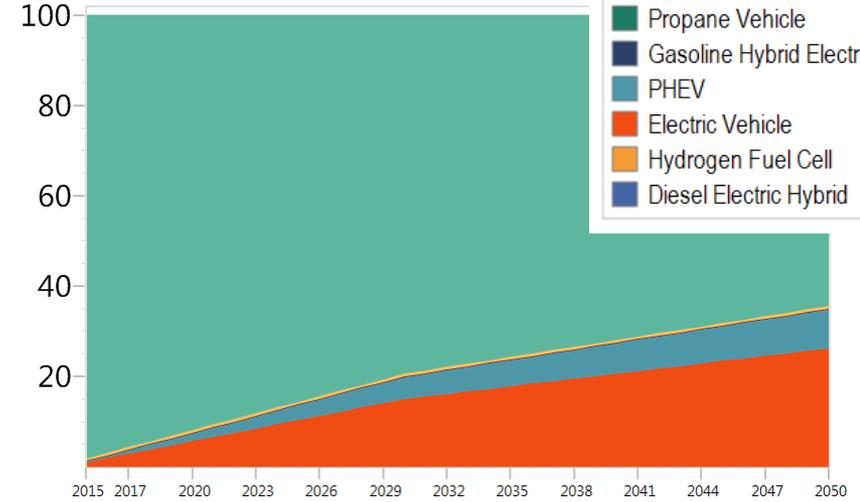
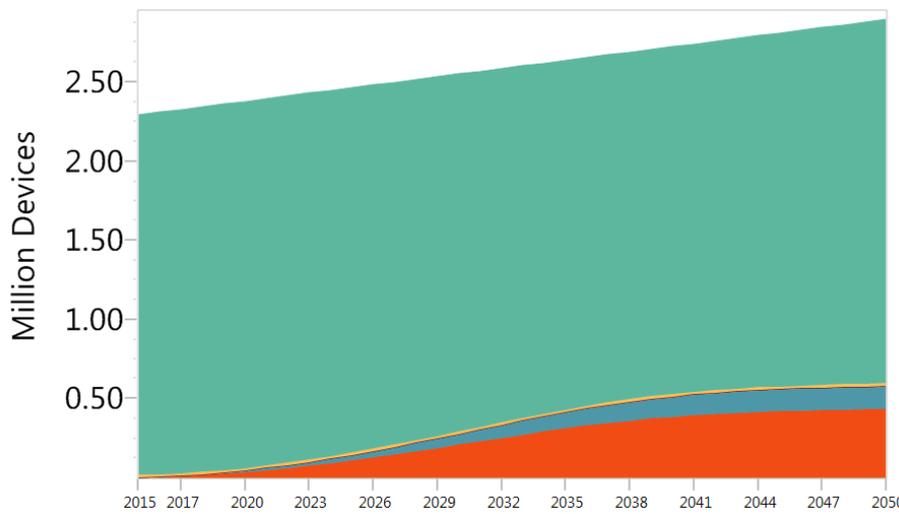
### Reference Scenario

% 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)

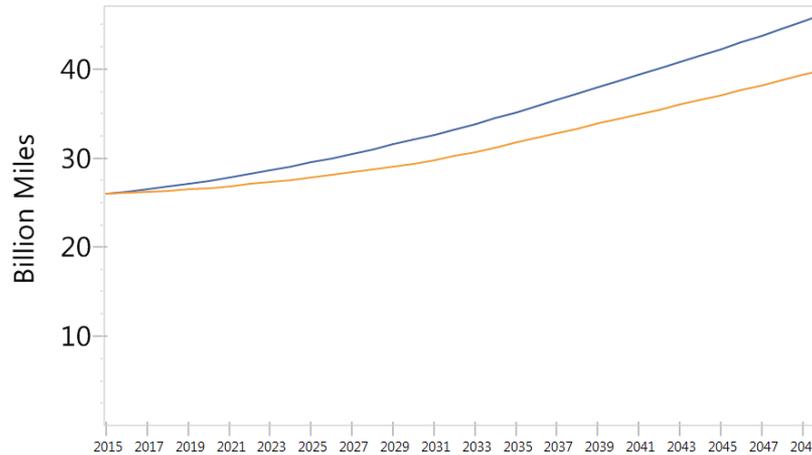
## Policy Scenario 1

- + 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)



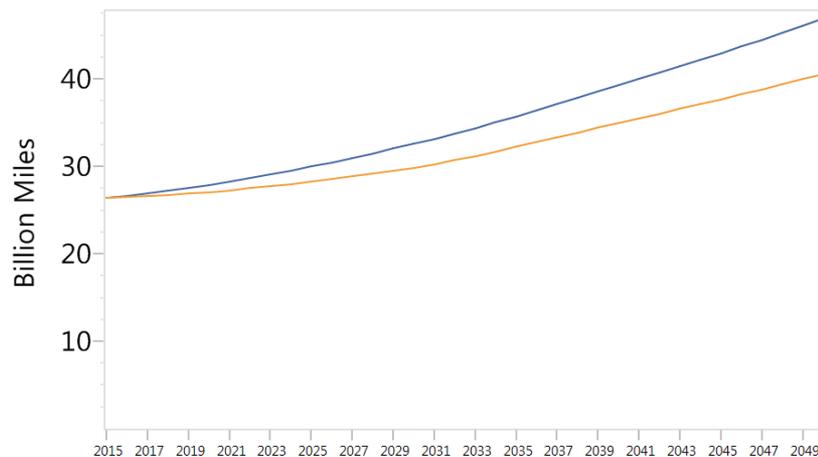
# Vehicle Miles Traveled by Scenario

## Light Duty Autos

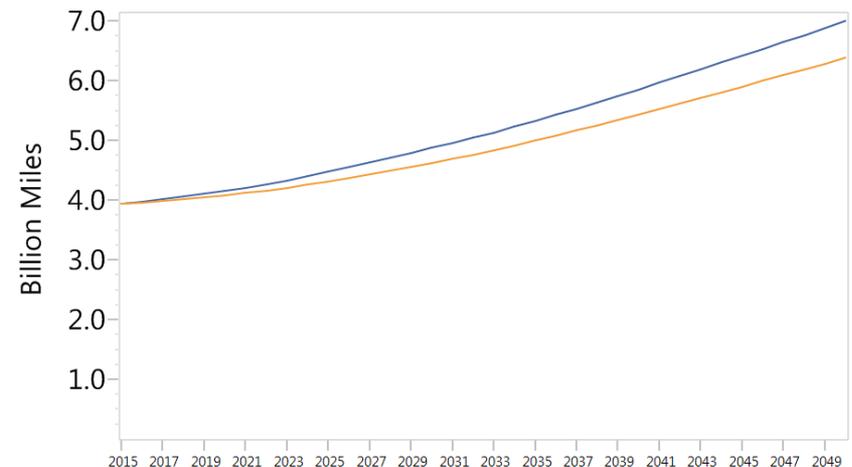


— Reference Scenario  
— Policy Scenario 1

## 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)

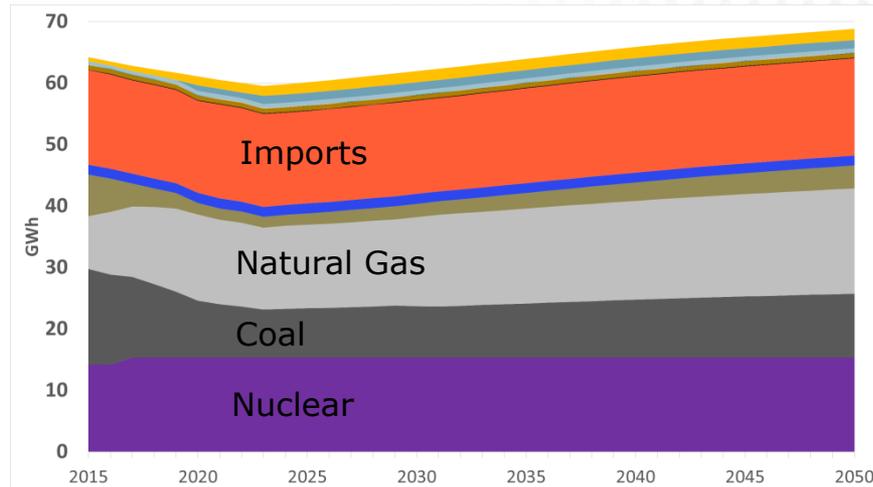


# Electricity Generation by Resource Type

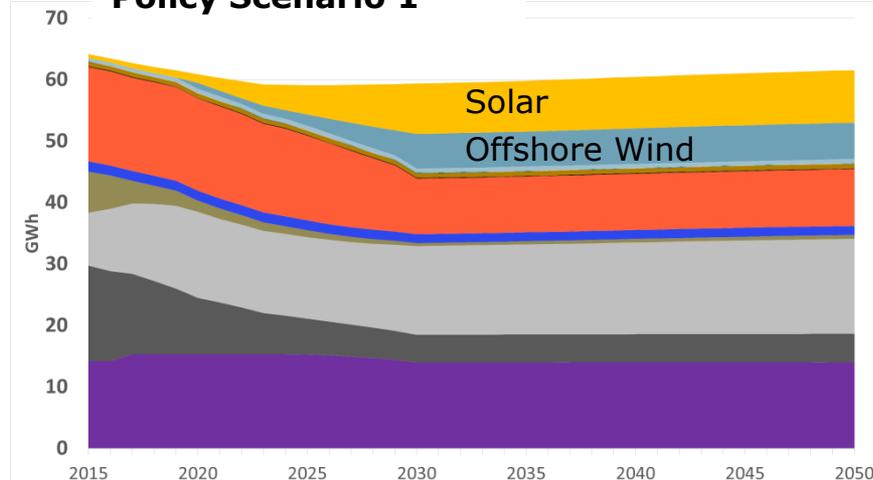
+ Reference Scenario reaches 25% RPS in 2020, increased load growth after 2023 due to end of EmPOWER

+ 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

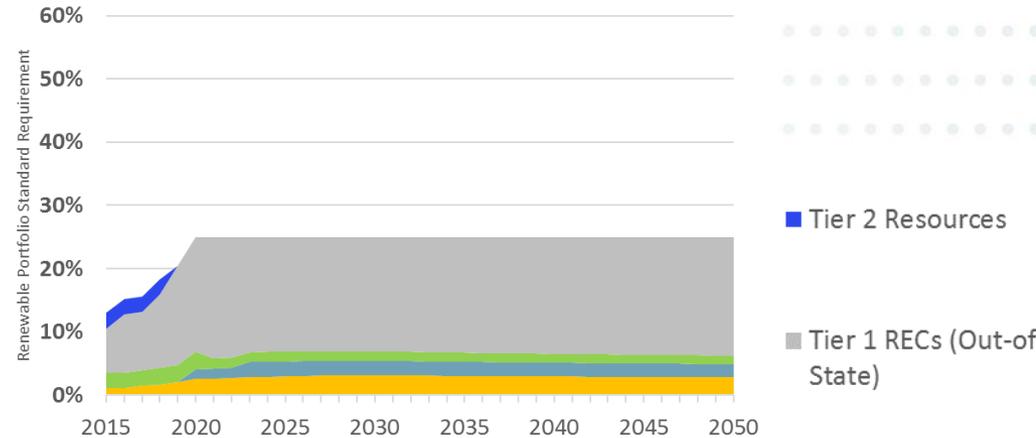




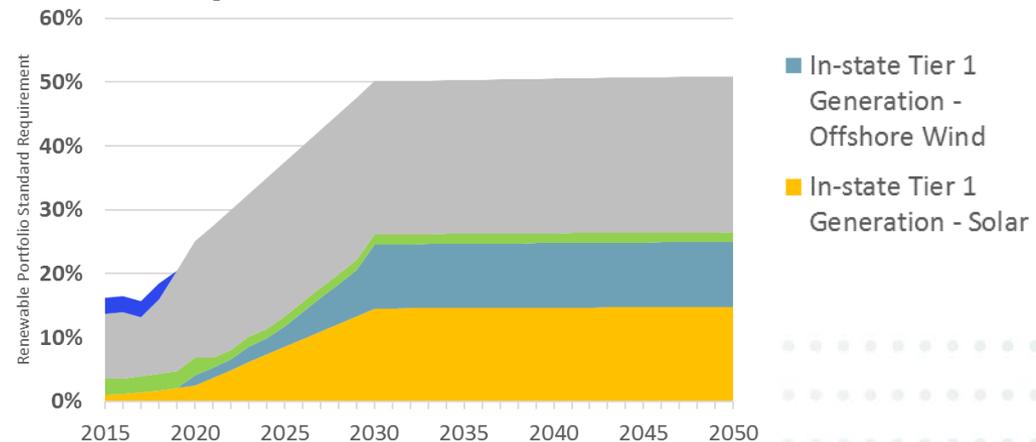
# RPS Requirements

- + **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

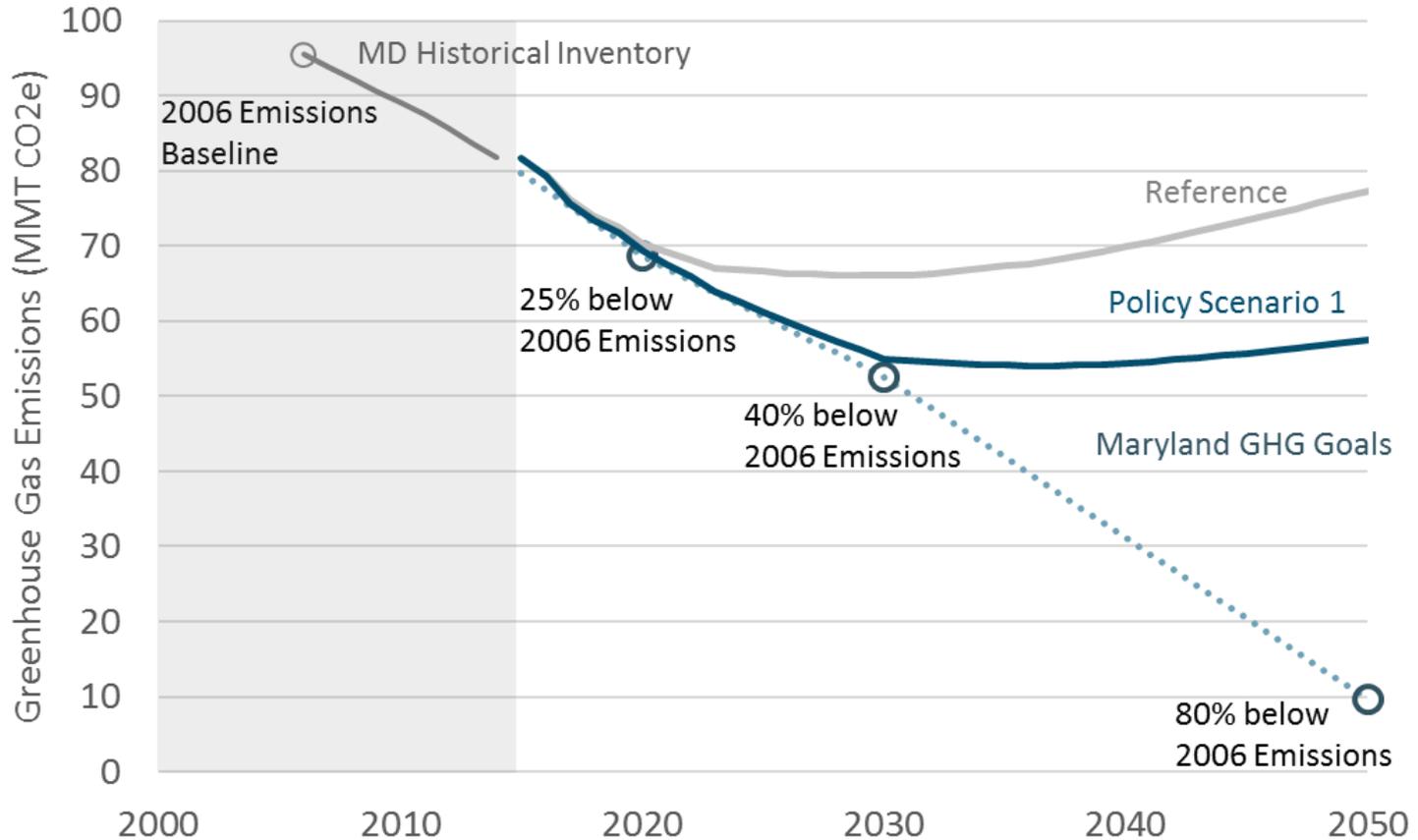


### Policy Scenario 1





# Policy Scenario 1 total GHG emissions

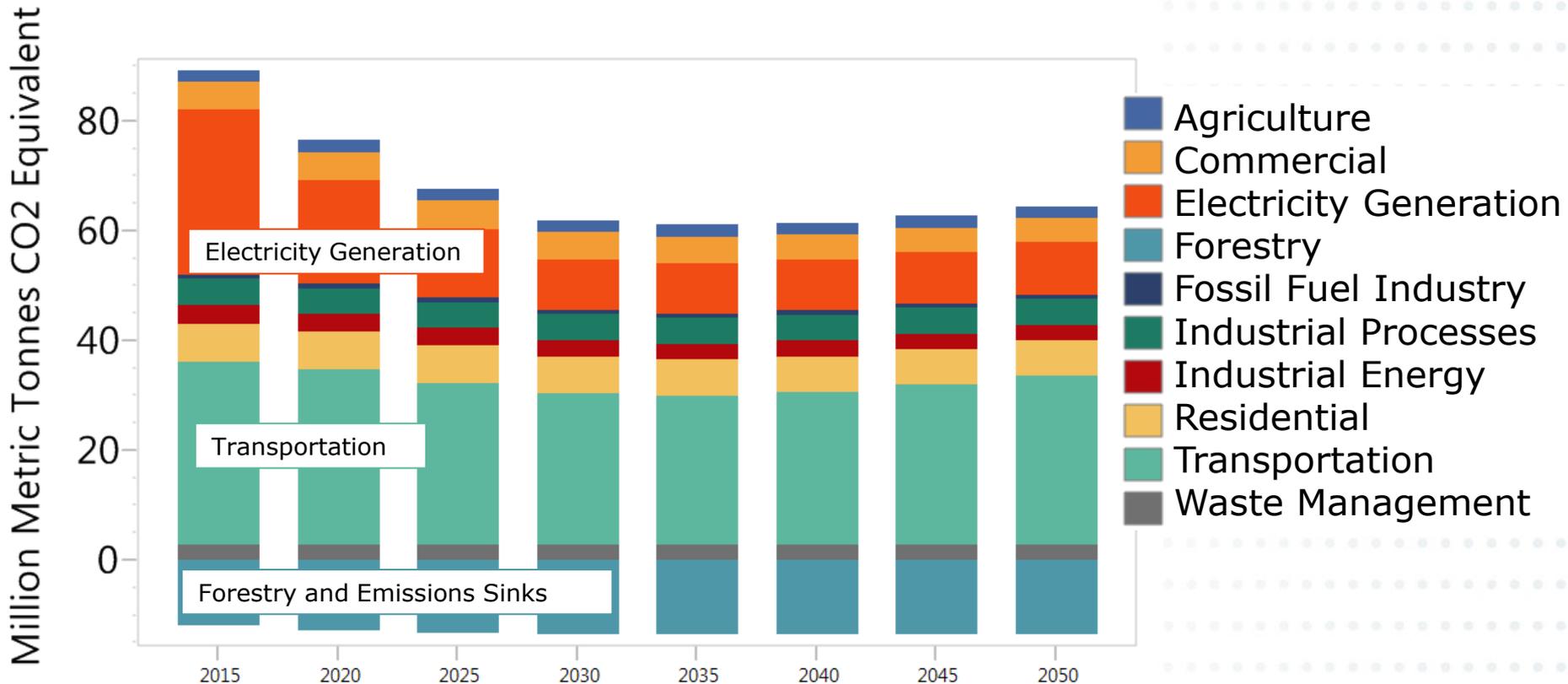


**Gap in 2020: 0.7 MMT (1% above goal)**  
**Gap in 2030: 2.4 MMT (5% above goal)**  
**Gap in 2050: 47.8 MMT**



# Policy Scenario 1

## Total emissions by sector

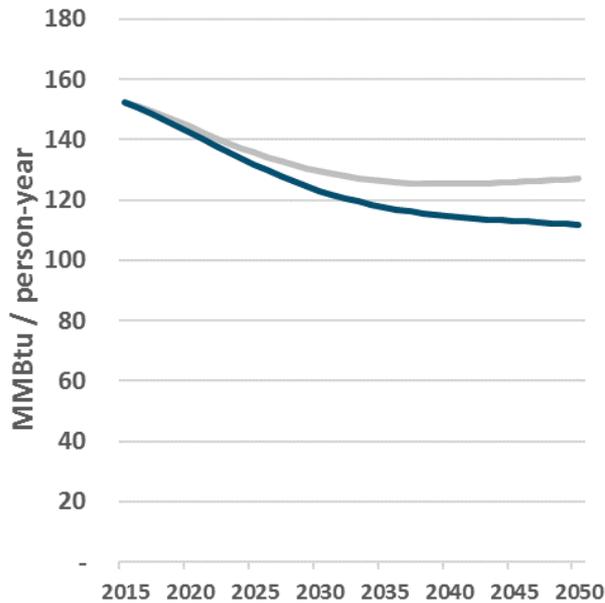




# Key Metrics: 3 Pillars of Decarbonization

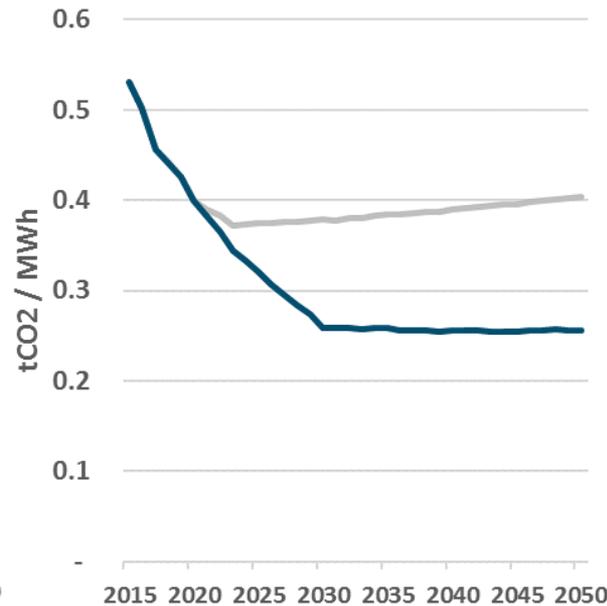
## (1) Energy Efficiency

[Energy Consumption per person]



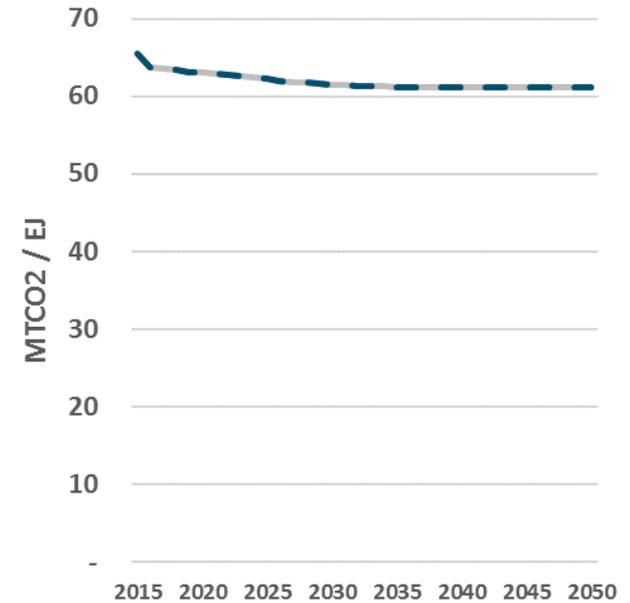
## (2) Clean Electricity

[Metric ton/MWh]



## (3) Clean Liquid and Gaseous Fuels

[Million Metric tonnes / EJ]



- Reference Scenario
- Policy Scenario 1



# NEXT STEPS



# How to close the gap: 2030

## 2.6 MMT CO<sub>2</sub>e needed in 2030

Methane capture and flaring

Refrigerant F-gas mitigation

Electrification of water heating

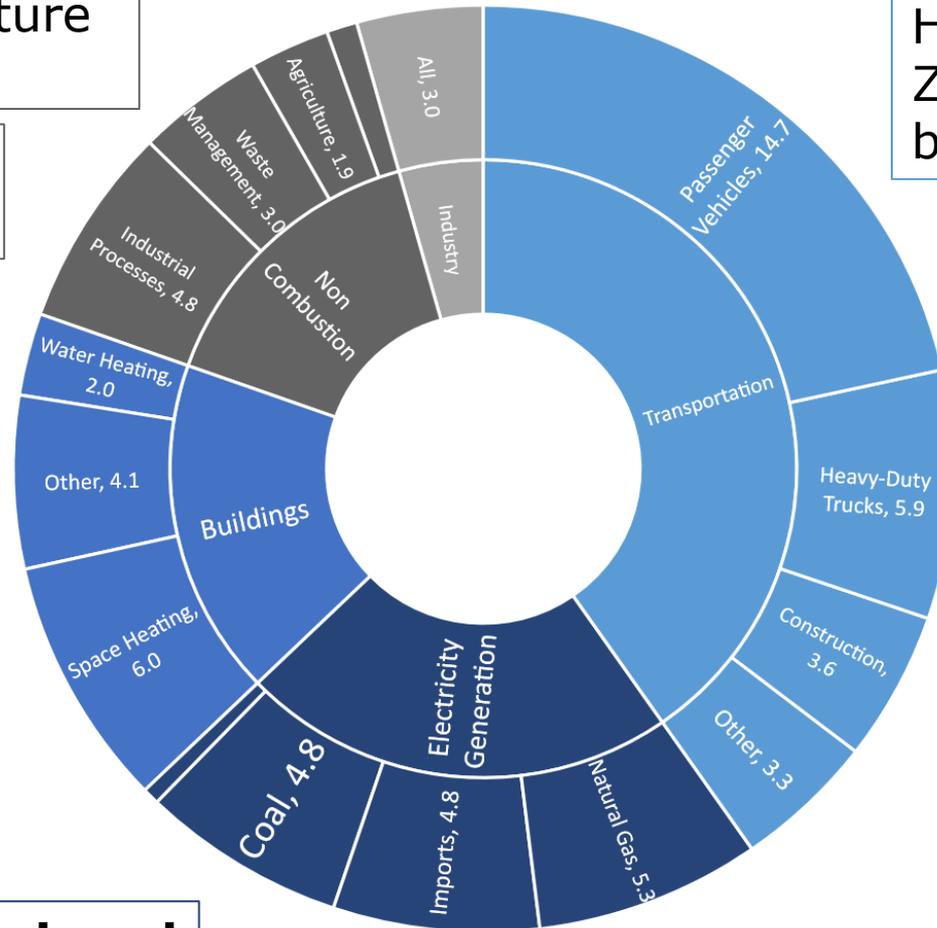
Electrification of space heating

**Additional coal retirements**

**Update RPS REC accounting**

Higher rate of ZEV Sales before 2030

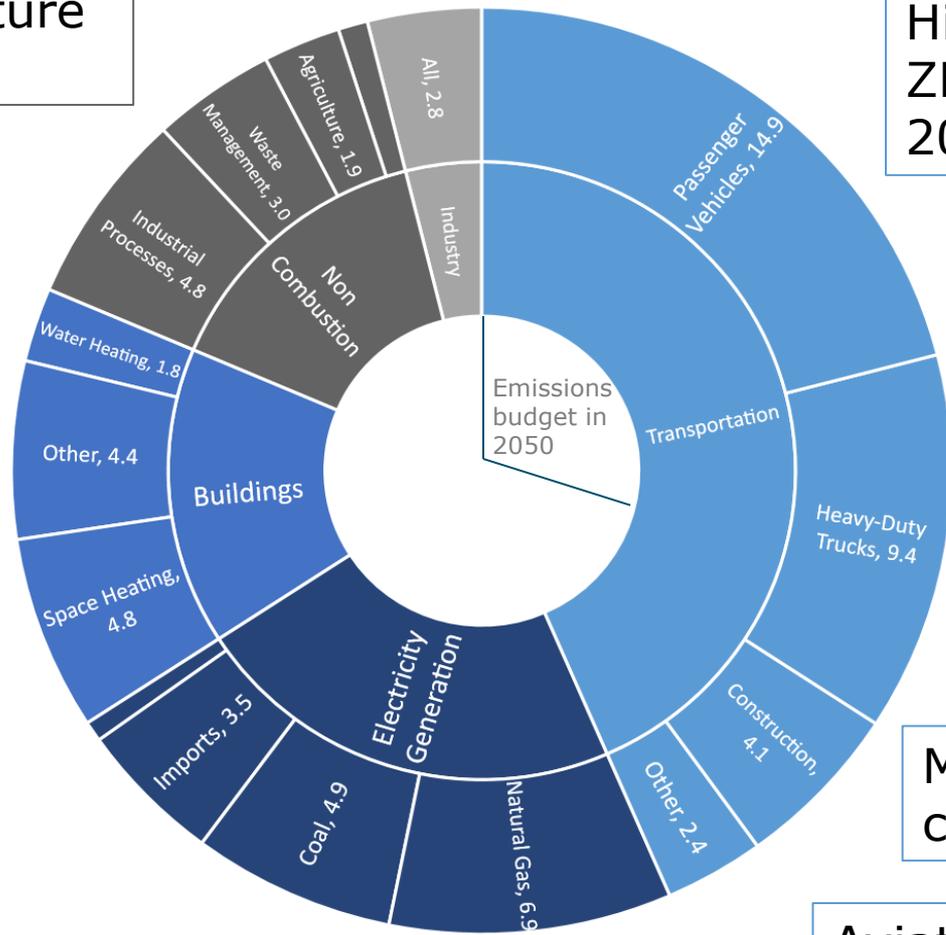
ZEVs or Hybrid vehicles in HDVs





# How to close the gap: 2050

## 47.6 MMT CO<sub>2</sub>e needed in 2050



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 2030-2050

ZEVs or Hybrid vehicles in HDVs

Measures in construction

Aviation efficiency



# Potential measures to close emissions gap

## + 2030

- Coal retirements
- Update RPS REC accounting/procurement to include emissions credit for renewable generation (~5 MMT CO<sub>2</sub>e 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



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

# APPENDIX

SINGLE-STATOR WATTHOUR METER

TYPE AB1 S. [REDACTED]

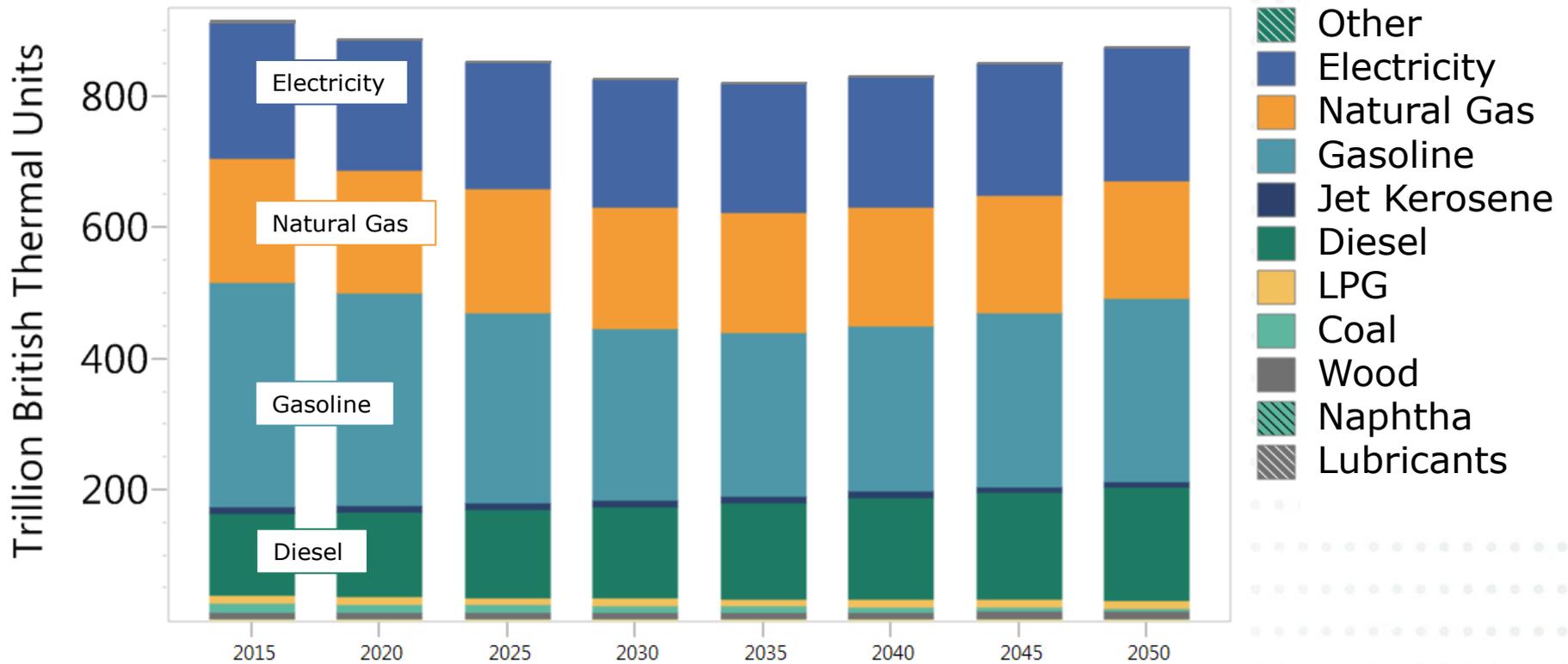
200 CL 240 V 3 W 60 Hz TA 30

MADE  
IN



# Policy Scenario 1

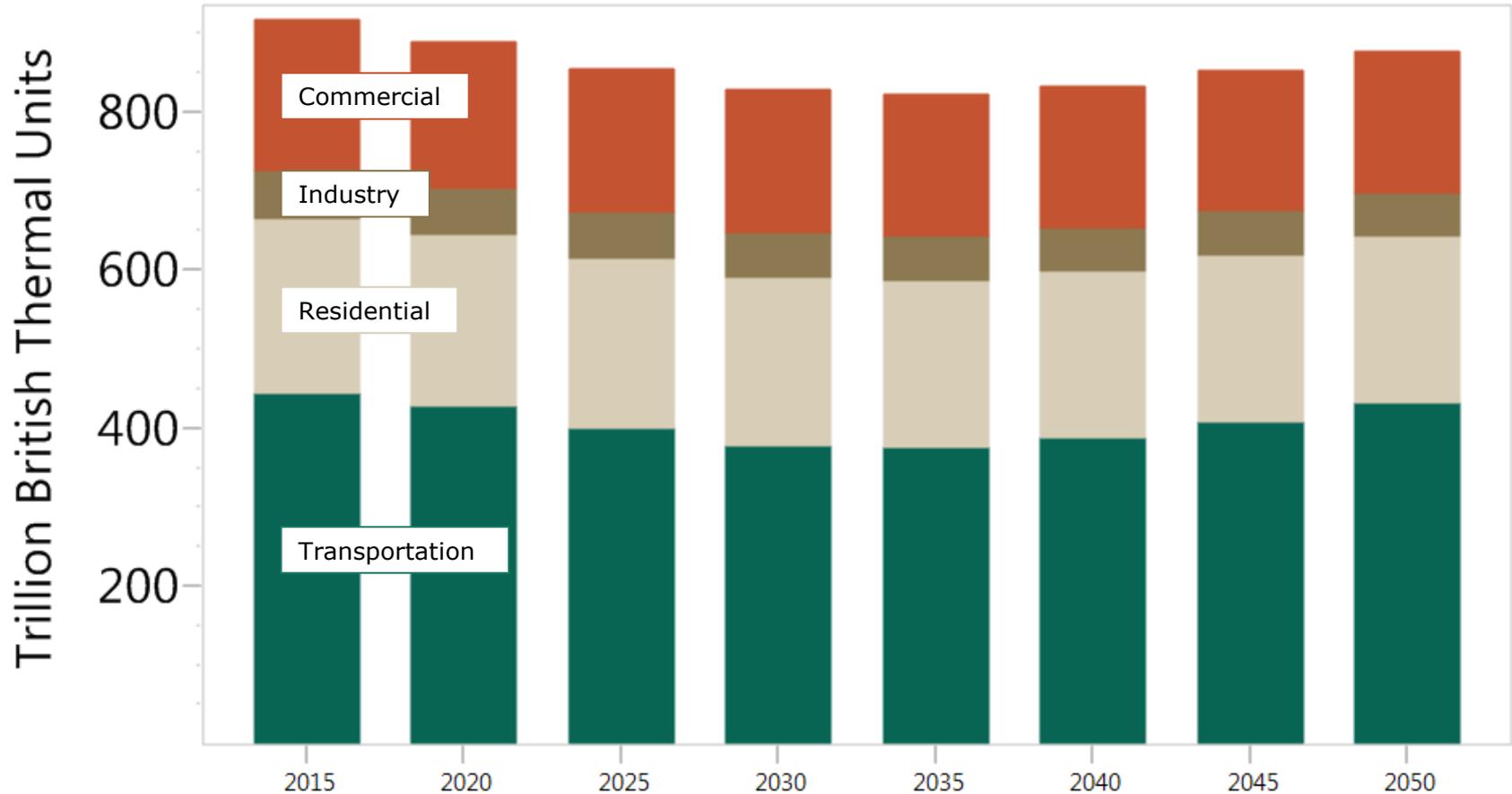
## Total energy by fuel





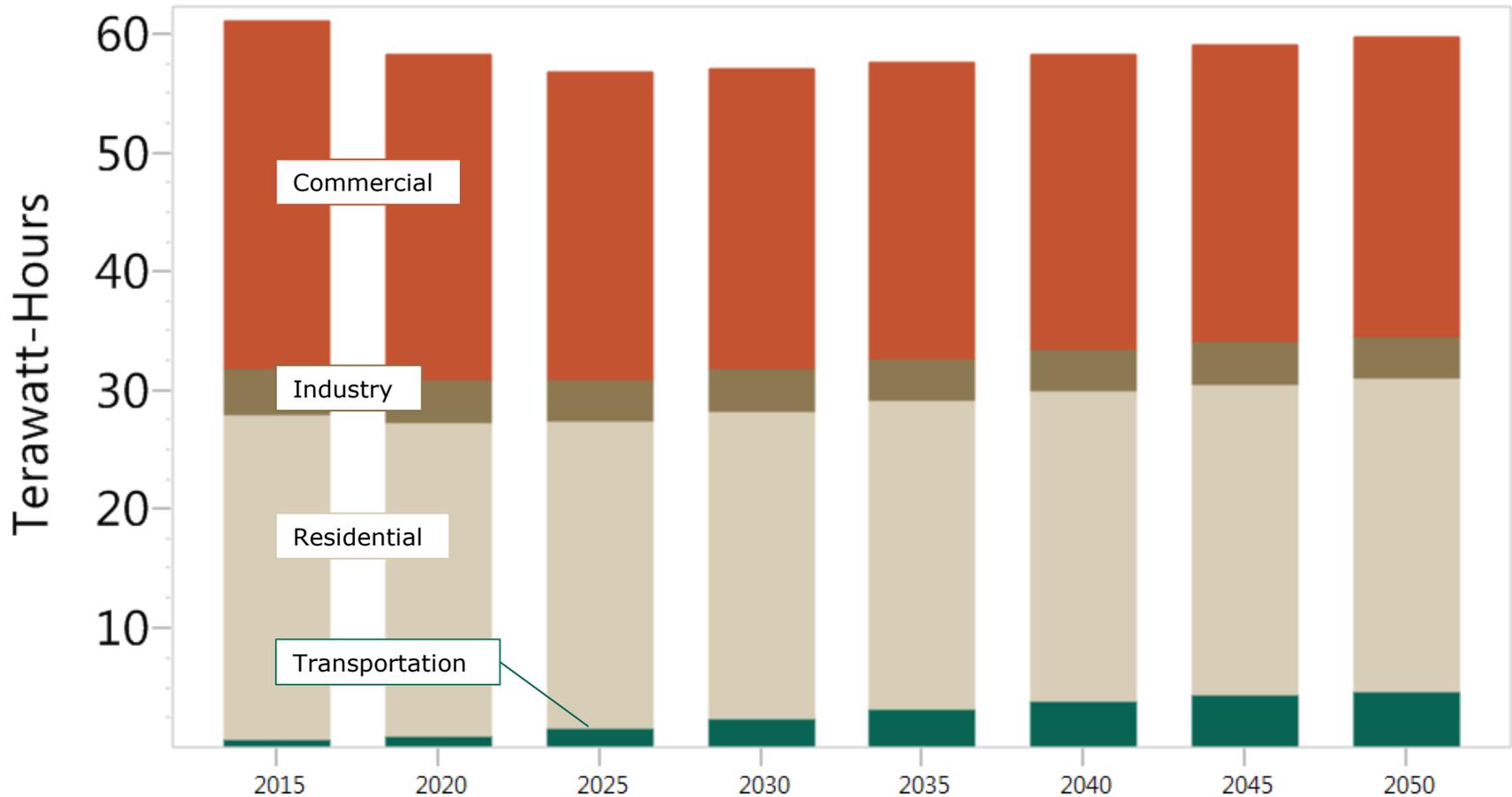
# Policy Scenario 1

## Total energy by sector





# Policy Scenario 1 Electricity Use by Sector

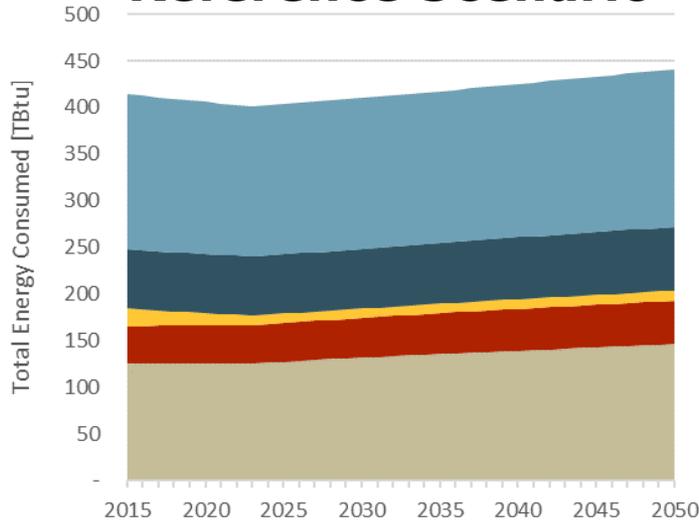




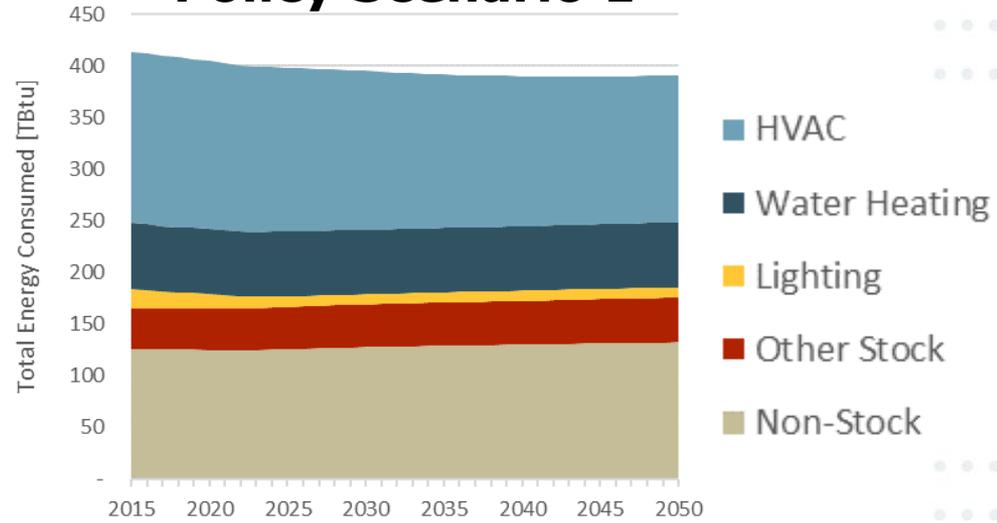
# Building Energy Consumption Policy Scenario 1 vs. Reference

All Fuels

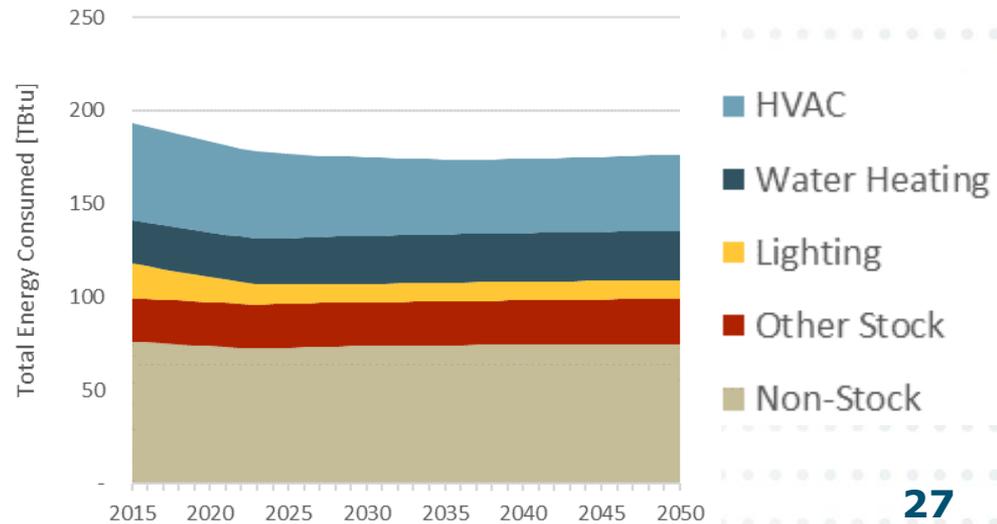
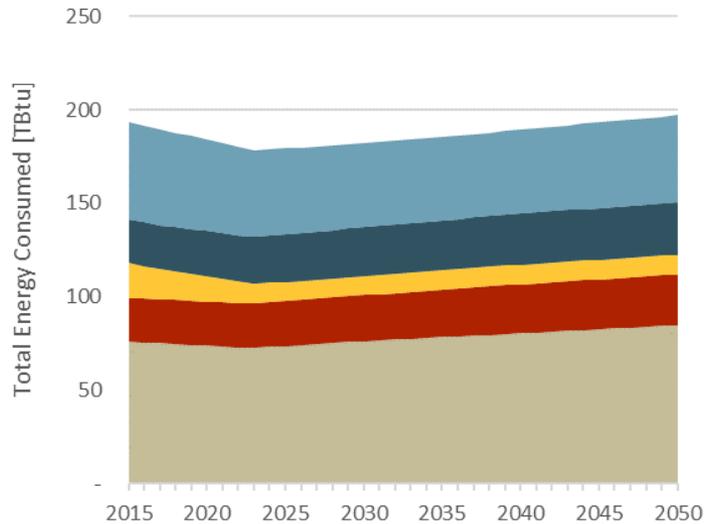
## Reference Scenario



## Policy Scenario 1

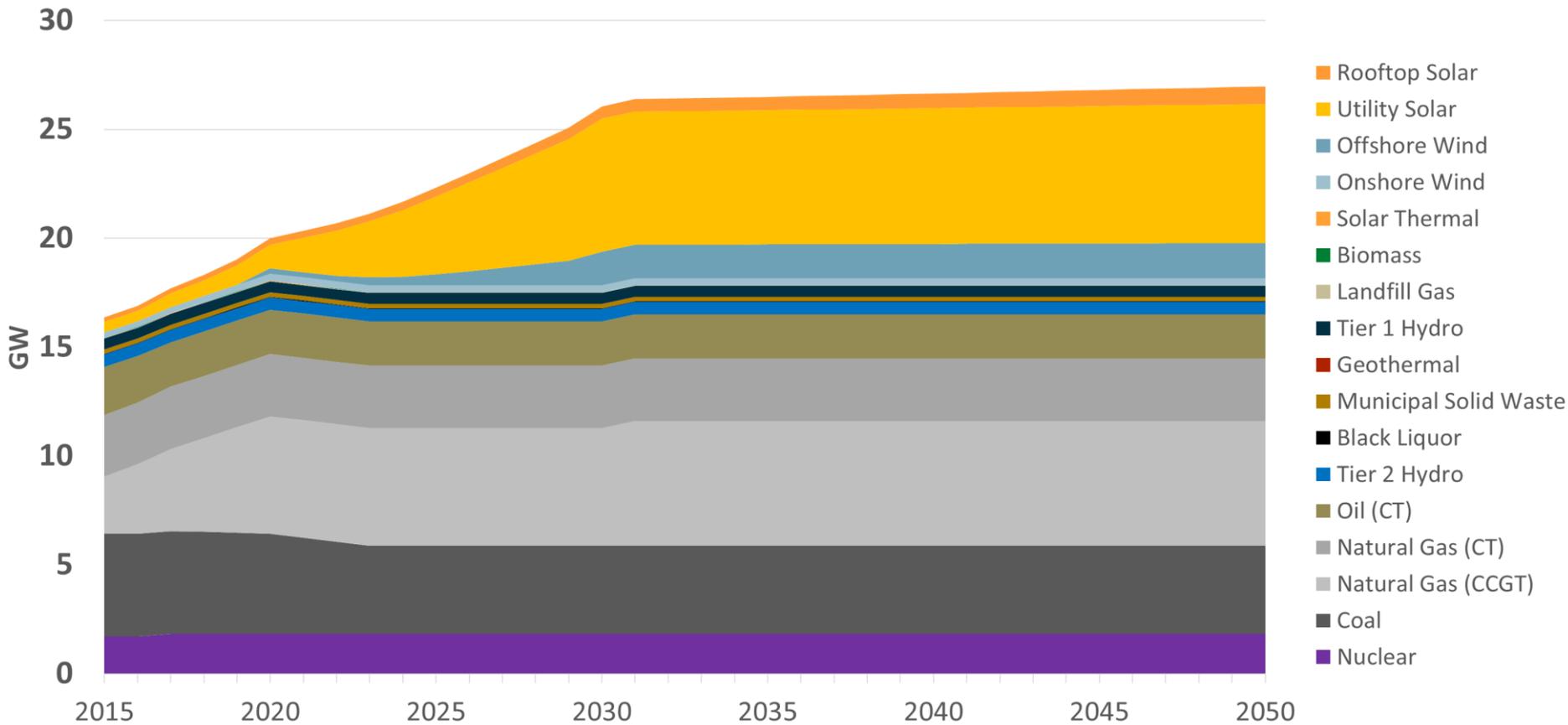


Electricity





# 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

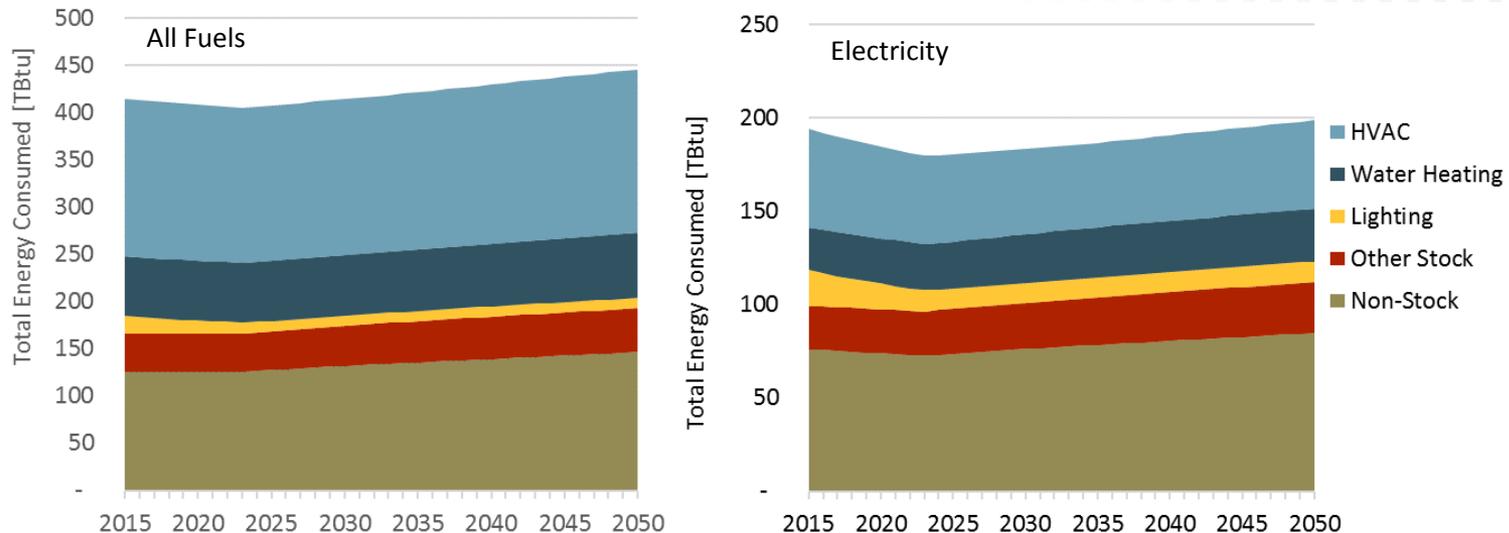
	Reference Scenario (Existing Policies)
<b>Renewable Portfolio Standard</b>	25% RPS by 2020
<b>RGGI</b>	30% cap reduction from 2020 to 2030
<b>Nuclear power</b>	Assume Calvert Cliffs is relicensed in 2034/2036 at end of license
<b>Existing coal power plants</b>	IPM planned retirements (670 MW of coal by 2023)
<b>Rooftop PV</b>	Moderate growth from current levels of 200 MW (2% a year; 400 MW in 2050)
<b>Energy Efficiency (Res., Com. &amp; Industrial)</b>	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
<b>Electrification of buildings (e.g. NG furnace to heat pumps)</b>	None
<b>Transportation</b>	Federal CAFÉ standards for LDVs by 2026, Meets ZEV mandate by 2025 (270,000 ZEVs)
<b>Other transportation sectors (e.g. aviation)</b>	AEO 2017 reference scenario growth rates by fuel
<b>Industrial energy use</b>	AEO 2017 reference scenario growth rates by fuel
<b>Biofuels</b>	Existing ethanol and biodiesel blends, but no assumed increase
<b>Other (fossil fuel industry, industrial processes, agriculture, waste management, forestry)</b>	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

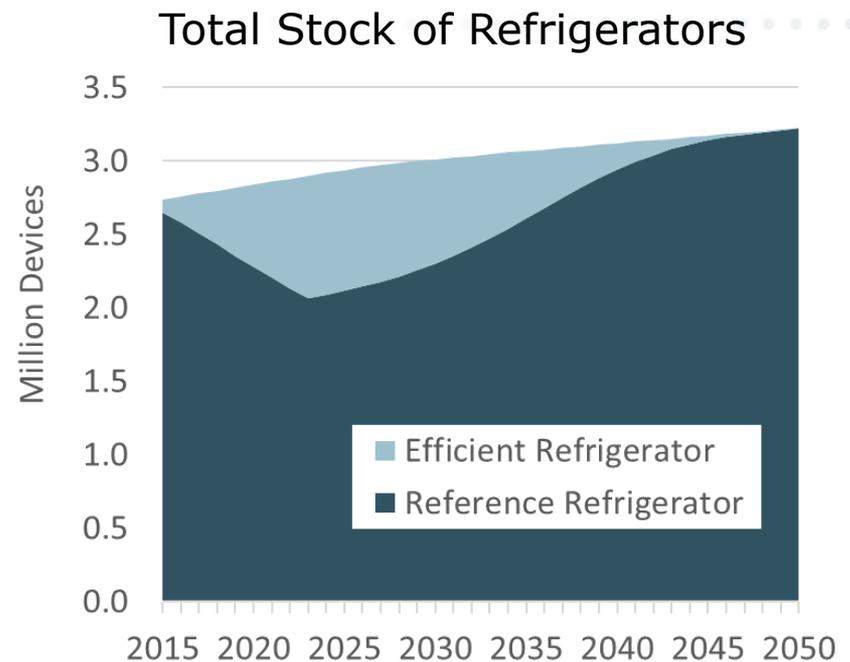
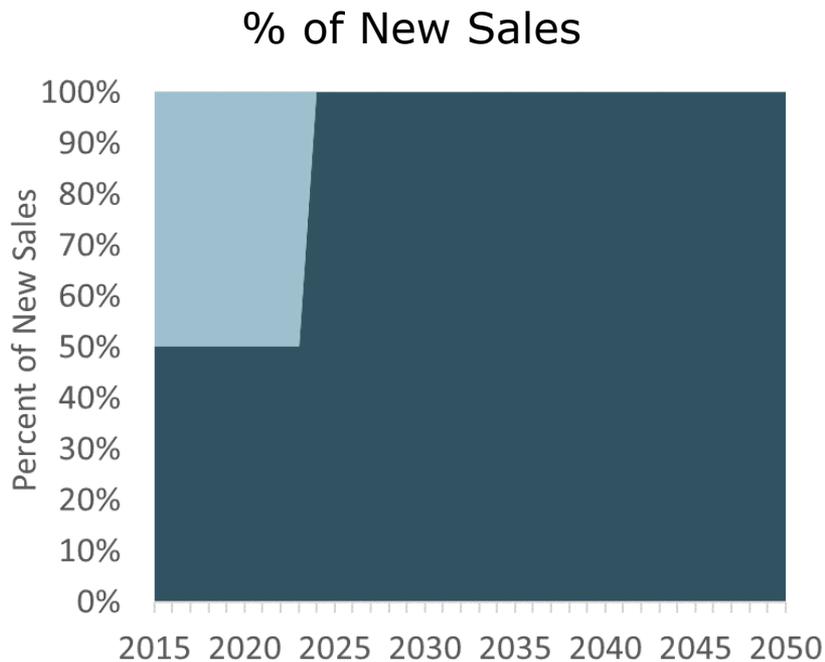




# Stock Rollover Example

## 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	<b>50% RPS by 2030</b>
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	<b>Doubling of reference levels (800 MW in 2050)</b>
Energy Efficiency (Res., Com. & Industrial)	<b>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)</b>
Electrification of buildings (e.g. NG furnace to heat pumps)	<b>Moderate electrification – increase of 15% in electric heat pump sales by 2050 (replacing natural gas furnaces and boiler sales)</b>
Transportation	Federal CAFÉ standards for LDVs by 2026, <b>Meets ZEV mandate by 2025 (270,000 ZEVs), increases to 1.4 Million ZEVs by 2050</b>
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)	<b>Forest management and Healthy soils sequestration</b>



# Scenario Assumptions – Transportation Measures

Strategy	Description	2030 VMT Reduction	VMT type	2030 Gas reduction (g)	2030 Diesel reduction (g)
<b>2018 MPO Plans &amp; Programs yield lower annual VMT growth (1.4%/yr)</b>	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		
<b>EV/PHEV sales grow to 15%/5% by 2025</b>	EV market share analysis within reference case already assumes 15%/5% sales growth by 2030.			-	
<b>On-Road Technology (CHART, Traveler Information)</b>	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
<b>Freight and Freight Rail Programs (National Gateway and MTA rail projects including new locomotive technologies)</b>	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		
<b>Public Transportation (new capacity, improved operations/ frequency, BRT)</b>	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		
<b>Public Transportation (fleet replacement / technology)</b>	This strategy includes MTA planned fleet replacement to Clean Diesel and WMATA planned fleet replacement based on current replacement strategy.				2,367,995
<b>Intercity Transportation Initiatives (Amtrak NE Corridor, Intercity bus)</b>	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		
<b>Transportation Demand Management</b>	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		
<b>Pricing Initiatives (Electronic Tolling)</b>	Ongoing Conversion to All-Electronic Tolling			2,241,454	209,554
<b>Bicycle and Pedestrian Strategies (Provision of non-motorized infrastructure including sidewalks and bike lanes)</b>	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		
<b>Land-Use and Location Efficiency</b>	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		
<b>Drayage Track Replacements</b>	Emission benefit of estimated 600 total dray trucks replaced through 2030.				590,523
<b>BWI Airport parking shuttle bus replacements</b>	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

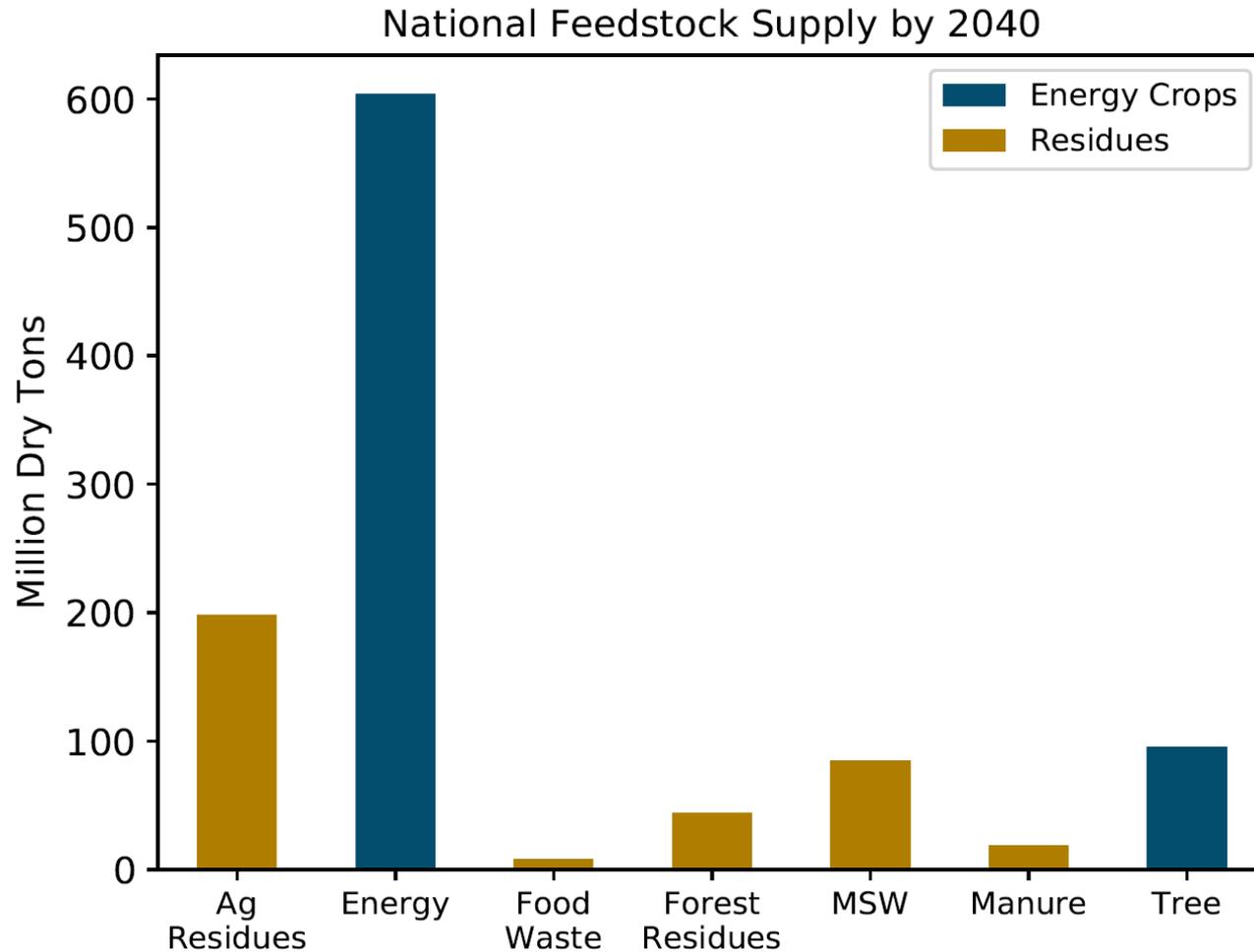
- Renewable natural gas
- Renewable oil products (diesel, gasoline, jet kerosene)

### Hydrogen

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



# Biomass Feedstock Potential

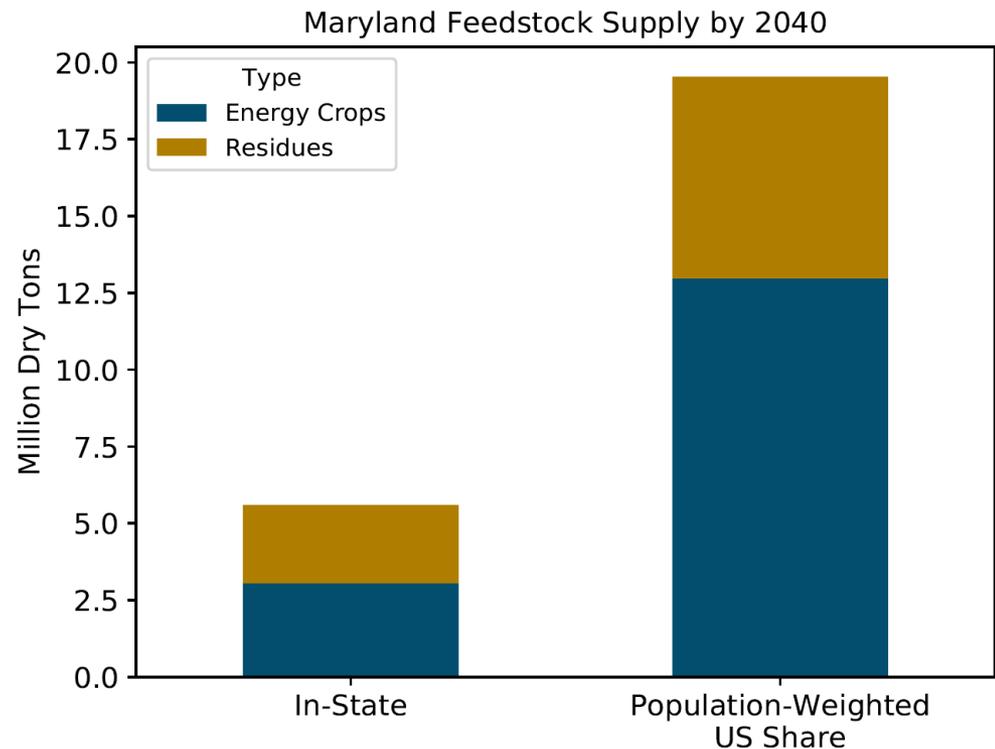


Source: DOE, 2016. Billion Ton Update



# 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 CO<sub>2</sub>e, depending on use of energy crops

