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.
Maryland Pathways
Policy Scenario 1

September 18th, 2018

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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
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)
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
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

- Electricity Generation
- Transportation
- Forestry and Emissions Sinks
- Agriculture
- Commercial
- Electricity Generation
- Forestry
- Fossil Fuel Industry
- Industrial Processes
- Industrial Energy
- Industrial Energy
- Residential
- Transportation
- Waste Management

Million Metric Tonnes CO2 Equivalent

Year: 2015, 2020, 2025, 2030, 2035, 2040, 2045, 2050
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]
How to close the gap: 2030
2.6 MMT CO2e needed in 2030

Methane capture and flaring

Refrigerant F-gas mitigation

Higher rate of ZEV Sales before 2030

Electrification of water heating

Electrification of space heating

Additional coal retirements

Update RPS REC accounting

ZEVs or Hybrid vehicles in HDVs
How to close the gap: 2050
47.6 MMT CO2e 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

Emissions budget in 2050

- Transportation
- Heavy-Duty Trucks, 9.4
- Construction, 4.1
- Other, 2.4
- Natural Gas, 6.9
- Coal, 4.9
- Imports, 3.5
- Space Heating, 4.8
- Water Heating, 1.8
- Other, 4.4
- Non Combustion
- Industry
- Agriculture, 1.9
- Waste Management, 3.0
- Industrial Processes, 4.8
- Passenger Vehicles, 14.9
- Buildings
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*
Thank You!

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101 Montgomery Street, Suite 1600
San Francisco, CA 94104
Tel 415-391-5100
Web http://www.ethree.com
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)
**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

% of New Sales

% of New Sales

Reference Scenario

Policy Scenario 1

Total Stock

Total Stock

Reference Appliance

Efficient Appliance

Reference Appliance

Efficient Appliance

Million Devices

Million Devices

2015 2018 2021 2024 2027 2030 2033 2036 2039 2042 2045 2048

2015 2018 2021 2024 2027 2030 2033 2036 2039 2042 2045 2048

1.50

1.50

1.00

1.00

0.50

0.50

Million Devices

Million Devices

2015 2018 2021 2024 2027 2030 2033 2036 2039 2042 2045 2048

2015 2018 2021 2024 2027 2030 2033 2036 2039 2042 2045 2048

Energy + Environmental Economics
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

Policy Scenario 1

% of New Sales

Total Vehicle Stock

Percent

Million Devices

Energy+Environmental Economics

19
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)
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 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.
Policy Scenario 1
Total energy by fuel

<table>
<thead>
<tr>
<th>Year</th>
<th>Electricity</th>
<th>Natural Gas</th>
<th>Gasoline</th>
<th>Jet Kerosene</th>
<th>Diesel</th>
<th>LPG</th>
<th>Coal</th>
<th>Wood</th>
<th>Naphtha</th>
<th>Lubricants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
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<td>2025</td>
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<td>2040</td>
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<td>2050</td>
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</tr>
</tbody>
</table>
Policy Scenario 1
Total energy by sector

Trillion British Thermal Units

Commercial
Industry
Residential
Transportation

2015 2020 2025 2030 2035 2040 2045 2050
Policy Scenario 1
Electricity Use by Sector

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial</th>
<th>Industry</th>
<th>Residential</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
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<tr>
<td>2020</td>
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<td>2025</td>
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<td>2030</td>
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<td>2035</td>
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<td>2045</td>
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<td>2050</td>
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</tbody>
</table>
Building Energy Consumption
Policy Scenario 1 vs. Reference

**Reference Scenario**

- **All Fuels**
- **Electricity**

**Policy Scenario 1**

- **All Fuels**
- **Electricity**

Legend:
- HVAC
- Water Heating
- Lighting
- Other Stock
- Non-Stock
Policy Scenario 1 In-State Electric Generating Capacity
## Key Drivers 2015-2050

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable Portfolio Standard</strong></td>
<td>25% RPS by 2020</td>
</tr>
<tr>
<td><strong>RGGI</strong></td>
<td>30% cap reduction from 2020 to 2030</td>
</tr>
<tr>
<td><strong>Nuclear power</strong></td>
<td>Assume Calvert Cliffs is relicensed in 2034/2036 at end of license</td>
</tr>
<tr>
<td><strong>Existing coal power plants</strong></td>
<td>IPM planned retirements (670 MW of coal by 2023)</td>
</tr>
<tr>
<td><strong>Rooftop PV</strong></td>
<td>Moderate growth from current levels of 200 MW (2% a year; 400 MW in 2050)</td>
</tr>
<tr>
<td><strong>Energy Efficiency (Res., Com. &amp; Industrial)</strong></td>
<td>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</td>
</tr>
<tr>
<td><strong>Electrification of buildings (e.g. NG furnace to heat pumps)</strong></td>
<td>None</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td>Federal CAFÉ standards for LDVs by 2026, Meets ZEV mandate by 2025 (270,000 ZEVs)</td>
</tr>
<tr>
<td><strong>Other transportation sectors (e.g. aviation)</strong></td>
<td>AEO 2017 reference scenario growth rates by fuel</td>
</tr>
<tr>
<td><strong>Industrial energy use</strong></td>
<td>AEO 2017 reference scenario growth rates by fuel</td>
</tr>
<tr>
<td><strong>Biofuels</strong></td>
<td>Existing ethanol and biodiesel blends, but no assumed increase</td>
</tr>
<tr>
<td><strong>Other (fossil fuel industry, industrial processes, agriculture, waste management, forestry)</strong></td>
<td>Assume held constant at MDE 2014 GHG Inventory levels, with specific projections for forest management and healthy soils</td>
</tr>
</tbody>
</table>
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
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

<table>
<thead>
<tr>
<th>Policy Scenario 1 (updates from Reference in Bold)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable Portfolio Standard</strong></td>
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</tr>
<tr>
<td><strong>Rooftop PV</strong></td>
</tr>
<tr>
<td>Doubling of reference levels (800 MW in 2050)</td>
</tr>
<tr>
<td><strong>Energy Efficiency (Res., Com. &amp; Industrial)</strong></td>
</tr>
<tr>
<td>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)</td>
</tr>
<tr>
<td><strong>Electrification of buildings (e.g. NG furnace to heat pumps)</strong></td>
</tr>
<tr>
<td>Moderate electrification – increase of 15% in electric heat pump sales by 2050 (replacing natural gas furnaces and boiler sales)</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
</tr>
<tr>
<td>Federal CAFÉ standards for LDVs by 2026, Meets ZEV mandate by 2025 (270,000 ZEVs), increases to 1.4 Million ZEVs by 2050</td>
</tr>
<tr>
<td><strong>Other transportation sectors (e.g. aviation)</strong></td>
</tr>
<tr>
<td>AEO 2017 reference scenario growth rates by fuel</td>
</tr>
<tr>
<td><strong>Industrial energy use</strong></td>
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<tr>
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</tr>
<tr>
<td>Forest management and Healthy soils sequestration</td>
</tr>
</tbody>
</table>
## Scenario Assumptions – Transportation Measures

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
<th>2030 VMT Reduction</th>
<th>VMT type</th>
<th>2030 Gas Reduction (g)</th>
<th>2030 Diesel Reduction (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018 MPO Plans &amp; Programs yield lower annual VMT growth (1.4%/yr)</td>
<td>Modeled VMT and emissions outcomes (through MOVES2014a) from implementation of MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.</td>
<td>3,158,758,638</td>
<td>On-road fleet</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EV/PHEV sales grow to 15%/5% by 2025</td>
<td>EV market share analysis within reference case already assumes 15%/5% sales growth by 2030.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>On-Road Technology (CHART, Traveler Information)</td>
<td>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.</td>
<td>16,165,665</td>
<td>-</td>
<td>1,326,297</td>
<td>-</td>
</tr>
<tr>
<td>Freight and Freight Rail Programs (National Gateway and MTA rail projects including new locomotive technologies)</td>
<td>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.</td>
<td>26,431,915</td>
<td>HDV only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Public Transportation (new capacity, improved operations/ frequency, BRT)</td>
<td>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.</td>
<td>84,137,696</td>
<td>LDV only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Public Transportation (fleet replacement / technology)</td>
<td>This strategy includes MTA planned fleet replacement to Clean Diesel and WMATA planned fleet replacement based on current replacement strategy.</td>
<td>-</td>
<td>-</td>
<td>2,367,995</td>
<td>-</td>
</tr>
<tr>
<td>Intercity Transportation Initiatives (Amtrak NE Corridor, Intercity bus)</td>
<td>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.</td>
<td>47,806,157</td>
<td>LDV only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Transportation Demand Management</td>
<td>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</td>
<td>486,499,923</td>
<td>LDV only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pricing Initiatives (Electronic Tolling)</td>
<td>Ongoing Conversion to All-Electronic Tolling</td>
<td>-</td>
<td>-</td>
<td>2,241,454</td>
<td>209,554</td>
</tr>
<tr>
<td>Bicycle and Pedestrian Strategies (Provision of non-motorized infrastructure including sidewalks and bike lanes)</td>
<td>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.</td>
<td>79,504,966</td>
<td>LDV only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Land-Use and Location Efficiency</td>
<td>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.</td>
<td>979,733,809</td>
<td>LDV only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Drayage Track Replacements</td>
<td>Emission benefit of estimated 600 total dray trucks replaced through 2030.</td>
<td>-</td>
<td>-</td>
<td>590,523</td>
<td>-</td>
</tr>
<tr>
<td>BWI Airport parking shuttle bus replacements</td>
<td>Emission benefit of replacing 50 diesel buses with clean diesel buses and CNG buses for expansion.</td>
<td>-</td>
<td>-</td>
<td>150,000</td>
<td>-</td>
</tr>
</tbody>
</table>
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

National Feedstock Supply by 2040

Source: DOE, 2016. Billion Ton Update
+ **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**
Using the MD-share of the US supply, Maryland can reduce up to 6-16 MMT CO2e, depending on use of energy crops.