

Prosperous, Renewable Maryland

IEER 1.5 C ENERGY AND CLIMATE PLAN FOR MARYLAND

**PRESENTATION TO THE MITIGATION WORKING GROUP OF THE MARYLAND COMMISSION
ON CLIMATE CHANGE**

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Global Context

United Nations Framework Convention on Climate Change, UNFCCC, to which the United States is a party and the 2015 Paris Agreement

- **The technical targets in the IEER 1.5 C Scenario are ambitious;** they are derived from the upper end of the ranges of GHG reductions indicated in the 2018 IPCC report.
- **Achieving these targets is the minimum needed to lay the foundation of compliance** because Maryland will still exceed the average remaining global carbon budget of 500 gigatons of CO₂ on a per person basis by mid-century. Continued net sinks needed after that.
- **Complementary measures to decrease net emissions further will be needed** to meet obligations of wealthy countries under the UNFCCC.

Outline

- General principles
- IPCC 1.5 C 2018 report and implications for GHG reductions in wealthy regions
- Technical targets by sector in Prosperous, Renewable Maryland, updated in light of IPCC 2018 report
- Affordability and Just Transition
- Supplementary slides on how the clean, renewable, affordable energy system will work.

General Principles

- Clean, renewable energy for all
- Affordable for all
- Equitable for all
- Conforms to upper end of IPCC 2018 1.5 C targets, taken as requirements for wealthy countries
- Transparent and democratic process
- Just transition and focus on vulnerable communities

IEER Maryland 1.5 C Scenario

- IEER scenario (CO₂ net + methane 20-y GWP + N₂O + HFCs, SF₆ = CO₂eq) – See Notes 2 and 3
 - 60% CO₂eq reduction by 2030 relative to 2011.
 - 100% CO₂-eq net reduction by the mid-2040s
 - CO₂eq negative after mid-2040s to 2100 and beyond
 - Agriculture and waste stream emissions included but not considered in detail, so very approximate. More detailed study needed.
 - Sinks included, mainly MDE numbers.

Clean, renewable energy: What is it?

IPCC 5 definition of renewable energy

“Any form of energy from solar, geophysical, or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use.” IPCC 2014, Mitigation volume, p. 1261.

Details

- Period over which rate is calculated was not defined by IPCC. I recommend one year – biomass energy must be replaced by natural processes within the year of use. For example, cutting down and burning old growth biomass would not qualify as renewable.
- Very difficult to make solid biomass renewable – replacing within the year of use; taking soil carbon into account makes it even more difficult but important as the palm oil example has shown.
- **Trash is not renewable.** Plastic for example is not renewed by natural processes.
- **Nuclear fuel is not renewable** because the primary materials, uranium and thorium, came with the Earth and are not renewed by natural processes.
- “Clean”: There is no definition in the IPCC. IEER recommends that it must be (i) renewable, and (ii) have minimal or zero air water, and soil pollution in the course of its utilization. Air pollution should take indoor and outdoor air pollution into account.

Co-benefits of solar and wind energy

- Very low water use
- No wastes from fuel production (unlike coal, natural gas, and nuclear)
- No mining for fuel
- No thermal discharges into the Chesapeake Bay
- Essentially no air pollution due to energy use or transportation
- Significant health and economic benefits
- More jobs in Maryland since money not going out of state to buy fossil fuels

Electricity – Technical Targets

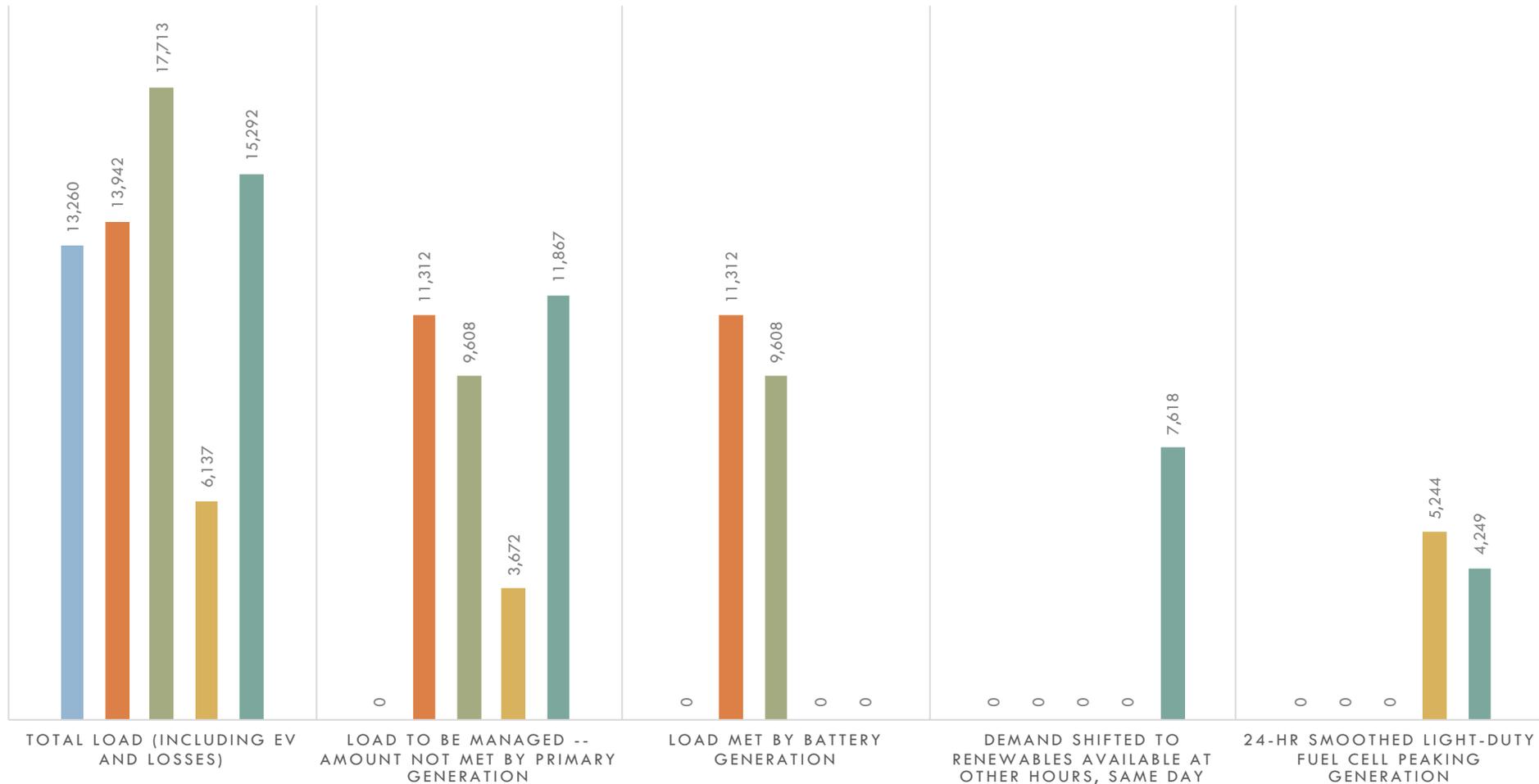
- Electricity:
 - ▣ 75% clean, renewable by 2030; actual electrons, not just renewable energy certificates separated from the electricity.
 - ▣ No subsidies for Calvert Cliffs nuclear power plant.
 - ▣ 100% clean, renewable electricity by 2040, actual electrons.
 - ▣ Efficiency: 2%/year for existing uses – i.e., excluding electrification of transportation and building fossil fuel uses.
 - ▣ Primary electricity sources: solar, onshore wind, offshore wind, Conowingo (small)
 - ▣ Smart grid and aggregated smart demand response
 - ▣ Renewable hydrogen is made from solar and wind in surplus hours by electrolysis – existing technology. It is used to replace natural gas for peaking power supply and for combined heat and power in the commercial and industrial sectors

Meeting load reliably with renewable electricity, without nuclear or fossil fuels.

Five example hours 1. Adequate wind + solar -- light blue bar at left. 2 and 3. Wind + solar + generation from battery storage, brown and grey bars. 4. wind + solar + peaking generation, no battery generation, beige bars. 5. Wind + solar + demand response + peaking generation; no battery generation, blue bars at right. See notes.

MEETING LOAD IN A SOLAR AND WIND ELECTRICITY SYSTEM, MW

■ 7/9, 4 pm ■ 1/11, 6 pm ■ 1/24, 7 am ■ 11/19, 1 am ■ 12/12, 7 am



Transportation -- Technical Targets

- Transportation
 - ***Ban petroleum/fossil fuel vehicle sales in and after 2035***
 - ***100% zero emission road transport by 2050***
 - Some aircraft, ship, rail and other non-road transport emissions would be reduced gradually to 3 million metric tons in 2050.

Buildings: Technical Targets

- Net zero new buildings, solar can be on or offsite:
 - ▣ 2022 for residential
 - ▣ 2025 for commercial
- Existing building conversion away from fossil fuels to efficient electric systems – See Note 1
 - ▣ 40% oil and propane and 20% natural gas converted by 2030
 - ▣ 80% oil and propane and 60% natural gas converted by 2040
 - ▣ 100% fossil fuel buildings converted to electricity by 2050.

Industry – Technical Targets

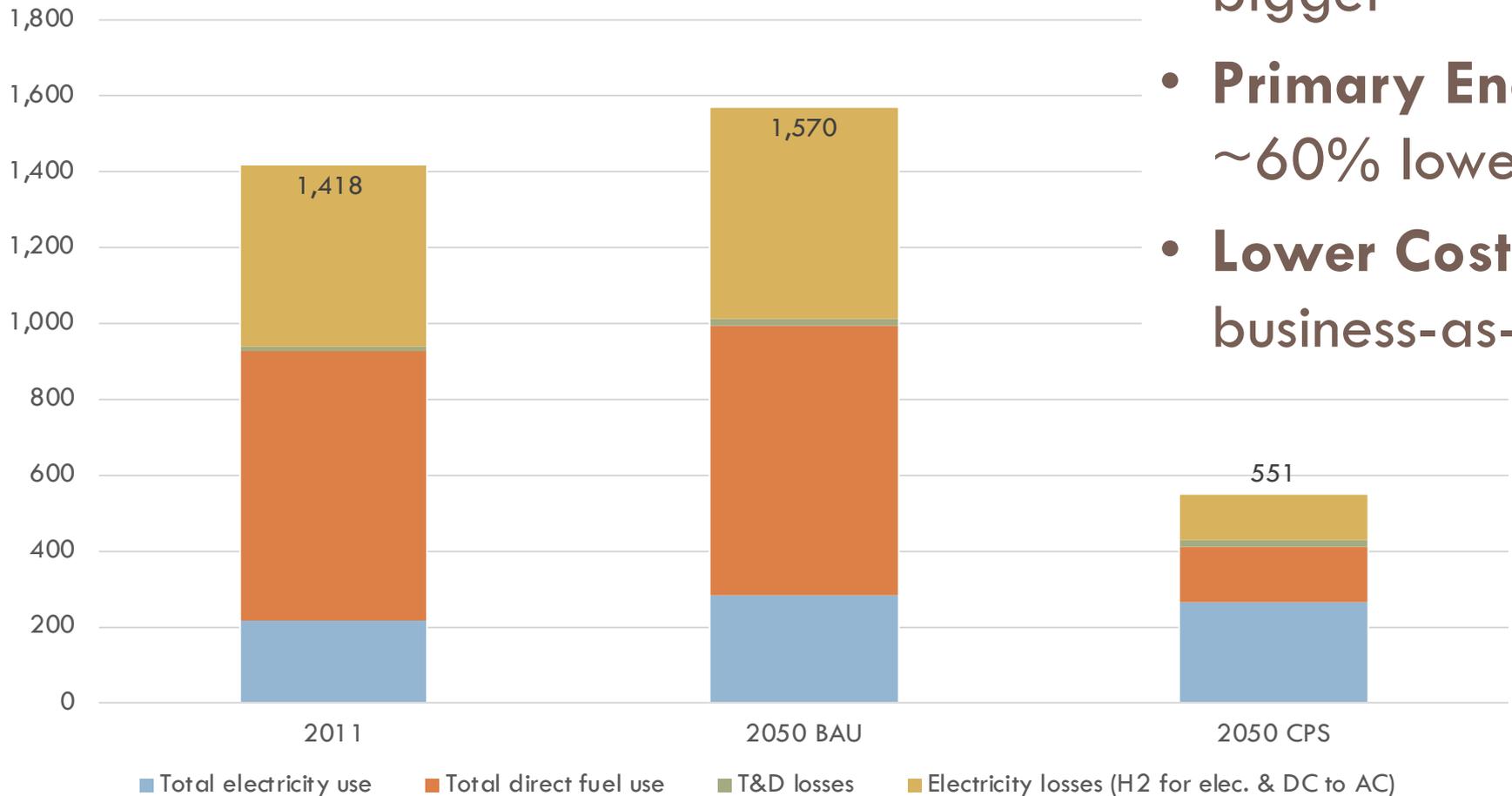
- Goal: 90% reduction in industrial petroleum use by 2050 relative to 2011
- Goal: 50% reduction in natural gas use by 2050 relative to 2011
- Renewable hydrogen, made with wind and solar, can be used in place of much oil and natural gas both as fuel and feedstock.
- HFC (refrigerants) and SF₆ (electrical equipment):
 - ▣ Adopt the EU target of a two-thirds reduction of fluorinated gases by 2030 relative to a 2014 baseline.
 - ▣ Phase-out fluorinated gases completely by 2050.

Carbon Sinks

- Used MDE inventory as the basis – nearly 12 million metric tons per year of “sinks” – meaning net sequestration of carbon in various ways, including in soil, forests, urban trees.
- Add one million tons to this per decade – regenerative agriculture, forestry, buildings. This gives 15 million metric tons, rounded, in sinks in 2050.
- These numbers, including MDE’s inventory numbers for sinks, need further detailed analysis.

Total primary energy requirements. Requirements in the year 2050 include electrification of transportation and buildings. Much lower energy use while economy grows. See Notes 1 and 2

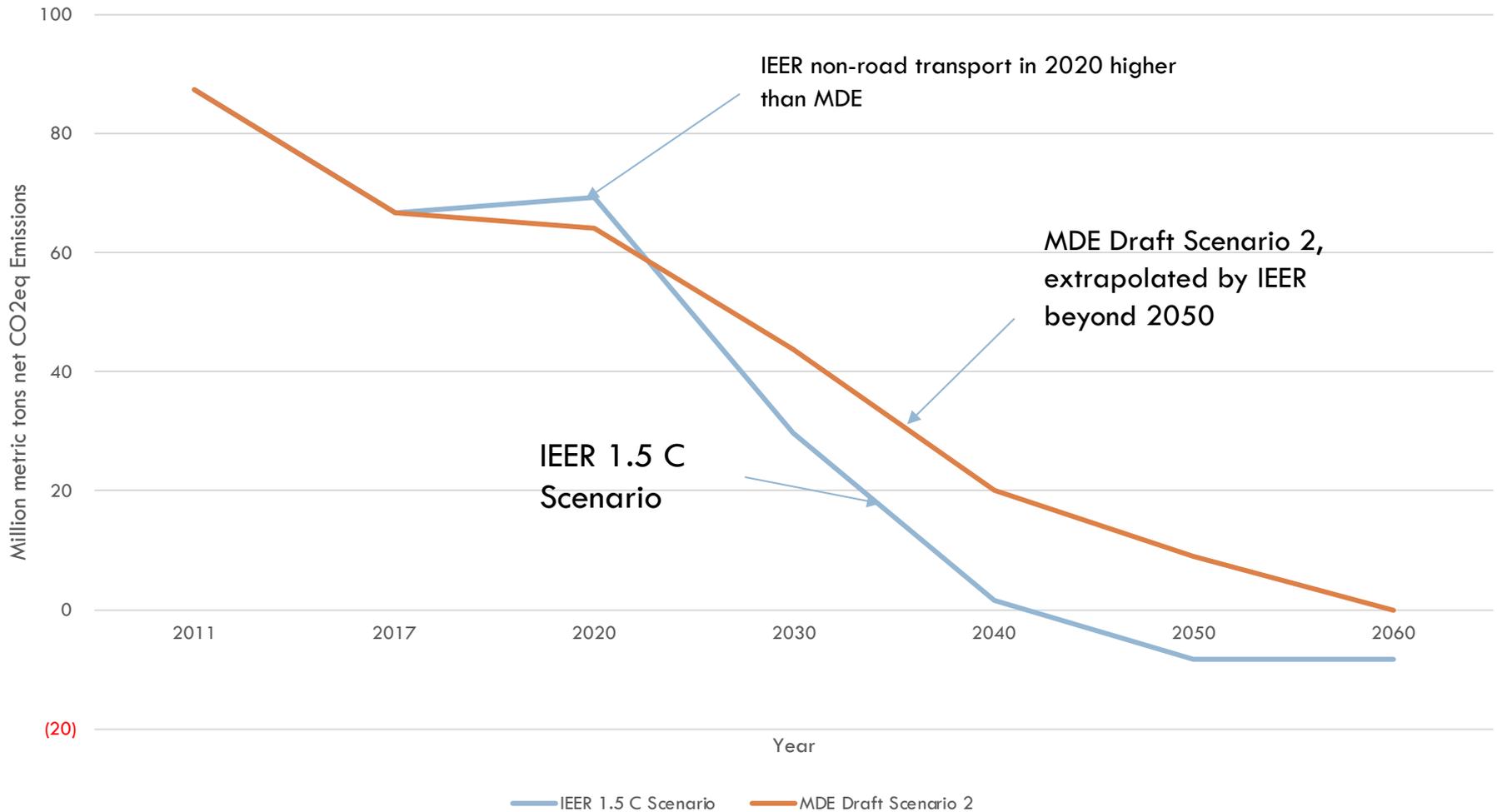
Total primary energy input, trillion Btu



- **Economy ~2x bigger**
- **Primary Energy ~60% lower**
- **Lower Cost than business-as-usual**

IEER 1.5 C Scenario and MDE Draft Scenario 2. Methane 100-y GWP for comparability

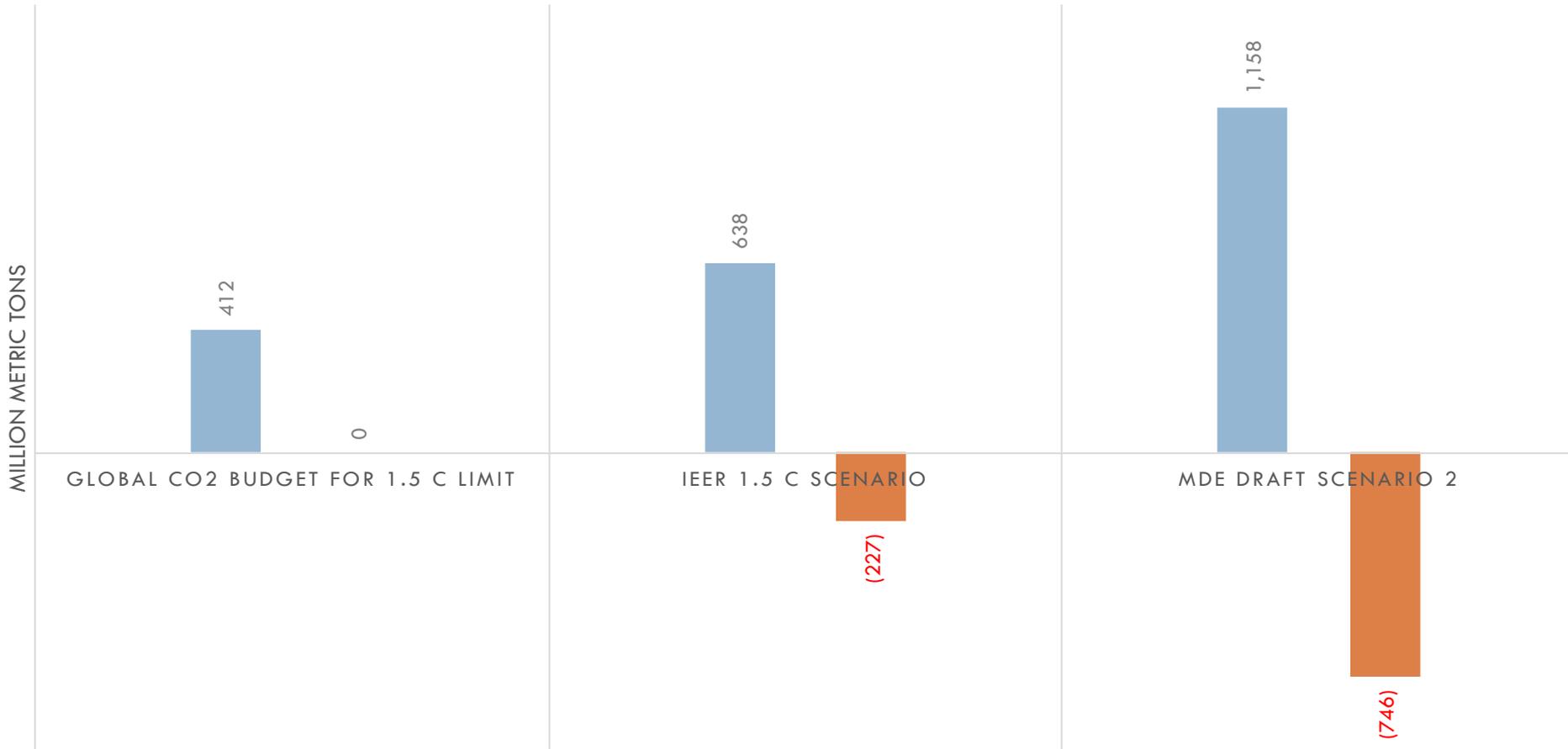
IEER 1.5 C Scenario and MDE Draft Scenario 2



Cumulative net CO₂eq emissions to 2060. Negative emissions needed from 2060 to 2100. Annual sinks in addition to the net CO₂eq: IEER: 6 million metric tons/year. MDE: 19 million metric tons/year

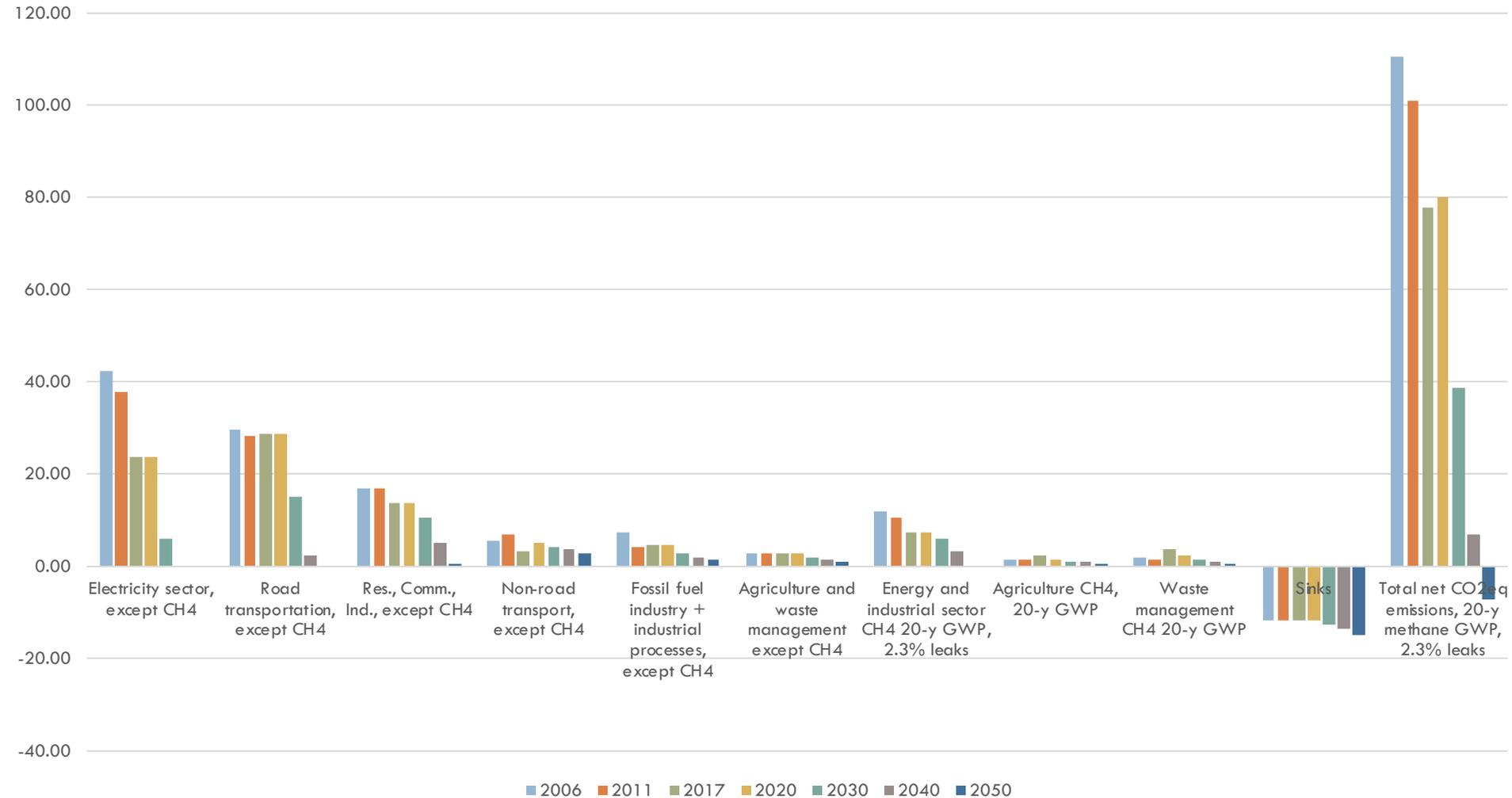
CARBON BUDGETS TO CONFORM TO THE GLOBAL 1.5 C LIMIT OF 500 GIGATONS CO₂, CALCULATED ON A PER PERSON BASIS

■ Cumulative emissions to 2060 ■ Cumulative negative emissions needed 2060 to 2100



Sectoral details for Maryland IEER 1.5 C scenario

Sector totals of source and sinks and overall GHG emissions, 20-y methane GWP



Cost Summary: The Year 2050

BAU = Business-as-usual; CPS = Climate Protection Scenario: From Prosperous Renewable Maryland. “High” assumes higher costs and “low” assumes lower costs than the “reference” CPS scenario

	2011	2050 Business as Usual	2050 Climate Protection Scenario
Electricity generation (all uses, including transportation), T&D, storage, and smart grid (Note 1)	\$8,300	\$15,000	\$15,400
Energy efficiency and demand response relative to BAU (includes HVAC conversions from fossil fuels to electricity) (Note 2)	\$0	\$0	\$7,100
RCI direct fuel use (includes industrial H ₂ in Climate Protection Scenario) (Note 3)	\$3,200	\$5,400	\$1,400
Transportation direct fuel use and electric transport infrastructure (for CPS) (Note 4)	\$11,800	\$12,800	\$2,800
Road maintenance revenue to replace BAU transportation fuel taxes (Note 5)	\$0	\$0	\$500
Affordable Energy Program and Community and Worker Protection Fund (Note 6)	\$0	\$0	\$400
Total	\$23,300	\$33,200	\$27,700

Avoiding stranded assets

- Cumulative capital investments of a fossil fuel/nuclear dominated future are of the same order of magnitude as a renewable energy future – in the \$150 billion to \$200 billion range.
- Investing heavily in both guarantees billions of dollars of stranded assets.
- Savings in a renewable energy future come from two areas – much higher efficiency and zero fuel cost for electricity

Conclusion: A ban on new fossil fuel investments is essential not only for a low emissions future but also for avoiding stranded assets and unnecessarily high energy costs for Maryland households, businesses, and industry. Such higher energy costs will reduce job growth in the state.

Just and Equitable Transition

Low-income households

- Limit bills to 6% of gross household income as is done in New Jersey
- Provide practical and equitable access to rooftop and community solar and to energy efficiency investments including for renters.

Communities

- Ensure communities have equivalent revenue streams after fossil and nuclear plants close – but make sure they do before the plants close
- Proactively invest to create good jobs in the rural communities where fossil fuel and nuclear plants are located

Examples of options for good union jobs:

- Renewable hydrogen production and fuel cell peaking plants potentially at current power plant locations
- Offshore-related supply chain. Efficiency-related manufacturing – e.g., advanced heat pumps

Additional Critical Concepts – Not Quantified in IEER 1.5 C Scenario

- **Public transit as a public utility: affordable, dense, frequent, emissions-free.** Detailed study needed. Also connected to housing and zoning. Need to reduce vehicle miles.
- **Long distance transport revolution**– electric hydrogen aircraft, electrified rail.
- **Buildings as centers of carbon sequestration.** For example hemp-based building materials, bamboo grown regeneratively.
- **A circular materials economy:** e.g., recycle batteries and metals; recover lime from building rubble; supply industrial materials from regenerative agriculture; materials efficiency.
- **Make a complete transition to regenerative agriculture** with support for farmers to de-risk the transition.

Resources. First five are from the Renewable Maryland Project

- [Renewable Maryland Project webpage](#) with links to many publications
- [Prosperous, Renewable Maryland](#)
- [Beyond a Band-Aid](#) – Just transition paper – with Labor Network for Sustainability
- [Energy justice](#) in Maryland – equity and affordability book and [infographic](#)
- [IEER 2015](#) report on conversion of buildings from fossil fuels to efficient electric systems
- [IEER/PSE Healthy Energy 2017](#) New Jersey renewable energy roadmap, including comparison of nuclear subsidies with renewable energy costs
- IPCC 2018 [Summary for Policymakers](#) and URL from which [other chapters can be downloaded](#)
- [IPCC 2014](#), URL from which all chapters can be accessed
- United Nations Framework Convention on Climate Change, 1992: [UNFCCC text](#)
- Maryland's [2016 Greenhouse Gas Reduction Act](#)
- Maryland Greenhouse Gas Inventories for various years are on the [MDE GHG inventory webpage](#).
- Sept. 17, 2019 presentation at the MDE Mitigation Work Group meeting by [C2ES and the Clean Air Task Force](#)

STOP PRESENTATION HERE

SUPPLEMENTAL SLIDES FOLLOW

GETTING TO 100 PERCENT

How it all works

Today's Energy System

- Generally Reliable - but Lack of Choices
- Unaffordable for many
- Inflexible, Inefficient. Polluting. Not very resilient
- Difficult for democratic control; frequent conflicts over petroleum

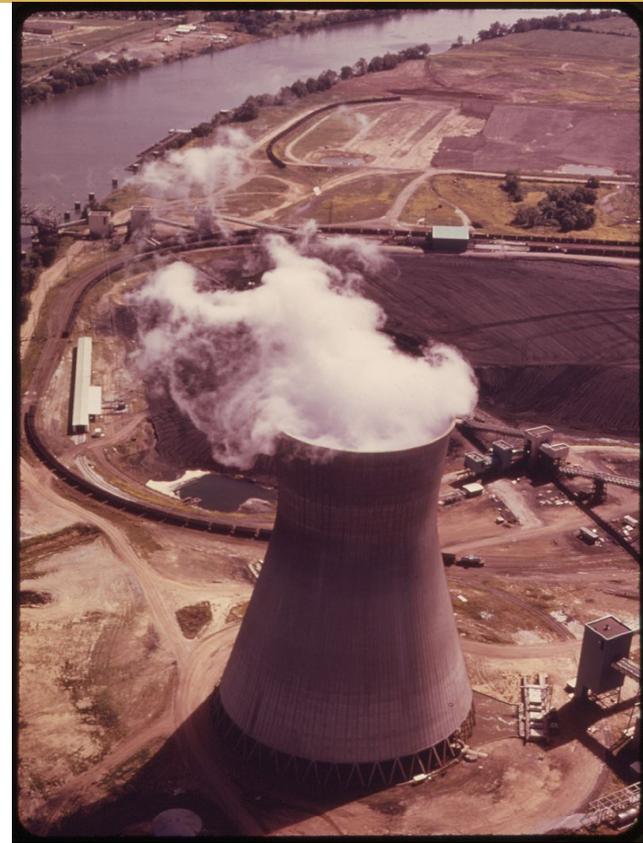


Electricity generation: Only ~30% of primary energy reaches the home or business

**Cattenhom nuclear power plant,
France**



**John Amos coal-fired plant, West
Virginia**



Inefficiency: Example 2

Incandescent bulb



LED bulb



Incandescent bulb: $\sim 3\%$ of electricity converted to visible light.
LED: $\sim 20\%$.

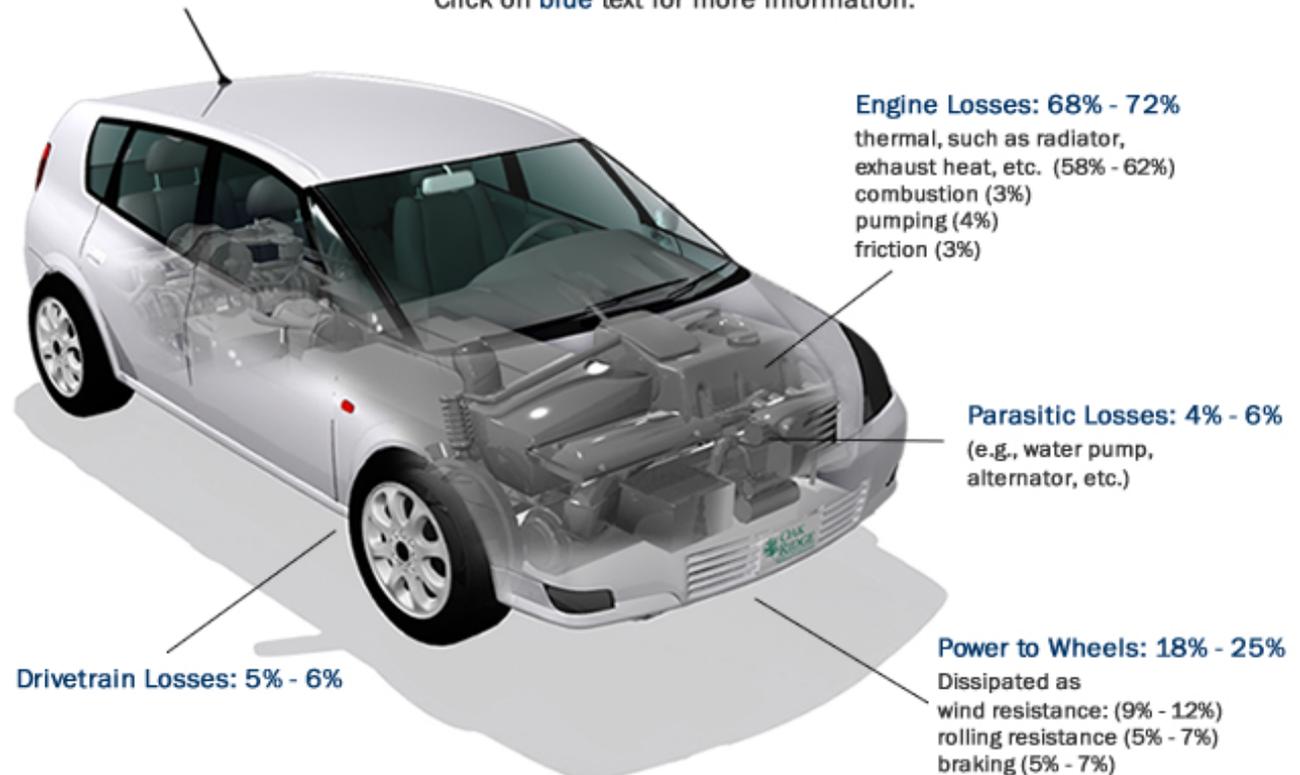
Inefficiency, example 3. Automobiles with internal combustion engines

Typical gasoline vehicle: 75 to 82 percent waste

(not including oil production, pipeline, and refining losses)

Energy Requirements for Combined City/Highway Driving

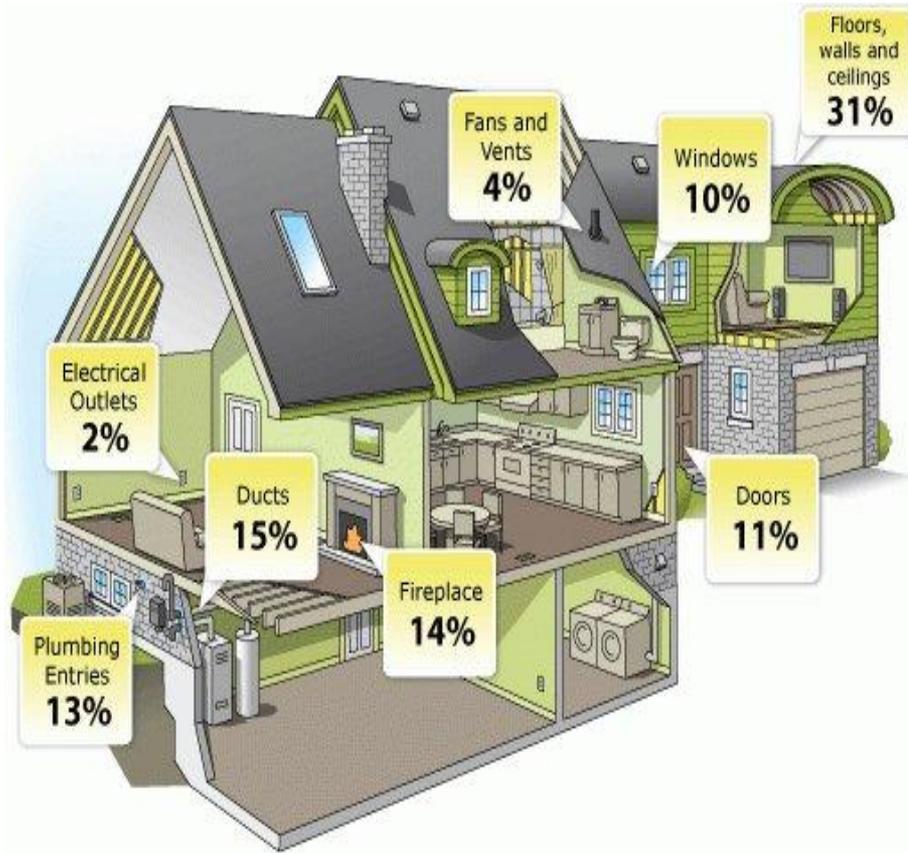
Click on blue text for more information.



Idle Losses: 3%

In this figure, they are accounted for as part of the engine and parasitic losses.

Inefficiency, example 4: Leaky homes waste fuel



Maryland's Renewable Energy Sources



Maryland has at least 10x more solar and wind resources than needed for meeting the state's energy requirements, including conversion of fossil fuel use transportation and buildings to electricity

Present and Future Grid

Present: One-way communication

- Flip switch - turn power on and off.

Future smart grid: Two-way communication.

- Consumer has real time information about system.
- Appliances are smart and responsive

Consumers can be producers.

Grid operated for reliability and resilience

- Adapt to variable energy supply

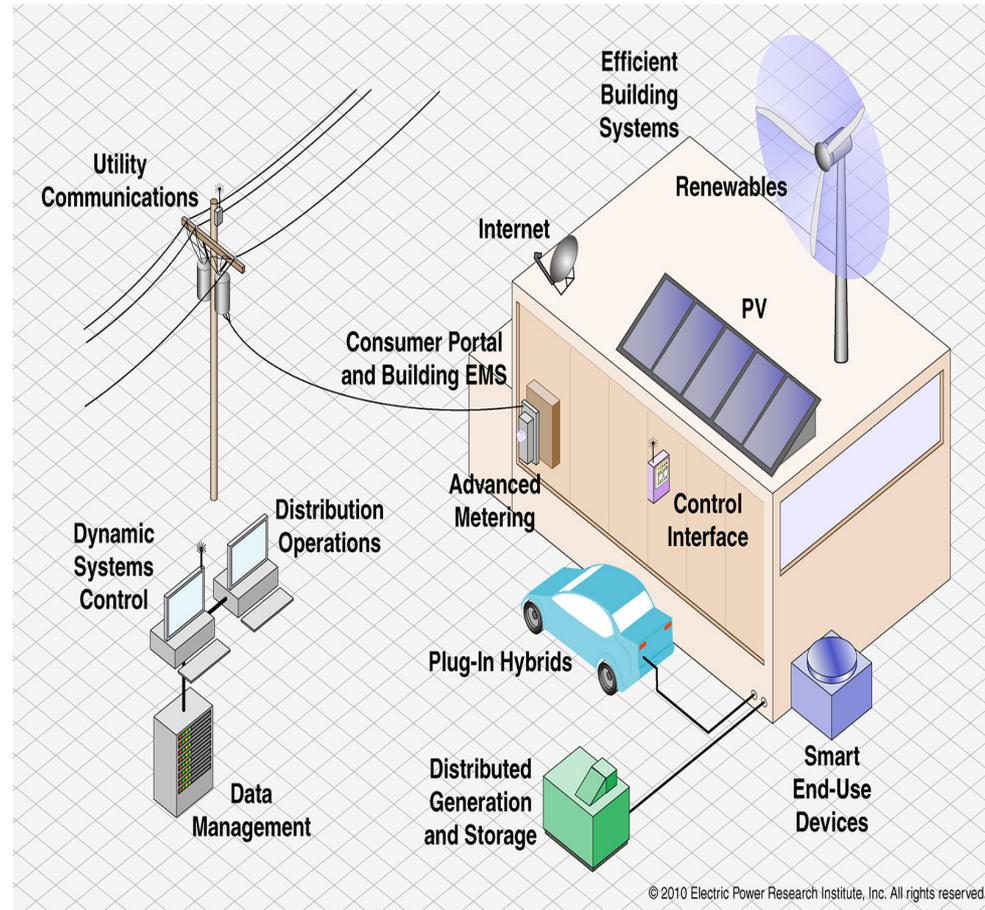


All of the information in all consumer on-off switches in the United States can be put on one \$15 USB flash drive

Grid-of-the-Future

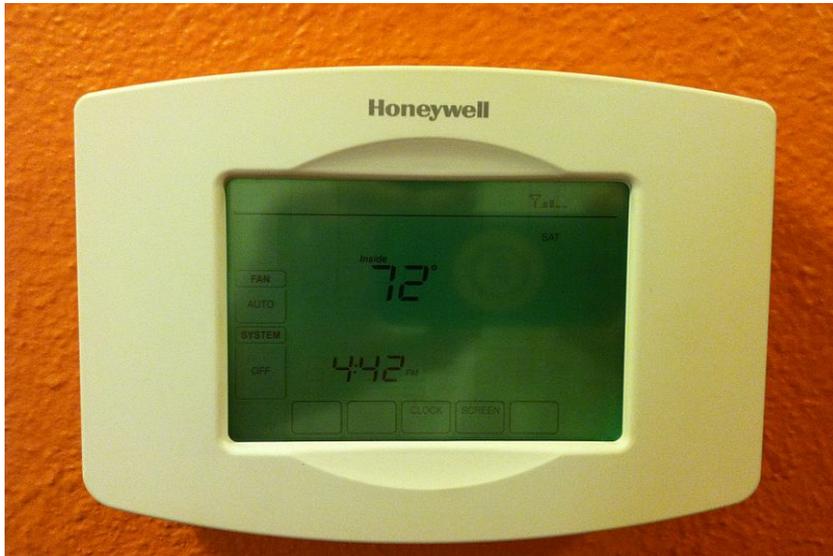
Renewable, Resilient, Democratized

- Solar and wind mainstays of energy system
- Increase efficiency
- Storage, combined heat and power, microgrids
- Demand response
- Control consumption to minimize bills
- Electrified transportation and HVAC
- Provide services to the grid, including via V2G and local storage ownership

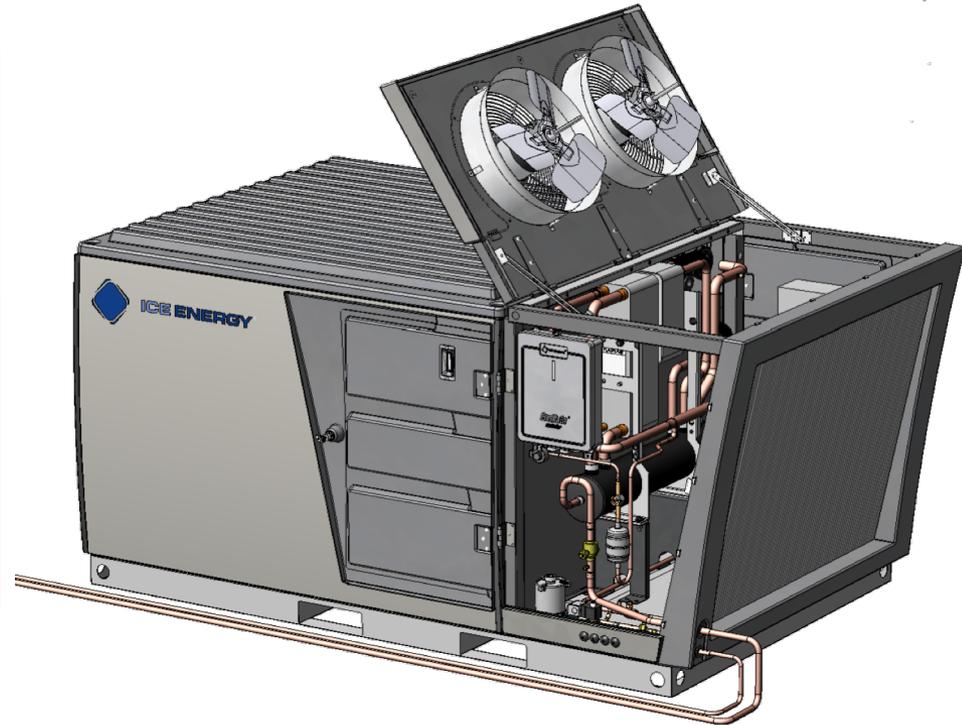


Demand Response Examples

Smart thermostat



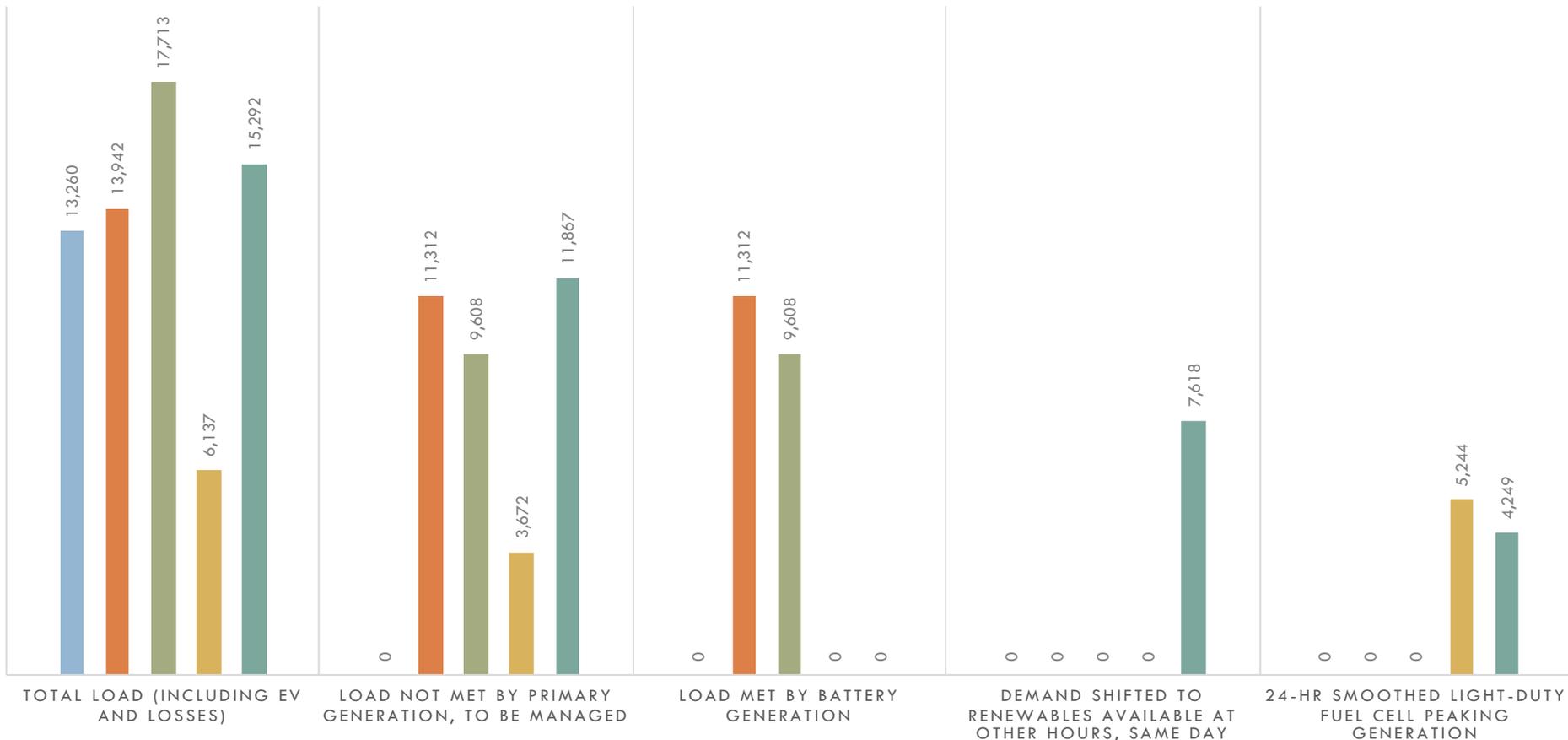
Storing coldness



Meeting load fully and reliably with fully renewable electricity sector without nuclear
 Five example hours: Load met by primary generation only – one example,
 + storage, two examples, + aggregated demand response, renewable hydrogen peaking, two
 examples. See notes for details

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Reliability & Resilience

Reliability

- ❑ Loss of power less frequent than today
- ❑ Demand response and smart grid (including smart appliances)
- ❑ Storage
- ❑ Peaking generation (with renewable hydrogen)

Resilience:

- ❑ Essential services maintained through outages
- ❑ Quick recovery
- ❑ Distributed renewable generation (solar, fuel cells with renewable hydrogen)
- ❑ Distributed storage (electrical)
- ❑ Microgrids
- ❑ Future: storing heat and cold seasonally for space heating and cooling, including as part of microgrids.

Co-benefits of clean, renewable energy

- Very low water use
- No wastes from fuel production (unlike coal, natural gas, and nuclear)
- No mining for fuel
- Essentially no outdoor air pollution due to energy use or transportation
- Greatly reduced indoor air pollution
- Significant health and economic benefits
- More jobs in Maryland since money not going out of state to buy fossil fuels

Future Grid Needs

- A communications structure to parallel power system
- Smart appliances with automatic response to grid status and prices
- Access to aggregators for demand response
- Access to real-time understandable information and the choice to deal with demand response automatically or manually, according to changing personal circumstances
- Access to financing or other purchase options

**High energy
burdens**

=

**Ill-health and
homelessness**



IMPOSSIBLE CHOICES: RENT, MEDICINE OR HEAT

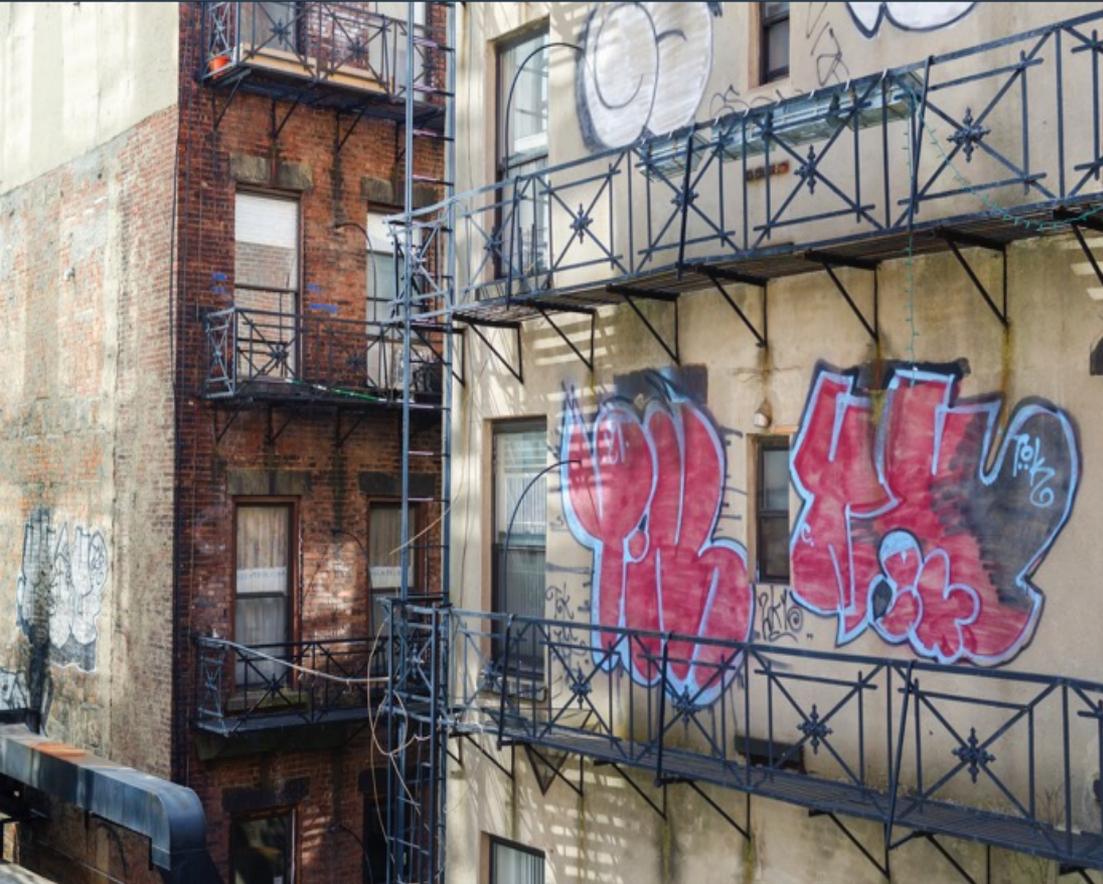


**High public
shelter costs**



**High health
costs**

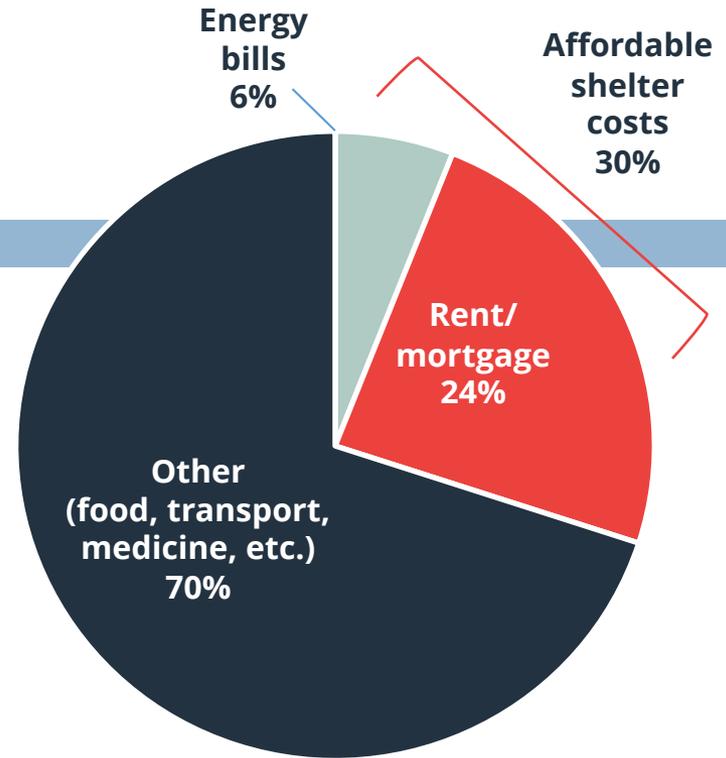
Renter-landlord issues



Renters often trapped in low efficiency homes

Solutions

- 1. Make bills affordable –
Maximum 6% of gross income for eligible households. Rest paid from assistance funds**
- 2. Enable ownership of solar energy – rooftop or community**
- 3. Fix landlord-renter power imbalances**



Glossary – Slide 1

- Aggregator: An entity that aggregates the electrical attributes of many sources or customers and offers them as a bundle to the grid. Examples: aggregating pre-heating of water, pre-cooling of homes, dishwashing or clothes washing time. Also aggregation of distributed storage, vehicles that are part of V2G. Done voluntarily and with compensation.
- BAU: Business-as-usual scenario
- CO₂eq or CO₂e: Carbon dioxide equivalent. The expression of the impact of a certain amount of a GHG in terms of its equivalent amount if it were CO₂. Depends in part on the time over which the equivalence is calculated.
- CPS: Climate Protection Scenario (by IEER)
- GHG: greenhouse gases: CO₂ – main one. Others: methane, N₂O, HFCs, SF₆, black carbon particulates, aka soot.
- GWP: Global warming potential. Heat trapping capacity of a GHG molecule relative to CO₂. CO₂ GWP = 1 by definition. Depends on the property of the molecule and how long it stays in the atmosphere. Short atmospheric lifetime means effect is intense but of short duration – and vice versa.
- HFCs: hydrofluorocarbons, used as refrigerants. Powerful greenhouse gases.

Glossary – Slide 2

- HVAC: heating, ventilation, and air-conditioning
- IPCC: Intergovernmental Panel on Climate Change, a large body charged with assessing climate impacts of human activities and approaches to mitigation and adaptation.
- MDE: Maryland Department of the Environment
- Methane: powerful GHG. Main constituent of natural gas;. Also emitted in the agricultural sector.
- N₂O: nitrous oxide – air pollutant and also emitted from farm fields
- RD research and development
- SF₆: sulfur hexafluoride, used as an insulating material in circuit breakers and other electrical equipment. Long-lived, powerful greenhouse gas.
- Sink: An absorber of a greenhouse gas, like soil or the oceans.
- Stranded assets: Assets like pipelines and fossil fuel power plants that could be used based on their physical condition but have no value in the marketplace, given prices and policies in effect.
- T&D: transmission and distribution
- UNFCCC: United Nations Framework Convention on Climate Change. Negotiations for protecting climate occur in the framework of this 1992 treaty, which recognizes the greater responsibility of wealthy countries. The United States
- V2G: Vehicle-to-Grid: This technology allows vehicle batteries to provide services to the grid in return for compensation
- VMT: vehicle miles travelled