



• August 15-18, 2010 • Dallas, Texas •
• Dallas Convention Center •



Kathleen Judd
Pacific Northwest
National
Laboratory

Roadmap to a Climate Neutral Federal Government by 2030

Purpose

FEMP's vision is for a climate neutral federal government by 2030

- **Purpose of Roadmap:** Explore scenarios in which the federal government could achieve climate neutrality through a combination of
 - Conservation
 - Efficiency
 - Renewable energy generation

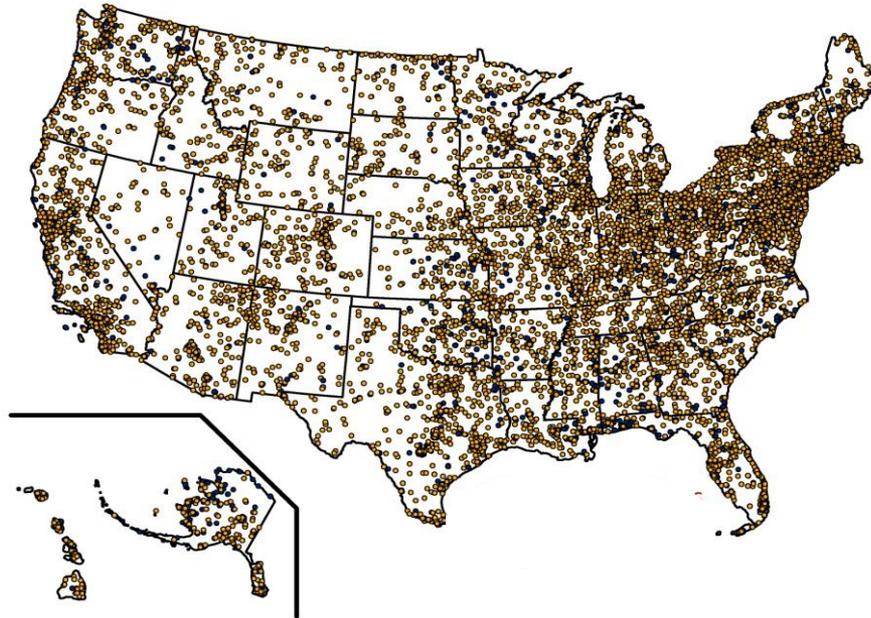


Boundaries and Key Assumptions

- Operational boundaries
 - Scope 1 – stationary and mobile combustion
 - Scope 2 – purchased elect/heat/steam
- Organizational boundaries
 - Domestic and international buildings
 - Domestic fleet vehicles (excludes non-fleet vehicles and equipment, primarily for tactical use)
- Assumes no growth in total federal building square feet or # of vehicles
- Abatement opportunities are technically feasible

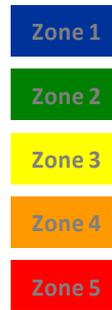
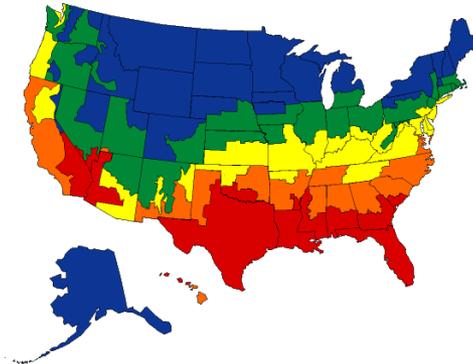
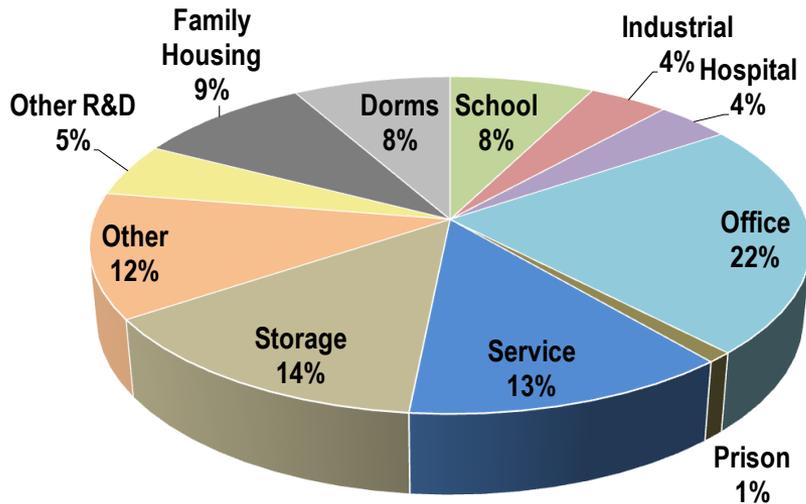
Roadmap Objective

- Develop Federal GHG emission reduction projections that account for the unique attributes of federal assets
 - Building location/climate zone
 - Building type (e.g. office, R&D, hospital, residential)
 - Vehicle type (e.g. light duty, heavy duty) and fuel use

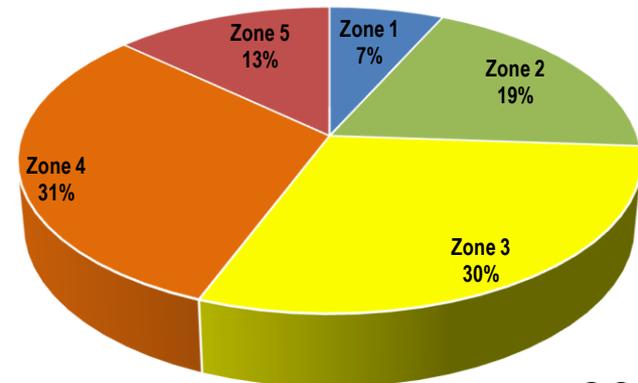


What we know about Federal Buildings

FY2008 Federal Predominant Use of Buildings by Square Footage

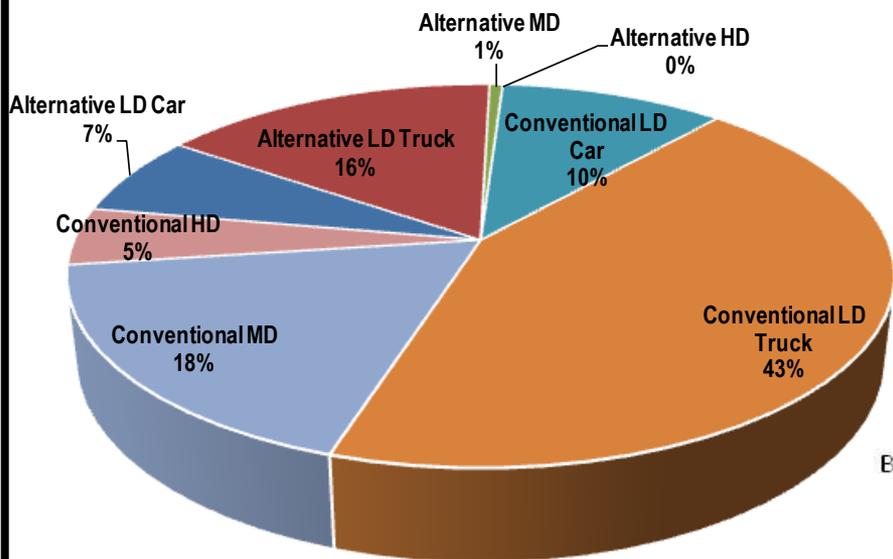


FY2008 Federal Predominant Square Footage of Buildings by Climate Zone

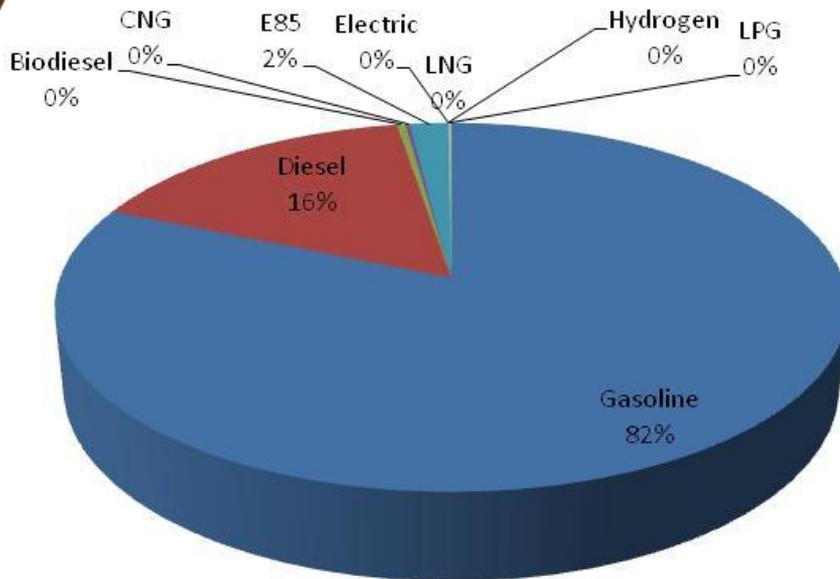


What we know about Federal Fleet Vehicles

2008 Federal Fleet Inventory

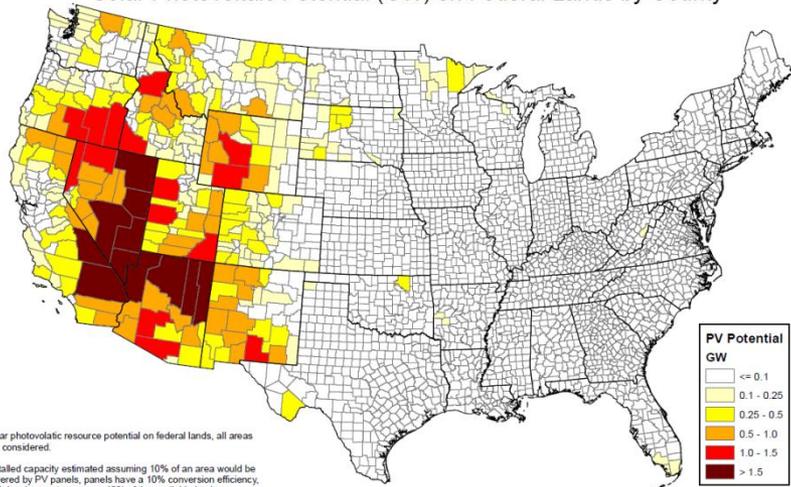


FY2008 Federal Fleet Fuel Consumption (GGE)



What we know about Renewable Power Potential on Federal Lands

Solar Photovoltaic Potential (GW) on Federal Lands by County



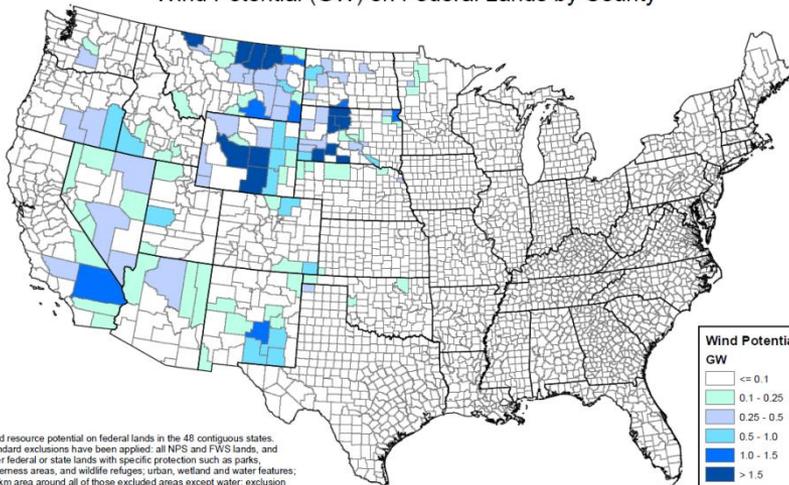
Solar photovoltaic resource potential on federal lands, all areas are considered.

Installed capacity estimated assuming 10% of an area would be covered by PV panels, panels have a 10% conversion efficiency, and development occurs on 10% of the available lands.



U.S. Department of Energy
National Renewable Energy Laboratory
Jan 30, 2009

Wind Potential (GW) on Federal Lands by County



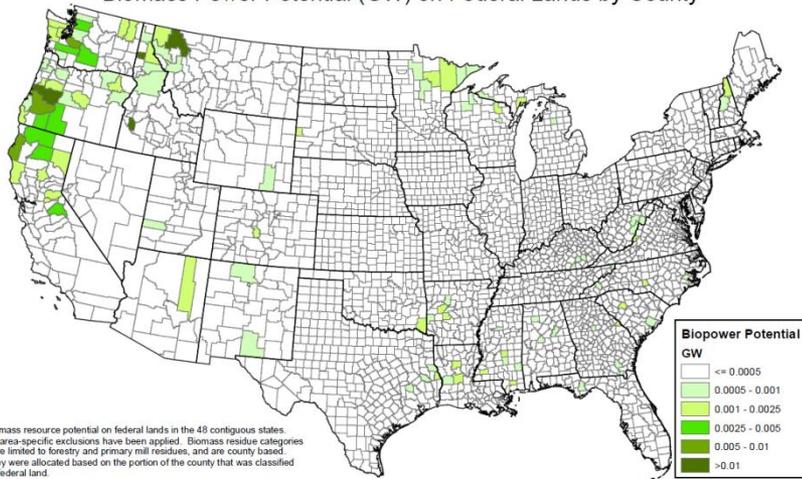
Wind resource potential on federal lands in the 48 contiguous states. Standard exclusions have been applied: all NPS and FWS lands, and other federal or state lands with specific protection such as parks, wilderness areas, and wildlife refuges; urban, wetland and water features; a 3 km area around all of those excluded areas except water; exclusion of 50% of the remaining USFS and DOD lands; exclusion of 50% of non-ridgecrest forested areas, and exclude areas with slope >20%.

Installed capacity estimated assuming 5 MW/km² on 10% of the available lands.



U.S. Department of Energy
National Renewable Energy Laboratory
Jan 30, 2009

Biomass Power Potential (GW) on Federal Lands by County



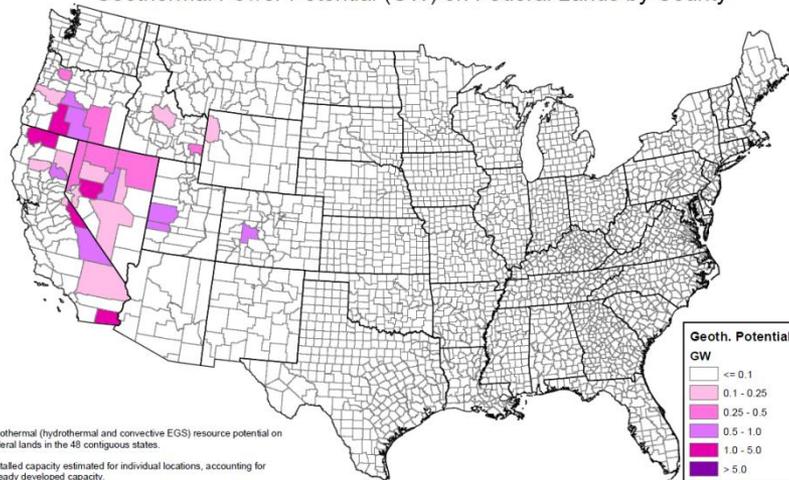
Biomass resource potential on federal lands in the 48 contiguous states. No area-specific exclusions have been applied. Biomass residue categories were limited to forestry and primary mill residues, and are county based. They were allocated based on the portion of the county that was classified as federal land.

Installed capacity estimated assuming 1 dry ton/hr/MW (20% efficiency industry average) on 10% of the available lands.



U.S. Department of Energy
National Renewable Energy Laboratory
Jan 30, 2009

Geothermal Power Potential (GW) on Federal Lands by County



Geothermal (hydrothermal and convective EGS) resource potential on federal lands in the 48 contiguous states.

Installed capacity estimated for individual locations, accounting for already developed capacity.

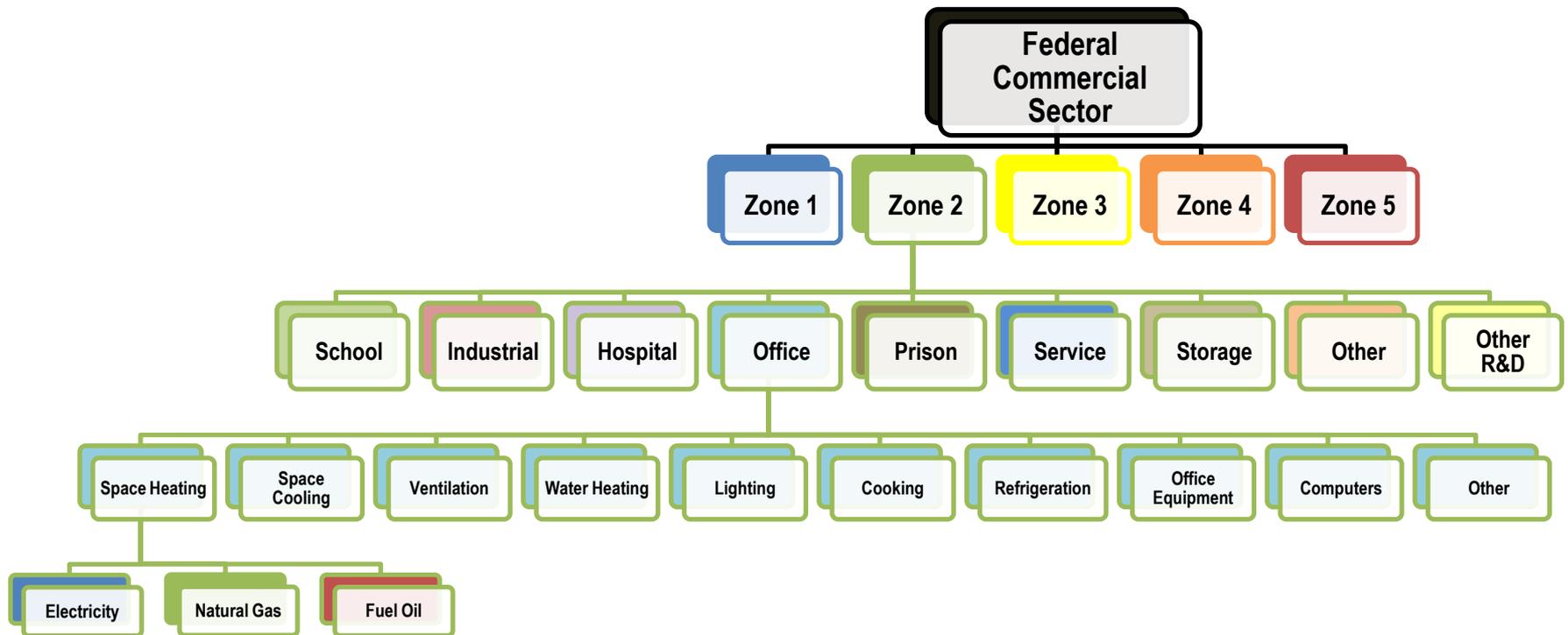


U.S. Department of Energy
National Renewable Energy Laboratory
Jan 30, 2009

Methodology: Overview

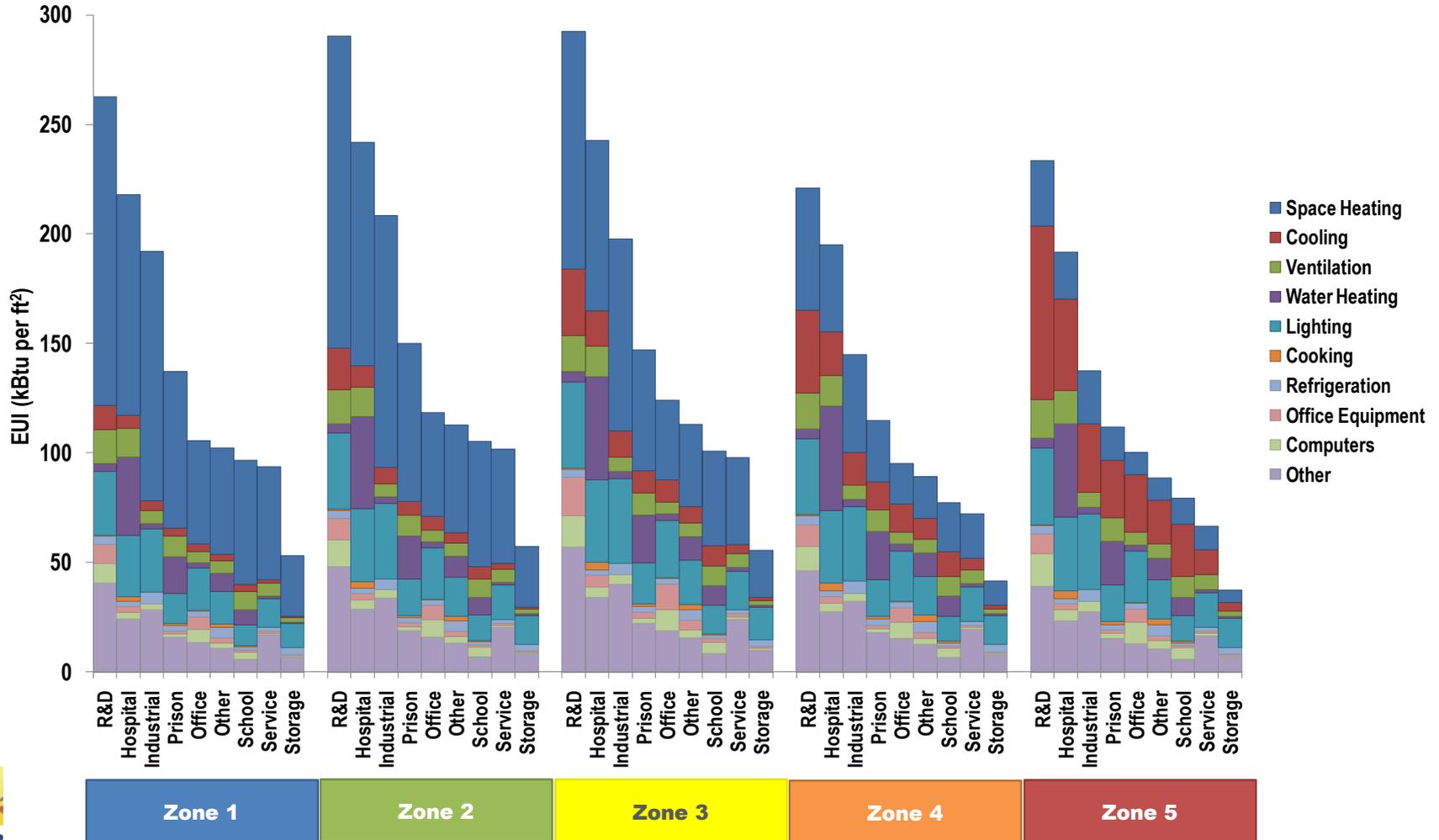
- **Meta-Analysis**
 - Assess available data for federal sector
 - Federal renewable energy potential
- **Model Selection and Development**
 - LEAP (Long-range Energy Alternatives Planning) software for building and vehicle scenario modeling
 - Developed Excel-based tool for assessing renewable energy potential on federal lands
- **2008 Baseline Development**
 - Estimated federal sector energy use intensities (EUIs) by climate zone, building type and end use (i.e. heating, cooling, lighting, etc)
 - Estimated vehicle emissions from federal vehicle inventory and reported fuel use
- **2030 Scenario Development**

Methodology: Buildings Structure in LEAP



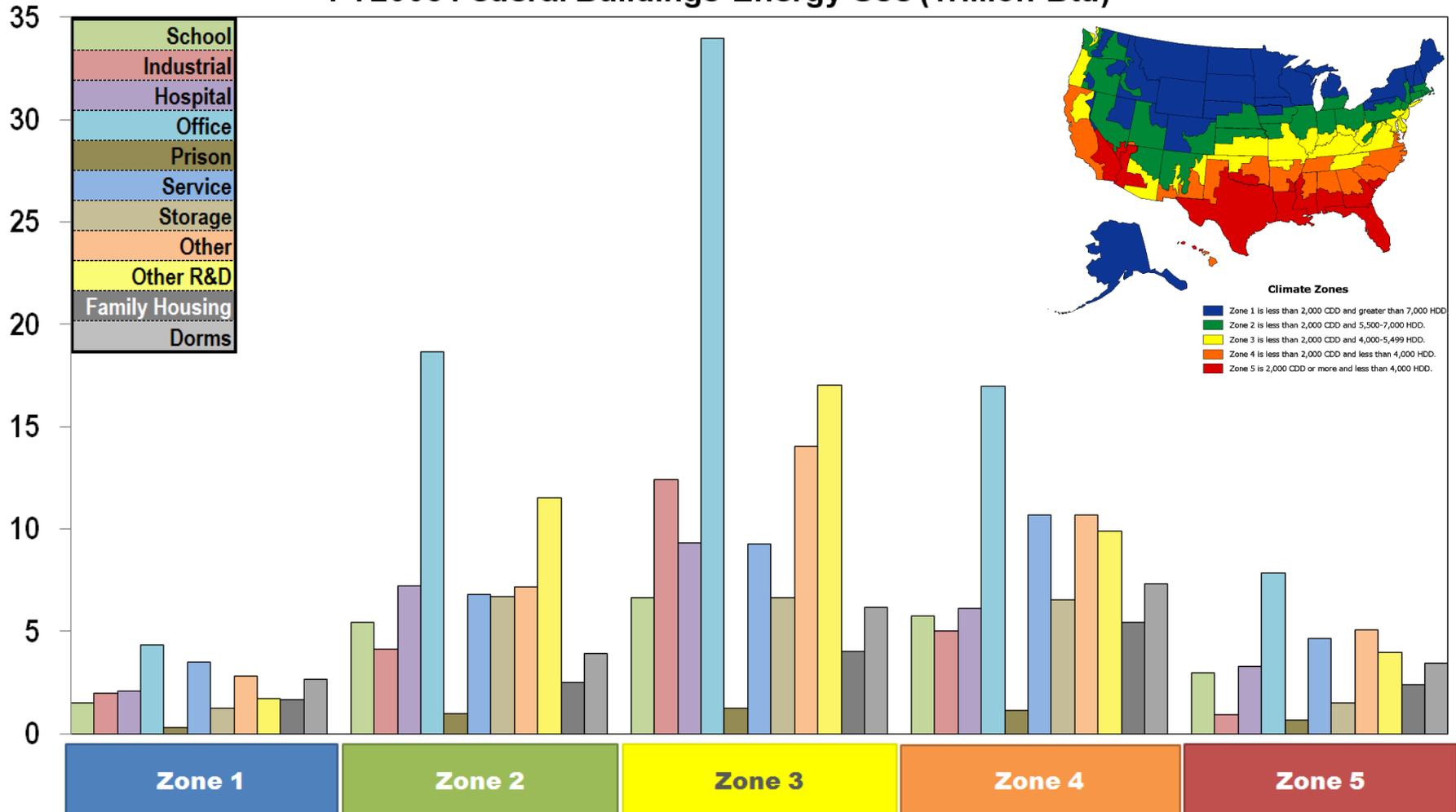
2008 Baseline Energy Intensities

Energy Intensities by Commercial Building Type, Climate Zone and End Use

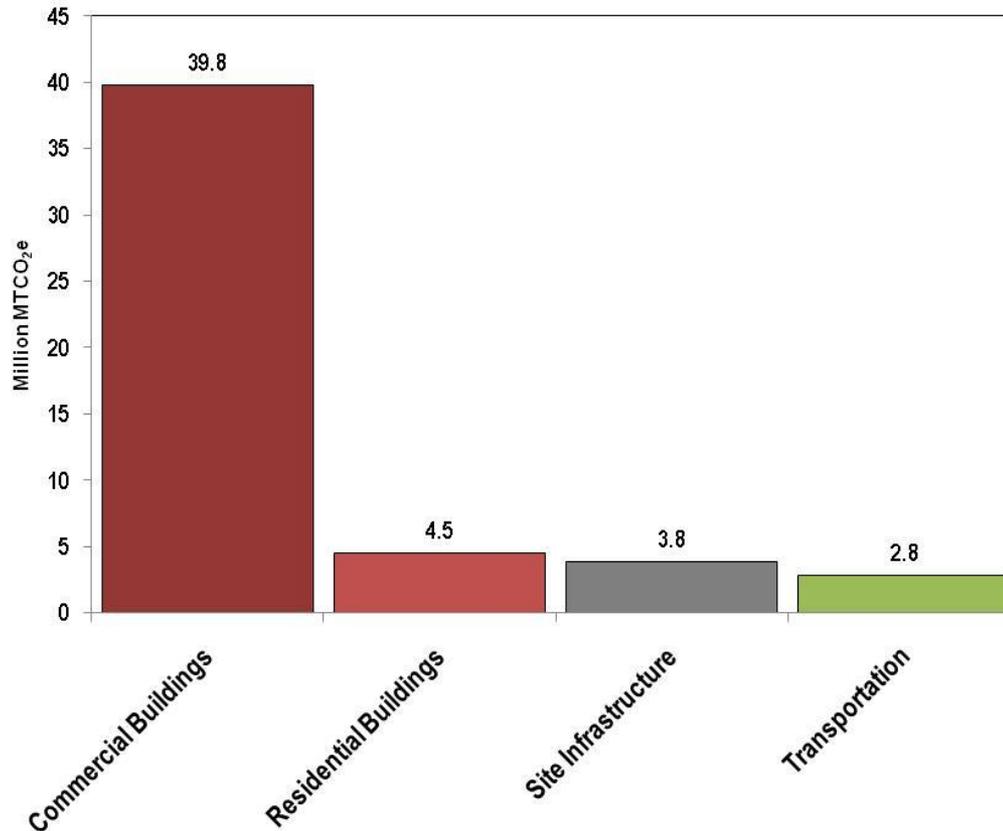


2008 Baseline Energy Consumption

FY2008 Federal Buildings Energy Use (Trillion Btu)



Federal Government Baseline Emissions By Sector

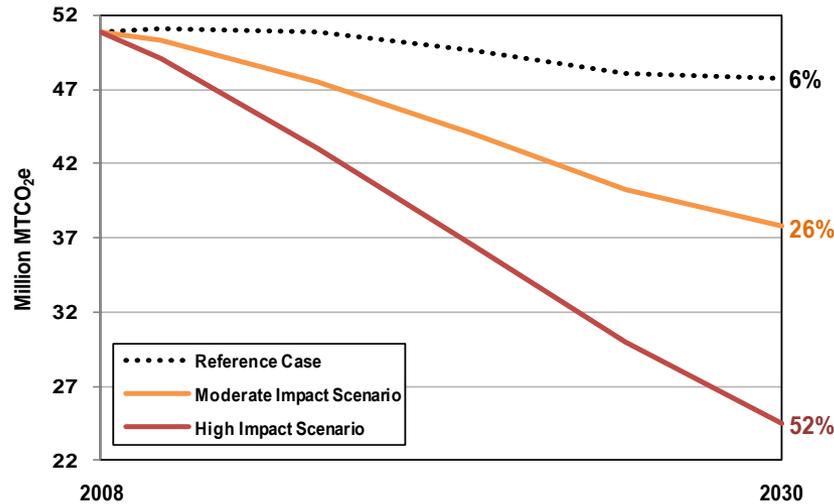


FY2008 FEDERAL GHG EMISSIONS
(EXCLUDES TACTICAL VEHICLES AND EQUIPMENT)

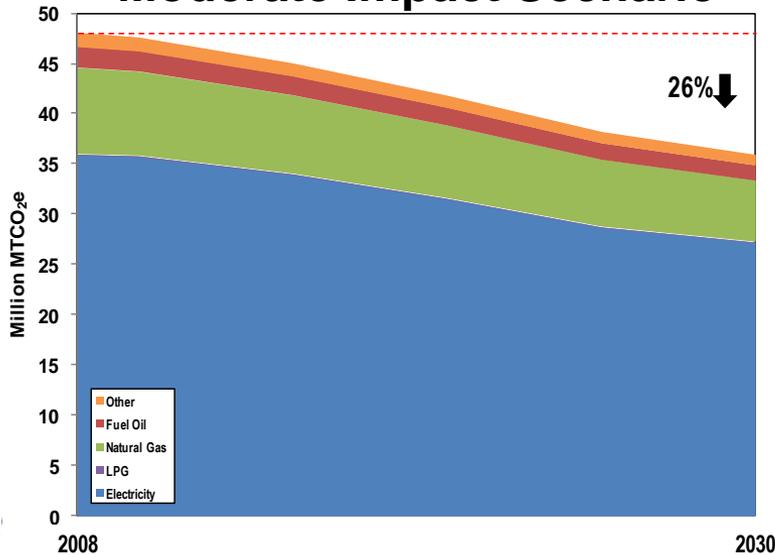
Methodology: Scenario Development

- **Reference Case**
 - Applied AEO projections for commercial and residential buildings and fleet vehicles
 - Current level of renewable energy production remains constant
- **Moderate Efficiency Impact – High Renewables**
 - Applied building energy savings projections from PNNL carbon abatement analysis for buildings
 - Applied new CAFE standards for vehicles
 - Renewable energy assessed to offset energy balance
- **High Efficiency Impact – Moderate Renewables**
 - Applied aggressive building energy savings with increased penetration levels
 - Applied additional EIA scenarios at higher deployment rate for vehicles
 - Renewable energy assessed to offset energy balance

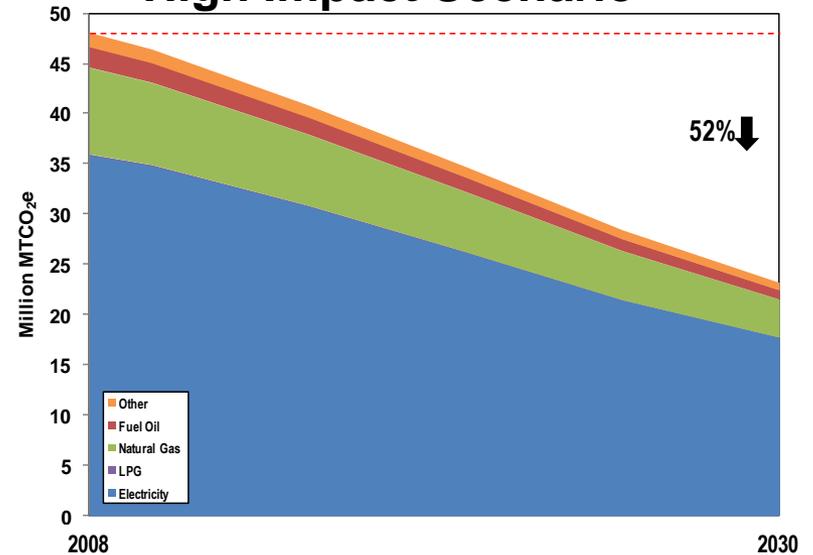
2030 Emissions Reductions by Scenario and Fuel Use



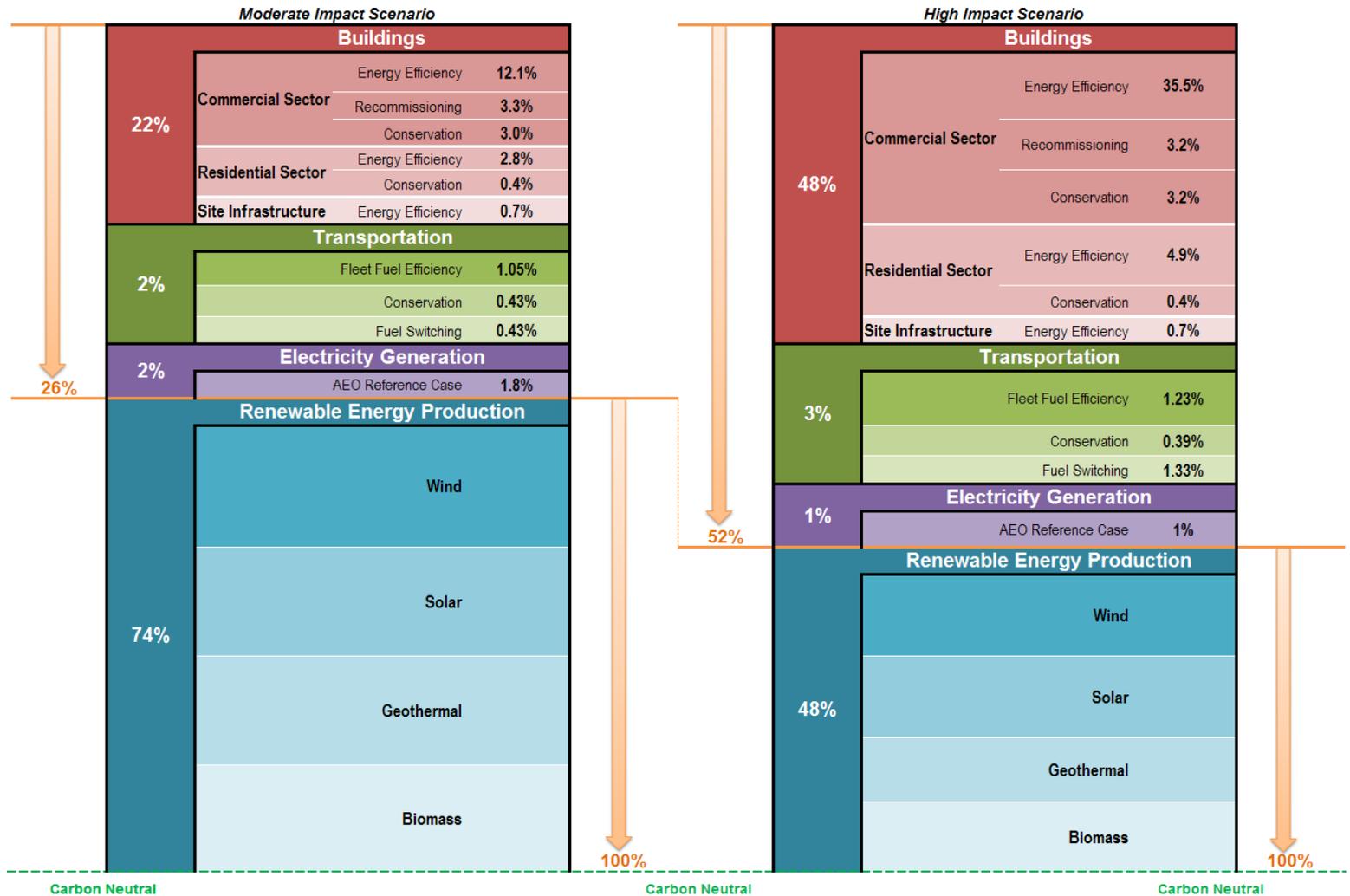
Moderate Impact Scenario



High Impact Scenario



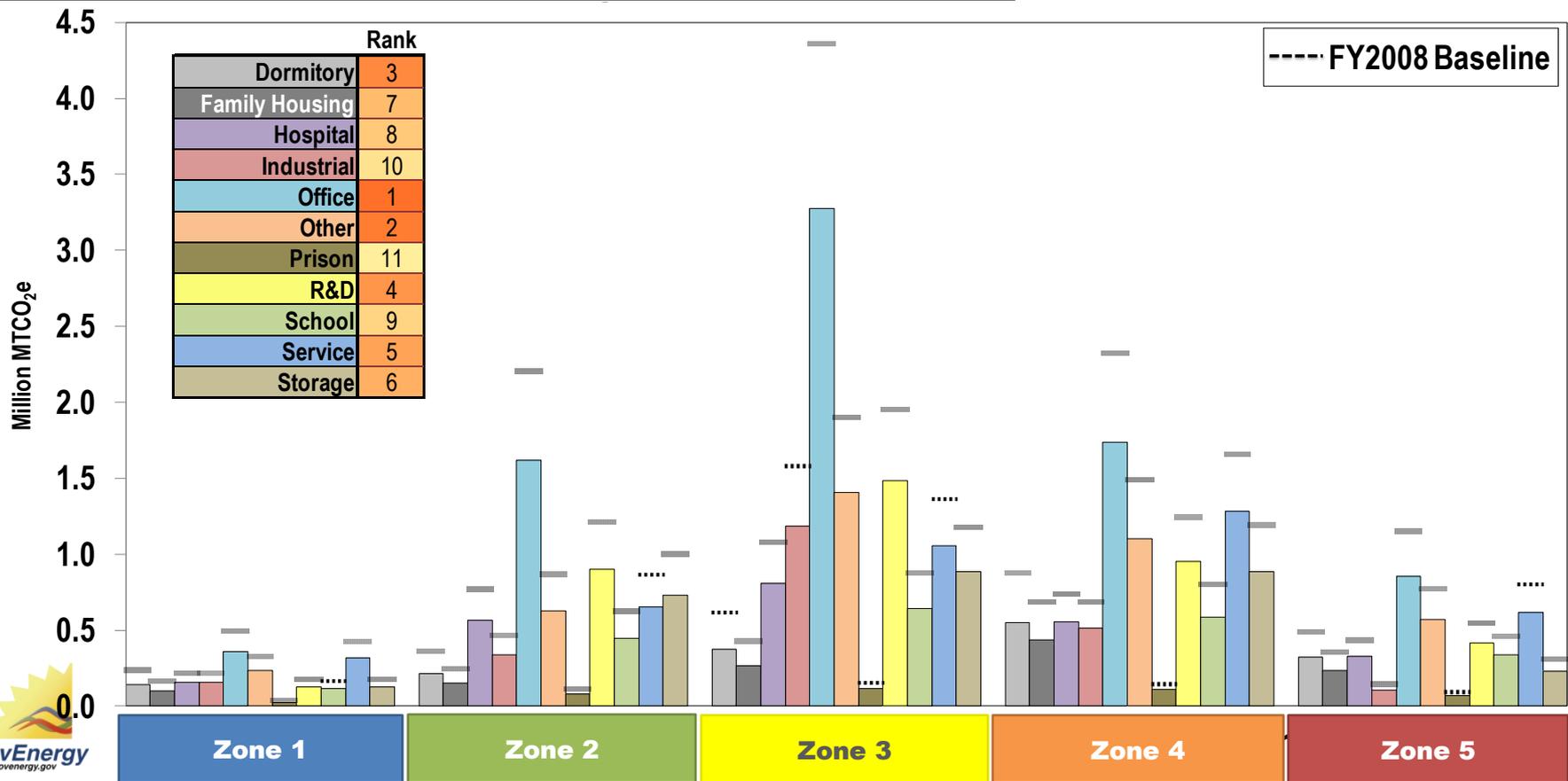
2030 Moderate and High Impact Scenarios – Emission Reductions by Sector



GHG Abatement Potential by Building Type and Climate Zone – Moderate Impact Scenario

Commercial Sector Scenarios	Lighting	Space Heating	Space Cooling	Ventilation	Office Equipment	Refrigeration	Water Heating	Computers	Cooking	Other
Moderate Impact	1	2	3	5	4	6	7	8	9	10

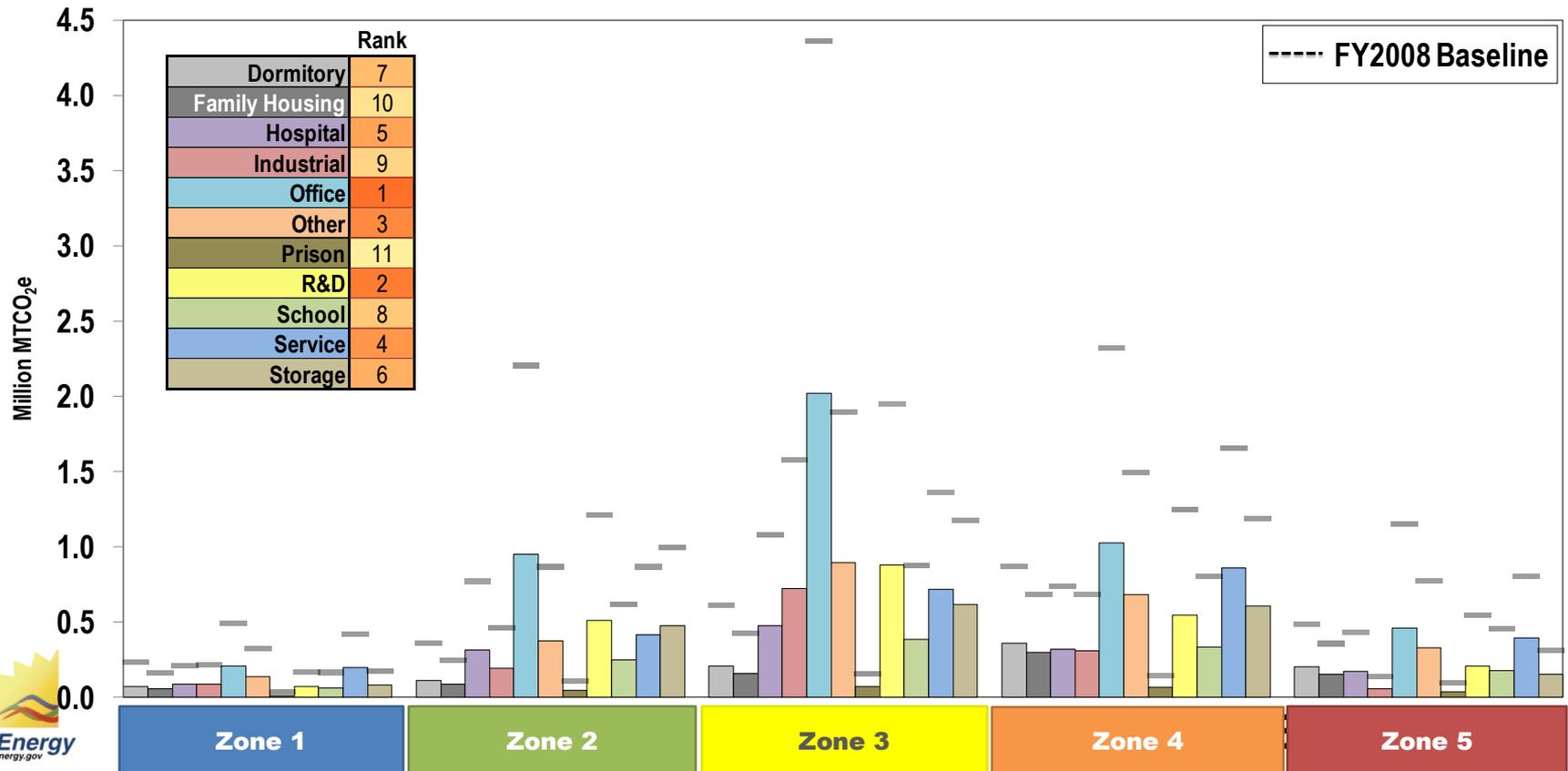
Residential Sector Scenarios	Heating	Lighting	Cooling	Water Heating	Other Appliances	Refrigeration
Moderate Impact	1	3	5	4	2	6



GHG Abatement Potential by Building Type and Climate Zone – High Impact Scenario

Commercial Sector Scenarios	Lighting	Space Heating	Space Cooling	Ventilation	Office Equipment	Refrigeration	Water Heating	Computers	Cooking	Other
High Impact	1	2	3	4	5	6	7	8	9	10

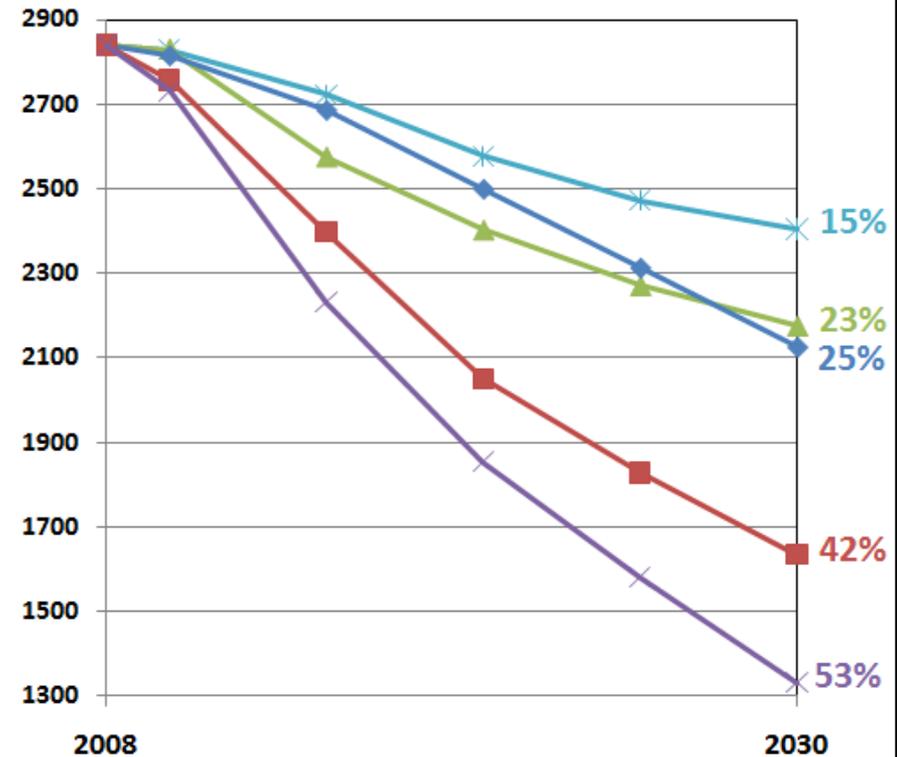
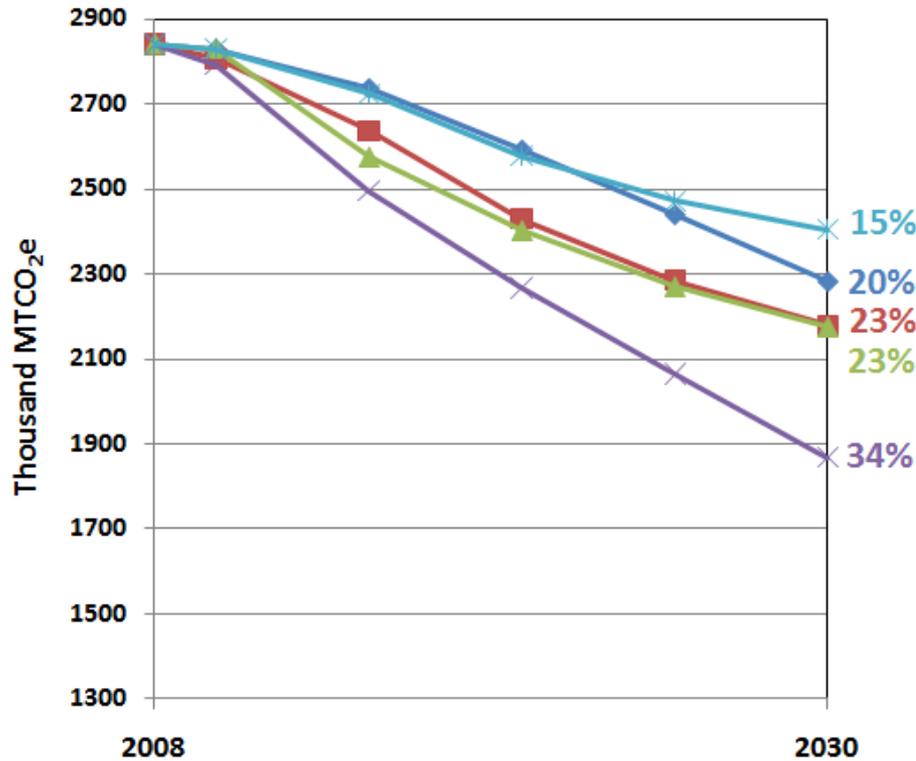
Residential Sector Scenarios	Heating	Lighting	Cooling	Water Heating	Other Appliances	Refrigeration
High Impact	1	2	3	4	5	6



Moderate and High Impact Fleet Scenarios

Moderate Impact Scenario

High Impact Scenario



Gross Renewable Energy Potential on Federal Lands

- If all lands with renewable energy potential were developed, the quantity would well exceed current energy consumption of the Federal Government.*

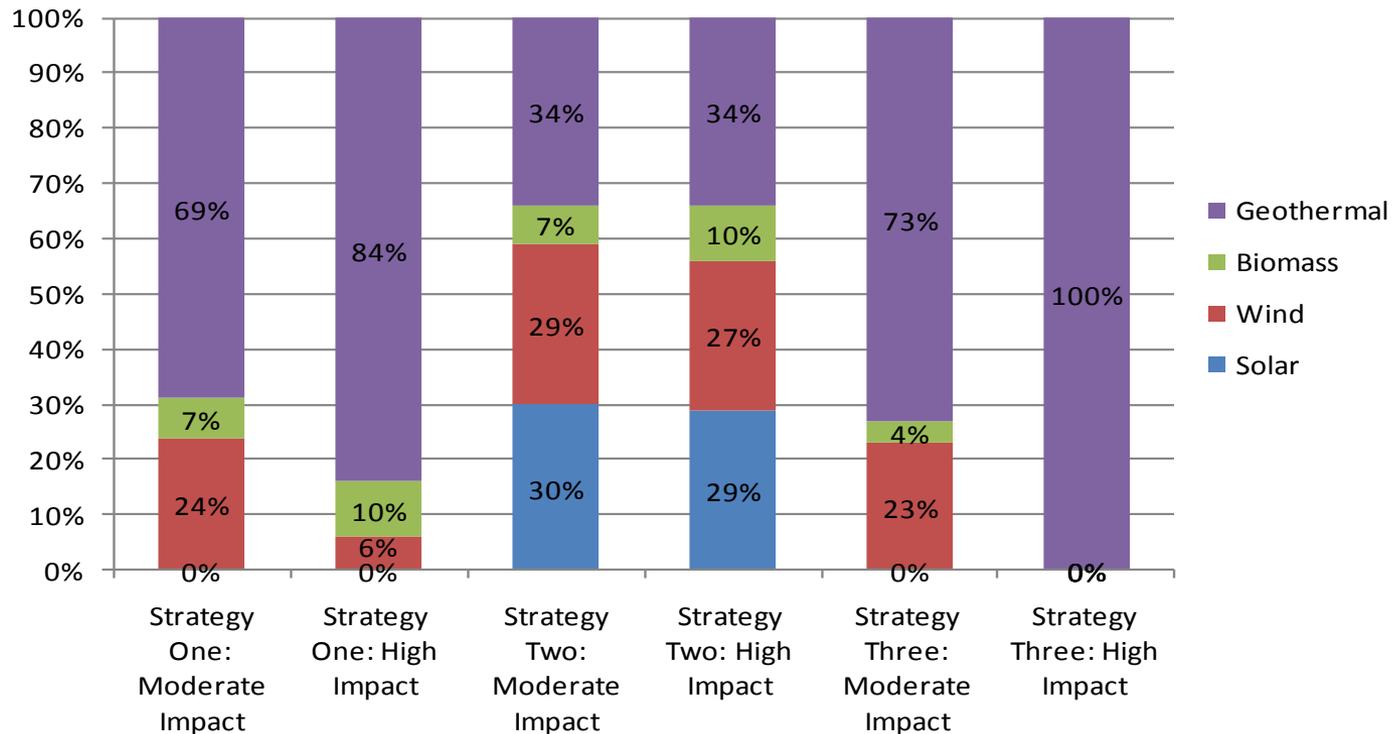
Resource	Installed Power Capacity (GW)	Energy Production (GWh)	Emissions Savings (Million MTCO ₂ e)
Solar PV	1,435	2,498,967	1,306
Wind	835	2,929,397	1,837
Biomass	3	19,984	10
Geothermal	21	164,987	74
Total	2,295	5,613,336	3,226

Development of Potential Scenarios for Renewable Energy Output on Federal Lands

- Renewable resources sorted by:
 - Resource quality (e.g., solar potential and wind speed)
 - Economic feasibility (i.e., simple payback)
 - Minimum plant size (for biomass and geothermal)
- Moderate and High Impact scenarios developed considering different factors:
 - Renewable system capital costs (\$/kW)
 - Investment incentives (\$/kW)
 - Production incentives (\$/kWh)
 - Fuel costs (\$/kWh, biomass only)
 - Proportion of filtered lands to be developed

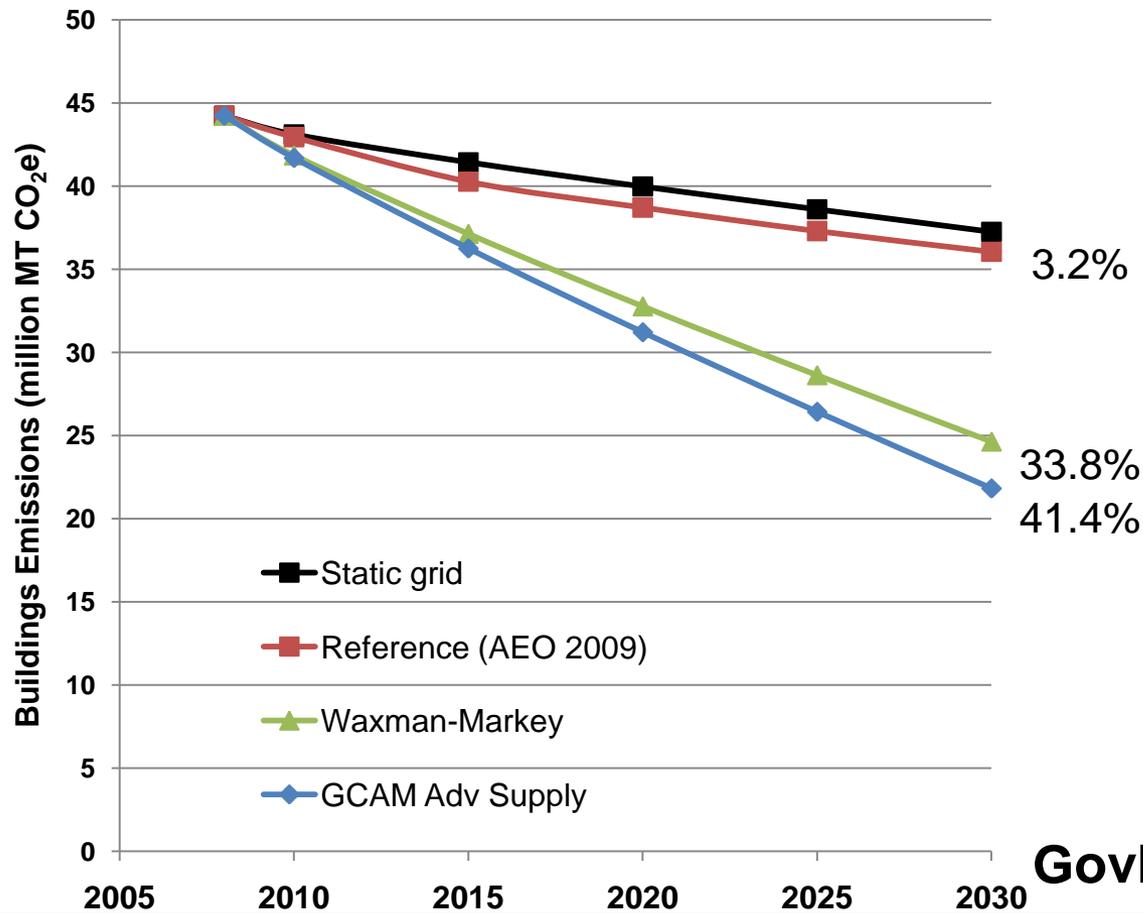
Potential Scenarios for Renewable Energy Output on Federal Lands

- Alternative strategies:
 1. Develop most cost effective renewable energy
 2. Develop even shares of renewable energy technology generation
 3. Develop the highest quality resources first



Impact of Reduced Carbon Intensity of Electricity Production

- GHG Emissions from Federal Buildings with either a static grid or one of three power production scenarios



Thank you!

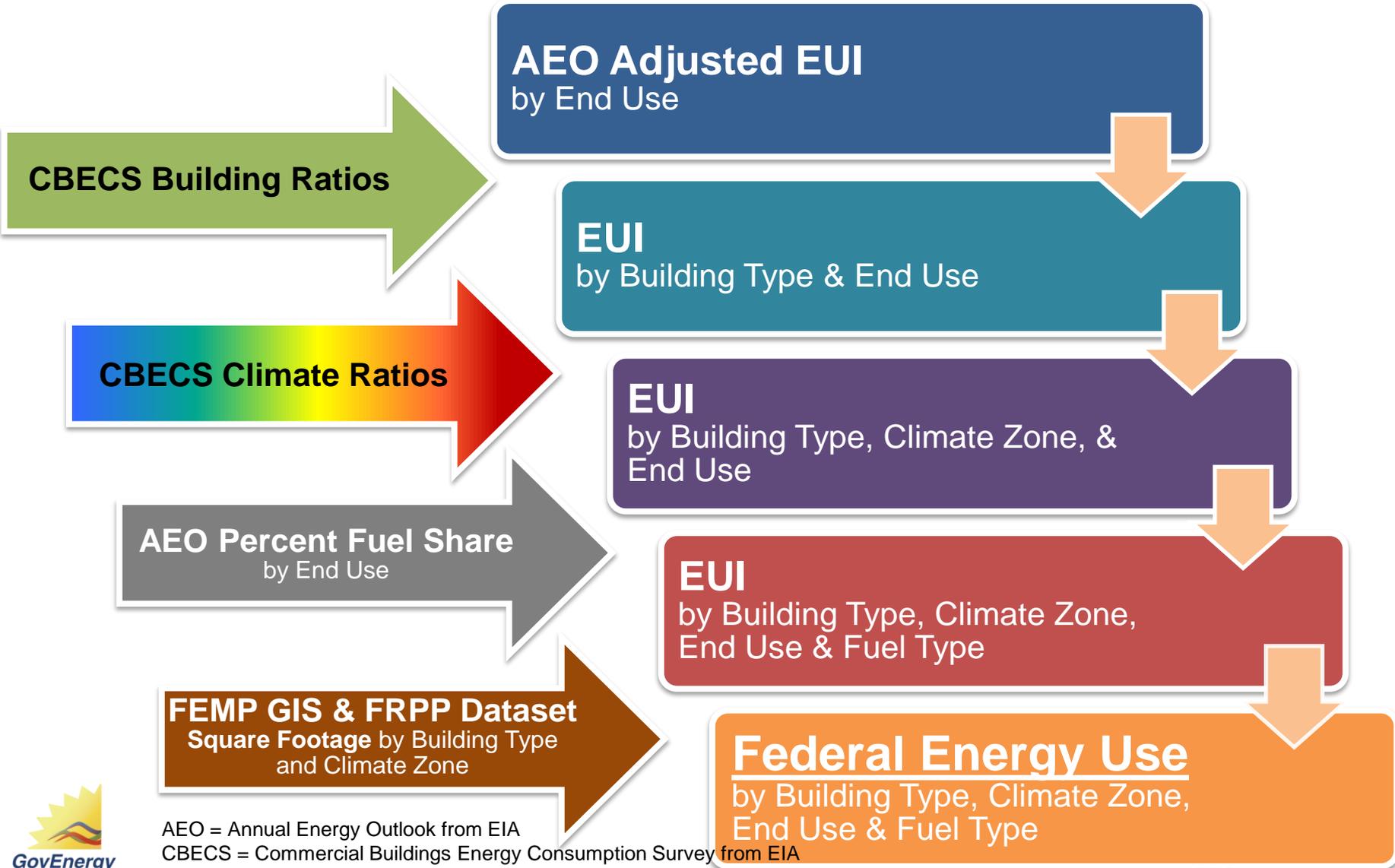
Kathleen Judd

Pacific Northwest National Laboratory

Kathleen.Judd@pnl.gov

Tel: 206 528 3330

Methodology: Estimate Federal Building EUIs for Baseline



AEO Adjusted EUI
by End Use

CBECS Building Ratios

EUI
by Building Type & End Use

CBECS Climate Ratios

EUI
by Building Type, Climate Zone, & End Use

AEO Percent Fuel Share
by End Use

EUI
by Building Type, Climate Zone, End Use & Fuel Type

FEMP GIS & FRPP Dataset
Square Footage by Building Type and Climate Zone

Federal Energy Use
by Building Type, Climate Zone, End Use & Fuel Type



AEO = Annual Energy Outlook from EIA
CBECS = Commercial Buildings Energy Consumption Survey from EIA
EUI = Energy Use Intensity (kBtu/sq ft)

Summary of Strategies Applied to Commercial Buildings at End Use Level

Impact Area	Strategies
Optimize Building Envelope	<p>Increase insulating capacity (R-value) for roofs, walls and floors.</p> <p>Install high efficiency windows that meet insulating capacity (U-value) and shading coefficient¹⁰ performance specifications.</p> <p>Install high efficiency electrochromatic/thermochromatic windows in Education, Food Service, Health Care, and Office buildings that meet shading coefficient performance specifications.</p> <p>Minimize air infiltration while maintaining ventilation requirements through advanced construction practices (e.g., sealing all joints and/or properly installing air barriers).</p>
Space Heating	<p>Optimize building envelope as described above.</p> <p>Install electric heat pumps that meet heating performance specifications in spaces where lower capacity equipment is appropriate.</p> <p>Install high efficiency gas/oil heating equipment where heat pumps are not appropriate.</p> <p>Install Energy Recovery Ventilation systems.</p>
Space Cooling	<p>Optimize building envelope as described above.</p> <p>Install electric heat pumps in spaces where lower capacity equipment is appropriate.</p> <p>Install packaged cooling units in spaces where medium capacity equipment is appropriate.</p> <p>Install chillers in spaces where large capacity equipment is appropriate.</p> <p>Install Energy Recovery Ventilation systems.</p>
Ventilation	<p>Install Energy Recovery Ventilation in buildings with integrated heat pumps.</p> <p>Install Energy Recovery Ventilation systems in bldgs using gas/oil for heating and electric cooling.</p> <p>Follow more efficient ventilation practices such as installing variable air volume (VAV) systems and energy efficient motors in buildings with high ventilation requirements.</p>

Summary of Strategies Applied to Commercial Buildings at End Use Level (2)

Impact Area	Strategies
	Install electric heat pump water heaters in buildings with low/medium hot water loads.
	Install gas condensing water heaters in buildings where fuel is available and high hot water loads.
Lighting	Replace all lighting technologies with SSL by 2030, in combination with increases in daylighting.
Refrigeration	Use highest efficiency refrigeration equipment available.
Computers	Use highest efficiency PC office equipment available
Non-PC Office Equipment	Use highest efficiency non-PC office equipment (e.g., servers, copiers) available.
Cooking	Use highest efficiency cooking equipment available.
Other End Uses	Use highest efficiency equipment for miscellaneous end uses (e.g., elevators)
Commissioning	Enhanced commissioning in new buildings and retro-commissioning in existing buildings.
Conservation	Curtail energy demand through adoption of consumer systems that provide detailed and timely information and feedback on energy usage in small/medium commercial buildings.
Site Infrastructure	Minimize central plant distribution leaks by following a comprehensive leak detection and central plant maintenance program, insulating pipe runs as appropriate, and seasonal shut-down of systems where feasible. Consider decentralization where possible.