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# Projected growth in small-scale, fossil-fueled distributed generation: Potential implications for the U.S. Greenhouse Gas Inventory

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National Renewable Energy Laboratory

EPA's International Emissions Inventory Conference

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# Project background

**Goal**:

- Define system of metrics to measure progress of grid modernization and validate with relevant stakeholders

**Approach**:

- Establish metrics for six categories: Reliability, Resilience, Flexibility, Sustainability, Affordability, and Security
- Engage key stakeholders to help shape development of metrics
  - Working collaborators: EPA, EIA, DHS, NERC, FERC, EPRI, APPA, NARUC, NASEO, City of New Orleans, ComED, CAISO, WA-UTC

**Timeline**:

- Year 1: Define initial metrics and methods
- Year 2 + 3: Implement use cases with specific partners to test the initial metrics; define additional metrics

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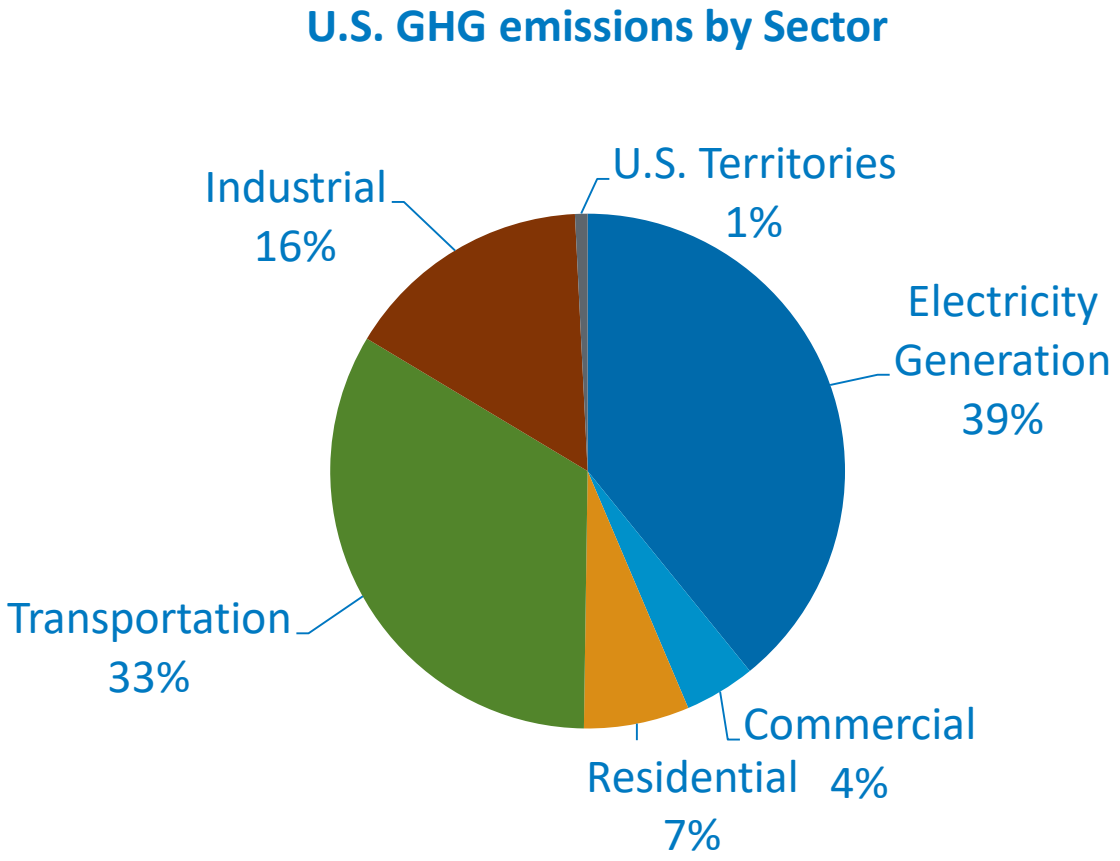
# Sustainability metrics – GHG emissions




**Source:** EPA. 2016. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014.

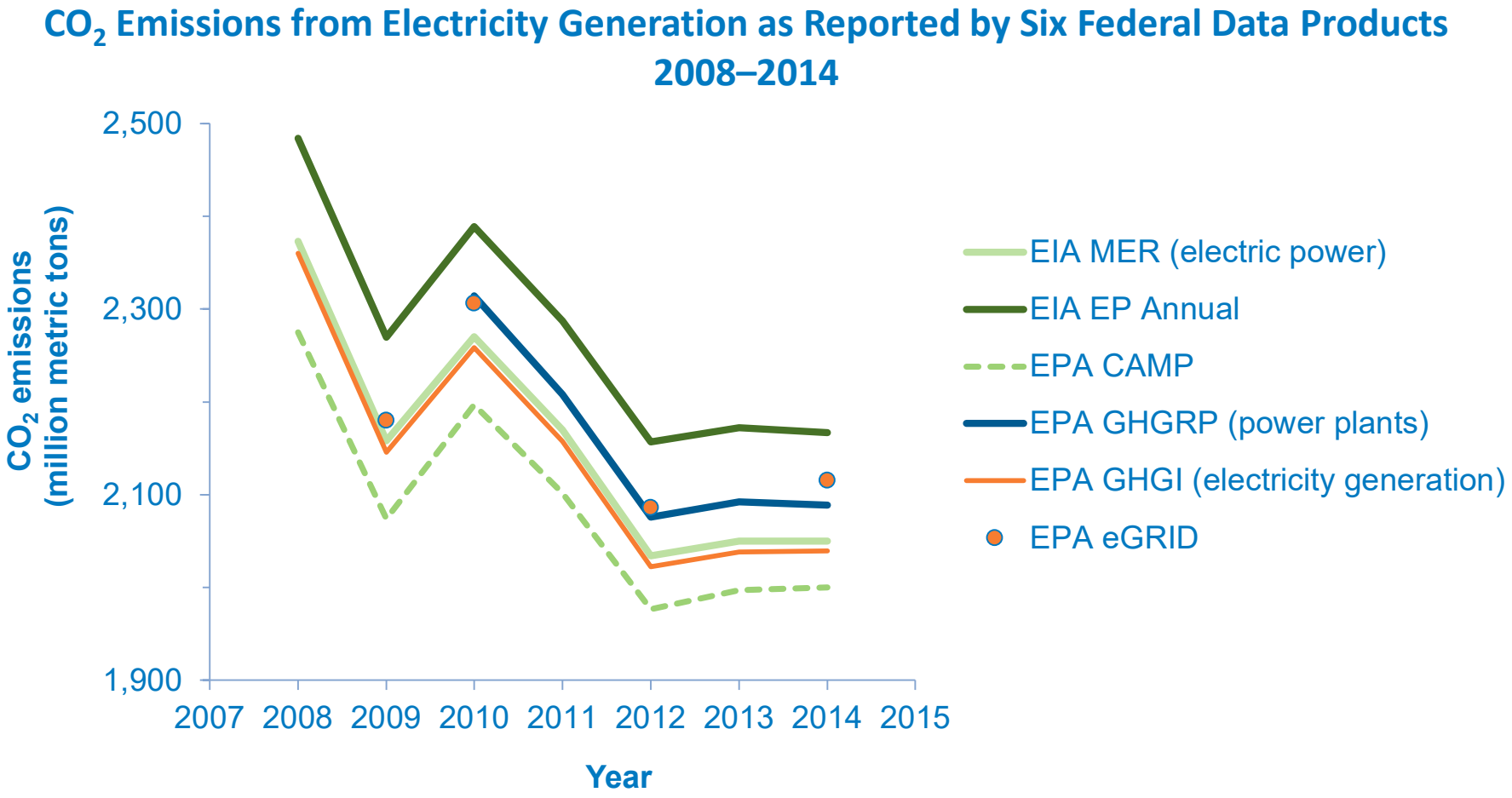
# Federal data sources for electric-sector GHG emissions

| Data product | Primary purpose | Lowest level of resolution | | Primary estimation method |
|---|---|---|---|---|
| | | *Spatial* | *Temporal* | |
| EIA EP Annual | Informational | State* | Annually | Fuel consumption times EF |
| EIA MER | Informational | State* | Monthly | Fuel consumption times EF |
| EIA STEO | Informational | National | Monthly | Projection |
| EIA AEO | Informational | Regional | Annually | Projection |
| EPA GHGI | Treaty obligation | National | Annually | Relies on MER data |
| EPA CAMP | Statutory | Boiler | Hourly | CEMS |
| EPA GHGRP | Statutory | Facility | Annually | CEMS |
| EPA eGRID | Informational | Boiler | Biennially | Relies on CAMP & MER data |

*Facility-level supplements available upon request.
Abbreviations: EPA = Environmental Protection Agency; EIA = Energy Information Administration; GHGI = Greenhouse Gas Inventory; GHGRP = Greenhouse Gas Reporting Program; eGRID = Emissions and Generation Resource Integrated Database; CAMP= Clean Air Markets Program; MER = Monthly Energy Review; EP Annual = Electric Power Annual; STEO = Short-Term Energy Outlook; AEO = Annual Energy Outlook; CEMS = continuous emission monitoring system; EF = emission factor.

# Federal estimates of electric-sector GHG emissions

- All data products are currently able to achieve their intended purposes
- Historical data products are aligned on discerning trends
- GHG emission estimates differ because they have different purposes and scopes



# Electricity generation sources may shift as grid modernizes

**Potential Changes*:**

- Growth in distributed generation
  - » More on-site power generation, especially using small-scale generators
- Increased deployment of renewable energy
  - » More wind power
  - » More solar power
  - » More biopower
  - » More hybrid (renewable/conventional) power
- Greater use of combined heat and power
- Increased energy storage

*Compiled from EPRI, 2017, The Integrated Energy Network; DOE, 2015, Quadrennial Energy Review; EPRI, 2014, The Integrated Grid – Realizing the Full Value of Central and Distributed Energy Resources; Pratt et al (PNNL) 2010 – The Smart Grid: An Estimate of the Energy and $CO_2$ Benefits; NETL 2007 – A Vision for the Modern Grid; DOE 2003 – Grid 2030: A National Vision for Electricity's Second 100 Years; DOE 2004 – National Electric Delivery Technologies Roadmap; DOE Smart Grid Booklet

# Research question

**How might the accuracy and completeness of federal data products' estimates of GHG emissions from electricity generation be impacted by grid modernization?**

# Federal data sources for electric-sector GHG emissions

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|---|---|---|---|---|---|
| | | *Spatial* | *Temporal* | | |
| EIA EP Annual | Informational | State* | Annually | 9 mo. | Fuel consumption times EF |
| EIA MER | Informational | State* | Monthly | 1 mo. | Fuel consumption times EF |
| EIA STEO | Informational | National | Monthly | 1 mo. | Projection |
| EIA AEO | Informational | Regional | Annually | 1 yr. | Projection |
| EPA GHGI | Treaty obligation | National | Annually | 2 yr. | Relies on MER data |
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# Focused research question for this presentation

**How might the accuracy and completeness of the U.S. Greenhouse Gas Inventory's estimate of GHG emissions from electricity generation be impacted as distributed generation grows?**

# Scope of U.S. Greenhouse Gas Inventory

**Overview**

- Developed in accordance with the Intergovernmental Panel on Climate Change's (IPCC's) extensive, internationally agreed carbon accounting methods
- Accounts for all sources and sinks of GHG emissions in the U.S.
- Submitted to the United Nations in accordance with the Framework Convention on Climate Change

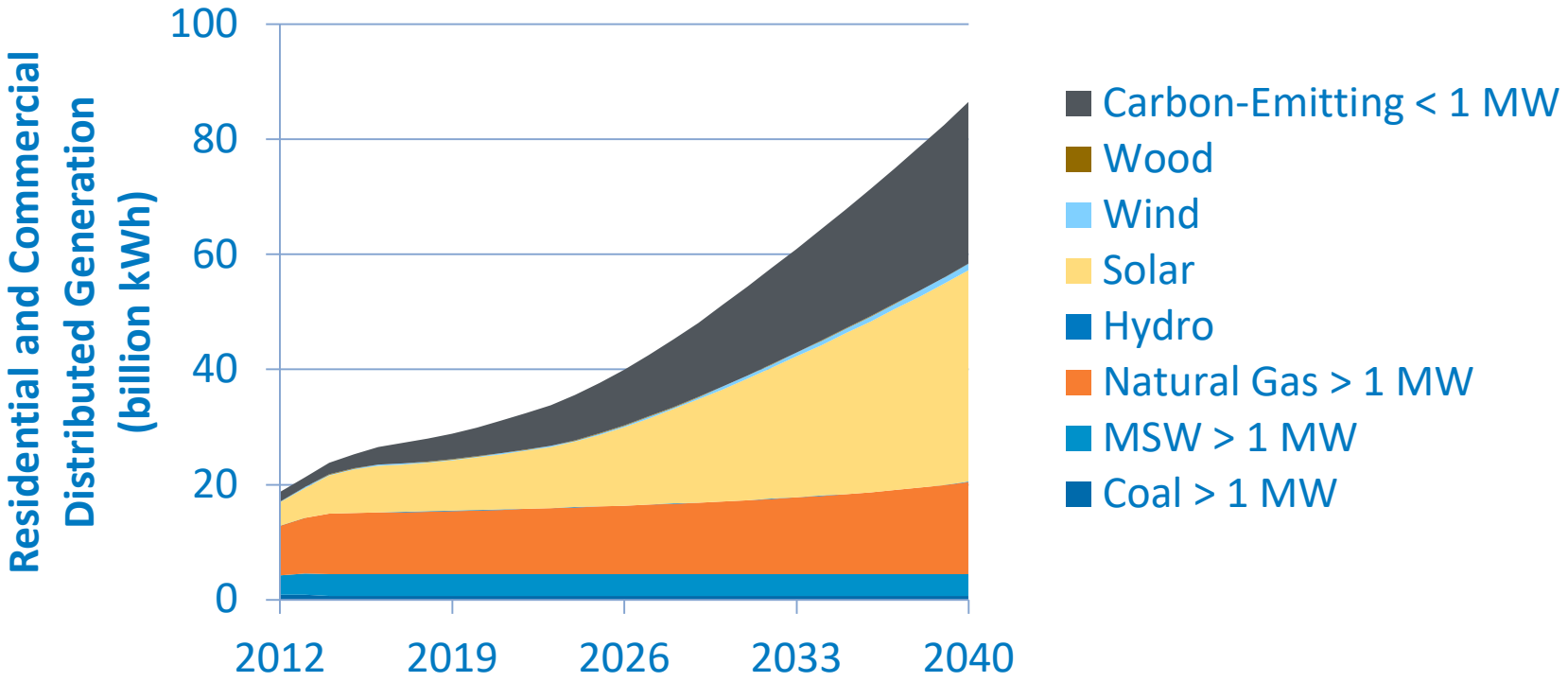
**Accounting for Distributed Generation (DG)**

- IPCC's methods have historically separated GHG emissions by the economic sector that generates the GHG emissions
  - For example, emissions from DG (a.k.a. autoproduction or on-site generation) are assigned to economic sector that owns the units (i.e., commercial, industrial, or residential) rather than to electricity
  - Category of electricity generation only includes GHG emissions from producers whose primary purpose is to produce electricity (IPCC Category 1.A.1.a.i)

# Projected growth in distributed generation (DG)

Residential and commercial electricity from DG is projected to more than triple from 2015 to 2040*

- The majority of this growth is expected to be met from renewable energy sources, which will have minimal impact on GHG emissions
- However, carbon-emitting DG is also projected to grow, particularly at scales < 1 MW

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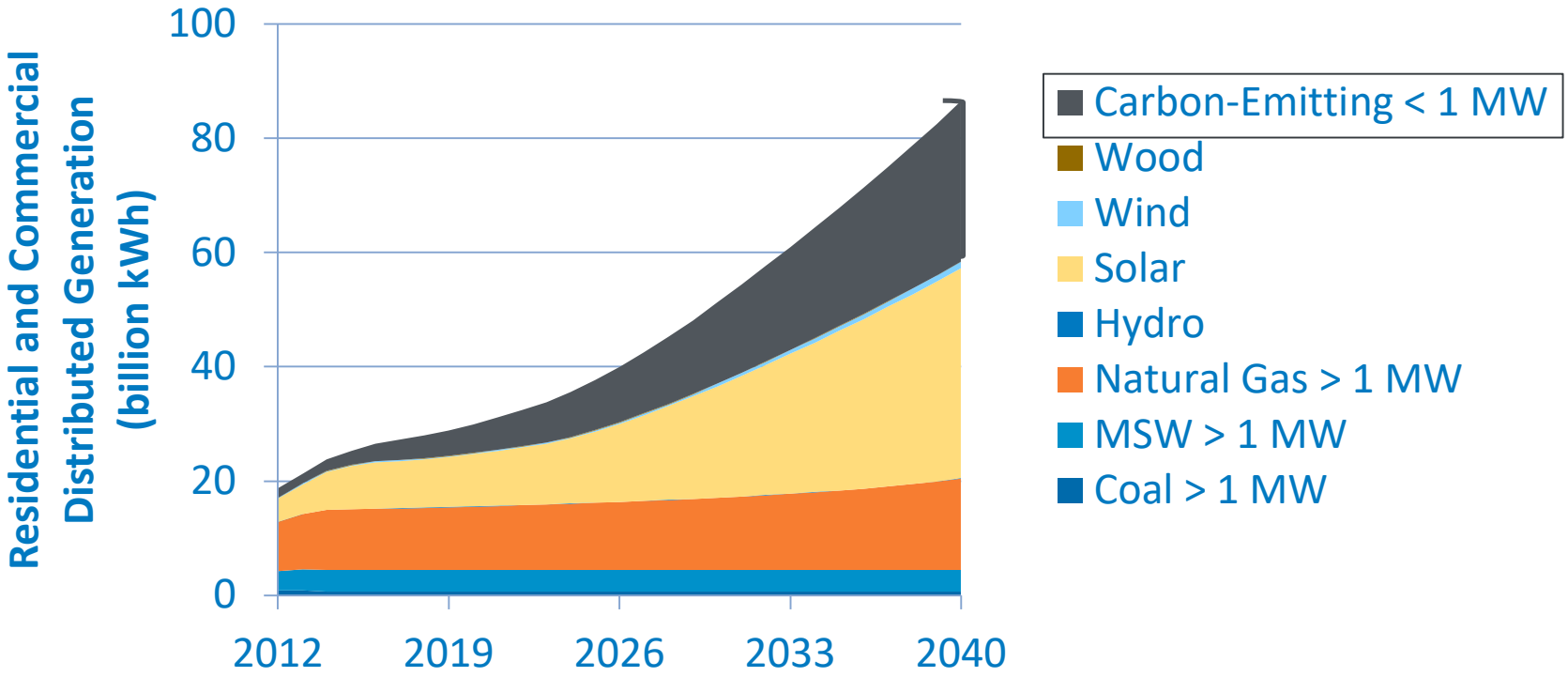


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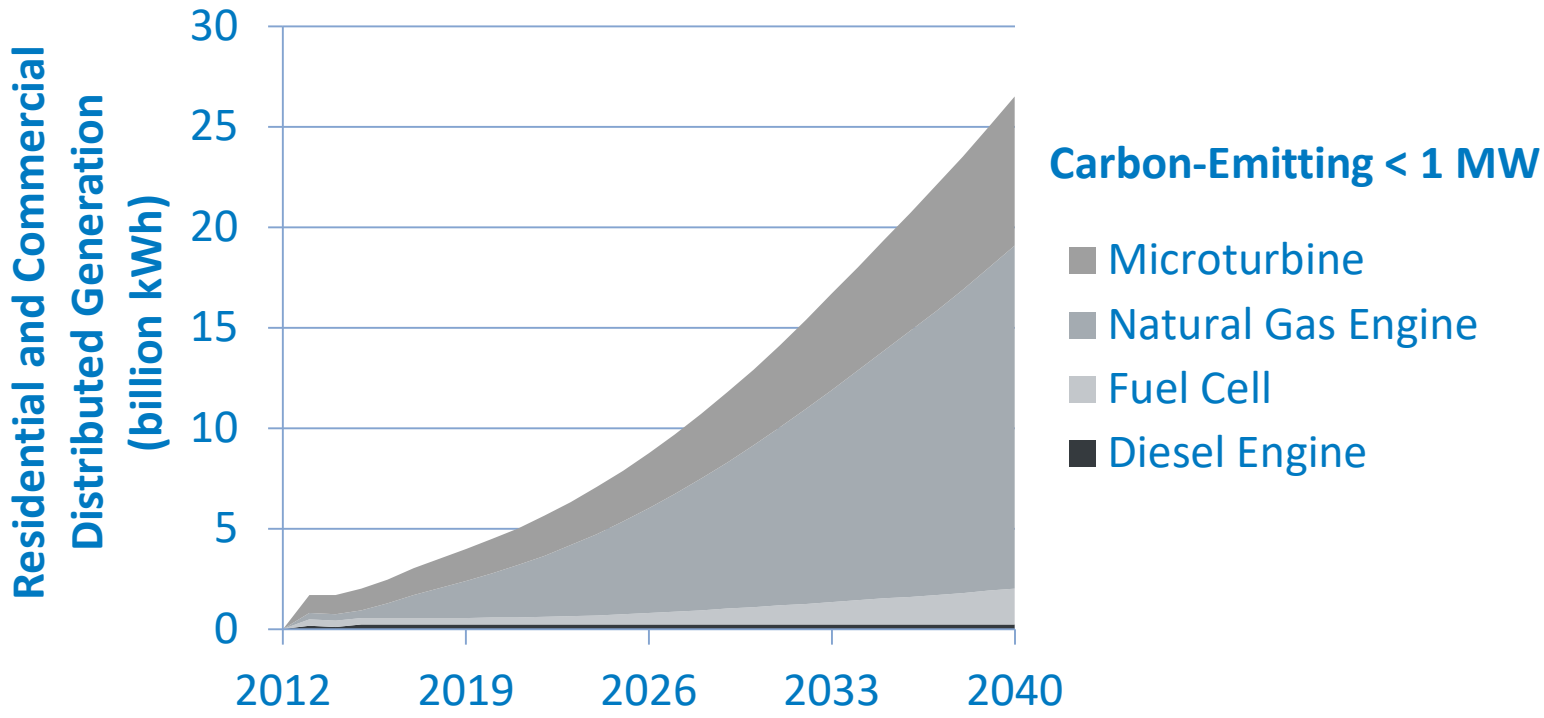
# Projected growth in small-scale, carbon-emitting DG

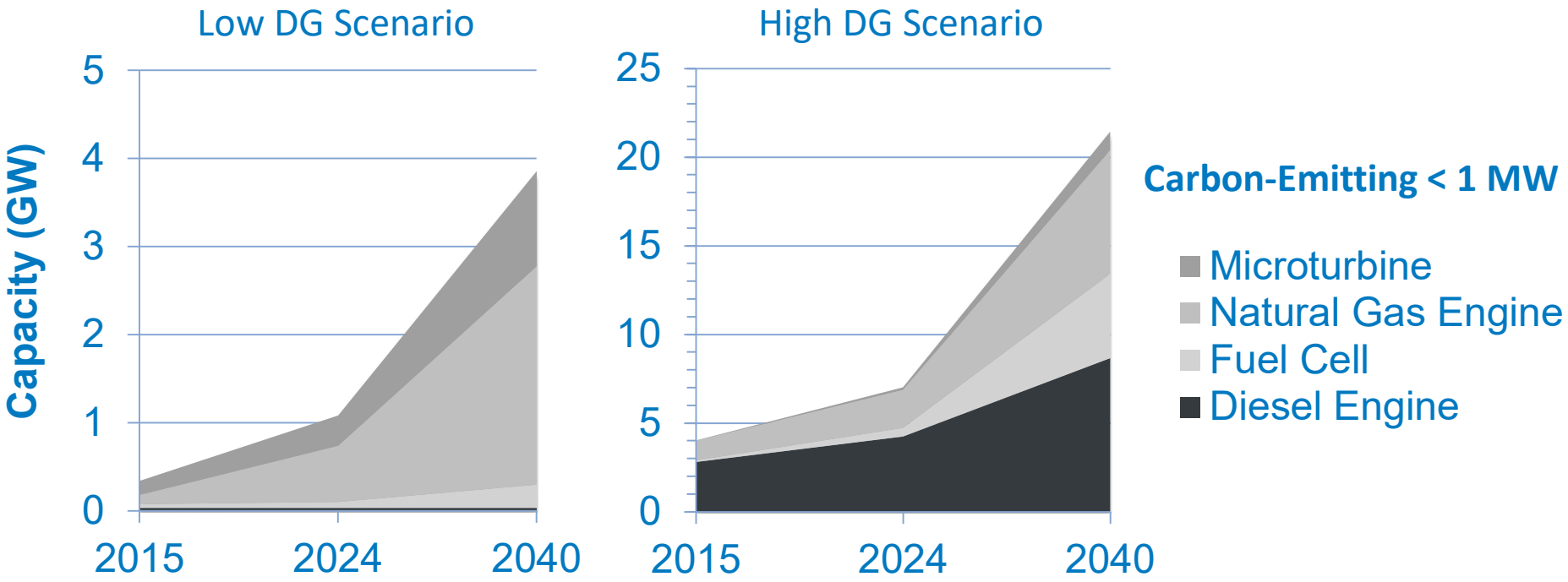
Small-scale (< 1 MW), carbon-emitting distributed generation for commercial and residential buildings is expected to grow more than nine-fold from 2015 to 2040*




*Data from detailed buildings results for the 2016 Annual Energy Outlook obtained through personal communication with the Energy Information Administration (EIA).

# Projected growth in small-scale, carbon-emitting DG

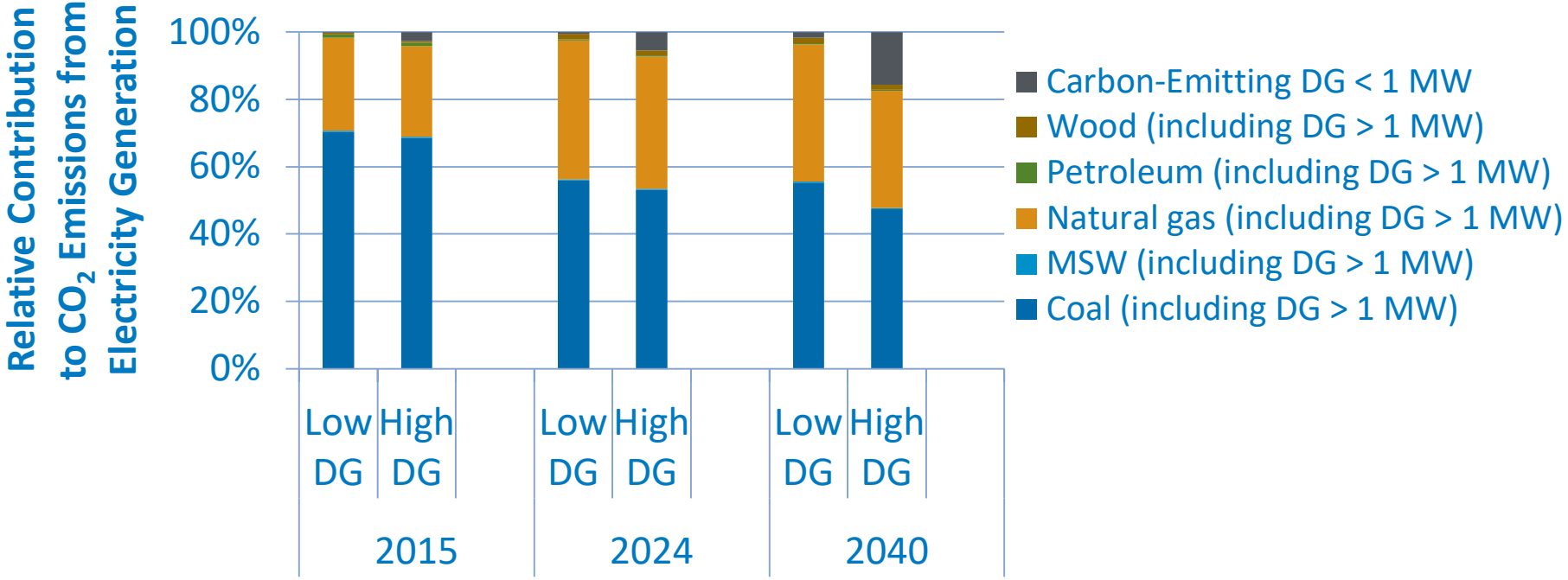
We combined literature forecasts of DG capacity (below) with literature data for capacity factors and emissions factors to develop two scenarios (low DG and high DG) to assess the potential $CO_2$ emissions that could result from increased use of small-scale, carbon-emitting DG




*Data from detailed buildings results for the 2016 Annual Energy Outlook obtained through personal communication with the Energy Information Administration (EIA) (conservative scenario) and Navigant capacity forecasts for DG (aggressive scenario).

# Projected growth in GHG emissions from small-scale DG

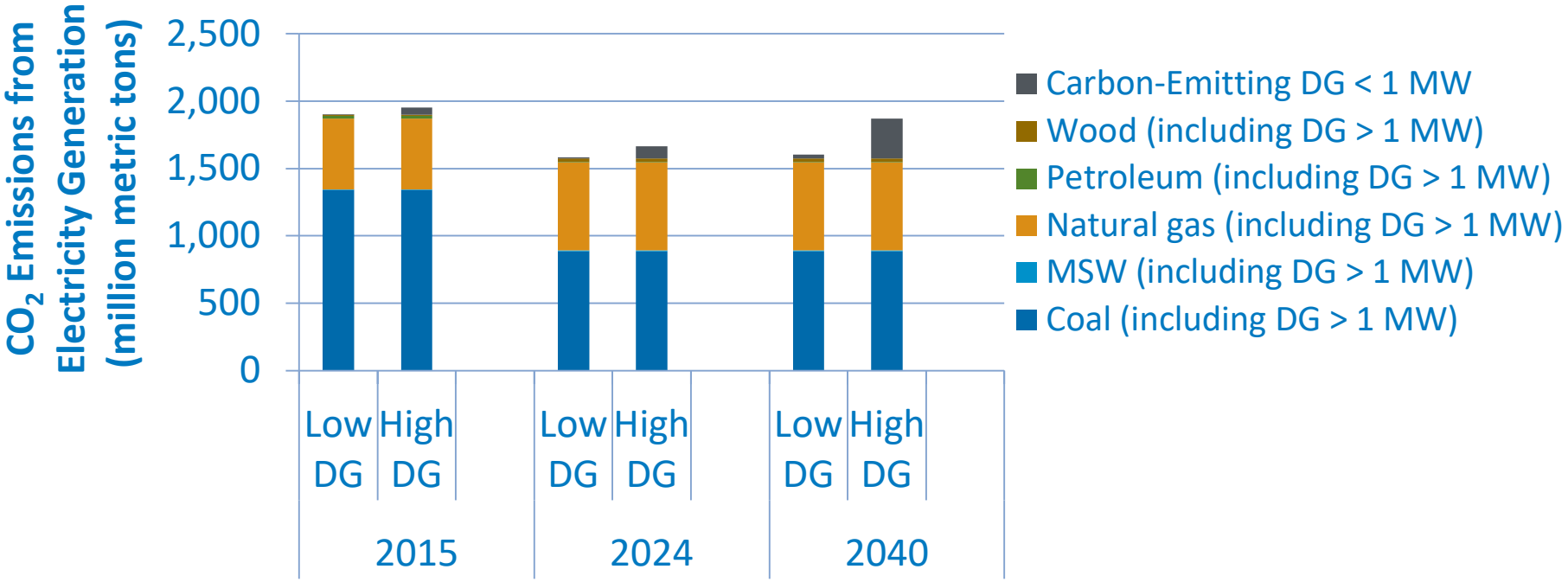
- $CO_2$ emissions from small-scale (< 1 MW), carbon-emitting distributed generation (DG) currently comprise less than 3% of $CO_2$ emissions from electricity generation
- By 2040, $CO_2$ emissions from small-scale DG could account for 2 to 15% of $CO_2$ emissions from electricity generation




**Source:** Eberle and Heath (in prep). Based on data from EIA's 2016 Annual Energy Outlook, Navigant's market analysis reports, documented capacity factors and emission factors.

# Projected growth in GHG emissions from small-scale DG

- Absolute $CO_2$ emissions from small-scale (< 1 MW), carbon-emitting distributed generation (DG) are expected to increase from 2015 to 2040
- Absolute $CO_2$ emissions from other sources are expected to remain similar or decrease from 2015 to 2040

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# Potential implications for the GHGI

**How might the accuracy and completeness of the U.S. Greenhouse Gas Inventory's estimate of GHG emissions from electricity generation be impacted as distributed generation grows?**

# Potential implications for the GHGI

**How might the accuracy and completeness of the U.S. Greenhouse Gas Inventory's estimate of GHG emissions from electricity generation be impacted as distributed generation grows?**

- GHGI's autoproduction (DG) accounting method is currently sufficient
  - Small-scale DG currently minor contributor to electricity generation and emissions
- Methods may need to be modified to better track change in emissions from electricity generation as DG grows
  - For example, as the grid modernizes, energy production and emissions from DG are expected to increase
  - Current accounting does not allocate DG emissions to the electric power sector, which could make it difficult to accurately track changes in emissions from electricity generation and allocate mitigation resources

# Acknowledgements

This work was supported as part of the Grid Modernization Laboratory Consortium's Metric Analysis project (GMLC 1.1), which was funded by the U.S. Department of Energy under Contract DE-AC36-08GO28308.

**Sustainability Metrics Team**

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Jordan Macknick (NREL)

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# Relationship between Voluntary GHG Emission Metrics and Federal GHG Data Products

- EPRI (2014, 2016) identified 78 electric-sector GHG metrics that are reported by voluntary reporting programs, including
  - $CO_2$ emissions from company, equity-owned net generation by fuel type (tonnes $CO_2$)
  - Scope 1, Scope 1 and 2, and Scope 3 $CO_2e$ emissions (tonnes $CO_2e$)
  - Scope 1, Scope 1 and 2, and Scope 3 $CO_2e$ emissions intensity (tonnes $CO_2e$ per MWh)
- Data for these voluntary metrics could come from federal GHG data products, which generally report
  - $CO_2$ or $CO_2e$ emissions at unit, facility, state, regional, and/or national levels
  - $CO_2$ or $CO_2e$ emissions intensity at unit, facility, state, regional, and/or national levels
- However, federal data products differ in several ways, including their purpose, scope, and methods
- It is important for users of federal GHG data products (e.g., policymakers, analysts, companies and climate modelers) to clearly understand how, what, and why data are reported
  - Implications for accurate tracking of commitments (voluntary and mandatory), for properly interpreting trends

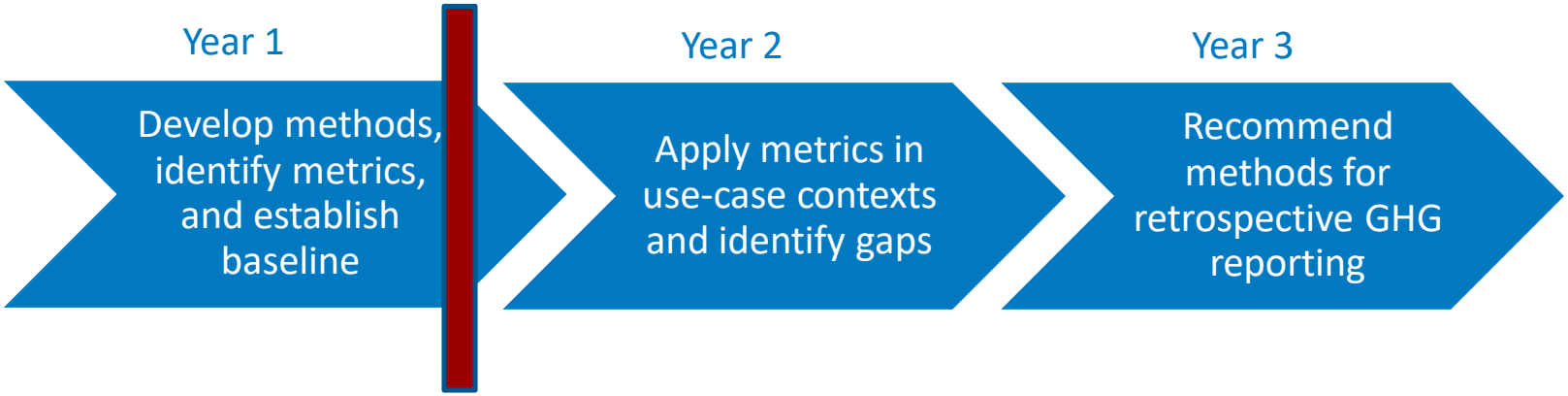
# Goal and approach for GHG sustainability metrics

**Goals:**

- To assess the ability of federal data sources to discern changes in GHG emission performance of the grid as it modernizes.
- To develop recommendations based on gaps identified so that the U.S. has the ability to track GHG emissions from the electric sector as it modernizes.

**Approach:** Develop an objective, comprehensive, and critical review of the landscape of federal GHG emission estimation products and compare the ability of these products to capture aspects of grid modernization.

**Timeline (GHG):**



# Project funded by U.S. Department of Energy

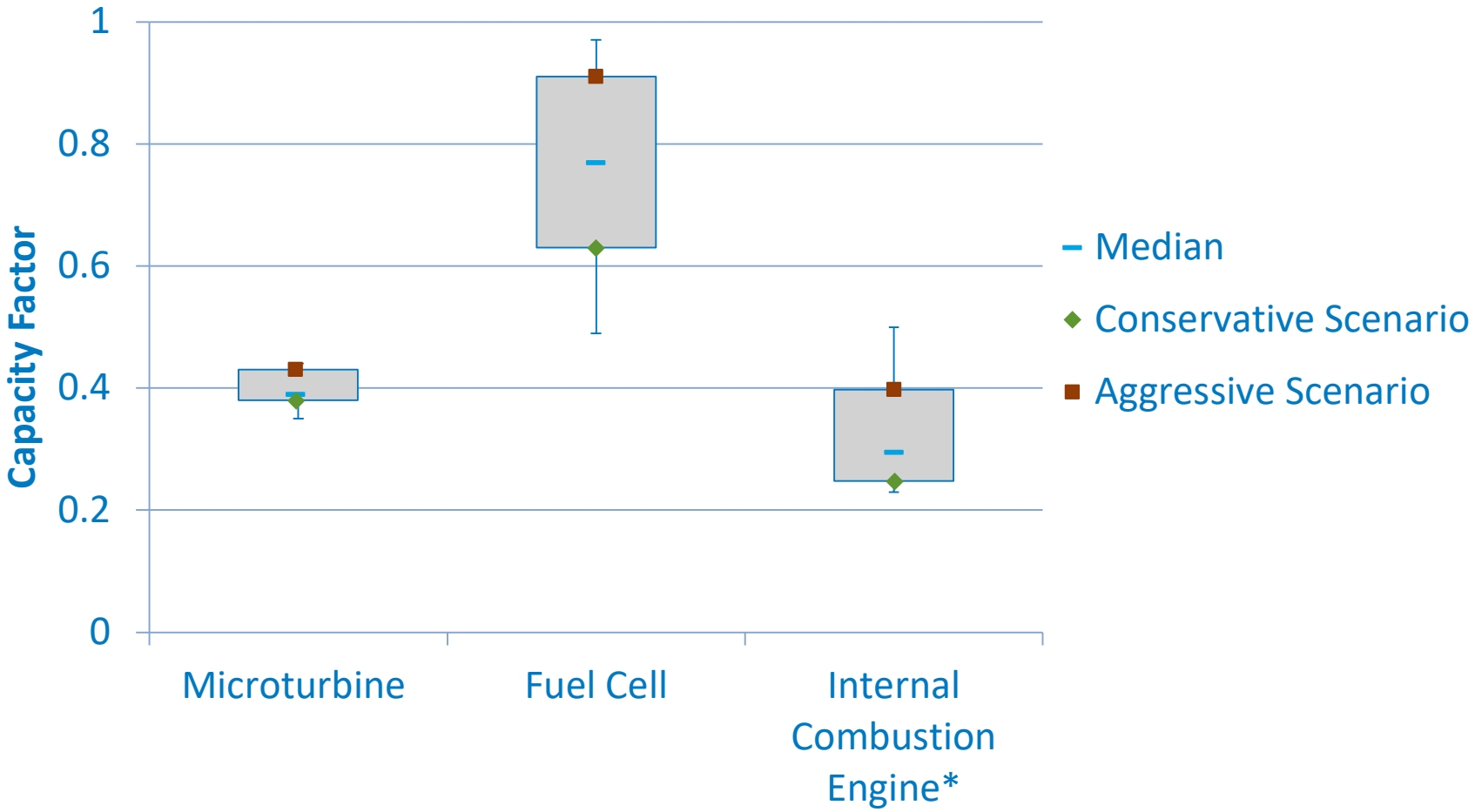
Grid Modernization
INITIATIVE

*The future grid provides a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy.*

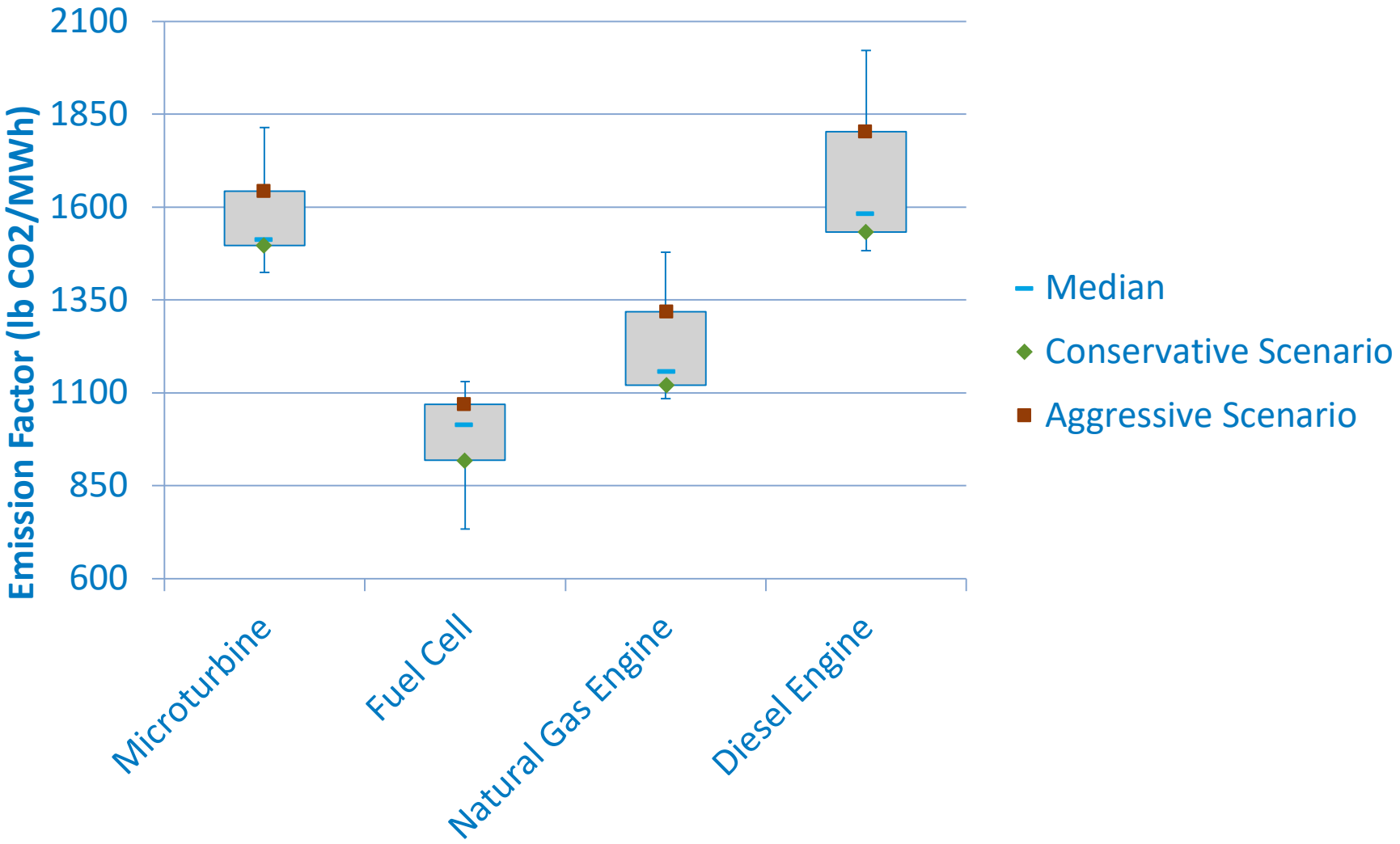
*It must deliver **reliable, affordable,** and **clean electricity** to consumers where they want it, when they want it, how they want it.*


GRID
MODERNIZATION
LABORATORY
CONSORTIUM
U.S. Department of Energy

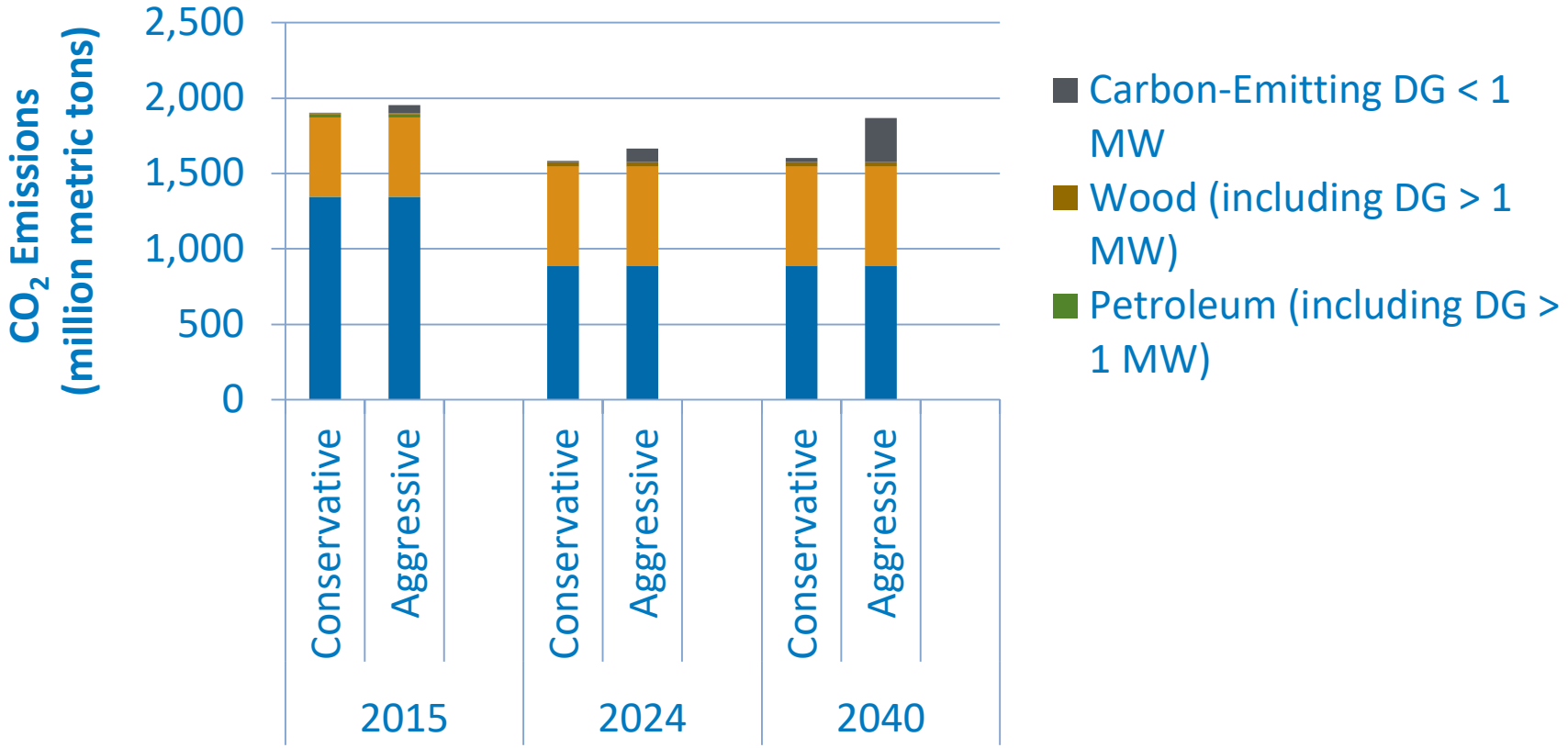
# Capacity Factors



# Emission Factors



# Absolute $CO_2$ Emissions by Source

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