H2@Scale: strategic perspectives from DOE
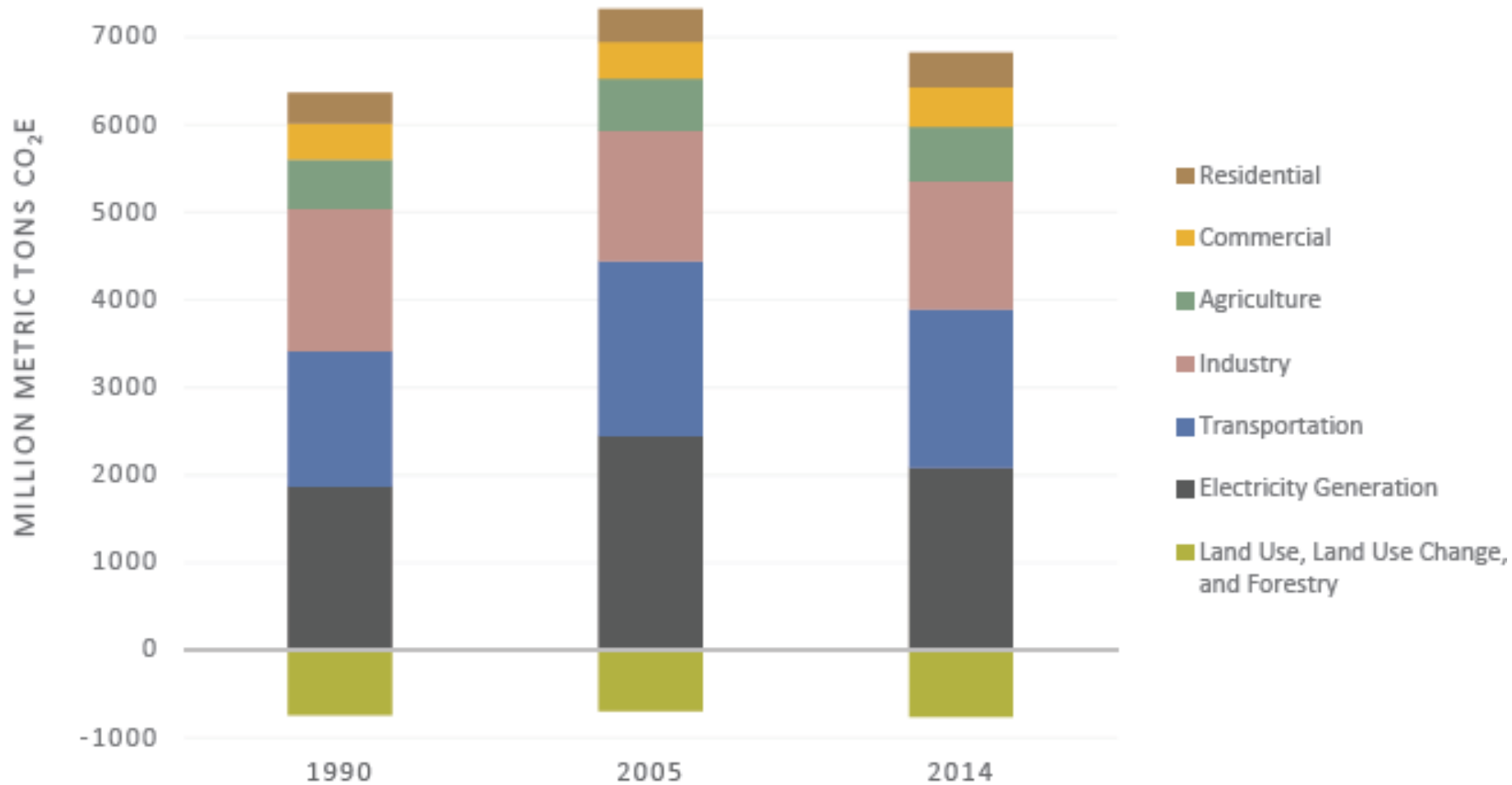
Brian Walker, EERE Strategic Programs

November 17, 2016

Colin McMillan, Richard Boardman, Mark Ruth, Dylan Cutler, Shannon Bragg-Sutton, Jong Suk Kim, Michael McKellar, Piyush Sabharwall, Paul Spitsen, Steve Capanna

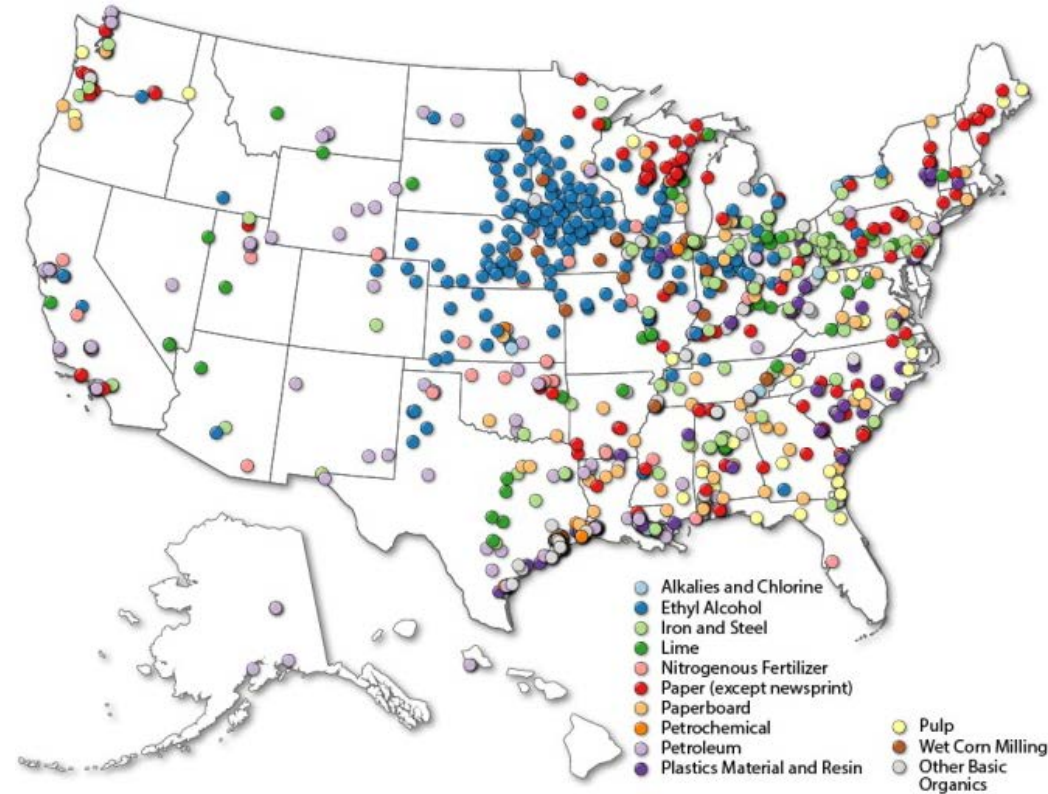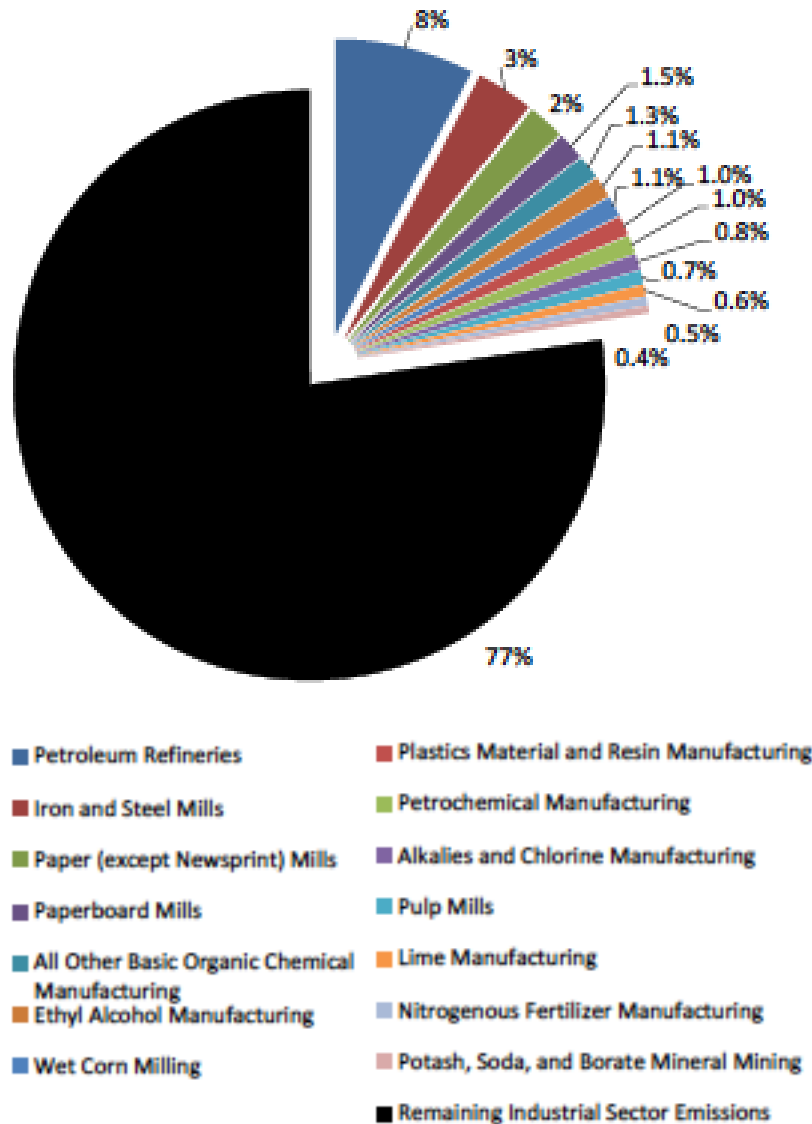**U.S. DEPARTMENT OF ENERGY** | Energy Efficiency & Renewable Energy

Deep energy transformation must include industry

White House Mid-century Strategy for Deep Decarbonization, 2016

# First: understand diversity of industrial energy use

8%
3%
2%
1.5%
1.3%
1.1%
1.1% 1.0%
1.0%
0.8%
0.7%
0.6%
0.5%
0.4%
77%

- Petroleum Refineries
- Iron and Steel Mills
- Paper (except Newsprint) Mills
- Paperboard Mills
- All Other Basic Organic Chemical Manufacturing
- Ethyl Alcohol Manufacturing
- Wet Corn Milling
- Plastics Material and Resin Manufacturing
- Petrochemical Manufacturing
- Alkalies and Chlorine Manufacturing
- Pulp Mills
- Lime Manufacturing
- Nitrogenous Fertilizer Manufacturing
- Potash, Soda, and Borate Mineral Mining
- Remaining Industrial Sector Emissions

Map legend:
- Alkalies and Chlorine
- Ethyl Alcohol
- Iron and Steel
- Lime
- Nitrogenous Fertilizer
- Paper (except newsprint)
- Paperboard
- Petrochemical
- Petroleum
- Plastics Material and Resin
- Pulp
- Wet Corn Milling
- Other Basic Organics

Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Remove its Carbon Emissions (McMillan, Boardman et al. INL-NREL, forthcoming)

Many industrial resources are hard to electrify.

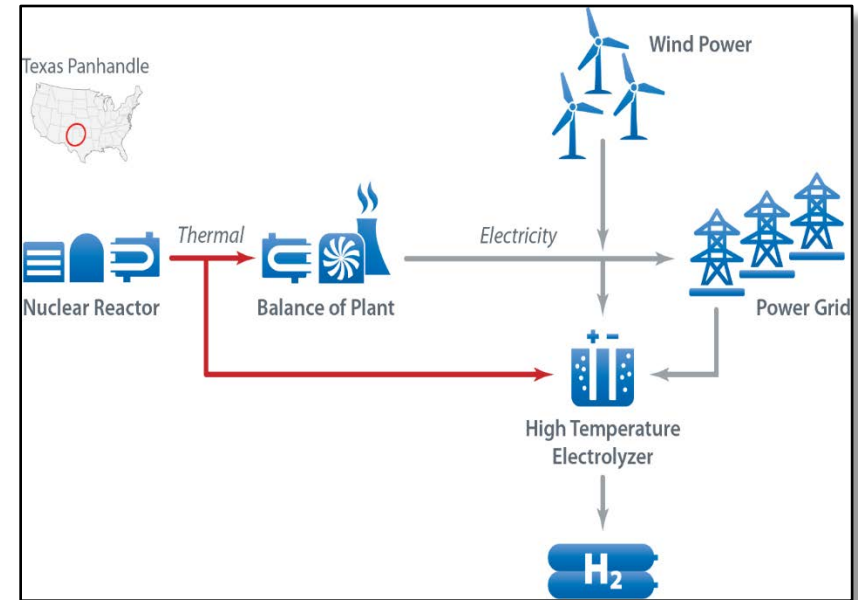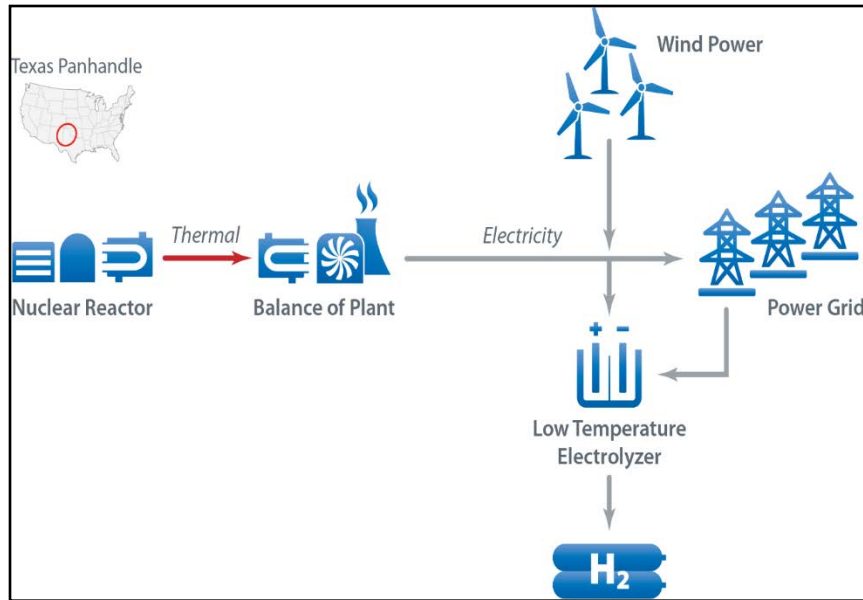(McMillan, Boardman et al., forthcoming. Data from EPA 2016)
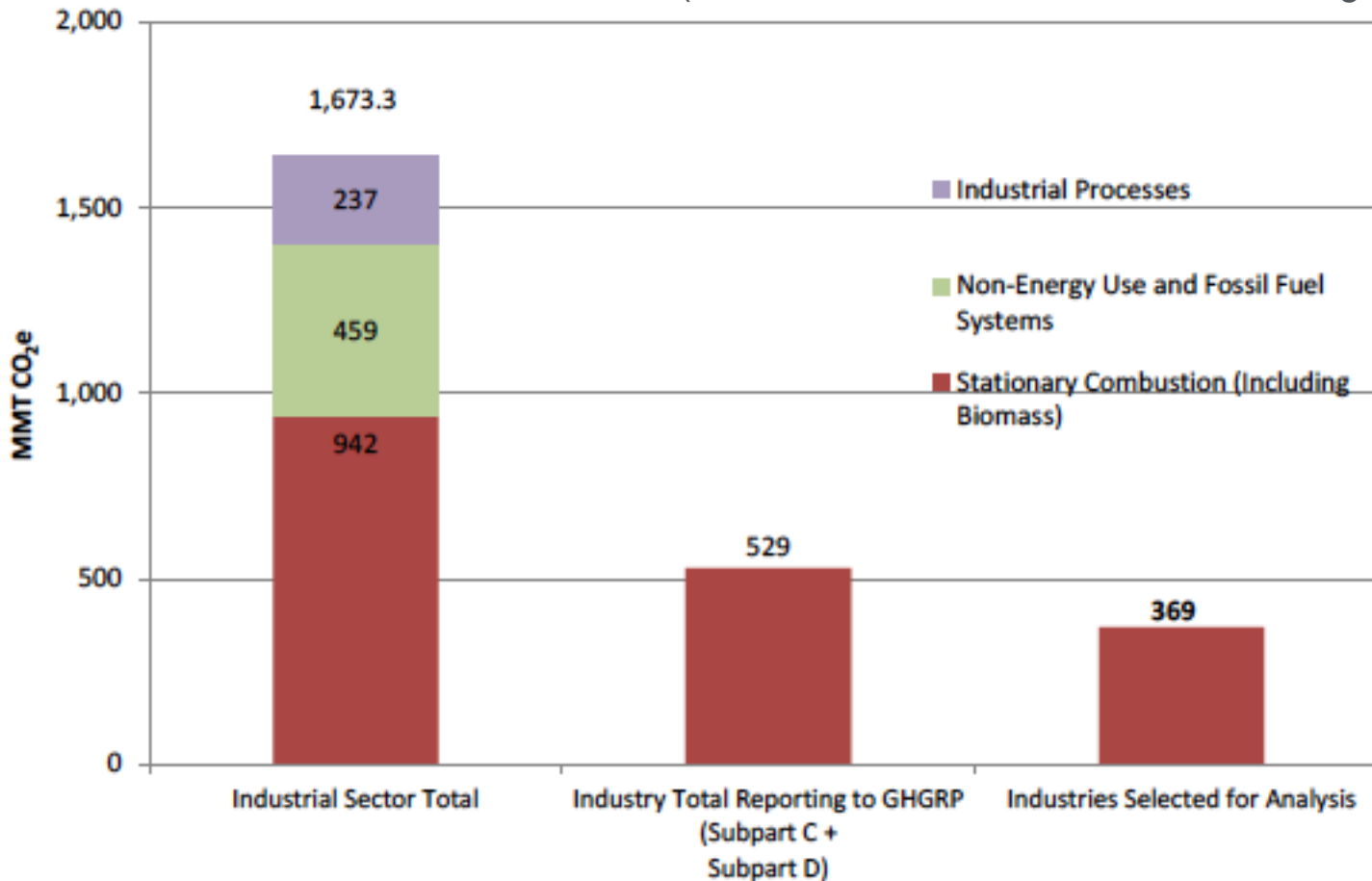
Expanded industrial role for H_2 : feedstock, mobile/stationary energy carrier

Two INL-NREL case studies on nuclear and renewable energy

- Analyzes the potential profitability of a nuclear-renewable hybrid energy system producing hydrogen for industrial and transportation applications.

- Expected publication data January, 2017).

Analysis on Nuclear-Renewable Energy Systems

- **Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Remove its Carbon Emissions** (*late 2016*)
  - o Joint INL-NREL analysis of the quantity of thermal energy used in the U.S. industrial sector, identifying largest sub-sectors along with quantity and quality requirements and opportunities to provide that heat with fewer GHG emissions.

- **Status on the Component Models Developed in the Modelica Framework: High-Temperature Steam Electrolysis Plant & Gas Turbine Power Plant** (*late 2016*)
  - o INL development of high temperature steam electrolysis (HTSE) and gas turbines for use in Modelica models of nuclear-renewable hybrid energy systems (N-R HESs) and case studies modeling N-R HES performance

- **The Economic Potential of Three N-R HESs Providing Thermal Energy to Industry** (*late 2016*)
  - o NREL analysis of non-manufacturing N-R HESs that generate heat and electricity. Heat can be generated from both nuclear and renewable sources and provided either at a constant or varying rate.

Analysis on Nuclear-Renewable Energy Systems

- **The Economic Potential of N-R HESs Producing Hydrogen** (*January 2017*)
  - o NREL analysis of two N-R HESs that produce hydrogen: one with low temperature electrolysis and a second with HTSE

- **POWER-UP** (*2017-2018*)
  - o Potential for Widespread Electrification to Reduce Unwanted Pollutants
  - o Multi-lab study on potential for decarbonization of the U.S. economy

Conclusions

- **DOE has done, and will continue to do techno-economic analysis: watch this space**

- **DOE work is not limited to one office, lab, or technology**

- **We need push/pull with industry: reality check and roadmaps**