Fuel Cells and Renewable Gaseous Fuels

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

Bioenergy 2015: Renewable Gaseous Fuels Breakout Session

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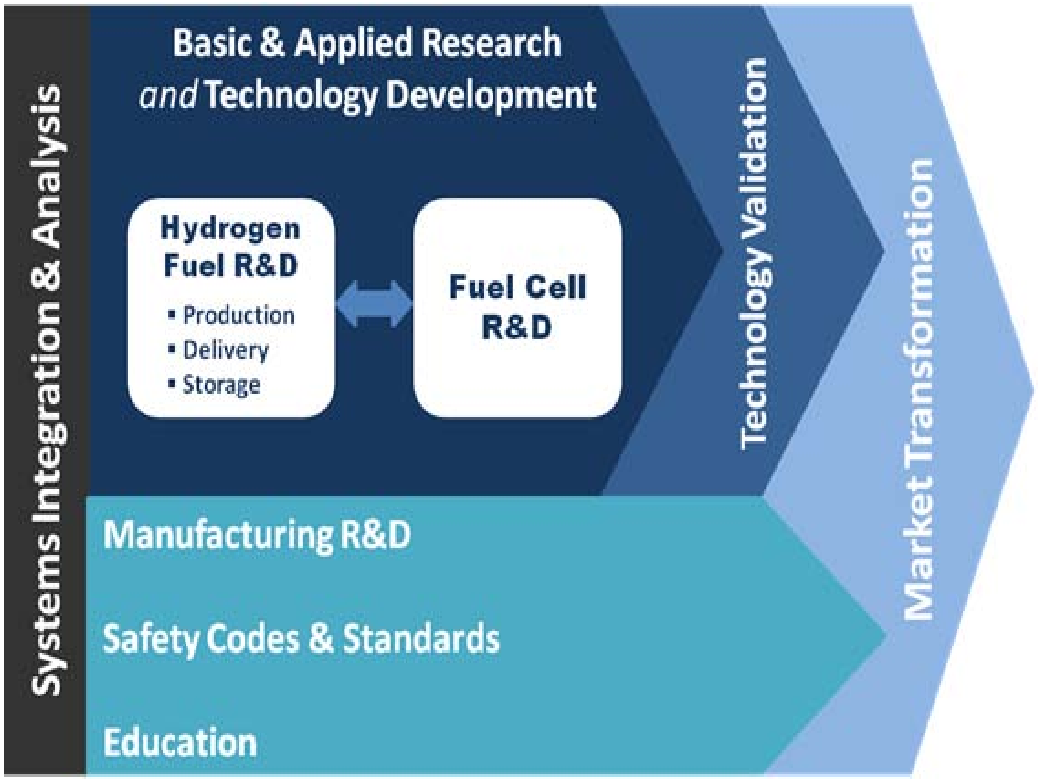
U.S. Department of Energy

Integrated Work Areas



2020 Targets by Application

Fuel Cell Cost	\$40/kW	\$1,000/kW* \$1,500/kW**
Durability	5,000 hrs	80,000 hrs
H_2 Storage Cost (On-Board)	\$10/kWh 1.8 kWh/L, 1.3 kWh/kg	
H_2 Cost at Pump	<\$4/gge	

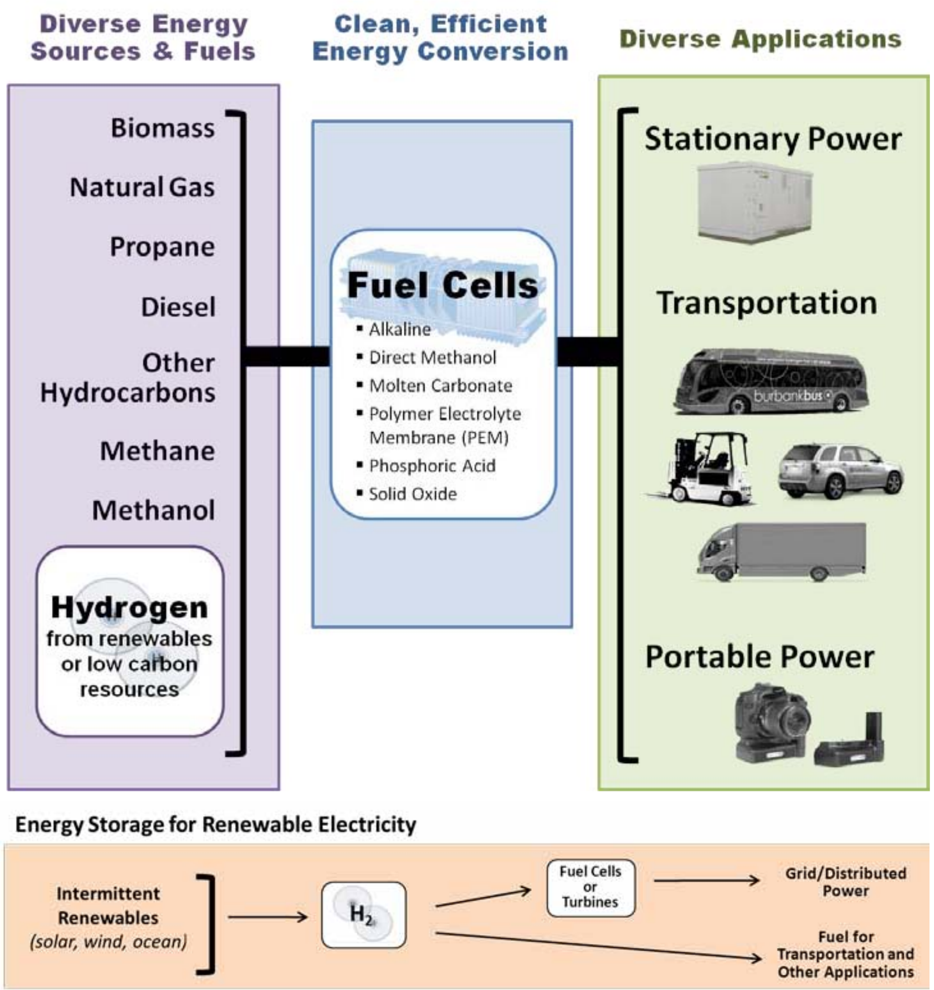
*For Natural Gas
**For Biogas

Multi-year Research Development and Deployment plan:
http://energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-year-research-development-and-22

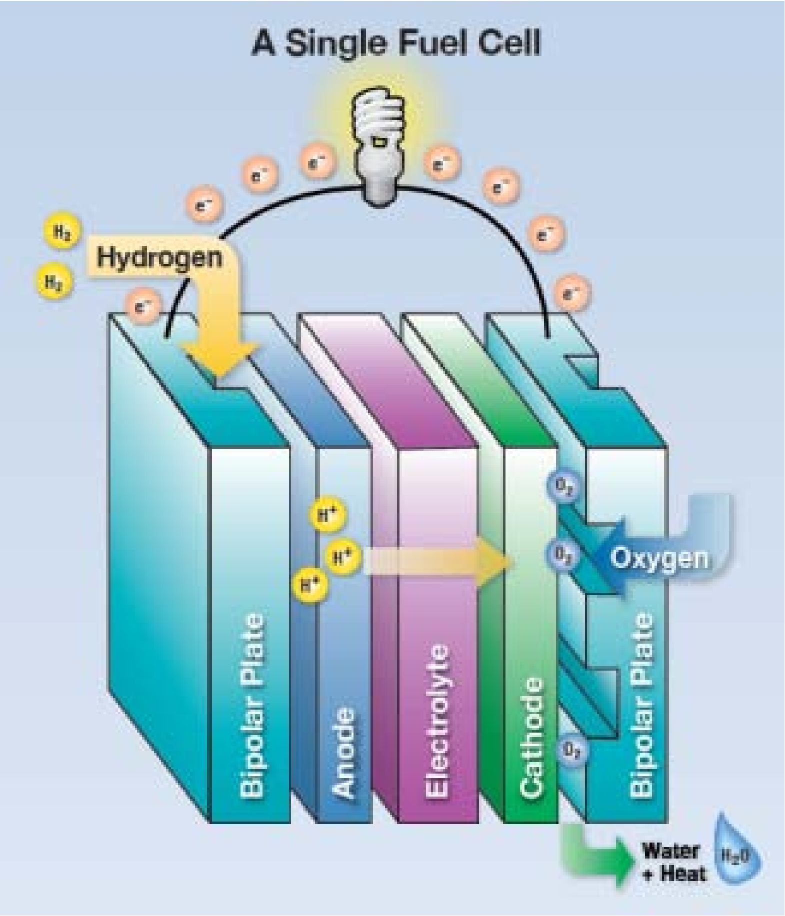
Integrated approach to widespread commercialization of H_2 and fuel cells

Background on Fuel Cells

The Role of Fuel Cells



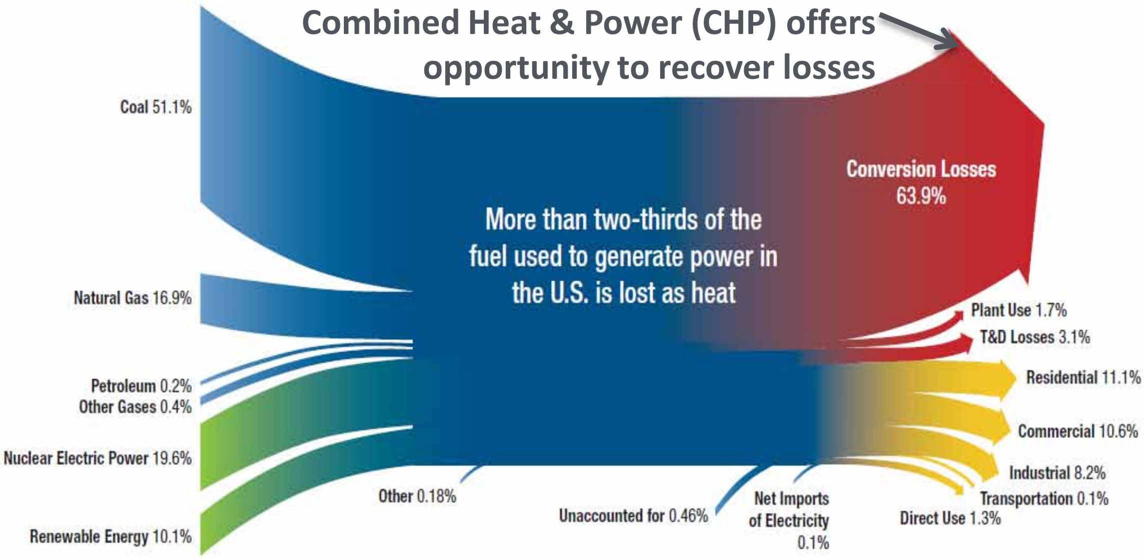
Example of a fuel cell



2x as efficient as today's gasoline engine

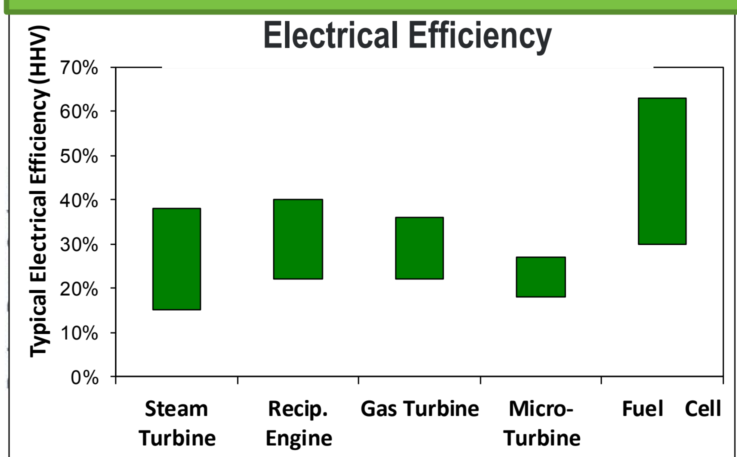
Fuel cells convert chemical energy directly to electricity without the need for combustion and are more efficient than conventional technologies

Opportunities for Distributed Generation (DG) and Efficient use of Natural Gas or Biogas



Source: http://www.chpcenterse.org/pdfs/ORNL_CHP_Report_Dec_2008.pdf

Range of electrical efficiencies for DG technologies



Source: EPA, Catalog of CHP Technologies, December 2008

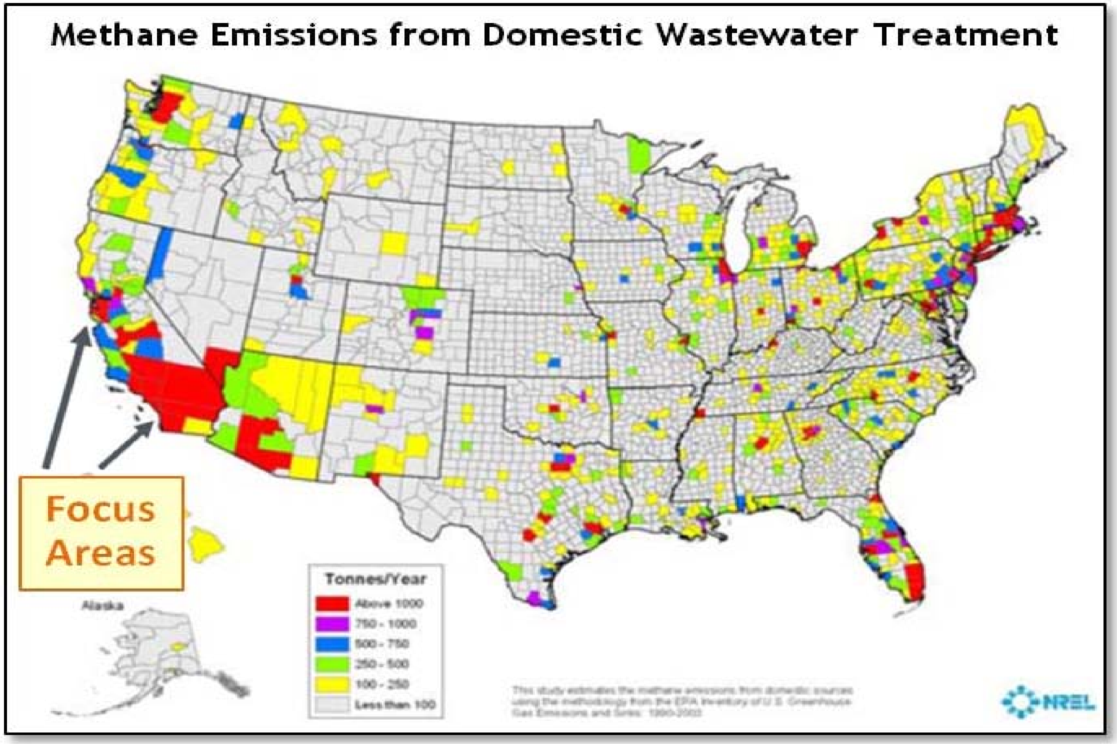
Examples of fuel cell deployments using natural gas for critical loads

Supermarkets one of several in the food industry interested

New World Trade Center will use **12 fuel cells totaling 4.8MW**

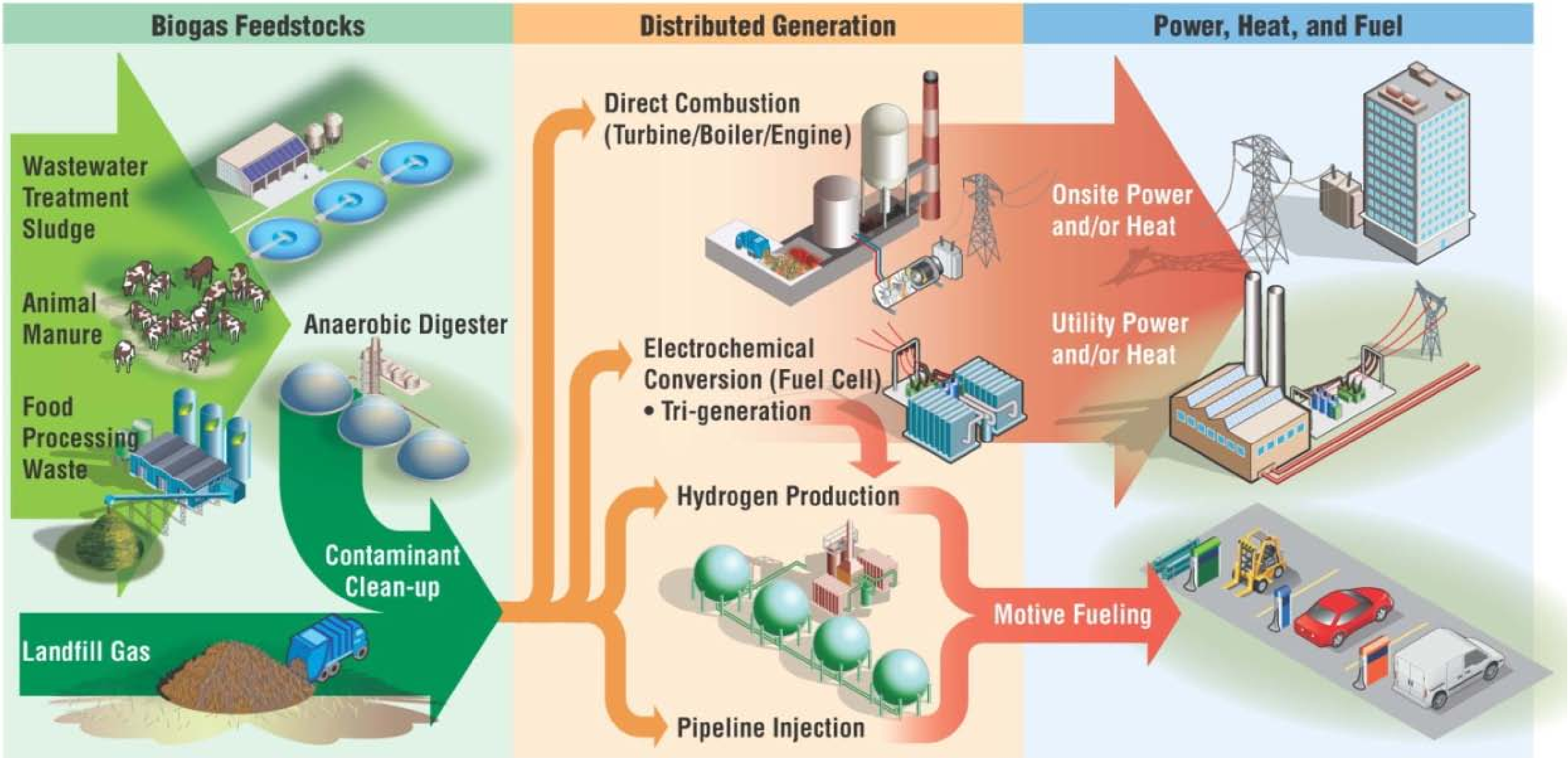
Biogas: Early Source of Renewable Fuels

- Majority of biogas resources are near large urban centers, ideally located near the major demand centers for FCEVs and power
- Power can be produced by stationary fuel cells
- Hydrogen can be produced using existing steam-methane-reforming technology



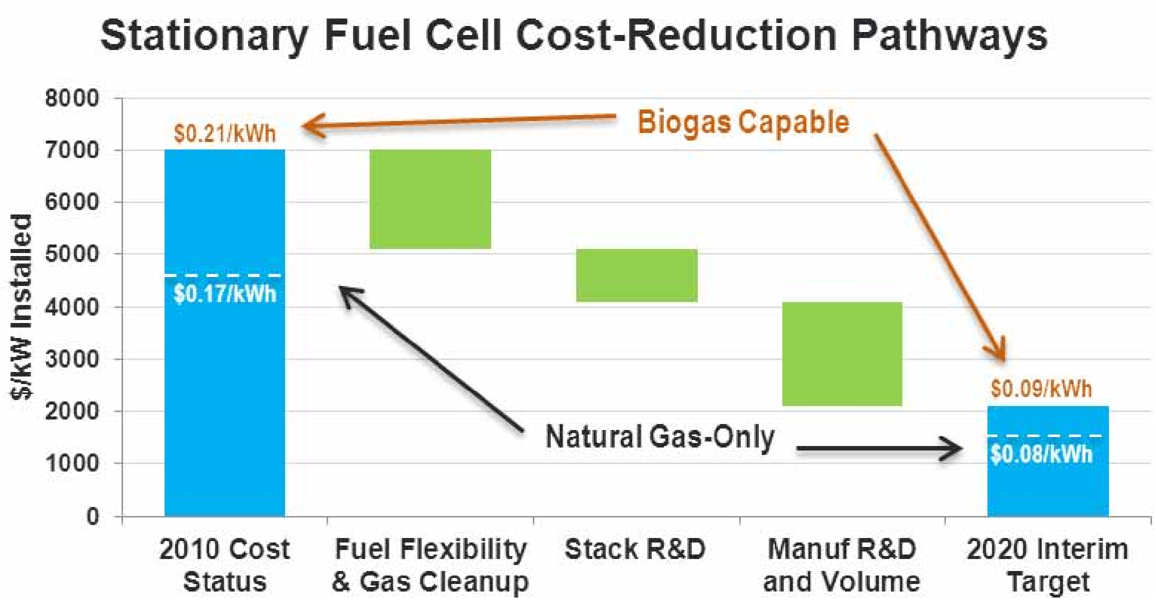
Wastewater treatment plants alone have the potential to provide enough hydrogen to support ~1-3M FCEVs/yr

Biogas Opportunities for Fuel Cells



Biogas fuel cell projects are being demonstrated in real world conditions and provide a foundation for growth

Challenges and Strategy: Stationary Applications



- Further reduction of fuel cell system cost is required to expedite commercialization
- Biogas-compatible systems have increased costs associated with capital equipment, O&M and durability issues
- Development of a cost-effective process for removing fuel contaminants would allow for fuel flexibility

Reductions in the costs of modifications needed for use of biogas are needed to facilitate widespread commercialization

Biogas Clean-up Impacts on Fuel Cell Costs

- Clean-up components are customized for impurity species and concentrations
- Impurity concentrations vary
- Sorbents used for removal have limitations
  - Low capacity
  - Combination of several sorbents are necessary
  - Presence of moisture, HCs reduce capacity
- Inadequate online sensors increase costs
  - Oversizing of media beds
  - Early switching (underuse of media) to prevent breakthrough
- Some spent media are hazardous and costly to dispose

Existing strategies can meet removal targets but increase capital costs 50%-100%

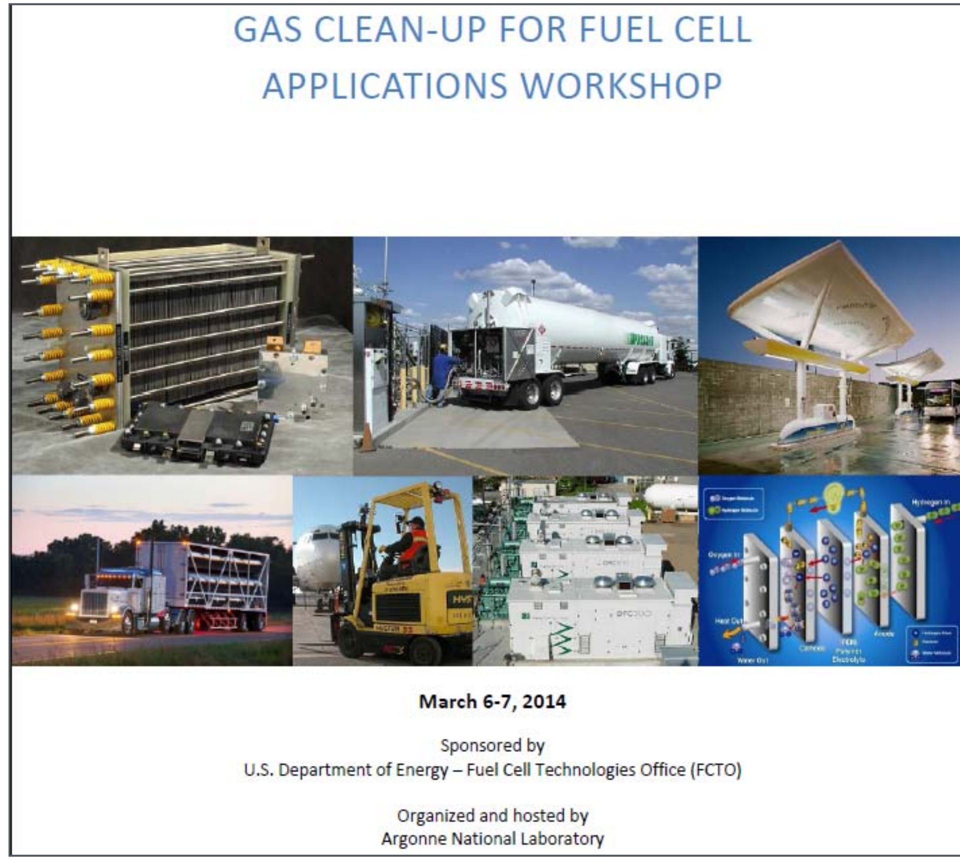
Key Impurities

- Sulfur
  - Corrosive, affects catalyst and electrolyte
  - Rapid initial followed by slower voltage decay
  - More severe effect with CH_4/CO rich fuels to fuel cell and anode recirculation
  - Tolerance limits of 0.5-5 ppm
  - Effect may be recoverable
- Siloxanes
  - Fouls surfaces (e.g., sensors, catalysts)
  - Thermally decompose forming glassy layers
  - Few studies of effects on fuel cells, but tolerance limits may be practically zero
- Halogens
  - Corrosive, affects electrolyte
  - Long term degradation effect
  - Tolerance limits of 0.1-1 ppm

Sulfur, Siloxanes, and Halogens damage fuel cell materials and are costly to remove

R&D Needs Identified at Recent Workshop

- Analysis indicates using biogas instead of natural gas for fuel cells adds ~$2400/kw to the installed cost status. R&D needs to address this include:
  - Affordable analytical equipment for rapid onsite analysis
  - Higher capacity sorbents
  - Methods to convert fuel impurities or spent sorbents into useful byproducts



GAS CLEAN-UP FOR FUEL CELL APPLICATIONS WORKSHOP

March 6-7, 2014

Sponsored by
U.S. Department of Energy – Fuel Cell Technologies Office (FCTO)

Organized and hosted by
Argonne National Laboratory

Workshop report and RFI: closes July 1, 2015

http://energy.gov/eere/fuelcells/articles/doe-issues-request-information-gas-clean-fuel-cell-applications

Seeking removal strategies that can reduce plant complexity, reduce cost, and improve plant durability

Utilization of bioderived feedstocks

Bio-Fueled Solid Oxide Fuel Cells

TDA Research, Inc.

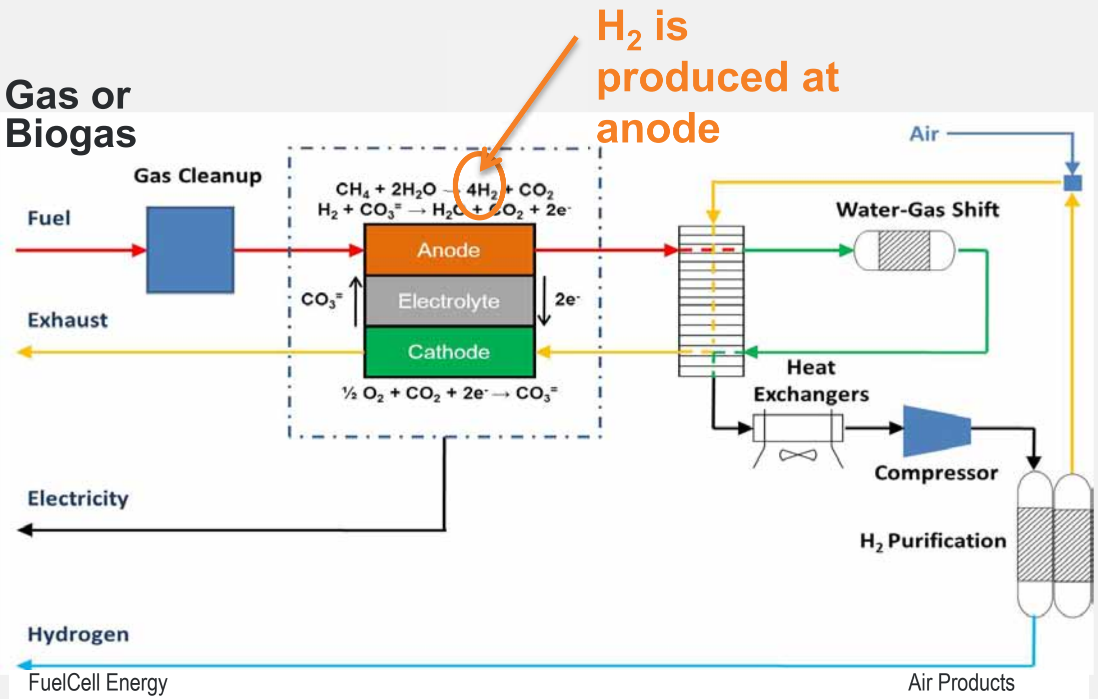
Cal-Denier Dairy in Galt, CA: prototype testing site

Skid-mounted field-deployable prototype biogas clean-up system

Gas clean-up system successfully treated 250,000 cubic feet of biogas containing 500 to 2,000 ppmv of H_2S.

Tri-Generation: Power, Heat and Hydrogen

- Demonstrated co-production of electricity and hydrogen with 54% efficiency
- Uses biogas from wastewater treatment plant



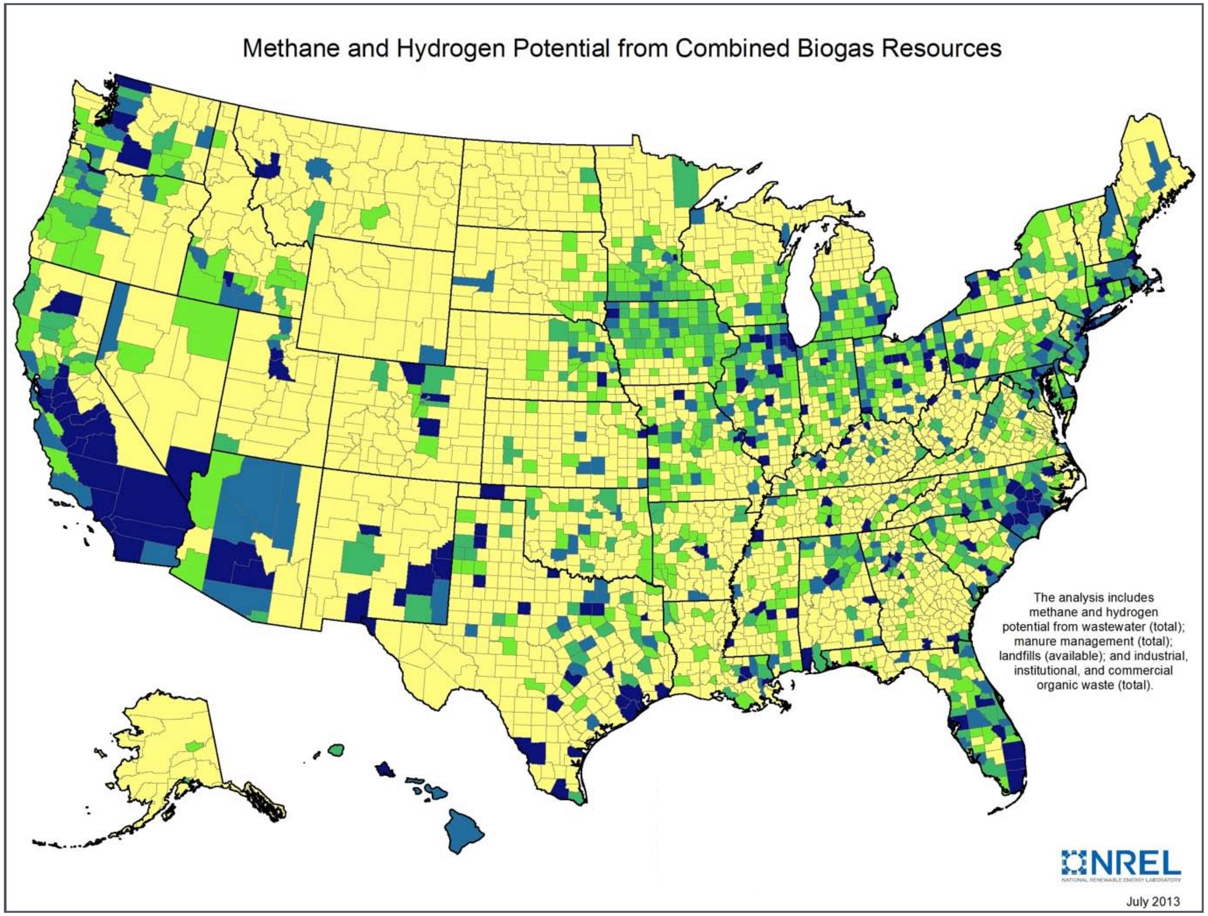
Co-funded by DOE/FCTO and multiple partners

Fountain Valley completed demonstration

- ~250 kW of electricity
- ~100 kg/day hydrogen capacity (350 and 700 bar), enough to fuel 25 to 50 vehicles.

World's first fuel cell and hydrogen energy station demonstrated in Orange County

Renewable Hydrogen From Biogas



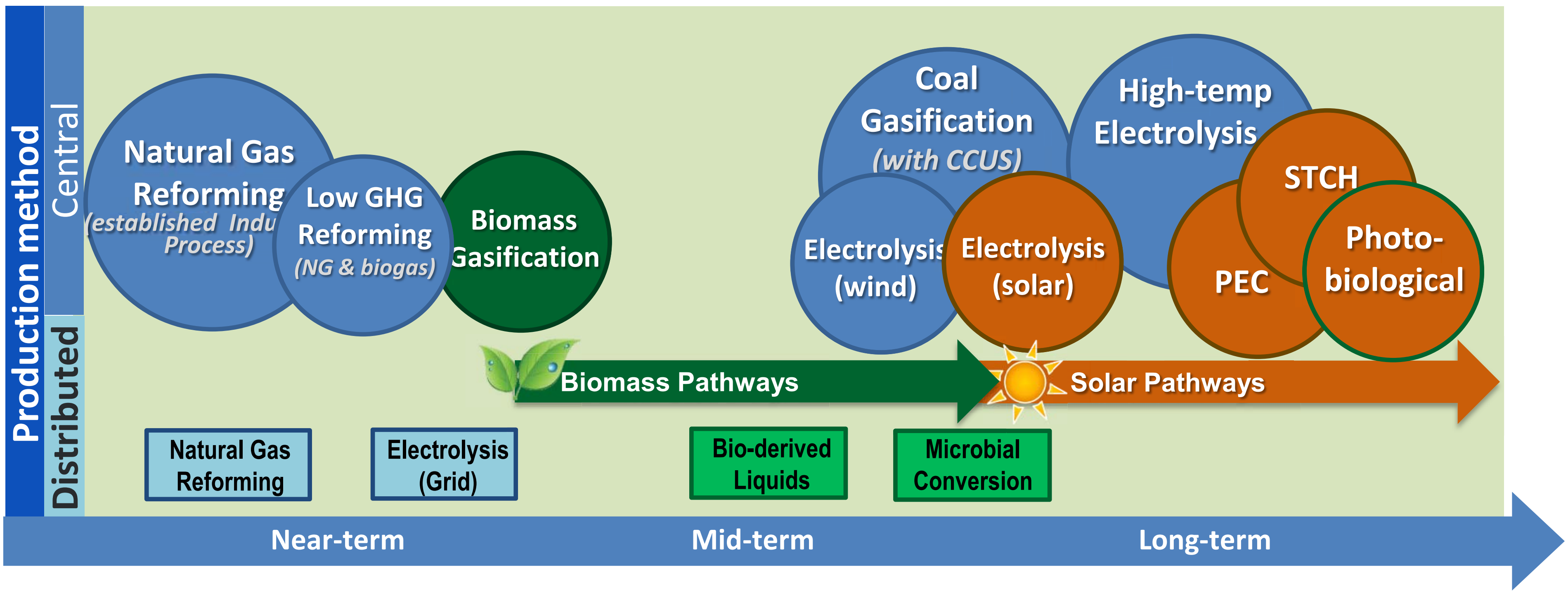
Methane potential in tonnes
(Hydrogen potential in tonnes)

- > 10,000 (> 2,670)
- 5,000 - 10,000 (1,149 - 2,670)
- 2,500 - 5,000 (660 - 1,149)
- 1,000 - 2,500 (264 - 660)
- < 1,000 (< 264)

- Hydrogen from biogas is already available in California due to incentives for renewable fuels

Significant opportunities across the country for renewable hydrogen from biogas

Hydrogen Production Pathways



Hydrogen can be produced from diverse, domestic resources, including renewables

Next Steps

- Fuel cells and biogas
  - Technologies to reduce the cost of clean-up need to be developed to enable widespread commercialization of fuel cell systems capable of using biogas
  - To provide feedback on the Gas Clean-Up for Fuel Cell Applications Workshop report, respond to the RFI – due July 1st
- Renewable hydrogen production
  - Applied RD&D in materials & devices to address efficiencies, performance, durability, cost, and safety for renewable hydrogen production options
  - System-level innovations including renewable integration schemes, tri-generation, balance-of-plant improvements, etc.
  - Continued resource assessments to identify near-term regional solutions and a long-term sustainable portfolio of cost-competitive hydrogen production and delivery options

Ongoing R&D in the Fuel Cell Technologies Office addresses barriers for renewable fuel cell energy technologies

Thank You

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hydrogenandfuelcells.energy.gov