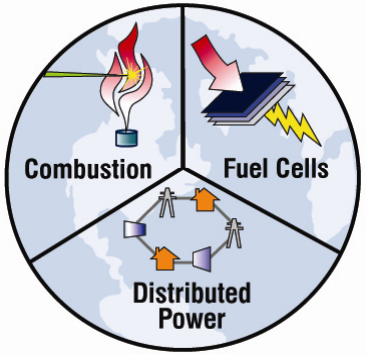
Hydrogen and Fuel Cell Technology: Status and Opportunities

IEPR Transportation Workshop No. 2

Advanced Power and Energy Program
University of California, Irvine



Brendan Shaffer
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Hydrogen and Fuel Cells

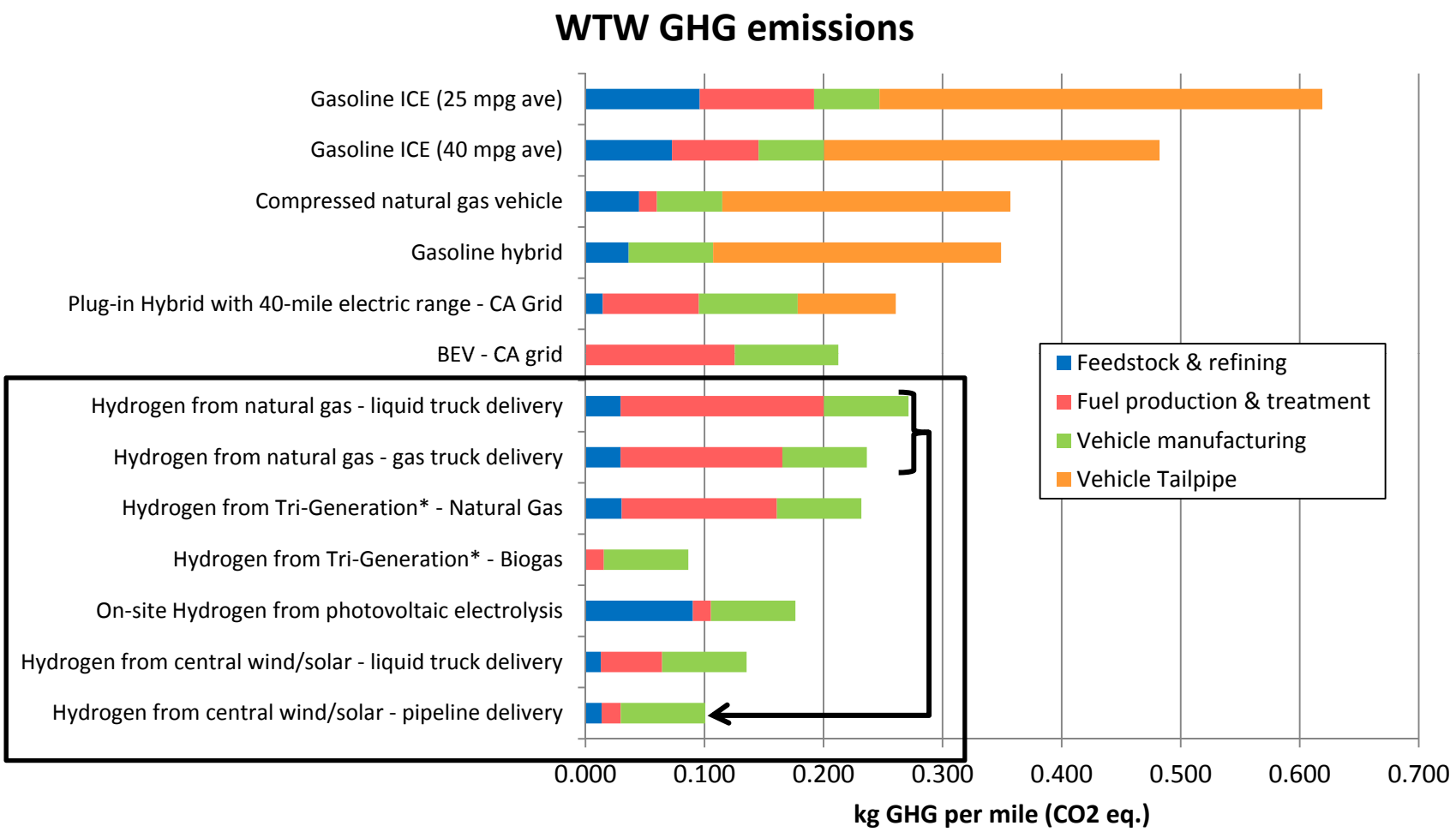
- **Air quality issues and climate change require ZEVs**
  - → **FCEVs, BEVs**

- **Electrification of LDVs provides opportunities for grid support**

- **Grid will require NG and BG resources to support operation**
  - → **Fuel Cells**
  - → **TIGER Stations**

- **Grid will require storage to avoid excessive curtailment at high penetration**
  - → **Battery**
  - → **Hydro**
  - → **Hydrogen**

HYDROGEN SUPPLY CHAIN ANALYSIS



http://www.apep.uci.edu/3/research/pdf/SustainableTransportation/WTW_vehicle_greenhouse_gases_Public.pdf

FCEV GHG Reduction Potential

Dual Sector Analysis – Transportation and Electric Systems

FCEVs provide large potential for GHG reduction

- **60% FCEV penetration at 60% Renewable penetration**

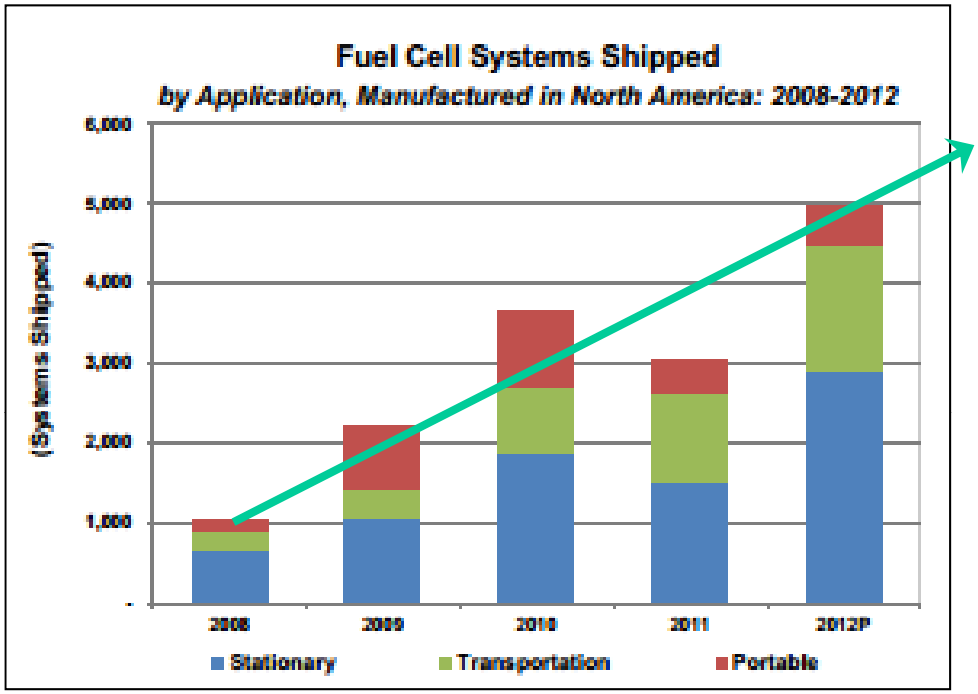
  → enables 60% reduction in GHG

Central Dispatch of Electrolysis Can Reduce Curtailment

- **H_2 Fueling Infrastructure portends large storage potential**

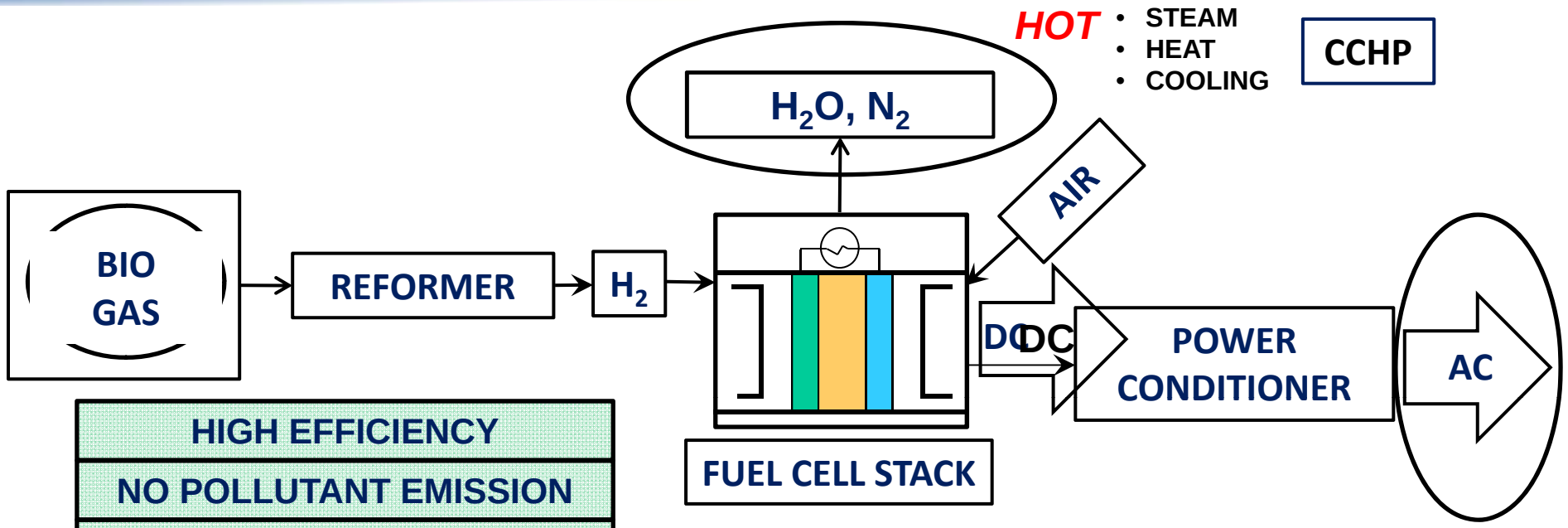
  → To support grid balancing operations at high renewable penetrations

Fuel Cell System Shipments – North America



Source: US DOE, 2012 Fuel Cell Technologies Market Report, October 2013.

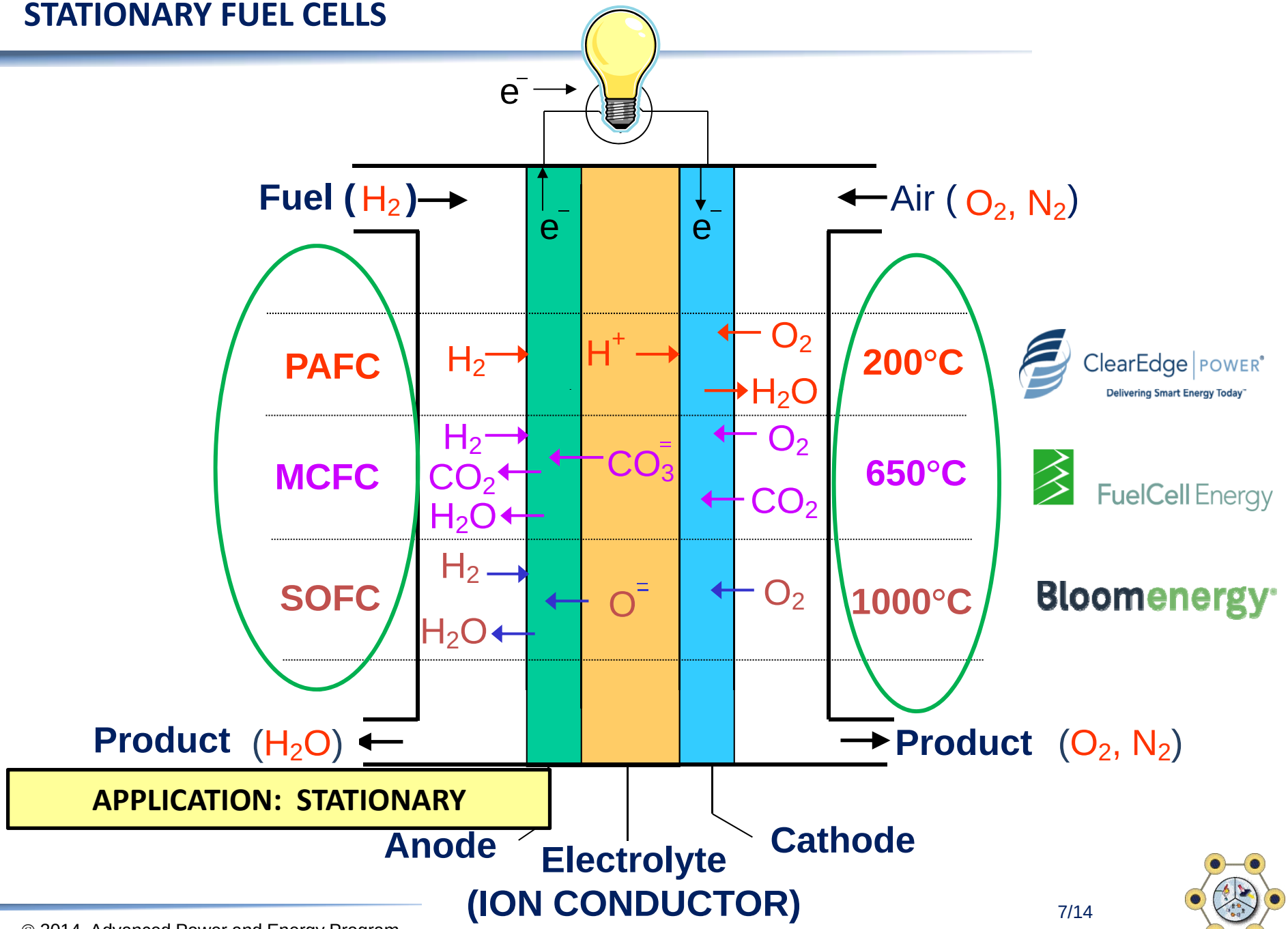
STATIONARY FUEL CELLS



- HIGH EFFICIENCY
- NO POLLUTANT EMISSION
- ACOUSTICALLY BENIGN
- HIGH QUALITY HEAT
- NO WATER CONSUMPTION
- RELIABLE, 24/7 OPERATION
- POWER QUALITY

APPLICATION: STATIONARY

STATIONARY FUEL CELLS



ClearEdge POWER
Delivering Smart Energy Today

FuelCell Energy

Bloomenergy

STATIONARY FUEL CELLS

STATIONARY FC DEPLOYMENTS

- NATURAL GAS 38
- RENEWABLE 43

TOTAL = 81 MW

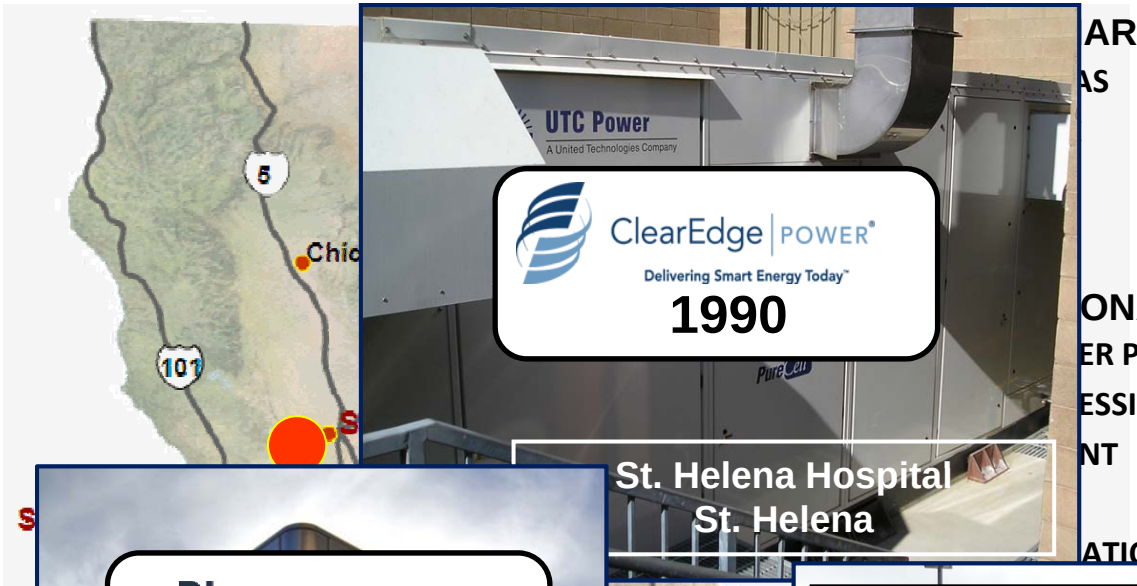
STATIONARY FC MARKETS

- WASTEWATER PLANTS
- FOOD PROCESSING
- GOVERNMENT
- HOSPITALS
- COMMUNICATIONS
- GROCERY STORES
- HOTELS
- BREWERIES
- UNIVERSITIES
- INDUSTRIES
- UTILITIES
- MANUFACTURING

SOURCE: SGIP

APPLICATION: STATIONARY

STATIONARY FUEL CELLS



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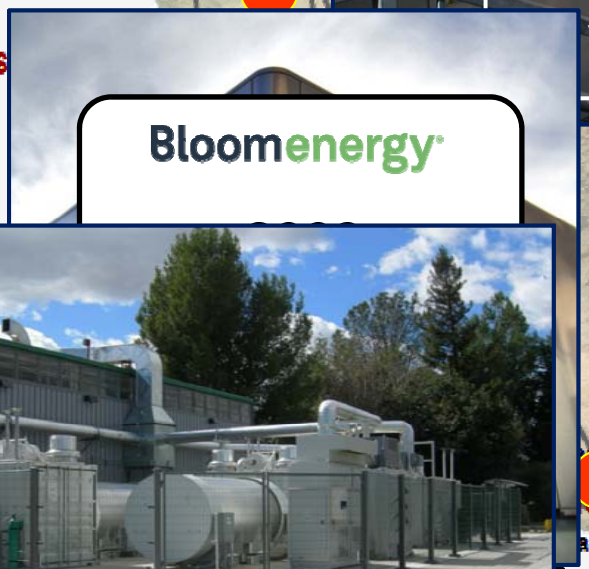
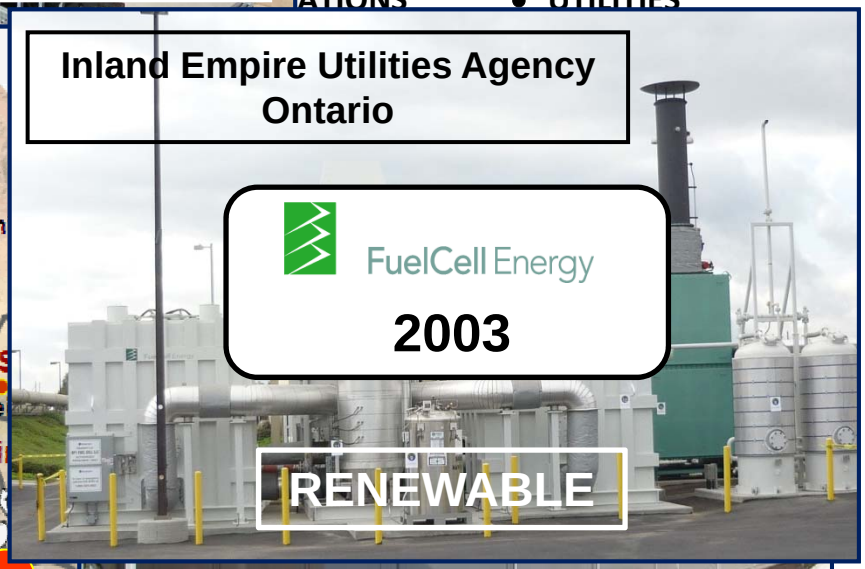
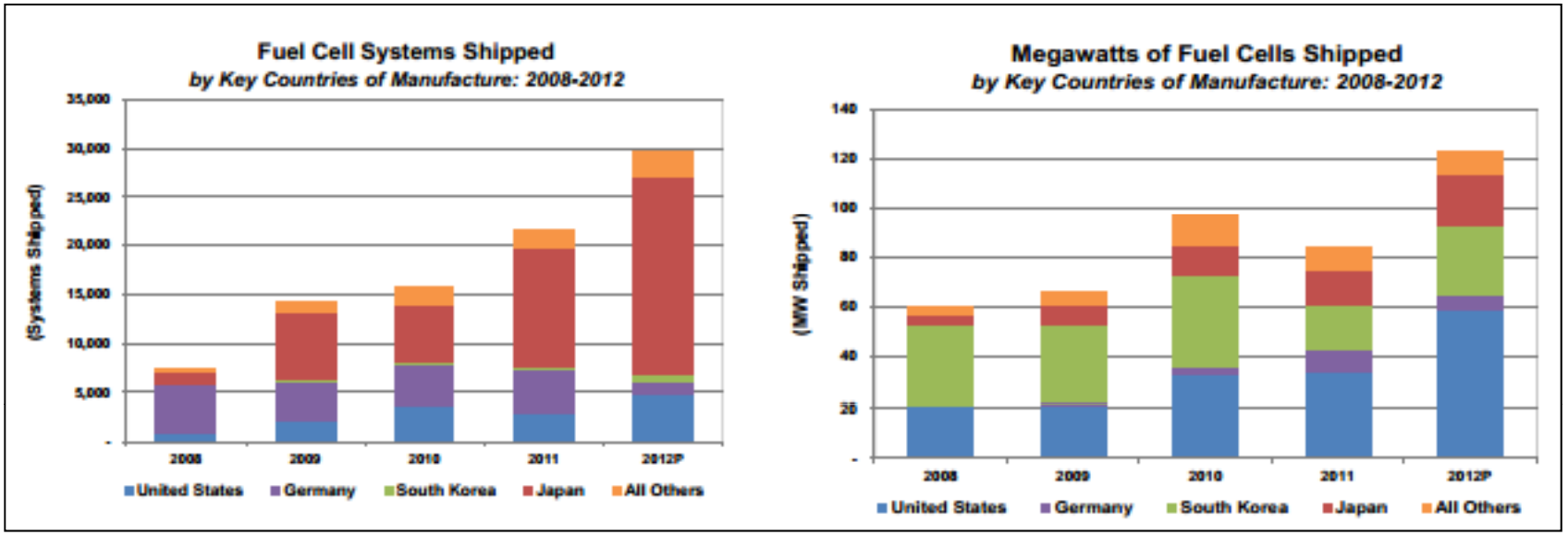




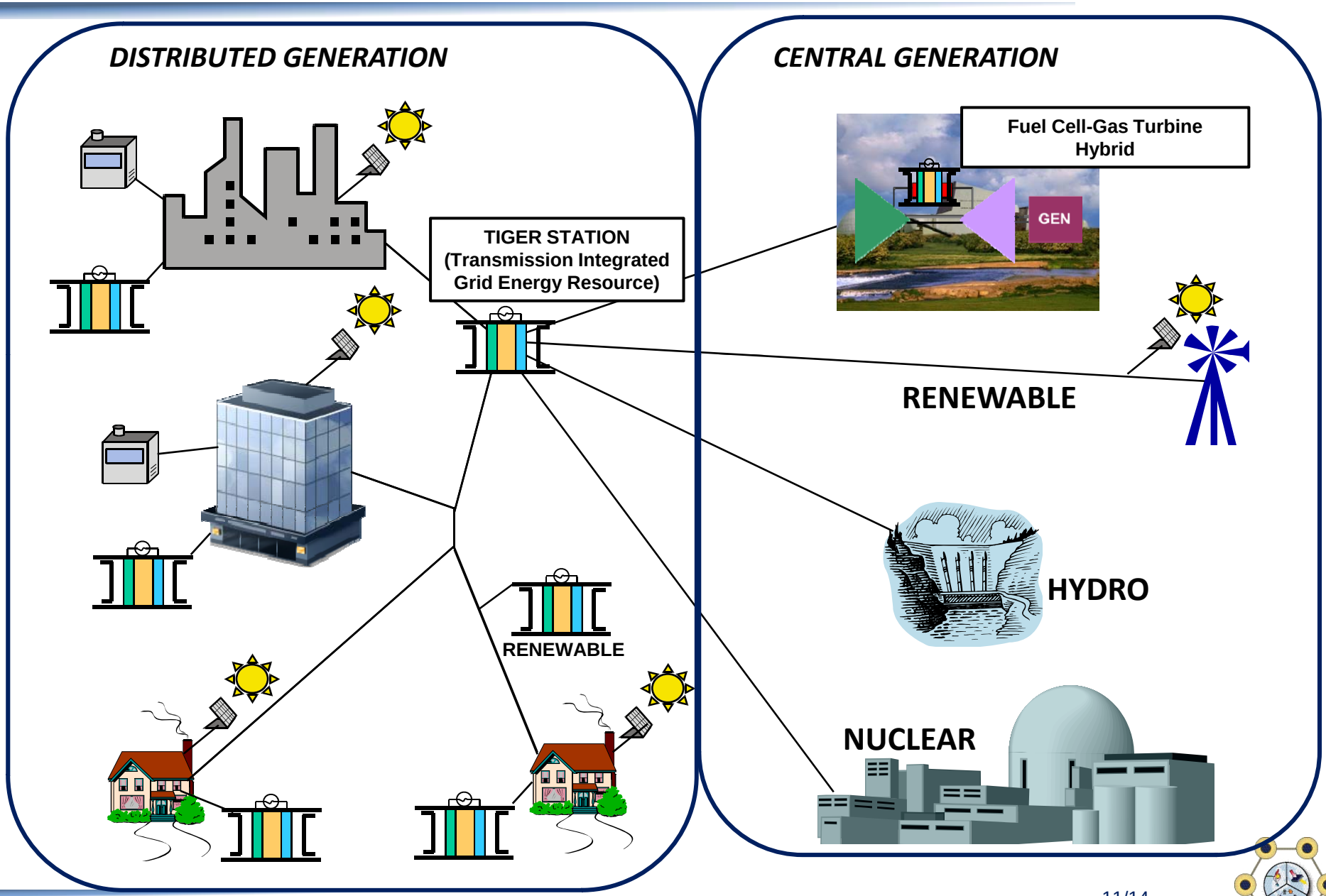
STATIONARY FUEL CELL SHIPMENTS



Source: US DOE, 2012 Fuel Cell Technologies Market Report, October 2013.

- **US, South Korea, and Japan major markets**
- **Japan → many small units**
- **South Korea → a few large units**

STATIONARY FUEL CELLS



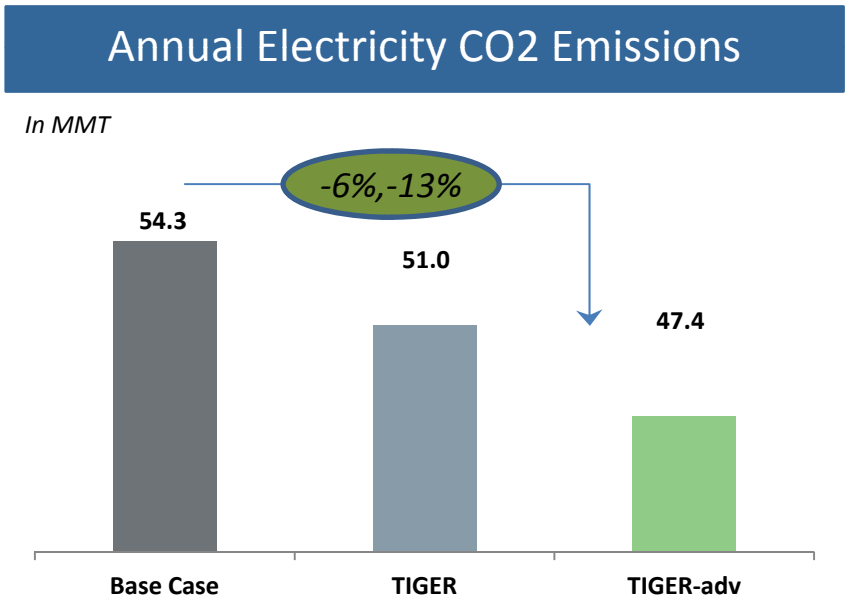
STATIONARY FUEL CELLS

STATIONARY FUEL CELLS

TIGERs to Support GHG Reduction Targets

CA Grid Modeling → CO_2 Emissions

- **Base Case:** **33% Renewable Penetration,** **No Coal**
- **5GW Deployment of TIGER stations (NG fueled)**



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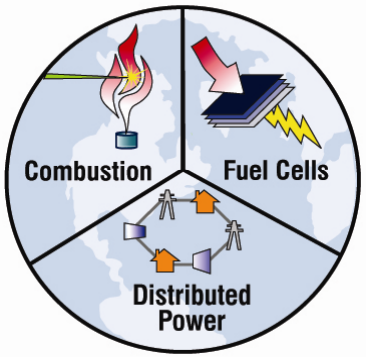

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