

Fuel Cell Technologies and Their Markets

Robert Rose
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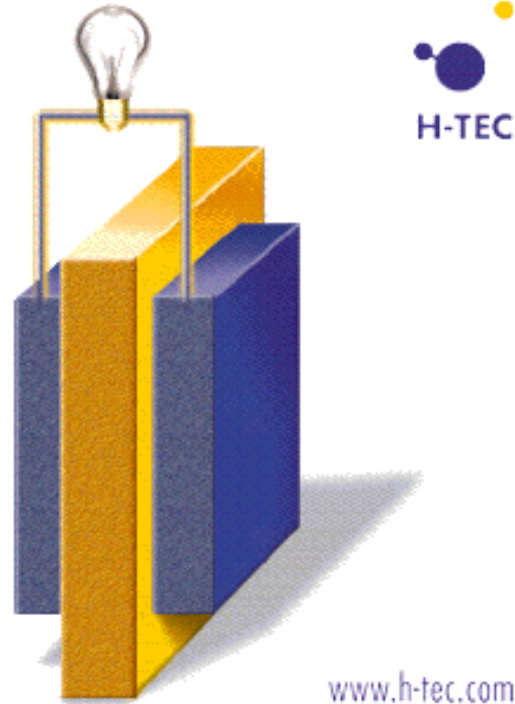


Fuel Cells 2000 / BTI

- U.S. nonprofit organization
- Leading non-aligned source for fuel cell information since 1993
- Award-winning services
- Education through outreach/publications/website
- www.fuelcells.org
- www.fuelcellinsider.org

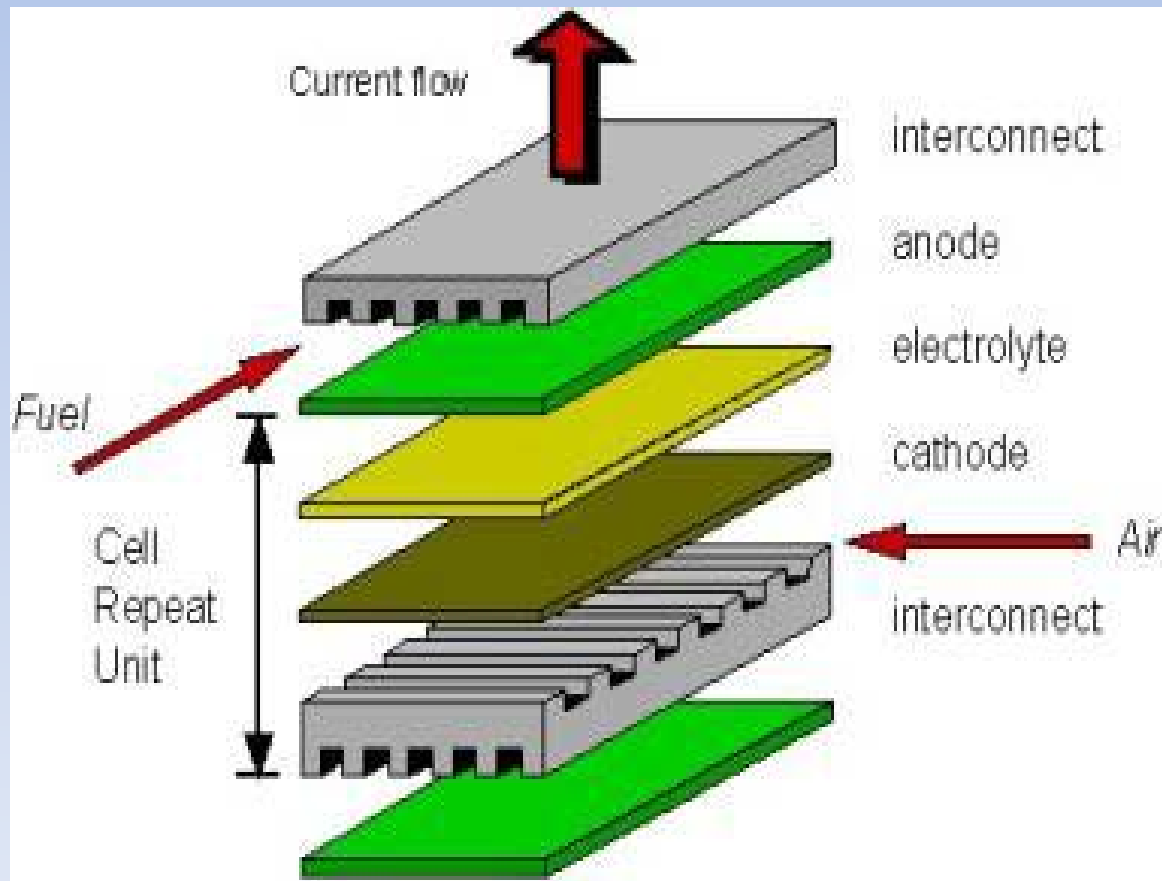


Inside a Fuel Cell

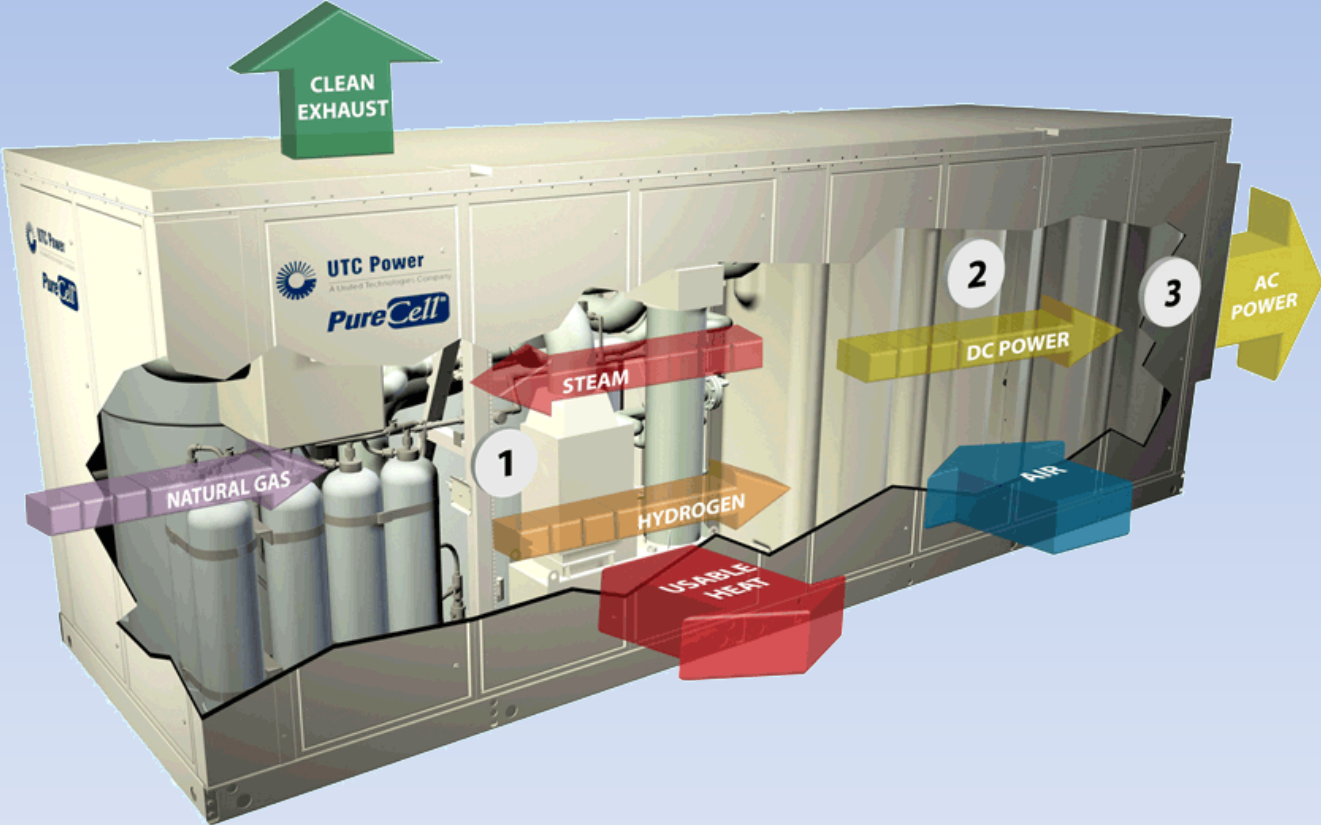


Fuel Cells Stacks

Since each cell generates less than 1 volt, cells are “stacked” in series to increase voltage

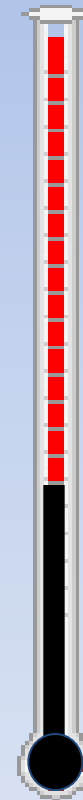


Fuel Cell System



A Family of Technologies

<u>Type</u>	<u>Efficiency</u>	<u>Operating Temp.</u>
Solid Oxide	45-65%	800°C+
Molten Carbonate	50%	650°C
Phosphoric Acid	40%	200°C
Alkaline	50-60%	80°C
Direct Methanol	40%	80°C
Polymer (PEM)	40%	50°C

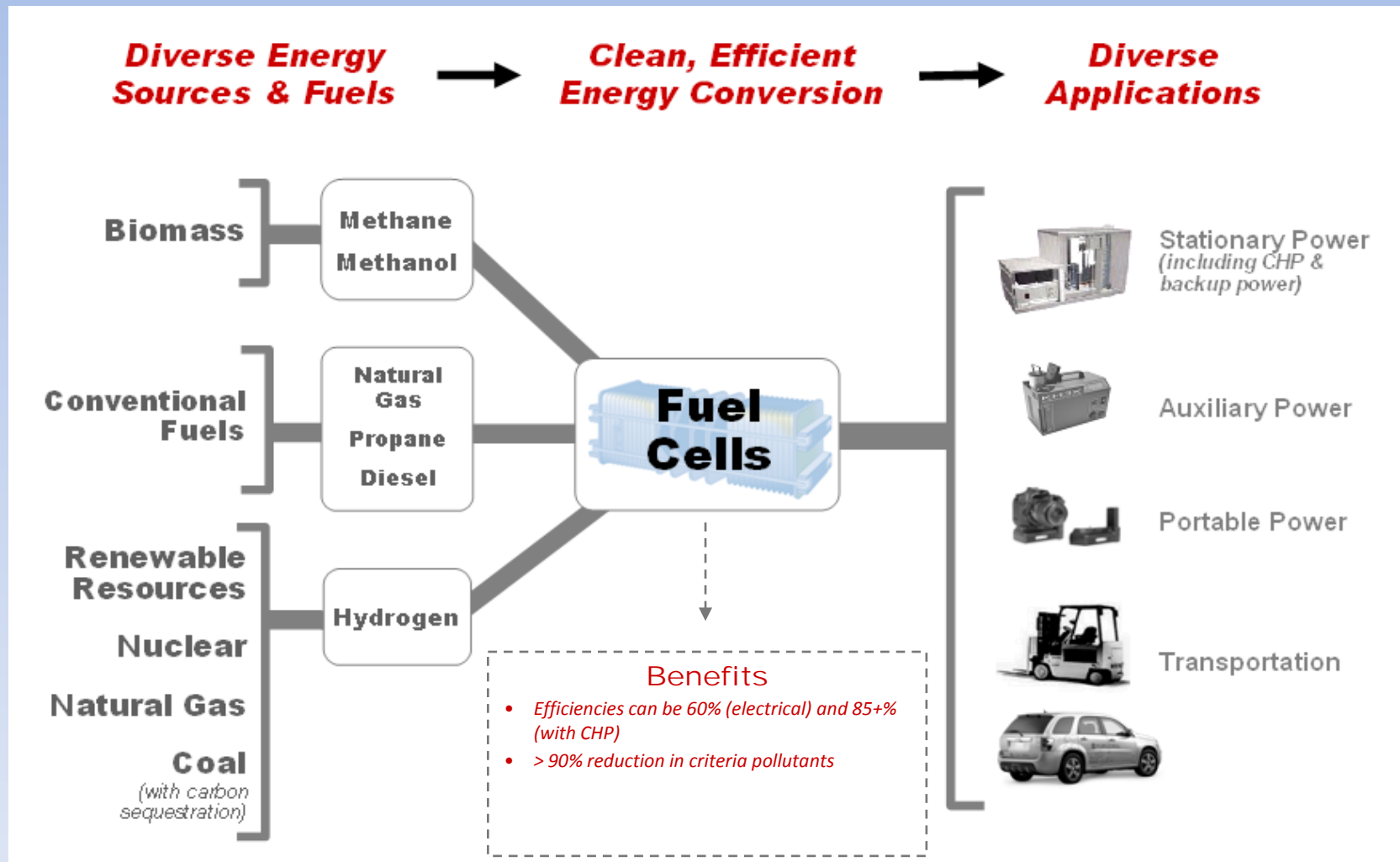


Fuel Cells: Naturally Cleaner

No other energy technology offers the combination of benefits that fuel cells offer:

- ✓ Energy efficiency and resource diversity
- ✓ Emissions-free with renewable fuel
- ✓ Dramatically reduced CO₂ and other emissions with hydrocarbon fuel
- ✓ Exceptionally wide range of applications and fuels
- ✓ Modular/high reliability
- ✓ High quality power
- ✓ Quiet/few moving parts

Fuel Cells Enhance All Energy Options



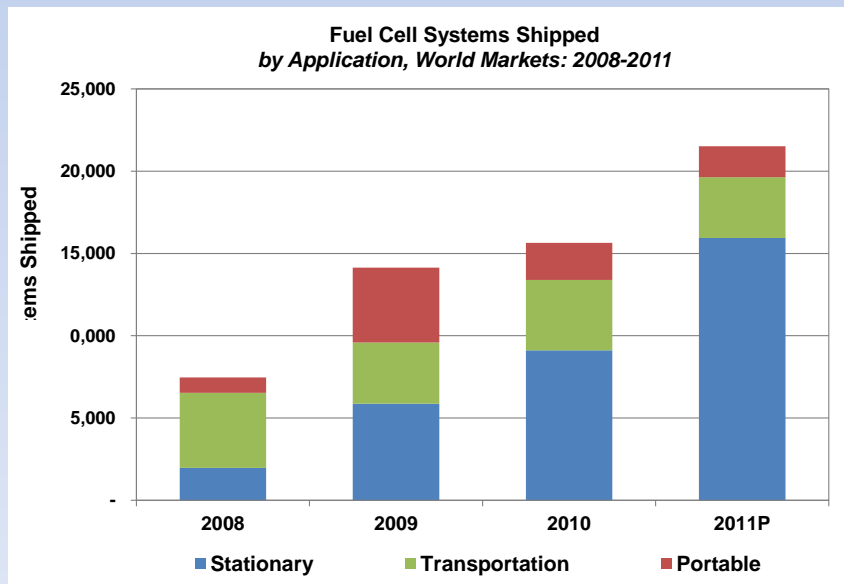
Industry Snapshot: Early Markets

Markets

- Commercial
- Industrial
- Individual/School
- Gov't /Military

Products

- CHP or prime power
- Grid connect or off grid
- Backup power
- Grid support/storage
- Industrial vehicles
- Battery chargers
- Military/Specialty
- Educational
- Recreation



Source: Pike Research (Copyright 2011)

Systems You Can Buy Today

Available:

- ✓ 100 - 400 kW, 1 MW+ CHP and prime power
 - ✓ Multi-megawatt available with scaling
- ✓ Material Handling Equipment
- ✓ 1-50 kW Generators
- ✓ Educational Units
- ✓ Battery Chargers, Range Extenders, APUs
- ✓ 1-5 kW Residential Units

Pre-Commercial Advanced Demonstrations:

- ✓ Various Specialty Sizes (PEM, SOFC)
- ✓ Small Portable (PEM, DMFC)
- ✓ Passenger Cars, Buses, Specialty Vehicles

Power Generation

Stationary Fuel Cells in the Field

Commercial

- Agribusiness
- Grocery Store
- Restaurant
- Data Center

Municipal

- Office
- School
- Hospital
- Waste
Treatment

Residential

- Home CHP
- Multi-Family

Power Generation Systems



Big Name Customers

- Coca-Cola
- Whole Foods
- Kaiser Permanente
- Google
- eBay
- Walmart
- Hilton Hotels
- Cabela's
- Sprint



Fuel Cells and the Grid

Location	Fuel Cell System	Grid Independence
Central Park Police HQ	UTC Power PC25 – 200 kW	100 %
The Octagon	UTC Power PC400 – 400 kW	100 %
Palace Hotel	ClearEdge5 – 10 kW	100 % (w/ PV)
Sonoma County Administrative Campus	FuelCell Energy – 1,400 kW	90 %
St. Helena Hospital	UTC Power PC400 – 400 kW	63 %
Whole Foods Market	UTC Power PC400 – 400 kW	50 %
Tulare WWTP	FuelCell Energy – 1,200 kW	45 %
Adobe Headquarters	Bloom Energy – 1,200 kW	30 %

Help Is Available

- Power purchase agreements (PPAs)
- Federal investment tax credit (30%)
- Federal hydrogen installation credit (\$30,000)
- Federal grants (FAA)
- State credits
- State/local incentives and grants
- Utility incentives and grants
- Net metering
- Renewable energy credits

Micro/Portable Fuel Cells

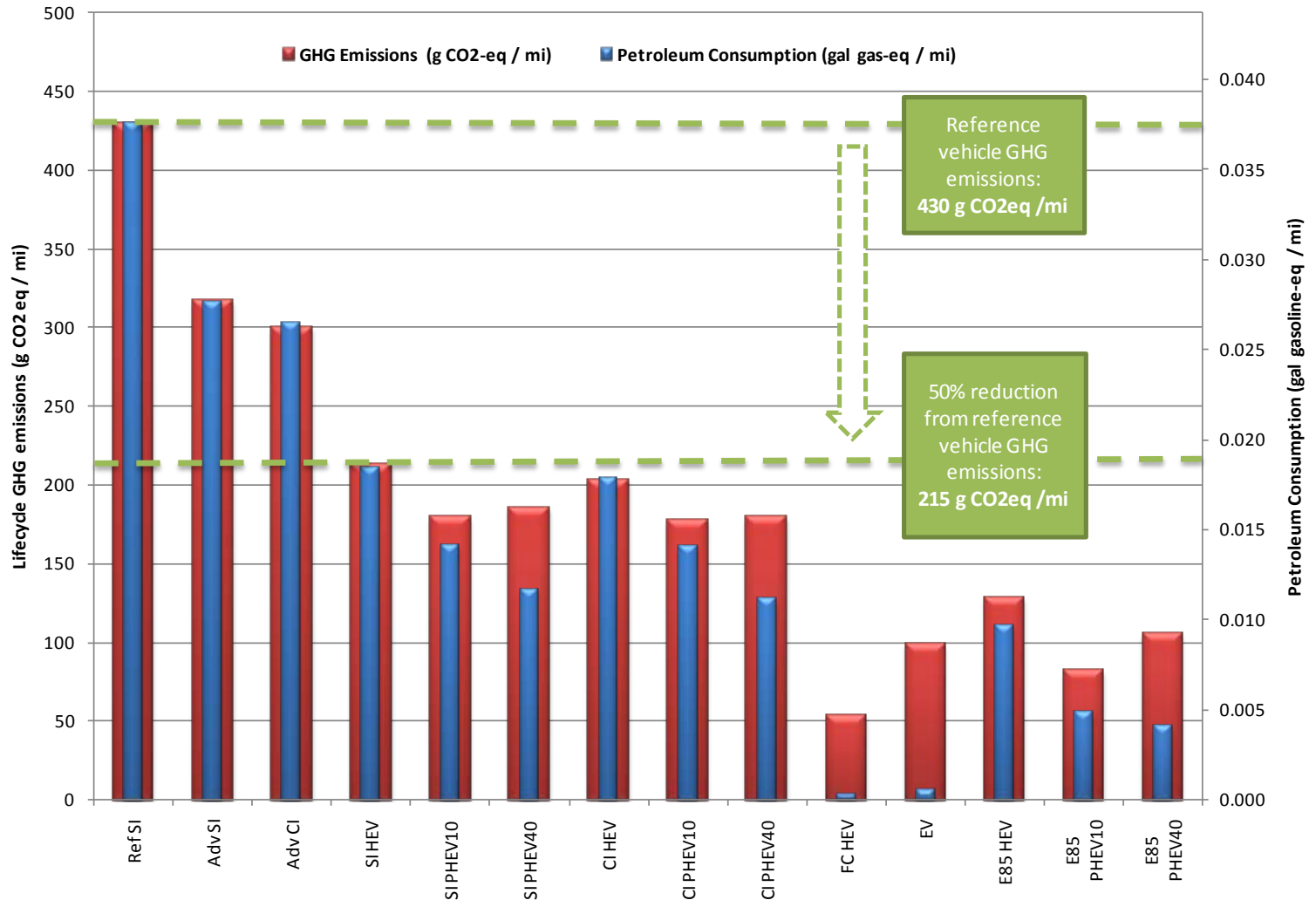


Motor Vehicles

FCVs Get Us Across the Goal Line

- Vehicle GHG emissions fall into 3 major groups:
- Conventional
- Electric-drive
- Combination electric-drive & biofuel
- Petroleum consumption loosely mirrors GHG emissions

GHG Emissions and Petroleum Consumption by Vehicle Technology



The Cars Are Coming...



Some Are Here Today

www.fueleconomy.gov

the official U.S. government source for fuel economy information

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Find a Car | Save Money & Fuel | Benefits | Your MPG | Advanced Vehicles & Fuels | About EPA Ratings | More...

- Fuel Cell Vehicles
- How Fuel Cells Work
- Benefits and Challenges
- Fuel Economy
- Videos
- Links

Recently Tested Vehicles

    |  Share

Fuel cell vehicles (FCVs) are not yet for sale in the United States. However, manufacturers are producing small fleets of FCVs for evaluation and have estimated the fuel economy of some vehicles using EPA test procedures. Fuel economy estimates and other information for recently tested vehicles are provided below.

**2012 Honda
FCX Clarity**



**2012 Mercedes-Benz
F-Cell**



Fuel Economy and Driving Range

Fuel Economy (miles/kg)

Note: One kg of hydrogen is roughly equivalent to one gallon of gasoline.

Hydrogen	
60	
Combined	
60 City	60 Hwy

Hydrogen	
52	
Combined	
52 City	53 Hwy

Hitting the Road

- Auto companies committed (2014-2015)
 - Daimler: 2014
 - Honda
 - Toyota
 - Hyundai: up to 1,000 this year, 10,000 by 2015
- GM will be “commercial ready”
- Nissan very active
- BMW & VW strong research programs
- California fleet > 50,000 by 2018.

Cars will follow the infrastructure

Infrastructure Emerging

Hydrogen Fueling Stations 2011 – All Kinds	
Europe	85
US-N. America	80
Asia-Pacific	47
Latin America	3
Total	215

LBST

	Open	Under Way	Planned	Desired 2015
Germany	12	4	20	50-100
Japan	12	3		100
Korea	13	5		43
California	8	15	9	68
Scandinavia	8	3		40 (15)

BTI

But . . .

Financing is a critical challenge

Vehicle Infrastructure

- H2Mobility:
 - Modular Stations
 - UK, France Signing on
- New \$18.7M Funding in CA



More Than Just Cars...



Fuel Cell Forklifts

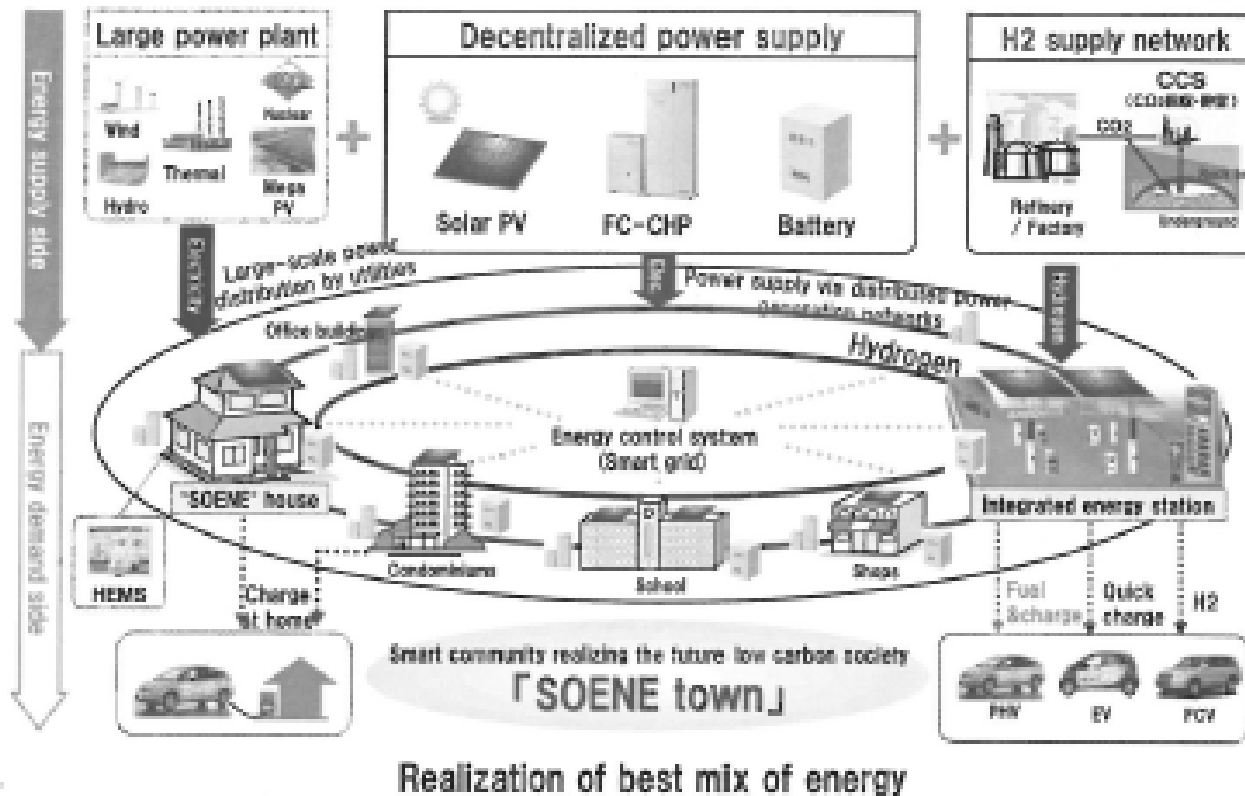


Aviation Potential



Japan: 3-11 Changes Everything

6-(8) Decentralized energy network under low carbon society

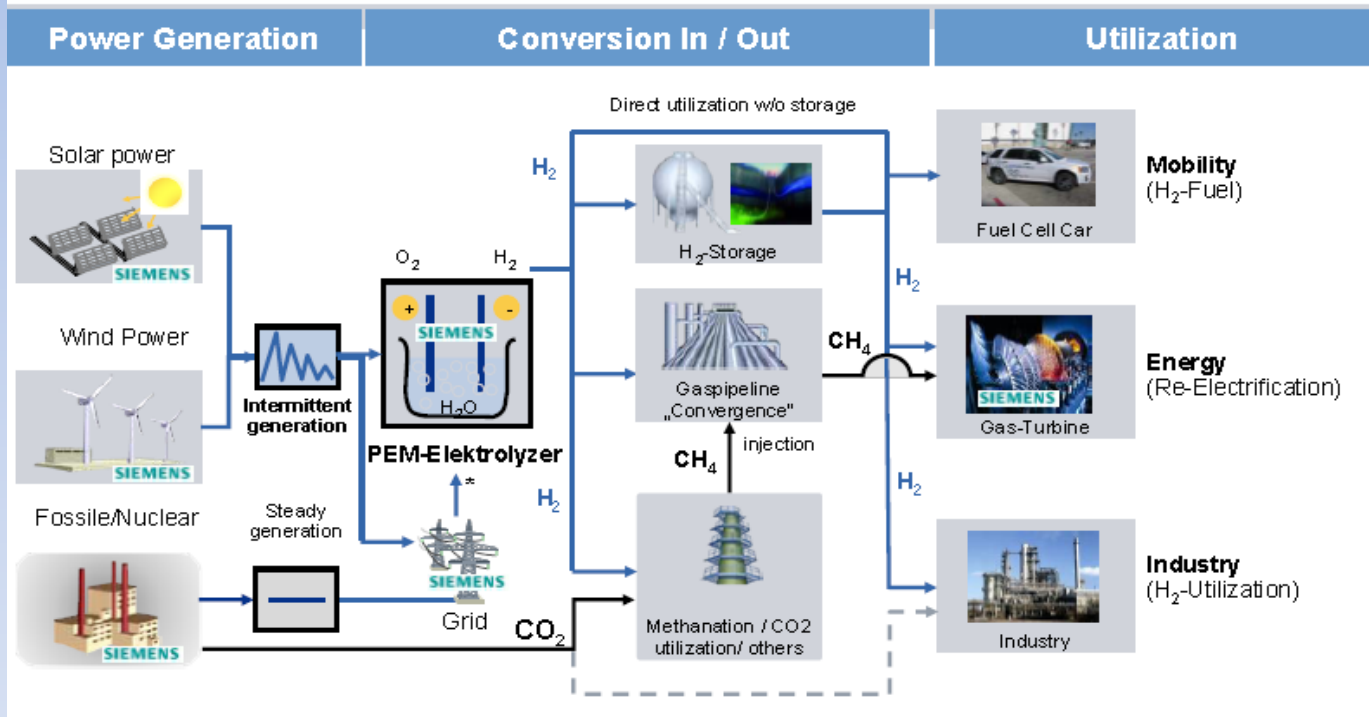


Siemens: An Integrated Future

Hydrogen as multi-fuel

Conversion of electrical into chemical power

SIEMENS



H₂ drives the convergence between energy & industry markets