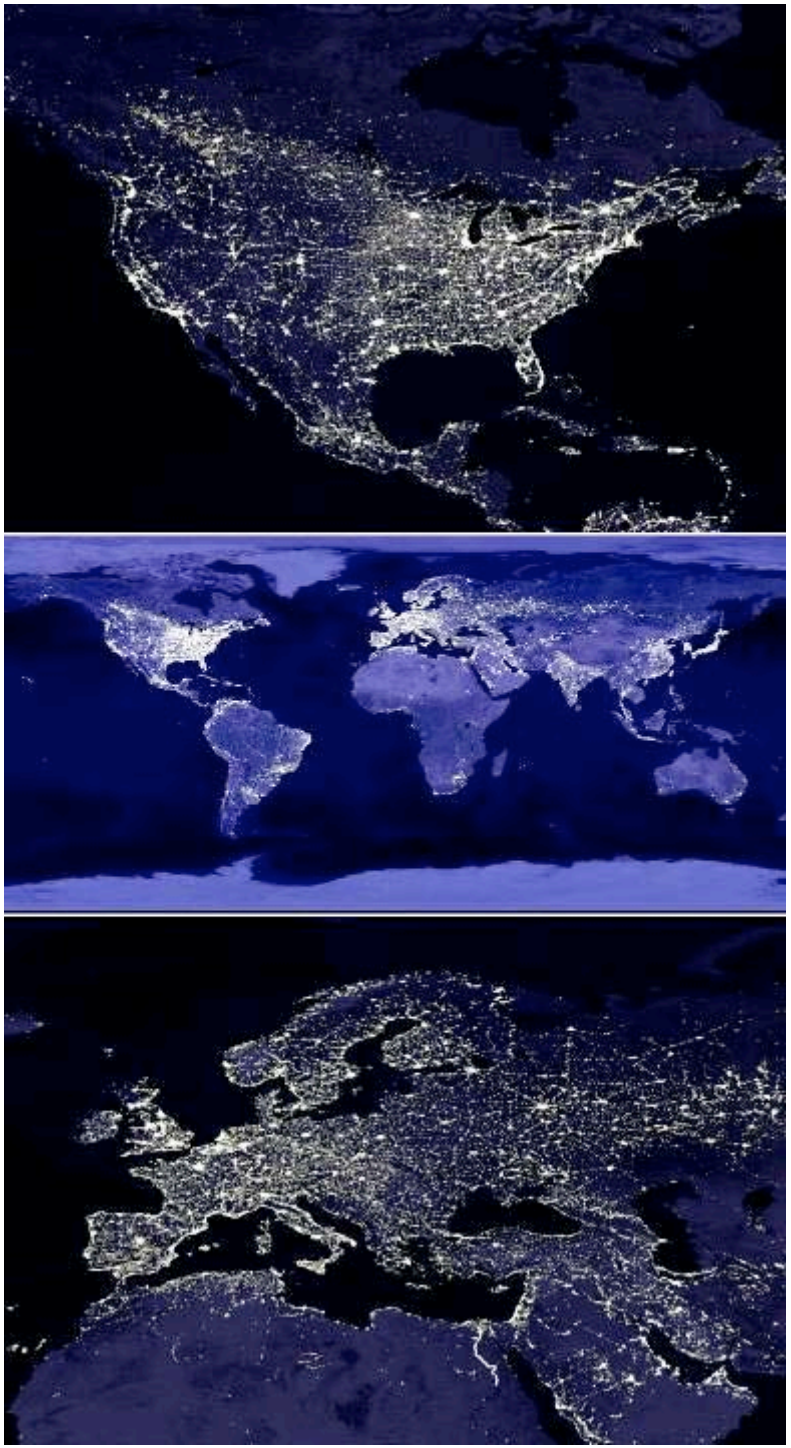

# Technology Advancements and New Concepts

## DOE Electrolysis-Utility Integration Workshop

Dan Smith
GE Global Research

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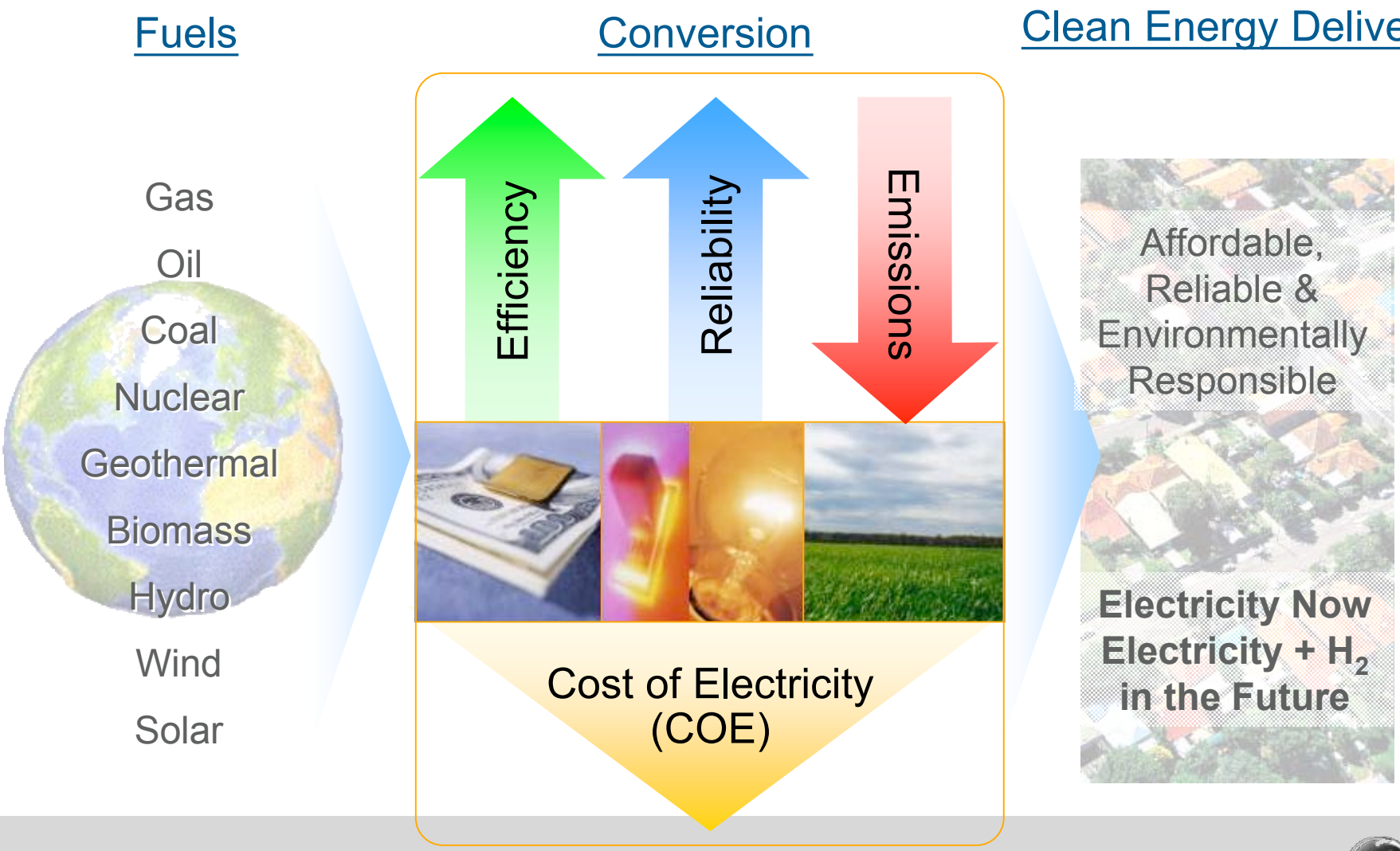
# Power Generation Technology Objectives

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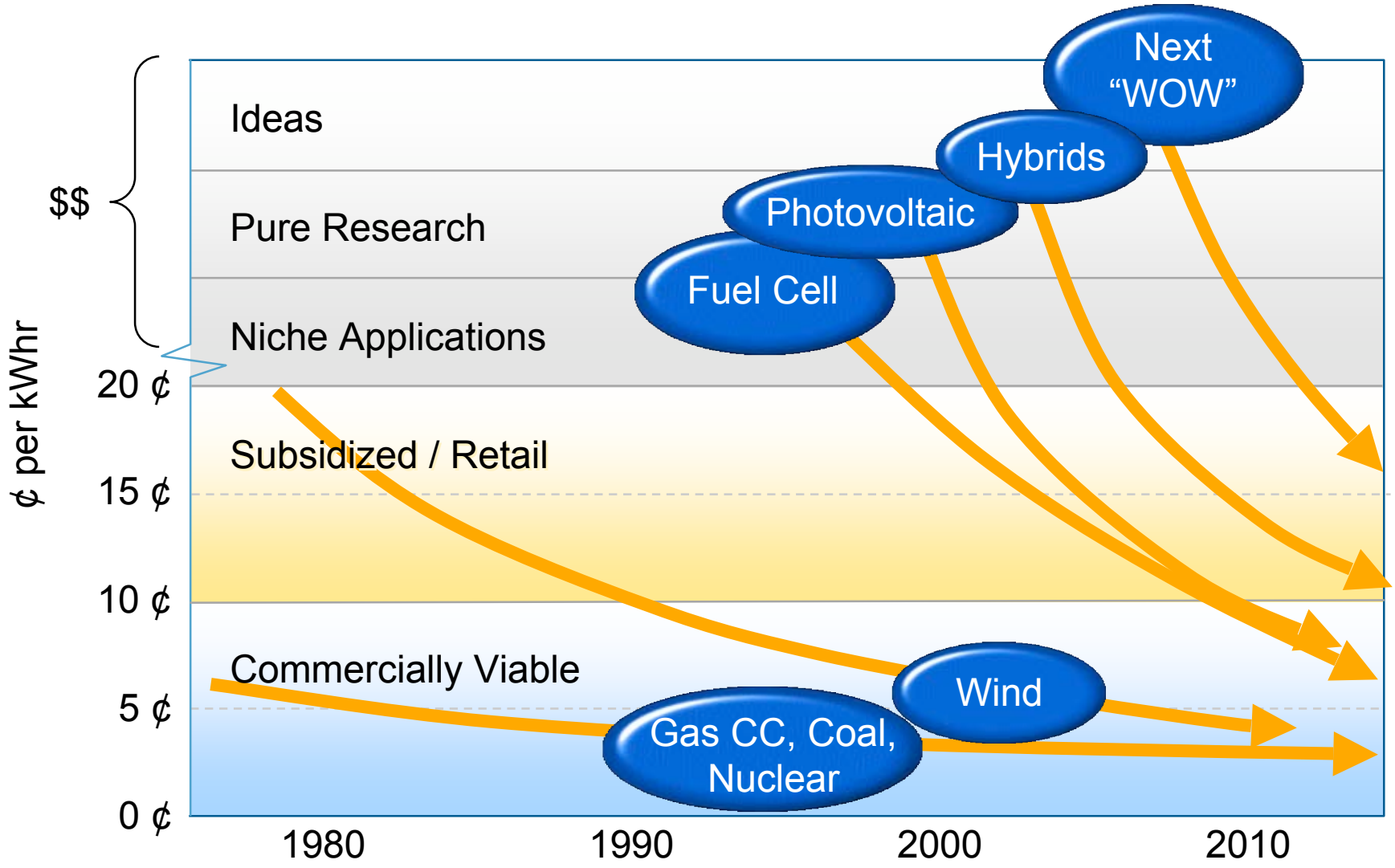
# Technology Reduces Cost of Energy

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# Utility Hydrogen … Polygeneration

**Coal**

**Advanced Nuclear**

## Hydrogen Benefits

- Energy / kg ≅ 3X NG & Gasoline
- Energy Emissions = Water
- Primary Energy Source Flexibility

## Enablers

- Electrochemistry
- Materials Science
- High Density Storage Systems

## Challenges

- Cost
- Low Energy / Volume
- Infrastructure Investment
- Global Codes & Standards

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# Utility Hydrogen Demand

- Hydrogen production, storage and electricity generation
  - Substation level, zero emissions, peak capacity additions
- Hydrogen Assisted Renewable Energy (HARP)
- Hydrogen-electricity Power Parks, Mini-grids, commercial sites
- Hydrogen-fueled, zero emissions CCHP
- Hydrogen for vehicle fueling
  - Utility vehicles and fleets
  - Fuel supply for municipal and industrial customers
  - Potential merchant hydrogen supply
- Hydrogen for internal uses i.e. generator cooling, emergency power

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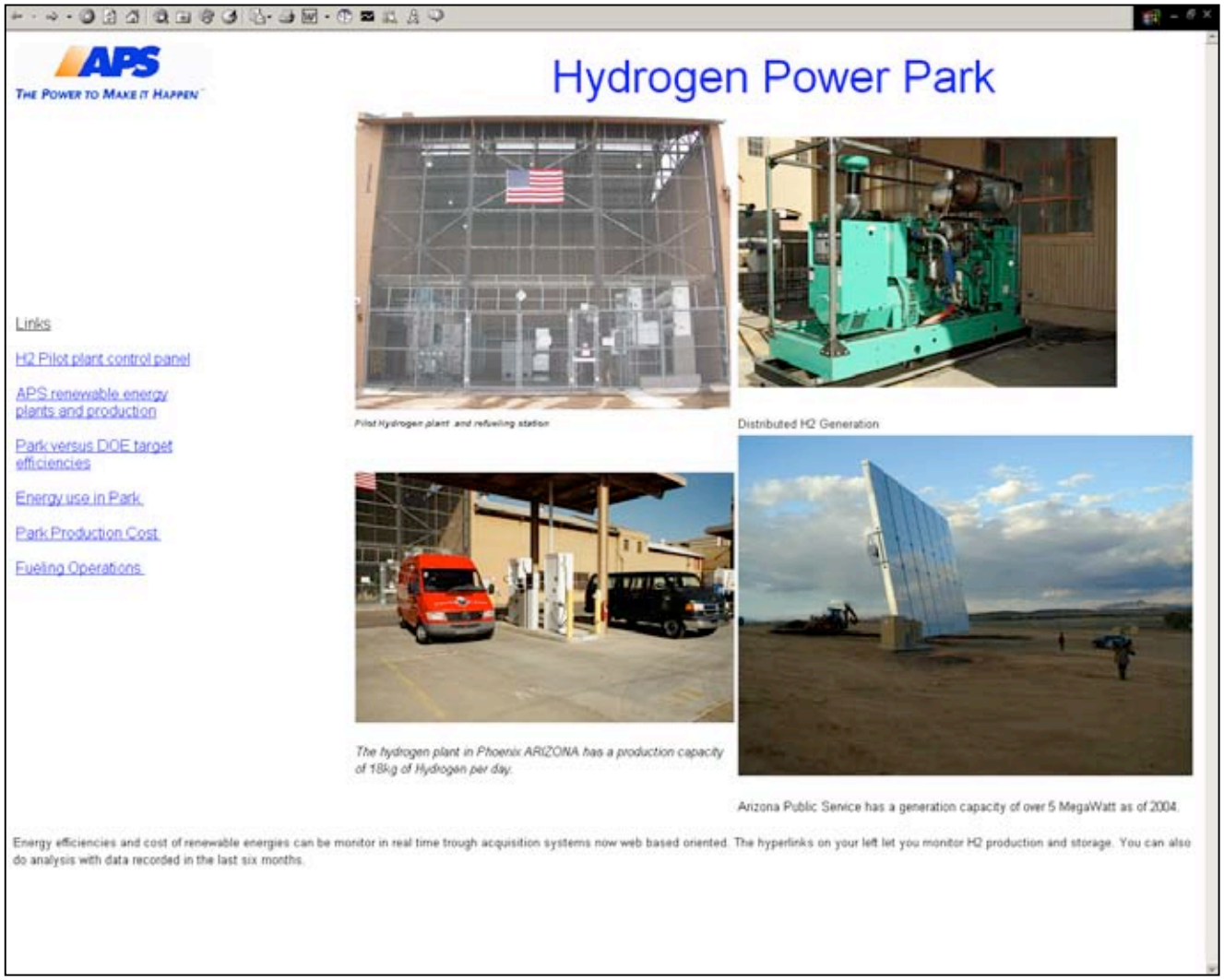
# APS Hydrogen Power Park

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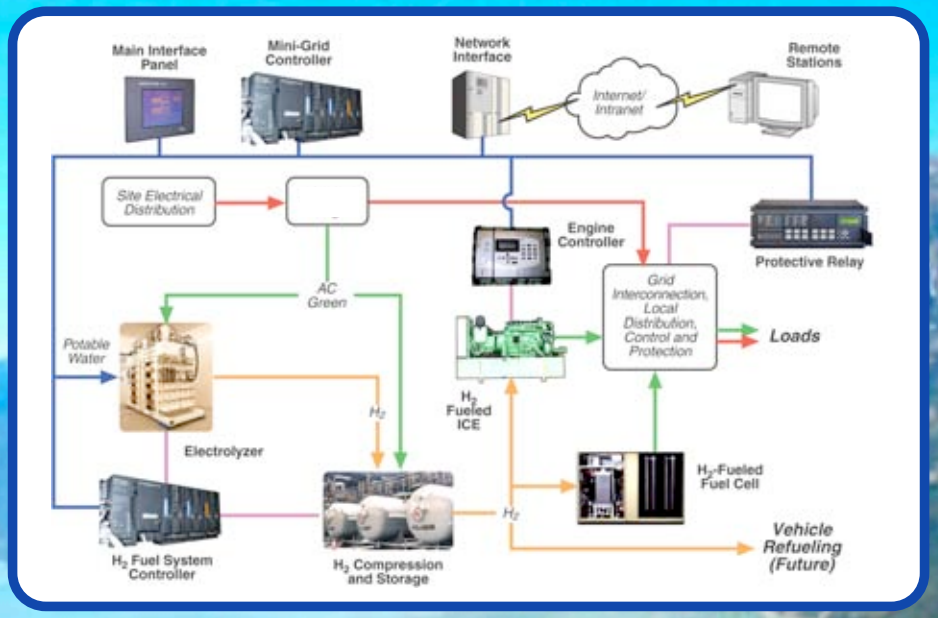
# HARP Hydrogen Assisted Renewable Power

**Replace diesel power generation with economically feasible, environmentally attractive hydrogen assisted renewable power**

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# Utility electrolysis vision

- MW-scale utility electrolyzers
- Affordable capital investment
  - Total system cost considerations
- Off-peak, wholesale electricity
  - Operated by utility
- Distributed, substation level operation
- Tightly integrated with electrical grid

***Hydrogen and electricity become the primary currencies in the future energy economy***

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# Challenges for electrolysis-based hydrogen production

Electricity cost and capacity

Capital cost

Equipment design and operation

- Unattended, remote operation
- Grid integration
- Utility RAM design basis

Electrical system integration strategy

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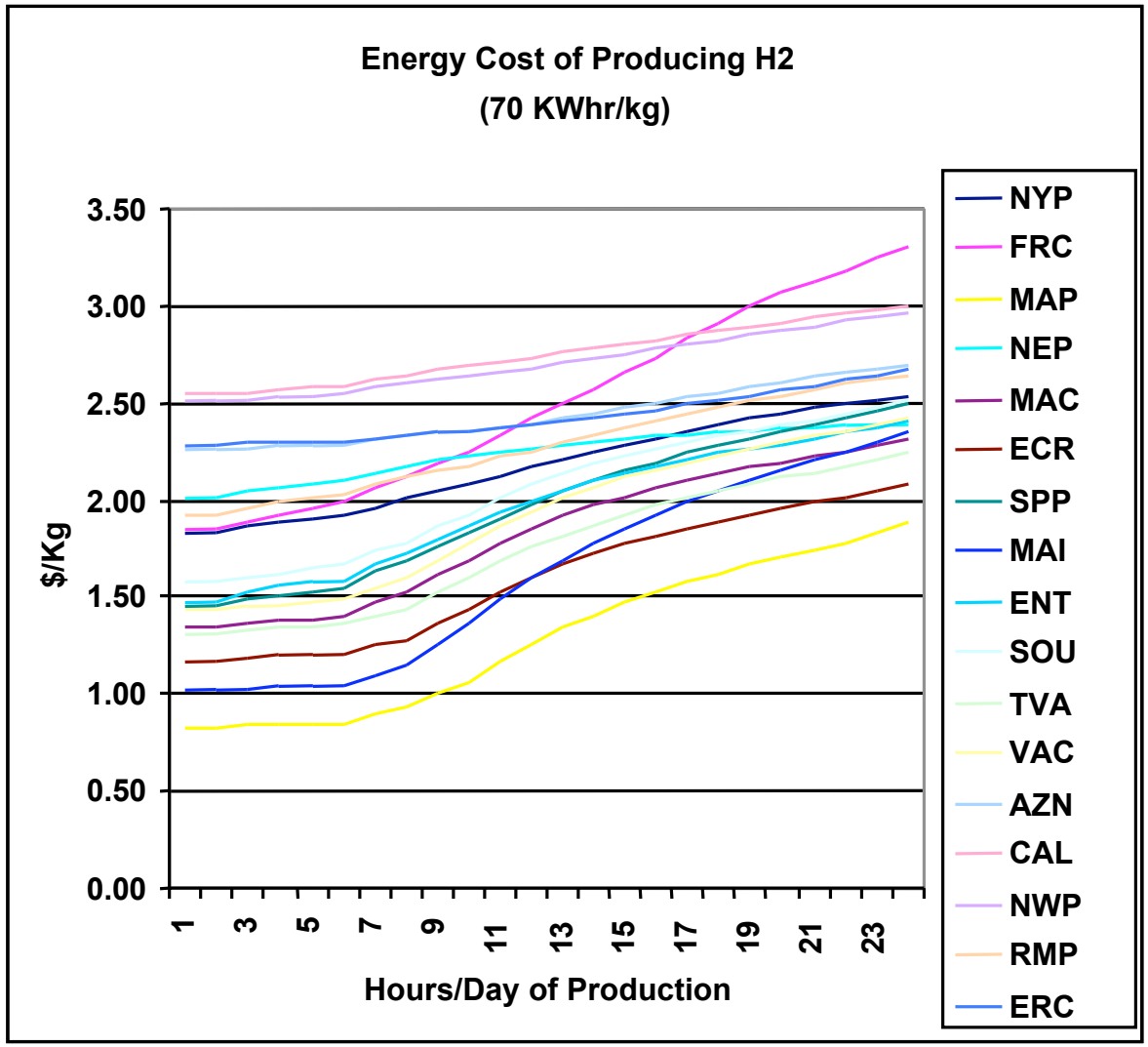
# Energy Cost of Production

Assume same hours of production each day

Cheapest hours first

Results are MAPS simulations (predictions)

>500GW-hrs/day power available in US at <$25/MW internal cost (<9M Kg $H_2$/day)

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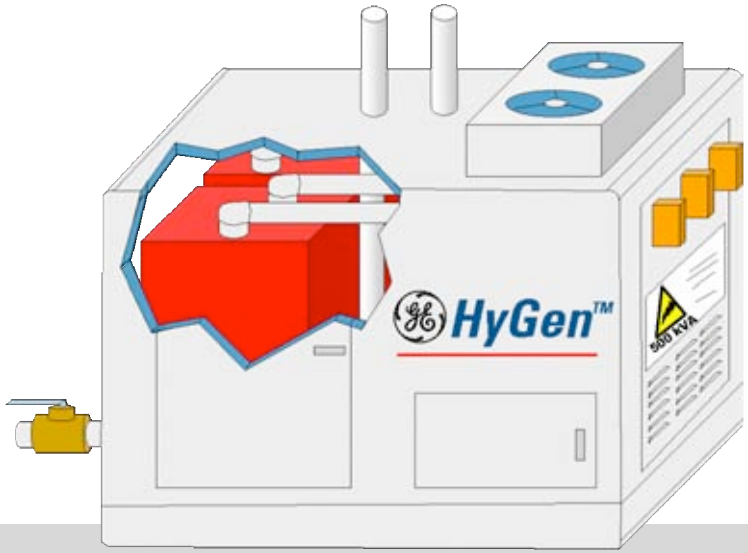
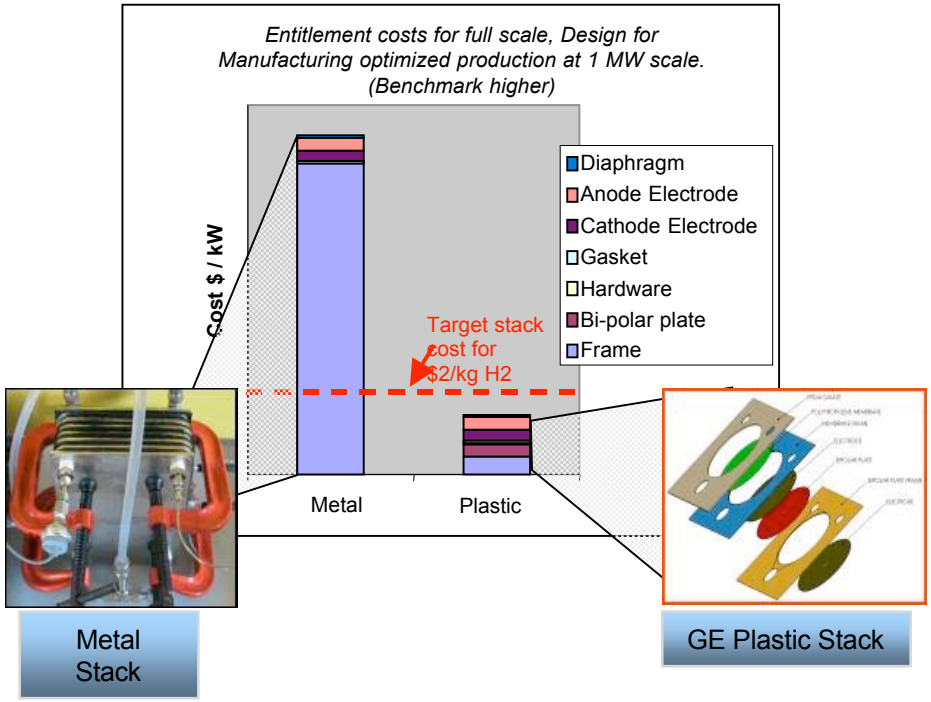
# Electrolysis Technology Advancements

Equipment capital cost reduction through electrolyzer stack materials and novel design concepts

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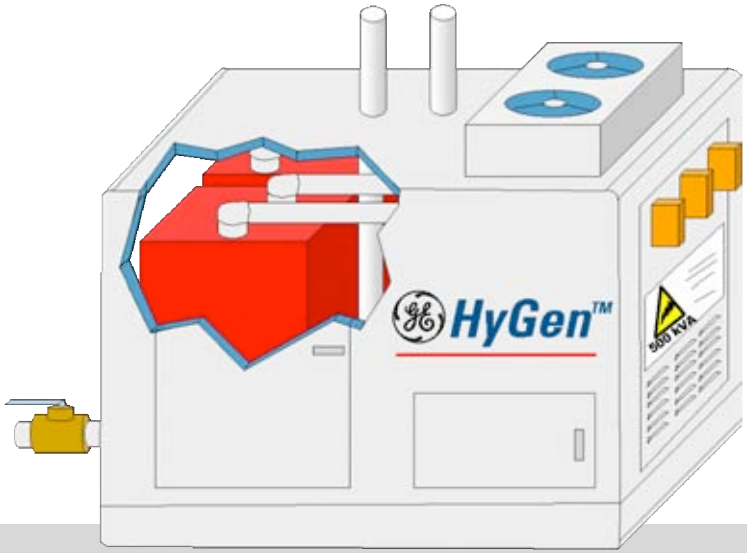
# Electrolysis Technology Advancements

## Hydrogen production cost reduction through system integration




- Energy management system integration for low cost energy utilization
- Hydrogen compression advances for reduced energy consumption
- Integration with renewable systems for firming

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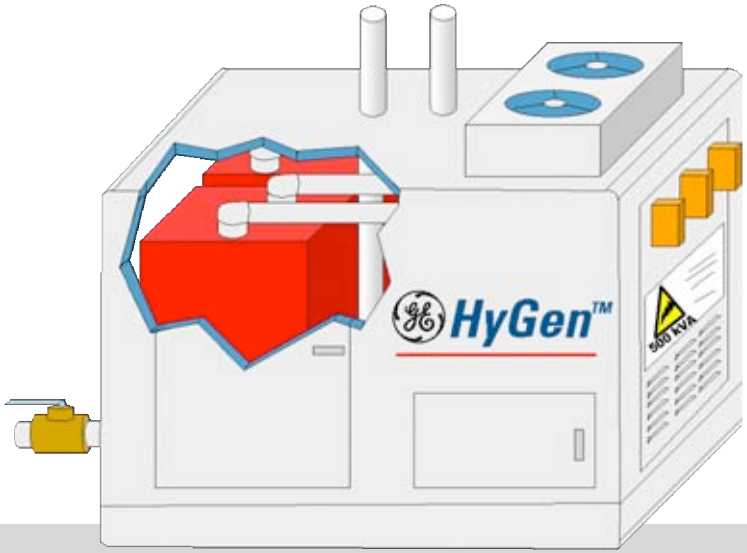
# Electrolysis Technology Advancements

## Utility system benefits through electrical integration




- Large controllable load aids stability
- Integrated VAR compensation capability
- Integration with renewable system electricals for reduced cost
- SCADA and RM&D integration for reduced cost of operation

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# Future Technology Advances

- Higher conductivity electrolytes
- Electrode materials and morphology for higher current density and smaller / cheaper stacks
- Higher temperature electrolysis for higher efficiency
- Advanced engineered plastic materials and manufacturing techniques
- Thermodynamic integration with power generation equipment and with electrical systems
- Advanced controls for production cost optimization

***Electrolysis technology advances will drive increased penetration and value***

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# High Temperature Electrolysis

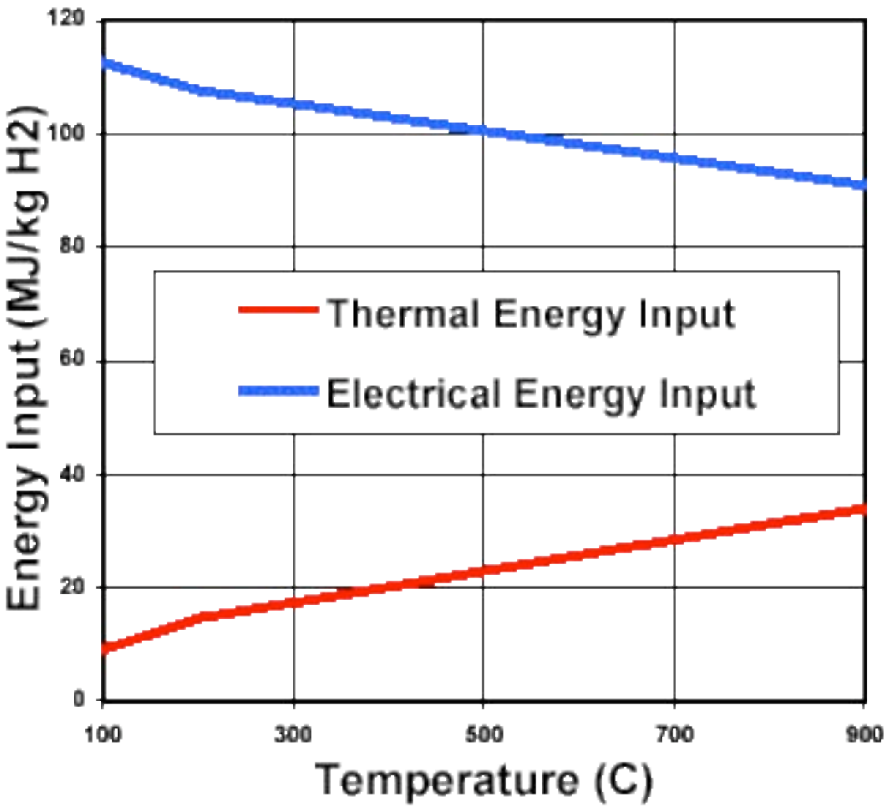
$$\underbrace{\Delta H}_{total} = \underbrace{\Delta G}_{electrical} + \underbrace{T\Delta S}_{heat}$$

Electrical contribution is reduced as temperature rises

Extended membrane operating ranges

Sources of heat:

- Nuclear reactor
- Combined Cycle Gas Turbine
- Geothermal
- Industrial low grade heat

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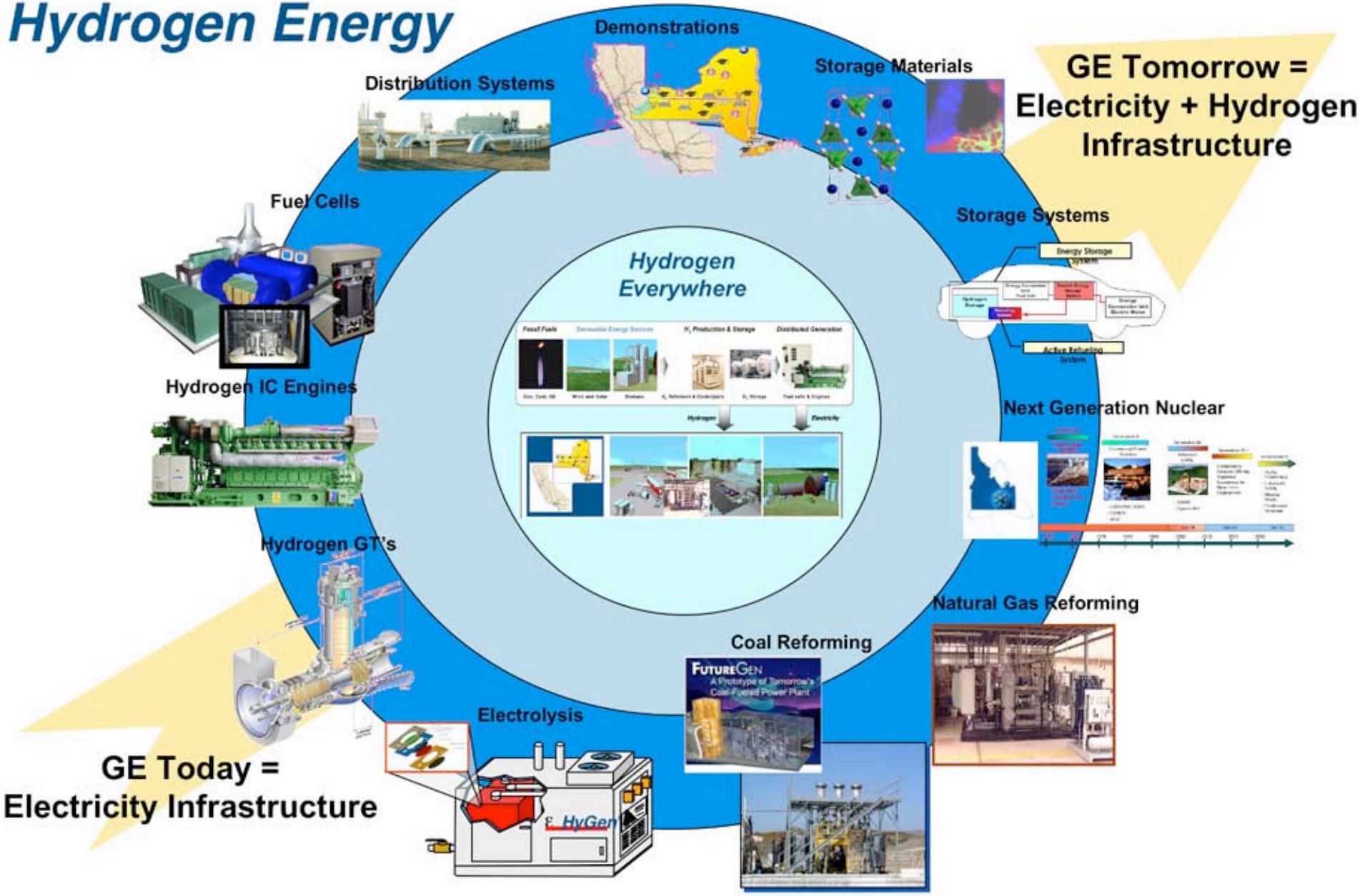
# Hydrogen Energy

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