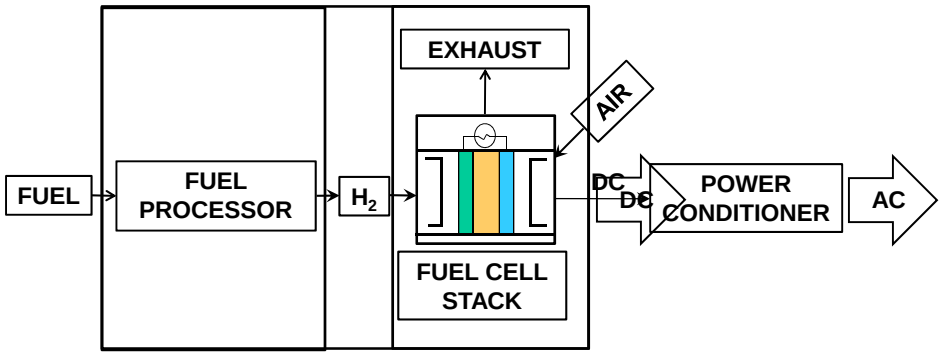
# Stationary Fuel Cells in California

## National Fuel Cell Research Center

University of California, Irvine
http://www.nfcrc.uci.edu

February 16, 2011

## FUEL CELL POWER PLANT




**APPLICATION: STATIONARY**

## ATTRIBUTES OF STATIONARY FUEL CELLS

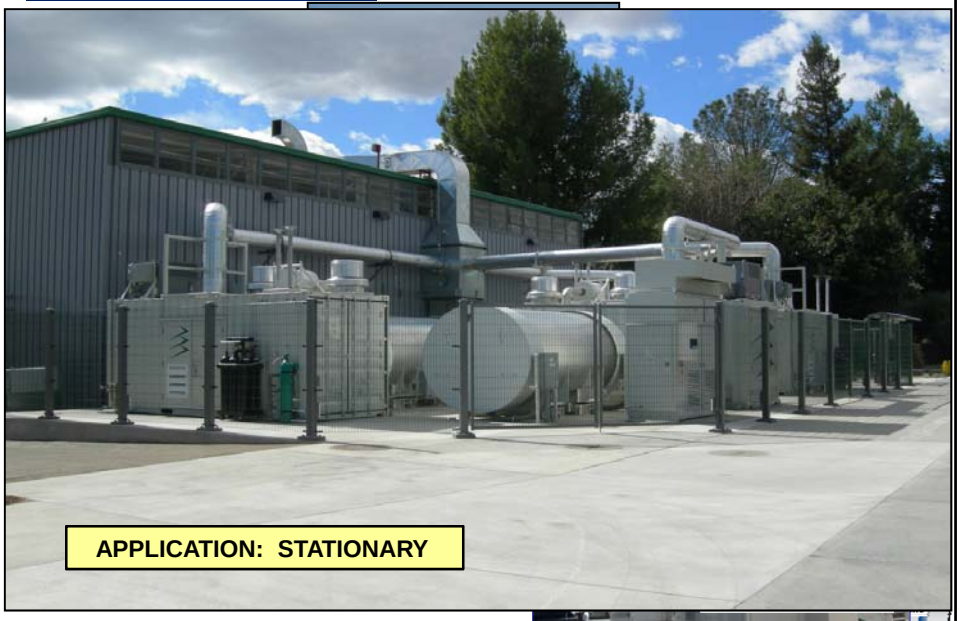
- High Fuel-to-Electricity Efficiency
- High Quality Heat
- Acoustically Benign
- Virtually Zero-Emission of Criteria Pollutants
- "Fortuitous Fit"
  - **Distributed Generation**

    - **Local Control**
    - **Reliability**
    - **Power Quality**
    - **Heat Recovery**
    - **Real-Time Pricing**
    - **Potential Efficiency Gains from DC**
    - **…….**





## FUEL CELL POWER PLANT



# Molten Carbonate FCs

## MCFC Case Study: Baseload Power (500 kW)

- **Santa Barbara Wastewater Treatment Plant**
  - **Commissioned 2004**
- **Two DFC300® MCFCs**
  - **Grid Independent/Grid Connect**
  - **100% Electrical Loading @ 500kW**
  - **75% High-Grade Heat Utilization (Fuel Cell Oversized for Growth)**
  - **90% Guaranteed Availability (Including Scheduled Outages)**
  - **55% Total Energy Efficiency at Current Utilization (Oversized for growth)**
  - **30,511 Operating Hours through February 2008**
- **Installed Cost** **2004** **2008**

| | | |
|---|---|---|
| Base | $9,850/kW | $6,050/kW |
| SGIP | $4,500/kW | $4,500/kW |
| Federal ITC | --- | --- |
| Net Installed Cost | $5,350/kW | $1,450/kW |
| Simple Pay Back | 8.9 years | 4.8 years |





# MCFCs

## MCFC Case Study: Baseload Power (500 kW)

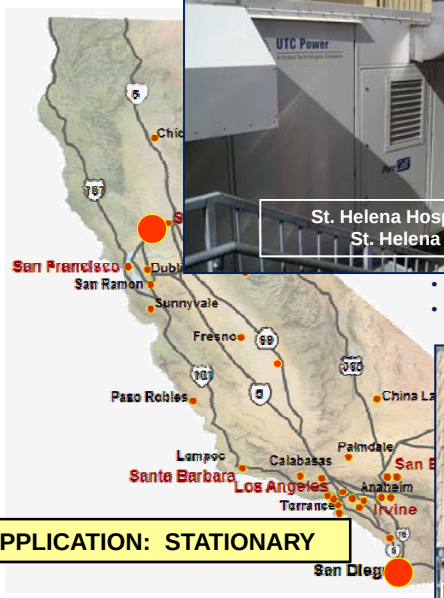
- **Utility Cost Savings (Annual)**

| | |
|---|---|
| Electric Utility Savings | $301,500 |
| Gas Utility Savings | ---- |

- **Environmental Benefits (Annual)**

| Species | Avoided Emissions Versus CA Grid* [metric tons] | Actual Emissions [metric tons] |
|---|---|---|
| $CO_2$ | 332 | 1,861 |
| $NO_x$ | 0.37 | 0.24 |
| $SO_2$ | 0.07 | 0.02 |

## FUEL CELL POWER PLANT


| | |
|---|---|
| TER TREATMENT | 9.10 |
| ENEWABLES | 3.90 |
| | 2.75 |
| ENT | 2.25 |
| S | 1.00 |
| CATIONS | 0.50 |
| STORES | 1.00 |
| IES | 5.00 |
| S | 1.00 |
| L | 4.20 |
| TURING | 0.50 |
| • FOOD PROCESSING | 0.50 |
| • UTILITIES | 0.25 |
| TOTAL = | 33.00 MW |




# Phosphoric Acid FCs

## PAFC Case Study: Baseload Power (200 kW)

- Fujitsu America
  - Provider of Comprehensive Information Technology Solutions
  - Sunnyvale, CA
  - Commissioned August 2007
- PureCell® Model 200
  - Grid Independent/Grid Connect
  - 100% Electrical Loading @ 200 kW
  - 100% High-Grade Heat Utilization
  - 95% Guaranteed Availability (Including Scheduled Outages)
  - 60% Total Energy Efficiency
  - 4,215 Operating Hours through February 2008
- Installed Cost

| | |
|---|---|
| Base | $5,685/kW |
| SGIP | $2,500/kW |
| Federal ITC | $ 955/kW (30% Project Cap) |
| Net Installed Cost | $2,230/kW |
| Simple Pay Back | 4.9 years |

# Phosphoric Acid FCs

## PAFC Case Study: Baseload Power (200 kW)

- **Utility Cost Savings (Annual)**

| | PureCell® Model 200 | PureCell® Model 400 |
|---|---|---|
| Electric Utility Saving | $218,036 | $460,000 |
| Gas Utility Savings | $ 46,129 | $ 92,000 |

- **Environmental Benefits (Annual)**

| Species | Avoided Emissions Versus CA Grid* [metric tons] | Avoided Emissions Versus CA Grid* [metric tons] |
|---|---|---|
| $CO_2$ | 30 | 141 |
| $NO_x$ | 1.6 | 3.2 |
| $SO_2$ | 0.7 | 1.4 |

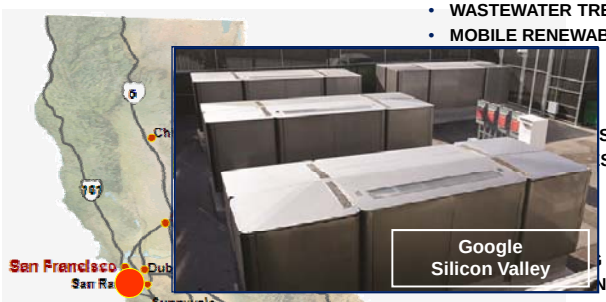
| Avoided Water Consumption** [gallons] | Avoided Water Consumption** [gallons] |
|---|---|
| 250,000 | 500,000 |

*** Source: EPA eGrid Data** ****Source: USGS (1995) CA Utility**





## FUEL CELL POWER PLANT




- **WASTEWATER TREATMENT** 9.10
- **MOBILE RENEWABLES** 3.90
- 2.75
- 2.25
- 1.00
- S 0.50
- S 1.00
- 5.00
- 1.00
- 4.20
- 0.50
- NG 0.50
- **UTILITIES** 0.25

**TOTAL =** **33.00 MW**

SOURCE: CASFCC.ORG

**APPLICATION: STATIONARY**

## SUMMARY

- **Proven Technology?**
  - 20 years of successful deployment
  - Wide portfolio of applications
  - Burgeoning track record in deployment over a wide portfolio
- **Principal "MW-Class" Baseload FC Technologies?**
  - PAFC (UTC Power), MCFC (FuelCell Energy), SOFC (Bloom Energy)
- **Renewable Operation?**
  - In excess of 10MW deployed in California alone
- **Environmental Footprint?**
  - Remarkably benign
- **Financing?**
  - Strong State incentive and Federal tax credit programs
  - Competitive third-party providers
- **Cost?**
  - Competitive today with incentives
  - Accelerating deployment promoting cost reduction





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## CALIFORNIA STATIONARY FUEL CELL COLLABORATIVE


**Co-Chairs**

**Mary Nichols, Chair**
**California ARB**

**Dr. Scott Samuelsen, Director**
**National Fuel Cell Research Center**

**Executive Director**

**Mike Tollstrup**

**Industry Advisory Panel**

**Katrina Fritz-Intwala, UTC Power**

**www.stationaryfuelcells.org**

**Established 2001**

**CA Air Resources Board**
**CA Department of General Services**
**CA Energy Commission**
**CA Environmental Protection Agency**
**CA Public Utilities Commission**
**CA Resources Agency**
**CA Trade and Commerce Agency**
**CA Transportation and Housing Agency**
**CA Governor's Office**
**CA Food and Agriculture**

**U.S. Department of Energy**
**U.S. Department of Defense**
**U.S. General Service Administration**
**U.S. Environmental Protection Agency**

**National Fuel Cell Research Center**
**LA Department of Water and Power**
**South Coast Air Quality Mgt District**
**Bay Area Air Quality Mgt District**

13/11



## California Fuel Cell Value

**100% Natural Gas, 90% CHP**

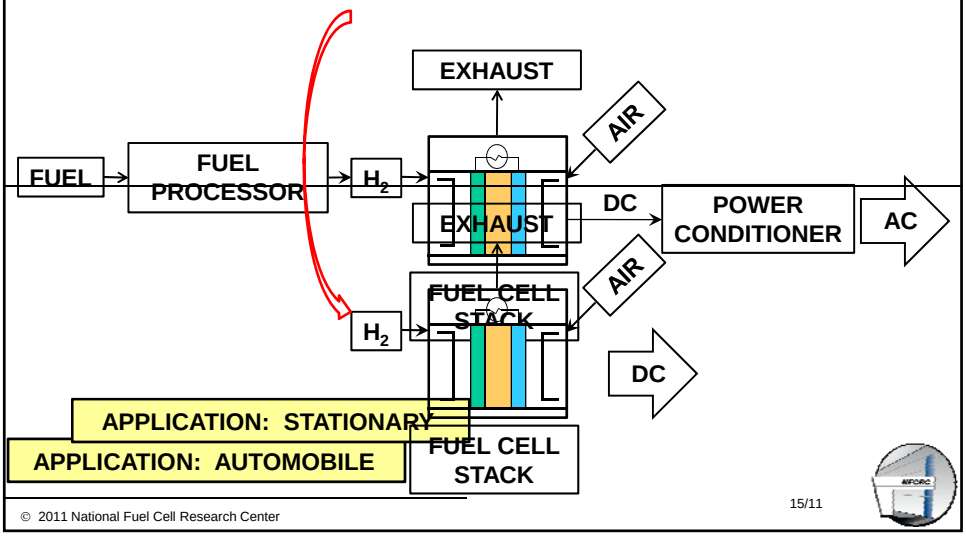

| | ¢/kWh |
|---|---|
| Other Values | TBD |
| Value of Deployment Ease | Site Specific |
| Value of Job Creation Potential | 0.13 - 0.17 |
| Value of Health Benefits* | 2.17 - 2.20 |
| Value of Avoided $CO_2$ Emissions* | 0.20 - 2.57 |
| Value of Other Avoided Emissions (NOx*, SO2*, VOC*, PM10*, CO*^, Hg) | 0.32 - 4.46 |
| Increased Reliability/Blackout Avoidance/Power Quality | <0.01 - 0.40 |
| Value of Avoided Losses (Generation, T&D, Related Emissions) | 0.22 - 0.41 |
| Value of Grid Support | 0.04 - 0.28 |
| Value of Avoided Distribution Cost (All Costs Allocated to Peak) | 0.07 - 1.02 |
| Value of Avoided Transmission Cost (All Costs Allocated to Peak) | 0.02 - 0.25 |
| Value of Avoided Water Use | <0.01 - 0.11 |
| Value of Avoided Fossil Fuel as a Price Hedge* | 0.34 - 0.83 |
| Value of Avoided Central Station Generation Fuel Cost* (Efficiency Gain + CHP Credit) | 1.17 - 6.72 |
| Value of Avoided Generation Variable O&M Cost | <0.01 - 0.47 |
| Value of Avoided Generation Capacity Fixed Operation & Maintenance Cost | 0.14 - 0.29 |
| Value of Avoided Generation Capacity Capital Cost (93% Effective Load Carrying Capacity) | 0.78 - 2.23 |

* Indicates inclusion of Cogen Credit

**RANGE OF TOTAL FUEL CELL VALUE: 5.6 – 22.4¢/kWh**

1/26/2011 R2

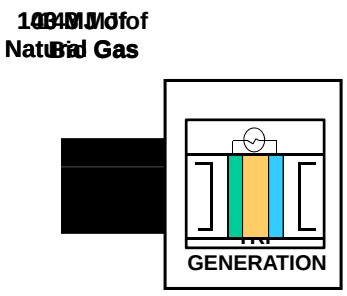
## FUEL CELL POWER PLANT








## HIGH-TEMPERATURE FUEL CELL WITH H2 TRI-GENERATION




100 MJ of Natural Gas

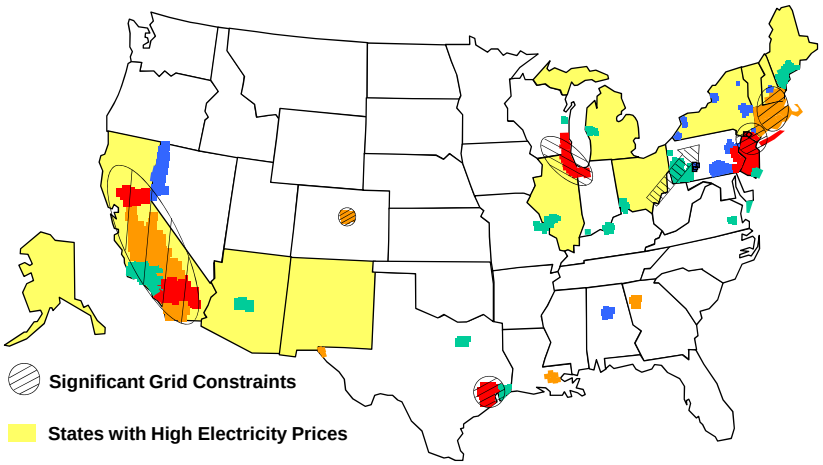
53 MJ high quality heat
$\eta$=53%

47 MJ electricity
$\eta$=47%

43 MJ $H_2$
$\eta$=~100%

Bio Hydrogen

# MARKET DRIVERS



Significant Grid Constraints

States with High Electricity Prices

**Ozone Non-Attainment Classifications**

- Marginal
- Moderate
- Serious
- Extreme (LA) & Severe

*Source: Energy Information Administration*