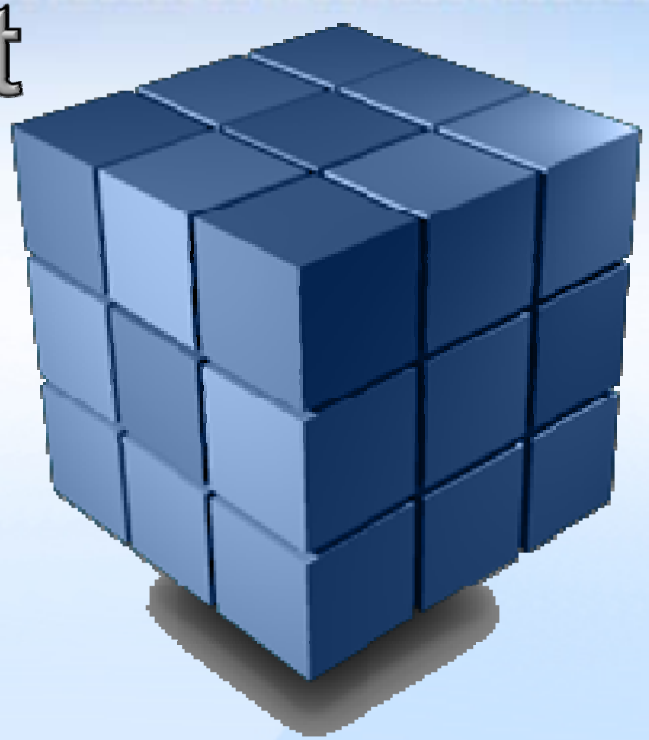
Hydrogen—The Ultimate Fuel

Pathway to Fuel Cell Deployment

The 3rd Party Transaction; A Vehicle to Implementation

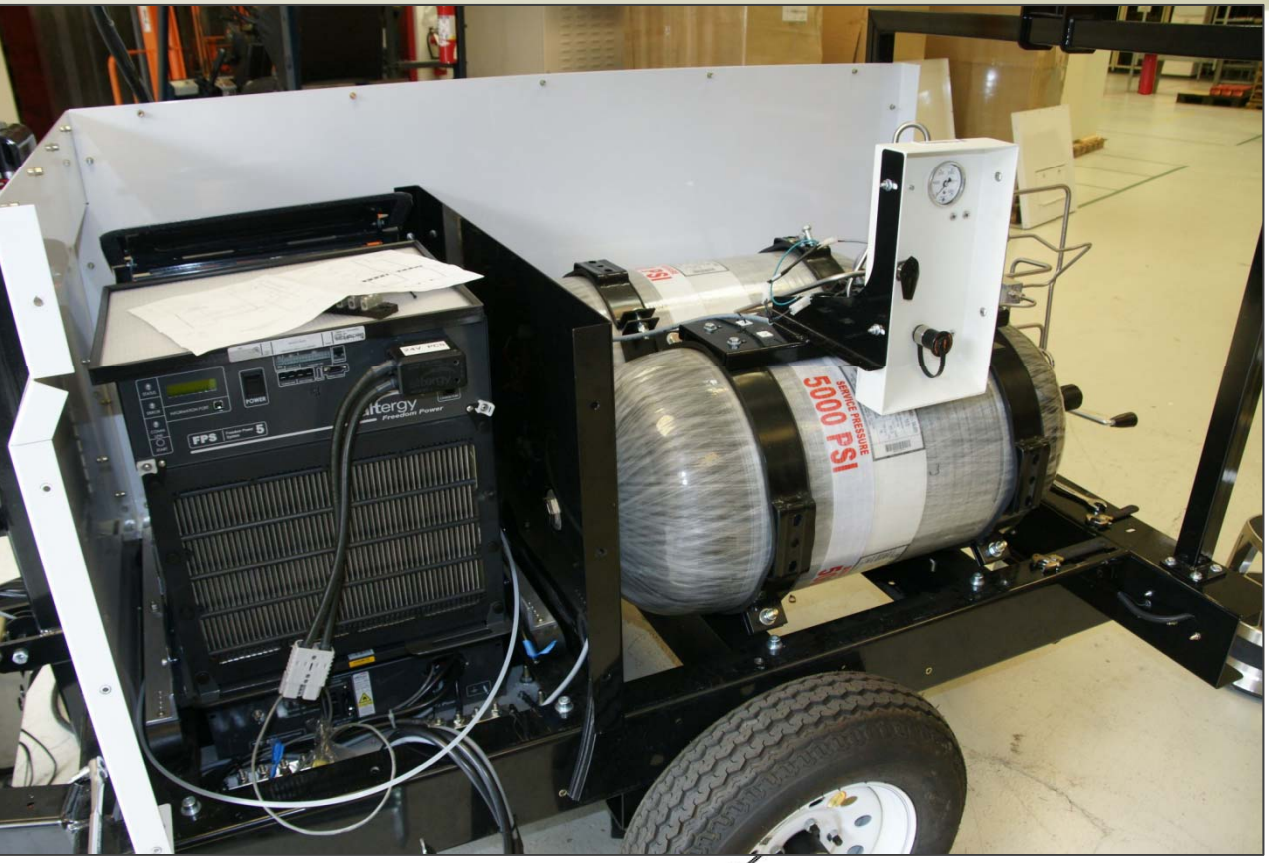
Presented by
Thomas Damberger, Ph.D., CEM
Golden State Energy
damberger@goldenstateenergy.com
11-16-09

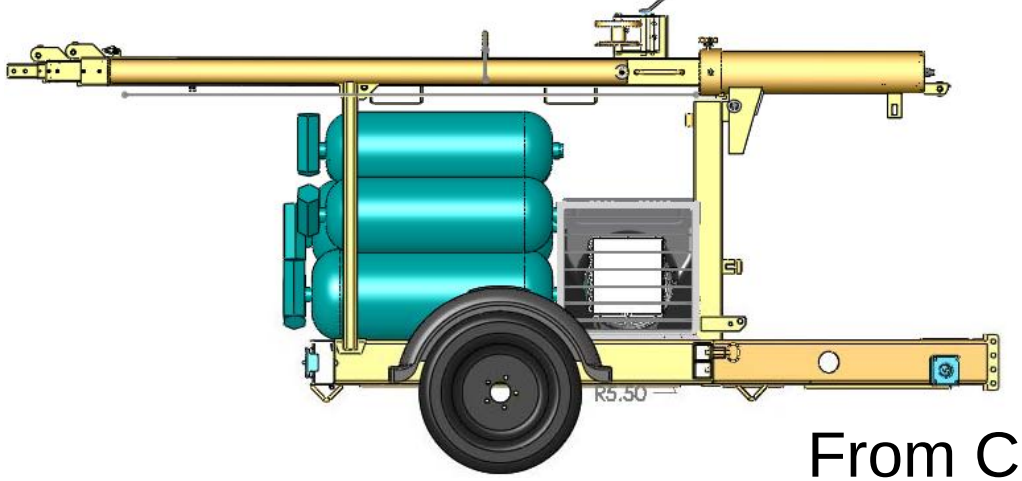
Identify the Building Blocks to a Successful Project



- REC's
- Site Location
- State Incentives
- Federal Incentives
- Commodity Price
- Short Opportunity Timelines
- Team Orientation/Communication
  (internal & external)
- System Engineering & Integration
- A Team "Can Do" Attitude

Fuel Cell Team Experience





From Concept to Commissioning

H_2/Fuel Cell Mobile Lighting

Caltrans
altergy systems
MQ MULTIQUIP
LUXIM
BOEING
Sandia National Laboratories
VT
OVONIC HYDROGEN solutions
SFO San Francisco International Airport
LUMENWORKS DESIGN WITH LIGHT
STRAY LIGHT
GOLDEN STATE ENERGY GSE

Advantages:

Zero Emissions
2x Increase in Energy Efficiency
Can Be Used Indoors

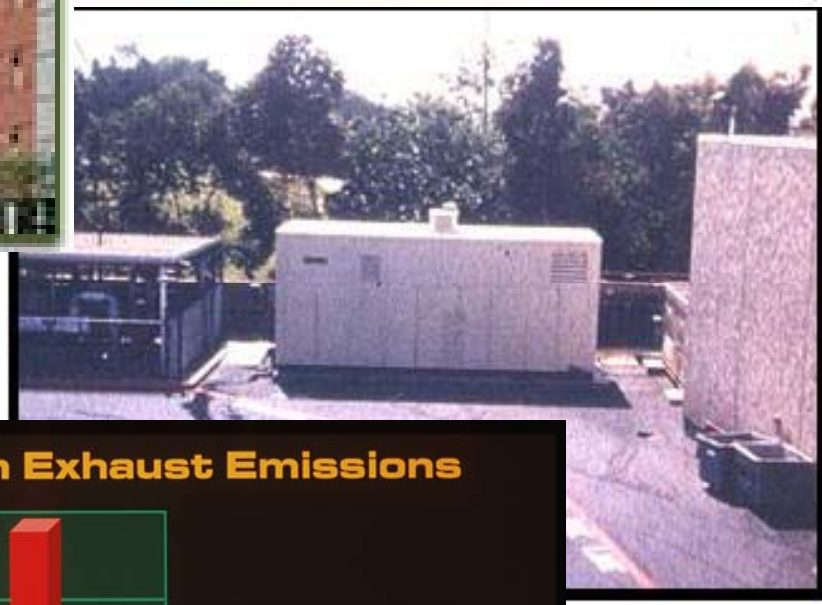
For further information contact:
Lennie Klebanoff
Sandia National Laboratories
(925) 294-3471

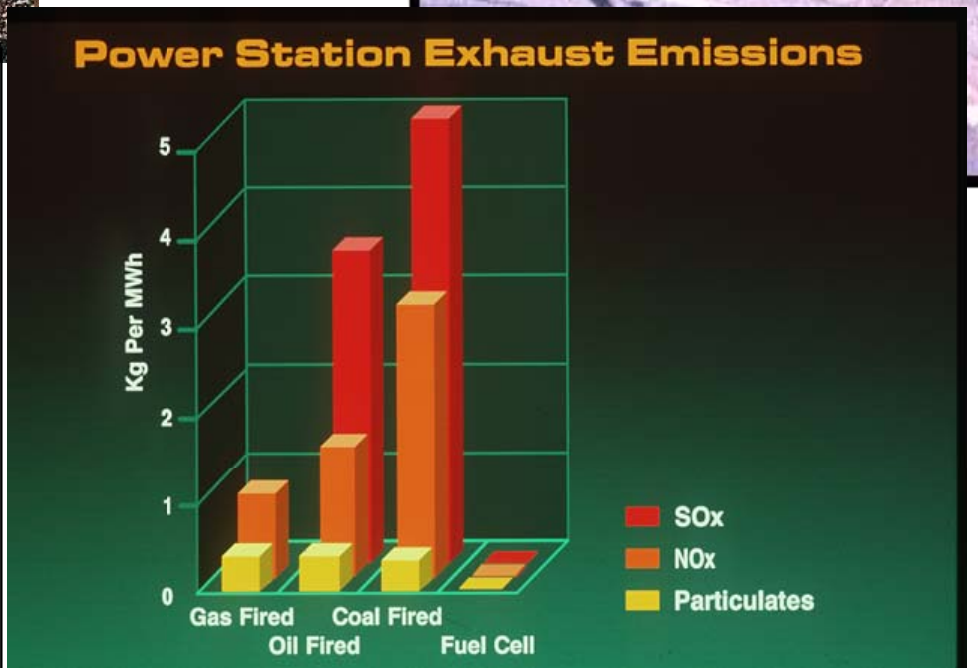
Fuel Cell Powered
Lighting Tower
Palm Springs, CA
10-24-09

Fuel Cell Powered
Christmas Tree
2008

Pasadena Radio Club Event
Powered by 1 kW
Altergy Systems Fuel Cell--2007

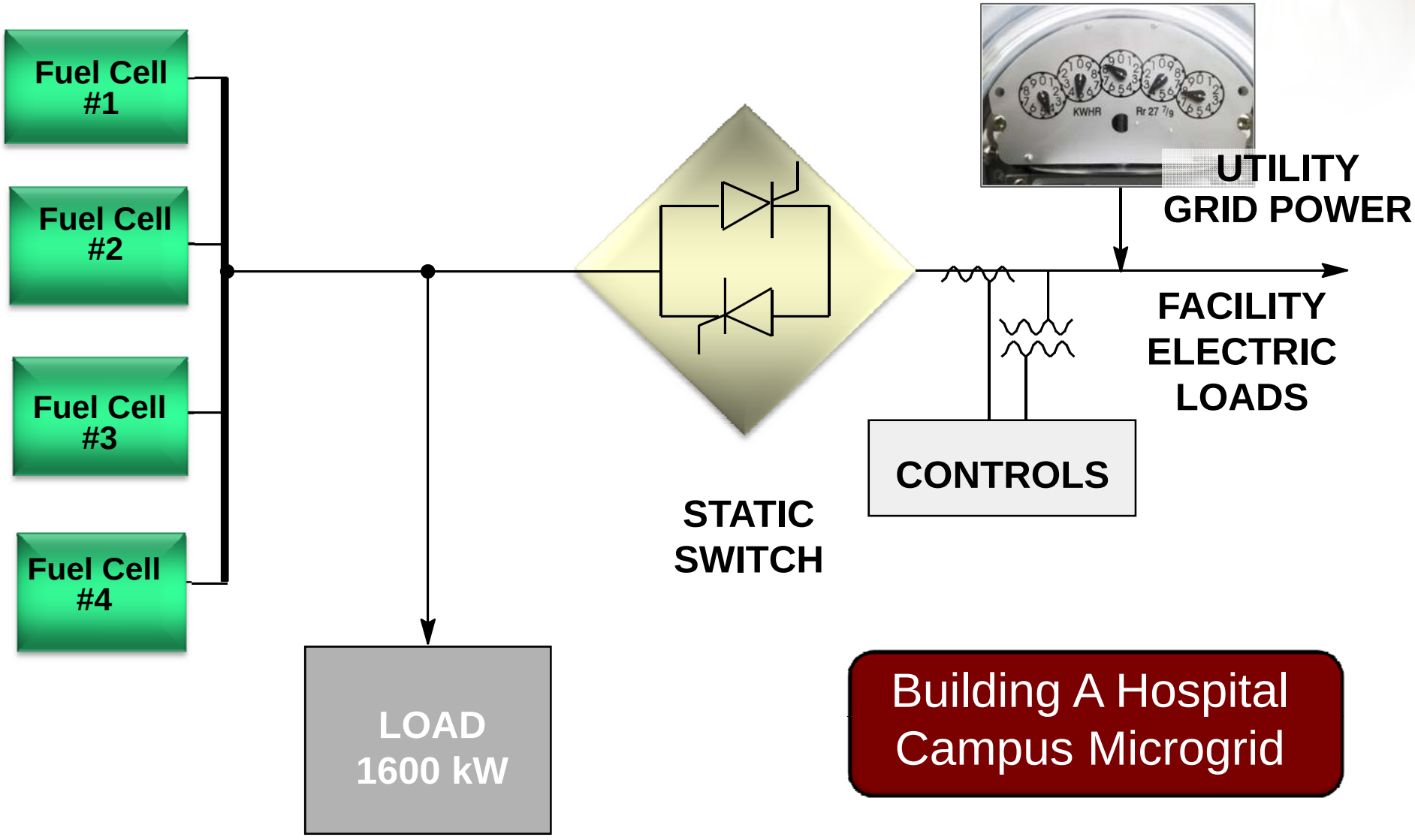
Fuel Cells for Hospitals





Fuel Cells for Hospitals

Multiple Units Assured Power/Grid Connect/ Load-Following Seamless Transfer



Building A Hospital Campus Microgrid

Measures

National Renewable Energy Laboratory
Innovation for Our Energy Future

Use Readily Available Resources for Solutions

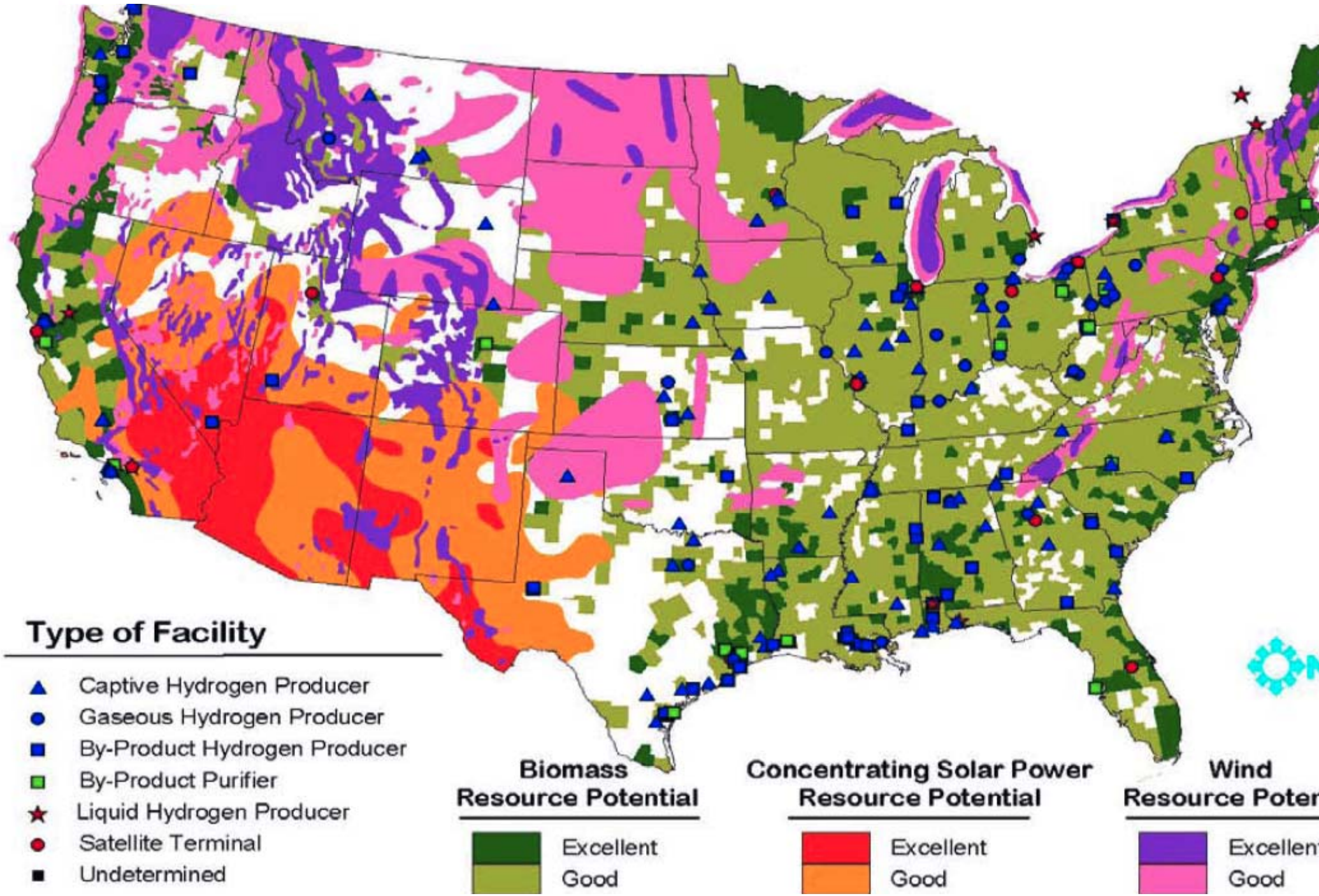
Working with National Laboratories for Power Solutions

NASA

Lawrence Livermore National Laboratory

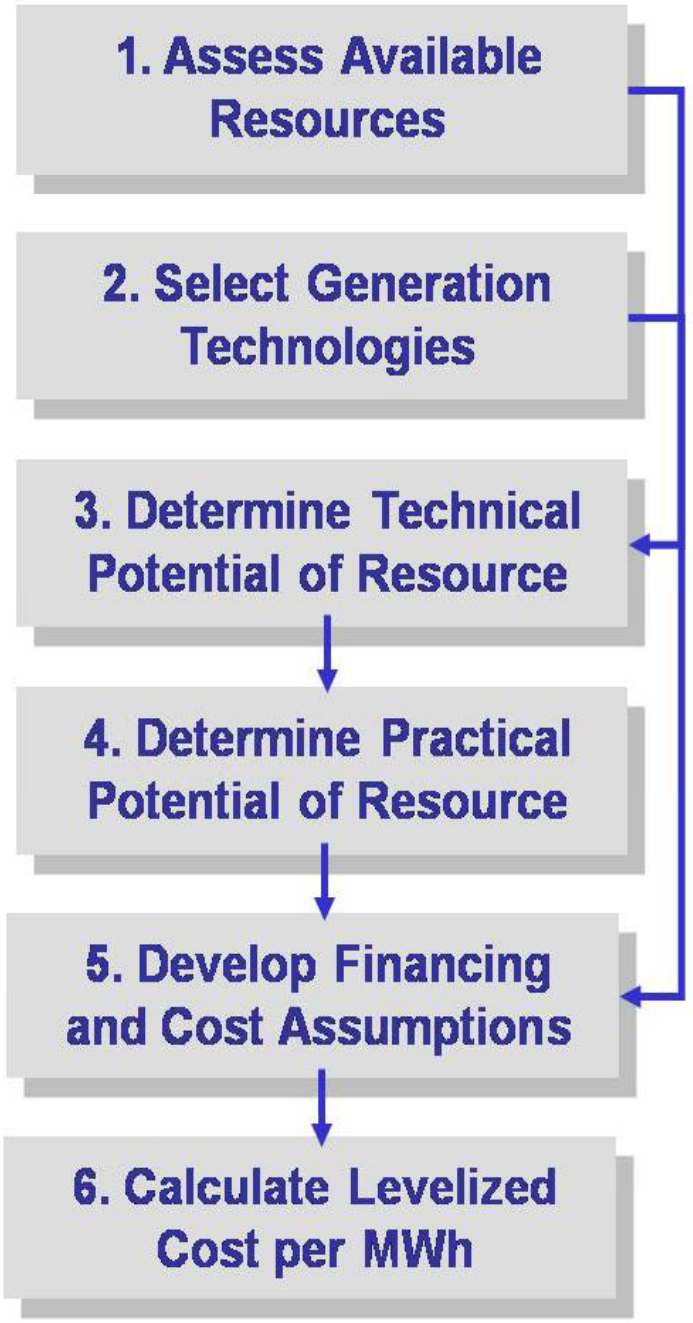
Sandia National Laboratories

U.S. Renewable Energy Resources



Approach

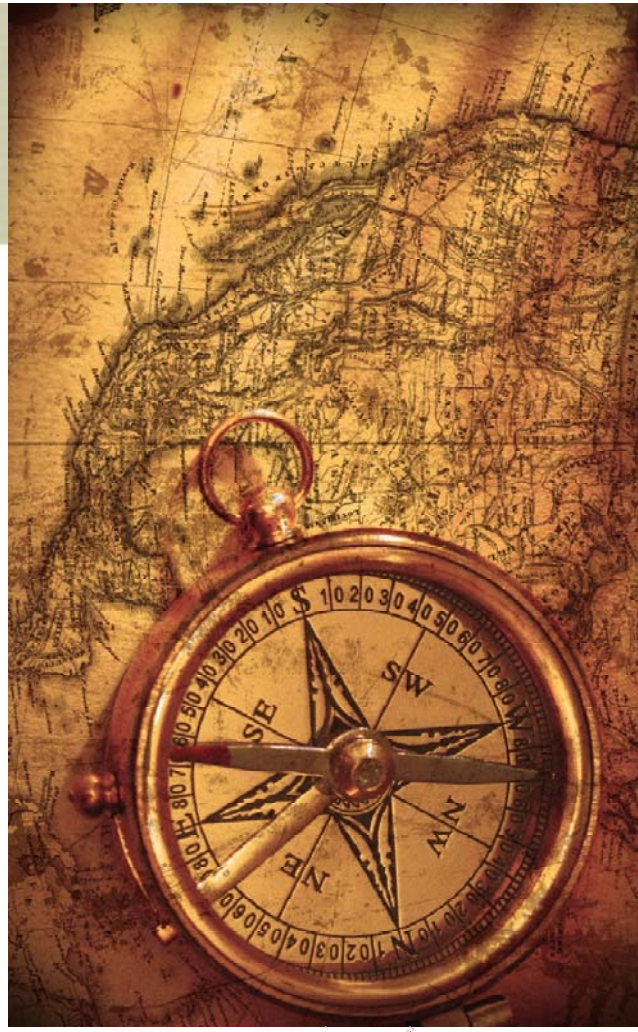
1. **Assess the total renewable resources or fuels (biomass, landfill gas, etc...) available in the state.**
2. **Select generation technologies that can utilize the resources in the near-term.**
   - These technologies must be commercially available or the technologies themselves are mature, though they may be lacking mass deployment.
3. **Translate the resources into electric energy (and nameplate capacity) Technical Potential.**
   - Use performance characteristics of select technologies to estimate technical potential.
4. **Determine Practical Potential from Technical Potential.**
   - Criteria used for practical potential is different for each resource, but attempts to quantify the maximum potential that could reasonably be expected to be implemented.
5. **Develop financing assumptions, range of costs and operating characteristics for such technologies.**
6. **Calculate levelized costs ($/MWh) for electricity produced from selected renewable technologies given resource availability.**



Mapping The Incentives

What are the Drivers?

- PUC Feed-in Rate Tariff
- Desire to Have Renewable Energy
- Onsite Power—Energy Security
- Full Energy Utilization
- Reduced Carbon Footprint/Environmental
- Development of Public Private Partnership
- Economic Development/Employment
- Improve Power Quality to the Local Grid
- Federal Tax Incentives to Investor
- Utility Incentives to Investor
- Carbon Credit to Host Site
- Willing 3rd Party for Finance
- Power Purchase Agreement



The Gold Rush of Today;
Biofuel/Biogas
Biohydrogen

Renewable Biogas

Description

Anaerobic digester biofuels can be produced in various forms, including Biomethane or biohydrogen. In this section, the focus is on Biomethane for electricity generation.

Technologies

- **Anaerobic Digestion:** Treatment of waste dates back to the 10th Century BC.
- **3 steps of AD:**
  - Hydrolysis
  - Volatile Acid Fermentation
  - Methane Formation.

Digester Type	Solids handling	Total Solid Concentration in Feedstock	Solids loading	Biogas Production	Methane content in biogas	O&M costs
APS	**Batch**	**30%**	**High**	**Continuous**	**60-75%**	**Low**
Two-Phase	Continuous	5-10%	Medium	Continuous	40-60%	Medium
SEBAC	Batch	>10%	Medium	Discontinuous	40-60%	Low
Plug Flow	Continuous	5-10%	Low	Continuous	50-70%	Medium
Complete Mixed	Continuous	2-10%	Low	Continuous	50-70%	High

UC Davis Biogas Energy Project

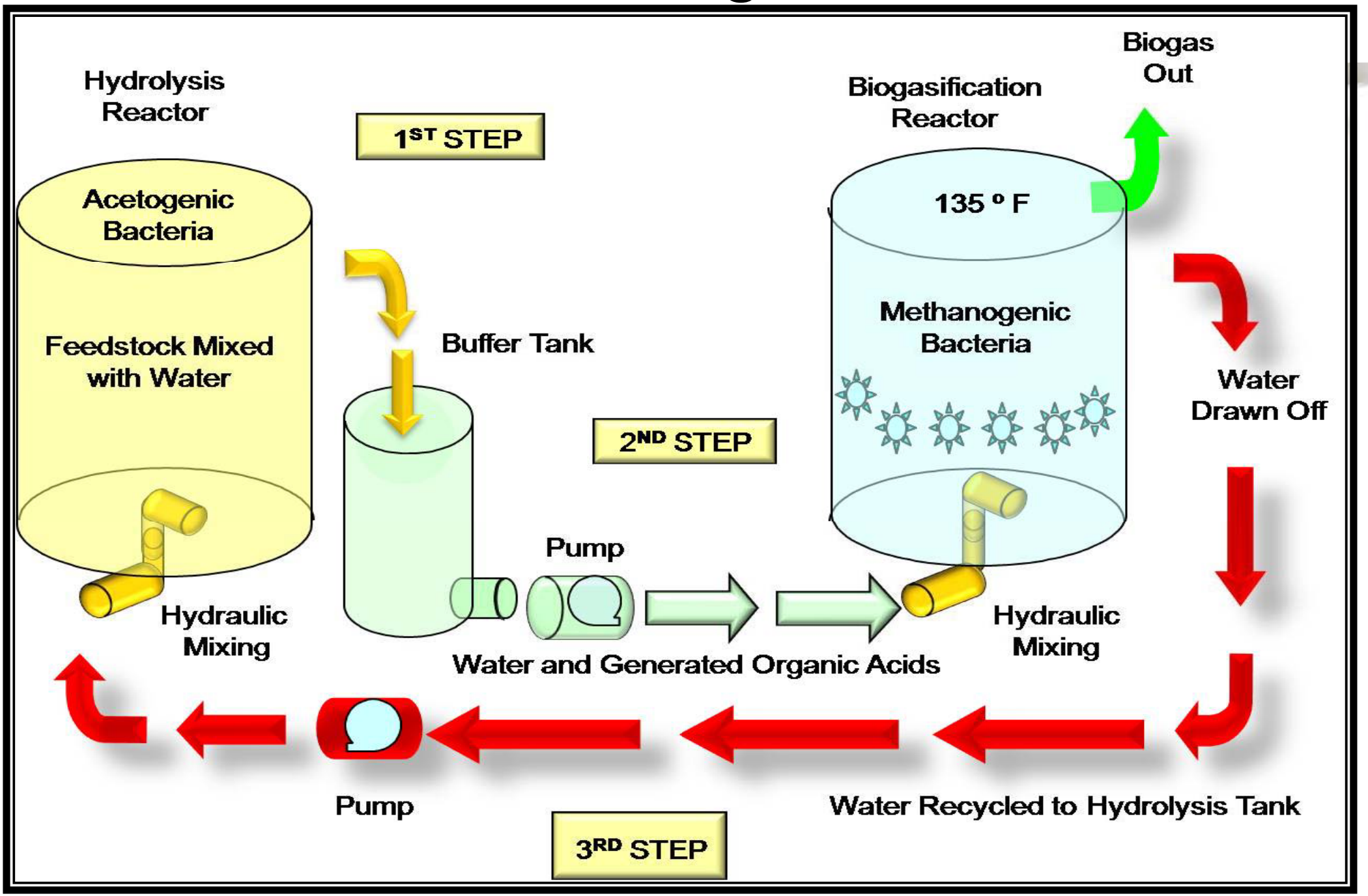
Digester capacity –
3-8 tons per day
Digestion temperature –
135 F
Expected biogas yield –
11,000- 22,900 ft^3/day
Electricity output –
600- 1200 kWh/day

Hydrogen Production = >25% 1st Stage

Sponsors:

- California Energy Commission
- California Integrated Waste Management
- University of California, Davis
- Onsite Power Systems & Other Companies

The Anaerobic Digester Process



The Anaerobic Digester Process

Biogas Fuel Cells

City of Santa Barbara has a 500 KW fuel cell cogeneration system operating on anaerobic digester biogas at the **El Estero Wastewater Treatment Plant**. The project includes a fuel gas cleaning skid, two 250-KW molten carbonate fuel cell modules, and heat recovery systems to produce approximately 0.6 mmBTU/hr of hot water from the fuel cell exhaust.

The facility was commercially available in December 2004.

Monitor Federal, State & Local Incentives for Anaerobic Digester & Fuel Cell Projects

Develop
Incentive Based
Projects

For More Information:

http://www.dsireusa.org/

2009

RENEWABLE ENERGY TAX INCENTIVES

Photo Courtesy
Altergy Systems
5 kW PEM Fuel Cell

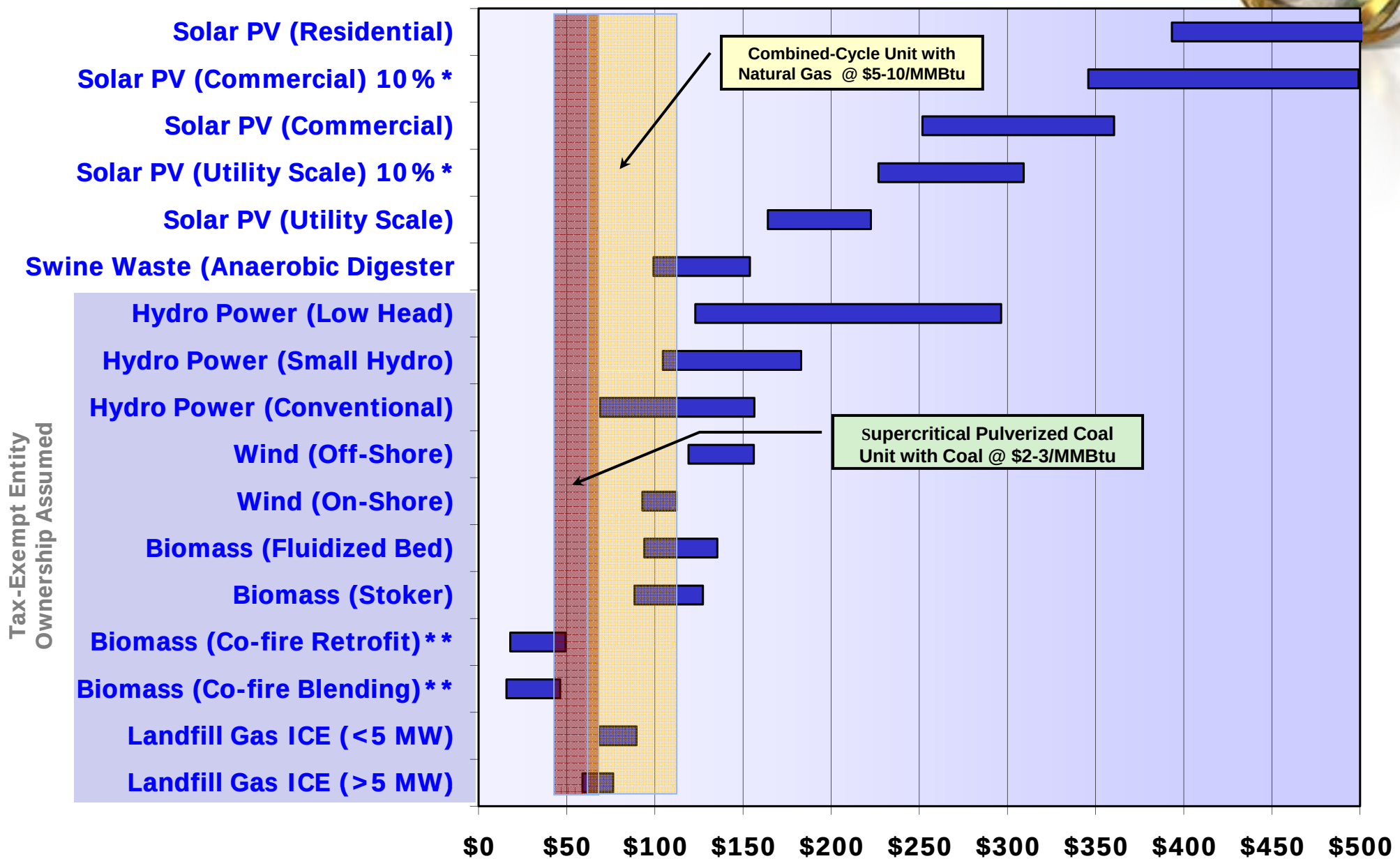
Governmental Support
&
Project Incentives

Compiled by Golden State Energy
Information Courtesy of DISRE
4/22/2009

1. Assess Available Resources
2. Select Generation Technologies
3. Determine Technical Potential of Resource
4. Determine Practical Potential of Resource
5. **Develop Financing and Cost Assumptions**
6. **Calculate Levelized Cost per MWh**

Financing and Cost Assumptions

Levelized Cost Comparison (2008$)



*Cost estimates include reduction of federal solar tax credits to 10% after 2008 for commercial/utility scale installations.

**Co-firing costs are calculated as incremental costs of avoiding coal consumption for generation ($2.25/MMBtu (2007) coal cost assumed).

Financing Assumptions Used

- Tax-exempt entity ownership is assumed for most utility-scale generation, so tax incentives are not utilized.
  - CREBs financing is not included since availability after 2012 is uncertain.
- Exceptions to tax-exempt entity ownership are for Solar PV and Anaerobic Digesters.

Financial Assumption	Tax Exempt Entity	Merchant PV Owner	Residential PV Customer	Anaerobic Digester Owner
Weighted Average Cost of Capital (WACC)	6.0%	7.0% (after-tax equity req. for 100%)	4.8% (after-tax mortgage rate)	7.0% (after-tax equity req. for 100%)
Project Life	20 years	20 years	20 years	20 years
Tax Credits	None	30%/ (10% after 2012)	$2000 cap per panel	50% of PTC (~$10/MWh)
Depreciation	None	5-year MACRS	None	7-year flat
Discount Rate	6.0%	7.0%	7.0%	7.0%
Calculated Carrying Charge	**8.72%**	**6.63% (9.35%)**	**7.72%**	**11.08%**

Typical 3rd Party Transaction

Relationship Between Parties

Onsite Utility (LLC)

Energy Assets and Associated Items

Natural Gas, Therms

Electricity, kWh

Electricity, kWh

Heat - MMBtus

Cooling - Ton-hrs

Host Site

Utilities Contract

($/ton-hr, kWh, and $/MMBtu's)

Guaranteed delivery & efficiencies

Funding, Oversight, Monitoring & Billing

Steam Power Partners

Engineering Technical Oversight

FuelCell Energy

Design, Construction/O&M Service Provider

- Equipment Vendors
- Construction Companies
- Specialized O&M Providers

Alliance Power, Inc.

To Develop Fuel Cell Project, What is Needed?

- ✓ Innovation
- ✓ Buy-in by All Stakeholders
- ✓ Anticipated Site Location
- ✓ Connected Electrical Load
- ✓ Plot Plan & Utility Interconnections
- ✓ Full Energy Utilization
- ✓ Utility Incentives
- ✓ Governmental Incentives
- ✓ Timing & Opportunity
- ✓ Preparation & Economics
- ✓ Connections/Networking
- ✓ Solid Teaming Effort

Summary & Conclusion

Biogas & Biohydrogen Enhance the Economics & Viability of Fuel Cell Installations

Increased Market Demand for Both Fuels
& Onsite Fuel Cell Power

All Successful Projects Start with an Idea.

Teamwork is the Key to Success