# *Low Temperature Electrolysis*

## Presented at the

## DOE Solar-Hydrogen Workshop
## UMUC Conference Center
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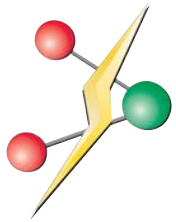
**Transforming Energy™**

*Hydrogen By Wire*™



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# Discussion Points

PV-Electrolysis is one pathway to zero emissions hydrogen fuel/energy

Technology has been demonstrated

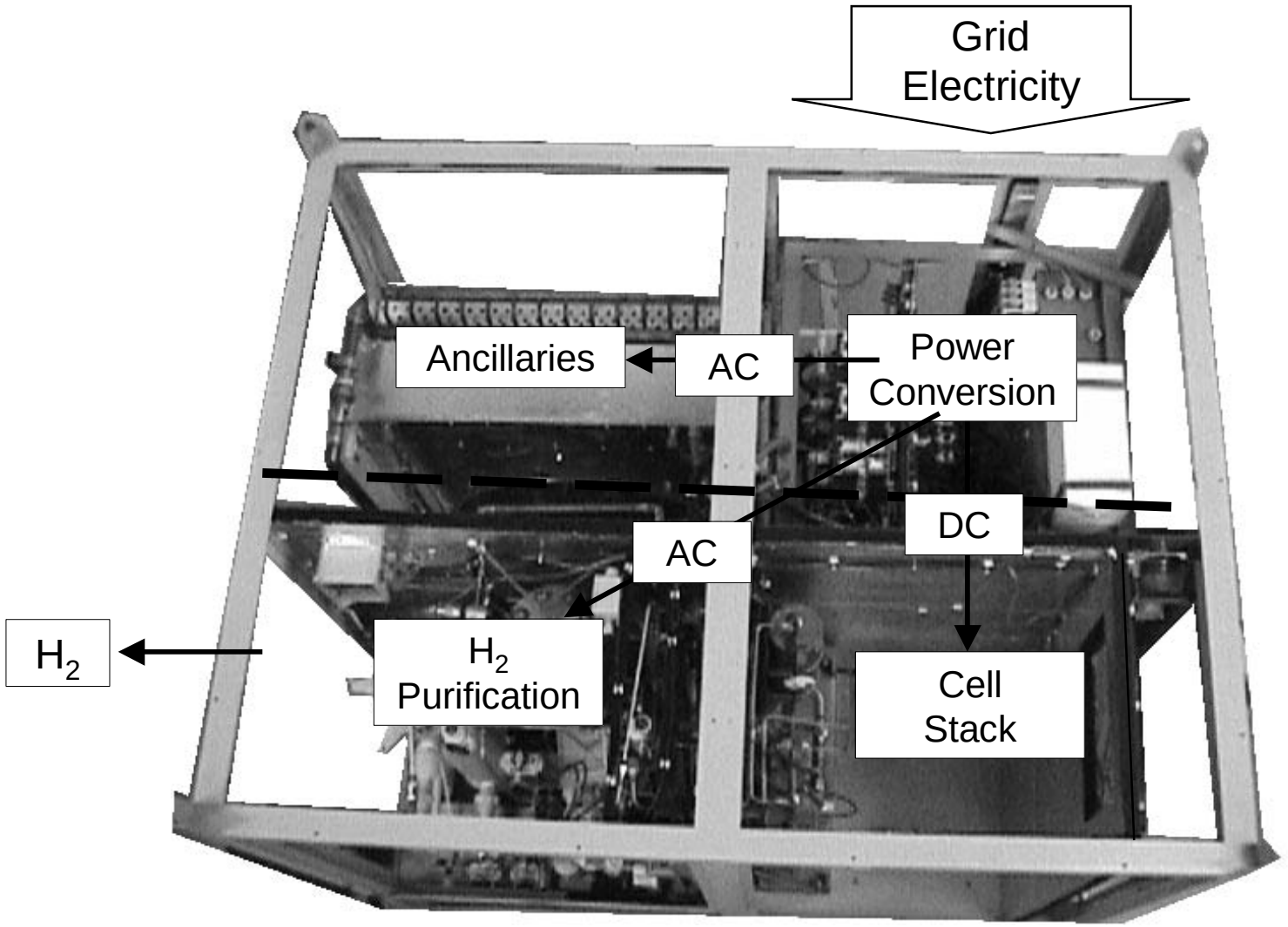
Efficiency can be improved; Cost reductions for all subsystems can be obtained

What is best way to utilize PV?

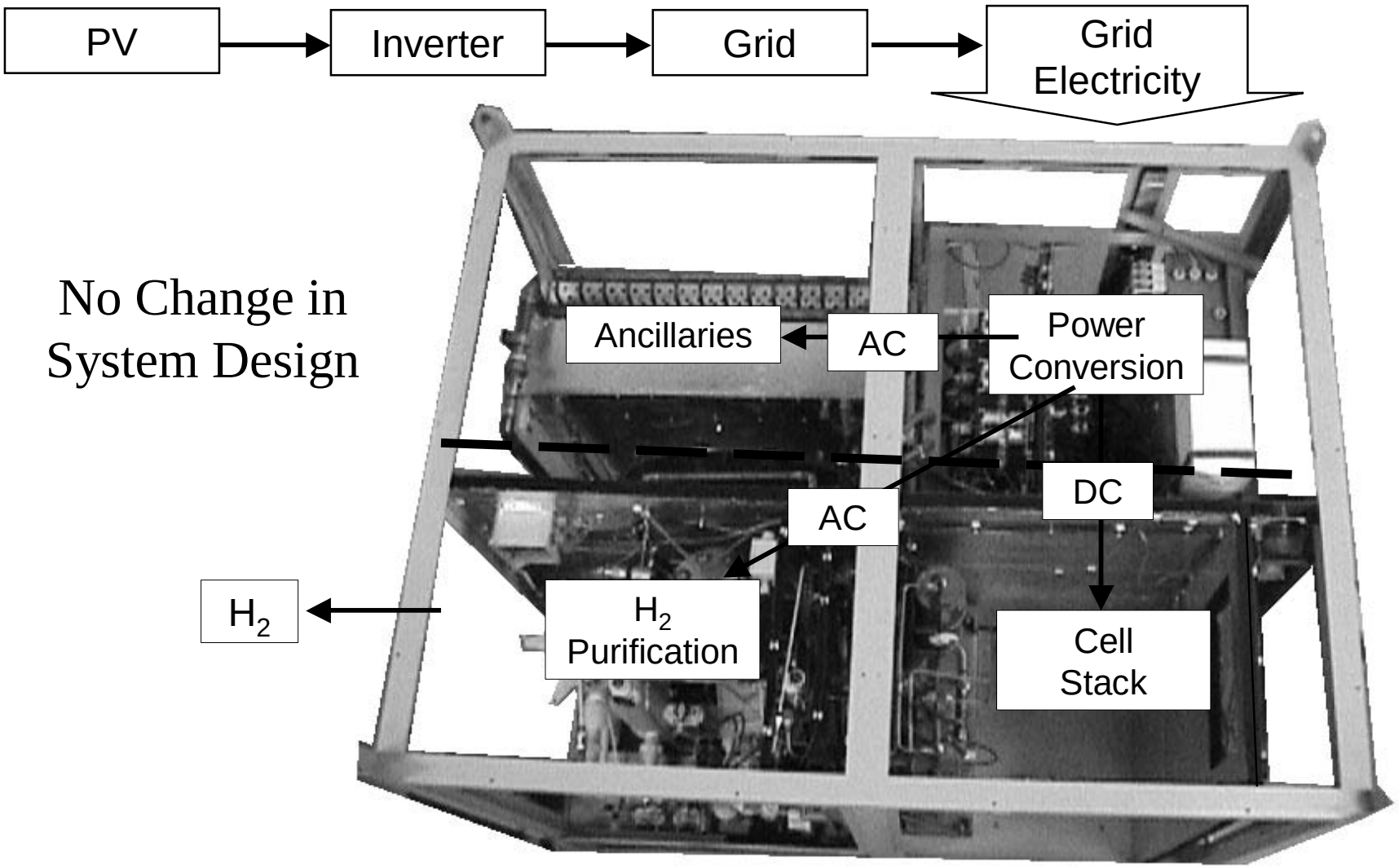
- All PV output inverted and delivered to grid (if grid is available)
- PV output utilized by cell stack; AC Grid powers the ancillaries
- PV output powers the entire system (AC/DC)

(PEM and Alkaline are “Low temp.” electrolysis technologies)

# Conventional PEM Electrolysis Systems



# Conventional Electrolysis Systems - with PV



# Conventional Electrolysis Systems - with PV

Several Different Power Requirements:

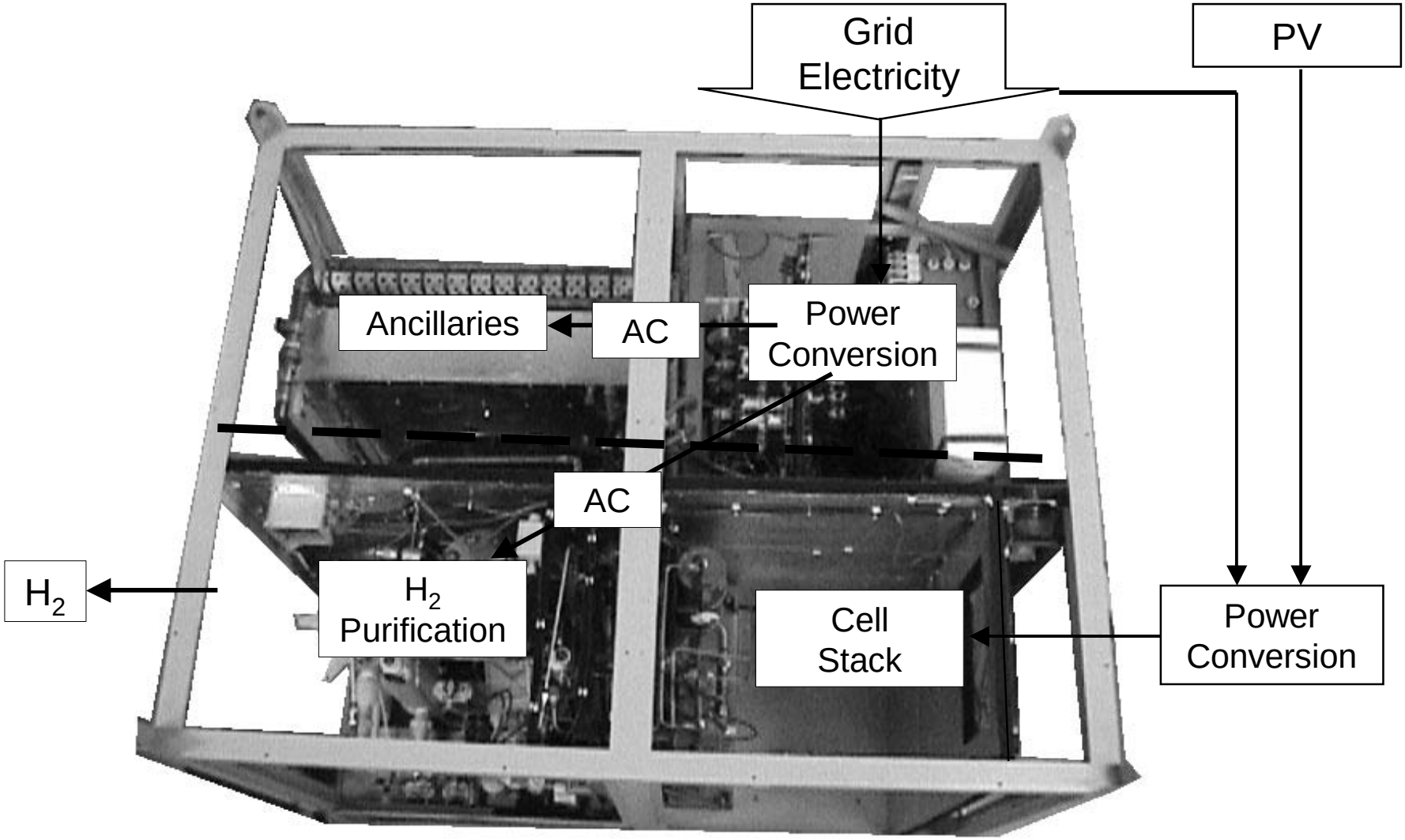
- DC Electricity for Cell Stack
- DC Electricity for Valves/Controls, Sensors
- AC Electricity for Pumps, Fans, Heaters, Sensors

Power Conversion: Cost, Inefficiency

Operational Issues with PV:

- Transients (ancillaries, not cell stack)
- Start-Stops (ancillaries, not cell stack)
- Utilization (PV may be available but not needed)

# PV-Cell Stack Configuration (HOGEN 40 RE™)

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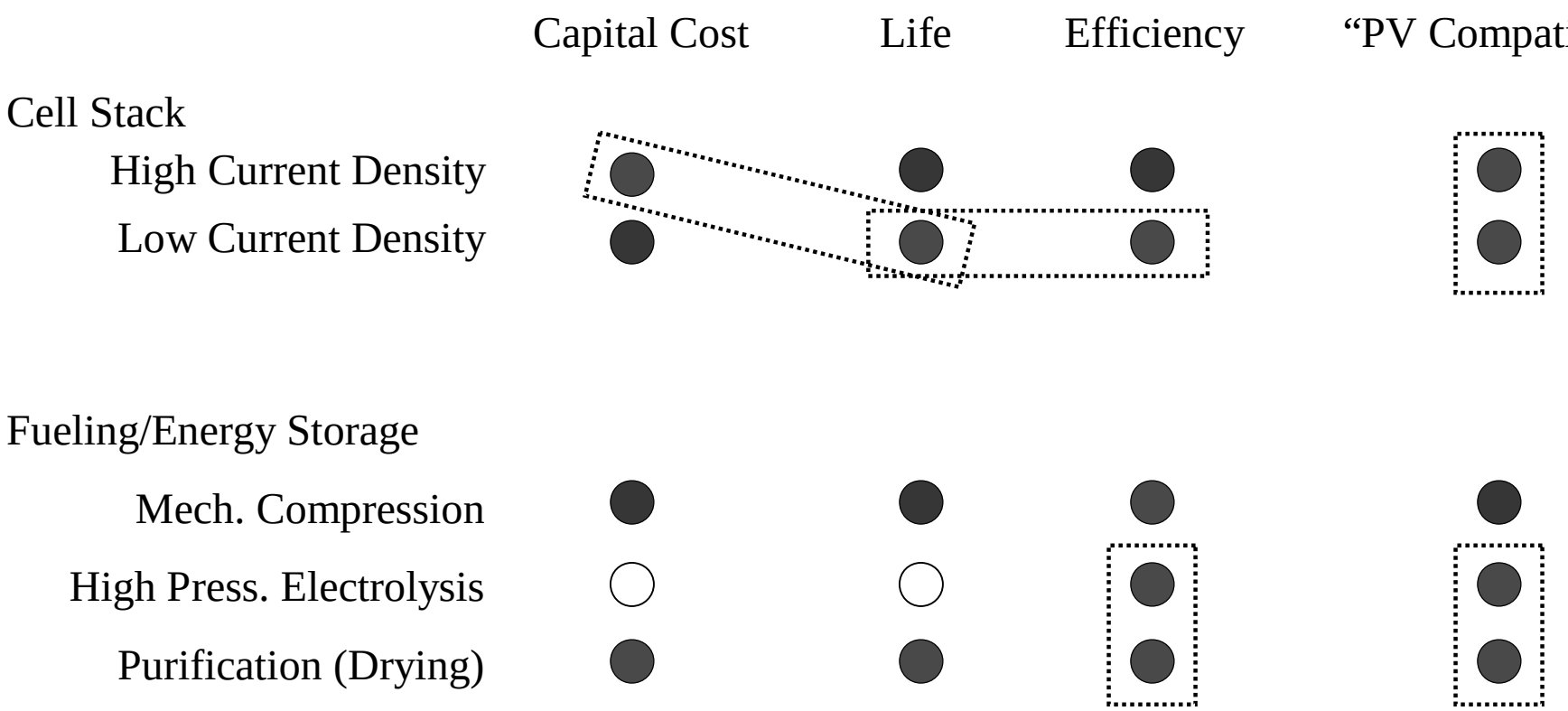
# PV-Electrolysis Qualitative Assessment



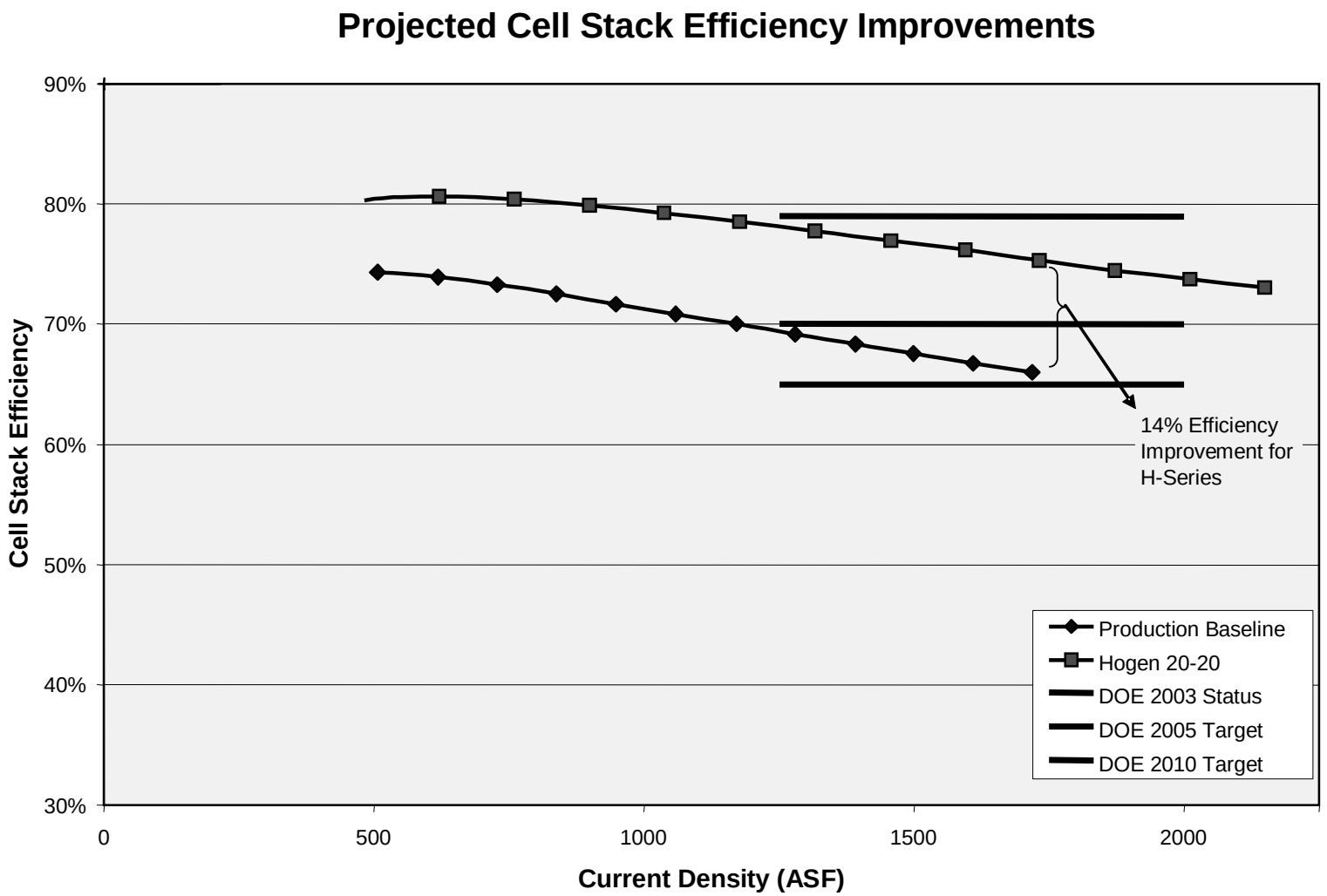
# Electrolyzer Cell Stack Efficiency (and Cost)

Some parameters that can impact efficiency:

- Catalyst
- Cell Design
- Membrane (thickness)
- Temperature
- Current Density

| | |
|---|---|
| Change catalyst – | may add cost, reduce life |
| Change cell design – | NRE cost, time to market |
| Membrane – | improved voltage efficiency but possibly decreased current efficiency, may add cost |
| Higher Temperature – | improved voltage efficiency but possibly decreased current efficiency, decreased life |
| Lower Current Density – | improved voltage efficiency, increased capital cost |

# Electrolyzer Cell Stack Efficiency

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# Electrolysis System Efficiency (and Cost) using PV

| | |
|---|---|
| PV Power Interface - | High Efficiency at 0-100% of rated load |
| Ancillaries – | Simplify / make “compatible” with PV |
| Advanced Technologies - | Electrochemical Compression<br>High Pressure Electrolysis |
| Cost Drivers- | Installed PV cost<br>Life<br>Utilization<br>Efficiency |

# China Lake Project
# PV Electrolysis RFC Energy Storage

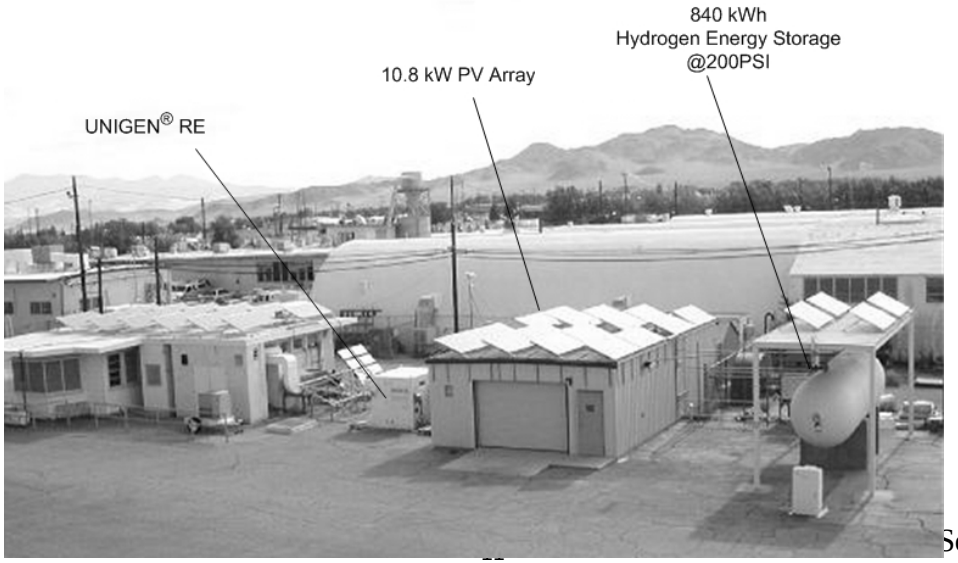

**Project Goal: Battery Replacement**

**Project System Parameters:**

- **24/7 Power from Photovoltaics**
- **10.8 kW Photovoltaic Array**
- **840 kWh stored as $H_2$ @ 200 psi**
- **Two 1.2 kW PEM Fuel Cells**

**Next Phase:**

- **Higher Pressure Electrolyzer**
- **5 kW Output**

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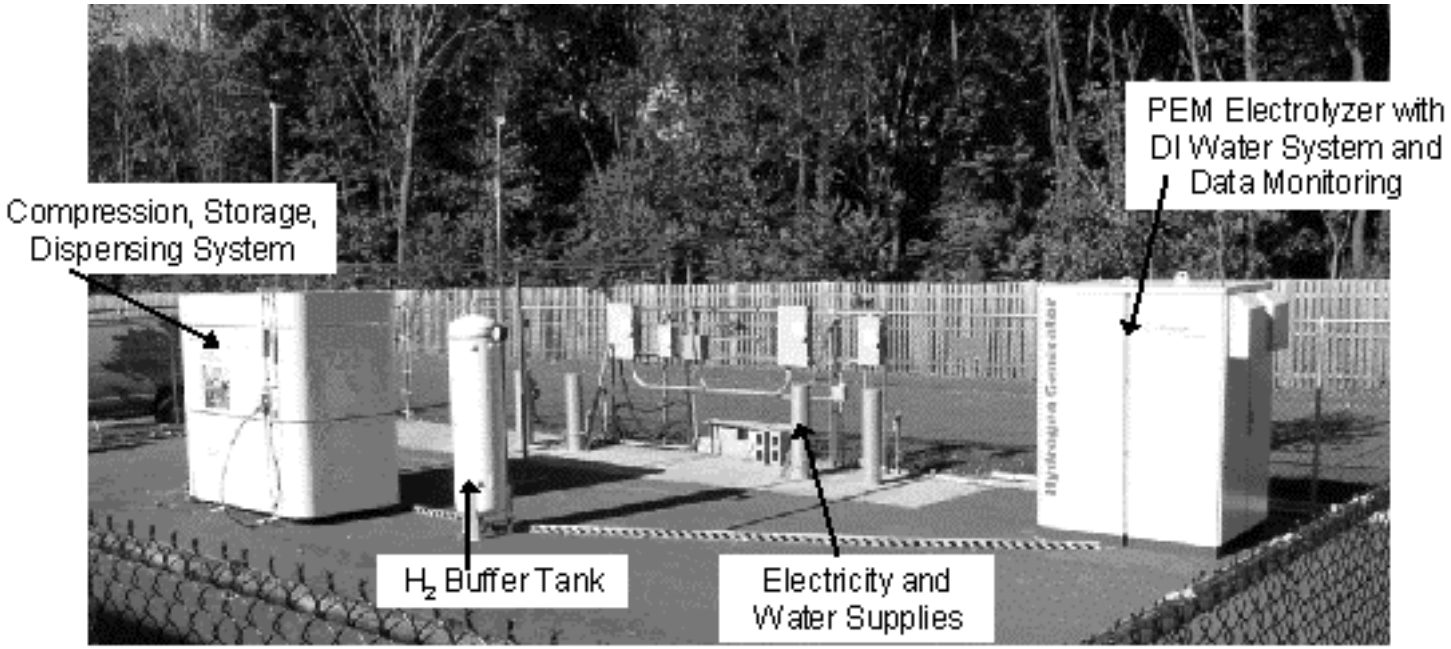
# PV-Electrolysis Fueling - UNLV Fueler




2 year program – DOE Earmark to UNLV Research Foundation

Year 1: Design and Install PV – PEM Electrolysis fueling station in Las Vegas
Year 2: Develop 2,000 psig PEM electrolysis capability

Status: System designed and installed at Proton. Testing in progress. Ready to install system at UNLV (when site there is ready)

Year 2 effort to begin mid-November 2004