Balance of Plant Needs and Integration of Stack Components for Stationary Power and CHP Applications

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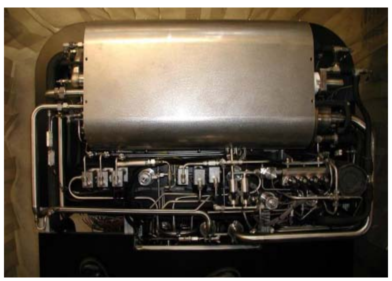
Background

- Experience integrating systems based on fuel cells and reformers.
- Applications include vehicles, combined heat and power (CHP), industrial plants, and forklifts.



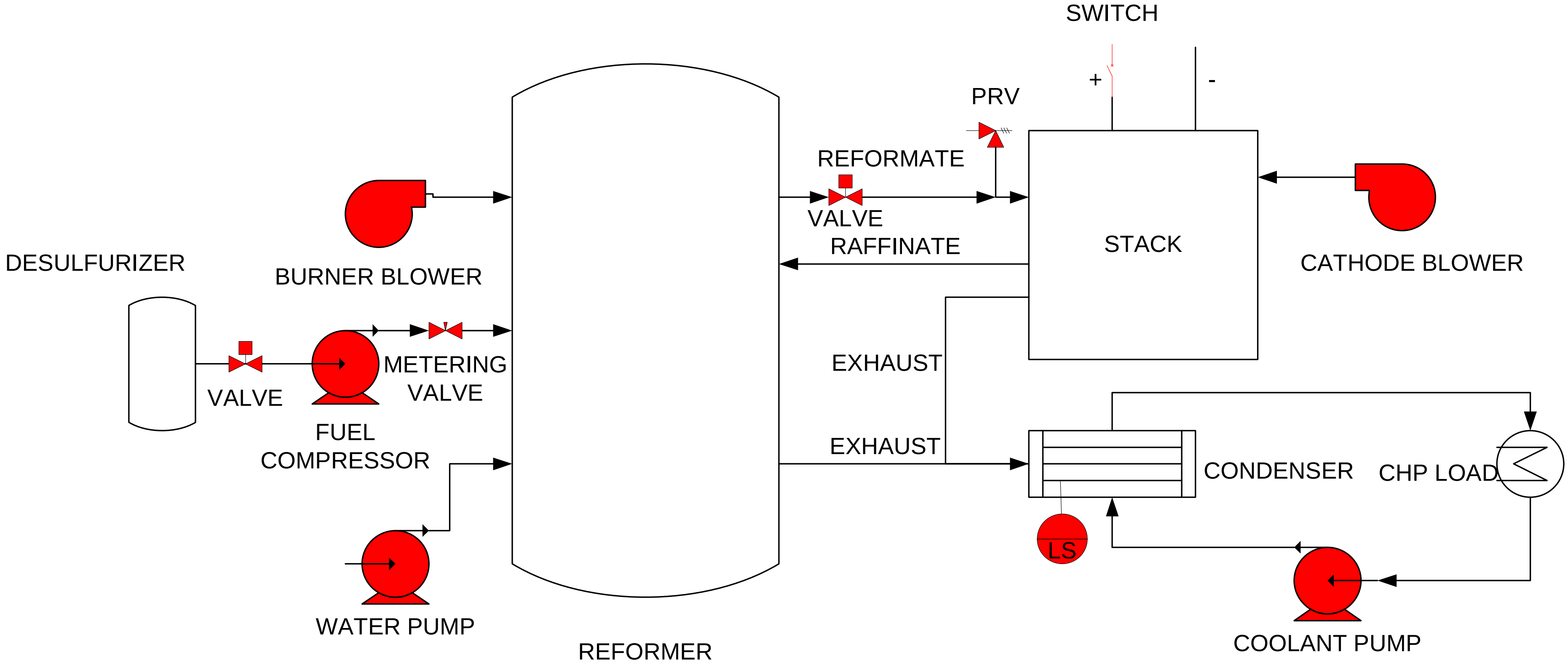
Who Needs Balance of Plant?

- "…an electric generator that has no moving parts…This elegant device is called a fuel cell."

Skerrett, P. J. "Fuel Cell Update." *Popular Science*. June 1993:89. print.

No Moving Parts Except These

- The typical fluid components in a PEM CHP system based on steam/methane reformer technology. (in red)



SIMPLIFIED PEM CHP SYSTEM

Scope of the Challenges

- Trends
  - What drivers are pushing the need for better balance-of-plant components?
    - Reliability
    - Cost
    - Regulatory
    - Efficiency
- Components
  - What types of components represent the greatest challenges?

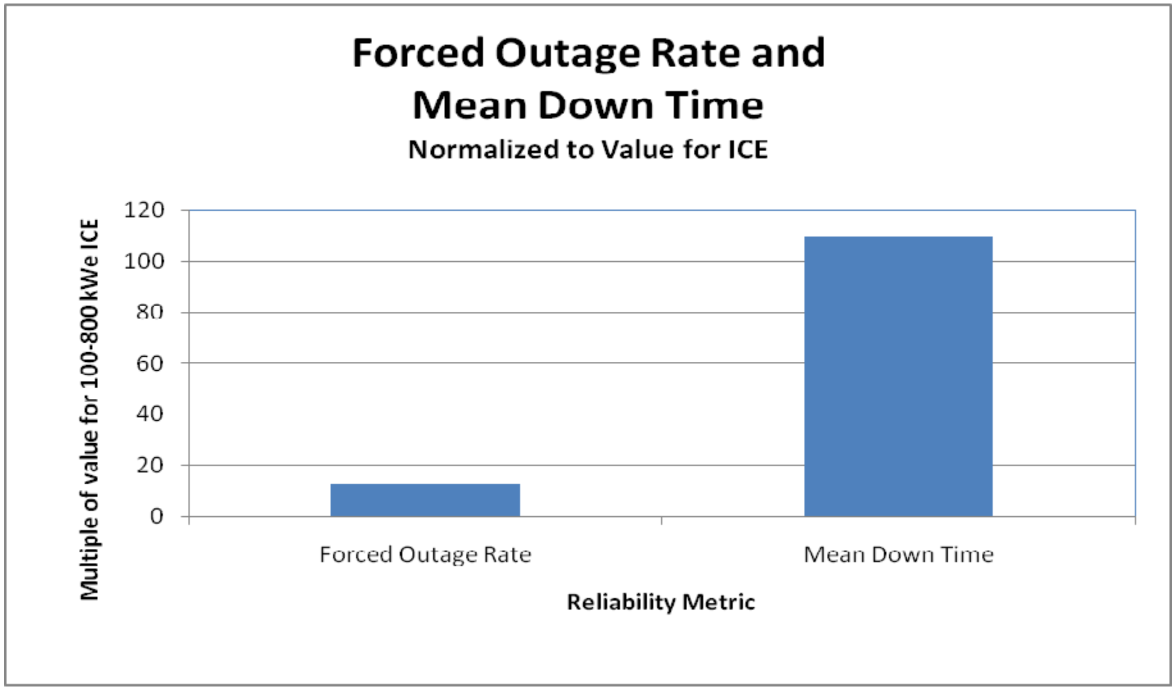
Reliability

- Backup Power
  - The National Emergency Number Association recommends that all 911 call centers have long term emergency power supplies.[1]
  - Fuel cell systems employed in this application are the power used when all else fails. Lives may be at risk if the fuel cell system also fails.

1. National Emergency Number Association. 2001. Recommended Generic Standards for E9-1-1 PSAP Equipment. NENA

Reliability snapshot

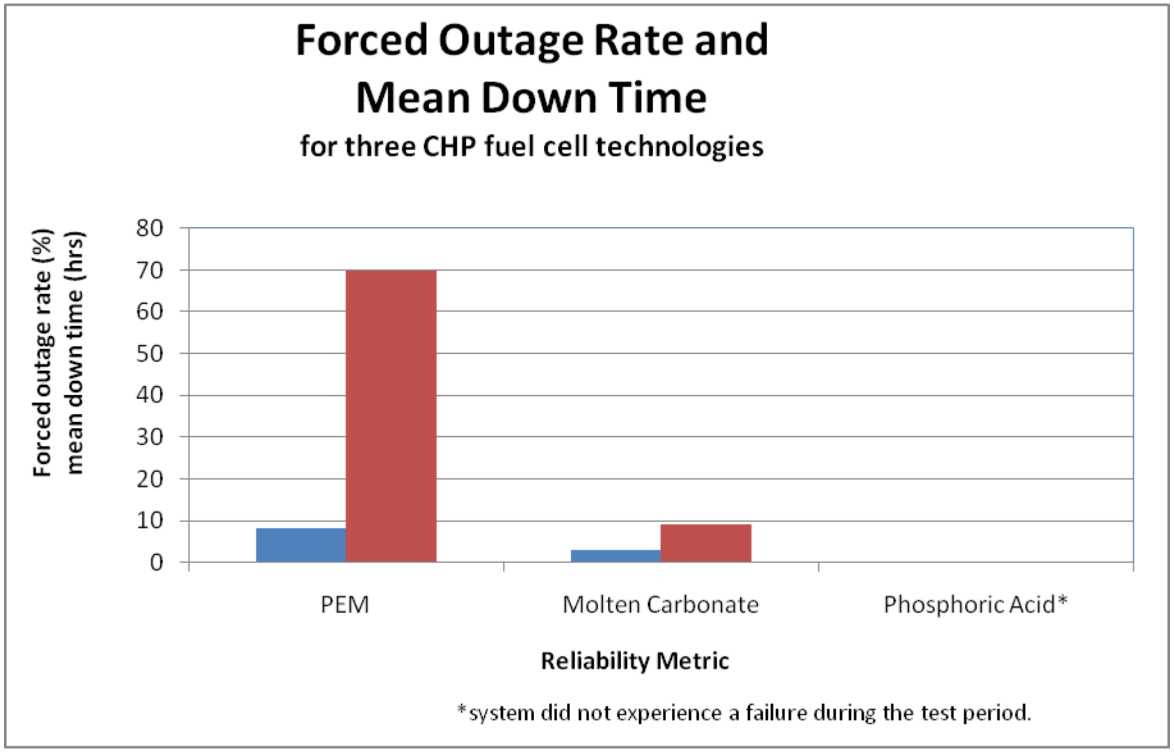
- CHP
  - NYSERDA data show that current fuel cell installations (PA, MC and PEM) lag behind internal combustion engine (ICE)-based CHP in reliability[2].



2. New York State Energy Research and Development Authority, DG/CHP Integrated Data System. Web. 2004-2010.

Reliability closeup: Fuel Cell based CHP

- CHP
  - Among fuel cell technologies, PEM lags behind molten carbonate and phosphoric acid in key reliability metrics[3].

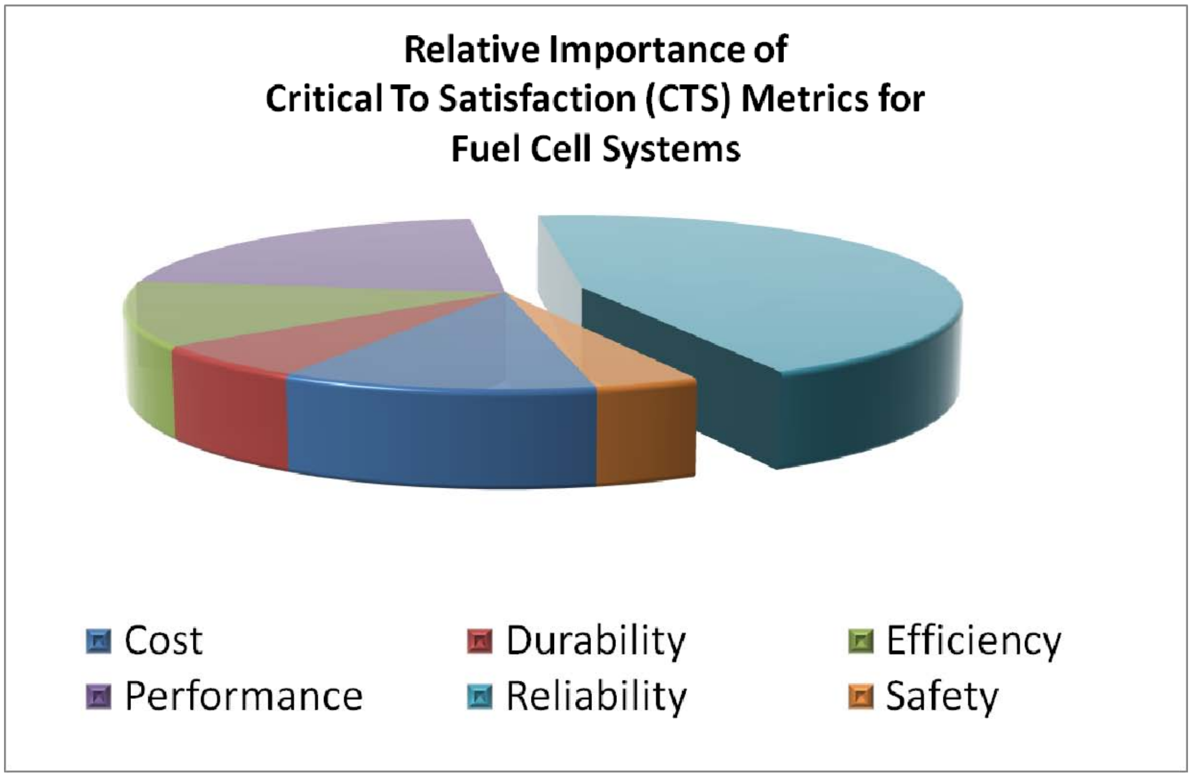


3. New York State Energy Research and Development Authority, DG/CHP Integrated Data System. Web. 2004-2007.

Reliability

Industrial Motive Power

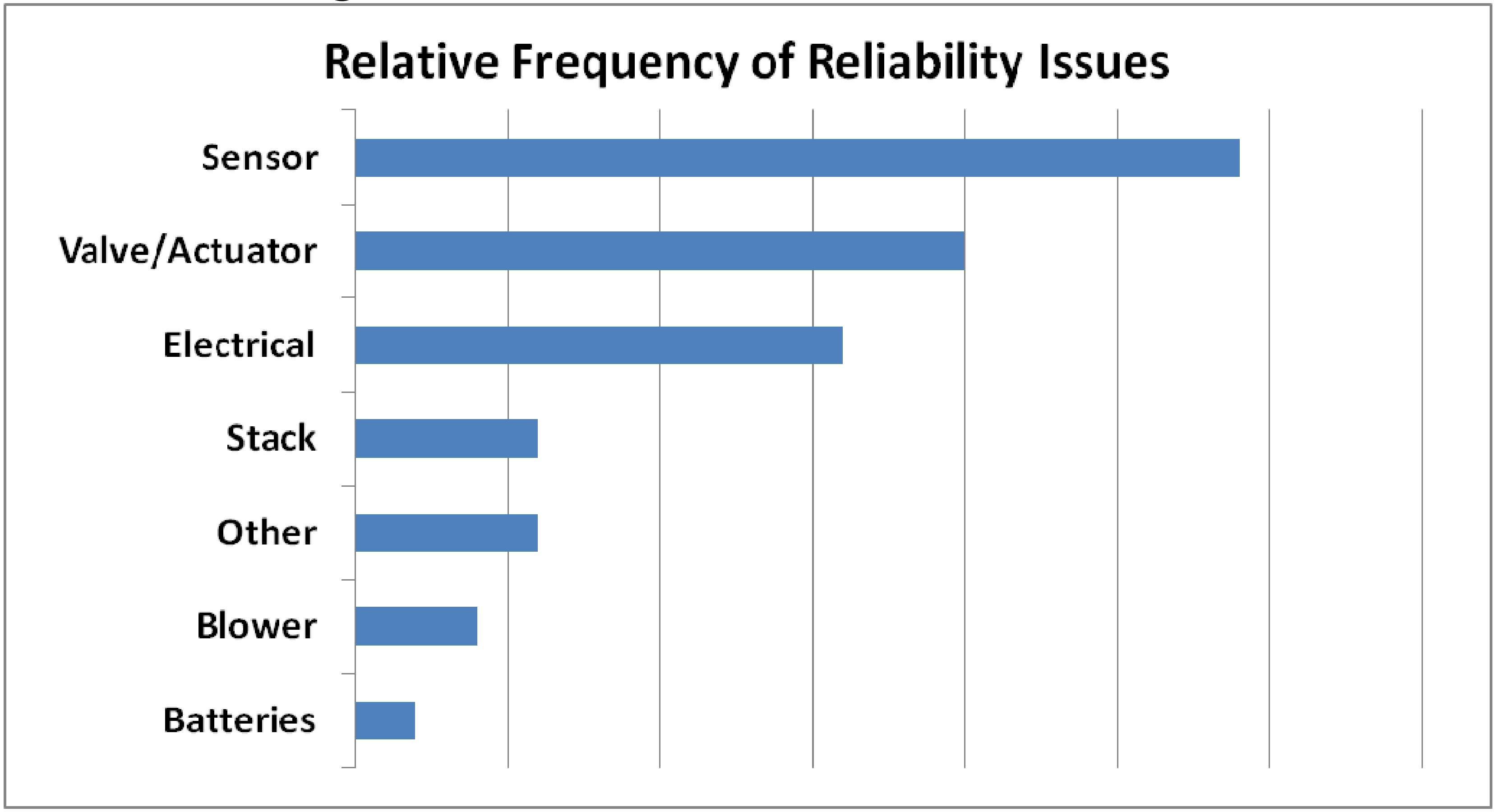
- Reliability is the top concern among likely buyers of fuel cell systems, topping cost, efficiency and lifetime.[4]



4 Nuvera Market Research, 2009

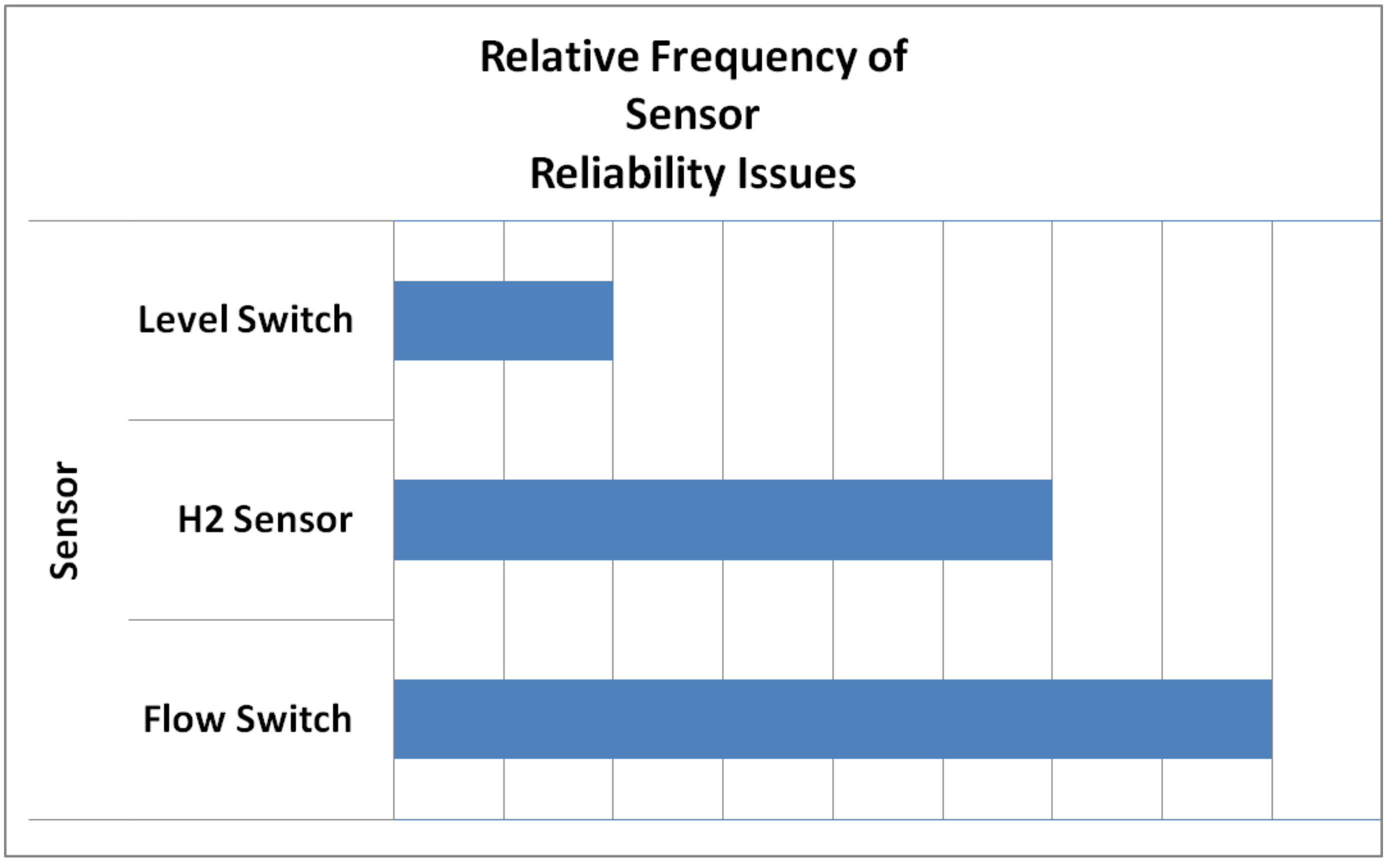
Reliability Pareto

- Stack reliability issues have largely been addressed. The real challenge lies in the BOP.



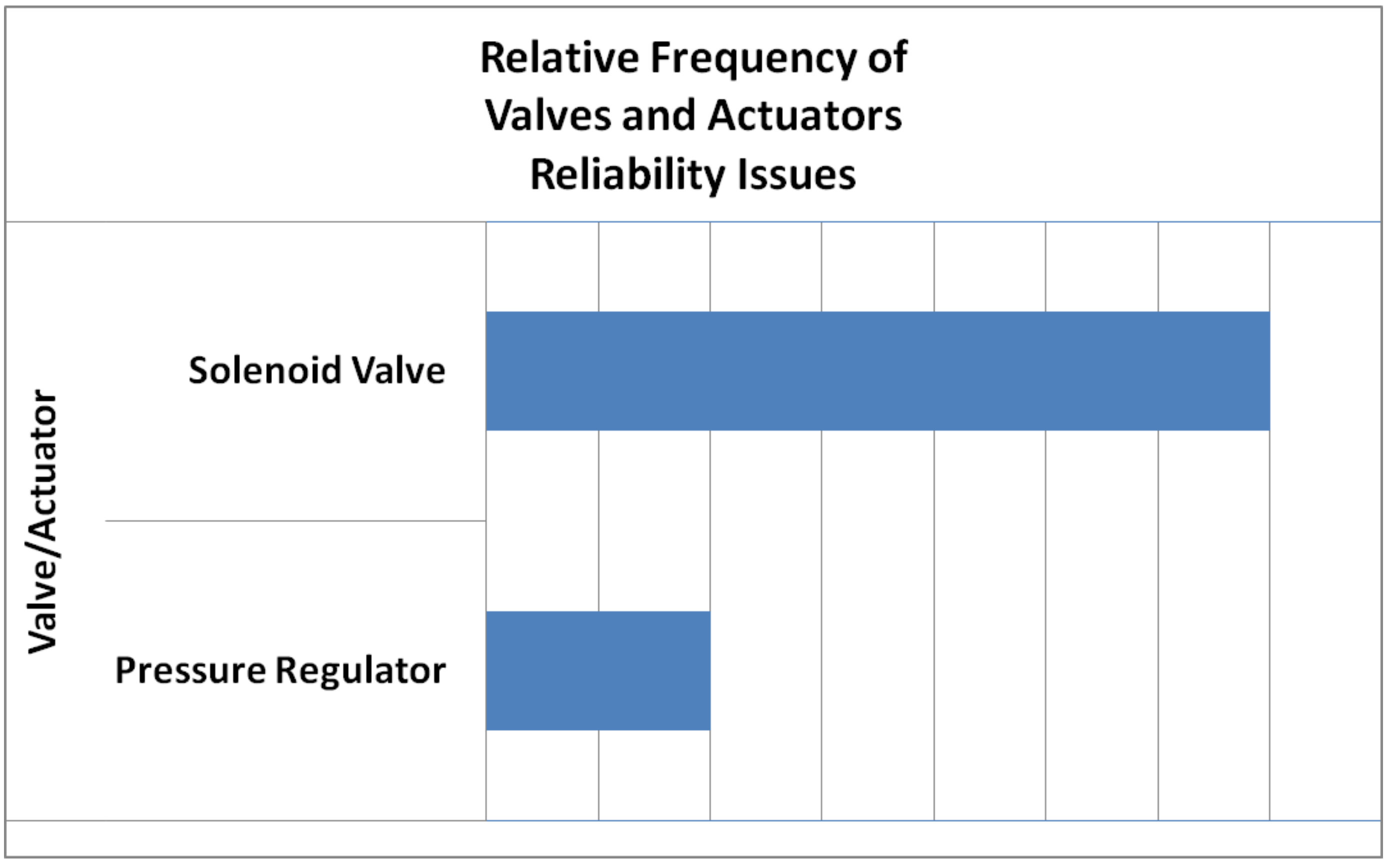
Reliability Closeup: Sensors

- Availability of a low cost, stable, highly selective hydrogen sensor is an ongoing challenge.



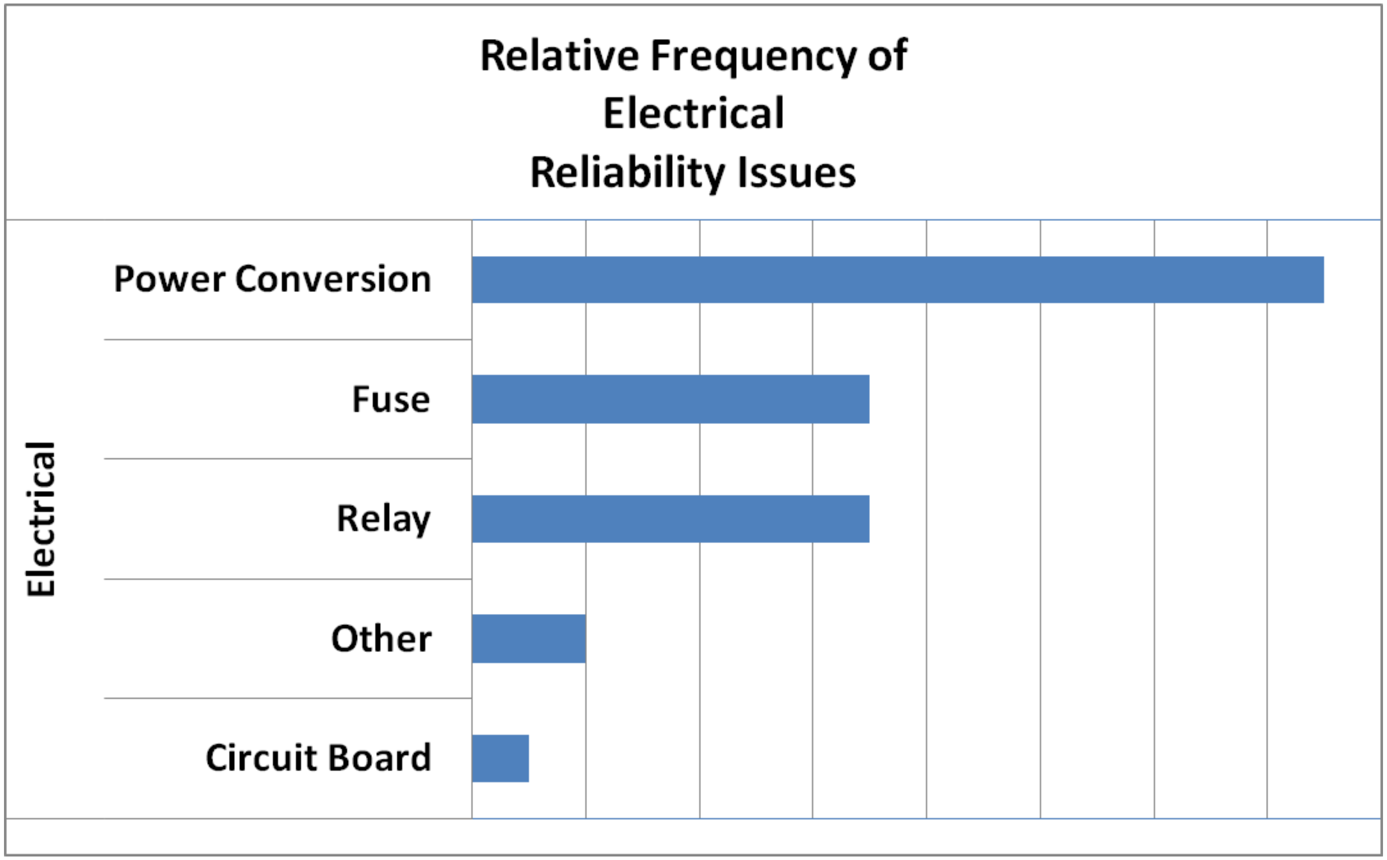
Reliability Closeup: Valves

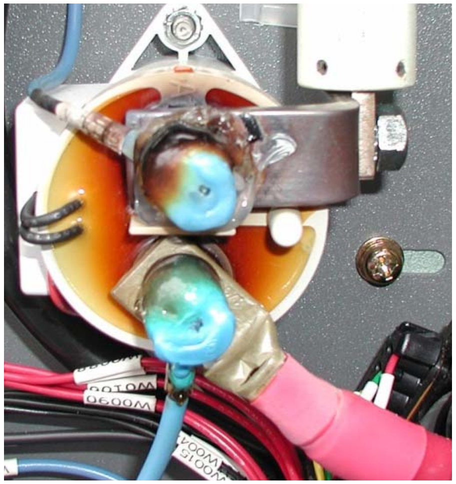
- Solenoid valves are ubiquitous, yet remain troublesome. Leaking and failing closed are the largest problems.



Reliability Closeup: Electrical

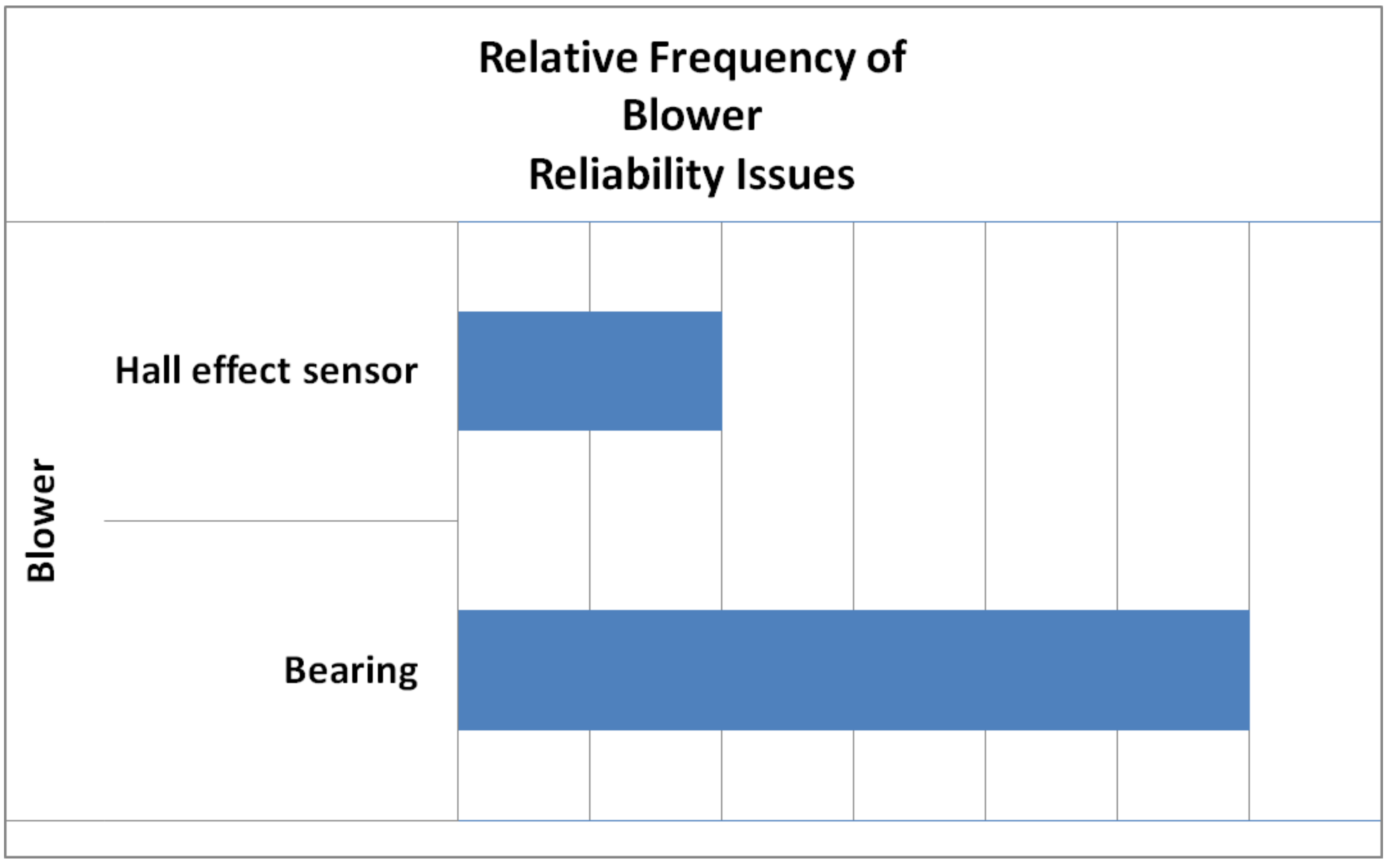
- Power conversion is the leading cause of electrical complaints.





Reliability Closeup: Blowers

- Some of the leading causes of blower failures are bearings and internal sensors.

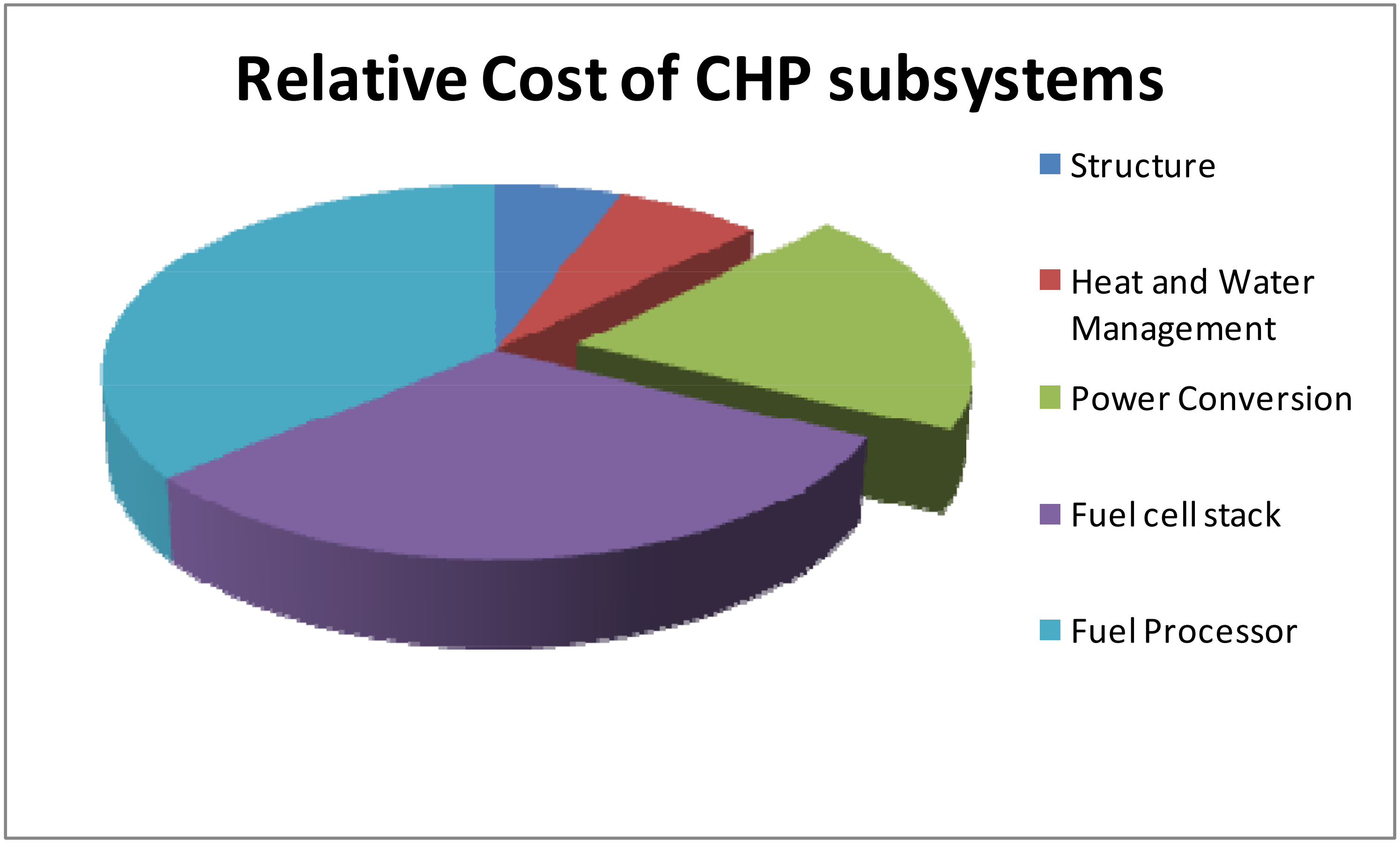


Cost

- DOE fuel cell CHP Targets
  - 40% electrical efficiency at rated power
  - 80% combined efficiency at rated power
  - 40,000 hour durability10% power degradation
  - $750/kW (including reformer)

Cost Pareto

- Power conversion remains the single largest cost among all BOP.



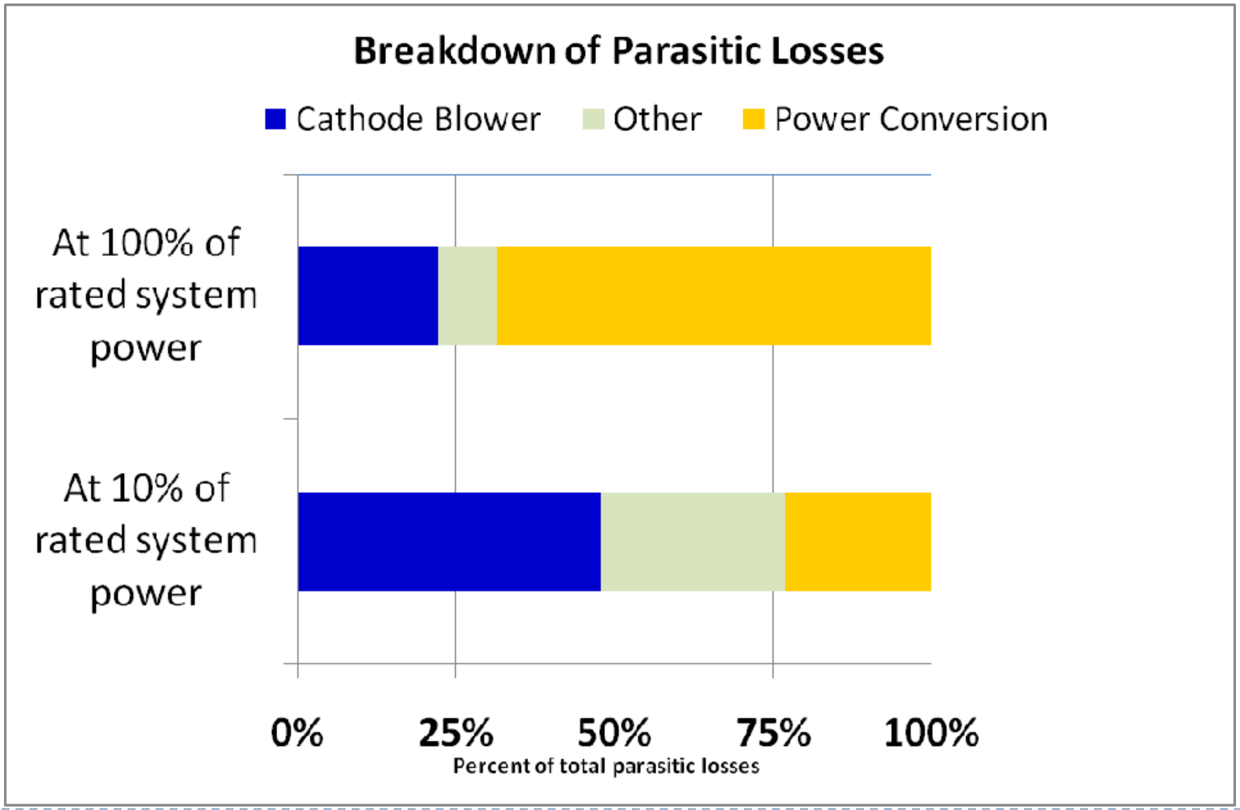
Regulatory

- The current regulatory climate is extremely challenging due to the sheer number of standards.
- Components which meet the required standards often do not exist as COTS items.

Stationary Fuel Cell Standards		
ANSI/CSA America FC1 IEC 62282-3-1 EN 62282-3-1 DVGW VP119 JIS C 8821-23 CAN/CSA-IEC 62282-3 CEN/CENELEC pr EN 50465:2007 UL Subject 2266 JIS C 8811	EN 62282-2:2004 CAN/CSA C22.2 No. 62282-2:07 JIS C 8831 JIS C 8832 CSA America FC4 UL 1741 JIS C 8826 ANSI/NFPA 853 JIS TR C 0004 IEC 62282-3-201 NIST IR 7131	CAN/BNQ 1784-000 ANSI/NFPA 70: Article 692 - NFPA 110 ANSI/IEEE 1547 IEEE 1547.1 JIS C 8802 -8824 ASME PTC 50 IEC 62282-3-2 EN 62282-3-2:2006

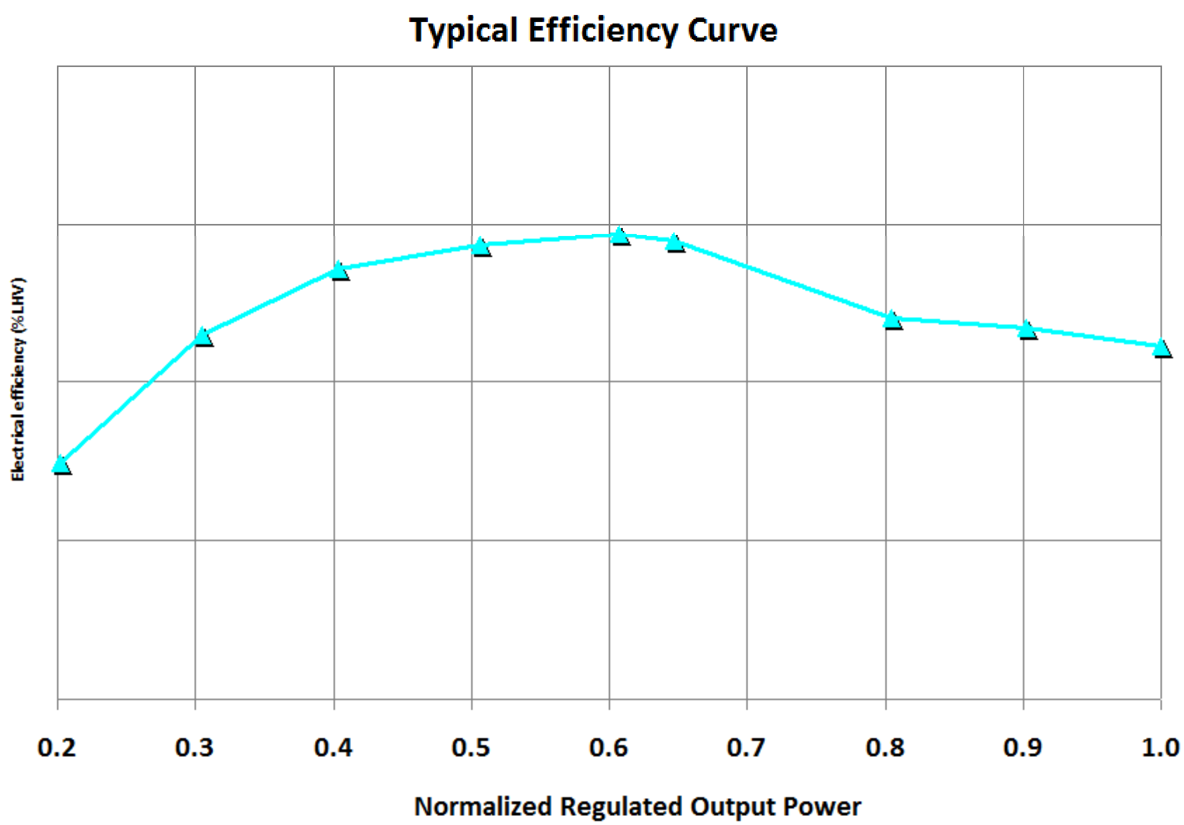
Efficiency

- Two components account for ~75% of parasitic system losses. Cathode blower and DC/DC or DC/AC power conversion.



Efficiency

- The overlap of DC/DC and blower results in efficiency falloff at the high and low ends of system power.



Summary of needs

- Where is attention needed the most?
  - 1 – little 3-moderate, 9- great challenge

Component/ Area of concern	Reliability	Cost	Regulatory	Efficiency
Power Conversion DC/DC and DC/AC	1	9	3	9
Cathode Blower	3	3	3	9
Buffer Energy Storage	9	9	3	3
Controls	1	3	3	1
Sensors	9	9	3	1

Summary of needs

- Power Conversion
  - Efficient - >95%
  - Scalable – need add-on modules to increase power, rather than re-engineering.
  - Flexible – Capable of interfacing with current battery technologies and AC line voltages:
    - DC:12, 24, 36, 48, 80
    - AC: 120, 240, 480 (single and three phase)
- Cathode Blower
  - Low cost - < $10 per kW of stack power supported.
  - Quiet - < 60-dBa at 1 meter
  - Efficient - >35%

Summary of needs

- Buffer energy storage
  - Highly cyclable - > 20,000 deep discharge cycles
  - Low cost - < $15/Ah (12 V system)
  - Compact - > 400-500 Wh/L
- Sensors
  - Wide temperature extremes: -30°C to +50°C.
  - Compatible with harsh fluids (DI water).
  - Shock and vibration hardened.
  - Low cost, selectable hydrogen sensor, which is immune to hydrogen overdose.

Questions?

- Thank you for your time.
- Questions?