DMFC Power Supply for All-Day True-Wireless Mobile Computing

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PolyFuel

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Project # FC46

Overview

Timeline

Project Start Date: Sept, 2004

Project End Date: Sept, 2008

Percent Complete: 85%

Budget

DOE share:	$3.00 M
PolyFuel share:	$3.34 M
Total:	$6.34 M
FY07 Funding:	$868 K
FY08 Funding:	$1.06 M

Barriers

Volumetric Power Density:	> 30 W/l
Gravimetric Power Density:	> 30 W/kg
Energy Density:	> 500 W·h/l
Lifetime:	> 1000 hours

Partners

Catalyst & MEA Materials: **Johnson Matthey**

MEA Materials & plates: **GrafTech**

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Objectives

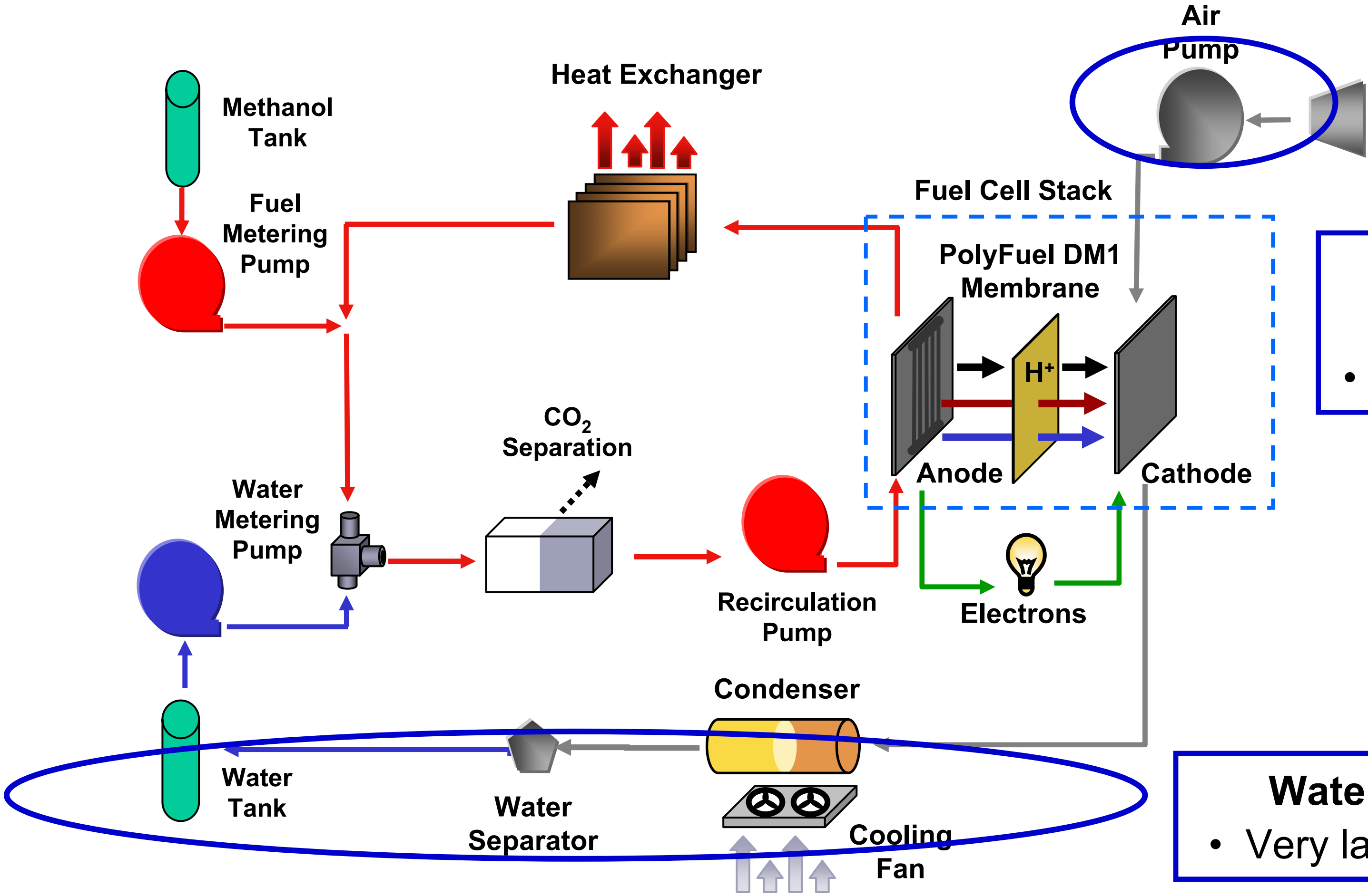
- To build a DMFC laptop power supply with a significant advantage over lithium ion batteries
- To fully integrate this power supply into a laptop computer
- A radical departure from conventional active systems is required to realize competitive power density
- PolyFuel's intention is to license any arising IP to electronics OEMs

Parameter	Target	Projection
▪ Volumetric Power Density:	> 30 W/l	48 W/l
▪ Gravimetric Power Density:	> 30 W/kg	35 W/kg
▪ Energy Density:	> 500 W·h/l	325 W·h/l (one cartridge) 435 W·h/l (two cartridges)
▪ Lifetime:	> 1000 hours	> 1000 hours

Milestones

Key fuel cell system components identified & tested	Jun 2006
Passive water recovery demonstrated in single cell	Jan 2007
600 hours demonstrated in single cell	Oct 2007
Operational (non-integrated) system producing power	Dec 2007
Fully integrated system producing power	Mar 2008
Durability tests on complete systems	Sep 2008

Conventional DMFC operation



Air Pump
- Noisy
- Power Hungry

Water Separation
- Very large components

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Solution is Passive Water Recovery

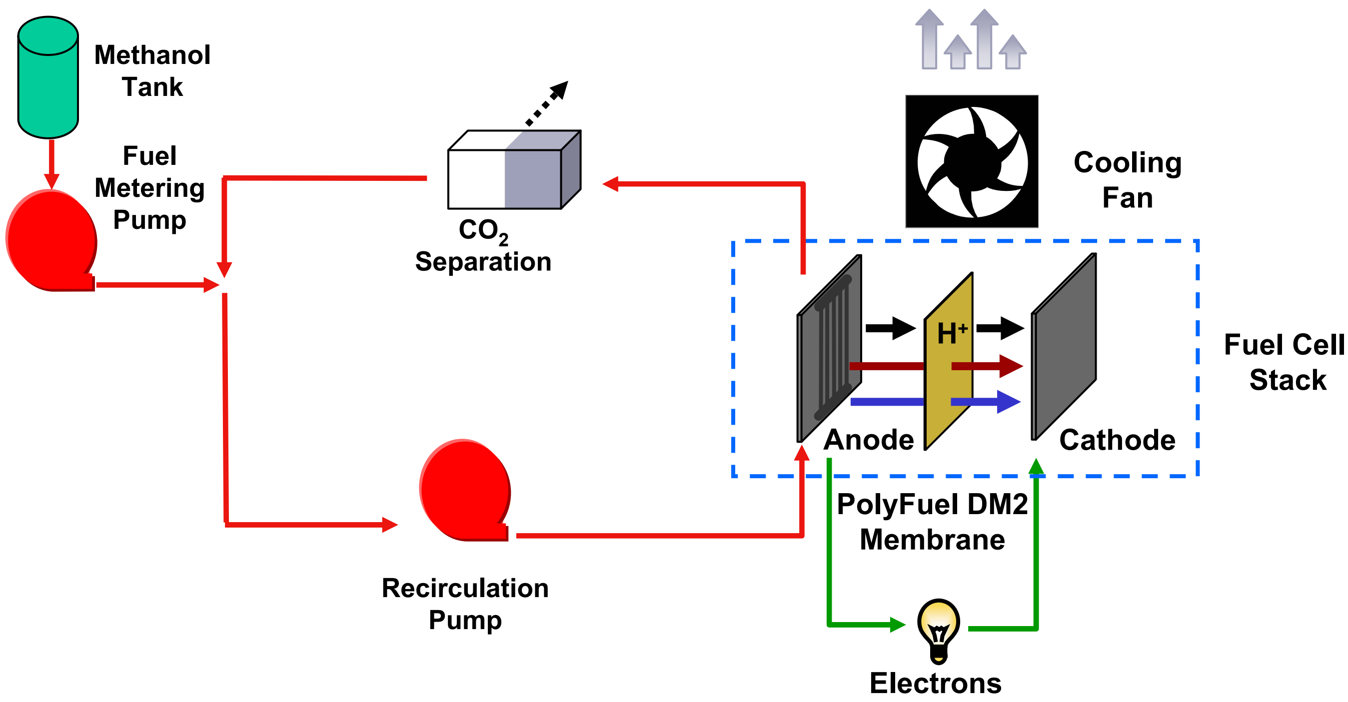
- Recovering gaseous water from the fuel cell exhaust is space intensive
  - Requires large condenser system to remove heat from air
  - Requires large separator tank to remove liquid water from air exhaust
  - Requires air compressor to operate at ~2 psi to remove liquid water from flow fields in cathode plate

- Instead, directly transfer water from cathode to anode through membrane
  - Enables low pressure fans to be used for combined oxidant & cooling
  - Eliminates need for condenser and liquid separation system

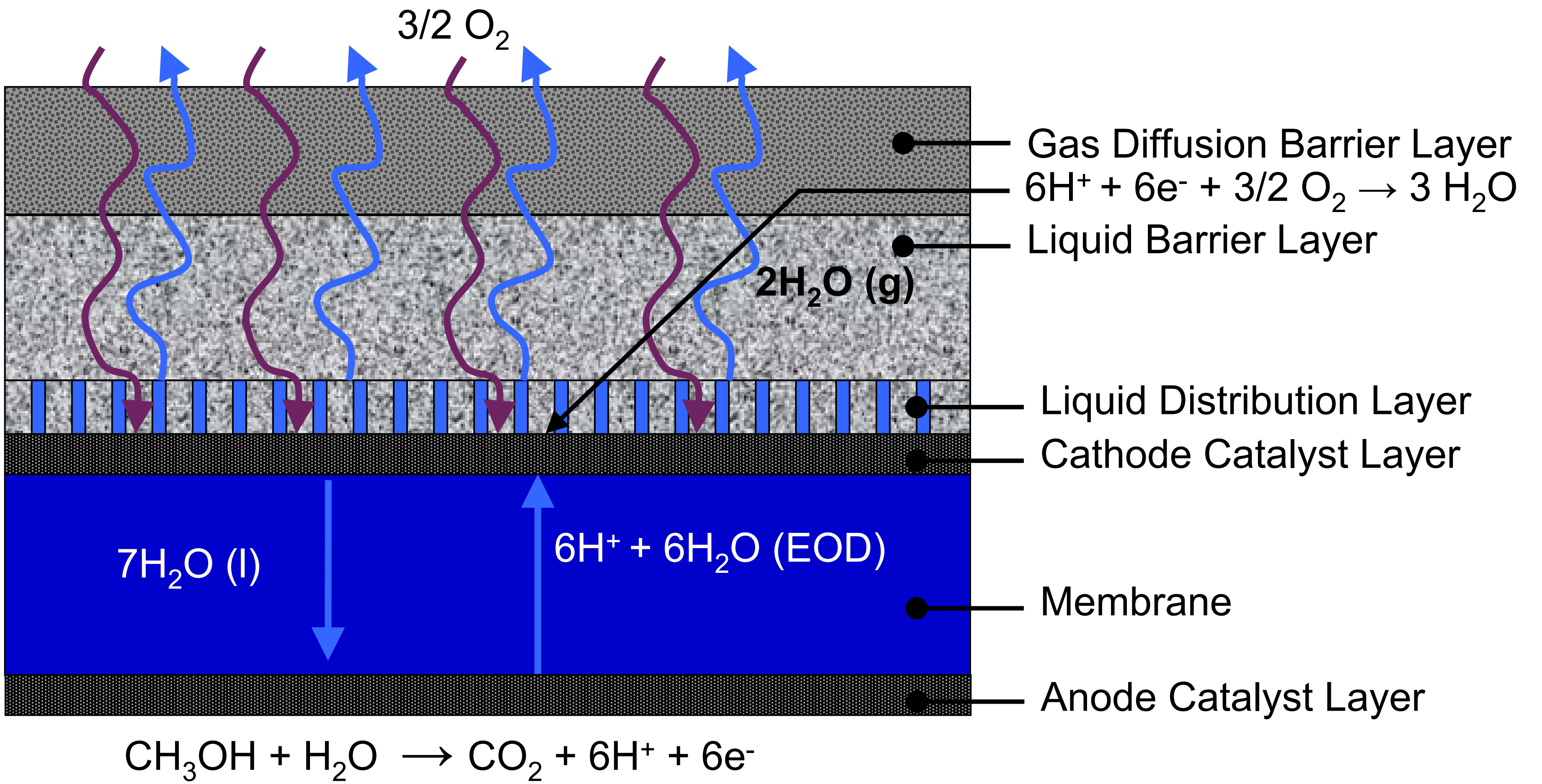
PolyFuel has developed a new MEA to meet these requirements

✱ New PolyFuel membrane allows high water permeability with low methanol crossover
✱ New GDL barrier layer allows only right amount of water to leave MEA

PolyFuel Passive Water Recovery



Barrier Layer Structure to Retain Water



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Target Conditions for Passive Water Recovery

Fuel Cell Performance Targets:

- **Power Density** — **58 to 60 mW/cm^2**
- **Fuel Cell Current Density** — **150 mA/cm^2**
- **Fuel Cell Temperature** — **50 C**

Barrier Layer Properties:

- **Water Escape Fraction** — **0.66**
- **Minimum Liquid Water Pressure** — **140 kPa**
- **Barrier Water Transport** — **K_{H2O} = 1.5 mm/s**

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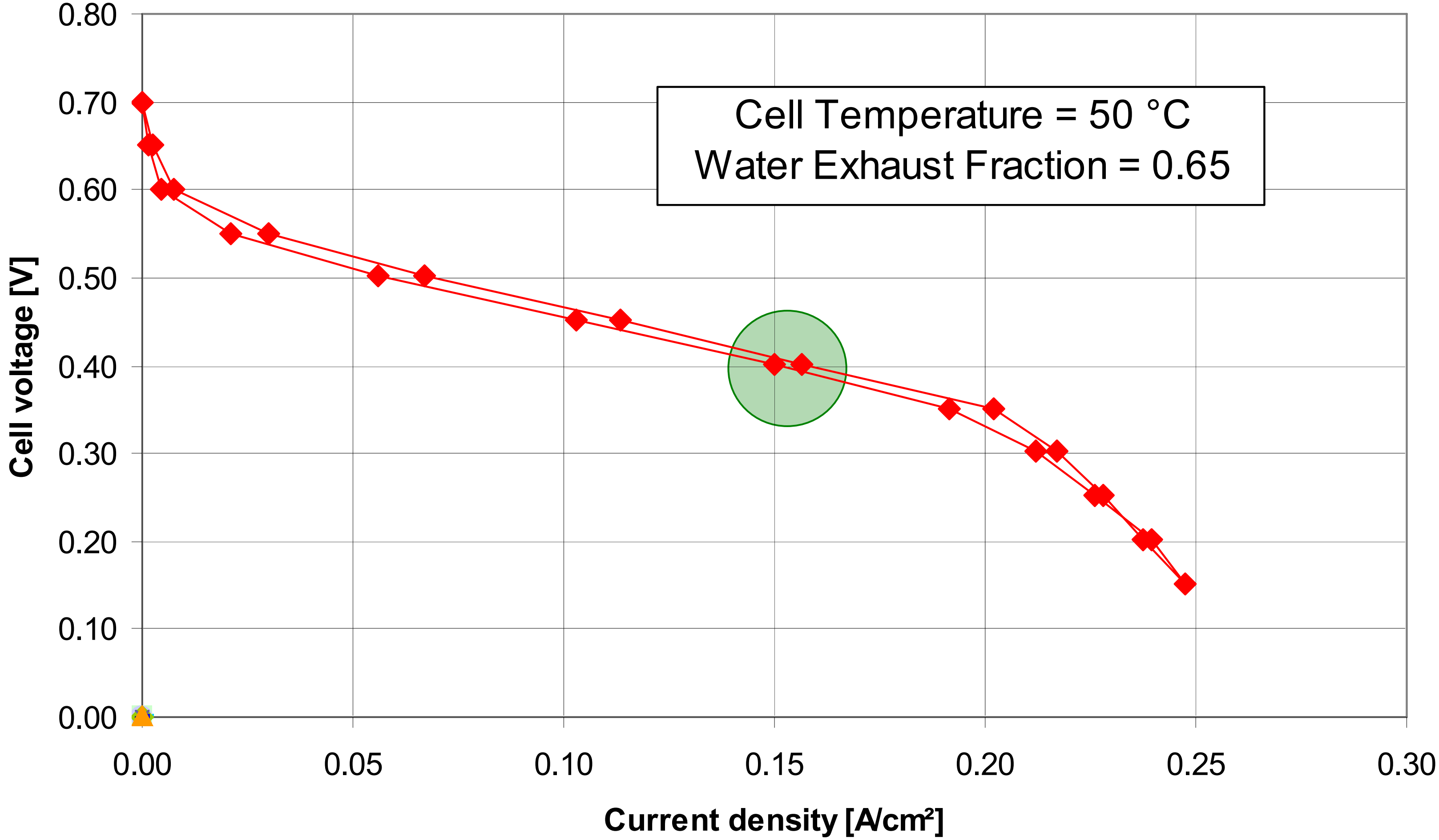
Cell Performance with Sufficient Power & Water Recovery



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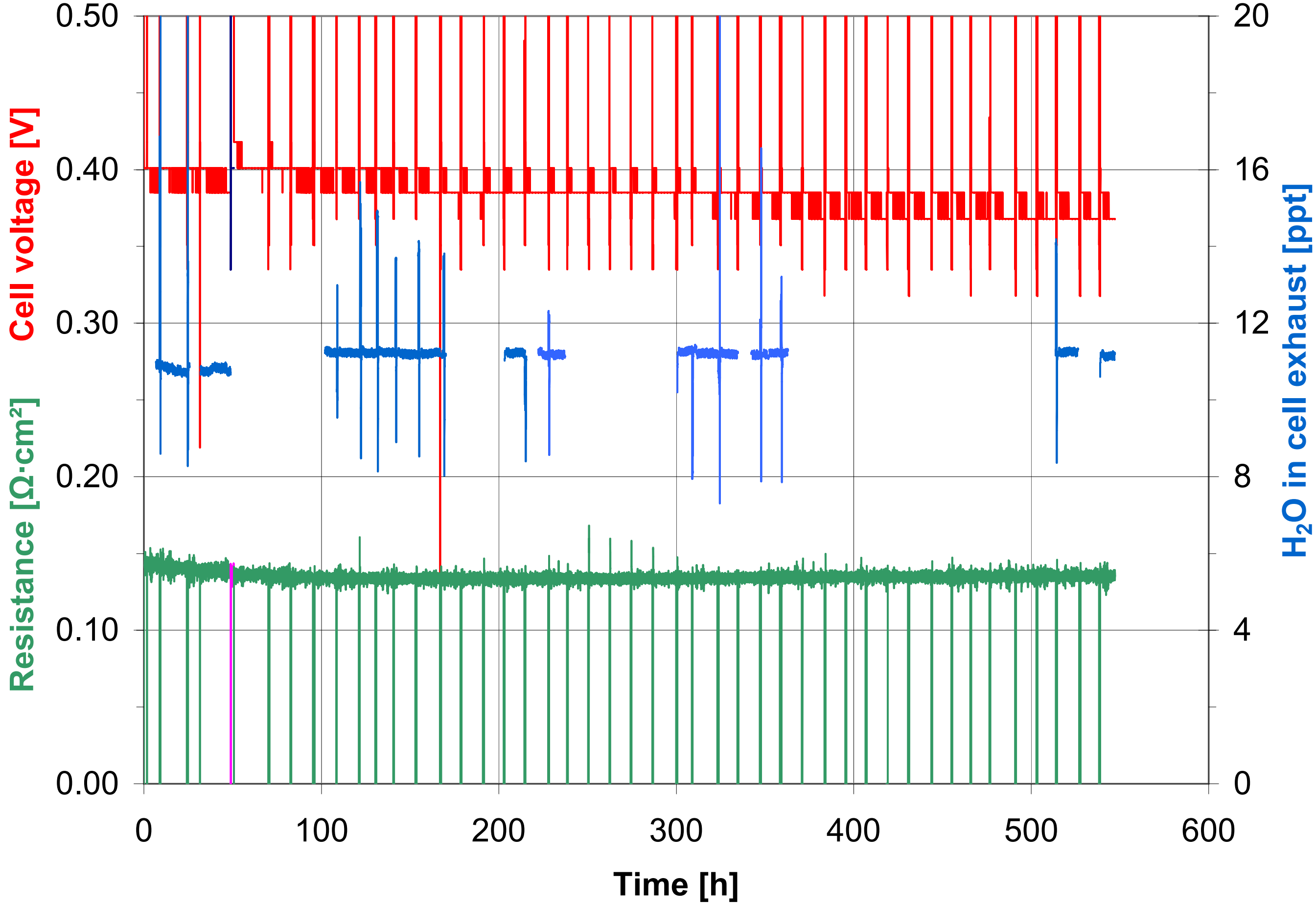
Lifetime Testing



Conditions

Temperature = 50 C

Current = 150 mA/cm²

Water Loss Ratio = 0.65

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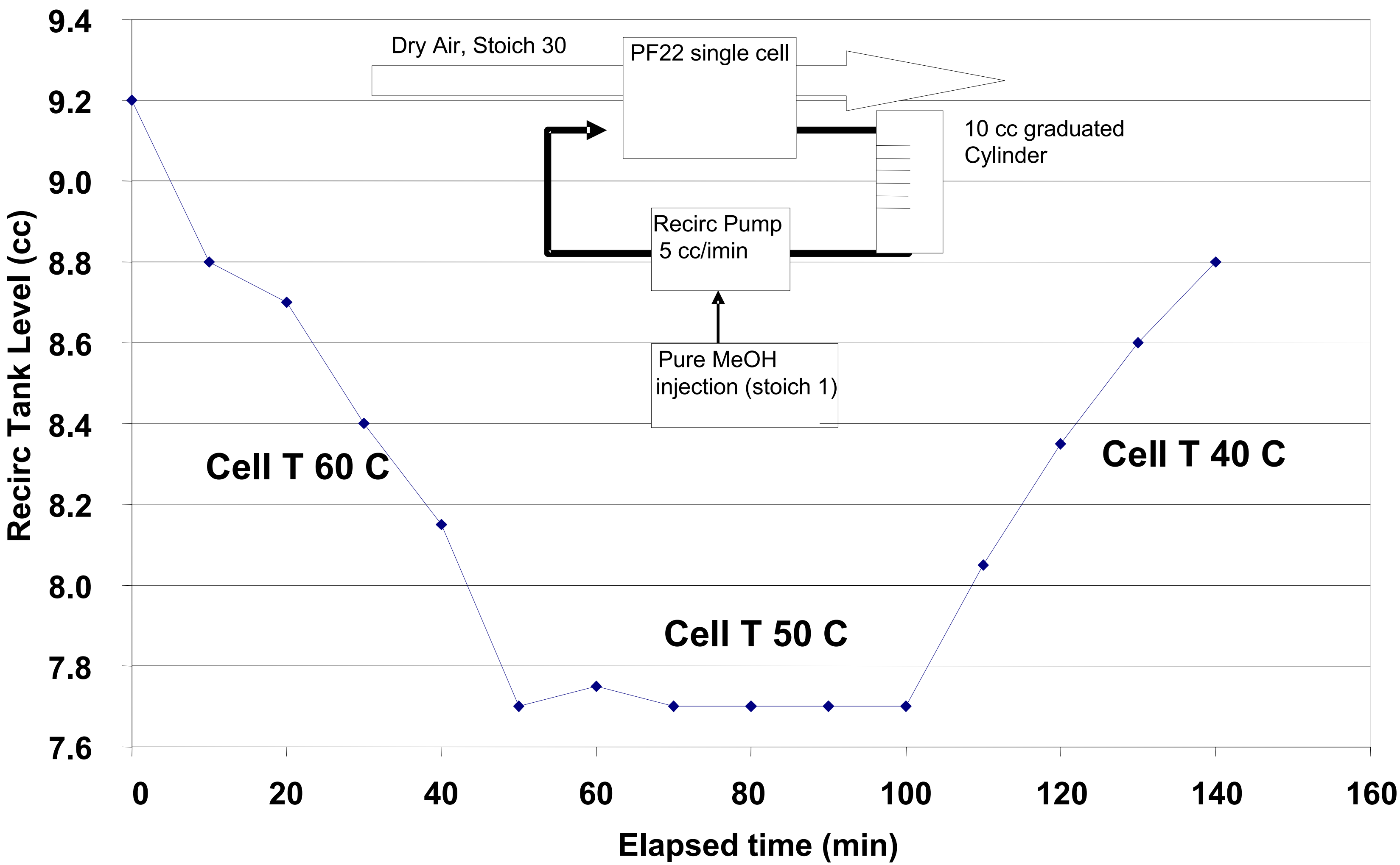
Recirculation Tank Level vs. Time for Water Neutral Test



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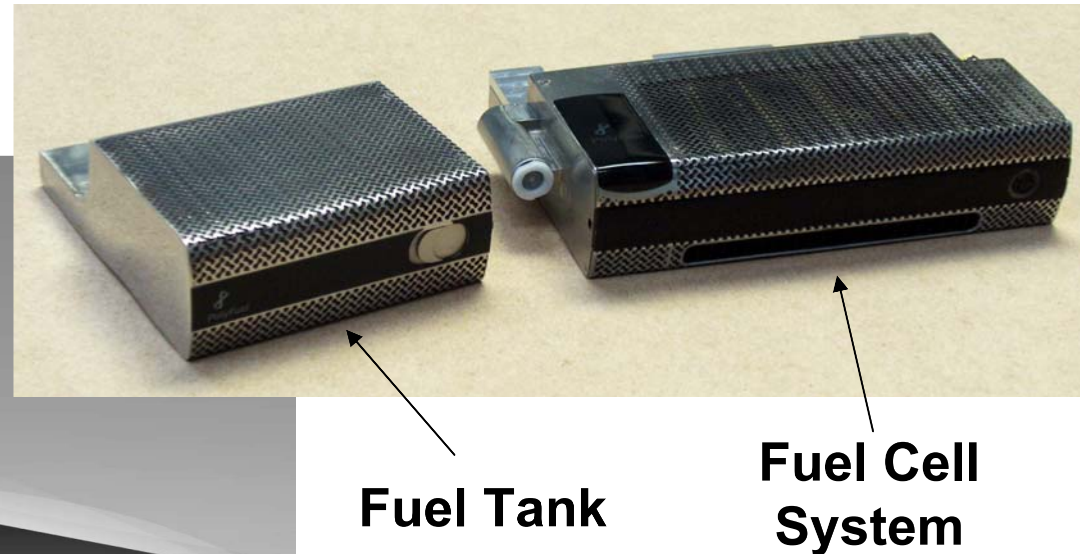
Complete Fuel Cell System



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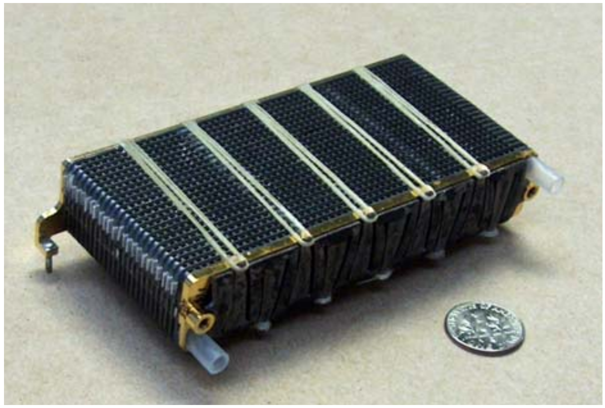
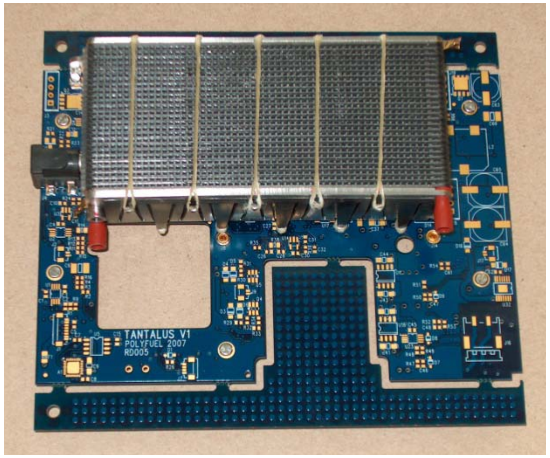
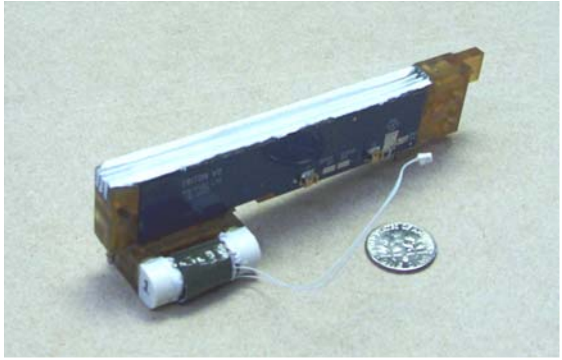
System Components



Fuel Cell Stack and Dime

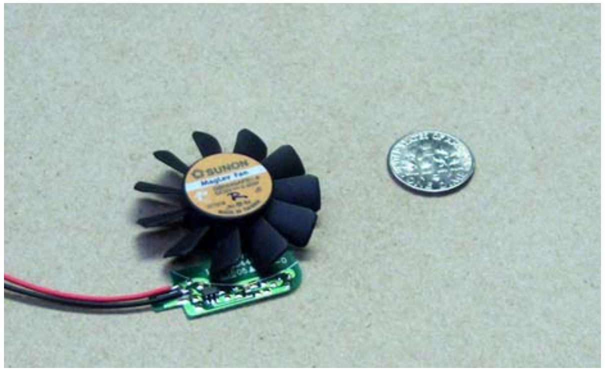


Stack Mounted on Control Board

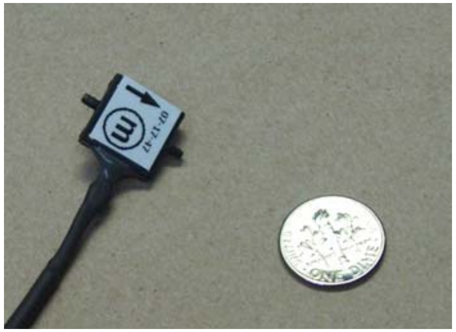


CO_2 Separator, Recirculation Pump

Stack Components



Cooling Fan and Dime



Fuel Injection Pump and Dime

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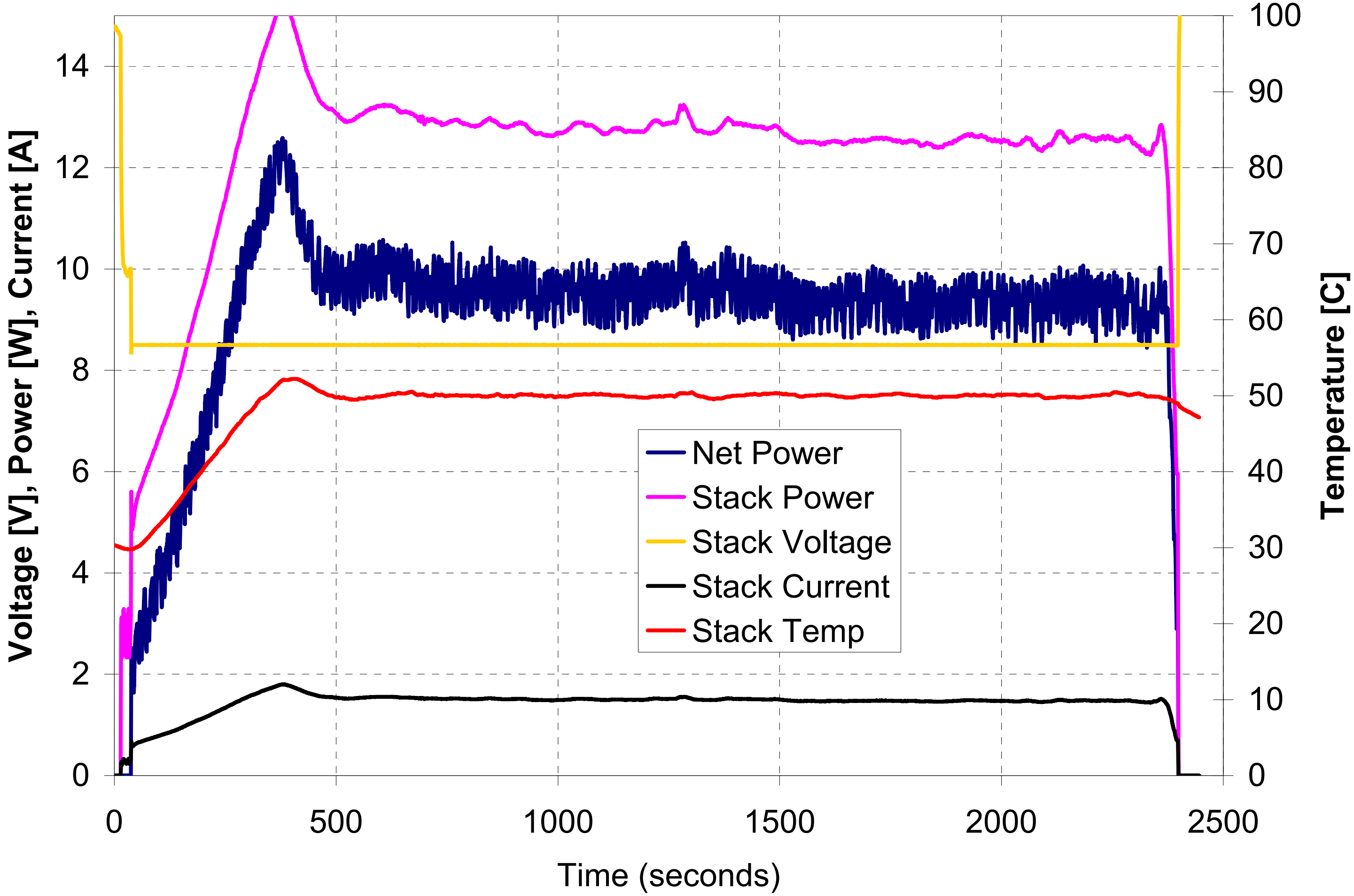
System Operation



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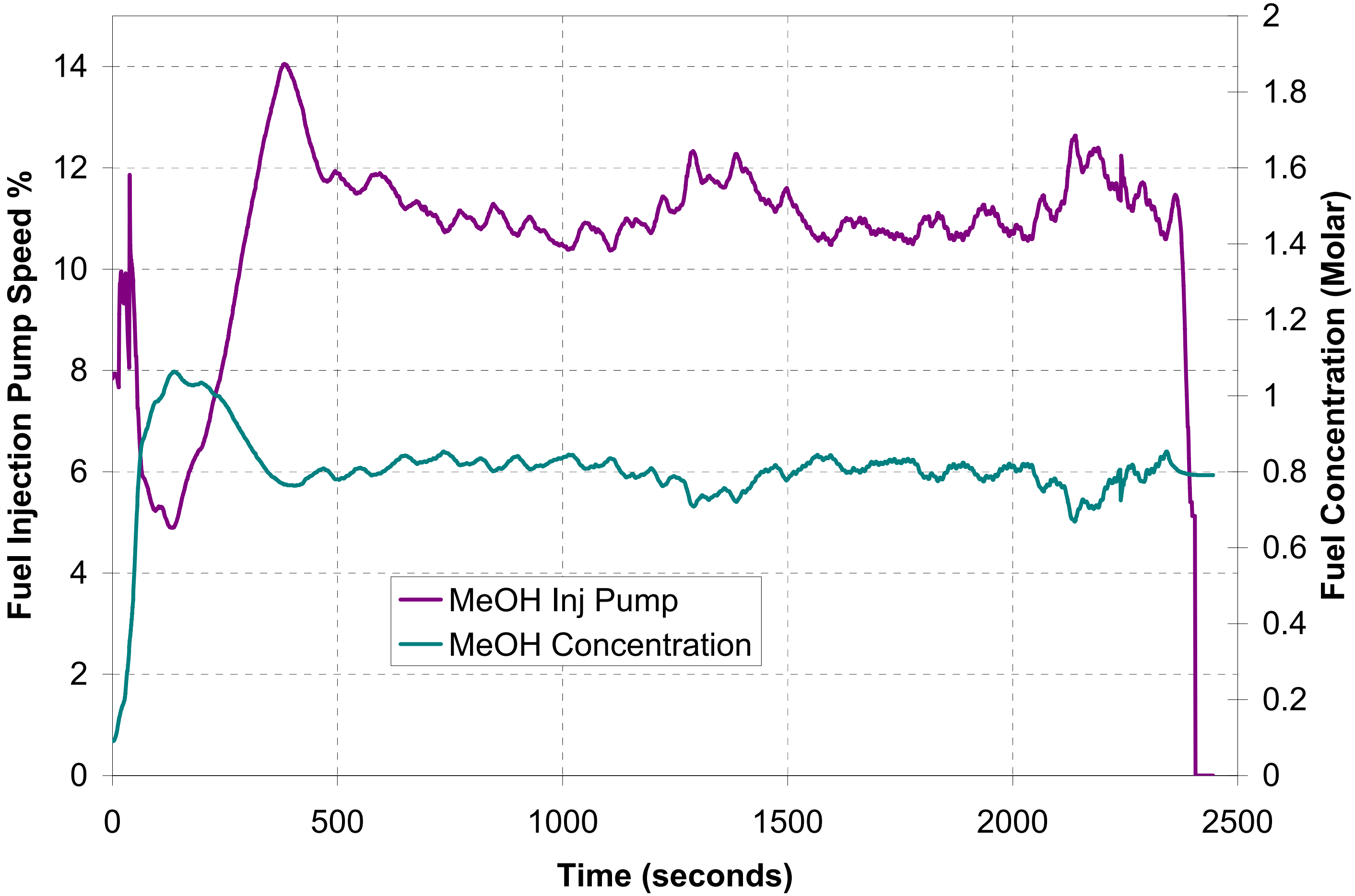
MeOH Concentration Control



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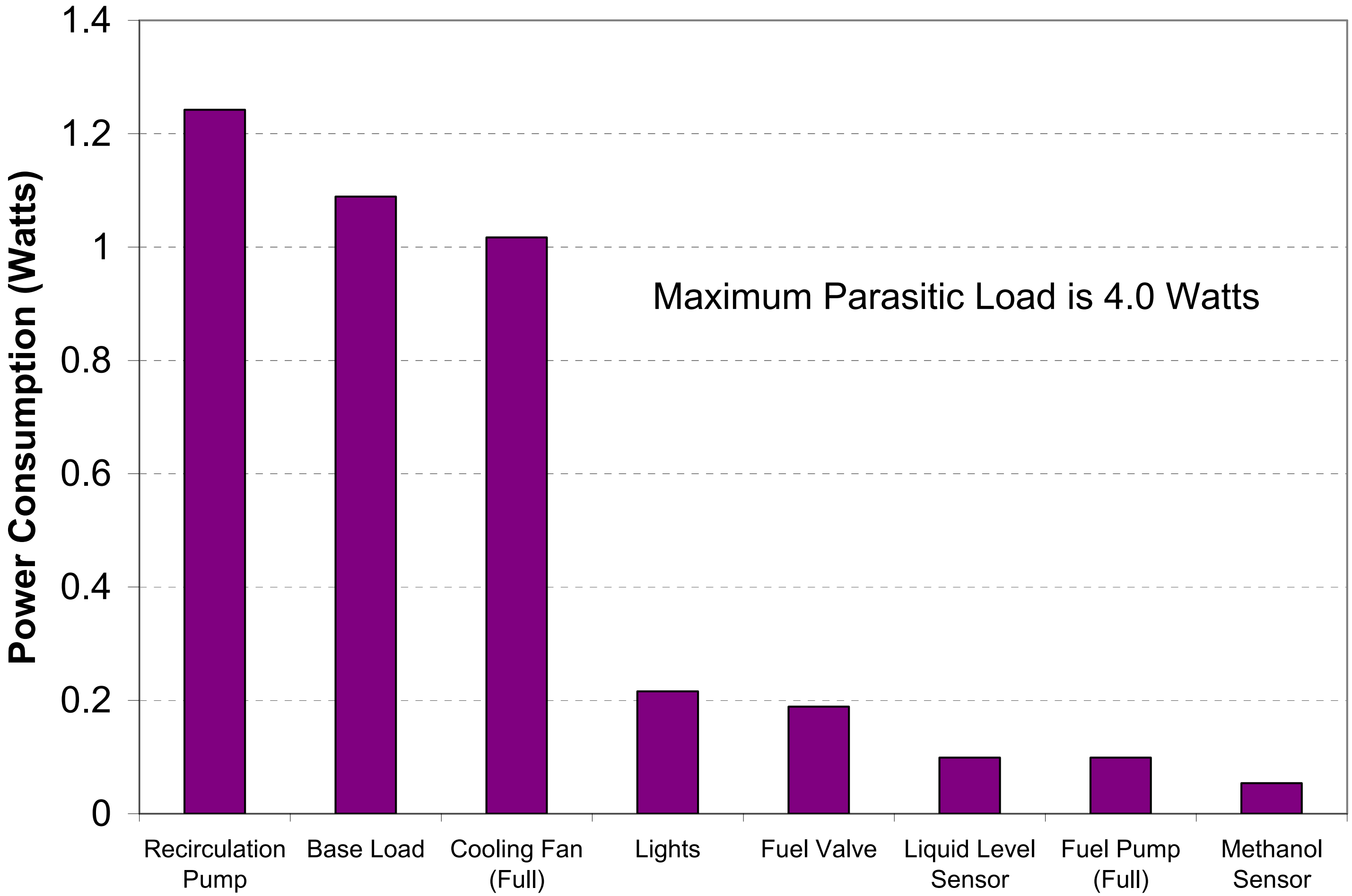
Parasitic Losses



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Future Work

- **Improve stack performance to match single cell performance**
  - **Single cell power density = 58 mW/cm^2**
  - **Stack power density = 40 mW/cm^2**
- **Conduct long term durability studies on re-circulated fuel**
  - **Initial tests indicate additional degradation from re-circulated species**
- **Conduct durability studies on complete fuel cell systems**

Summary

- PolyFuel has identified a novel method of MEA construction with a new membrane and GDL structure
- New MEA design allows for passive water recovery up to an operating temperature of 50 C
- Performance and water recovery have been demonstrated in single cells
- Full stack and system performance are below targets by ~20%
- Future work will improve overall system power to meet 15W target
- Durability tests on complete units will be conducted, building on cell level life tests