PEM Fuel Cell Cost Status - 2005

Fuel Cell Seminar
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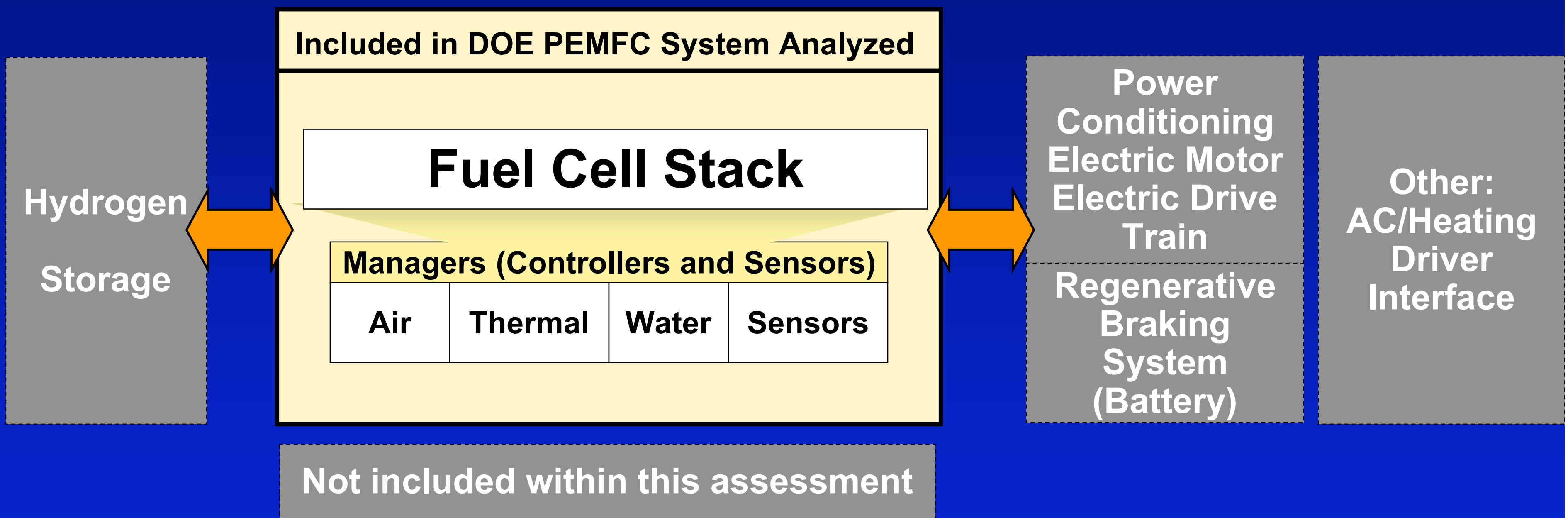
Reference: D0318

Outline

- Project Overview
- System Specification
- Cost Projections
- Summary

The status of PEMFC cost manufactured at high volume was assessed relative to the 2005 DOE target of $125/kW.



The project scope included the fuel cell stack and related balance-of-plant components.

The FreedomCAR Fuel Cell Tech Team and developers provided critical feedback to 2005 cost update.

Task 1 Baseline Analysis

- Update 2004 system specifications
- Bottoms-up assessment of membrane, bipolar plate, and GDL processing and material costs
- Work with ANL to develop system configuration and model
- Develop baseline cost estimate
- Prepare an interview guide for discussions with developers

Task 2 Developer Feedback

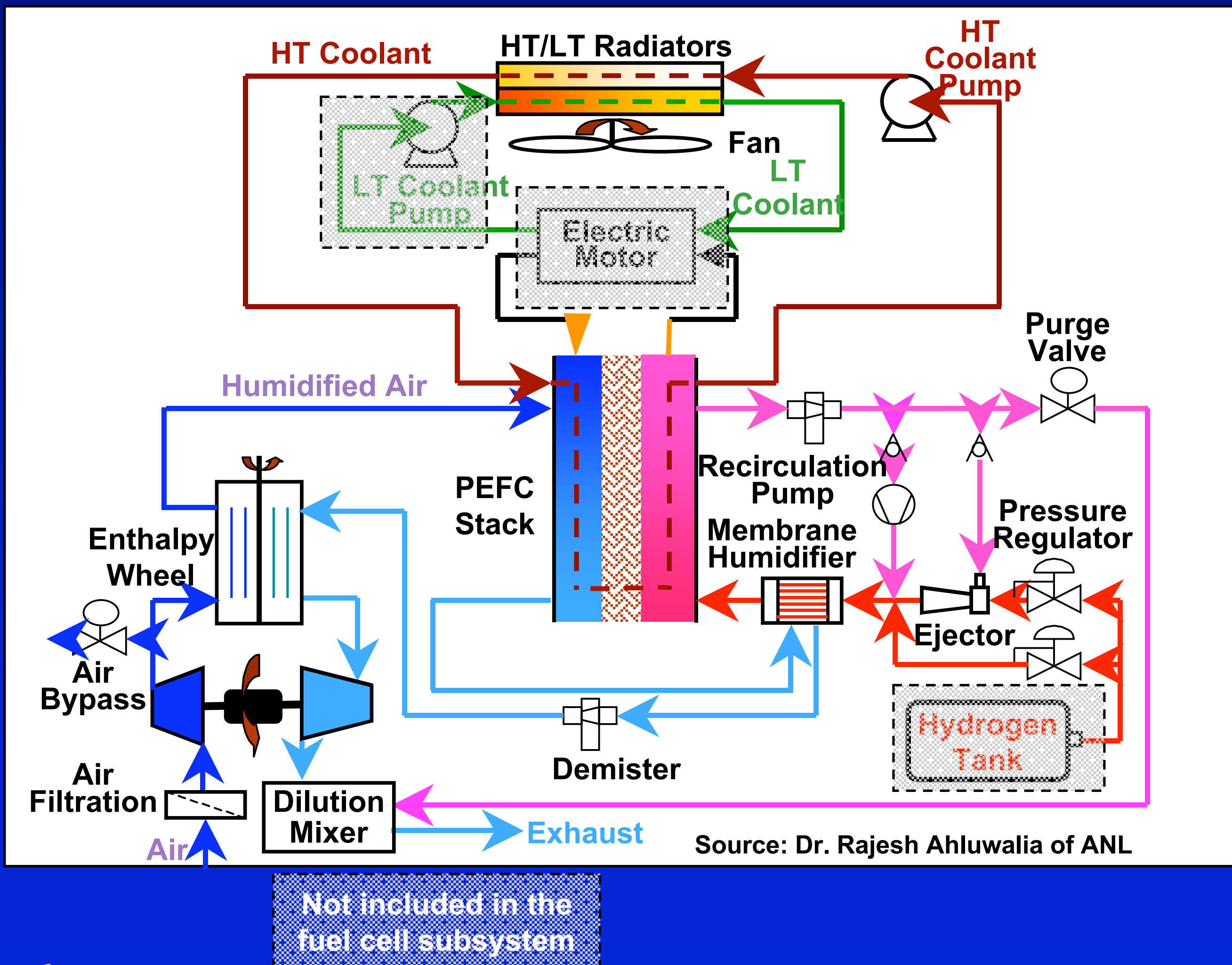
- Interview key developers for feedback on performance and cost assumptions
- Revise performance, process, and material assumptions based on developer feedback
- Perform sensitivity analysis to key parameters
- Assess impact of feedback on design parameters and potential technology breakthroughs on overall system costs

Task 3 Final Report

- Prepare final written report
- Prepare final presentation to DOE

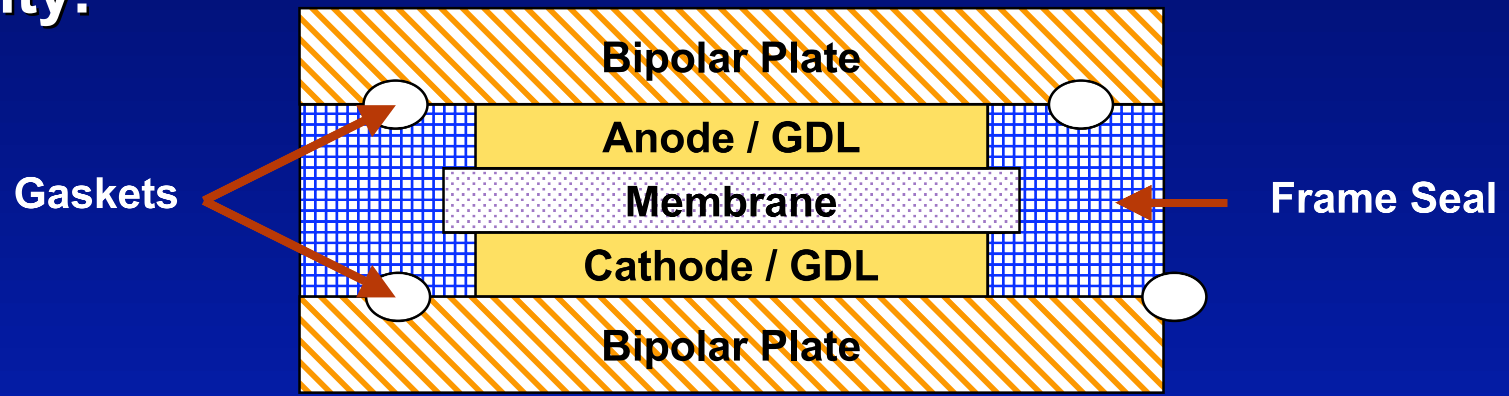
System Specification Configuration

ANL provided the system model and performance results to size the balance-of-plant components.



Parameter	Value
Net Power	80 kW
Gross Power	90 kW
Efficiency @ Rated Power	46
Efficiency @ 25%	55
Cell Voltage @ Rated Power	0.65

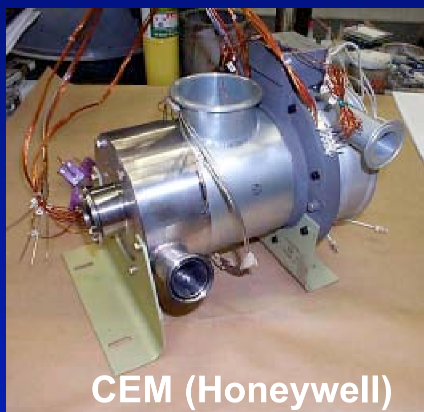
Stack parameters are key drivers of system cost and power density.

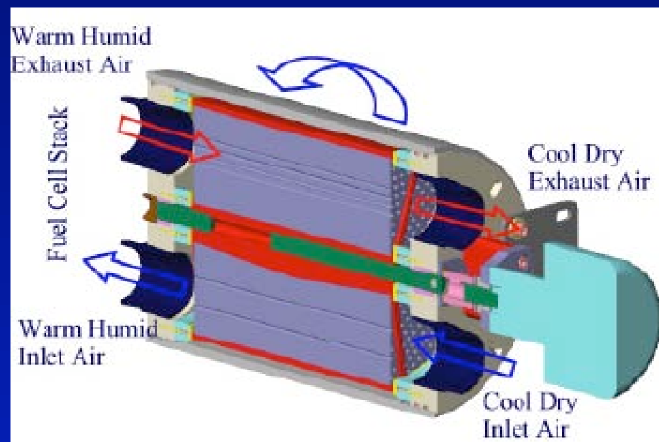


Parameter	Unit	2005 Value	S/C[1]
Stack Efficiency @ rated power	%	51.7	C
Cell Pitch	Cells/cm	3.8	C
Total Platinum Loading	mg/cm^2	0.75	S
Power Density @ 0.65 V	mW/cm^2	600	S
Total Stack Platinum	g/kW	1.4	C
Stack Power Density	W_e/L	1570	C
Stack Specific Power	W_e/kg	1380	C

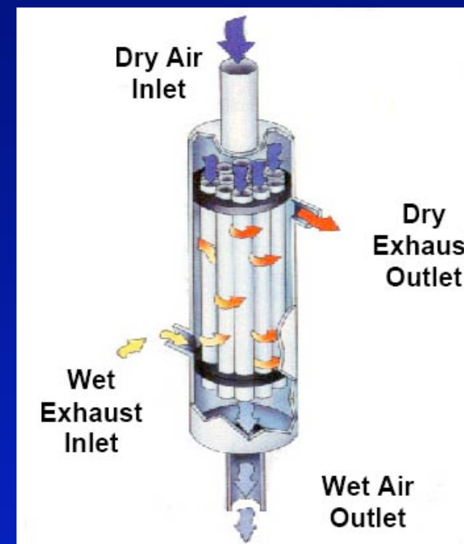
[1] S- Specified C-Calculated

We talked with developers of BOP components to estimate the cost and power losses for these components.

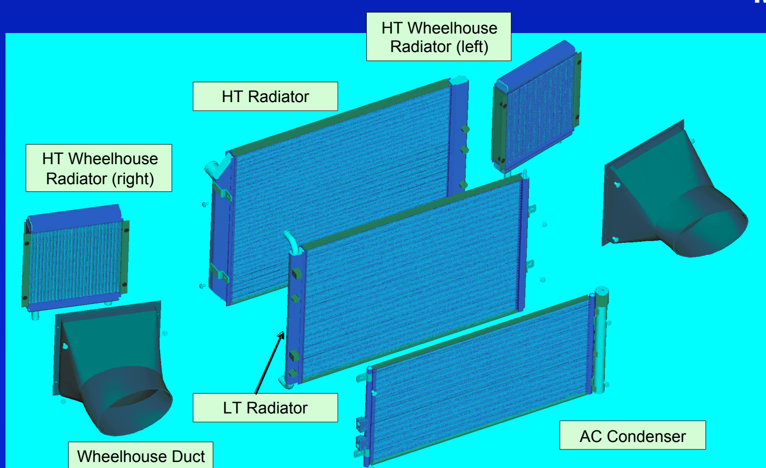

CEM (Honeywell)



Enthalpy Wheel for Air Water Management (Emprise)



Membrane Humidifier (Perma Pure LLC)



Heat Exchangers (Modine)

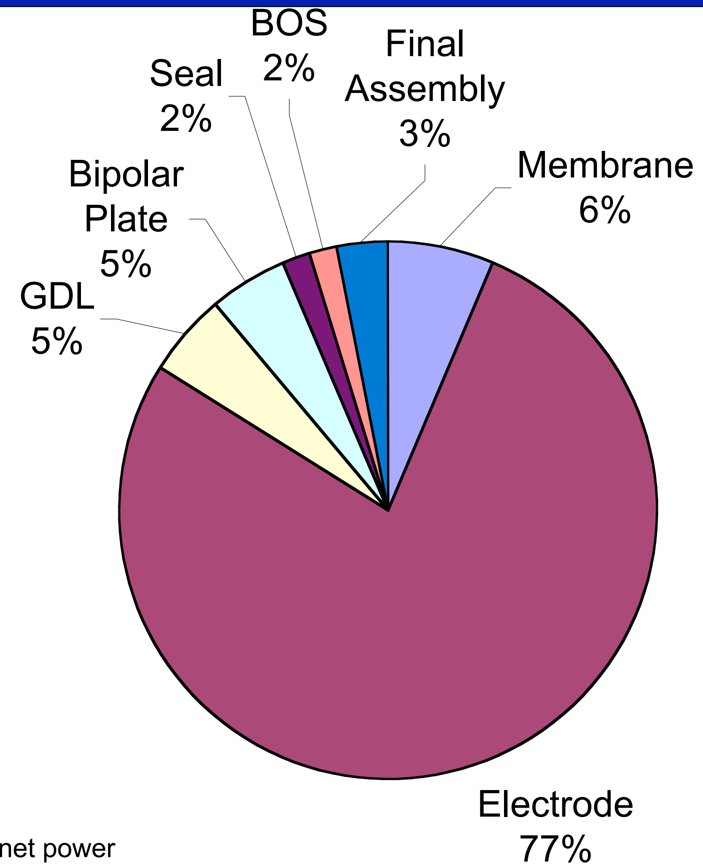

H_2 Recirculator (H_2 Systems)

Cost Projections Stack

The electrodes dominated the stack cost because of the high platinum loading and price.

Parameter	Unit	2005 Value
Pt Cost	$/troz	900
Pt Loading	mg/cm^2	0.75
Stack QC and Conditioning not Included		

Fuel Cell Stack Cost – 80 kW Direct H_2
(67 $/kW[1], $5,360)



[1] kW of net power

Increased Pt loading and cost resulted in a 60% higher stack cost on an area basis than 2004 despite decreases in all other materials.

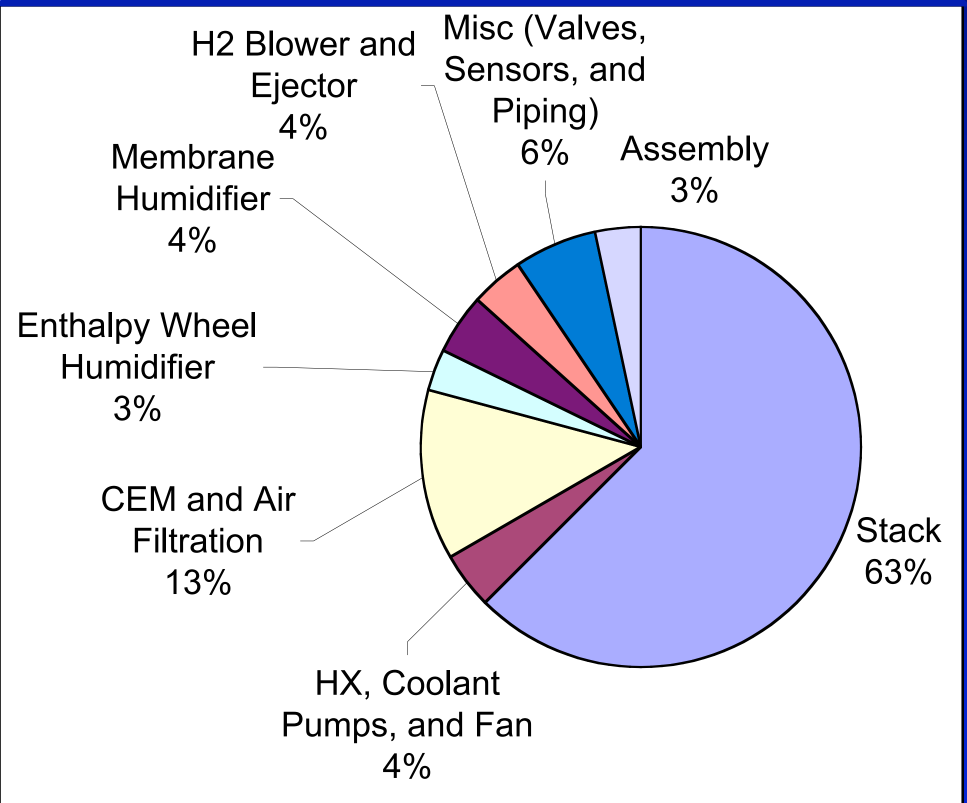
Component	2005 Cost[1] ($\$/m^2$)	2005 Value
Membrane	**23**	2 mil unsupported membrane
Electrode	**280**	Catalyst markup over LME price – 20%
GDL	**18**	Thickness decreased from 350 to 260 μm
Bipolar Plate Pair	**17**	Expanded graphite, thinner plate
Seal, BOS, Assembly	**22**	Other stack components and materials
Total	**360**	

[1] m^2 of active area

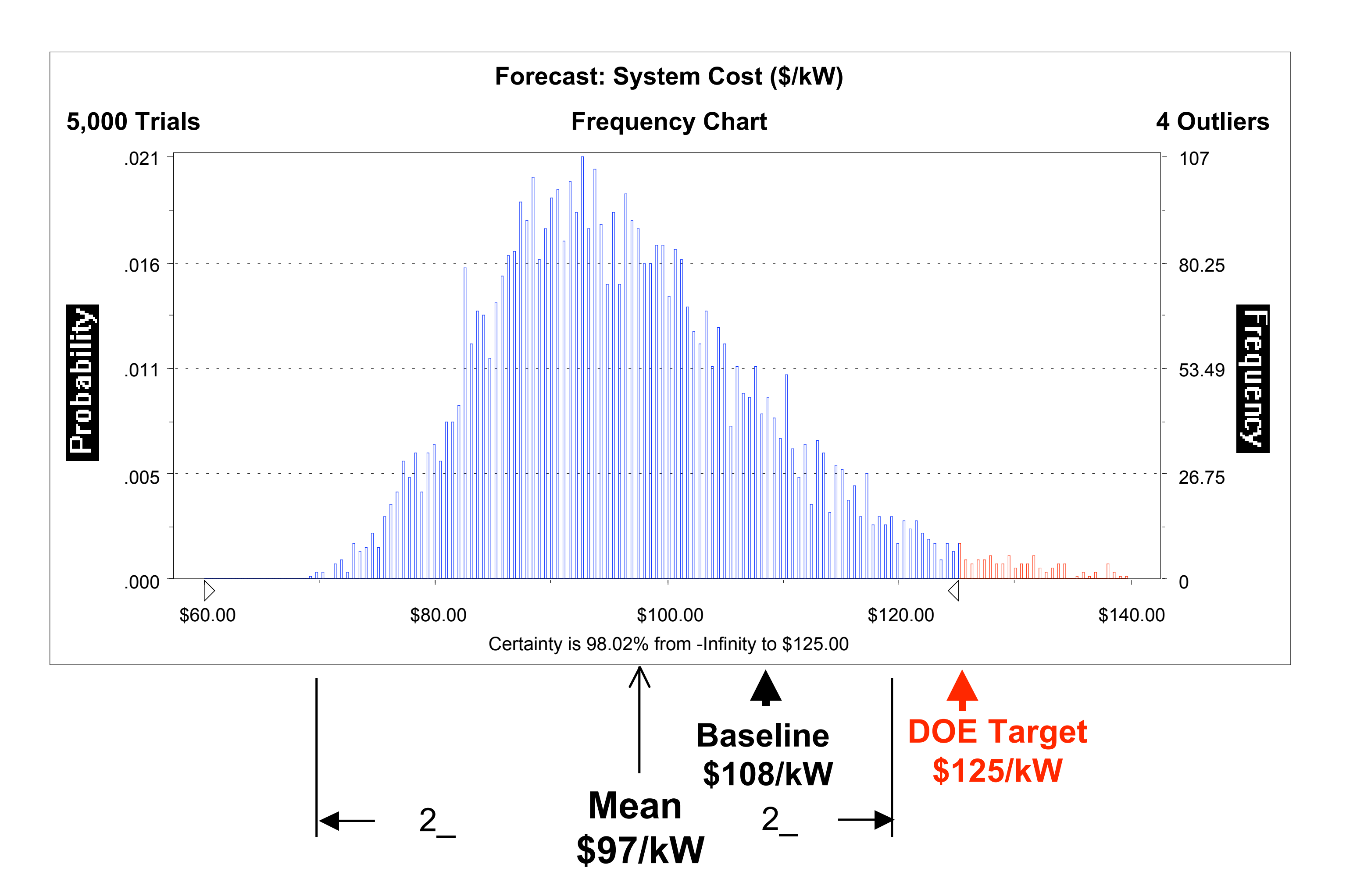
The stack represents 63% of the 108 $/kW system cost. Greater system complexity increased the BOP costs.

	2004 System Cost ($/kW)	2005 System Cost ($/kW)
Stack	72	67
BOP & Assembly	25	41
Total	97	108

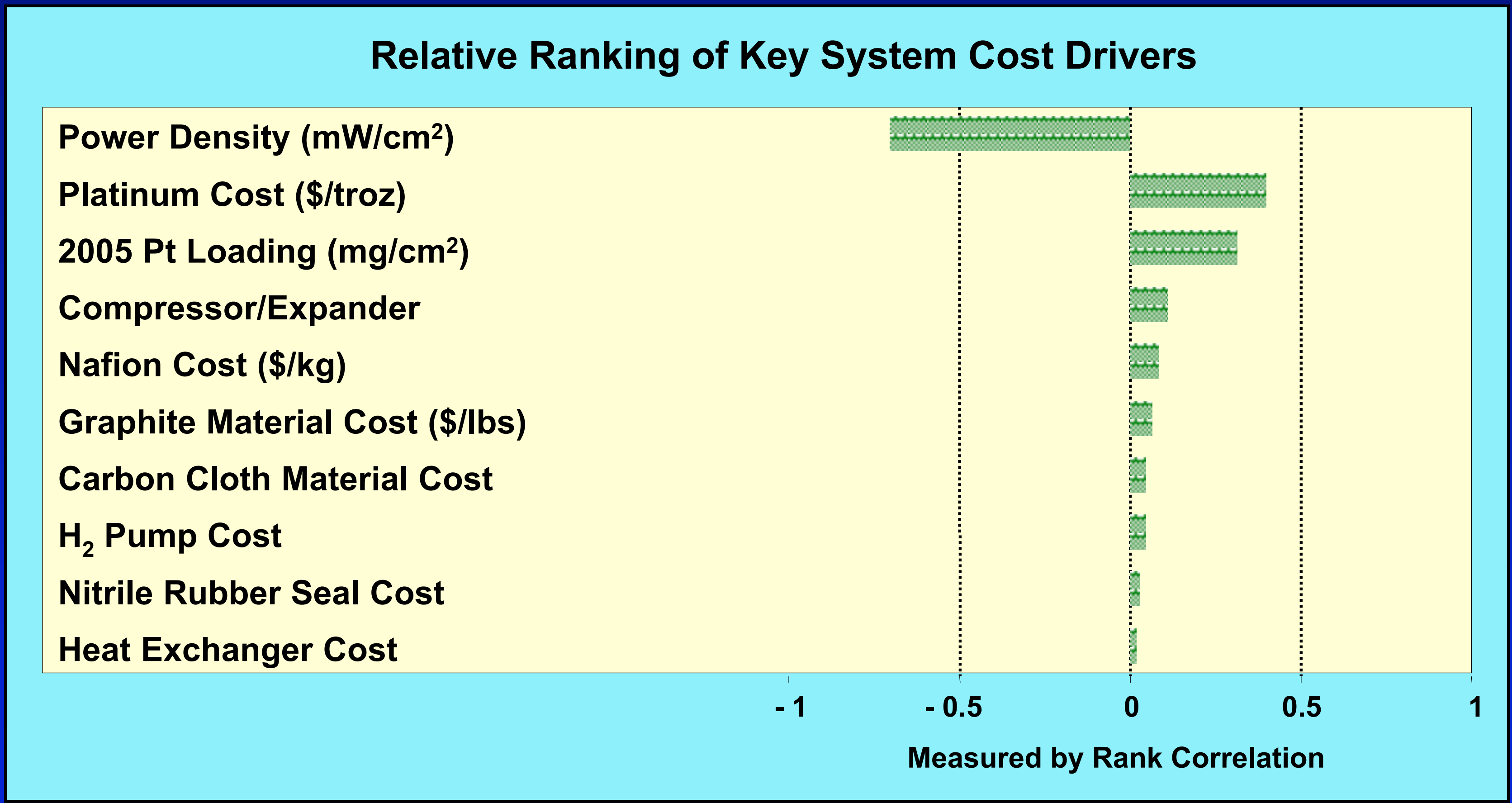
Fuel Cell System Cost – 80 kW Direct H_2 (108 $/kW[1], $8,640)



The analysis showed a high probability that the system cost would be below the DOE target of $125/kW.



Power density, platinum cost, and platinum loading are the top three drivers for the system cost.



Summary   Performance Relative to 2005 Targets

The specified system meets the DOE targets for specific power and cost but misses the efficiency targets by 5%.

Subsystem	Volume[1] (L)	Weight (kg)	Cost ($/kW)	DOE 2005 Target
Stack	51	58	67	65 $/kW
Stack power density (W_e/L)	1569			1500 W_e/L
Stack specific power (W_e/kg)	1379			1500 W_e/kg
Total fuel cell system size/weight	131	138	108	125 $/kW
FC System power density (W_e/L)	610[1]			500 W_e/L
FC System specific power (W_e/kg)	580			500 W_e/kg
FC System Efficiency @ rated power	46			50%
FC System Efficiency @ 25% rated power	55			50%

[1] Does not include packing factor, which would lower volumetric power density

Decreased bipolar plate thickness and higher stack power density were the main drivers for increased specific power.

Several factors will add to the challenge of meeting future cost targets.

- Quality control will add to the projected 2005 costs
  - Stack material quality will be critical to stack yields
  - Burn-in protocols for rapid stack characterization will be important to minimize cost of this step
- Value chain margins will add to the stack cost if the stack integrator purchases components from suppliers
- In the future as fuel cell system costs are reduced, BOP, packaging, and system QC costs will become more important contributors

Acknowledgments

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- The fuel cell component, stack, and system developers for their efforts in providing feedback on our assumptions and findings

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