A Stack Cost Comparison of 100 kW Combined Heat and Power Fuel Cell Systems

LMAS

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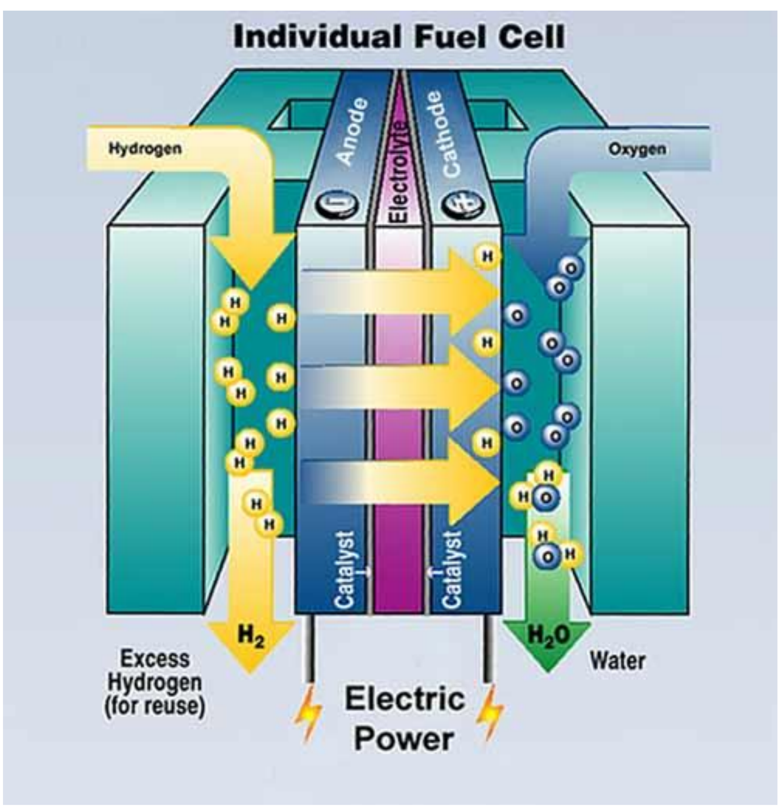
Motivations and Objectives

- How to address the fuel cell cost challenge?
  - *E.g., Manufacturing costs*
- What are key potential cost reduction opportunities?
  - *E.g., Lack of High-Volume Membrane Electrode Assembly Processes; Platinum Loading on CCM*
- How do stack costs compare between different fuel cell systems (low and high temperature proton exchange membrane and solid oxide fuel cells)?
- Create an interactive model that allow users to see how changing parameters influences the fuel cell cost.

Fuel Cell Background

- A fuel cell stack is made up of many individual fell cells.
- The critical stack components are the membrane, gas diffusion layer, frame, seal, and bipolar plates.
- SOFC replace the membrane and gas diffusion layer with an cathode-electrolyte-anode assembly.
- The stack assembly is also explicitly cost modeled.



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Cost Assumptions and Functional Specs

- 250 working days per year is assumed with shift sizes of 8,12, or 16 hours per day.
- Taxes are assumed to be zero since fuel cells are not yet profitable.
- Functional specifications are derived from industry inputs are different for each system type.

Parameter	Value
Operating hours	8,12,or 16 hrs/day
Annual Operating Days	250 Days
Avg. Inflation Rate	0.026
Avg. Mortgage Rate	0.05
Discount Rate	0.15
Energy Inflation Rate	0.056
Property Tax	0.014
EOL Salvage Value	0.02
Tool Lifetime	15 Years
Energy Cost	0.1 $/kWh
Floor-space Cost	1291 $/m^2
Building Depreciation	0.031
Building Recovery	31 Years
Hourly Labor Cost	28.08 $/hr

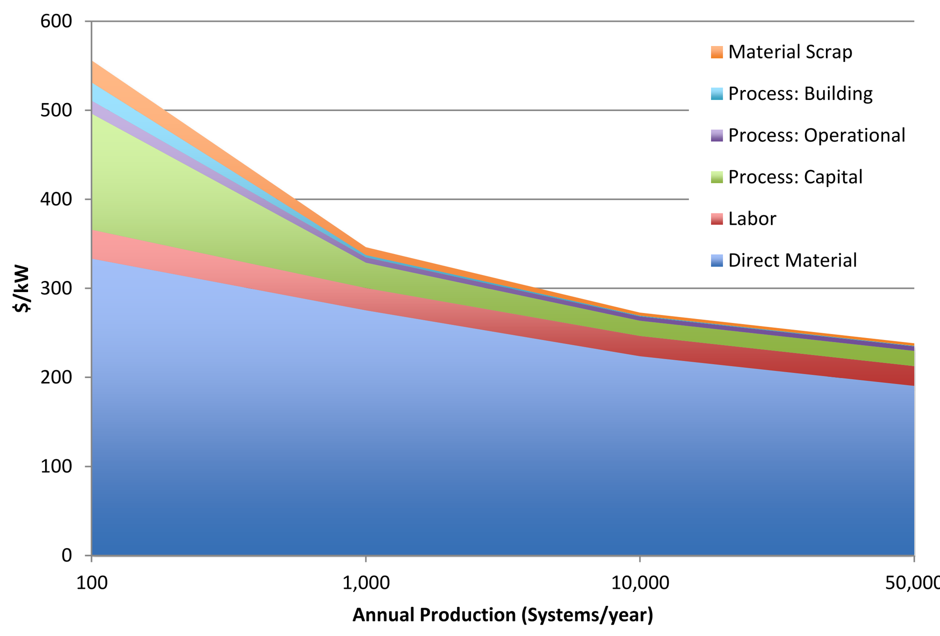
citations in LBNL report

Parameter	LT PEM	HT PEM	SOFC	Unit
Total plate area	362.5	725	540	cm^2
CCM/GDL coated area	259	464	329	cm^2
Single cell active area	220	423	299	cm^2
Gross cell inactive area	39	41	30	cm^2
Current density	0.51	0.23	0.35	A/cm^2
Power density	0.354	0.141	0.282	W/cm^2
Single cell power	77.9	59	84	W
Cells per stack	122	136	26	Cells
Stacks per system	13	15	50	Stacks
Platinum Loading	0.5	0.7	n/a	mg/cm^2

Low Temperature Proton Exchange Membrane

- Stack costs range from $550/kW to $240/kW.
- Capital cost is large at low production volumes due to low line utilization.

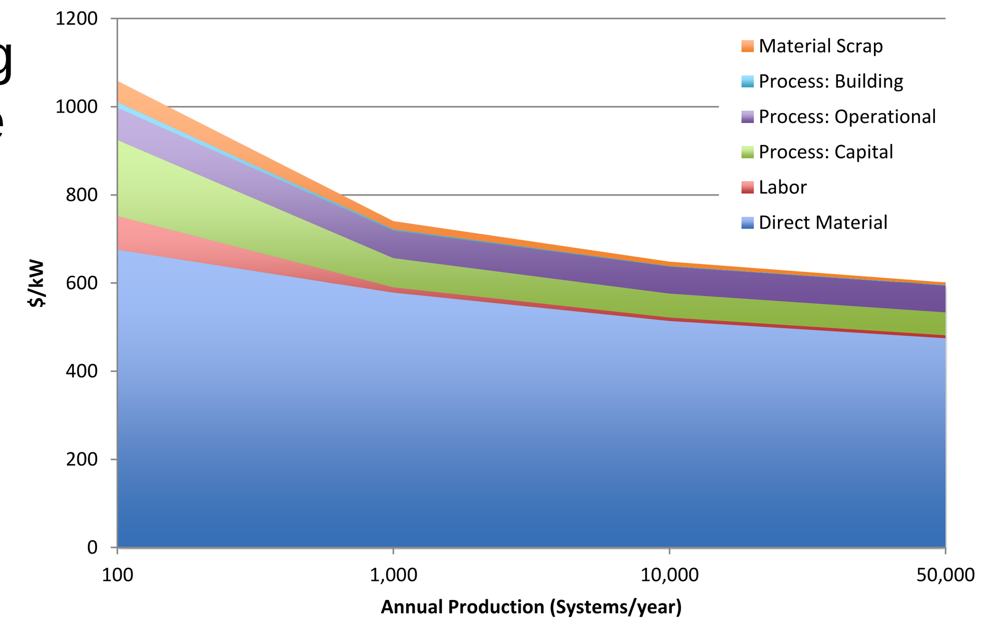
Annual Volumes	100	1,000	10,000	50,000
Direct Material	333.31	275.34	223.85	190.30
Labor	32.52	25.06	22.65	22.39
Process: Capital	130.35	28.58	17.24	16.94
Process: Operational	14.60	5.93	4.82	5.25
Process: Building	20.67	2.44	0.77	0.68
Material Scrap	24.67	8.92	3.28	2.65
Total ($/kWnet)	556.13	346.27	272.60	238.22



High Temperature Proton Exchange Membrane

- Stack costs range from $1,050/kW to $600/kW.
- Operational cost is larger than the other two systems due increased electricity consumption of heating the bipolar plates while molding them.

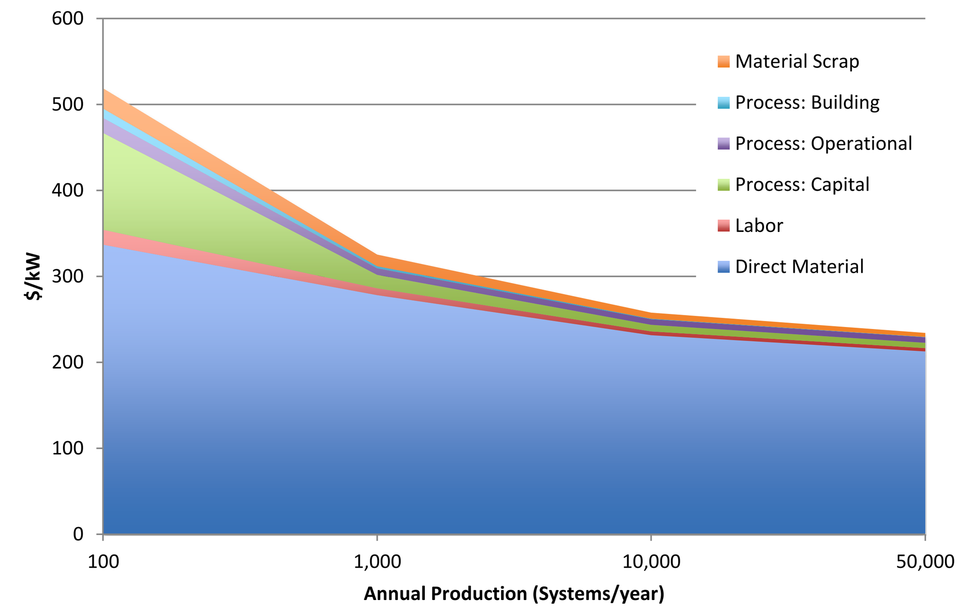
Annual Volumes	100	1,000	10,000	50,000
Direct Material	675.75	578.07	514.17	474.74
Labor	76.38	12.09	7.51	7.05
Process: Capital	172.58	66.65	54.43	51.63
Process: Operational	72.90	62.50	61.36	61.19
Process: Building	13.22	3.04	1.29	1.16
Material Scrap	48.05	18.17	9.87	5.29
Total ($/kWnet)	1,058.87	740.52	648.64	601.06



Solid Oxide

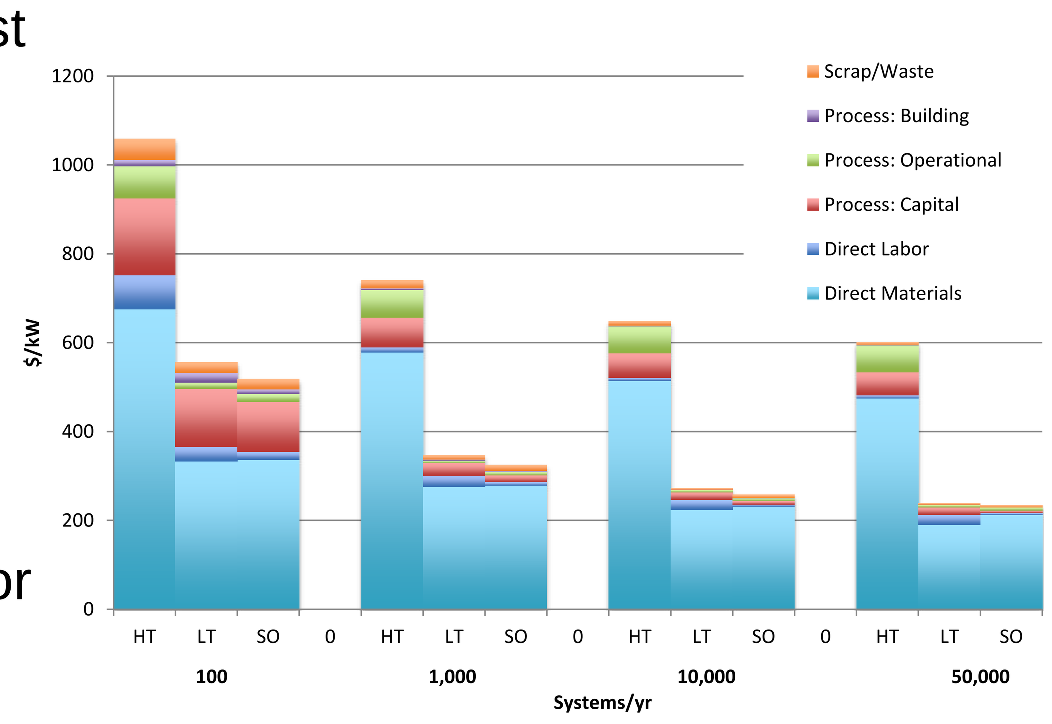
- Preliminary cost analysts (will be finalized in early 2015).
- Stack costs range from $520/kW to $230/kW.

Annual Volumes	100	1,000	10,000	50,000
Direct Material	336.78	278.22	231.38	212.64
Labor	17.48	7.82	4.59	3.83
Process: Capital	112.66	15.61	7.64	6.12
Process: Operational	17.35	7.70	6.59	6.47
Process: Building	10.92	2.26	0.54	0.29
Material Scrap	23.65	13.61	6.88	4.76
Total ($/kWnet)	518.83	325.22	257.61	234.12



Stack Cost Comparison

- Solid-oxide fuel cell systems are the lowest stack cost.
- Low temperature PEM are a close second.
- High temperature PEM trail far behind.
- Direct material cost dominate stack cost for all systems at all production volumes.



Conclusion

- High temperature PEM stack cost lags that of the low temperature PEM and solid-oxide systems because it is not yet a mature technology.
- New materials should be explored for the reduction of stack cost for all systems.

Method and results are presented in greater detail within the LBNL report.

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