Non-Automotive Fuel Cells: Market Assessment and Analysis of Impacts of Policies

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AN015

Overview

Timeline

- Start: April, 2010
- Complete: 2012
- 70% complete

Budget

- Total project funding
  - $360,000
  - DOE 100%
- FY10: $260,000
- FY 2011: $100,000

Barriers

- Market transformation barriers:
  - Scale economies
  - Learning by dong
- Impacts of national policy
  - Incentives
  - Procurements

Partners

- Oak Ridge National Laboratory (ORNL) lead
- ICF/H-D Systems
- Fuel Cell Today
- University of Tennessee, Dept. of Industrial and Information Engineering
- With the cooperation of fuel cell manufacturers in U.S., Japan and the European Union (EU).

This study contributes to the Hydrogen Program Systems Analysis goals via integrated assessment of the dynamic evolution of markets for non-automotive hydrogen fuel cells to improve understanding of market barriers and risks and the role of policy in overcoming them.

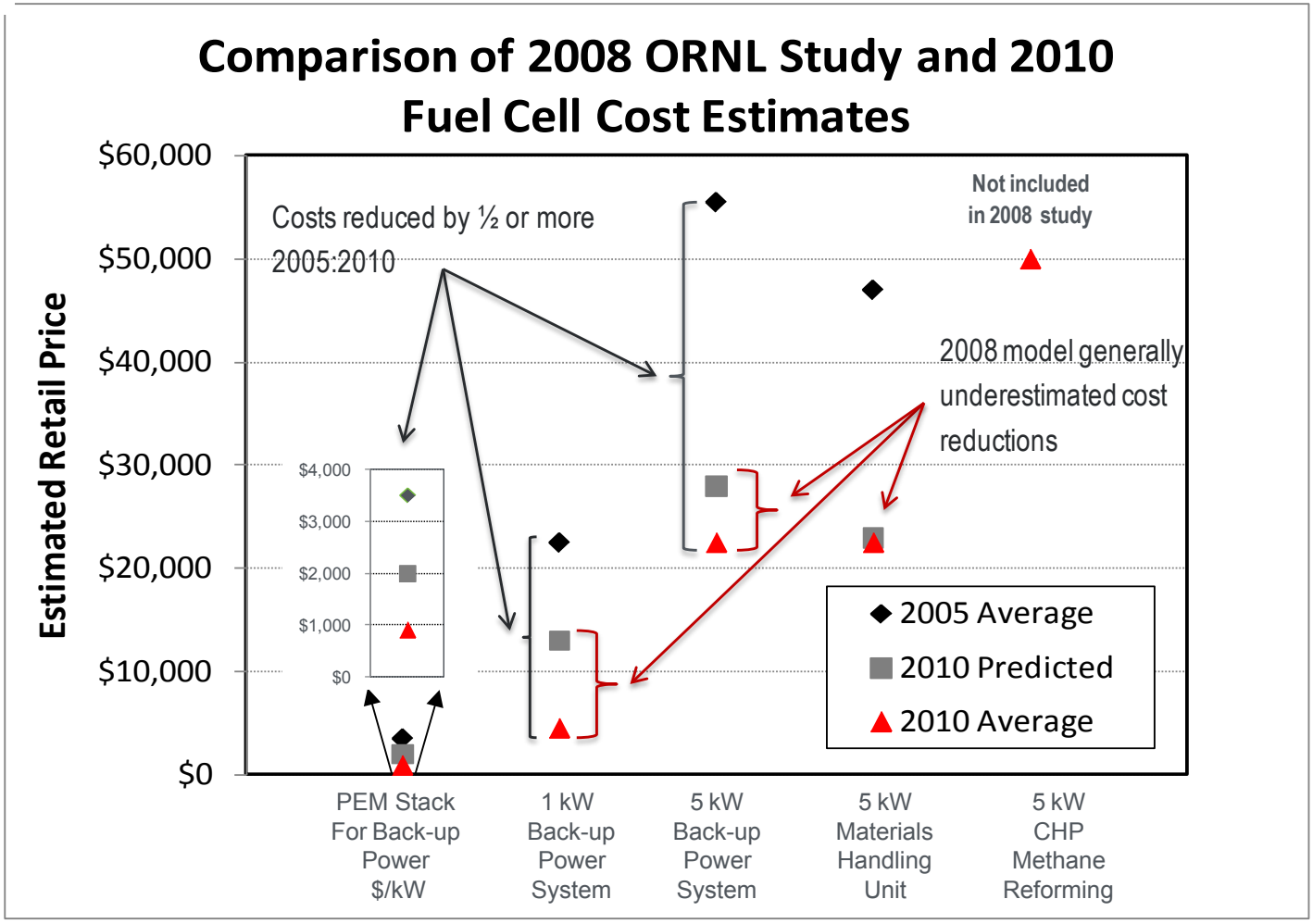
- "Until sufficient sales volumes materialize, industry will be unable to achieve economies of scale and establish a viable domestic supplier base.
- To reduce costs, industry will also have to invest in advanced manufacturing technologies, expand their production capacities, and develop efficient supply-chain networks.
- There may not be sufficient national commitment to maintain policy support and financial incentives. (As with other technologies that support key national goals, fuel cells will require incentives during market introduction to overcome the higher initial costs, before economies of scale are achieved.)
- As with any emerging technology, there is fundamental uncertainty about the direction of the market—success in the market cannot be predicted, regardless of how much progress is made in advancing the technologies."

The Department of Energy, 2010. *Hydrogen and Fuel Cells Program Plan*, http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/program_plan2010.pdf .

Our research approach comprised interviews with original equipment manufacturers (OEMs), literature review, development of an integrated market model, sensitivity analysis and extensive peer review.

- Builds on and extends 2008 analysis of potential impacts of government procurements on U.S. non-automotive proton exchange membrane fuel cell (PEMFC) industry.
- The study began with in-person interviews and data gathering from 10 U.S., 3 Japanese and 3 EU fuel cell OEMs.
- Additional information was obtained from the peer-reviewed literature, trade press and consultant studies, company web sites and other internet sources.
- We developed an integrated market model representing learning-by-doing, scale economies, technological change and (for PEMFCs) buyers' choices among competing alternatives.
- Input data are thoroughly documented, key parameter assumptions are explicitly compared with published estimates, and an extensive sensitivity analysis is presented in the project report.
- After internal DOE/ORNL review, the draft report was sent to 18 external expert peer reviewers in industry, academia, and research institutes.

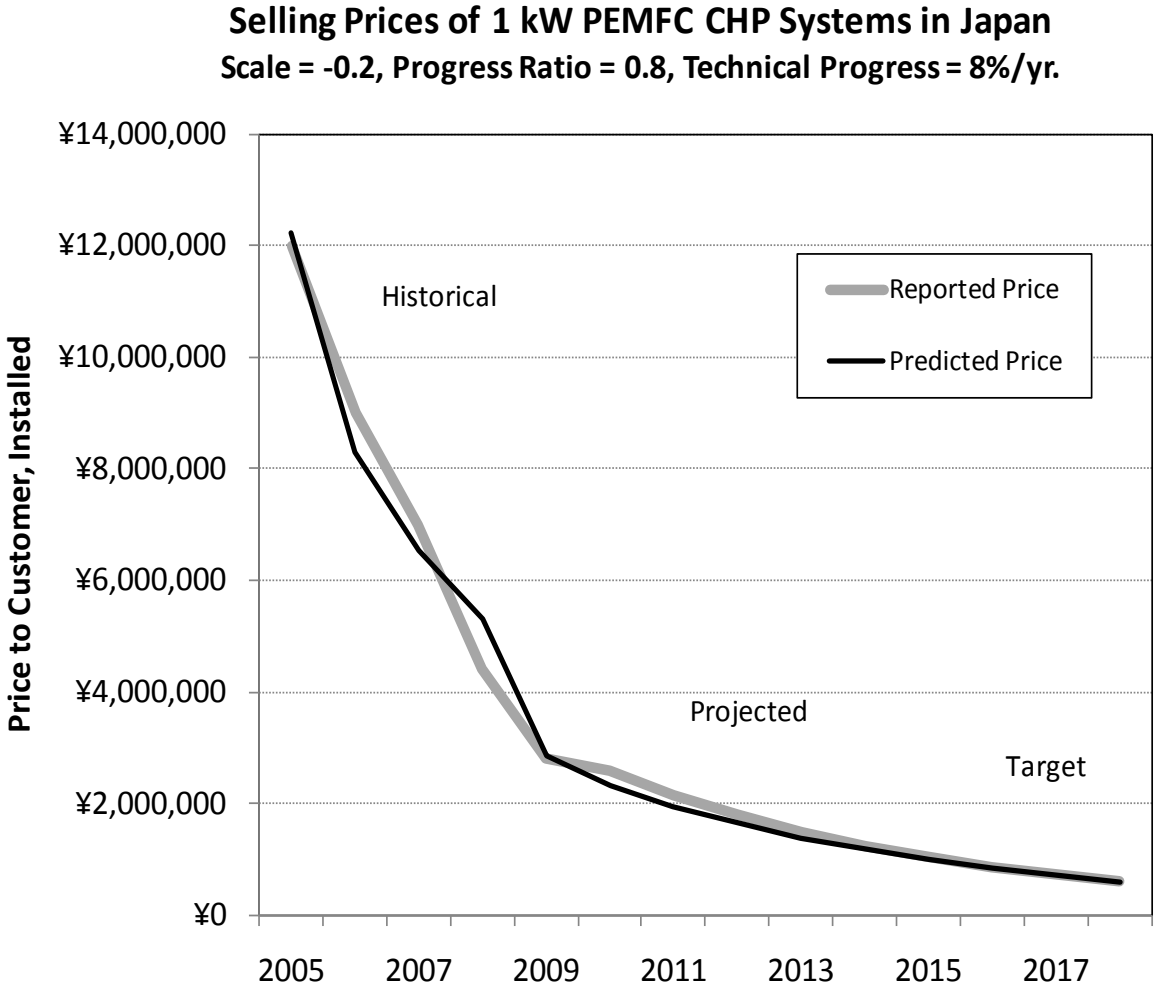
PEM fuel cell OEMs reduced costs by one half or more between 2005 and 2010. Projections of 2010 retail price equivalents (RPE) made in our 2008 study turned out to be conservatively high.



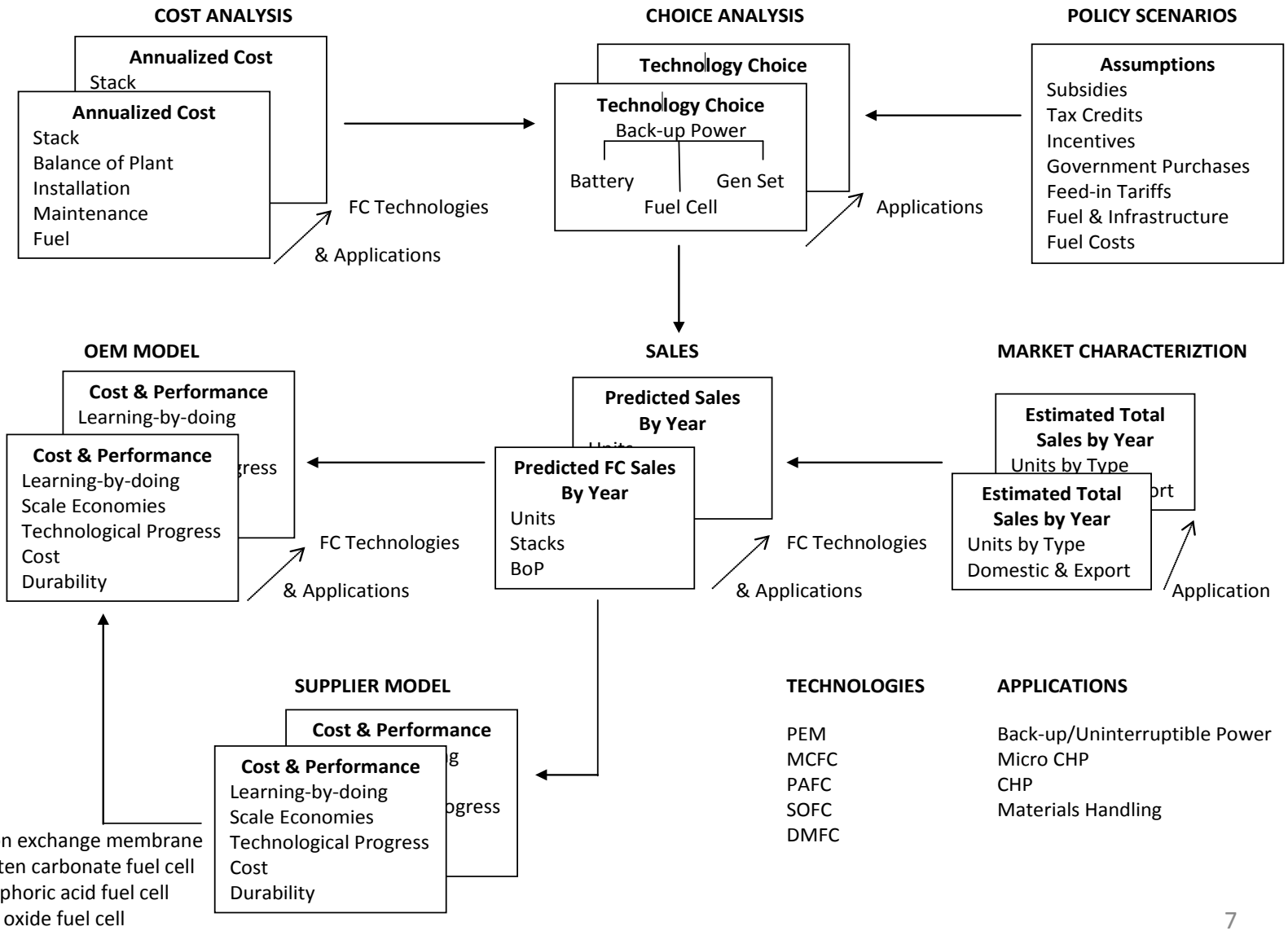
2005 and 2010 averages based on estimates supplied by OEMs. 2010 predicted assumed government procurements of 2,175 units per year, total for all market segments. Predictions assumed a progress ratio of 0.9 and scale elasticity of -0.2.

CHP = Combined heat and power

Similar progress has been achieved by Japanese and EU OEMs.
(Japanese EnerFarm 1 kW PEM micro-CHP Program)
Japanese gov't: stationary fuel cells among 21 key technologies for the future.

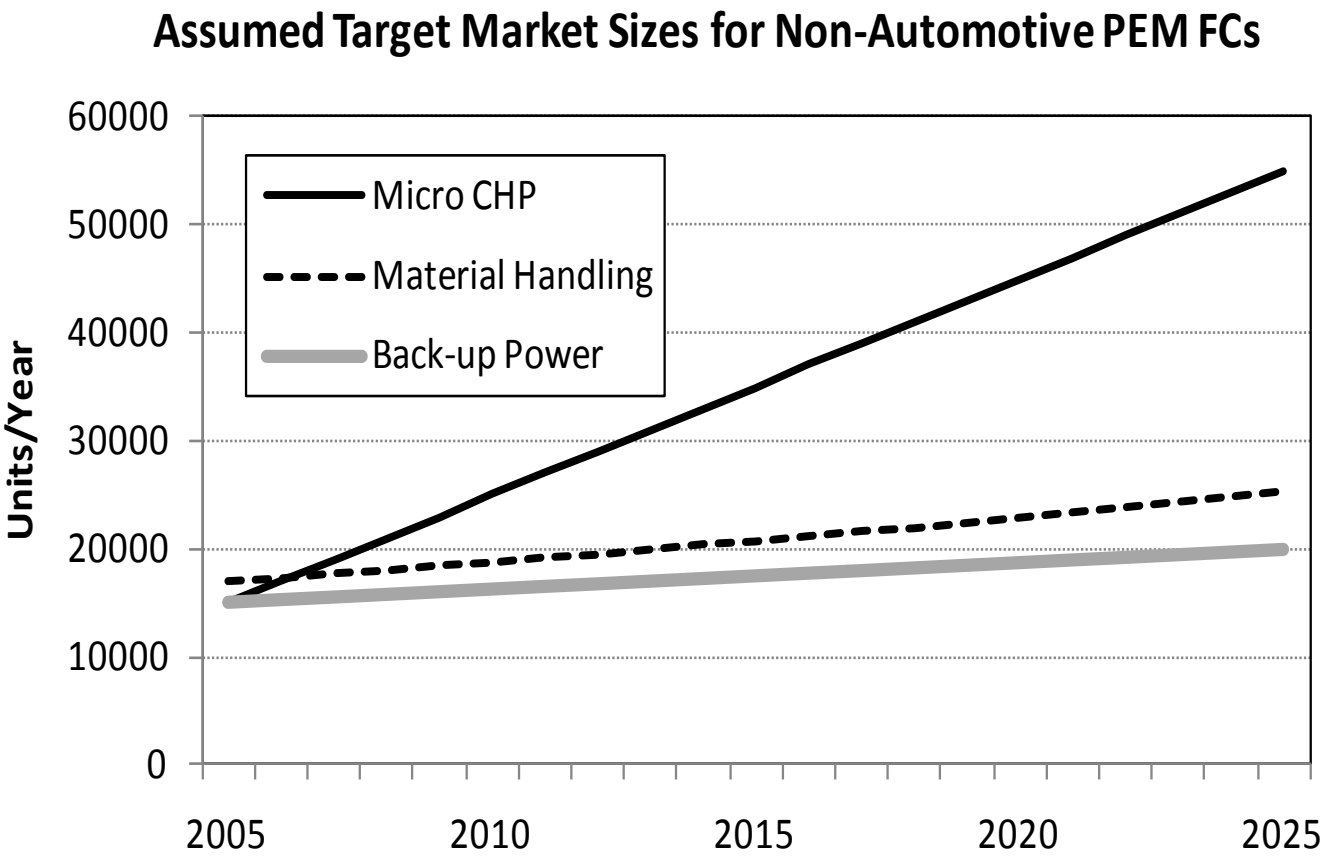


The integrated market model developed for this study is more detailed than that of our 2008 study, yet still highly generalized.



Acronyms:
PEM = proton exchange membrane
MCFC = molten carbonate fuel cell
PAFC = phosphoric acid fuel cell
SOFC = solid oxide fuel cell
DMFC = direct methanol fuel cell

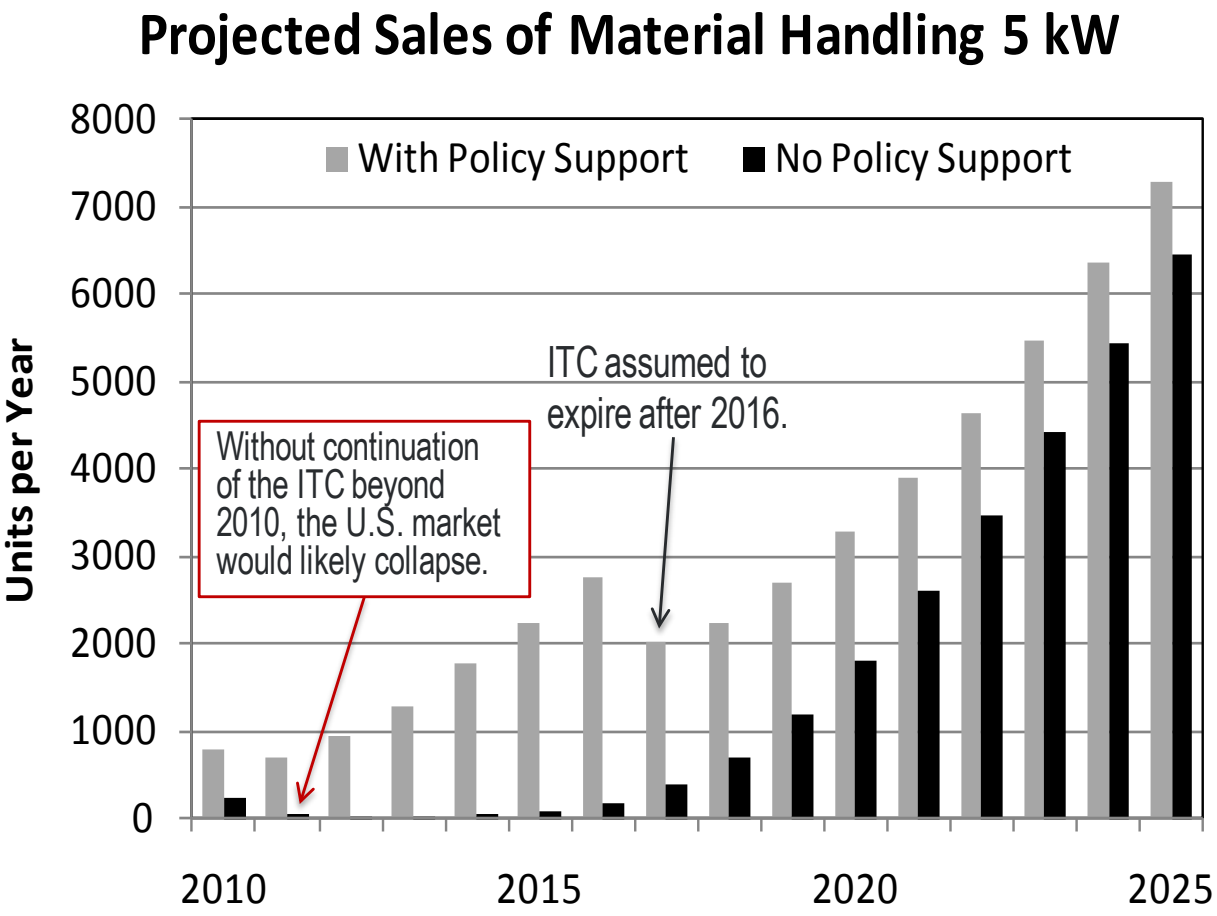
We considered only domestic markets, and generally limited market size to correspond to circumstances in which fuel cells were likely to be competitive with alternative technologies.



Default assumptions were progress ratios of 0.9, scale elasticities of -0.2, and R&D driven technological progress of 1-2% per year.

Parameter	Micro-CHP	Backup Power	Material Handling	PEMFC Stacks	300 kW PAFC	3 MW MCFC
Scale Elasticity	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20
Economical Scale	5000 (units)	5000 (units)	3000 (units)	25000 (kW)	200 (units)	200 (units)
Progress Ratio	0.90	0.90	0.90	0.90	0.90	0.90
Learning Exponent	-0.152	-0.152	-0.152	-0.152	-0.152	-0.152
Rate of Tech. Progress	2%/yr.	2%/yr.	2%/yr.	1%/yr.	2%/yr.	2%/yr.
No. of Firms in 2010	1	3	3	3	1	1
No. of Firms in 2025	1	3	3	4	2	2

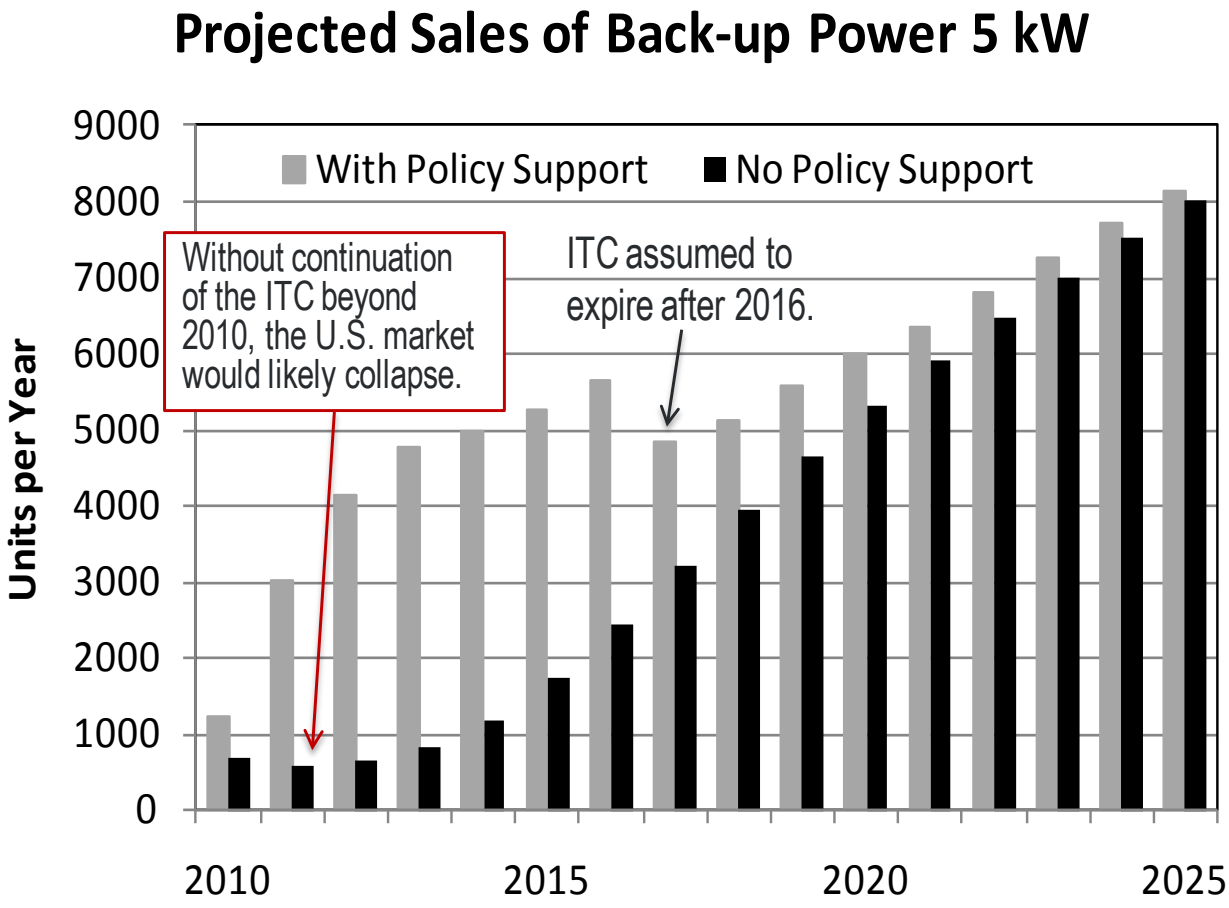
The model's estimates are not definitive but describe general relationships among key factors. In general, the non-automotive fuel cell industry currently depends strongly on policy support.



Only ARRA purchases have been excluded from the "No Policy" case. Other government procurements prior to 2011 are included in both cases. Progress ratio of 0.9, scale elasticity of -0.2. Government and private procurements of 100 units/yr. for demonstrations continue in the policy case.

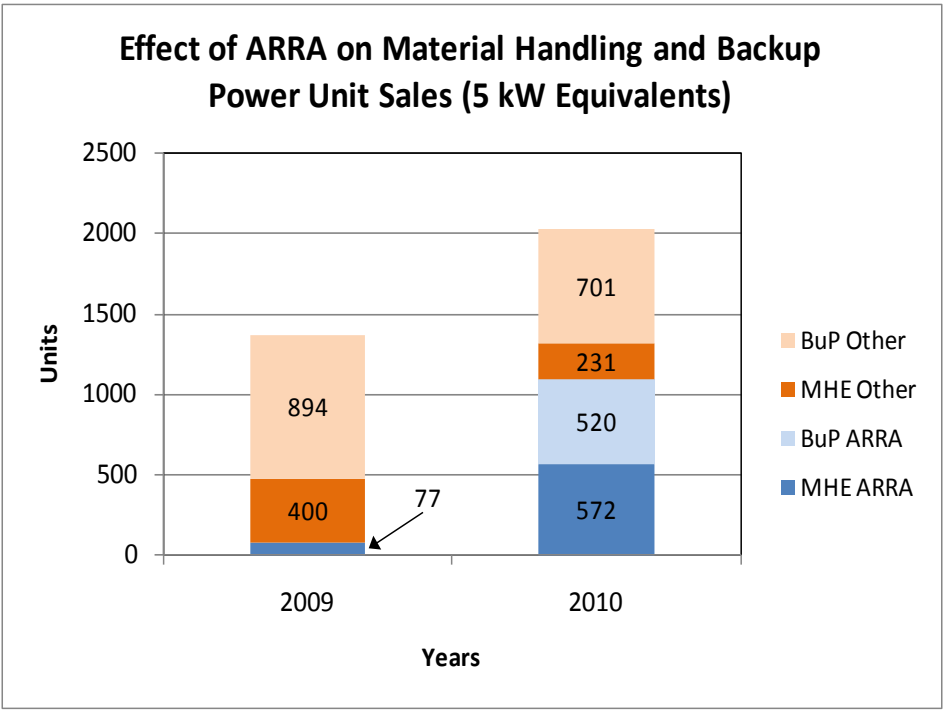
ITC = Investment Tax Credit
ARRA = American Recovery & Reinvestment Act of 2009

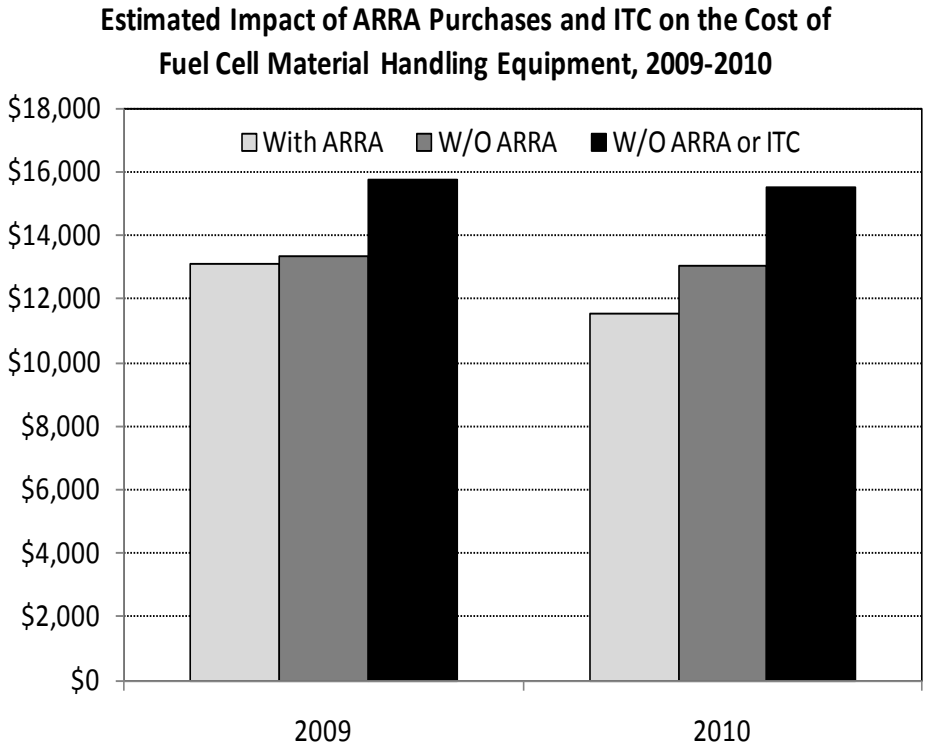
In the long run, it appears that the non-automotive fuel cell industry can be viable, if progress continues.



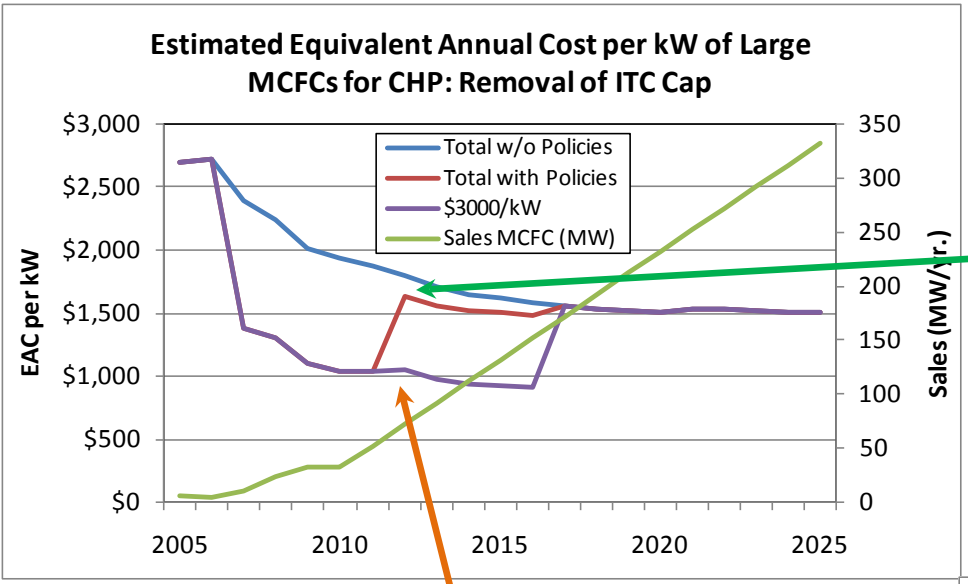
Only ARRA purchases have been excluded from the "No Policy" case. Other government procurements prior to 2011 are included in both cases. Progress ratio of 0.9 and scale elasticity of -0.2. Number of OEMs is assumed to be 3. Government and private purchases for demonstrations are 100 units/yr. in the policy case.

Even over a period as short as 1-2 years, the ITC and ARRA appear to have had important impacts on fuel cell costs via scale economies and learning-by-doing.



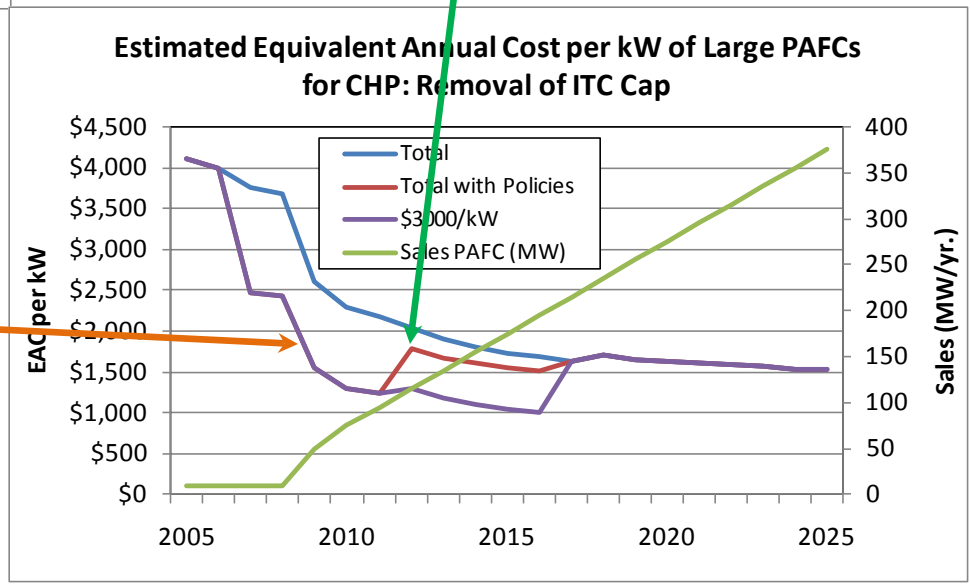


We did not model the market demand for MCFCs and PAFCs, but assumed a steady increase in unit sales per year and calculated the effects on equivalent annualized cost per kW.

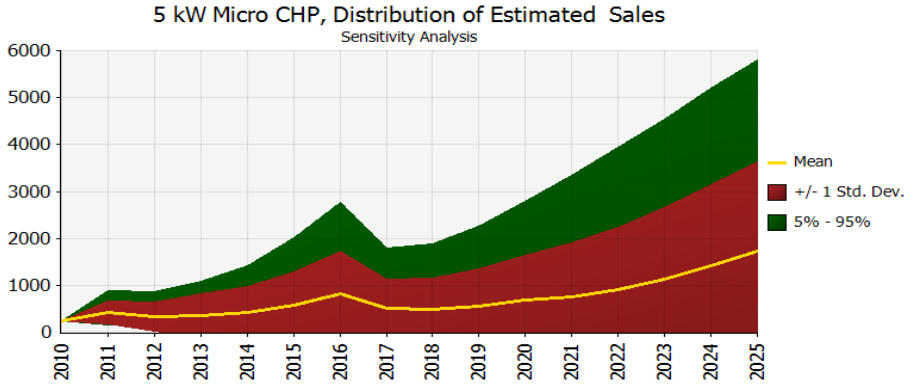


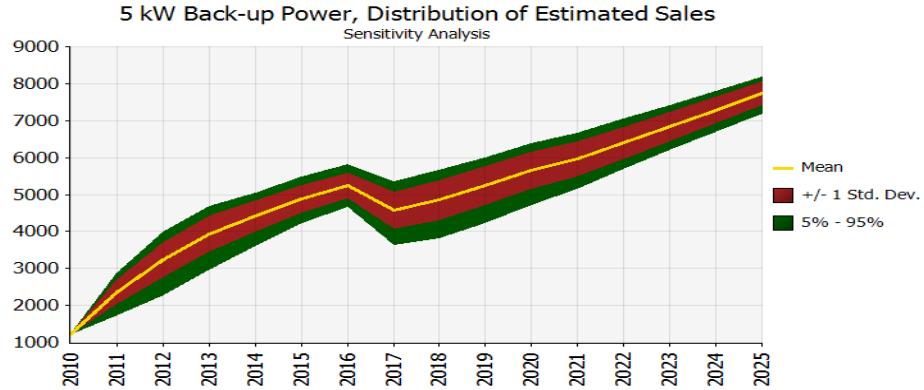
If California's Self-Generation Incentive Program (SGIP) funds were to run out after 2011, the impact on the costs of FCs in CA would be very significant.

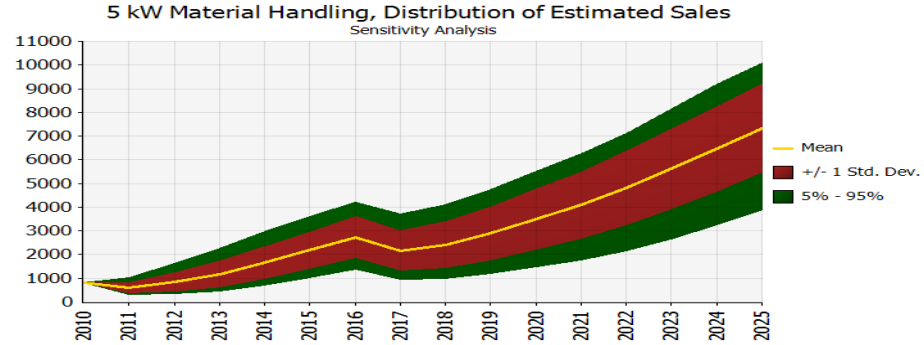
Removing the 30% cap on the $3,000/kW Investment Tax Credit would compensate for the loss of the SGIP and extend the benefit nationwide.



Sensitivity analysis showed large uncertainties about future fuel cell sales but which factors were key differed by application.







- For micro CHP, the price elasticity of demand was most important.
- For backup power, the rate of learning-by-doing was the most influential parameter.
- For material handling equipment, the cost of hydrogen (incl. storage) had the greatest impact on future sales.

This study would have been impossible without the cooperation and assistance of fuel cell manufacturers and others who provided invaluable data on costs, production volumes and operations.

- USA/Canada
  - Altergy
  - Ballard
  - ClearEdge
  - FC Energy
  - IdaTech
  - Nuvera
  - Oorja
  - Plug Power
  - Relion
  - UTC Power
- Japan
  - JX Energy
  - Panasonic
  - Toshiba
- EU
  - Nedstack
  - SFC Energy
  - CFCL
- Also
  - NOW
  - RWE

Future work will focus on more precise characterization of markets and incorporating new information from customers as well as additional manufacturers.

- Publish report including responses to external peer review before this Annual Merit Review.
- Building on research by Fuel Cell Today, characterize and incorporate export markets.
- Meet with fuel cell OEMs not included in this phase of the analysis, update information for those included.
- Contact and interview key fuel cell purchasers to validate cost information and improve calibration of choice model.

In summary, while we are not able to accurately predict the future of the non-automotive fuel cell market, this study has produced some useful insights.

- Fuel cell OEMs have achieved large cost reductions, on the order of 50% over the past 5 years.
- Substantial improvements in durability have also been achieved.
- Manufacturers are generally operating well below existing capacities and see scale economies as having major potential for cost reduction.
- OEMs have narrowed their product offerings to be more competitive.
- Manufacturers believe further cost reductions of 40% to 50% are necessary to compete with alternative technologies.
- In the current market, government incentives are critical to sustaining the U.S. fuel cell industry. This is likely to remain so for the next 5-10 years.
- Analyses using the non-automotive fuel cell market model indicates that continuing or expanding government incentives is essential to sustaining the U.S. fuel cell industry through its transformation period.
- If progress can be continued, even at slower rates than in the past, it appears likely that the U.S fuel cell industry will become self-sustaining within a decade.

Thank you.

Technical backup slides.

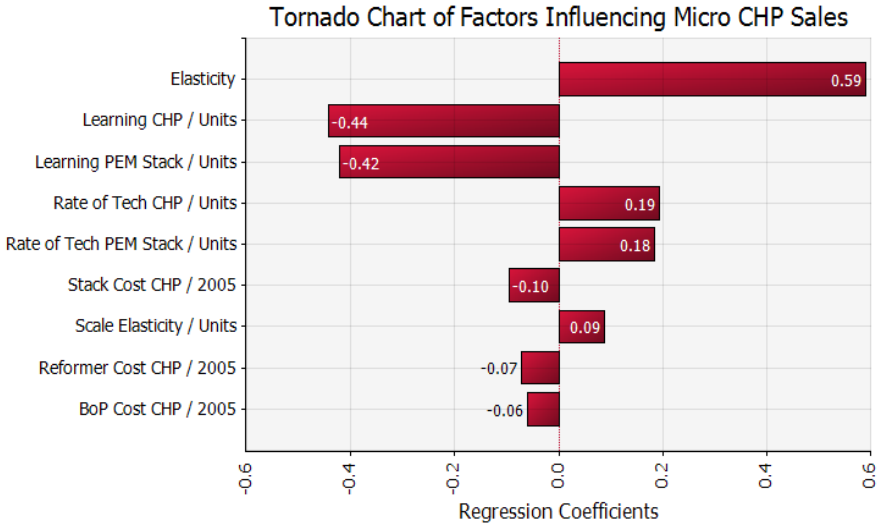
Table 5. Key Assumptions for Calculating Equivalent Annual Costs: Fuel Cell Systems

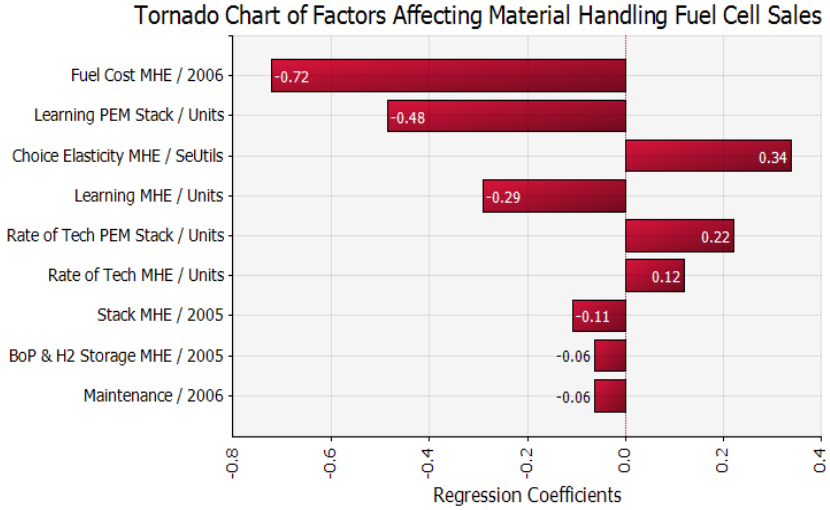
	Micro-CHP	**Backup Power**	**Material Handling**	**PAFC (per kW)**	**MCFC (per kW)**
Size	5 kW	5 kW	5 kW	400 kW	3 MW
Stack Life	5	10 increasing to 15 in 2015	5	5 increasing to 10 in 2025	5 increasing to 10 in 2025
Stack RPE in 2010	$19,500	$6,500	$19,500	$1,500	$2,000
BoP Life	10	10 increasing to 15 in 2015	10 increasing to 15 in 2015	20	25
BoP RPE in 2010	$15,500	$5,000	$22,000	$2,500	$1,000
Reformer Life	6	10 increasing to 15 in 2015	-	-	-
Ref. RPE in 2010	$15,500	$5,000	-	-	-
Capital Subtotal	*$50,500*	*$16,500*	*$41,500*	*$4,000*	*$3,000*
Installation	$2,000	$4,500	-	$700	$500
Maintenance $/yr	$500	$500	$700	$700	$500
Energy Costs $/yr	$850	H2 $4,700/ MeOH $1,000	$8,000	$1,000	$700

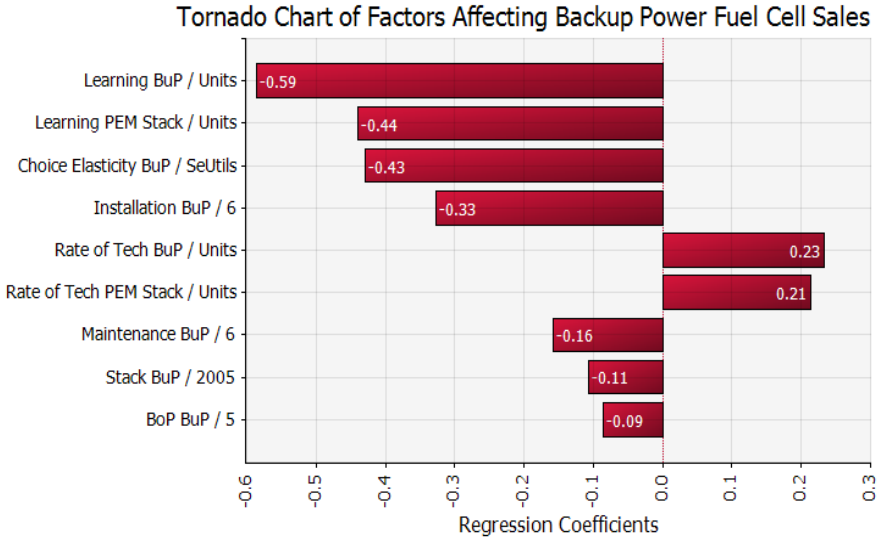
Table 6. Key Assumptions for Calculating Equivalent Annual Costs: Alternative Systems

	CHP: Electricity and NG	CHP: Natural Gas ICE	Batteries for Backup Power	GenSet for Backup Power	Batteries for Material Handling
Battery/GenSet Lifetime	-	10	6	-	5
RPE in 2010	-	$35,000	$14,000	$12,500	$10,800
Battery Charger Life	-	-	6	15	10
Charger RPE in 2010	-	-	$2,000	-	$2,500
Cost of Electricity	$1,000	-	$250	-	$1,500
Cost of Natural Gas	$500	$1,400	-	$500	-
Maintenance $/yr	-	$250	$500	$500	$1,000
EAC Cost $/yr	$1,500	$7,500	$5,000	$2,700	$6,000

Learning by doing rates for OEMs and in fuel cell stack manufacturing are always among the most important factors.







CHP = Combined heat and power
PEM = Proton Exchange Membrane
BuP = Backup Power
MHE = Material handling equipment