When will domestic fuel cell CHP be cost effective?

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Introduction

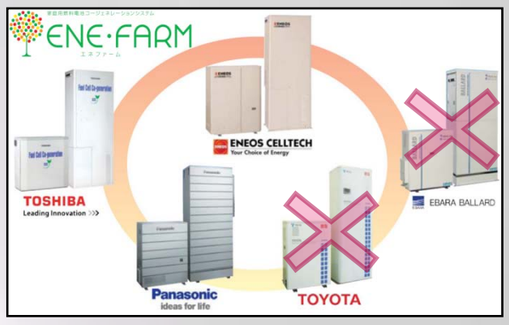
Everyone knows that fuel cells are expensive. The trouble is finding out exactly *how* expensive they are now – try asking some manufacturers today... It is also extremely difficult to calculate how rapidly prices are falling, as so little data has been available.

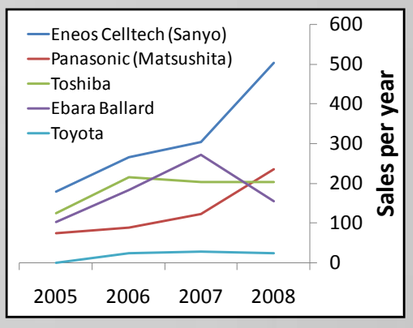
Economic analyses of fuel cell CHP systems have relied on estimated costs and learning rates. Policies, subsidies and market analyses therefore have to rely on educated guesses for future prices.

This study takes data from the largest demonstration of fuel cell CHP systems in Japan, and finds the current prices, and rate at which they fell during a 5 year period.

Domestic Fuel Cells in Japan

The ENE·FARM is the world's most advanced fuel cell micro-CHP system. Over 3,000 systems from five manufacturers have been installed in Japan since 2005, as part of the Large Scale Residential Fuel Cell Demonstration Project. These systems are now the first to be released on general sale to the public – but Toyota and Ebara-Ballard have cancelled their operations.





ENE·FARM systems feature a 0.7-1kW PEMFC stack with a reformer (natural gas or LPG), and a hot water storage tank.

The demonstration project saw around €200m of government subsidies given to early adopters, and data from the trials (including sale prices) was published throughout by the NEF.

Learning Curves

Learning-by-doing suggests that products become cheaper as manufacturers become more experienced. Optimised production facilities, R&D and economies of scale apply to all forms of industry, from producing cars to solar panels – so there is "overwhelming evidence" for this theory.

Experience curves can be fit to past data on product prices and the number that have been installed. These curves give an estimate of the rate that prices are falling, and can project prices in the future.

For every doubling of production *(X)*, the price *(P)* per unit falls by a given percentage *(L)*, which is usually between 10 and 20%:

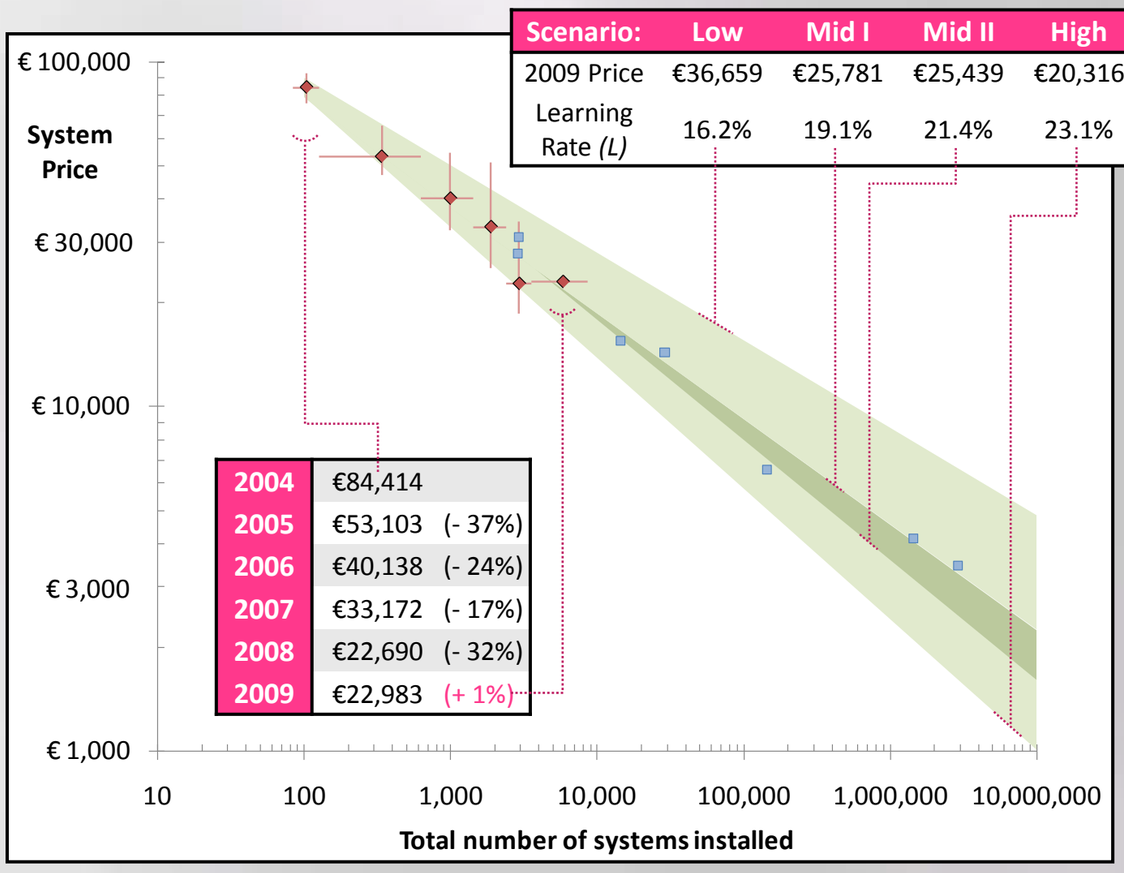
$$P_n = P_{base} \cdot \left(\frac{X_n}{X_{base}} \right)^{-b} \quad \text{and} \quad L = 1 - 2^{-b}$$

The adjacent graph plots the falling price of a 1kW fuel cell system against the cumulative number of systems installed.

Red data points: historic prices given for the years 2004 to 2008 (annual averages), plus the initial sale prices that have been announced for 2009.

Blue data points: the projections and targets of various organisations such as Panasonic and the METI Roadmap.

The green areas give the four learning curves that were fit to the historic data. The reference price (for 3500 installations) and learning rate *(L)* are given in the top-right table.



Scenario:	Low	Mid I	Mid II	High
2009 Price	€36,659	€25,781	€25,439	€20,316
Learning Rate *(L)*	16.2%	19.1%	21.4%	23.1%

Historic Prices & Learning Rate

- Prices have fallen **73% in five years** in Japan.
- A 1kW PEMFC system costs **€22-24,000** today.
- Prices have fallen by **19.1-21.4%** for every doubling in production – the same rate that solar panels have fallen for decades.
- Prices will reach €10,000 / kW when 60 to 90 thousand units have been sold. **Tens of millions** are required for prices to reach €1,000 to €2,000.

The straight lines fit historic data (except 2008), and industry projections generally follow the Mid curves.

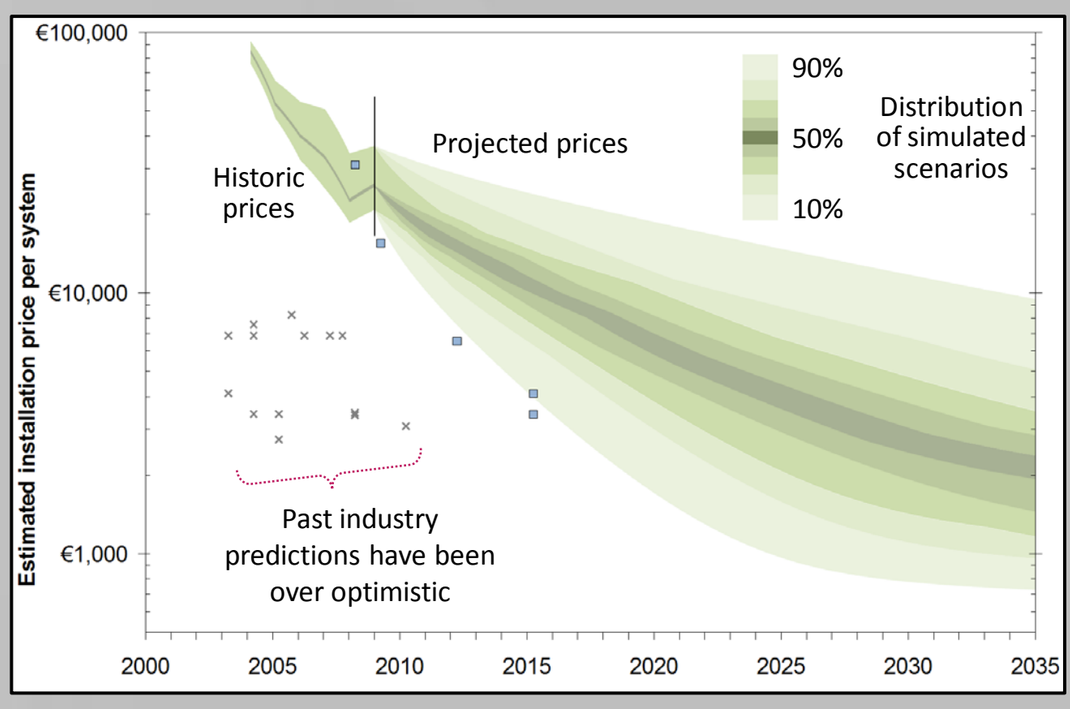
Prices fell by a third in 2008, as companies fought for market share and mass production began. They have bottomed out since, as further progress may require new models and production facilities to be introduced.

Future Cost Reduction & Implications

- With strong growth, prices will halve to €10,000 in 3-6 years time.
- At least a decade of gradual cost reduction is needed to give a 90% cost reduction (to ~€2,500) but 25 years is the mid-range estimate.
- Some major technology breakthroughs could give a step change to lower costs: Low humidity membranes and CO tolerant anodes would allow dramatic simplifications to balance of plant.
- These ENE·FARM systems are the most commercially advanced to date. European PEMFC are up to 10x the price, and SOFC systems are beginning to emerge from the laboratory into people's houses.
- Fuel cells face the same fate as solar panels: subsidies will be required for the foreseeable future to support uptake until costs can be reduced to a competitive point.

	Continued Regional Deployment 2500 sold in 2009, 40% p.a. growth			Rapid Global Deployment 5000 sold in 2009, 80% p.a. growth		
Scenario:	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**
Price in 2011 (Grove XII)	€28,300	€18,200 - €18,900	€14,100	€23,500	€14,100 - €15,200	€10,800
Price in 2019 (Grove XVI)	€13,600	€6,800 - €7,900	€4,900	€7,200	€3,000 - €3,800	€2,200

Future sales volumes were projected up to 2035 with three scenarios. Rapid and average deployment rates are shown above, plus a more conservative 20% p.a. growth rate. The four learning curves were mapped onto the projected numbers of installed units to estimate prices in the future. A range of predicted prices is given for the near future.



The green areas on the adjacent graph plots the spread of estimated prices from all combinations of learning curve and deployment scenarios. The rate that prices will fall depends as much on how fast they can be deployed as the learning rate.

The industry projections **(blue data points)** exceed the optimistic deployment rate, and assume that sales will double year on year for a decade. This in combination with high learning rates may prove difficult to achieve in practice.

UKERC

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This poster is based on "Estimating future prices for stationary fuel cells with empirically derived experience curves". Please take a copy of the abstract if you would like further information.