

Investment in volume building: the ‘virtuous cycle’ in PAFC

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Abstract

The world’s first commercial fuel cell power plant – the 200-kW PC25[®] – works. That is very good news for everyone interested in the market introduction of fuel cell power. Reaching this point has taken years of intensive R&D investment. However, we are finding out now that the investment game in phosphoric acid on-site power is far from over. It has only entered a new phase, where we must invest in creating market volume, to reduce our costs and increase volume. It is in initiating this ‘Virtuous Cycle’ that International Fuel Cells (IFC), through its stationary power subsidiary ONSI, is devoting almost all its time and investment today. © 1998 Elsevier Science S.A.

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1. Status of the PC25

IFC/ONSI’s 200-kW PC25, natural gas, fuel cell stationary power plant is, today for the first time ever, a commercial product. As of the beginning of September we had sold 144 units, of which 91 were already installed and in operation around the world (Fig. 1). These 18+ MW of distributed fuel cell power have accumulated over 1.5 million h of operation, in North America, Europe, and Asia. The great majority of units are installed at commercial or industrial facilities for on-site power, just as originally intended.

The new technology incorporated in the PC25 – fuel cell stack, gas processing, and system integration – required intensive capital investment, over decades, to bring to fruition. We know now that it works, and works extraordinarily well (Fig. 2). Fuel cells’ benefits over all other generation technology are unprecedented reliability; unusual efficiency and extreme cleanliness and siteability.

1.1. Reliability

Many PC25s have achieved 95% availability during their life, with a mean time between forced outage of over 2200 h. One record setting PC25 operated for 13 months, in 1996–1997, at full power, without shutdown for any reason. In fact, the PC25 is so reliable in operation that we are now selling it into uninterrupted power supply (UPS) applications, to continuously power critical loads like computers.

1.2. Efficiency

Electrical efficiency is 40%, which compares very favorably with other on-site generators, the best of which can reach 30% in this size range. Our cogen heat can boost site efficiency to 85%.

1.3. Cleanliness

Emission levels from the PC25 are the lowest ever for a fossil-fueled generator. So low indeed, that fuel cells have now been exempted from air permitting in most areas of California, which has the most stringent standards in the world. This cleanliness, coupled with low noise, no vibration, and compact size, means the PC25 can be installed and operated in almost any commercial site location.

2. Product investment

The demonstrated benefits of fuel cell power have not come cheaply. One estimate is that US\$200 million has been spent on PC25 R&D (Fig. 3), over the approximately 20 years of product development. These funds have come mostly from United Technologies, and Toshiba and other partners. Significant contributions have been made by the US government, utilities, and the utility industry. It has all paid off, however, in the demonstrated product performance of the PC25.

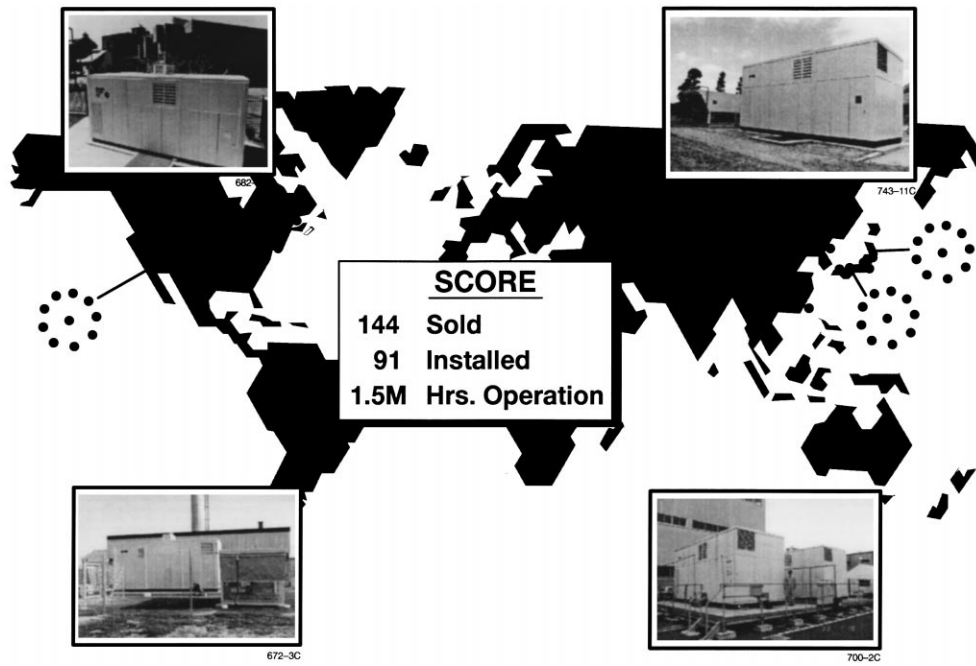


Fig. 1. The PC25 is a commercial product.

If that were the end of the investment story in phosphoric acid and on-site power plants, we could declare victory and move on to new products and technologies. But as the great American technology guru – Yogi Berra – once said ‘It ain’t over ‘til it’s over’ Our investment in the product and technology continues today at almost the same pace as during the development years. Investment focus, though, has shifted very significantly. Our investment aims now are to make the market go.

3. Investment in the ‘virtuous cycle’

We are investing now in the ‘virtuous cycle’ (Fig. 4). We need to build our volume of manufacturing and sales. When we do that, we will be able to bring our power plant cost down rapidly. Bringing our cost and price down will allow more customers access to the technology. This will mean

- Reliable**
 - 95% availability
 - Used as UPS
- Efficient**
 - 1/3 greater than conventional
 - CoGen heat
- Clean**
 - Lowest emissions ever
 - Air permit exempt
 - Eligible for Global Climate Change grant
 - Noise of an air conditioner

Fig. 2. The technology works.

more volume, leading to lower cost, and an ever accelerating ‘virtuous cycle’.

The trick today is giving the cycle a shove to get it spinning. The PC25 is still an expensive form of generation; one with special and valuable characteristics, but expensive. IFC must apply its investment dollar today to priming the pump: applying impetus to the market and our volume, to start the cycle.

Our volume-building investment falls into three areas: market subsidy, applications expansion, and direct technology cost reduction.

3.1. Market subsidy

Our initial PC25 A models cost us over US\$1 million each to manufacture. Not surprisingly, we did not find many customers who were willing to pay that price. Even-

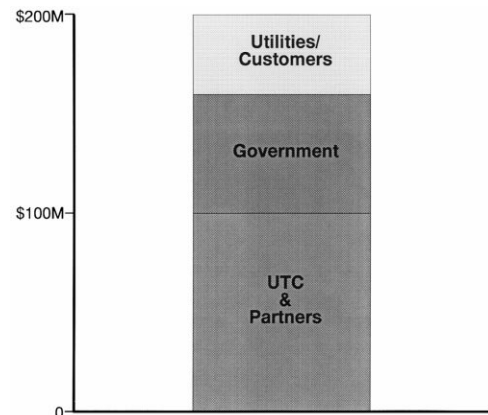


Fig. 3. Technology investment has been significant.

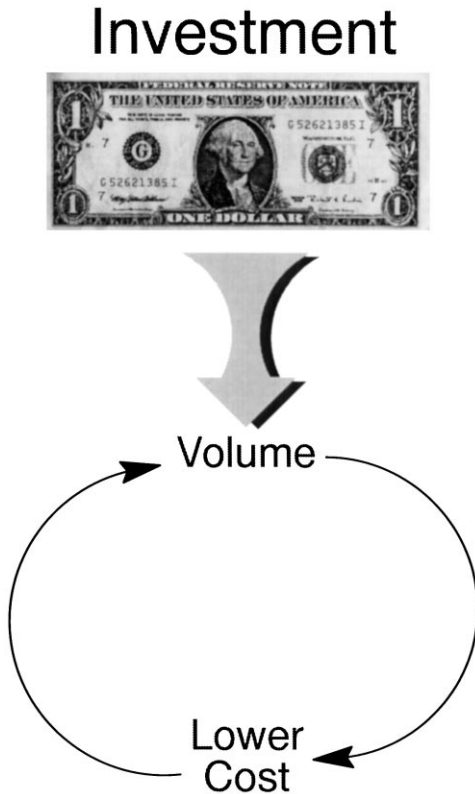


Fig. 4. The ‘virtuous cycle’.

tually, we were able to sell the A’s at about one-half their cost. The difference between our cost and customer price was market subsidy. As we have reduced our costs over the last five years, that market subsidy has lessened. Still, every one of the 144 PC25s sold so far has carried some IFC market subsidy. Since 1992, this has totaled roughly US\$50 million.

With continued cost reduction, our costs will fall below our price, and we will be able to both reduce price and make a positive margin. This form of volume investment, then, will be ending shortly.

3.2. Applications expansion

Another method of increasing sales volume is to add

- Outputs**
 - 1996 Grid independent
 - High grade heat
 - 1998 Multi unit paralleling
- Fuels**
 - 1997 Propane/dual fuel
 - 1998 H₂
- Size**
 - 1992 60,000 lbs. 2760 ft³
 - 1995 38,000 lbs. 1800 ft³

Fig. 5. Applications expansion.

Application expansions

- Methanol, diesel fuel, LPG/Butane
- Chiller integration

Cost reduction

- Active electrolyte replacement
- High temperature, solid electrolyte
- Repackaging 30% smaller

Fig. 6. Future investment possibilities.

more capability to the PC25, to allow it to reach more applications. Our investment in applications expansion has gone into three power plant areas: outputs, fuels and size (Fig. 5).

- Electrical output has been improved with the introduction of grid independent operating capability last year, and the ability to connect several units in parallel grid independent next year. We also have high grade heat available as an option.
- Besides natural gas, we can now operate the PC25 on propane, as a dual fuel option. We have successfully modified a PC25 to operate on pure hydrogen in Germany and will introduce that as an option in 1998.
- Investing in size and weight reduction, which opens more sites for application, has brought the PC25 down by over one-third since 1992.

3.3. Cost reduction

We are almost one year into another three year technical cost reduction program. All major elements of the power plant – cell stack, module, fuel processing, and power conditioner – will yield significant savings. Total investment in this program alone will be over US\$20 million. Impact on

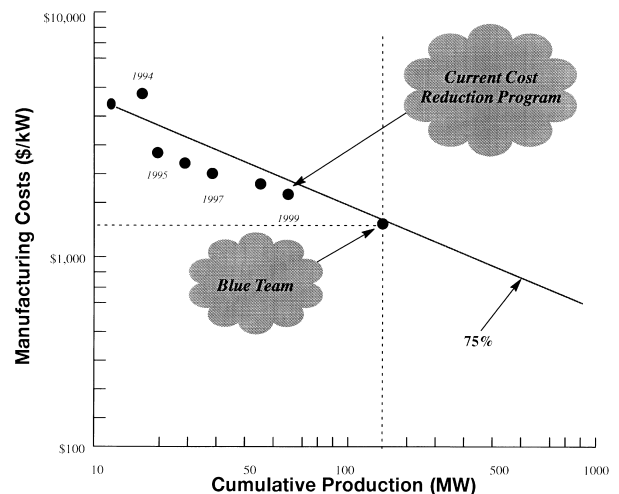


Fig. 7. We are having success.

power plant cost should be well in excess of 20%, by the year 2000.

4. The future

Although we plan to end the investment in market subsidy, there is still plenty of opportunity in applications expansion and technical cost reduction for future volume increases (Fig. 6). Besides increasing fuel flexibility, we can engineer the power plant to integrate with absorption chilling equipment, an important building heat use. Improvements in basic cell stack technology can offer significant cost improvements, and of course, further miniaturization and repackaging can deliver big benefits.

Is early investment in volume building paying off? We think it is. Our cumulative production of PC25s should grow to in excess of 60 MW in 1999. Since 1992, given that

volume, we have had an outstanding history of reducing our manufactured cost (Fig. 7). We are on a very aggressive cost/experience slope line of 75%, i.e. every time we double our cumulative production experience, we are able to take 25% of cost out of the product. This is comparable with semiconductor and computer industry performance.

5. Conclusions

IFC has already proven that investment in fuel cell technology can lead to a product that works for customers, and works well. We are now proving the efficacy of investing in volume, to get the 'virtuous cycle' spinning. We have the internal capability to dramatically reduce our product's costs, given market volume. Market response to fuel cell power, then, will allow us to ride the 'virtuous cycle' to success in the 21st Century.