

FUELING OUR FUTURE: SETTING THE STAGE FOR THE COMING HYDROGEN ECONOMY

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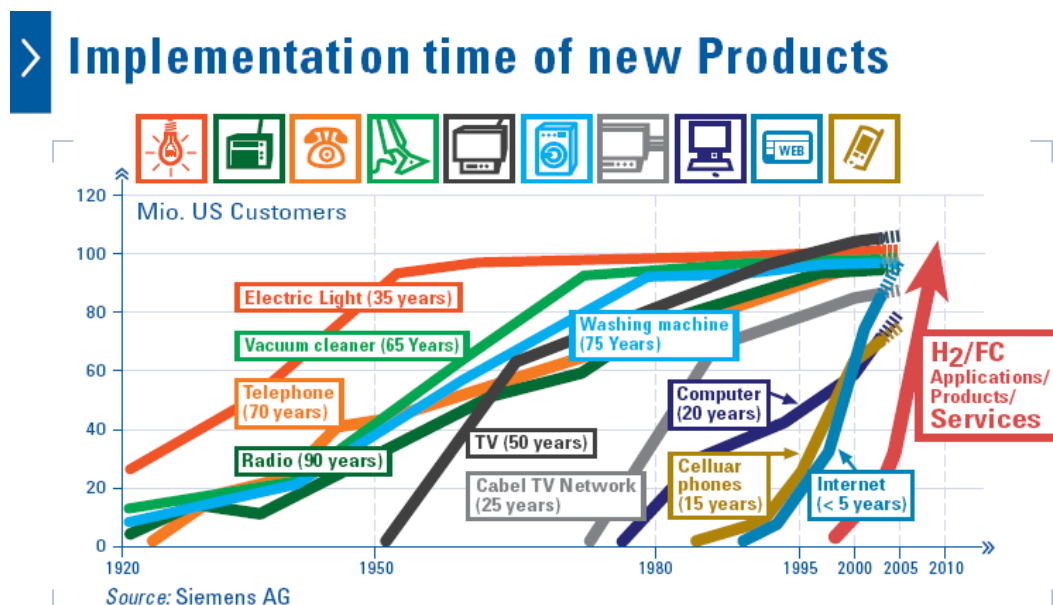
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Abstract: This outlook demonstrates the possible driving factors and necessary elements needed to move Hydrogen and Fuel Cells (H₂/FC) to commercialisation. Rather than focusing on the technology itself, the presentation looks at the “bigger picture” comparing how certain trends have impacted the progress of new technologies developments in the past and how these models can be applied to our present day situation. In this process, the consumer has played and will continue to play the key and leading role. And due to such strong influence, the consumer will ultimately fuel the future of H₂/FC commercialisation by a desire for new and not yet discovered products & services. Future products & services powered by Hydrogen and Fuel Cells. One possible step towards realising the H₂/FC Economy could be the use of Personal Power Cars equipped with a Fuel Cell which not only drive on Hydrogen, but also supply (while standing) electricity /heat to residential and commercial buildings. An outlook of current activities and initiatives in Europe and China are also explained.

Fuel Cell Applications (Stationary/Mobile/Portable)

More than 100 international Fuel Cell companies are supplying their equipment to a few Utility companies around the globe. Car manufacturers worldwide are working on vehicles with Fuel Cells and electrical motor drives or ICE's, powered by Hydrogen. All computer manufacturers are working on portable fuel cells. A Toshiba H₂/FC notebook powered by Hydrogen will come on the market in 2004 as announced at CeBIT '03, March 2003.



On Probation or Ready for Take-Off?

Fuel Cell technology has been on worldwide probation for the last 30 years. Billions of US \$ – both from Private finance and Governmental funds - have already been invested. Adoption was announced several times, but often postponed. There are two critical issues to bear in mind. First, how long will it take for H2/FC to become commercial? Second, will H2/FC be on probation for another 30 years?

Implementation Time of New Products

Figure 1: Chart illustrating implementation time of new products. According to Siemens AG, over the years, new appliances have taken different time spans to reach 100 million U.S. customers. The radio, for example, took 90 years to reach 100 million U.S. customers; telephone, 70 years; television, 50 years; cable TV Network, 25 years; computer, 20 years; mobile phones, 15 years; Internet less than 5 years. The speed of implementation continues to grow faster and faster with every new product invented. I am convinced that the introduction of Hydrogen and Fuel Cells applications, products and services will take even less time; maybe just a few years.

> Why do Customers buy new Products?



Not Technical possibilities but Consumer Demand

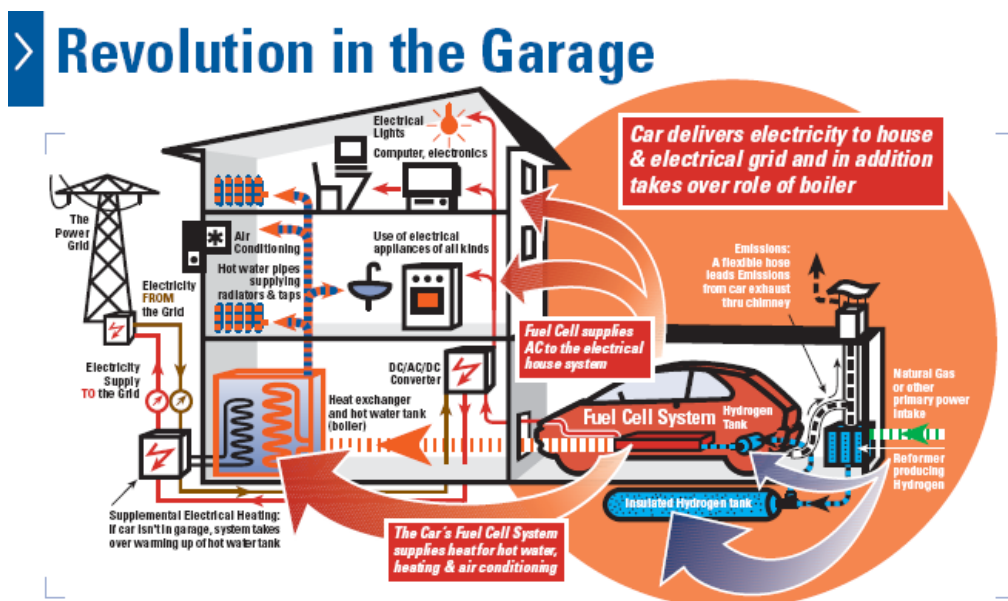
The future of an H2/FC economy will not be dependent on the replacement of existing energy-powered products, but rather in products and/or services unknown today which will benefit our daily life tomorrow. Because of the “added value” benefits of these new products and/or services, this development is going to happen sooner than many “experts” think today. All new appliances in the past were luxury goods in the beginning. They had their breakthrough due to the fact that they improved the consumer’s daily life by added convenience. Some examples including year of invention: Matches (1827), Refrigerator (1850), Elevator (1857), ICE (1860), Telephone (1876), Record Player (1877), Lamp (1878), Automobile (1885), Camera (1887), Aircraft (1891), Radio (1894), Movies (1895), Television/Aspirin (1897), Loudspeaker (1898), Razor (1901), Vacuum Cleaner (1901), Air Conditioning (1902), Copy machine (1904), Washing Machine (1906), Computer (1977) Figure 2: Consumers on the move.



Four Steps to an Energy Supply based on Hydrogen and Fuel Cells

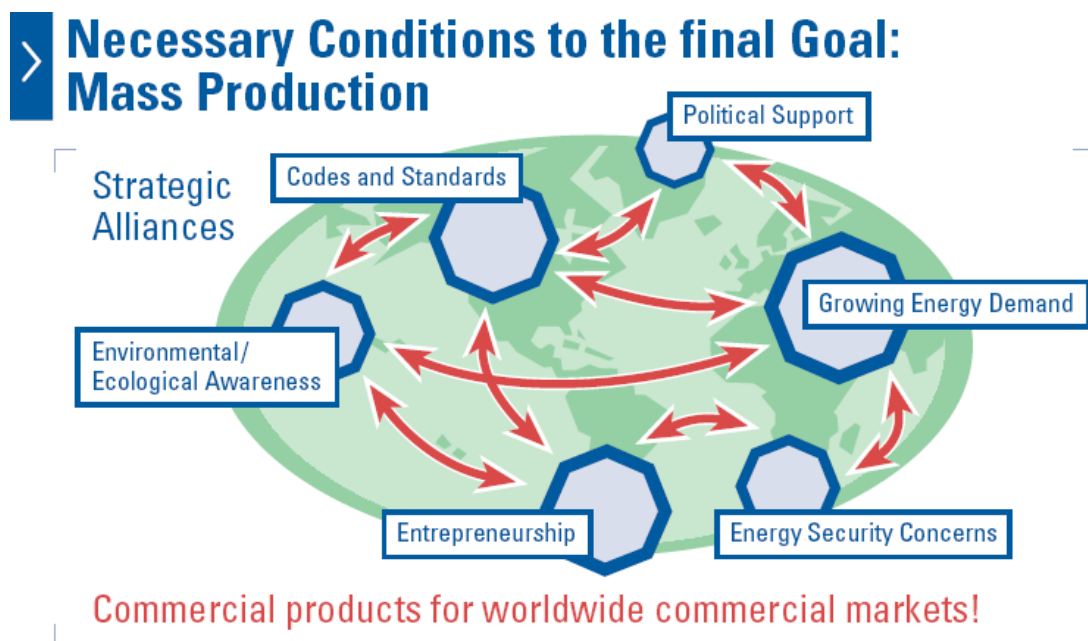
Figure 3: Illustration of steps towards a cleaner, reliable, decentralised energy supply. In my opinion, cars are the key for a new Energy Supply based on H₂/FC. All it takes is four steps. Step 1 – Renewable energies (like wind, solar, hydroelectric and/or biomass energy) produce Hydrogen. Step 2 – The cars drive on Hydrogen using Fuel Cells and electrical motors. (The first two steps are readily available worldwide. However, at this time, there’s no public demand for use of these options. To get the repeatedly promised Hydrogen economy on its wheels, two more steps must follow.) Step 3 – While parked, these vehicles drive idle and supply electricity to the buildings where they are parked. Step 4 – Car owners earn money based on the electricity/heat supplied by their cars.

The incentive for car owners driving and using vehicles equipped with Hydrogen and Fuel Cells systems is twofold. They can either save or earn money while their cars are parked and plugged into buildings via a smart docking station. For example, your car parked at home in your garage will supply electricity to your home and additionally, replace the function of your existing boiler, thus saving you money. You can earn money by selling the electricity generated, but not used at home at that time, to the utilities and feed it into the existing electricity grid.



Revolution in the Garage

Figure 4: Illustration of Personal Power Car taking over the role of the boiler & delivering electricity to house & electrical grid whereby creating a “revolution in the garage”. Looking at today’s so-called “western” countries, if all registered cars would be equipped with a Fuel Cell system, they could (all together) easily take over the function of today’s existing stationary power plants. This is due to the fact that the total power installed in the cars’ engines exceed the capacity of existing stationary power plants by 20-35 times. In the first stage, the Hydrogen needed to power this system will come from natural gas which is presently and widely available. The individually produced Hydrogen will be stored in a personal tank inside the garage or the cellar. The Fuel Cell in the cars produces DC, which will be converted in the house into AC. When needed, DC can also be used directly with nearly all advanced appliances like computers, plasma screens, mobile phones. The heat generated by the fuel cell in the car will warm your home in winter, and in summer, the heat will be converted by means of special heat exchangers to eventually replace all residential air-conditioning units.

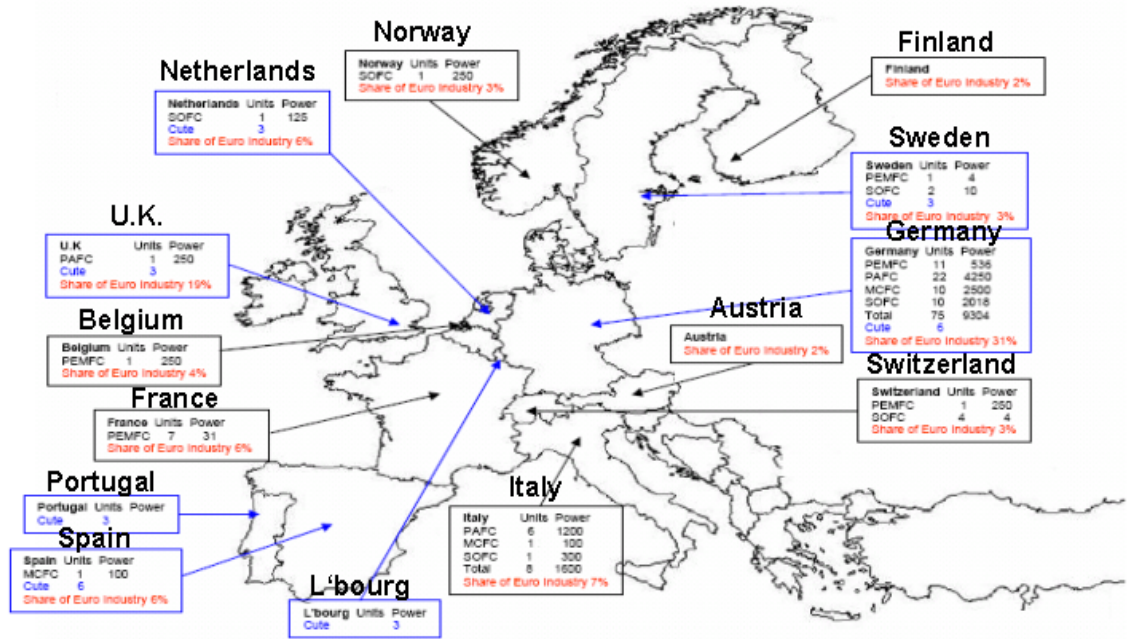


Necessary Conditions to reach the final Goal:

Mass Demand will drive Mass Production

Figure 5: Illustration of Strategic Alliances and relationship to Mass Production. To achieve early market entry, it is first necessary to make the consumer excited and eager to use the new services provided by the H₂/FC technology. They must be motivated and be given certain incentives: personal advantages, product reliability and usefulness. Only when these factors are guaranteed, will the price, at least in the beginning, play a less important role. This means the more expensive the product/service is, the more chances the early adopters will buy this “luxury”. In addition, entrepreneurs involved in R&D, production & marketing of H₂/FC services must also be motivated and stand firmly behind their vision. Commitment and belief in their technology will play a critical role in the early stages of fuel cell commercialisation. Strong efforts are needed in convincing the politicians, the media, and the involved companies that H₂/FC is a viable solution for the growing energy demand. Raising energy security concerns and the impact of global pollution will additionally support the implementation. These general conditions will lead to worldwide mass-production and make H₂/FC’s appearance in the marketplace, sooner rather than later.

European Map: 12MW Stationary, 27 Buses



Source: Phil Doran, Core Technology Ventures LLP

CORE TECHNOLOGY VENTURES LLP

Market Outlook: Europe and China

Europe:

Figure 6: Map of European Fuel Cell stationary units and buses including percentage share of Euro industry by country. In Europe, there are currently 81 Stationary H₂/FC units (power plants) in operation with a total capacity of 12 MW power. There are 27 H₂/FC buses planned by the EU-sponsored CUTE programme. Germany leads with a share of the European industry of 31% followed by UK with 19%, Italy with 7% and France, Spain with 6%.

Some recent EU policy actions: Action plans on energy efficiency include improving energy efficiency by +18% from 1995 to 2010 and increasing the share of co-generation to 12% of EU-15 (member countries) electricity by 2010. A white paper on renewable energies recommends to double the share of renewable energies from now 6% to future 12% of final energy. There are active committees who analyze the communication on alternative fuels. They propose Hydrogen with a share of 5% of road transport fuel by 2020.



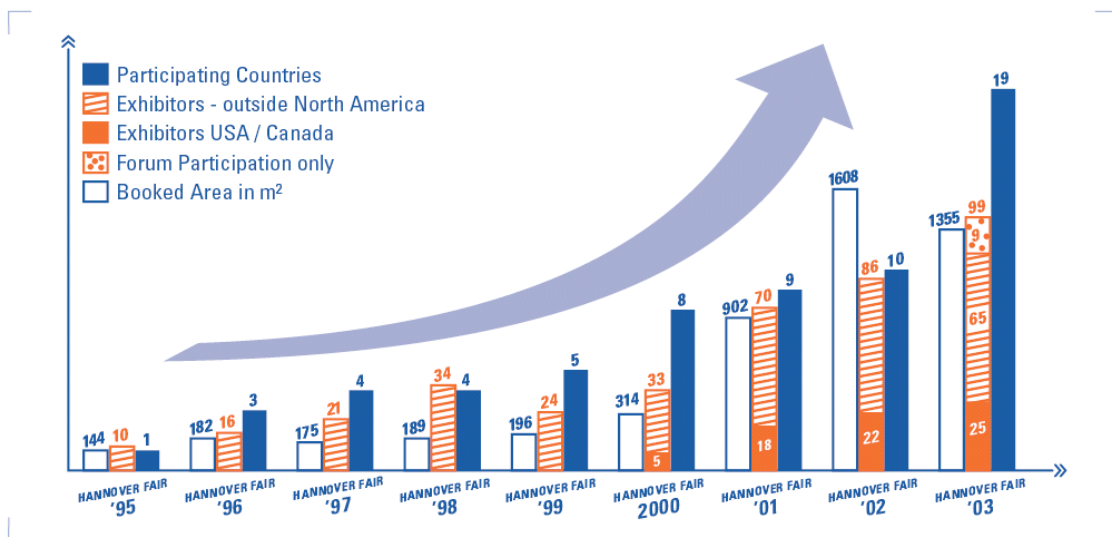
Chinese Market Impressions – 1.3 billion potential customers

China:

Figure 7: Chinese market impressions – 1.3 billion potential customers. The National Natural Scientific Foundation (NSFC) is responsible for Fundamental Research. Projects include: The "863 High Technology Research and Development" project deals with commercially potential ventures. Key projects include: Fuel Cell cars and buses with a allocated budget of 33 million EURO; Fuel Cell Key Material Project concentrating on membrane and bi-polar development; Future Energy Project focusing on DMFC, MCFC, SOFC.

The "973 Project" is dedicated to high technology fundamental research on Hydrogen Energy (including Fuel Cells). The NSFC is looking at new material possibilities and new Fuel Cell concepts. The Chinese Academy of Sciences, Ministry of Education works on fundamental and applied fundamental research in Fuel Cell engines and Hydrogen Technology. The up-and-coming Chinese H2/FC industry deals with applied fundamental research such as advances in Hydrogen production from Natural Gas, Methanol and Gasoline.

> Group Exhibits on Hydrogen + Fuel Cells at the HANNOVER FAIR 1995 – 2003 ... more to come ...



Conclusion

This industry overview shows that the demand of the consumer will play the critical role in the mass market evolution of H2/FC products and services. At first, H2/FC powered products/services will be considered luxury items with only a handful of the population being able to afford to buy them. However, over time and as the technological awareness and knowledge about the advantages grow, the consumer will become better educated as to the many benefits offered by services powered by H2/FC technologies. Increased convenience and awareness rather than the price of the merchandise, will have an enormous impact on the consumers and will compel them to buy H2/FC powered goods, and furthermore, lead to the development of completely new H2/FC products and services which are unobtainable today. The Personal Power Car as described is just one example. However, the current activities in Europe and China as presented are sure to further accelerate the trend towards the coming Hydrogen Economy. Figure 8: Diagram of growth and development - Hydrogen + Fuel Cells Group Exhibit