

## Scenarios and Strategies Leading to the Worldwide Commercialization of Hydrogen and Fuel Cells

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This lecture demonstrates how past trends and implementations of new technologies impacted daily life and explains how these models can be applied to the future implementation of hydrogen and fuel cells (H<sub>2</sub>/FC) into the reality.

The presentation is examining different products and markets worldwide; it compares how strong consumer influence has played a role in the success of the worldwide implementation of inventions over the centuries, with an outlook to the future. It shows, that today's Energy Balance is rather uneconomical due to high flaring and transmission losses. Example figures from Germany are released. They can be overcome by a decentralized energy system based on hydrogen and fuel cells.

It will be the consumers, who ultimately also fuel the future of hydrogen and fuel cells for practical commercial and profitable uses worldwide.

The desire for new and not yet discovered services, powered by fuel cells, which are running on hydrogen will be driven by a worldwide demand of the consumers to possess such new services. One way to commercialization will be by means of direct, distributed production of hydrogen, based on renewable energies. Only if the industry proves it cases both environmentally and economically, today's known obstacles will fall.

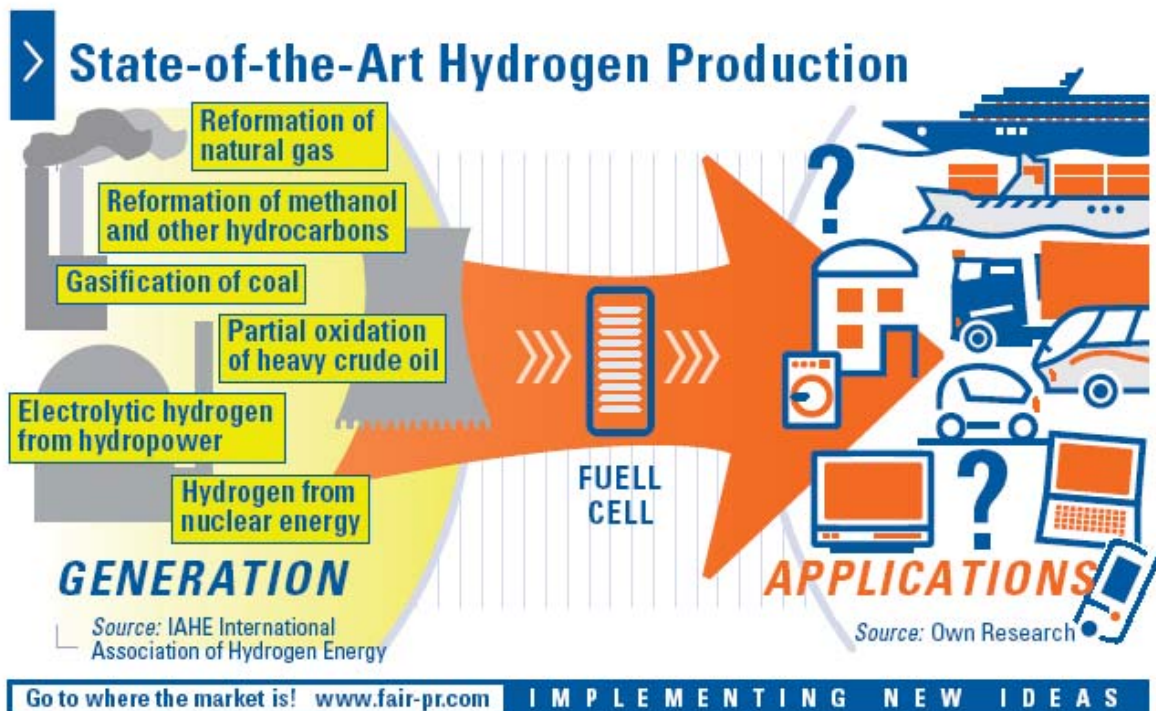
The presentation will further explain that with more than 1 billion potential consumers in each country, China and/or India can be the marketplaces of the future for the use of hydrogen and fuel cells applications and services. This lecture is based on twelve years personal international first hand-experience in the development of the commercialization of the emerging hydrogen and fuel cells industry worldwide.

## H2/FC Generation and Applications Process

There is much Hydrogen already in “daily use” today, but at this time not actually being used by the end consumer. The Hydrogen nowadays is used by the chemical industry in the production of fertilizers and most of it is produced from Crude Oil (55%), Natural Gas (25%), Coal (11%) and Electrolysis (5%). The question is: Where will the Hydrogen needed to power the Hydrogen Economy or even the Hydrogen Society possibly come from? This can only be solved with the usage of direct production of hydrogen from renewable energies.

Some activities are seen, however, they are still in the laboratory stage and far from mass production and end-user-availability. At the moment, all of these technologies are using electricity as a needed "by-product". If the use of fossil primary energies like crude oil and its products and/or natural gas should one day be eliminated, technologies have to be found who are sophisticated (and in the end: easy) enough to produce hydrogen directly from renewable energies. This could be done for example directly at the axle of a windmill, using the enormous torque there, without producing electricity and therefore without using a gear with all its mechanical losses. Another possibility is the use of solar energy to produce hydrogen directly - without the use of electricity.

This is now done in southern Spain at a big-scale test station however, it can be implemented into the daily life with the aids of Nano Structures and Nano Technologies. Time will (hopefully) tell...



## Available Solar Chargers

An estimated number of 1,1 billion cellular phones will be sold in 2007, the annual production rate is still increasing. With each of these new cellular phones, one AC/DC converter is supplied ("...free of charge", the price for it is of course included in the calculation). They do nothing else than using electricity from the grid (110-230 Volt AC), transform it to 3.5-12,0 Volts DC to charge the battery inside the cellular phones. This does not seem to cost very much, however, multiplied by the billions of phones (or better: of AC/DC converters) this adds up to a huge amount of energy, only used to recharge these cellular phones. It would be much more sensitive to use solar charges, capable to charge the cellular phones directly, using the sunlight without any detours. In a second step, direct solar produced hydrogen can be implemented in these functions.

**> Available Solar Chargers**

- Laptop**  
SolarRoll 14 by Brunton Inc.  
US\$ 330
- iPod**  
Solar Charger Solidus 1 by Soldius Inc.  
US\$ 90
- Mobile phone**  
Solar Charger by Haimei Electronics Ltd.  
US\$ 30
- Game Consoles**  
GBA SP Solar Charger by Logic3 plc  
US\$ 70

Source: Own Research,

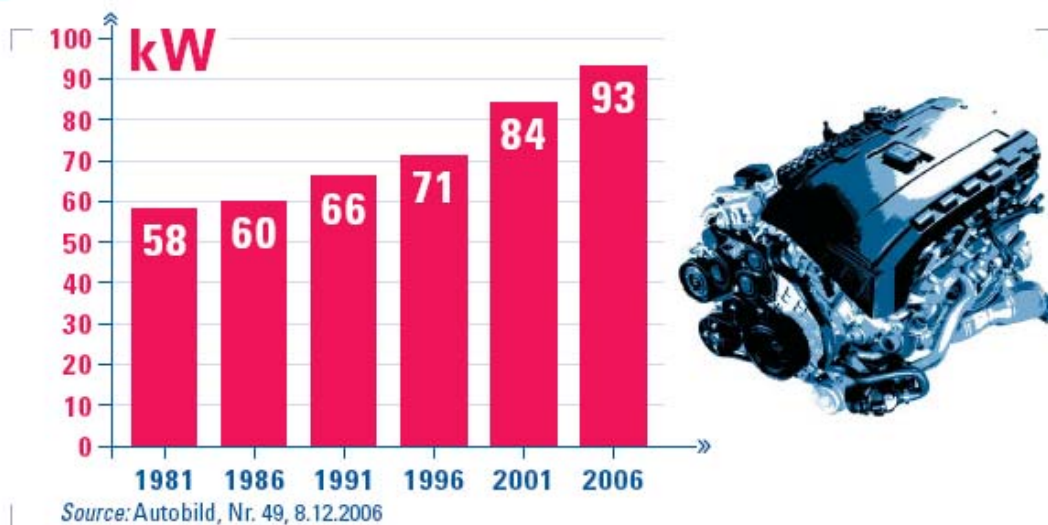
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## Average power of new registered cars in Germany 1981-2006

The figures shown (from 58 kW in 1981 to 93 kW in 2006) are highlighting the increase in engine-power of new registered cars in Germany. There is a trend towards: faster, higher, heavier, which also means: More weight, more consumption and more pollution. The questions in this context are: Is this a "mistake" of the automotive industry, a misleading of the consumers or only wrong information of the market? The other question is: Can this be a positive example for young potential car buyers in emerging countries like India and China?

### > Average Power of new registered Cars in Germany

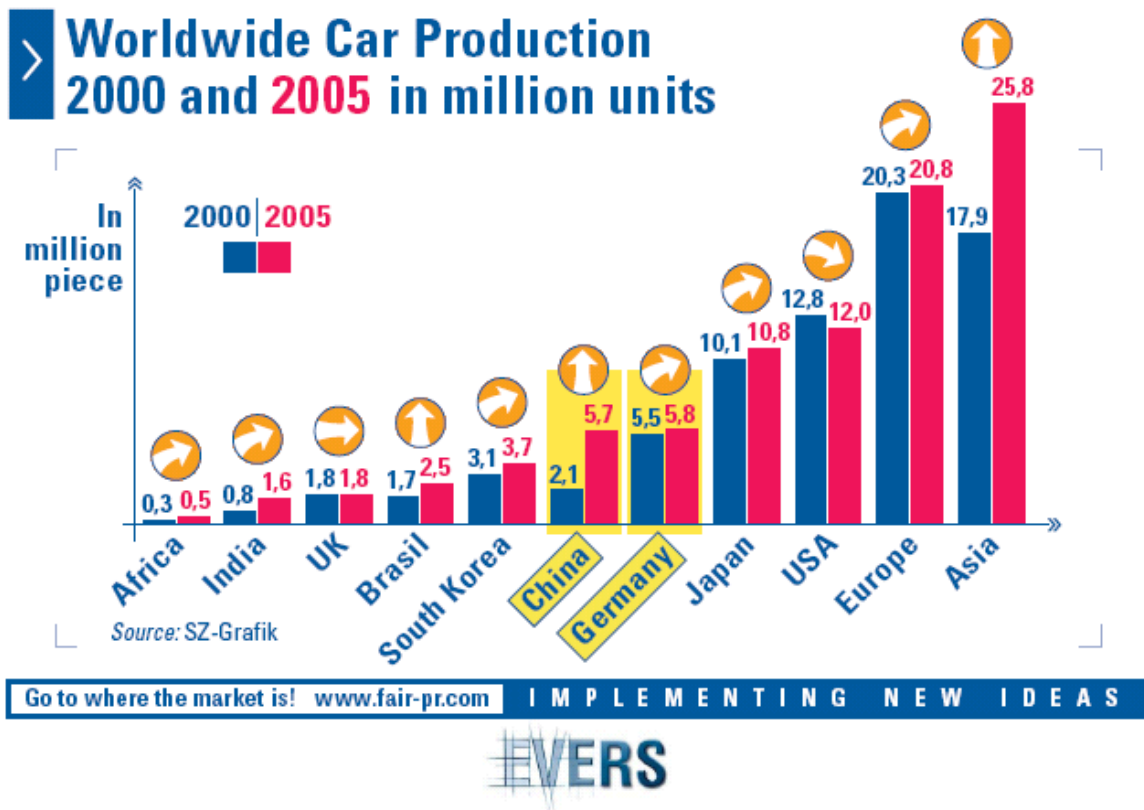


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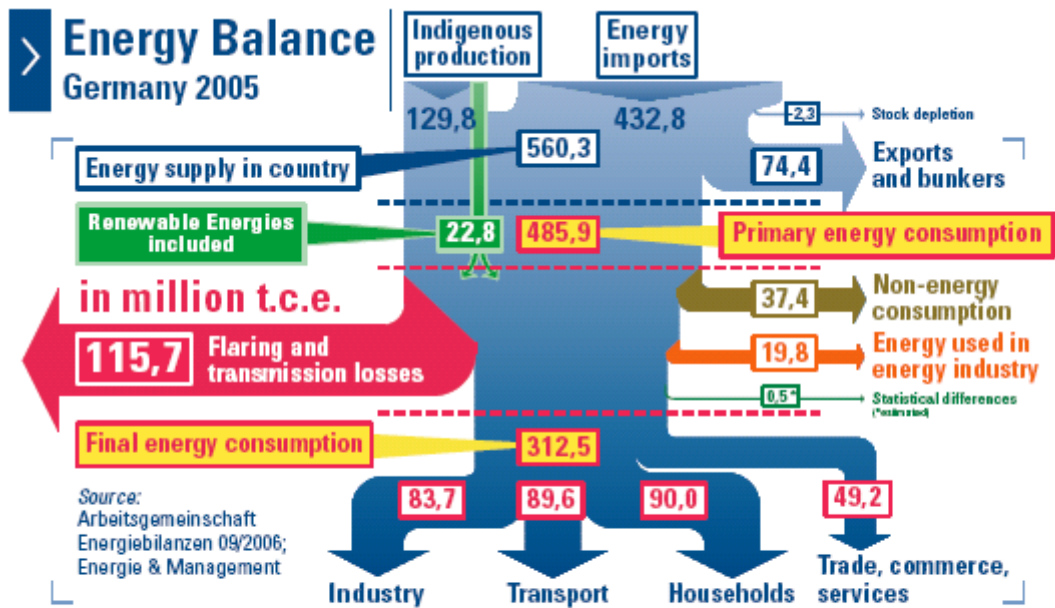
## Worldwide car production in 2000-2005

An analysis of the worldwide car production shows, that the biggest increase in car production is in Asia, especially in China. Here they have doubled their production rate within five years. In the US, car production was declining over the same period by 6 p.c. All information show, this development to further accelerate, driven by the high demand of consumers in China and India.



## Energy uses and losses in Germany 2005

This statistic shows the high amount of flaring and transmission losses, which are more than a quarter of the Primary energy being produced in Germany alone and bought from other nations, being used inside Germany in 2005. Should all the energy be used for Industry alone be eliminated to ZERO, this still would be less than the Transfer-losses (83,7 compared to 115,7 mio t.c.e - Tonnes Coal Equivalents). This knowledge should accelerate all our activities to decrease these Transfer-losses from today. Image how the situation and these figures are looking similar in other countries, who are not so technology "advanced" like Germany...(Just think of China, India but also of the US...)



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IMPLEMENTING NEW IDEAS



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

In my opinion, cars could be the key for a new Energy Supply based on H<sub>2</sub>/FC. All components to implement this idea are ready and available. All it takes is four steps: Step 1 – Renewable energies (like wind, solar, hydroelectric and/or biomass energy) produce Hydrogen. At this time, natural gas can also be used, as it is available today at many homes in question worldwide...

Step 2 – The cars drive on Hydrogen using Fuel Cells and electrical motors. These first two steps are readily available and used in prototypes by nearly all car manufactures worldwide. However, at this time, there is no public demand to use these options. To get the repeatedly promised Hydrogen economy on its wheels, two more steps have to 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 in this modus.

The incentive for car owners driving and using vehicles equipped with Hydrogen and Fuel Cells systems is twofold. They can either save (at their home) or earn (at the neighbour, drugstore, post office, airport) money while their cars are parked and plugged into buildings via a smart docking station.

## Four steps to a new reliable, cleaner and decentralized Energy Supply based on Hydrogen + Fuel Cells

[www.PersonalPowerCar.com](http://www.PersonalPowerCar.com)

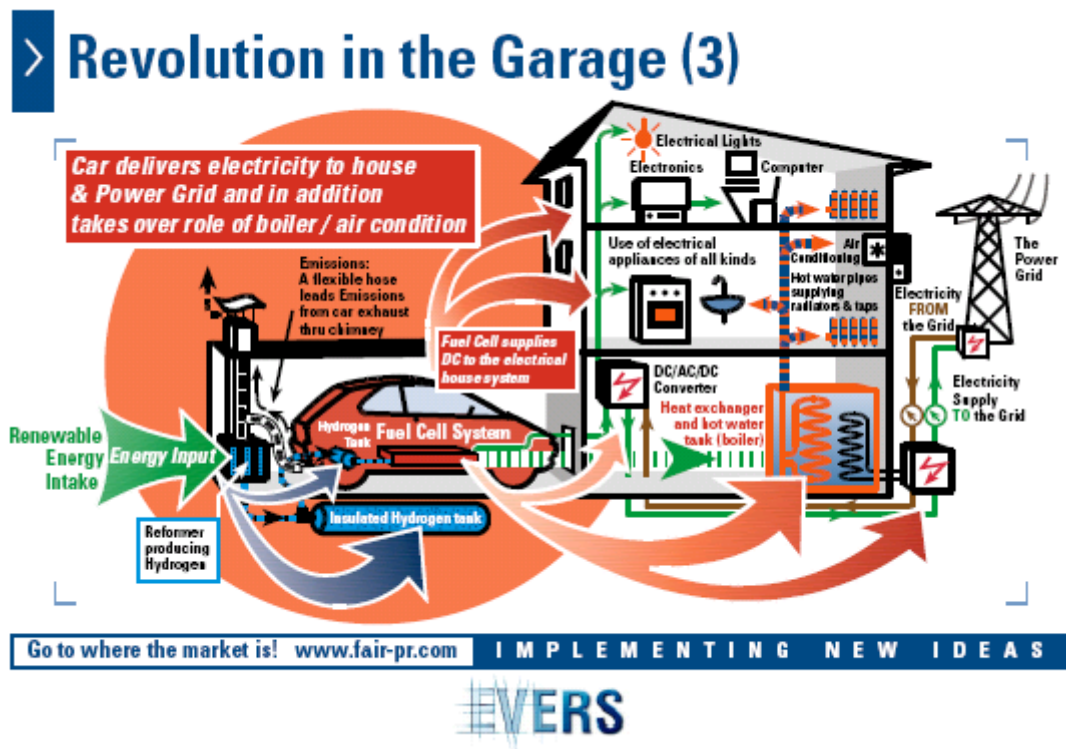


### Revolution in the Garage

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 (which all have to be replaced one day anyway). 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. At this time (2007) there are more than 800 millions cars registered worldwide. Just calculate with a medium power of 50 kW, which is not much for a car, but much in electricity. In average, cars are only being used running less than one hour per day. Please check with the figures of your own car and think about it, where your car is parking now, creating only depreciation and head aches at this moment, for example when you are searching for a parking lot...

In the first implementation stage, the Hydrogen needed to power this system will most likely come from natural gas which is currently widely available in most countries. Eventually, it will come from the direct-solar production of hydrogen from renewable energies. The individually produced Hydrogen (pH = personal Hydrogen) will be stored in a tank inside the garage. The Fuel Cells in the cars produce DC, which will be used directly with nearly all advanced home appliances like

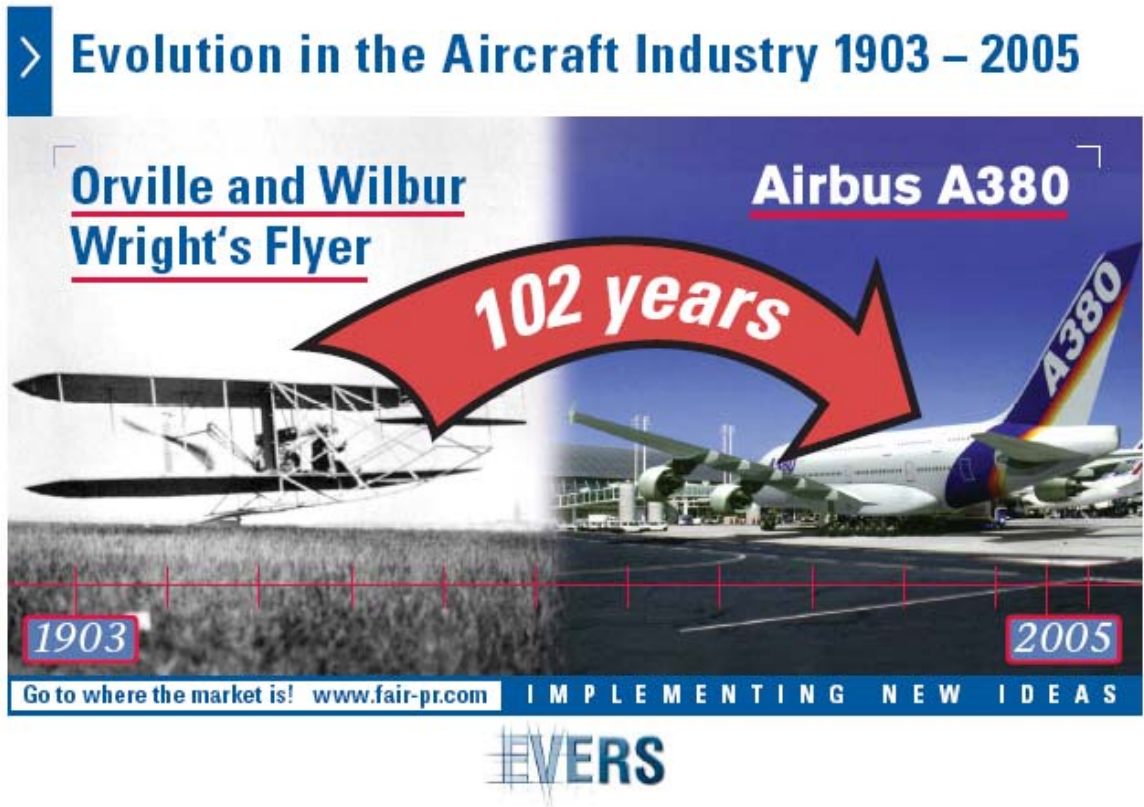
computers, TV and plasma screens, mobile phones and so on. The heat generated by the fuel cell in the car will warm homes in winter, and in summer, the heat will be converted by means of heat exchangers for cooling. So, this system will eventually replace all residential boilers and air-conditioning units. This idea has many „fathers“, Amory B. Lovins to mention one, and is just one example of where the hydrogen and fuel cell economy and even better: The Hydrogen and Fuel Cells Society could apply these technologies in combination with already existing systems. By implementing these technologies, the user of the energy will also be the producer. Surplus electricity can be transformed to AC (if needed - there can be a complete new DC grid) and sold to the grid and/or to neighbour properties like homes, offices, apartment houses and hospitals.



## Evolution of the Aircraft Industry 1903-2005

There are good examples about achievements in technologies, which changed our lives in creating new industries. One is the evolution of the Aircraft Industry comparing Wright's Flyer with today's Airbus A380 over the past 102 years. When Orville and Wilbur Wright left their plane after the first powered flight (lasting 57 seconds) in Kitty Hawk, North Carolina, December 17<sup>th</sup>, 1903, they, and nobody else, would ever imagine that only 100 years later there would be a commercial aircraft carrying more than 800 passengers over a range of more than 8,000 miles. These

technologies have developed today's worldwide industry: Tourism with more than 18 Mio. commercial aircraft passengers each and every day. Nowadays status of the Hydrogen and Fuel Cell industry status compares with that at the time of the Wright Brothers. There are more dramatic developments coming than anyone can imagine now, hopefully, in less than 100 years.



## Conclusion

Due to the worldwide high demand of fuel for mobile, stationary and transport applications, the need for Hydrogen will increase immensely. Technically, Hydrogen can be produced from every available primary energy in many different ways. For example, from Fossil fuels, from gasification of coal, steam reforming of natural gas, and even from nuclear energy. However, if the design target is to have a CO<sub>2</sub> emission-free energy carrier without polluted nuclear waste, hydrogen must be produced directly from renewable energies.

Hydrogen production is possible from all Renewable Energies including Wind, Photovoltaic and Biomass. However, to come to a direct production of Hydrogen without the use of electricity, much research and development work is required and needed. Only then, the implementation of the Hydrogen and Fuel Cells Society can follow.

In addition, the public demand can also play an important role: once a suitable new service, powered by Hydrogen, is on the market, it will create additional demand; the right decrease in prices will be followed by

the increase of mass production etc. However, these new products/new services will be luxury goods in the beginning.

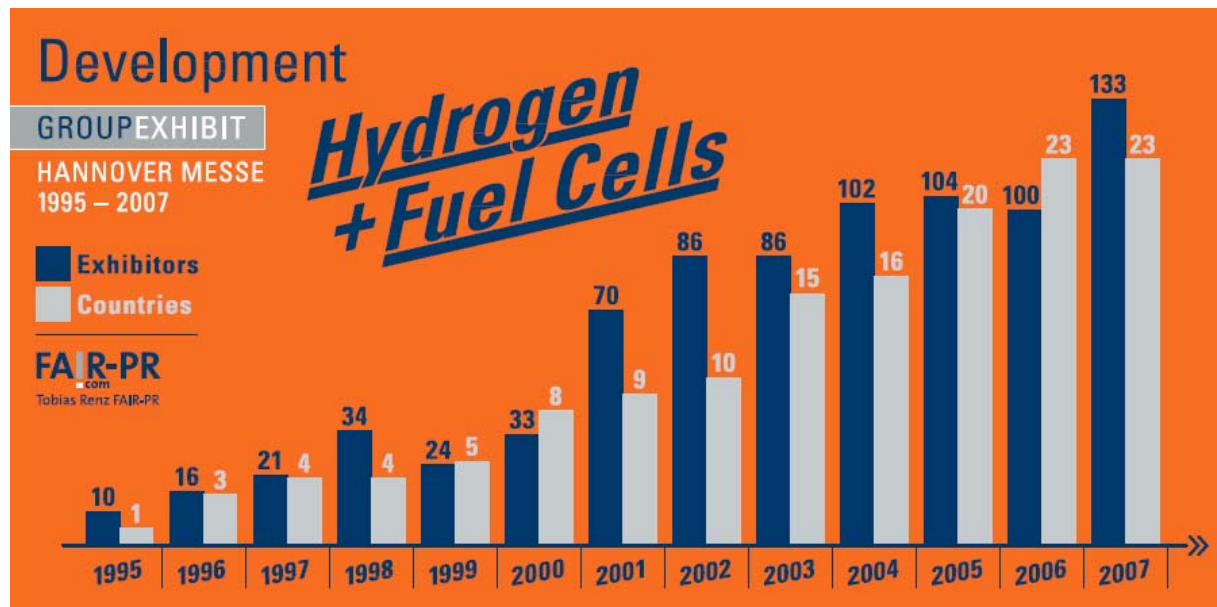
My "hypothesis":

The Hydrogen Economy will come soon

- > It will be personalised...
- > It will be decentralised...
- > It will come on a worldwide scale...
- > It will be very expensive in the beginning...
- > It will most likely come earlier than most experts think...
- > It will at first only be available to the few who can afford it...

## Development of the Group Exhibit Hydrogen + Fuel Cells

at the annual HANNOVER FAIR 1995 – 2007



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