How Hydrogen and Fuel Cells can conquer the international marketplace!

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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 (H2/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 will fuel the future of hydrogen and fuel cells for practical commercial and profitable uses worldwide.

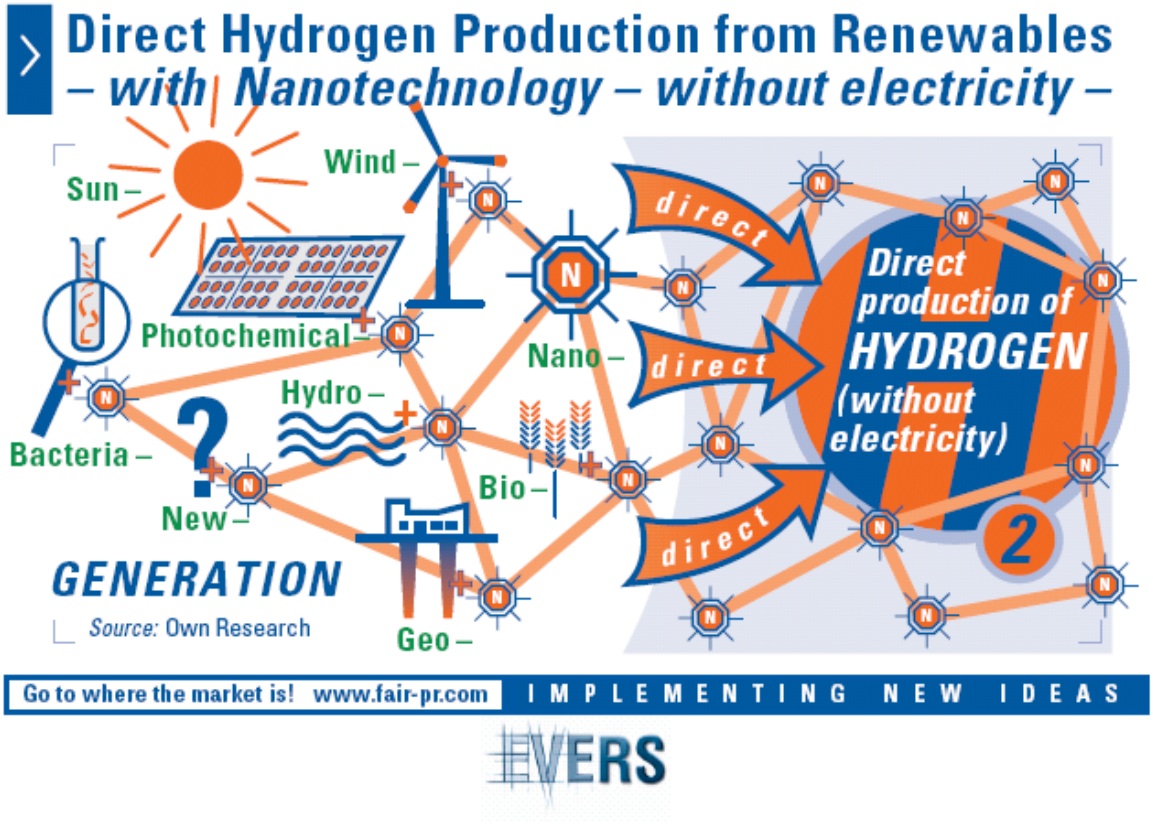
The desire for new and not yet discovered services, powered by fuel cells, which are running on decentralized produced hydrogen will be driven by a worldwide demand of the consumers to posses such new services. One way to commercialization will be by means of direct, distributed production of hydrogen, 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

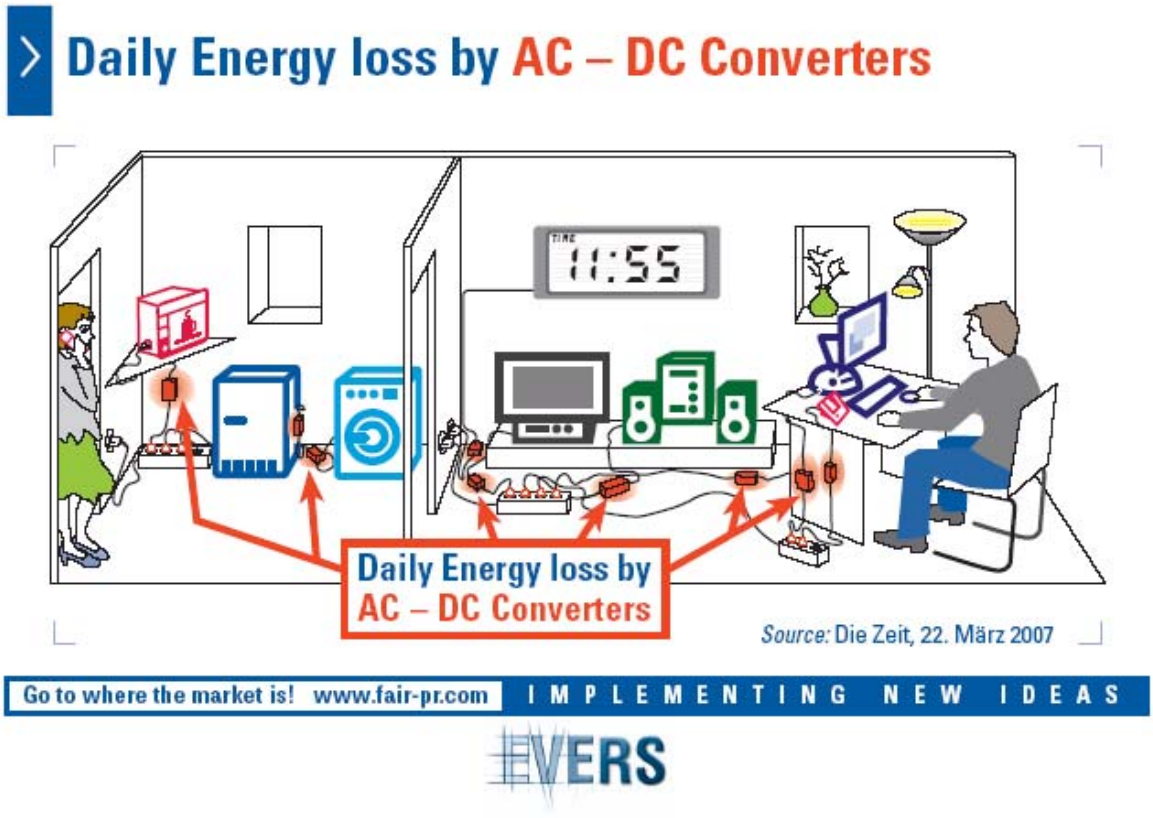
There is much hydrogen already in “daily use” today, but at this time not actually being used by the end consumer. The hydrogen nowadays is used by the chemical industry in the production of fertilizers and most of it is produced from crude oil (55%), natural gas (25%), coal (11%) and electrolysis (5%). The question is: Where will the hydrogen needed to power the hydrogen economy possibly come from? This can only be solved with the usage of direct production of hydrogen from renewable energies – without producing electricity fist and then electrolyse the hydrogen with all included transfer losses in the electrolyser.

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" in order to produce the hydrogen. If the use of fossil primary energies like crude oil and its products and/or natural gas should one day be eliminated, not to mention the use of coal, technologies have to be found who are sophisticated (and in the end: easy) enough to produce hydrogen directly from renewable energies, again: without producing electricity first. This could be done for example directly at the axle of a windmill, using the enormous torque and applying nanotechnologies there, without producing electricity first and without using a gear and a generator as it is done now in windmills worldwide with all their mechanical and electrical losses. Another possibility is the use of solar energy to produce hydrogen directly - without the use of electricity.

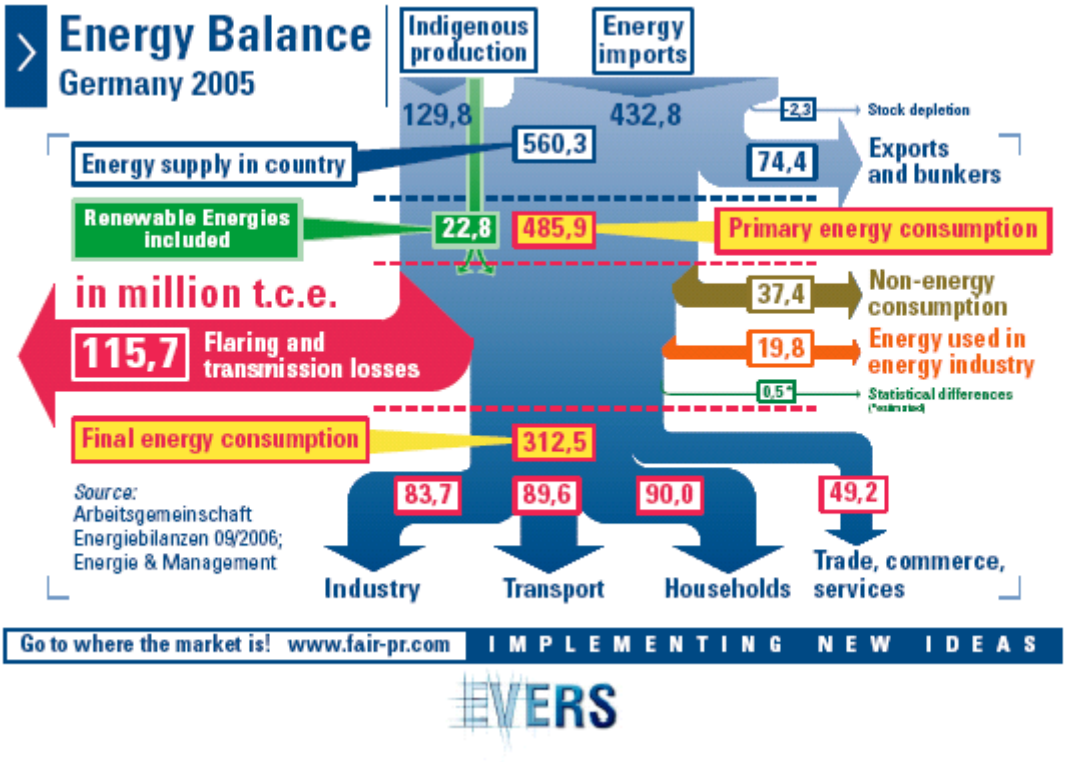


Energy losses through conversion and distribution

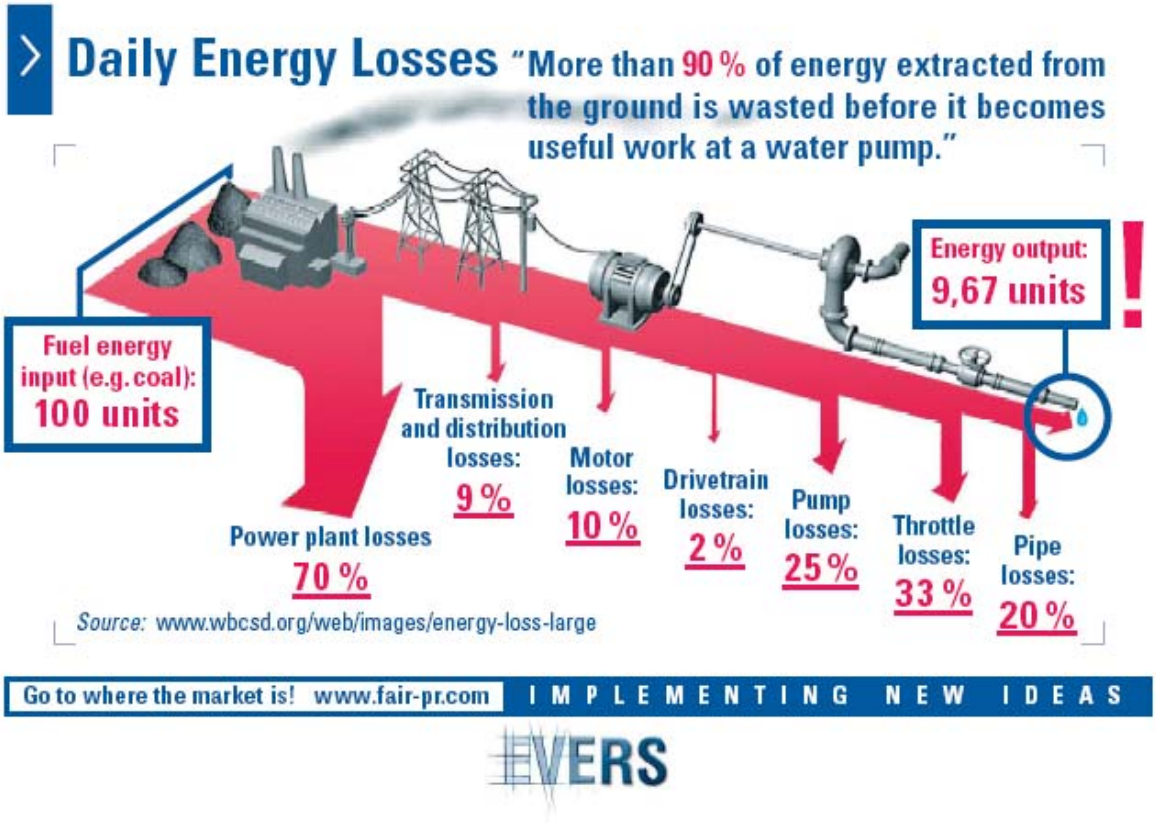
An estimated number of 1.1 billion cellular phones will be sold in 2007, the annual production rate is still increasing. With each of these new cellular phones, one AC-DC converter is supplied (they look like being “...free of charge", however, the price for these 1.1 billion AC-DC converters are of course included in the calculation of the cellular phones and paid by the consumers worldwide, even without them knowing it). These converters are do nothing else than transforming electricity from the grid (110-230 Volt AC), to 3.5-12.5 Volts DC to charge the battery inside the cellular phones. They have a very bad efficiency, which you can easily test when you touch one of the twenty (or more) AC-DC converters you have in your household. The electricity consumption does not seem to cost very much, however, multiplied by the billions of cellular phones (or better: …of AC-DC converters) this usage adds up to a huge amount of primary energy needed, only needed to recharge these new cellular phones, bought in 2007. It would be much more sensitive to use solar chargers, capable to charge the cellular phones directly, using the sunlight without any detours. The same applies to your flatscreens, TV receivers, monitors, printers and answering machines. In a second step, direct solar produced hydrogen can also be implemented in these functions.



The next statistic shows the high amount of flaring and transmission losses, which are more than a quarter of the primary energy 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 flaring and transmission losses. This knowledge should accelerate all our activities to decrease these Transfer-losses from today. The most efficient way to increase the efficiency here is to change to a decentralised energy supply. Imagine how this Energy Balance looks like in other countries, who are not so technology “advanced” as Germany (Just think of the energy production in China or India but also in the US…)



When you consider a “normal” electrical coal power plant, the counting of the efficiency only starts from the moment; the coal is at the venue of the plant. All efforts and all energy spent into the exploration, mining and transport of the coal, in many cases over continents and oceans, is not calculated. However, at the power plant itself the efficiency is around 30 pc. When you use an electrical pump at the end of the chain, together with all further transmission, distribution, motor, drive train, pump, throttle and pipe losses not more than 9,67 pc is actually used at the end. This figures speak for a decentralized energy supply, where the energy is produced where it will be used to eliminate most of these losses.



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

In my opinion, cars could be (or more pronounced: Cars have to be…) the key and the lead for a new energy supply based on H2/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. At the same time they are “refulling” while standing for example with a special “two or three component coating” on their surface, instead of the conventional painting as they now have.
Step 4:
– Car owners earn money based on the electricity/heat supplied by their cars in this modus. The balance will be drawn (in cash) at “check out”, when the car owner is leaving the parking position.

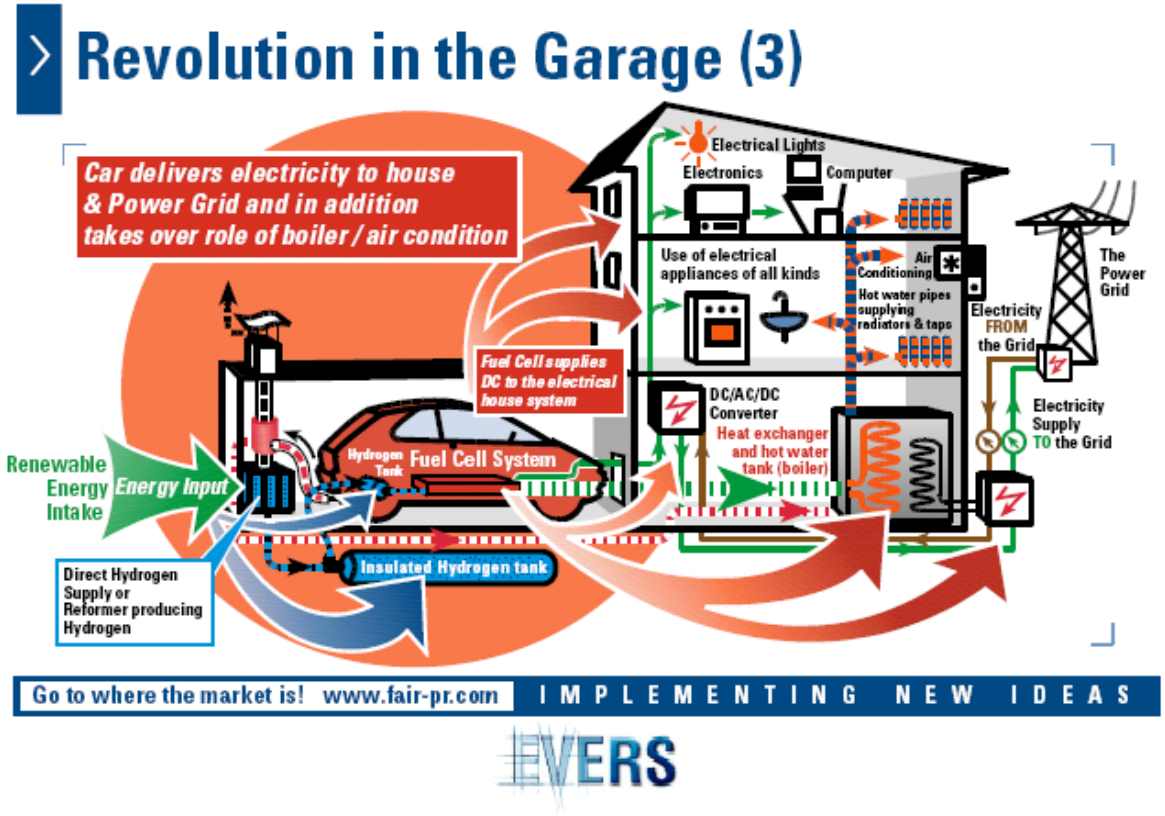
This incentive for car owners driving and using their vehicles equipped with a hydrogen powered fuel cells systems is twofold. They can either save (at their home) or earn (at the neighbour, drugstore, post office, airport) money while their cars are parked and plugged into buildings via a smart docking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

Revolution in the Garage

Looking at today’s so-called “western” countries, if all worldwide registered cars (800 Mio in 2006) would be equipped with a fuel cell system, they could (all together) easily take over the function of all 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. Just calculate with a medium moderate 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 an unknown location…

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 a direct-solar production of hydrogen from renewable energies. The individually produced hydrogen (pH = personal Hydrogen) will be stored in a tank inside the garage and a high density, high efficient tank in the car, made from nanostructures. The fuel cells in the cars produce DC, which will be used directly with nearly all today's 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 be used in heat exchangers based on nanotechnology to warm homes in winter. In summer, the heat will be converted by means of nanotechnology heat exchangers for cooling. This system will eventually replace all residential boilers and air-conditioning units. This idea is not new and it has many „fathers", Amory B. Lovins to mention just one, and is also just an example of where the hydrogen and fuel cell economy and even better: The Hydrogen and Fuel Cells Society could go to apply these technologies in combination with already existing systems. By implementing these technologies, the user of the energy will also be the energy producer. Surplus electricity can be transformed to AC (if needed - there will be a complete new DC grid worldwide, because DC is what is needed by the consumers) This electricity can be sold by the car owners to the grid and/or to neighbour properties like homes, offices, apartment houses, conference venues and/or hospitals.

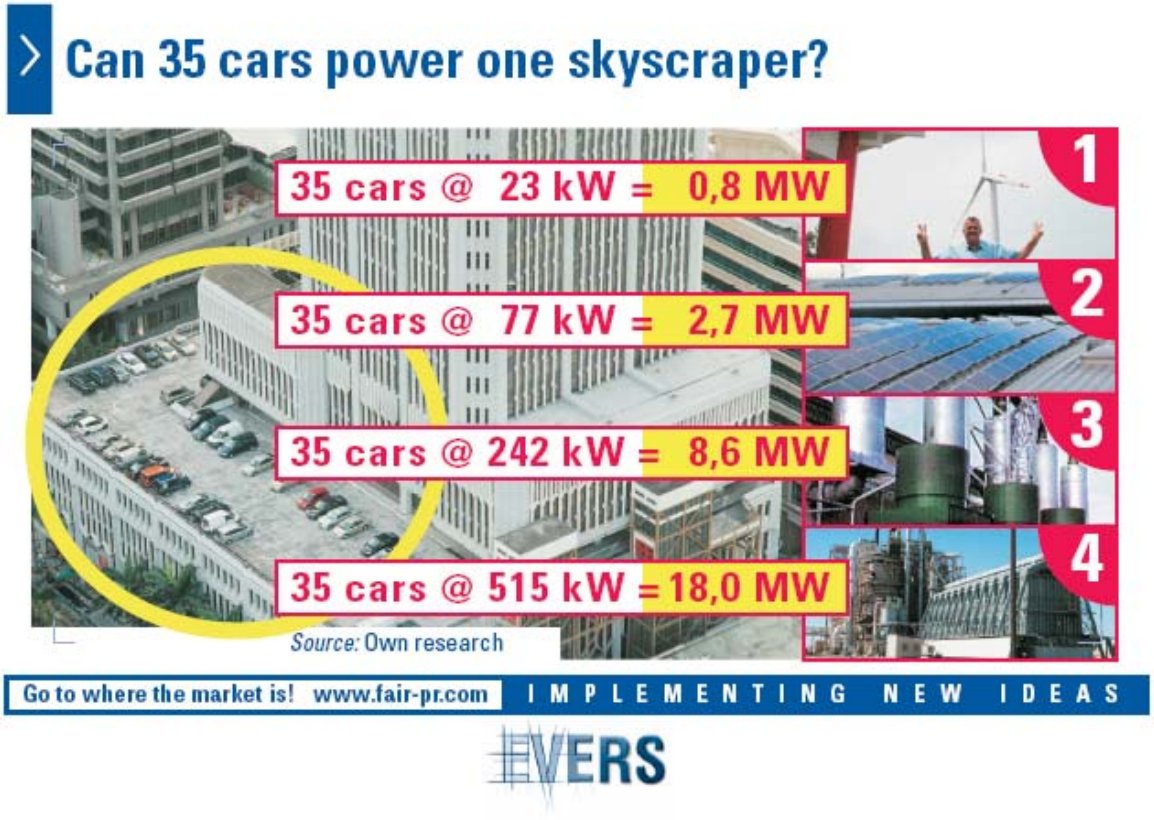


Can 35 cars power one skyscraper?

This building shows a skyscraper in Singapore. On the photo next to the building are 35 cars, a very typical situation world wide. Today, these cars have nothing to do with the energy supply, as they are only used for transportation and as an energy consumer. However, if you imagine, at one future day, all these cars have instead of an combustion engine (IPC) a fuel cell system installed, these cars might than as well being used to power the buildings where they are parked, with both electricity and surplus heat for cooling (in summer) and heating (in winter).
Under the assumption, that the cars have an installed power of 23 kW each, which is not much for a car, but a lot for electricity all cars plugged together via a smart docking station which is connected to the building, would create as much electricity as one wind power station in Hong Kong (0.8 MW). Further three examples are explained in the presentation. 35 cars with an installed power of 515 kW (which do not really exist yet, but can soon be on the market when you interpolate the increase of power in new cars in Germany, as seen before) can create as much electricity as is needed to power 90 single family homes in the US. This equals one 18 MW Waste Energy Power Plant with steam turbines.

The question of storage can also be solved, here again with nanotechnology and nanostructures. Only to give one example: A normal 35 mm colour film can store max. 36 photos chemically, the velocity and speed of the film is fixed at manufacturing. With a storage card of today,

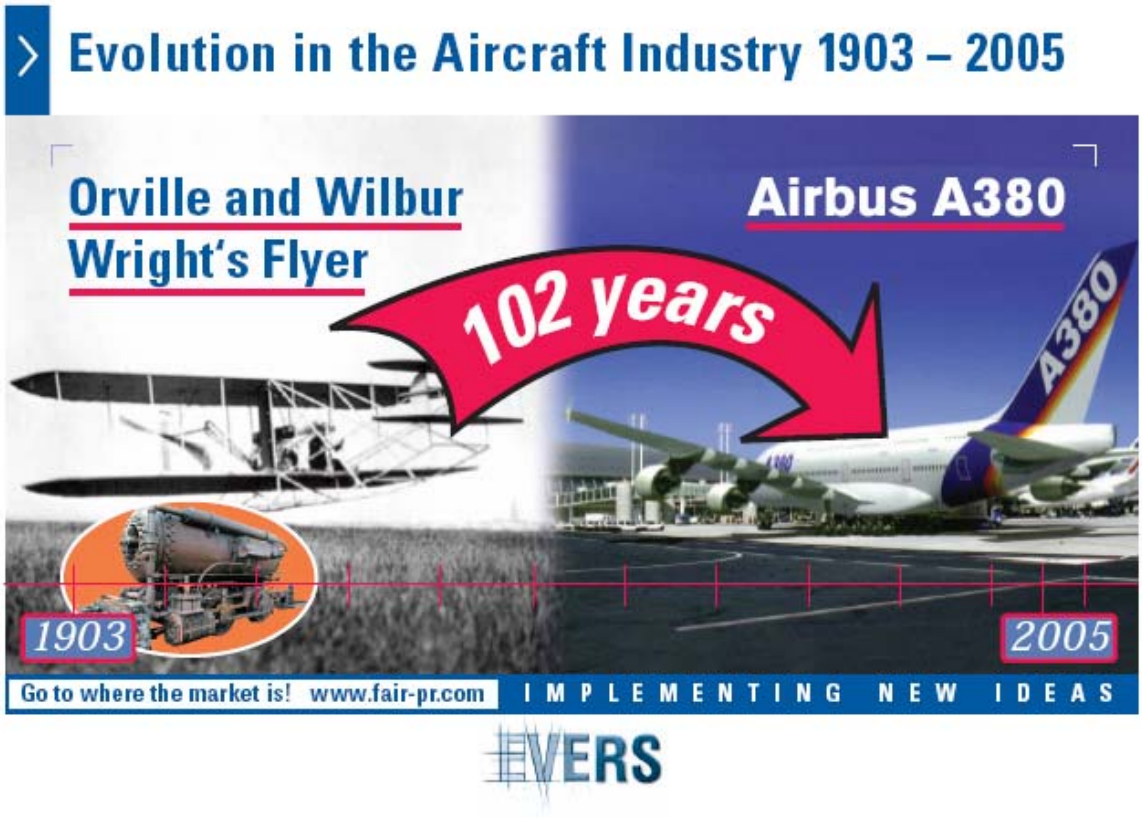
let us say for 1 GB you can store more than 1.000 photos electronically at very low cost (around 25 US Dollars) and the velocity and speed can be adjusted for each picture individually. In a similar way the storage question for hydrogen will be solved. It will need a lot of work to achieve this goal, but I am sure this can de done.



35 locomotives could not fly, or:
Evolution in the Aircraft Industry 1903-2005

There are many positive examples about achievements in technologies, which changed our lives in creating new industries. One example is the aircraft industry, where I am coming from. In 1903, 35 locomotives with a weight of 16 tonnes each could in fact not fly. However when you compare the Wright's Flyer with today's Airbus A380 over the past 102 years, big changes took place, both in services, daily usage, technology and infrastructure.
When Orville and Wilbur Wright left their plane after the first powered flight (lasting 57 seconds) in Kitty Hawk, North Carolina, on December 17th, 1903, they, and nobody else, could imagine at that time, that only 100 years later there would be commercial aircrafts carrying more than 800 passengers over a range of more than 8,000 miles at an altitude of 33.000 ft. These technologies have created today's worldwide biggest industry: Tourism with more than 8 Mio. commercial aircraft passengers each day. Starting from zero in 1903 we now have also 4,000 active

commercial airports worldwide. Today's status of the hydrogen and fuel cell emerging industry compares with that at the time of the Wright Brothers in 1903. There are more dramatic developments coming in the future of hydrogen and fuel cells than anyone can imagine today, hopefully, in less than 100 years.



Conclusion

Due to the worldwide high future demand of clean fuel for mobile, stationary and transport applications, the need for hydrogen will increase immensely. Technically, hydrogen can be produced from all primary energies available in many different ways. Some of them are efficient, some are not. It all depends on the primary energy you are going to use. For example, you can produce hydrogen 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_2 emission-free energy carrier without polluted nuclear waste, hydrogen has to be produced directly, decentralized from renewable energies.

Hydrogen production is possible from all renewable energies including wind, photovoltaic and biomass. However, to achieve a direct production of hydrogen without the use of electricity, much research and development work is required and needed. Only with these conditions,

the implementation of the hydrogen and fuel cells society can become reality. Nanotechnology has to play a very important role in this scenario.

In addition, the public demand will also play the most important role: once a suitable new service, powered by hydrogen, but unknown today, unknown today, will be on the market, it will create additional demand; the right decrease in prices will be followed by the increase of mass production etc. However, all these new products or: new services will be luxury goods in the beginning.

My six “hypothesis”:

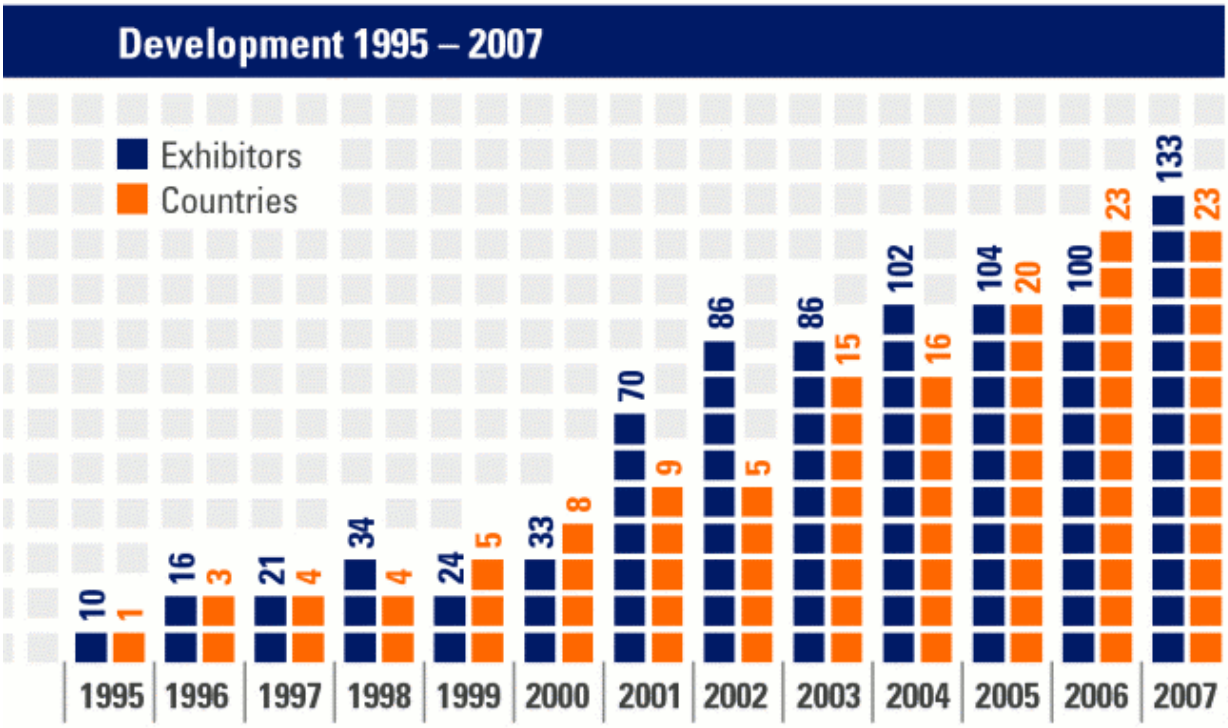
The hydrogen economy or better: the hydrogen society will come soon.

> It will be personalised…
> It will be decentralised…
> It will come on a worldwide scale…
> It will be scaleable from mW to MW…
> It will be a “holistic”, scaleable solution…
> It will create new markets, which are not known today…

The key are not only the cars, however, due to their worldwide availability, they can be a strong driver towards the above described scenario. The key for the future of hydrogen and fuel cells is also the implementation of knowledge and new ideas from the experts of nanotechnologies into new products and new services which we even do not know today!

Thank you very much for your support and taking up the lead!

Development of the Group Exhibit Hydrogen + Fuel Cells at the annual HANNOVER FAIR 1995 – 2007



Pleased to meet you at the next HANNOVER FAIR, April 21-25, 2008

You are most welcome!