Nanotechnologies:
The needed accelerator for Hydrogen and Fuel Cells

or:
Why Hydrogen and Fuel Cells need now to be accelerated by Nanotechnologies

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This keynote 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 with the aid of Nanotechnologies (nanoaided hydrogen and fuel cells).

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. The implementation of Nanotechnologies in the decentralized production of hydrogen and in the implementation of fuel cells will further accelerate this development.

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.

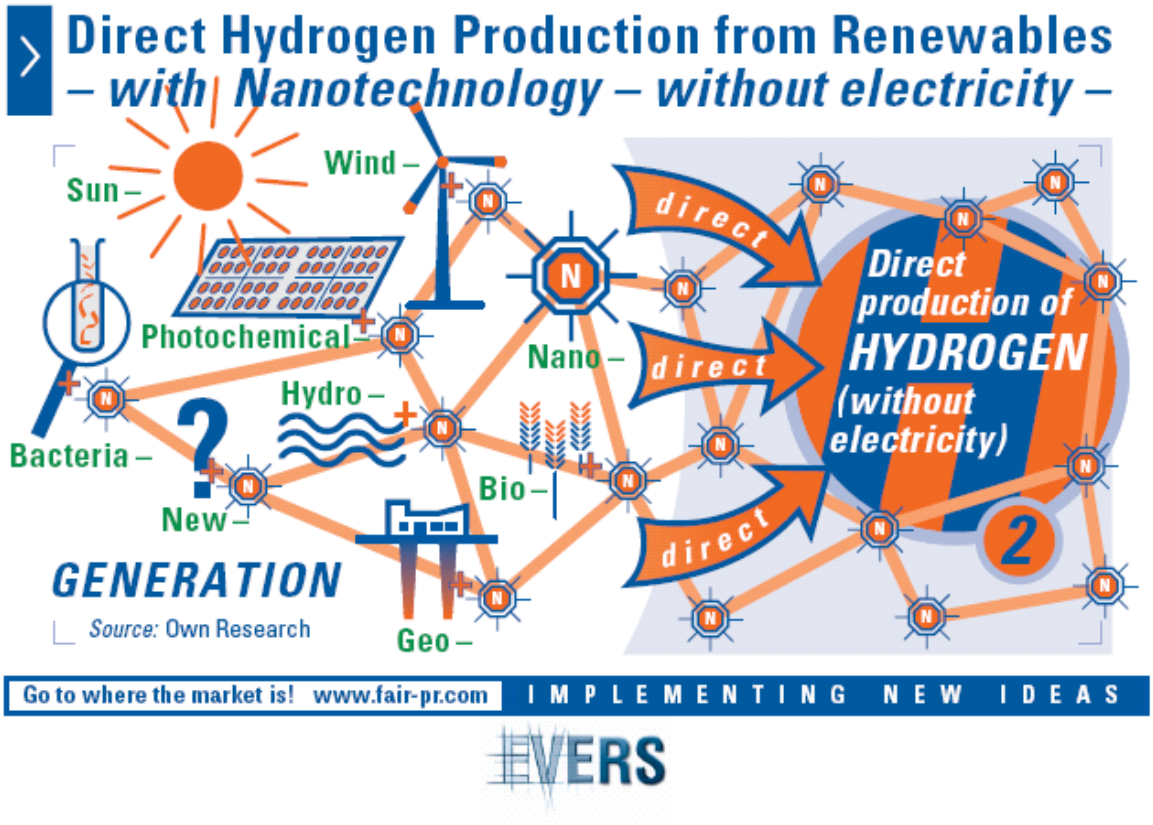
H2/FC Generation and Applications Process

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 or even the hydrogen society possibly come from? This can only be solved in introducing the direct production of hydrogen from renewable energies – without generating electricity fist and then using it in an electrolyser to produce the hydrogen with all included transfer losses in the electrolysis process. The same applies to steam reforming of natural gas or coal. Here the reformers are the weakest link.

Some activities in these directions can be 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 or coal 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, again: without producing electricity first. This could be done for example directly at the axle of a windmill, using the enormous torque and combining 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. In many domes of “modern” windmills today you will find air conditioning units to cool them inside, only a symbol for bad efficiency. Another possibility is the use of solar energy to produce hydrogen directly - without the use of electricity. This is already be done by a commercial company in Germany, based on electrochemical photolysis.

Direct production of solar hydrogen is also tested in southern Spain since the seventies, at an EU funded big-scale test facility; however, this idea has to be downscaled with the aids of nanotechnologies and nanostructures in order to be implemented into the daily life.

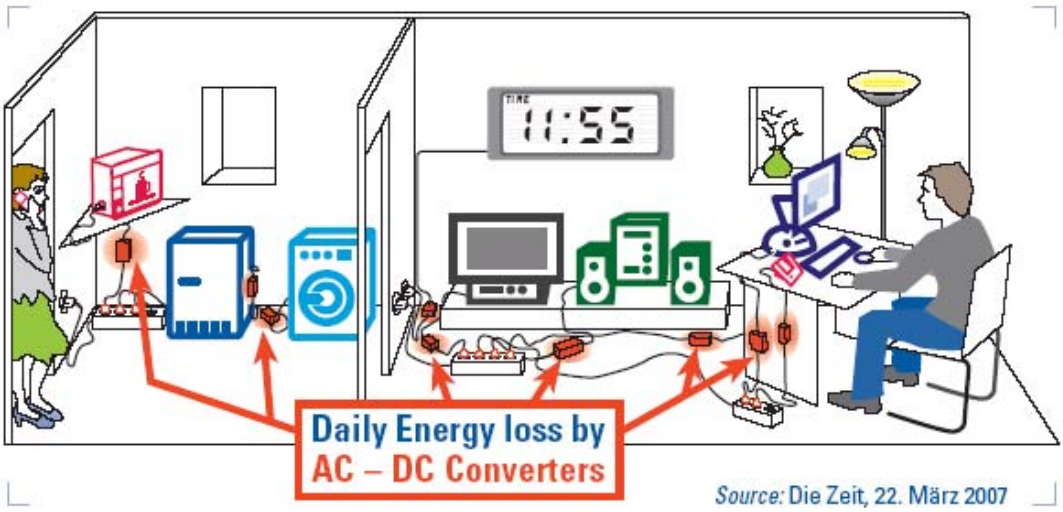
Time, the human genius and his or even better: her abilities to imagination, implementation and realisation will (hopefully) tell.
I sincerely do hope that we still have the time to tackle this world wide challenge. Is not too late already?



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 (they appear to be: "...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 a little stupid, they 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 or office. 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 used to recharge these new cellular phones, bought in 2007. It would be much more sensitive for all of us, 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.

Daily Energy loss by AC – DC Converters



Source: Die Zeit, 22. März 2007

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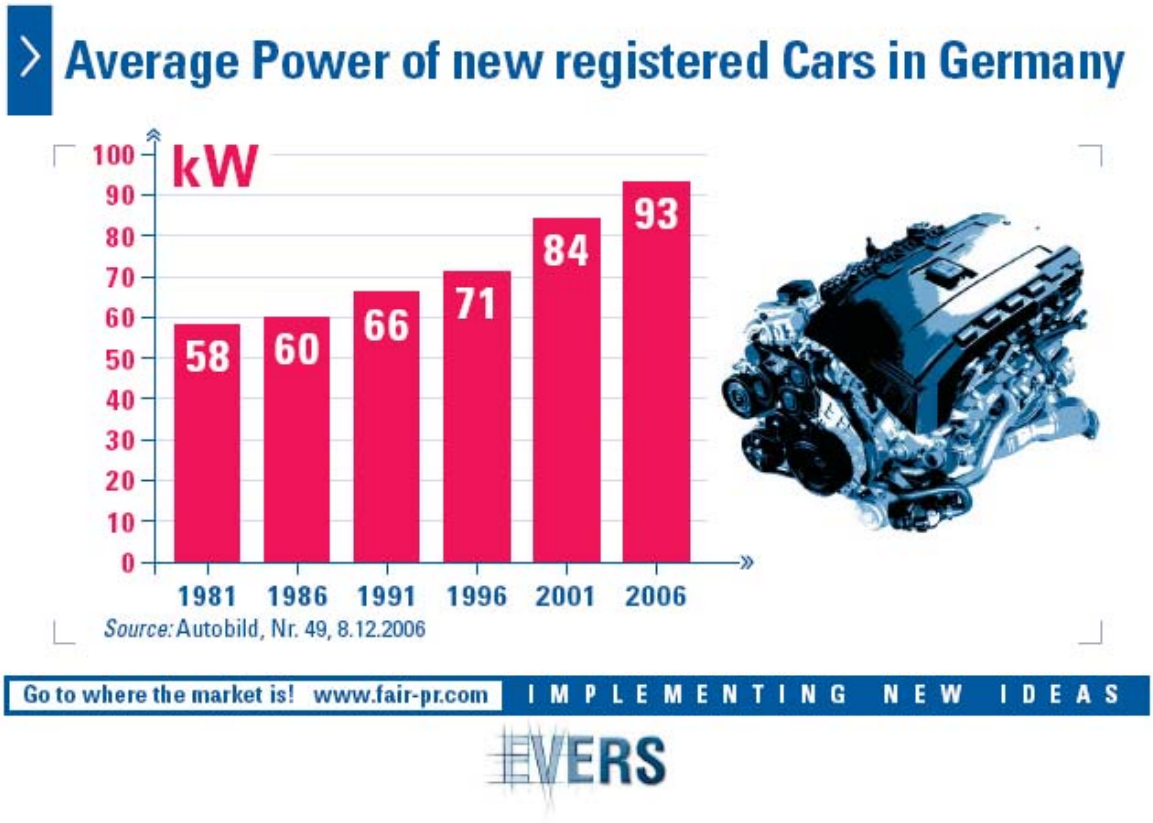
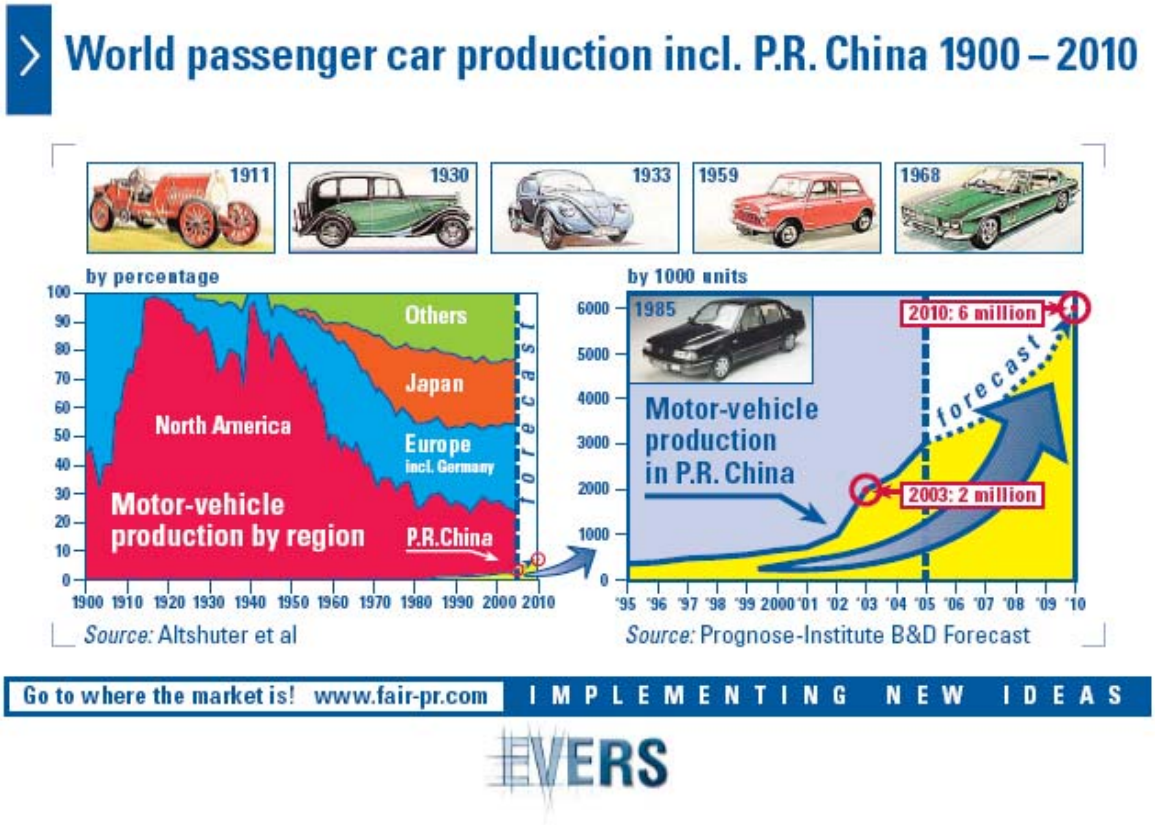
Average power of new registered cars in Germany 1981-2006

The figures shown (from 58 kW in 1981 to 93 kW in 2006) are highlighting the increase in installed engine-power of new registered cars in Germany. There is a trend towards: faster, higher, heavier, which also means: More empty-weight, more fuel 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? Maybe we should think a little more about our responsibility in using “our” or better: The next generation’s resources. Another question is: Can these figures be a positive example for young potential car buyers in emerging countries like India and China?



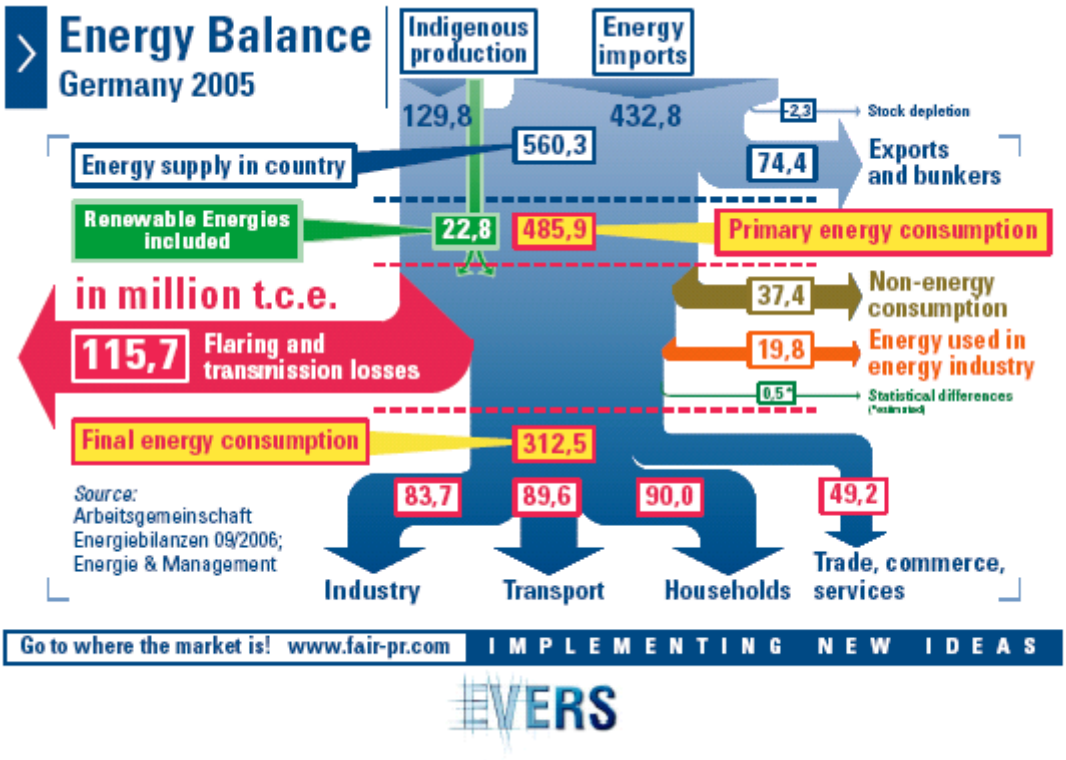
Worldwide car production in 1900-2050

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 is going to further accelerate, driven by the high demand of new consumers in China and India, who are now entering the marketplace based on their own initiative and not based on governmental funding.



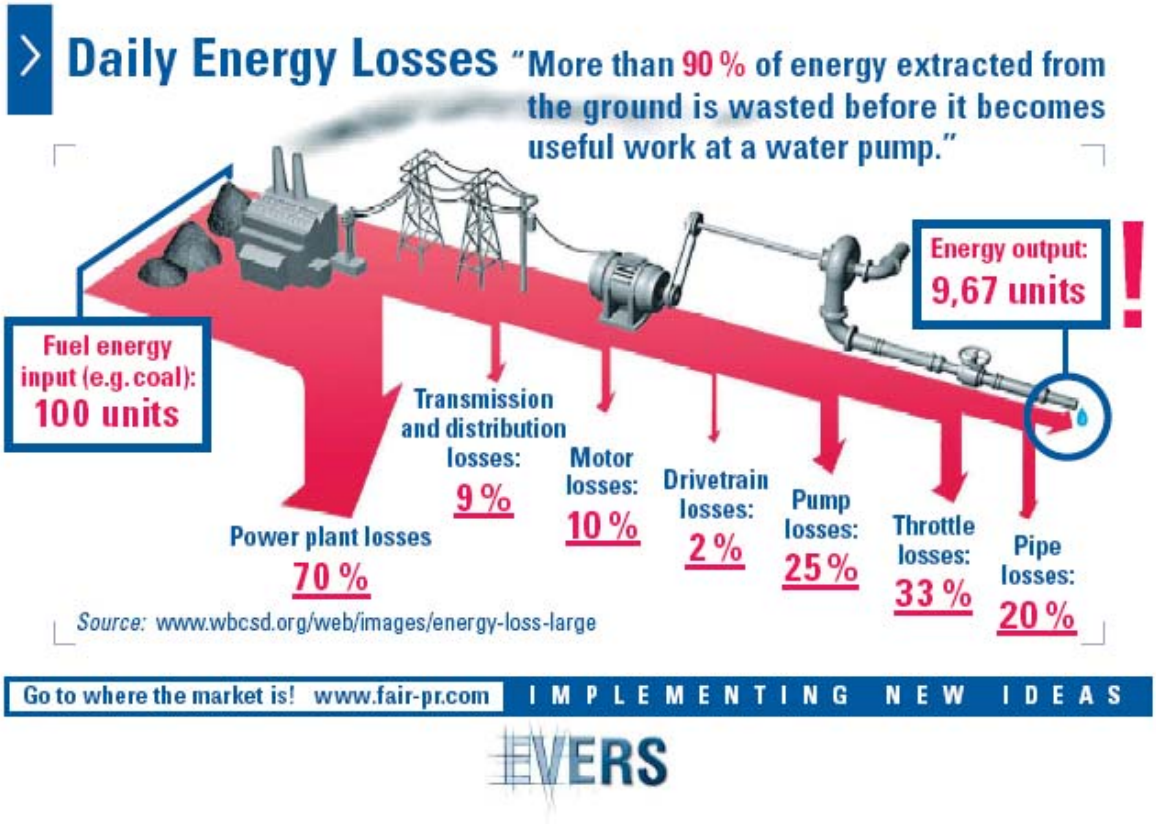
Energy uses and losses in Germany 2005

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 being used for industry alone be eliminated to ZERO, this still would be less than the flaring and transmission losses (83.7 compared to 115.7 t.c.e - Tonnes Coal Equivalents). 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.
Image how the Energy Balance are looking like in other countries, who are not so technology "advanced" as Germany seems to be...(Just think of the energy production, distribution and usage in China or India but also in the US...)



Daily Energy losses

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 survey, 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 water 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. These 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, geothermal and/or biomass energy) produce hydrogen. In order not to loose too much time, this system can start now, using natural gas, which is available today at many homes in question world wide…
Step 2:
– The cars drive on hydrogen using fuel cells and electrical motorsin the powertrain. These first two steps are readily available and used in prototypes by nearly all car manufactures world wide. However, at this time, there is no public demand to use these options. To get the repeatedly promised hydrogen economy on its wheels, two further additional 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 in the sun 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 or credit) at "check out", when the car owner is leaving the parking position.

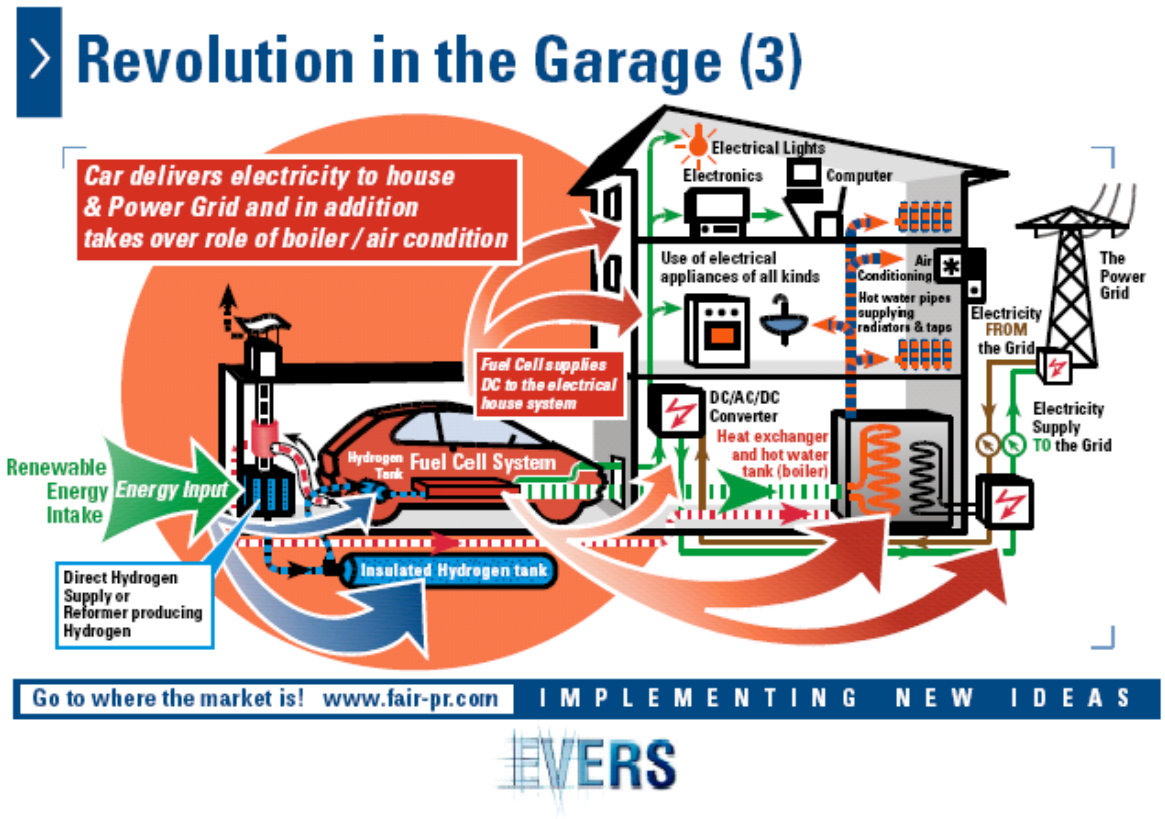
This incentive for car owners driving and using their vehicles equipped with a hydrogen powered fuel cells systems is twofold. They can either save (at their home) or earn (at the neighbour, drugstore, post office, airport) money while their cars are parked and plugged into buildings via a smart docking 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 or renewed one day anyway). This is based on 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 for transportation 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 houses in the relevant "Western countries". Eventually, the primary energy 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 (by technology) 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 air conditioning and 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 world wide, because DC is what is needed todatoda by the consumers) This electricity can also be sold by the car owners to the grid and/or to neighbour properties like homes, offices, apartment houses, conference venues and/or hospitals.

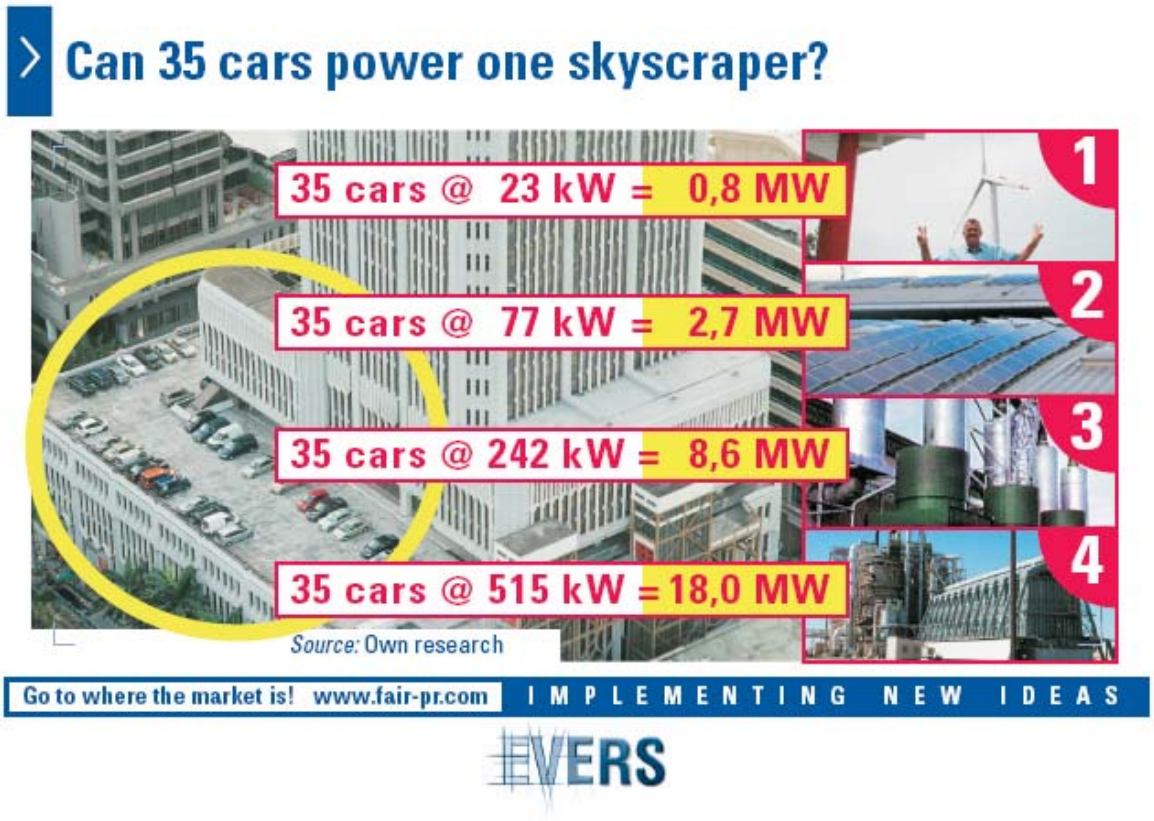


Can 35 cars power one skyscraper?

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 (with very bad efficiency at the moment). When you imagine, at one future day, all these cars have instead of an combustion engine (IPC) a fuel cell system in their power train 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 (maybe equivalent to a little Fiat 500 from the fifties…), but a lot for electricity, all cars plugged together via smart docking stations which are connected to the building, would create as much electricity as one wind power station in Hong Kong (0.8 MW). Further 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. Such units are avialable now for sale, free on board East Asia…

The question of storage can also be solved, here again with the implementation of nanotechnology and nanostructures. Only to give one

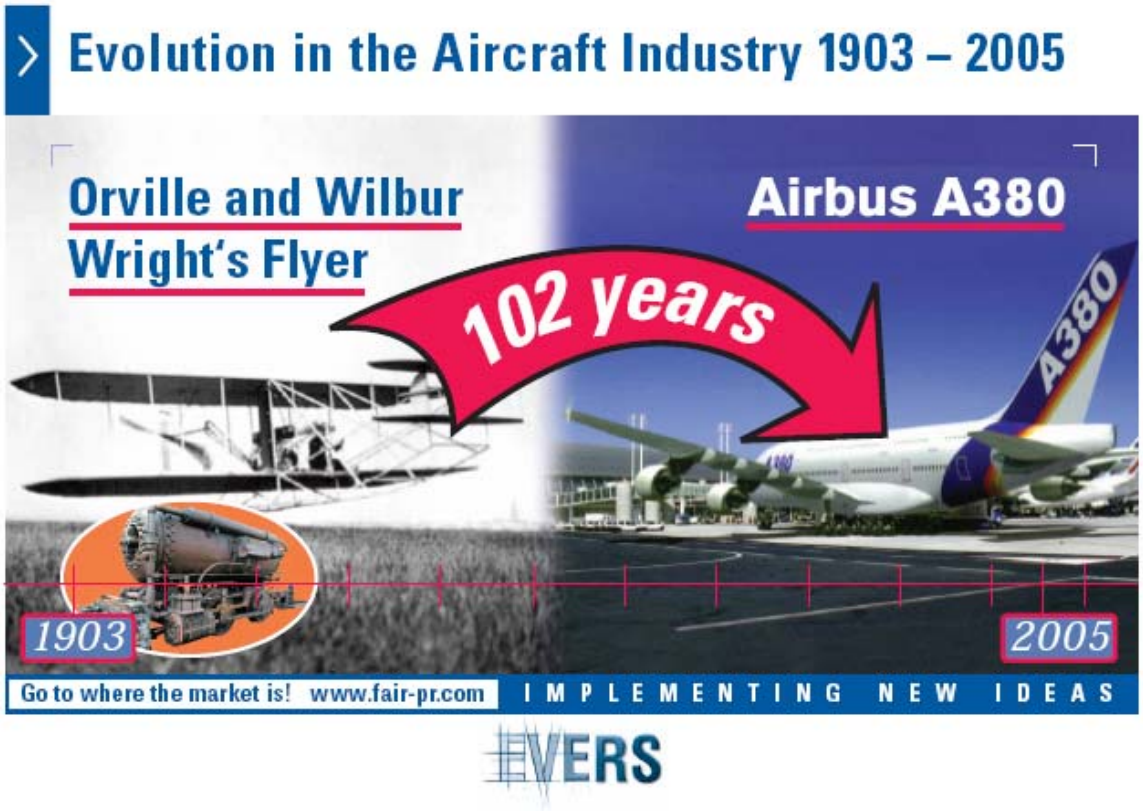
example: A normal conventional 35 mm colour film can store max. 36 photos chemically, the velocity and speed of the film is fixed at manufacturing. With a storage card of today, let us say for 1 GB you can store and erase more than 1,000 photos electronically at very low cost (around 25 US Dollars) and the velocity and speed can be adjusted for each of these 1,000 pictures individually inside the camera. In a similar way the storage question for hydrogen will be solved soon. It will take a lot of research work to achieve this goal, but I am sure this can de done, specially when the world wide demand for new services is growing over expotentially.



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

There are many positive examples about achievements in technologies, which rapidely changed our lives and creating new billion dollars industries. One example is the aircraft industry, where I am coming from. I was personally engaged in the implementation of the European Airbus Program into the world market from 1969 through 2001. The first flight of an Airbis A 300 B was in 1972, first commercial flight with Air France was in 1974, first delivery of an Airbus to Lufthansa in 1976 in Hamburg. (I happen to be the organiser of this event, which was not too far ago…)
The example: 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 world wide. 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 world wide 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 and the "mode of hydrogen production"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 fuel of choice, but only, when it will be produced directly and

decentralized from any renewable energies. This would eliminate huge flaring and transmission loses, which are existing in today`s energy balance.
Hydrogen production is possible from all renewable energies including wind, photovoltaic and biomass or algae. However, to implement the direct production of hydrogen without creating electricity first, much dedication in 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. With my personal observation, based on 14 years of experience with the implementation of hydrogen and fuel cells, too little emphasasis is taken into this “holistic” scenario. Specially ALL world wide governmental funded programmes to “support” the commercialisation of hydrogen and fuel cells are looking much too small, they do not see (and consider) the whole chain of energy balance an they do not consider the possibilities with yhrogen and fuel cells
In addition, the public demand will in future play the most important role: once a suitable new service, powered by hydrogen and using fuel cells, but unknown today, will be on the market, it will create additional demand; the decrease in production cost 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.

Here are 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”, sustainable solution…
> It will create new world wide 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!

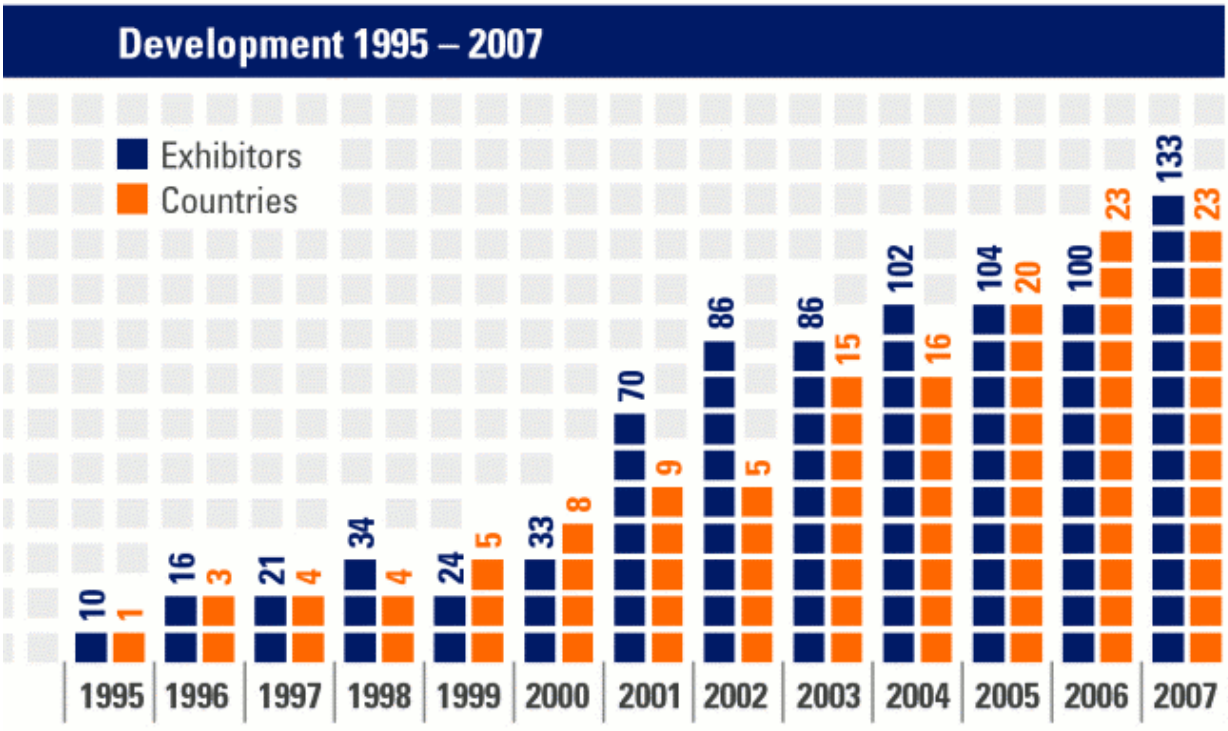
Thank you very much for your support and taking up the lead!

Please do not wait to start now, as maybe we do not have the time to “play” around further.

Go to where the market is!

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 all most welcome!