Our Car as Power Plant

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The Vision

Fuel cell cars: efficient and clean transportation AND clean and efficient production of electricity, heat and water.

Fuel cell cars can provide more efficient and cleaner transportation. But, we use our cars for transportation only 5% of the time. So when parked, the fuel cell in the car can produce electricity from hydrogen. Cleaner and more efficiently than the current electricity system – with useful ‘waste’ products heat and fresh water. The produced electricity, heat and fresh water can be fed into the respective grids or be used directly in our house or offices. The required hydrogen can be produced from gas (natural gas, biogas) or electricity (hydro, wind, solar, etc.). In the end these fuel cell cars can replace all power plants worldwide. As a result, the ‘car as power plant’ can create an integrated, efficient, reliable, flexible, clean, smart and personalized transport-, energy- and water system.

The change towards a sustainable transport and energy system is ongoing and inevitable. Our cars become more efficient, clean and safe. A major trend is electric driving. Electric cars with battery packs to store electricity for driving. Such an electric car has two main limitations. Driving distance is limited, between 100 and 300 km. And the charging time of batteries is too long. About 8 hours for normal charging and above 10 minutes for fast charging, which is longer than the 1 to 2 minutes to fuel your tank now. Of course for many of our transport needs this is not a problem, but to drive to your work, going on holidays and visiting clients or friends, it is not that comfortable.

For that reason hybrid cars are entering the market. Electric driving, batteries and an electricity-producing engine using gasoline, diesel or ethanol. But the energy efficiency of the present car engines is not very good, about 25 to 40%. Therefore many car manufacturers are developing the fuel cell car. A PEM fuel cell (Polymer Electrolyte Membrane or Proton Exchange Membrane) that can produce electricity using hydrogen. The efficiency to produce electricity with a PEM fuel cell from hydrogen is about 60%. Of course we have to produce hydrogen, for example by reforming gas into hydrogen. We can produce hydrogen from gas with an efficiency of 70-80%. So, with a fuel cell we can produce electricity from gas with an efficiency of about 45%. This is a higher efficiency than the system efficiency of our electricity production, which is below 40%.

We use our cars only for a very limited time. If we drive 20,000 km per year with an average speed of 50 km per hour, the time we use our cars is 400 hours – less than 5% of the time.

Our car, a major asset for us all, that we use less than 5% of the time? So what else can we do with our car; when it is parked? Once we build fuel cells into cars it is possible to produce electricity, with a high efficiency. The fuel cell in our car has a capacity of 100 kW, which is more than sufficient to produce all the electricity for about 100 European houses. So our future fuel cell cars can produce all the electricity that we need – with a better energy efficiency than the present power plants. The idea that the fuel cell car is not only used for transportation but also for production of electricity, heat and water, is a paradigm-changing concept. It will certainly change our energy-, water- and transport system dramatically.

Reasons to believe	
Efficiency	Fuel cell in the car has an efficiency of 60% to convert hydrogen in electricity Hydrogen production from gas or electricity has an efficiency of about 70-80%
Better	Car engines at present have an efficiency of 25-40% Electricity production system efficiency is below 40%
Time	Cars are in use for transportation less than 5% of the time Over 90% of time cars are parked at home, at work, in a car park, on the street
Available	Electricity production power plants are used between 5% and 90% of the time
Capacity	Worldwide 1 billion cars on the road, with an average engine capacity of 50 kW this represents a power capacity of 50.000 GW
Abundant	80 million cars are sold in 2011, with an average engine capacity of 100 kW this represents a power capacity of **8.000** GW Worldwide the electricity production capacity of all power plants is about **5.000** GW

100 years of car development

Our modern cars have developed considerably over the past 100 years. The first production of automobiles was by Karl Benz in 1888 in Germany. In the United States, brothers Charles and Frank Duryea founded in 1893 the first American automobile manufacturing company. Mass production started really at the beginning of the twentieth century when the Olds Motor Vehicle Company (known as Oldsmobile) started production in 1902. Many others followed, also Henry Ford who founded his company in 1903, producing cars in the thousands per year. Steam, electricity and petrol/gasoline-powered cars competed for decades, but in the 1910s the internal combustion engines on petrol/gasoline achieved dominance. Henry Ford became the icon of the automobile industry with his mission, building cars for everyone. The Ford T had a four-cylinder engine, used a planetary transmission, and had a pedal-based control system. The T-Ford weighted about 550 kg. The engine was capable of running on gasoline, kerosene, or ethanol. The Model T was capable to produce 20 horse powers (15 kW), for a top speed of 64–72 km/h. According to Ford Motor Company, the Model T had fuel economy on the order 11–18 liter/100 km.

Nowadays our cars do not look like the old T Ford and of course we have made a lot of technological progress. But the technology basically is the same. In our present cars we still use a combustion engine, a planetary transmission and pedals to control the gas and brake system. And the combustion engine is still capable to run on gasoline and/or ethanol. If we look to the specifications of a modern small family car we see the following. The combustion engine has a capacity of about 100 kW, a top speed of 200 km/h, weight about 1,500 kg and a fuel economy on the order of 6-7 liter/100 km. And on top of this, comfort and especially safety levels have improved dramatically. So of course impressive technological developments in a 100 year time frame. But if you compare on fuel economy we do a factor 2 better in 100 years' time! Is that impressive?

Fuel Cell Car for transport

The new technology is electric driving. The fuel cell car is an electric car with on board a fuel cell that produces electricity from hydrogen. That hydrogen is stored on board in a high pressure tank. Of course we need to fuel our tank with hydrogen at a fuelling station. At the fuelling station the hydrogen will be produced from natural gas, biogas or electricity. So a large scale hydrogen infrastructure is not needed, we simply use the gas infrastructure and the electricity infrastructure to transport energy

At first we will use natural gas for the production of hydrogen. That technology, steam reforming, is well known and nowadays widely used. Of course we have to improve this technology, especially the conversion efficiency and purity of the hydrogen produced. We expect that in the near future an efficiency of 80% is possible. We need to produce hydrogen from gas, store this hydrogen, compress it to put it in the tank of the car and de-compress it in the car to feed it into the fuel cell. Of course this leads to losses, overall we assume an efficiency of about 60%. Then we have the fuel cell itself that converts hydrogen into electricity with an efficiency of about 60% also.

Overall the energy efficiency comparison based on the same system components is about 25% for a modern gasoline car and about 33% for our fuel cell car. It means an overall energy efficiency improvement of 30% in our transport system. This would imply also that the carbon dioxide emissions will be at least 30% lower. Besides a fuel cell car has no local pollution and is very quiet.

energy efficiency gasoline car compared to fuel cell car

Gasoline car		Fuel cell car	
Extraction oil + transport	95%	Extraction gas + transport	95%
Crude oil to gasoline	90%	Gas to hydrogen (H_2)	80%
		H_2 storage + compression	85%
In the Gasoline car		*In the Fuel cell car*	
		H_2 de-compression	90%
		Fuel cell	60%
Combustion engine	35%	Electric motor	95%
Standby/Idle	85%		
Other system component efficiencies the same			

Overall Efficiency	**25%**	Overall Efficiency	**33%**

In future we can produce hydrogen from renewable electricity by electrolysis. When there is an excess of electricity produced by wind, solar, hydro, geothermal, waste or biomass we easily can convert this into hydrogen, store it in our tank of the fuel cell car. Then we effectively do not have any carbon dioxide emissions.

Fuel cell cars for energy and water production

We can use our fuel cell car as a power plant of course when it is not used for driving, but when it is parked somewhere. At this parking place we need at least to be able to connect the car to the electricity grid. And if we want to use also the heat and the fresh water that is produced as a waste product, we need to extract the heat and water from the fuel cell and bring this to a heat network and a (drinking) water grid. A logical place to do this, is a place where many cars are parked, a car park!.

An averaged sized car park with 500 cars each with a fuel cell capacity of 100 kW is a power plant of 50 MW. When we operate such a power plant with a load factor of 4,000 hours such a car park power plant generates 200,000,000 kWh which is 200 GWh. Let us assume that a household consumes 4,000 kWh a car park with 500 cars is able to generate all the electricity for 50,000 houses. Or in other words every fuel cell car with a 100 kW fuel cell can easily produce the electricity for 100 houses. Such a power plant is a very flexible power plant, almost instantaneously the power output of this car park power plant can be shut down or brought to full capacity. It is able to operate as a base load, intermediate load or peak load power plant. It can operate as spinning reserve, follow fast fluctuations in demand or as backup power.

We now compare the system efficiencies for both the fossil fired electricity production system, with coal and gas as fuel and the car park power plant system with gas as fuel. Based on the same system boundaries we see for the fossil fuel power plant system an efficiency of 38% and for the car park power plant system an efficiency of 45%. This means an overall energy efficiency improvement of 18% in our electricity system. This would imply also that the carbon dioxide emissions will be at least 18% lower. Besides a fuel cell car park power plant has no other local emissions to the air and is very quiet.

energy efficiency electricity production by power plants compared to fuel cell cars

Fossil fuel power plant system		**Car park power plant system**	
Extraction coal/gas + transport	95%	Extraction gas + transport	95%
		Gas to hydrogen (H_2)	80%
Power plant system	*40%*	*Fuel cell car park system*	60%
Other system component efficiencies the same			
Overall Efficiency	**38%**	Overall Efficiency	**45%**

Cars can take over power plant capacity

The statistics show that we have over 1 billion vehicles on the road worldwide. With an average engine capacity of 50 kW this represents a total power capacity on wheels of 50,000 GW. The total installed electricity production capacity in the world is only 5,000 GW. So at present we already have 10 times as much power capacity on the road than totally installed in our electricity production system.

The next thing is that we buy every year 80 million new vehicles on the road, with an engine capacity of at least 100 kW. This represents a total power capacity that we buy every year on wheels of 8,000 GW. So every year we buy more than 1.5 times power capacity on wheels then totally installed in our electricity production system.

If fuel cell cars will come to the market, it certainly will have the potential to take over all the production capacity in large power plants. In the end there will be abundant, very efficient, clean and flexible power production capacity available. Which of course raises the question: Will we still need power plants in the future?

Power plants and car power capacity

Power plant capacity		Car power capacity	
Installed capacity Worldwide (2010)	**5,000 GW**	Number of vehicles Worldwide (2012)	1 billion
		Average engine capacity	50 kW
		Total car power capacity	**50,000 GW**
		New vehicles on the road (2012)	80 million
		Average engine capacity	100 kW
		New 2012 car power capacity	**8,000 GW**

It is our car!

Fuel cell car will come, but do we want to use our car to produce electricity, heat and water. Why not, it does not depend on what companies, governments or organizations want us to buy, do or believe. No the car is ours or at least we can decide what to do with it. The fuel cell car will not only give us the freedom to go where we want to go, but it will give us also the freedom of energy and water. We can produce energy and water what and where we need it. We can even produce electricity with our fuel cell cars for others. Therefore, when we park our fuel cell cars we do not have to pay for parking but we get paid for parking. Is that not a nice future?

Essay based on the book

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