Why Solar Powered Mobility?

Roland Reichel, Bundesverband Solarmobil e.V. (German Solar Car Federation)

Abstract

The emission due to traffic causes considerable problems mainly in urban areas. Here "zero emission vehicles" could be a solution by avoiding any direct pollution. The German Solar Car Federation demands "Real Zero Emission Vehicles" and defines this as vehicles with a clean energy supply from solar, wind, water or similar sustainable and clean power sources. The solar power supply is feasible for so-called "LEMs" (light electric mobil) with low power requirements. LEMs require typically less than 10 kWh per 100 km. Some models are available in the market, and the energy can be supplied by the so-called "solar-net". The solar-net consists of solar power stations feeding the energy into the grid and charging stations for recharging the vehicles batteries. This idea or model is the basis for the "***Park & Charge***®" system of public charging stations for electric vehicles, which at present exists in Switzerland, Germany, Austria, France and Italy.

Keywords: Charging, emissions, energy-source, photovoltaic, primary-energy, solar-energy

1 Emission due to traffic

The emission due to traffic causes considerable problems and amounts to approx. 20 % of the C02 green-house gas in Germany. In cities with high density of traffic the pollution from vehicles is not tolerable any more and the so called „summer smog“ has become a health problem for the population. A dramatic change is needed on two levels:

- locally to avoid direct pollution in urban areas
- globally for the reduction of the CO_2 and other global pollution.

2 Zero Emission Vehicles

The car-manufacturers should build and offer a growing number of „Zero emission vehicles“. *Zero emission vehicles* are cars without exhaust gas. At present only electrical cars meet this demand. Under the Californian “clean air act”, a growing number of cars produced by large car manufacturers must be „*Zero emission vehicles*“. Furthermore Public or State enterprises are forced to buy a certain amount of *low emission vehicles* when ordering new cars.

3 Real Zero Emission Vehicles

The German Solar Car Federation (Bundesverband Solarmobil e.V.) demands a similar law for Germany and Europe. Furthermore the „*zero emission vehicle*“ is not enough since nothing is stated about the primary source of energy for the generation of electricity. Since an **electric car is only as clean as the energy which it uses**, the expression „zero emission“ should be expanded to "Real Zero Emission" and should include the definition of clean and sustainable sources of energy.

The German Solar Car Federation demands clean sources of energy for the charging of electrical cars. Clean sources of energy for electric cars could be photovoltaic plants, wind or water power plants or similar sources of so-called “green energy”.

4 Solar Grid System and Solar Vehicles

At the first Swiss Tour de Sol in 1985, solar cars had to use power from the solar modules on the car only. But as early as 1986 or 87, the definition of a solar car changed: The solar generator could be installed on the house or garage and was feeding the energy into the grid. For the Tour de Sol, the solar radiation was measured and the solar car was allowed to use the equivalent amount of energy which its related solar generator at home was feeding into the grid at that time.

The definition of the solar vehicle at present is a vehicle, which has at home or elsewhere a solar power source (or similar sustainable source from wind or water power etc.) which delivers the required amount of energy to recharge the batteries. The energy is fed into the grid system and can be taken out elsewhere from the system. This is very similar to the money and bank system: The money is paid in (..fed in) somewhere, and it can be drawn out at any other place and any other time. The relation between the money and the owner is mainly on paper: the account shows in writing, how much one owns.

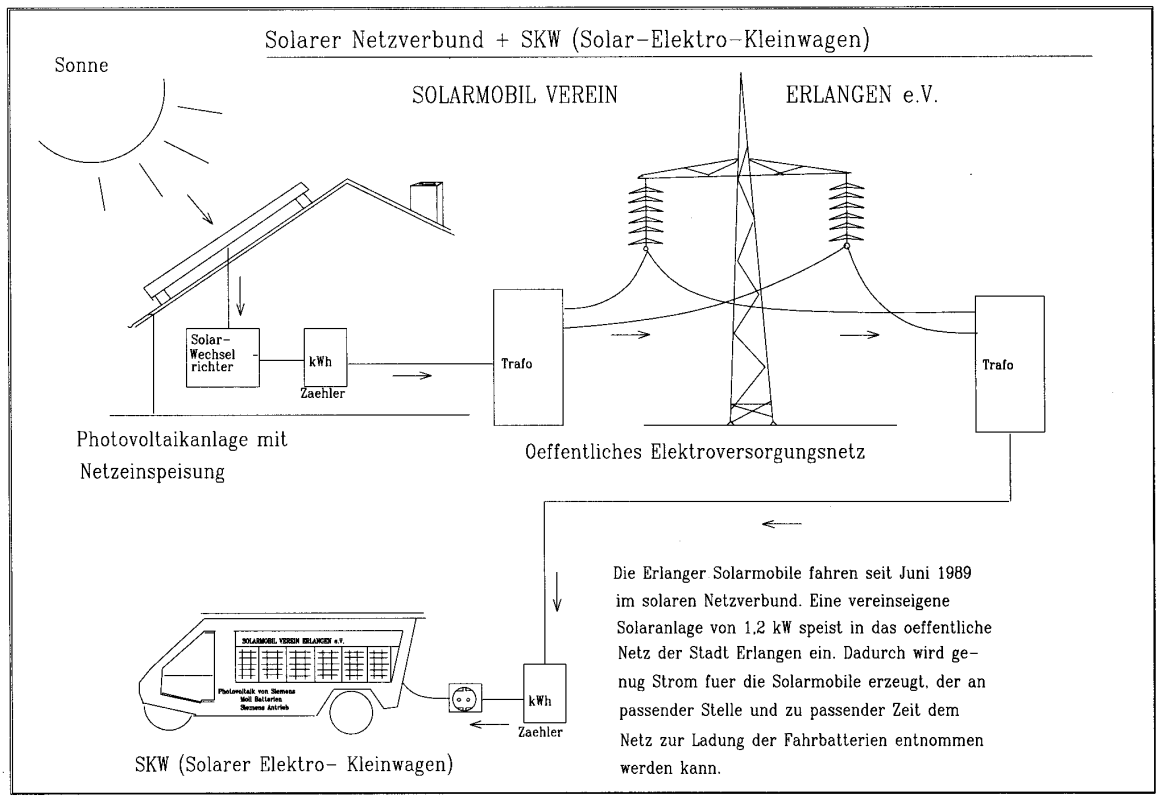


Figure 1: Solar Grid System - energy from the sun through the grid to the electric vehicle

This model works with energy accounts as well: The energy is fed into the grid, the owner can take the equivalent amount out at any point and at any time from the grid. On the long run - over the year or so - the balance should be positive, i.e. the amount of energy generated by the solar power plant should exceed the energy taken out for driving the vehicle. If the energy balance is positive, i.e. more solar power is generated as used by the vehicle, it is defined as a "Solar Vehicle".

This definition of "Solar Vehicle" is also included in the Rules and Regulations of the "German Solar Vehicle Championship"[1] organized annually by the Bundesverband Solarmobil e.V. The teams have to prove the ownership of a solar power station or similar source of sustainable energy large enough to deliver the amount of energy for running the vehicle for about 10.000 km per year.

Solar power stations of 1 to 5 kW feeding the energy into the grid exist in large numbers in Germany. About 100.000 will be installed under the EEG (Reneable Energy Law) within the next few years.

5 Power for Light Electric Mobiles

The power requirements for light electric vehicles were defined already in February 1990 in a meeting of 20 experts in Kassel. As a result of that meeting, the Ministry for Commerce and Technology of Hessen published a small booklet with guidelines for the construction of solar- and electric vehicles: "Pflichtenheft für die Konstruktion von Solar- und Elektroautos".[2] The energy consumption should be less than 10 kWh per 100 km, based on a vehicle carrying two persons of 75 kg each with an average speed of 50 km/h on flat road. The max. speed should be 100 km/h, the range also 100 km at 50 km/h speed and with 50 % load.

Several projects started, as the well known Hotzenblitz, the ATW Ligier Optima, the TWIKE and the City-El. Some projects were discontinued, like Hotzenblitz and the Ligier-Optima due to manufacturing and battery problems. Other vehicles survived, like the City-El and the TWIKE.

At the International German Solar Car Championship, the energy consumption of the participants is measured. The total energy consumption is the sum of the battery capacity in kWh plus the kWh for recharging the batteries at the event. The results indicate that under day to day driving conditions, the well known single-seater City-El, of which more than 5000 have been manufactured in Denmark and now in Germany, uses about 6 to 8 kWh per 100 km, and the double-seater TWIKE uses 3 to 6 kWh per 100 km.[3]

The energy requirements are so low that they can be supplied by solar panels. These panels are not installed on the vehicle but on the house. A solar generator of 1 kWp delivers about 700 to 800 kWh annually, which for both, the City-El and the TWIKE, is sufficient for more then 10.000 km. The price of the 1 kWp solar power station is in the range of 13.000 to 15.000 DM (7.000 to 7.600 Euro). Most vehicle owners regard the price as quite o.k. and like the idea of having an unlimited source of energy for future driving. They particular like the idea of no more worries about rising fuel prices.

Solar racing cars like the types running in Australia the World Solar Challenge from Darwin to Adelaide show the possibilities and the future of solar cars. Such racing cars are not the subject of this paper due to the fact that they are unfit for daily use to go to work or shopping or similar.

Another idea is to have at least a small solar panel of 100 Watt or so on the vehicle itself. The author made very good experiences with a 100 Watt solar panel on his City-El. The main advantages are: It gives some shade for the driver, the vehicle demonstrates that it’s a solar car, the range is extended by some 8 to 10 km per day, and the additional charge is very welcome for commuters who go to work in the morning and leave the car the whole day in the sun. Furthermore it was noticed that the life span of the batteries was extended. If the car is not used for long times, the solar panel keeps the batteries alive.

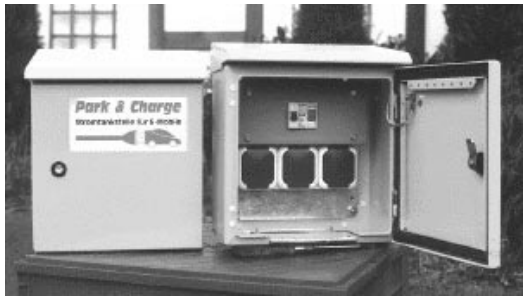
The research center Jülich (Forschungszentrum Jülich) made a very detailed report about the energy requirements and the pollution connected to electric vehicles and solar charging stations. The question was wether all the typical commuter vehicles running about 6500 km per year could be electric vehicles with own solar power supply and how much pollution they would make in comparison to other cars. The results show that only 2/3 of the parking space should be covered with solar panels and that small electric vehicles (less then 15 kWh per 100 km) with highly efficient solar panels will give the lowest pollution of all the investigated cars and power supplies. (Small and medium diesel cars, small and medium electric cars, various types of solar power supplies). [4]

The "DLR - Deutsches Zentrum für Luft und Raumfahrt" came to similar results: They investigated several drive systems using reneable sources of energy, like hydrogen from various sources, methanol, and the conventional electric vehicle with batteries. The primary energy requirements were the lowest for the electric car with batteries using around 25 kWh only per 100 km, in comparison to hydrogen supplied cars using 52 to 116 kWh per 100 km.[5]

6 Park & Charge® System

With the name ***Park & Charge***® there is a system of public charging stations for electric vehicles in Switzerland, Germany, Austria, France and Italy. The power supply is in many cases from solar- wind- or water-powered generators. All of them are connected to the grid.

The ***Park & Charge***®-system consists of simple power outlets 230V 16 A and all necessary fuses and protection circuits in a metal box with key. This key is the same key for all ***Park & Charge***® stations in Europe.



The participants get this key against a nominal fee. In addition they pay for the "vignette", a sign to be posted in the electric vehicle and documenting that this car is participating in the ***Park & Charge***® system.

The vignette must be renewed every year against a nominal fee depending on the required power, i.e. cars with higher power requirements pay a higher rate. The fee is a "flat rate", there is no individual bill for the electricity for charging.

The aim is to provide electricity for electric vehicles when they are away from home. Thus the vehicles can be recharged while shopping, sightseeing, eating in restaurants or even sleeping in hotels (Hilton Basel).

The ***Park & Charge***® system was first installed in 1992 in Bern (Switzerland). Now there are over 120 ***Park & Charge***® stations in Switzerland (500), about 20 in Germany (300), 8 in Italy (13) and 6 in Austria (58).
In brackets are the numbers for other power outlets for electric vehicles, most of them on private basis, as listed in the LEM-NET (a list of public charging places, published by the TWIKE-Klub, Internet adress: www.twikeklub.ch)

In Germany the adress for the ***Park & Charge***® System is Henning Braun or Udo Heers, Solargruppe Bielefeld, Tel. 0521 2089 758, Fax 0521 2067 40, e-mail: info@park-charge.de
Internet: www.park-charge.de

7 Conclusion

Small electric vehicles may very well get their electricity from solar power stations, both from own solar plants at home or from public charging stations like the ***Park & Charge***® System. The energy requirements are such that an initial investment of 10 to 15.000 DM (up to 8.000 Euro) is sufficient to get the power for the next 20 years or more and for up to 10.000 km annually. Research reports claim that the areas required would be less than for the parking space for each car, and the overall pollution would drastically drop. These studies include the manufacturing of the solar panels, where most of the pollution is emitted.

Solar mobility is no longer a dream - it is possible now and here. The photovoltaic panels and the inverter for grid connection are available, the number of installations in Germany will reach a 100.000 or more in the next few years. The vehicles are there: the well known City-El, a single seater, needs 6 to 8 kWh only per 100 km, the TWIKE, a two-seater, needs even less with 3 to 6 kWh per 100 km. Other cars like the TH!NK will be marketed soon, and "larger" cars like the Citroen Saxo and Berlingo are available with electric drive systems as well. There are also electric scooters like the Peugeot Scootelec and the Taiwan made EVT 4000 and a growing number of electric power assisted bikes available.

Besides solar mobility on land, there are many solar boats and ships manufactured, and solar planes and solar railways are demonstrated.

8 References

[1] Technisches Reglement der internationalen Deutschen Solarmobilmeisterschaft 2001, Bundesverband Solarmobil e.V. (Hrsg.)

[2] Pflichtenheft für die Konstruktion von Solar- und Elektroautos, September 1990, Hessisches Ministerium für Wirtschaft und Technik, Wiesbaden, ISBN 3-89205-084-8

[3] Solarmobil Mitteilungen Nr. 39, April 1999, Deutsche Solarmobilmeisterschaft 1998, Ergebnisse

[4] Berichte des Forschungszentrums Jülich 1993: Angewandte Systemanalyse Nr. 67: Umweltvorsorgeprüfung bei Forschungsvorhaben, Am Beispiel von Photovoltaik, v. Winfried Hirtz, Werner Huber und Gerhard Kolb, Band 1: Zusammenfassung und Ergebnisdarstellung, Nr. 2855, ISSN 0944-2952
Band 6: Praktische Durchführung, Nr. 2757, ISSN 0366-0885

[5] Globale Umweltvorteile bei Nutzung von Elektroantrieben mit Brennstoffzellen und/oder Batterien im Vergleich zu Antrieben mit Verbrennungsmotor, von Constantin Carpetis, DLR, Deutsches Zentrum für Luft- und Raumfahrt, STB-Bericht Nr. 22, April 2000

9 Author

Roland Reichel, Dipl.Ing.(FH), Ms.Sc.(Eng.)
Chairman of Bundesverband Solarmobil e.V. (German Solar Car Federation)
Reifenberg 85, 91365 Weilersbach, Germany, Internet: **www.solarmobil.org**
Phone +49 9194 8900, Fax +49 9194 4262, E-mail: RR@solarmobil.net

Dipl.Ing.(FH): Fachhochschule Wolfenbüttel/Braunschweig (1968),
Ms.Sc.(Eng.): University of Dar Es Salaam / Tanzania (1978)
1969-73: Cairo Institute of Technology, Helwan, Egypt (for GTZ)
1973-79: University of Dar Es Salaam, Tanzania (for GTZ)
1980-1997: Siemens Erlangen and Nürnberg