

# Solar Mobility

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## **Abstract:**

Is “solar mobility” a dream or a real possibility for the future?

Solar Mobility really started with the first “Tour de Sol” 1985 in Switzerland. Some of these solar vehicles were racing vehicles, which are still quite popular in Japan, Australia and the USA. Today’s world leader NUNA II comes from The Netherlands and shows the possibility of “solar mobility”: more than 96 km/h average speed over a distance of 3010 km on solar mode only, achieved at the “World Solar Challenge” in Australia.

In recent years solar vehicles for everyday use were constructed and manufactured in small scale. These vehicles are based on electric vehicles with either a small solar generator on top of the vehicle or larger grid-connected solar generators on top of a house or garage. The idea and system of “solar mobility” based on grid connected solar power generation will be demonstrated.

The report gives an overview of existing vehicles and demonstrates the possibility of operating them from sustainable sources of energy, i.e. based on solar, wind, hydro or similar clean sources of energy. It answers the usual questions about availability, price, speed, range and autonomy on solar mode. The report is based on “real world experience” with 18 years of solar car driving.

The report mentions briefly other possibilities of solar transportation on water with solar ships and solar boat. Solar boats might well be a very important mode of sustainable transportation in developing countries with small and medium sized boats of up to 100 passengers.

A future outlook for “Solar Mobility” is given with respect to new battery technology.

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# 1. The development of “Solar Mobility”

The history in modern solar vehicles started around 1978 or 1979 with Alan Freeman building in England small and ultra-light electric vehicles with photovoltaic generators on top for charging the batteries at good sunlight.

1985 started in Switzerland the first „Tour de Sol“. Only solar powered vehicles were permitted to run for one week all over Switzerland in a solar-car event. Even Daimler Benz had built a solar powered car, and about 73 solar vehicles participated. The idea of a “Tour de Sol” spread around the world, and there is still a “Tour de Sol America” with many solar-electric cars participating. But there are still events with pure solar racing cars, like the “World Solar Challenge” in Australia, and similar events in Japan, the USA and elsewhere.

The last of such demonstrations events was the “Phaeton 2004” in Greece end of may 2004. One of the most powerful solar car comes from The Netherlands: NUNA II has reached on direct solar power only an average speed of more than 96 km/h over a distance of 3010 km on the world solar challenge race in Australia. Racing is from 8 a.m. till 5 p.m. This demonstrates clearly the potential of “Solar Mobility” even for conventional light vehicles for everyday use.

The following pictures show some of the popular solar racing vehicles:



Daimler Benz solar racing car, Tour de Sol 1985



Michael Trykowski's solar racer



Aurora, Australia, winner WSC 1999



NUNA II, Holland (ESA), winner of the WSC 2001 and 2003

### 1.3 Solar vehicles prototypes

On the way to producing solar vehicles, a number of very remarkable prototypes have been built. Most of them were made by small companies or University teams, some of them as design-studies for later production cars. The most advanced prototypes and design studies came from Horlacher, Switzerland. Horlacher did - in cooperation with an insurance company and a technical university - quite some research and development into the question of safety of small vehicles including spectacular crash tests. Horlacher demonstrated, that small vehicles can be built with very high standards of safety. Some of these light electric vehicles have been produced in small quantities, like the Innovan (around 15) and the Hotzenblitz (around 150).

The pictures show some interesting „purpose design“ vehicles:



“Pre-production model“ Saxy or Innovan



Horlacher prototypes from Switzerland



Former production cars: “Hotzenblitz” (Germany),



“Sparrow” (USA)



and the “SAM” from Switzerland

The electric driven prototypes and production cars are different from petrol or diesel driven vehicles in many points:

- Less weight and thus less energy consumption
- Due to reduced energy consumption (10 to 20 kWh/100 km) solar supply is feasible
- Reduced range of typically 50 to 120 km per charge
- No emission when driving, no exhaust, almost no noise

All of the shown vehicles are battery operated electric vehicles.

## 2. Energy for “Solar Mobility”

### 2.1 Energy requirements

The energy required for solar electric vehicles is principally about 20 to 30 % of the energy used in conventional vehicles. Internal combustion engines “waste” about 60 to 70 % of the energy to produce heat and use 30 to 40 % only to produce mechanical energy (and sometimes even only 10 to 20 %). Good electric drive systems have efficiencies of typically 80 % for the motor plus motor control system. Still the question remains: Are solar-electric vehicles ecologically better than petrol- or diesel-driven vehicles?

There are a few arguments answering this question:

- The energy consumption of vehicles at „city-speed“ depends mainly on the rolling resistance of the tires and the weight, thus light weight vehicles have clear advantages.
- Solar- and electric vehicles have no emissions when driving, no exhaust and no noise and are very well suited for inner city driving, for recreational areas, inside of building, parks etc. and for inner-urban transport.
- Electric vehicles are as clean as their power supply. Is the electricity from hydro stations, wind- or from solar-stations or similar clean and sustainable sources, then the electric vehicle is “clean” and a “**Real Zero Emission**“ vehicle.
- Research in Germany showed that small and light electric vehicles with clean and sustainable electric power supply are ecological better than any other types of cars and produce less emissions. (research done by the Research Center Jülich GmbH. (2)
- According to the „Rügen-Studie“, where a number of quite heavy electric cars had been evaluated for many years on the Rügen-island, the electric vehicle prototypes have still lower CO<sub>2</sub>-emission than diesel- or petrol cars. This is based on the average CO<sub>2</sub> emission of the German electric power supply and vehicle energy consumptions of 25 to 35 kWh/100 km.
- Modern electric vehicles require only 10 to 20 kWh/100 km and are thus much cleaner than vehicles using oil for energy. (3) (4)
- Light electric vehicles use even less energy - in the range from 4 to 6 kWh/100 km (for the TWIKE and CityEl) and around 13 to 18 kWh/100 km for the Citroen AX électrique, as measured at many events by the bsm. (5)

## 2.2 Energy supply

If there is a clean “solar” source of energy, the vehicles may be called „solar vehicles“. The direct drive is normally by batteries (new systems with super caps and fuel cells are under development). Charging of the batteries can be done by the internal or an external solar generator or from the so-called “solar grid system”.

- The electric vehicle is „upgraded“ to solar vehicle if it uses clean energy from solar-, wind- or hydro-power.
- The vehicles batteries can be charged from solar panels integrated into the vehicle, directly from external solar modules or indirectly through the so called „solar-grid“.
- The size of the solar- or other clean power source must be sufficient to deliver the energy for the vehicle.

**Example:** A solar car takes consumes 10 kWh per 100 km and is running about 10 000 km per year. The solar generator must deliver around 1000 kWh per year. The size of the photovoltaic power station is around 1 kW peak, the required space is around 10 m<sup>2</sup>.

## 2.3 Solar generator on the vehicle

Solar modules on the vehicle are mainly used at solar racing cars. At the “World Solar Challenge” in Australia, the max. allowed solar panels measured 2 by 4 m for single seater racing cars. The best cells deliver around 1,5 kW from that generator. This is quite sufficient for a racing car, which may well run at speeds of more than 90 km/h at good sunshine. Racing cars are not practical for everyday use. On practical cars, solar generators have been used with remarkable results. Experience shows that solar modules of 100 to 300 Watt may be installed on the top of a production car. Thus most of the direct driving current is delivered by the battery. But the solar generator on the vehicle has many advantages:

- The battery is charged whenever the sun shines, when the car stops or parks
- The direct solar power provides enough energy for 8 to 12 km per day, or for 70 to 100 km solar driving per week (for more range, power is taken from the plug).
- The solar generator keeps the battery charged at long parking periods, even for weeks or months (6)
- The solar roof prevents the sun heating up the car too much, thus air conditioning might not be required for solar cars.



Vespa Piaggio Mobil, small delivery van, 600 Watt solar panels



Electric Trabi, Dresden (Germany) with 200 Watt solar roof

## 2.4 The stationary solar generator

Stationary solar generators can be built at almost any size. As a thumb rule, around 10 m<sup>2</sup> are required for 1 kW<sub>peak</sub>, which in turn supplies around 1000 kWh annually in Germany. In other countries with more sun, this might be more.

Stationary solar generators are normally connected to the grid via inverters. Whenever the sun shines, the energy is delivered into the grid. The vehicle connects to the 230V grid system and charges the batteries. Quite common is the 230V system with 16A plugs. Thus the max. charging power is around 3.5 kW for a single phase or around 10 kW for a three phase outlet. For higher power requirements, three phase outlets for 20 or 40 kW are quite common. Thus many cars may charge at the same time or rapid charging is possible.



3,3 kW solar power system in Erlangen, Germany



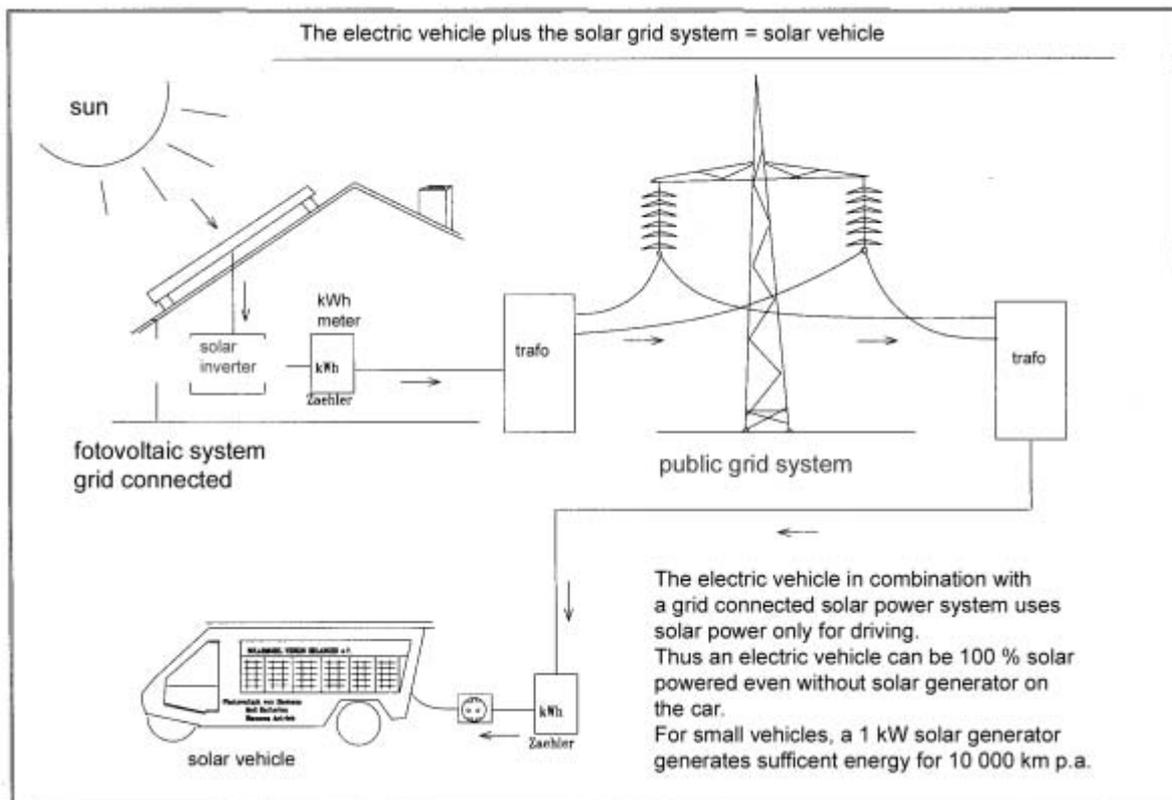
1,1 kW system, Solar Mobility Group Erlangen

## 2.5 The grid connected solar generator

The definition of “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.) supplying the required amount of energy for driving and 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 through the “account”: the account shows in writing, how much one owns. The electric grid system is normally powerful enough to deliver the power on demand for the electric vehicle. The solar generator must be large enough to deliver the energy required by the vehicle. Small electric vehicles require something in the range of 10 to 20 kWh per 100 km. Thus the photovoltaic generator should have a rated power of 1 to 2 kW to deliver the 1000 to 2000 kWh per year.

The picture shows the system:



## 2.6 Park & Charge system

Under the name *Park & Charge*<sup>®</sup> 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*<sup>®</sup>-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*<sup>®</sup> 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**<sup>®</sup> 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, Switzerland).

The **Park & Charge**<sup>®</sup> system was first installed in 1992 in Bern (Switzerland). Now there are over 120 **Park & Charge**<sup>®</sup> stations in Switzerland (500), about 35 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 address: [www.twikeklub.ch](http://www.twikeklub.ch))

In Germany the address for the **Park & Charge**<sup>®</sup> System is: Solargruppe Bielefeld, Tel. 0521 2089 758, Fax 0521 2067 40, Internet: [www.park-charge.de](http://www.park-charge.de)



Park & Charge - solar-charging station in Bielefeld, Germany

## **3. Vehicles and components**

### **3.1 Some available vehicles**

Production vehicles are - as the name implies - actually produced and available for the normal consumer. Prototypes, concepts cars and test-vehicles are not considered in the list of solar-electric vehicles. In the appendix there is a lists with some models available in Europe and elsewhere, but excludes most of the USA-models.

Some are vehicles built with electric drive systems only, like the single seater CityEl and the two-seater TWIKE, both produced in Germany. Others are available with petrol, diesel **or** electric drive, like the Citroen Berlingo or the Renault Kangoo.

Not included are hybrid vehicles. Some of the cars are no longer manufactured, but used models are still available.

### **3.2 Batteries for electric vehicles**

In common use are these types and technologies:

- Lead (Lead-Acid, Lead-Vlies, Lead-Gel types), for example used in the CityEl, Kewet and many others
- Ni-Cd, for example from SAFT used in the Citroen, Peugeot, Renault etc.
- Ni-Metal-Hydrid, for example Panasonic, used in the Toyota Prius
- Ni-Zi, Evercel (USA, China) - very promising technology, but not any more in production
- Lithium-batteries (very new, for example Thunder-Sky and others from China, SAFT (France), or FortuCell and Gaia (Germany))

Lead acid and NiCd are well known battery types and long term experiences exist. Ni-metal-hydrid is quite a new and very promising technology. Ni-Zi could not gain any market share. Lithium is the most promising technology. It has the advantage of high energy to weight ratio of about 100 to 200 Wh per kg (compared to lead-types with only 25 to 40 Wh per kg). Disadvantages are the higher price and the danger of fire. Under certain conditions, some lithium batteries have a tendency to burn itself.

Some of the lithium technologies (lithium-metal of FortuCell in Karlsruhe, Germany) is said to be not inflammable.

### 3.2.1 Project with lithium batteries

#### T-Zero, AC-Propulsion, USA

AC Propulsion in the USA had made a sports car with lithium batteries. They use many thousands of small cells in 25 moduls of 14,8 Volt each. The total voltage is 370 V, the pack with 33 kWh has a weight of 250 kg. They also built a pack of 370 Volt and 50 kWh with a weight of 350 kg. The max. power to be drawn from these batteries is 165 kW!



The T-Zero from AC Propulsion, USA was test driven September 9. in 2003 and achieved 3,6 - 3,7 s from 0 to 60 mph. More important is the long range test on the 3rd of Oct. 2003. A range of 302 miles (!) at an average speed of 57,1 mph. was reached. The battery delivered 130 Ah, the consumption was 160 Wh per mile. (see: [www.acpropulsion.com](http://www.acpropulsion.com)) AC-Propulsion has seemed to have sold the drive system including the batteries for some other projects (Volvo, Norway and Venturi, France, who is planning to offer a “super sports car”, electric drive system, 540 000 Euro!, see [www.venturi.fr](http://www.venturi.fr)). This projects shows that with modern lithium batteries ranges of several hundred km can be achieved.

#### Lithium batteries in bicycles

In 2004, the extraenergy consultant and specialist for power assisted bikes started testing lithium batteries in a bike for the German post office. These bikes use a small electric motor for assisting the pedalling. Typically the motor has 240 Watt and works only, when the driver is pedalling. A large number of such bikes are in use now in Japan and in Germany. At the end of 2004, lithium batteries of more than 8 manufacturers are tested. More about the extraenergy activities in the Internet at [www.extraenergy.org](http://www.extraenergy.org).

#### FortuCell

The FortuCell GmbH had developed the lithium-metal technology and plans to start production in 2005. The most promising type has 4V at 65Ah and a weight of 1,3 kg only (200 Wh/kg). According to the publications there is no danger of fire and the charging and battery monitoring is very simple and similar to those required for lead batteries. The price

is not yet published, but the company hopes to reach prices in the same range as for good lead-acid traction batteries. More at [www.fortu.de](http://www.fortu.de) or at [www.solarmobil.net](http://www.solarmobil.net).

### **Thunder-Sky Lithium**

ThunderSky of China is offering large lithium batteries designed specially for electric cars. Some tests in England brought promising results, and at present some small CityEl single seater cars are equipped with 40 Volt 100Ah (44 kg) and with 50 Volt 200 Ah (77 kg) test blocks.



Challenge-Bibendum 2004 in China, electric bus with ThunderSky Lithium batteries

The “Challenge Bibendum 2004” in China in October 2004 demonstrated the growing interest for electric vehicles in China. Many of them are electric scooters for basic transportation, i.e. with rather small motors of one kW power only or even less. The driving speed is quite moderate in the range of 25 to 45 km/h, the ranges are from 20 to 50 km. There is a growing industry in China producing electric scooters and the required components like electric drive systems and batteries of all kind and technologies.

### **Other Lithium battery manufactureres:**

In France, SAFT is producing and offering lithium cells, in Germany GAIA makes lithium batteries. In the USA, there are several lithium battery manufactures.

### 3.3 Solar boats

Solar boats are electrically-powered boats with photovoltaic modules on the roof. Such boats can be completely powered by the sun during daytime. Batteries held on board can store energy from the sun, so that the boats can be safely brought back home even in bad weather or at night. Solar boats are 100% emission-free and don't pollute our lakes and rivers. Solar boats might be well suited as so-called “water-taxis” in urban and suburban transport systems.



Solarboat of the Kopf AG, in operation in Heidelberg (Germany), Internet: [www.kopf-solardesign.com](http://www.kopf-solardesign.com)



Solarboats for hire at the solarpavillon in Berlin Köpenick (Germany), Internet: [www.solarwaterworld.de](http://www.solarwaterworld.de)

## 4. The future

### 4.1 Electric cars, scooters, power assisted bikes, quads

There are a number of aspects in the future of solar-electric mobility:

**1. Legislation:** In many countries in Europe, license and tax conditions are eased for so-called “voiturettes”, i.e. light vehicles of no more than 350 kg (excluding batteries), a max. speed of 45 km/h and a max. power of 4 kW. These vehicles may be driven at the age of 16. It is expected, that quite a number of manufacturers will offer such light vehicles with electric drive as well, mainly in Italy (Helektra townlife), France (Aixam, Ligier), Belgium (Chatenet) and Germany (CityCom, TWIKE, ATW). Even electric “quads” may be offered. In many countries, restrictions for conventional cars do not apply for electric cars. There is no restriction, for example, in London City for electric cars (which are imported now from

**2. Better batteries:** One of the main reasons that solar or electric cars are not yet widely offered or widely used are the batteries. Lead batteries are too heavy and last not long. NiCd batteries are quite expensive, but still the average range is limited to 100 km or so. A real breakthrough will come with new and better and cheaper batteries. Lithium are very promising, and the lithium technology is well established in fields like notebooks, mobile phones and camcorders. The breakthrough in electric cars take some more time and the technology is still quite expensive. With greater reliability and decreasing prices, more and more car manufacturers will offer electric vehicles with lithium batteries. Quite normal speeds up to 120 km/h or more can be reached and the acceleration of such electric cars is equal or better than that of petrol driven cars. With lithium batteries ranges of several hundred miles at one charge are expected and are already demonstrated.

**3. Rising cost of petrol and diesel fuel:** Rising fuel cost makes driving with electric energy really attractive. Electric vehicles use typically between 5 to 20 kWh per 100 km. Based on 10 Euro-Cent per kWh for electricity (price at night in Germany), the direct “fuel cost” is only 50 Cent to 2 Euro per 100 km!. In remote areas, where there is no other source of power, solar electricity might be feasible for light electric vehicles due to their low power consumption. The real cost of solar-electric driving is replacing the batteries from time to time. If the batteries really last 500 or 1000 or even more load-cycles (as promised by the manufacturers), then electric driving will become feasible.

**4. Environment:** Environmental considerations might play a role for institutions and some individuals. But this is quite a small niche-market. But with rising fuel cost, more and more people start thinking about the environment and are starting to look into the possibilities of “Solar Mobility”. In Germany, many people invested in own solar power stations on their house. Those people are more and more interested in solar driven cars and boats.

For developing countries the situation might be different. Conventional fuel might be very expensive in many countries, or it might just not be available locally. Alternatives are a necessity. Solar powered vehicles for short range driving might have a real chance in urban and sub-urban traffic systems.

**Own experience:** The author is driving solar electric cars since 1985, both in rallies and for every day “small mobility”. At current a small CityEl single seater using lead-acid batteries and four-seater Citroen AX with NiCd batteries are in use. For long range, a modified Volkswagen Golf III Variant Turbo Diesel is run on pure rape oil only. For long range driving, this “indirect solar energy” might well play its role in developing countries due to the fact that it can be produced locally, thus creating jobs and income locally.

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- since 1997: Publisher ([www.reichel-verlag.de](http://www.reichel-verlag.de))
  
- since 1992: Chairman: Bundesverband Solare Mobilität e.V. (The German Solar Mobility Federation is an NGO, non-profit and tax-exempted organisation)
- since 1988 Chief Editor: „Solarmobil Mitteilungen“ (German magazine for solar mobility and sustainable transportation),
- 1992: Head of Jury, Tour de Sol, Switzerland
- Webmaster “[www.solarmobil.org](http://www.solarmobil.org), [www.solarmobil.net](http://www.solarmobil.net)”
- 1999: Observer, Tour de Sol, USA and participant World Solar Challenge, Australia

## 6. Appendix: Electric Vehicles

	<p><b>Citröen AX électrique:</b> 4-wheels, 2- or 4 seats, weight 995 kg, LxWxH: 3,525m x 1,55m x 1,355m 11 (20) kW DC motor with recuperation</p>	<p>Battery: NiCd 120V 100Ah max. speed 91 km/h, range 80 to 100 km energy consumption 13 to 18 kWh /100km (out of production, replaced by the SAXO)</p>
	<p><b>Citröen SAXO:</b> 4 wheels, 4 seats weight 1085 kg, LxWxH: 3,718m x 1,595m x 1,390m 11 (20) kW DC motor with recuperation</p>	<p>NiCd battery 120V 100Ah speed 91 km/h range 75 km city driving energy: 18 kWh/100km  production stopped in 2003</p>
	<p><b>Citröen Berlingo:</b> 4-wheels, 2 seats, weight 1450 kg, payload 500 kg LxWxH: 4,108m x 1,719m x 1,809m</p>	<p>15,5 (28) kW DC engine with recuperation NiCd battery 162V 100Ah max. speed 95 km/h range 95 km, energy for 100 km: 20 bis 25 kWh</p>
	<p><b>City-EI</b> 3 wheels, 1 seat DC motor, either Thrige-Titan or Perm motor weight 290 kg, LxWxH 2,75m x 1,065m x 1,34 m Lead batteries 36V 100Ah,</p>	<p>max. speed 45 or 60 km/h, range ca. 40 to 80 km depending on type of battery energy for 100 km: 7 kWh Fa. CityCom, Industriestr. 5-9, D-97239 Aub bei Würzburg Tel. 09335-97170, Fax 09335-971728</p>
		<p><b>City-EI versions:</b> Targa-Fun or cabrio  CityCom AG Internet: <a href="http://www.cityel.com">www.cityel.com</a></p>
	<p><b>TWIKE</b> Aluminium frame with hull from Luran S plastic 2 seats, weight 220 - 250 kg, LxWxH: 2,65m x 1,2m x 1,2m, 5 kW three phase electric drive on rear wheels, plus pedals via 5-speed gear</p>	<p>NiCd-Batt. 2 or 3 kWh at 336V max. speed 85 km/h range 40 - 80 km energy for 100 km: 3 - 5 kWh  Info-Tel in Germany: 01805 463 463 e-mail: <a href="mailto:info@twike.de">info@twike.de</a> Internet: <a href="http://www.twike.de">www.twike.de</a> <a href="http://www.twikeklub.ch">www.twikeklub.ch</a></p>
	<p><b>REVA</b> made in Bangalore, India two doors, 2 adults + 2 children speed: max. 65 km/h charging time: 80% in 2.5 h, 100% in 6 h motor: DC-motor. 13 kW max. torque 70 Nm motorcontroller max. 400 A with regenerative braking</p>	<p>charger: 220 V, 2.2 kW, HF with microcontroller battery: 48V, 200 Ah (C5), lead acid traction heavy duty L 2638, W 1324, H 1510 [mm] Curb Weight : 670 Kg imported to Malta and England  <a href="http://www.revaindia.com">www.revaindia.com</a></p>

	<p><b>Helektra townlife</b> made in Italy electric drive 4 kW bei 2400 Upm, 48 Volt 110 A, lead batteries 48 V 180 Ah L x W: 2,521 x 1,44 m max. speed either 45 km/h or up to 60 km/h range 40 bis 70 km</p>	<p>More information for the Netherlands and Germany:  <b>BATHY Automotive</b>, Wilfried Baars, Van Rouwenoortweg 39, NL-6942 PK Didam, fon ++31 316 294 554, fax -960, Internet: <a href="http://www.bathy.nl">www.bathy.nl</a> und <a href="http://www.townlife.nl">www.townlife.nl</a> e-mail: <a href="mailto:info@bathy.nl">info@bathy.nl</a></p>
	<p><b>Bingo</b> petrol, diesel or electric electric: DC motor, 4 or 10 kW/48V 2,53m L x 1,43m W x 1,54m H curb weight 400 kg depending on model and extras payload ca. 200 kg front drive</p>	<p>Information in Germany:  Auto Technik Walther GmbH, Raiffeisenstr. 10, <b>74906 Bad Rappenau</b>, Tel. 07264 9187 0, Fax 07264 9187 27, <a href="http://www.atw-mobil.de">www.atw-mobil.de</a></p>
	<p><b>KEWET EI Jet 5</b> 2 passengers, LxWxH: 2,44m x 1,43m x 1,46m, Motor: 12 kW DC curb weight 840 kg, payload 160kg battery: lead acid 10,5 kWh, max. speed 60 to 80 km/h</p>	<p>range up to 70 km energy for 100 km: 15 -18 kWh  no new production, but many used cars available. KEWET is now in Norway:  Internet: <a href="http://www.kewet.com">www.kewet.com</a></p>
	<p><b>Aixam Mega</b> made in France motor: petrol, diesel or electric curb weight 770 kg, max. weight 1.025 kg 12 batteries lead-Gel a 26 kg, total 48V 210 Ah max. speed 45 km/h, range 70 km at 20 Grad C</p>	<p>more information in Germany:  Girke Fahrzeugbau GmbH, Rainer Girke, Harpener Hellweg 22, 44805 Bochum, Tel. 0234 – 50728 - 0 Fax - 28 Internet: <a href="http://www.girke.de">www.girke.de</a></p>
	<p><b>Electric Porter</b> made by Piaggio in Italy Van/Combi, Pick Up or Bigdeck Small lorry made by Daihatsu, with electric motor 9,2 kW at 84 Volt L: 3,37 - 3,75 m W: 1,395 - 1,46 m H: 1,72 m -1,87 m payload up to 400 kg</p>	<p>14 batteries of 6V each 180 Ah max. speed 60 km/h range up to 70 km Piaggio-Germany GmbH Postfach 43, 86416 Diedorf Tel. 08238 3008-50 Fax 08238 3008 973 e-mail <a href="mailto:info@piaggio.com">info@piaggio.com</a> Internet: <a href="http://www.piaggio.com">www.piaggio.com</a></p>
	<p><b>Trans</b> motor diesel or electric 48 V 4 kW rated power, battery 105 Ah (optional 210 Ah), range 30-60 km 2,67m L x 1,35m W x 1,82m H payload up to 500 kg front drive system</p>	<p>Information in Germany:  Auto Technik Walther GmbH, Raiffeisenstr. 10, D-74906 Bad Rappenau, Tel. 07264 9187 0, Fax 07264 9187 27, <a href="http://www.atw-mobil.de">www.atw-mobil.de</a></p>
	<p><b>Arrow 45</b> Quad, made in Germany max. speed 45 km/h range: 30-60 km max. payload. 120 kg weight incl. batteries: 130 kg L x W x H: 188 x 88 x 110 cm motor: 3phase, 0,715 kW 3 lead batteries 12V 80Ah</p>	<p>Information in Germany:  E.Mobile Technologies GmbH Postfach 12 63, 37553 Einbeck Telefon: 0 55 61/92 30-0 Fax: 0 55 61/92 30-99 Internet: <a href="http://www.e-mobile-technologies.com">www.e-mobile-technologies.com</a></p>

	<p><b>Peugeot electric scooter</b> made in France for 2 persons, DC motor 2,8kW with recuperation, batt. 18V 100Ah NiCd, max. speed 45km/h range 45 km, with eco-drive at 30 km/h about 60km charger: 1300 W for charging up to 95% in 2 h</p>	<p>L 1,76 m, W 0,80 m weight: 115kg</p> <p>Import to Germany: Jürgen Werner, Luppachstr. 18, 72116 Mössingen, Tel. 07473- 948 533, Fax 07473-948 530 UT-werner@solarmobil.de, Internet: www.elektro-roller.de</p>
 <p><b>EVT scooter 4000</b></p> <p>Both scooters made in Taiwan DC hub-wheel motor, direct drive</p>	 <p><b>EVT-scooter 168</b></p> <p>system for best efficiency 1,5 kW rated, 2,8 kW max. power ECO</p>	<p>drive for max. range (speed 35 km/h, range up to 70 km) and power drive (speed 45 km/h, range up to 50 km)batteries maintenance free sealed lead batteries 48 V 45 Ah, up to zu 250 cycles (ca. 10.000 km)</p> <p>Import to Germany: EVT-Scooter, Gustav-Schwab- Str. 14, 78467 Konstanz, Tel. 07531-60156, Fax 07531-60047, Internet: <a href="http://www.evt-scooter.de">www.evt-scooter.de</a></p>
	<p><b>eton Roller</b></p> <p>LxWXH: 1,71 x 0,645 x 1,06 m Wheelbase: 1,21 m, weight 121 kg max. speed: 45 / 57 km/h range 58 km at eco-mode hill climbing up to 22 % DC-motor, electronic control 3 kW at 5600 rpm</p>	<p>Made in China</p> <p>Import to Europe: <b>BATHY Automotive</b>, Wilfried Baars, Van Rouwenortweg 39, NL-6942 PK Didam, fon ++31 316 294 554, fax -960, Internet: <a href="http://www.bathy.nl">www.bathy.nl</a> e-mail: <a href="mailto:info@bathy.nl">info@bathy.nl</a></p>
	<p><b>e-max</b> made in China</p> <p>L / W / H: 1.6 / 0.65 / 1.07 m Weight: 111 kg / 224 kg max. speed: 45 km/h hub-wheel DC motor, 1,5 kW range: up to 60 km, 2 seats</p>	<p>sealed lead-silicone batteries</p> <p>import to Germany: <b>SAP System Auto Parts GmbH</b> Am Forst 17b D-92637 Weiden Telefon +49 (0) 961 388559 <a href="mailto:info@system-auto-parts.de">info@system-auto-parts.de</a></p>
	<p><b>Helio:</b> made in USA (Taiwan) motor: 1.700 W (cont.), 4.000 Wp battery: 2 x 12 V/34 Ah, sealed charger on board, 5 Ampere energy for 100 km: 1 kWh with recuperation max. speed: 37 km/h or as moped with 25 Km/h range: 32 - 40 km</p>	<p>hill climbing: up to 20% frame: aluminium L / W / H: 163 x 58 x 112 cm weight: 59 kg, load: 114 kg tires: 20 x 1,95 Zoll</p> <p>Information in Germany: Internet: <a href="http://www.egovehicles.de">www.egovehicles.de</a>. Tel. 06251 588 <b>Internet:</b> www.solar-mobil.de <b>e-mail:</b> info@solar-mobil.de</p>
	<p><b>Swizzbee Powerbike</b> Motor Heinzmann DC 24V, 270W Batterie NiCd (optional Metallhydrid)</p>	<p>Battery 7 Ah (optional 14 Ah) weight 26 kg incl. charger</p> <p>Internet: <a href="http://www.swizzbee.de">www.swizzbee.de</a></p>