Solar vehicle

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INTRODUCTION:

A **solar vehicle** is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions.

Solar vehicles are not sold as practical day-to-day transportation devices at present, but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies. However, indirectly solar-charged vehicles are widespread and solar boats are available commercially

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١ Limitation .

There are limits to using photovoltaic (PV) cells for vehicles:

- Power density: Power from a solar array is limited by the size of the vehicle and area that can be exposed to sunlight. While energy can be accumulated in batteries to lower peak demand on the array and provide operation in sunless conditions, the battery adds weight and cost to the vehicle. The power limit can be mitigated by use of conventional electric cars supplied by solar (or other) power, recharging from the electrical grid.

- Cost: While sunlight is free, the creation of PV cells to capture that sunlight is expensive. Costs for solar panels are steadily declining (٢٢% cost reduction per doubling of production volume).

- Design considerations: Even though sunlight has no lifespan, PV cells do. The lifetime of a solar module is approximately ٣٠ years. Standard photovoltaic's often come with a warranty of ٩٠% (from nominal power) after ١٠ years and ٨٠% after ٢٥ years. Mobile applications are unlikely to require lifetimes as long as building integrated PV and solar parks. Current PV panels are mostly designed for stationary installations. However, to be successful in mobile applications, PV panels need to be designed to withstand vibrations. Also, solar panels, especially those incorporating glass have significant weight. To be useful, the energy harvested by a panel must exceed the added fuel consumption caused by the added weight.

٢ Land .

٢.١ Solar car.

Solar cars depend on PV cells to convert sunlight into electricity to drive electric motors. Unlike solar thermal energy which converts solar energy to heat, PV cells directly convert sunlight into electricity.[١]

Solar cars combine technology typically used in the aerospace, bicycle, alternative energy and automotive industries. The design of a solar car is severely limited by the amount of energy input into the car. Solar cars are built for solar car races. Even the best solar cells can only collect limited power and energy over the area of a car's surface. This limits solar cars to a single seat, with no cargo capacity, and ultralight composite bodies to save weight. Solar cars lack the safety and convenience features of conventional vehicles.

Solar cars are often fitted with gauges and/or wireless telemetry, to carefully monitor the car's energy consumption, solar energy capture and other parameters. Wireless telemetry is typically preferred as it frees the driver to concentrate on driving, which can be dangerous in such a small, lightweight car. The Solar Electric Vehicle system was designed and engineered as an easy to install (٢ to ٣ hours) integrated accessory system with a custom molded low profile solar module, supplemental battery pack and a proven charge controlling system.

As an alternative, a battery-powered electric vehicle may use a solar array to recharge; the array may be connected to the general electrical distribution grid.

Ned, constructed in ١٩٩٩ by the South Australian Solar Car Consortium, can speed up to ١٢٠ km/h

٢.٢ Single-track vehicles:

A solar bicycle or tricycle has the advantage of very low weight and can use the riders foot power to supplement the power generated by the solar panel roof. In this way, a comparatively simple and inexpensive vehicle can be driven without the use of any fossil fuels.

Solar photo voltaics helped power India's first Quadricycle developed since ١٩٩٦ in Gujarat state's Surat city.

The first solar "cars" were actually tricycles or quadricycles built with bicycle technology. These were called solarmobiles at the first solar race, the Tour de Sol in Switzerland in ١٩٨٥ with ٧٢ participants, half using exclusively solar power and half solar-human-powered hybrids. A few true solar bicycles were built, either with a large solar roof, a small rear panel, or a trailer with a solar panel. Later more practical solar bicycles were built with foldable panels to be set up only during parking. Even later the panels were left at home, feeding into the electric mains, and the bicycles charged from the mains. Today highly developed electric bicycles are available and these use so little power that it costs little to buy the equivalent amount of solar electricity. The "solar" has evolved from actual hardware to an indirect accounting system. The same system also works for electric motorcycles, which were also first developed for the Tour de Sol. This is rapidly becoming an era of solar production.] With today's high performance solar cells, a front and rear PV panel on this solar bike can give sufficient assistance, where the range is not limited by batteries.

٢.٣ Applications:

The Venturi Astrolab in ٢٠٠٦ was hailed as the world's first commercial electro-solar hybrid car, and it was originally due to be released in January ٢٠٠٨.

In May ٢٠٠٧ a partnership of Canadian companies led by Hymotion altered a Toyota Prius to use solar cells to generate up to ٢٤٠ watts of electrical power in full sunshine. This is reported as permitting up to ١٥ km extra range on a sunny summer day while using only the electric motors.

One practical application for solar powered vehicles is possibly golf carts, some of which are used relatively little but spend most of their time parked in the sun.

An inventor from Michigan, USA has built a street legal, licensed, insured, solar charged electric scooter. It has a top speed controlled at a bit over ٣٠ mph, and uses fold-out solar panels to charge the batteries while parked.

Nuna ٣ PV powered car

٢.٤ Auxiliary power:

Photovoltaic modules are used commercially as auxiliary power units on passenger cars in order to ventilate the car, reducing the temperature of the passenger compartment while it is parked in the sun. Vehicles such as the ٢٠١٠ Prius, Aptera ٢, Audi A٨, and Mazda ٩٢٩ have had solar sunroof options for ventilation purposes.

The area of photovoltaic modules required to power a car with conventional design is too large to be carried onboard. A prototype car and trailer has been built Solar Taxi. According to the website, it is capable of ١٠٠ km/day using ٦$m^٢$ of standard crystalline silicon cells. Electricity is stored using a nickel/salt battery. A stationary system such as a rooftop solar panel, however, can be used to charge conventional electric vehicles.

It is also possible to use solar panels to extend the range of a hybrid or electric car, as incorporated in the Fisker Karma, available as an option on the Chevy Volt, on the hood and roof of "Destiny ٢٠٠٠" modifications of Pontiac Fieros, Italdesign Quaranta, Free Drive EV Solar Bug, and numerous other electric vehicles, both concept and production. In May ٢٠٠٧ a partnership of Canadian companies led by Hymotion added PV cells to a Toyota Prius to extend the range. SEV claims ٢٠ miles per day from their combined ٢١٥W module mounted on the car roof and an additional ٣kWh battery.

On ٩ June ٢٠٠٨, the German and French Presidents announced a plan to offer a cedit of ٦-٨g/km of $CO_٢$ emissions for cars fitted with technologies "not yet taken into consideration during the standard measuring cycle of the emissions of a car".This has given rise to speculation that photovoltaic panels might be widely adopted on autos in the near future

It is also technically possible to use photovoltaic technology, (specifically thermophotovoltaic (TPV) technology) to provide motive power for a car. Fuel is used to heat an emitter. The infrared radiation generated is converted to electricity by a low band gap PV cell (e.g. GaSb). A protoype TPV hybrid car was even built. The "Viking ٢٩" was the World's first thermophotovoltaic (TPV) powered automobile, designed and built by the Vehicle Research Institute (VRI) at Western Washington University. Efficiency would need to be increased and cost decreased to make TPV competitive with fuel cells or internal combustion engines.

٢.٥ Personal Rapid Transit:

Several Personal Rapid Transit (PRT) concepts incorporate photovoltaic panels.

JPods PRT concept with photovoltaic panels above guideways

٢.٦ Rail:

PV panels were tested as APUs on Italian rolling stock under EU project. PVTRAIN

PVTrain concluded that the most interest for PV in rail transport was on freight cars where on board electrical power would allow new functionality:

- GPS or other positioning devices, so as to improve its use in fleet management and efficiency.
- Electric locks, a video monitor and remote control system for cars with sliding doors, so as to reduce the risk of robbery for valuable goods.
- ABS brakes, which would raise the maximum velocity of freight cars to ١٦٠ km/h, improving productivity.

In addition to on-vehicle solar panels, there is the possibility to use stationary panels to generate electricity specifically for use in transport.

A few pilot plants have been built in the framework of the "Heliotram" project, such as the tram depots in Hannover Leinhausen and Geneva (Bachet de Pesay). The ١٥٠ kW_p Geneva site injected ٦٠٠V DC directly into the tram/trolleybus electricity network provided about ١% of the electricity used by the Geneva transport network at its opening in ١٩٩٩.

Direct feed to a DC grids avoids losses through DC to AC conversion. DC grids are only to be found in electric powered transport: railways, trams and trolleybuses.

٣. Water :

Solar powered boats have mainly been limited to rivers and canals, but in ٢٠٠٧ an experimental ١٤m catamaran, the Sun٢١ sailed the Atlantic from Seville to Miami, and from there to New York.

Japan's biggest shipping line Nippon Yusen KK and Nippon Oil Corporation said solar panels capable of generating ٤٠ kilowatts of electricity would be placed on top of a ٦٠,٢١٣ ton car carrier ship to be used by Toyota Motor Corporation.

In ٢٠١٠, the Tûranor PlanetSolar, a ٣٠ metre long, ١٥.٢ metre wide catamaran yacht powered by ٤٧٠ square metres of solar panels, was unveiled. It is set to circumnavigate the Earth and is so far the largest solar-powered boat ever built.

Various demonstration systems have been made. Curiously, none yet takes advantage of the huge power gain that water cooling would bring.

In ٢٠٠٧, the PV powered boat Transatlantic ٢١ successfully crossed the Atlantic Ocean power only by solar electricity.

Tûranor PlanetSolar, the world's largest solar-powered boat

٤. Air .

Solar ships can refer to solar powered airships or hybrid airships.

There is considerable military interest in unmanned aerial vehicles (UAVs); solar power would enable these to stay aloft for months, becoming a much cheaper means of doing some tasks done today by satellites. In September ٢٠٠٧, the first successful flight for ٤٨h under constant power of a UAV was reported. This is likely to be the first commercial use for photovoltaics in flight.

Many demonstration solar planes have been built, some of the best known by AeroVironment.

١. Manned solar planes

١.١ Gossamer Penguin,

١.٢ Solar Challenger - This plane flew ١٦٣ miles (٢٦٢ km) from ParisFrance to England on solar power.

١.٣ Sunseeker II - This plane is currently (May ٩) on a tour of Europe

١.٤ HB-SIA. Working prototype for Solar Impulse Project

٢. UAVs

٢.١ Pathfinder and Pathfinder-Plus - This unmanned plane demonstrated that an airplane could stay aloft for an extended period of time fueled purely by solar power.

٢.٢ Helios – Derived from the Pathfinder-Plus, this solar cell & fuel cellpowered UAV set a world record for flight at ٩٦,٨٦٣ feet (٢٩,٥٢٤ m).

٢.٣ Zephyr – built by Qinetiq, this UAV set the unofficial world record for longest duration unmanned flight at over ٨٢ hours on ٣١ July ٢٠٠٨

٣. Future projects

٣.١ Sky sailor (aimed at Martian flight)

٣.٢ Solar Impulse (aimed at manned circumnavigation of the globe)

٣.٣ various solar airship projects e.g. Lockheed Martin's "High Altitude Airship"

A solar-powered aircraft in Switzerland completed a ٢٦-hour test flight starting at ٧ a.m. on ٨ July ٢٠١٠ which ended at ٩ a.m. the next day. The plane was flown to a height of nearly ٢٨,٠٠٠ feet (٨,٥٠٠ meters) by Andre Borschberg. During the evening, the plane slowly descended to an altitude of ٤,٥٠٠ feet (١,٥٠٠ meters), where it remained for the rest of the night using battery power. An hour before dawn, the plane still had six hours of flying time left in its solar-fueled batteries.

Just ١٥ days later on ٢٣ July ٢٠١٠ the QinetiQ Zephyr, a lightweight solar-powered unmanned aerial vehicle engineered by the United Kingdom defence firm QinetiQ, claimed the endurance record for an unmanned aerial vehicle. It flew in the skies of Arizona for over ٢ weeks (٣٣٦ hours). It has also soared to over ٧٠,٧٠٠ feet (٢١.٥ km).

Gossamer Penguin

٥. Space .

٥.١ Solar powered spacecraft:

Solar energy is often used to supply power for satellites and spacecraft operating in the inner solar system since it can supply energy for a long time without excess fuel mass. A Communications satellite contains multiple radio transmitters which operate continually during its life. It would be uneconomic to operate such a vehicle (which may be on-orbit for years) from primary batteriesor fuel cells, and refuelling in orbit is not practical. Solar power is not generally used to adjust the satellite's position, however, and the useful life of a communications satellite will be limited by the on-board station-keeping fuel supply.

PV on the International Space Station

٥.٢ Solar propelled spacecraft.

A few spacecraft operating within the orbit of Mars have used solar power as an energy source for their propulsion system.

All current solar powered spacecraft use solar panels in conjunction with electric propulsion, typically ion drives as this gives a very high exhaust velocity, and reduces the propellant over that of a rocket by more than a factor of ten. Since propellant is usually the biggest mass on many spacecraft, this reduces launch costs.

Other proposals for solar spacecraft include solar thermal heating of propellant, typically hydrogen or sometimes water is proposed. An electrodynamic tether can be used to change a satellitte's orientation or adjust its orbit.

Another concept for solar propulsion in space is the light sail; this doesn't require conversion of light to electrical energy, instead relying directly on the tiny but persistentradiation pressure of light.

٥.٣ Planetary exploration:

Perhaps the most successful solar-propelled vehicles have been the "rovers" used to explore surfaces of the Moon and Mars. The ١٩٧٧ Lunokhod programme and the ١٩٩٧ Mars Pathfinder used solar power to propel remote controlled vehicles. The operating life of these rovers far exceeded the limits of endurance that would have been imposed, had they been operated on conventional fuels.

٦. Electric vehicle with solar assist

A Swiss project, called "Solartaxi", has circumnavigated the world. This is the first time in history an electric vehicle (not self sufficient solar vehicle) has gone around the world, covering ٥٠٠٠٠ km in ١٨ months and crossing ٤٠ countries. It is a road-worthy electric vehilce hauling a trailer with solar panels, carrying a ٦ m² sized solar array. The Solartaxi has Zebra batteries, which permit a range of ٤٠٠ km without recharging. The car can also run for ٢٠٠ km without the trailer. Its maximum speed is ٩٠ km/h. The car weighs ٥٠٠ kg and the trailer weighs ٢٠٠ kg. According to initiator and tour directorLouis Palmer, the car in mass production could be produced for ١٦٠٠٠ Euro. Solartaxi has toured the World from July ٢٠٠٧ till December ٢٠٠٨ to show that solutions to stop global warming are available and to encourage people in pursuing alternatives to fossil fuel. Palmer suggests the most economical location for solar panels for an electric car is on building rooftops though, likening it to putting money into a bank in one location and withdrawing it in another.

Louis Palmer standing in the Solartaxi.

Solar Electrical Vehicles is adding convex solar cells to the roof of hybrid electric vehicles.

٦.١ Plug-in hybrid and solar vehicles.

An interesting variant of the electric vehicle is the triple hybrid vehicle thePHEV that has solar panels as well to assist.

The ٢٠١٠ Toyota Prius model has an option to mount solar panels on the roof. They power a ventilation system while parked to help provide cooling. There are many applications of photovoltaics in transport either for motive power or as auxiliary power units, particularly where fuel, maintenance, emissions or noise requirements preclude internal combustion engines or fuel cells. Due to the limited area available on each vehicle either speed or range or both are limited when used for motive power.

PV used for auxiliary power on a yacht