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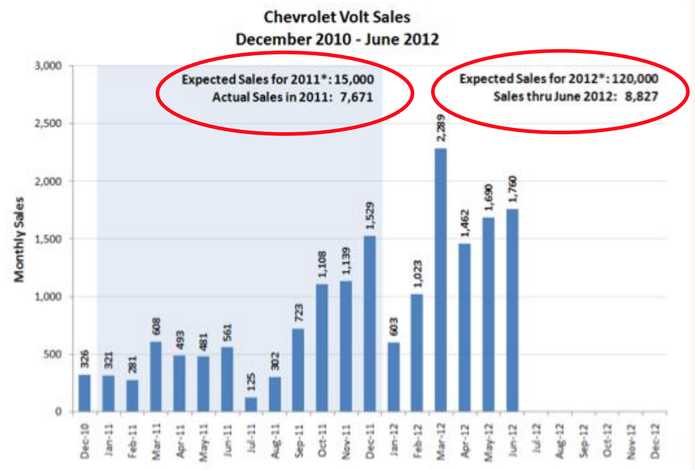
Solar Hybridization of Cars: a Short-Term Feasible Solution for Reducing Fuel Consumption and Emissions

Why car hybridization

In last decade, **Hybrid Electric Vehicles** (HEV) have been emerging as a feasible solution to the worldwide increasing consumption of petroleum fuels and, in turn, to the unbearable impact of carbon dioxide emissions of passenger cars fleets. However, the market share of hybrid and electric vehicles is still inadequate to produce a significant impact on fuel consumption and emissions. On the other hand, an **extensive reconversion** of the actual vehicle fleet to hybrid or electric in a short term scenario is rather **unrealistic**, due to the continuing effects of the economic crisis in many countries.



Converting a conventional car into a hybrid solar vehicle

The project **HySolarKit** focuses on the development and production of a kit (equipment, along with associated techniques and methodologies), aimed at converting conventional cars into hybrid solar vehicles, reducing fuel consumption and emissions, without affecting performance and safety. The kit could potentially be applied to the majority of existing vehicle fleet, specifically front-wheel drive cars. The idea has been **patented** by a group of researchers of the University of Salerno, with a wide international experience and numerous industrial collaborations (www.eprolab.unisa.it).

Photovoltaic Contribution

The integration of hybrid and electric vehicles with the **solar energy**, through **on-board photovoltaic panels**, can provide an important contribution to reducing both fuel consumption and emissions: during sunny days, photovoltaic energy can contribute up to 30% of the overall energy requested for vehicle traction, when vehicles are used for approximately one or two hours per day in urban areas (some recent statistics confirm that the majority of car users do not drive for longer time)- Photovoltaic **costs are constantly decreasing**, whereas, thanks to the continuous research efforts, electrical **efficiencies are growing**. Currently, high-efficiency (18%) flexible single-crystal silicon HF65 (ENECOM) photovoltaic panel have been installed on the vehicle roof and hood, for a total of about 270W of installed power.

Project development stage

A prototype of the hybridization kit has been developed and installed on a **FIAT Punto**, and preliminary **on-road tests** have demonstrated the **feasibility of the project**. The prototype, although not yet fully optimized, represents a successful proof-of-concept, having allowed to check possible critical issues related to in-wheel motors, battery, photovoltaic panels and control system. Different methodologies have been used to address on-line **energy management** of the kit, as well as offline investigation of maximum fuel economy: **fuzzy logic** is adopted to detect driver intention, facing the complex interaction between the driver and vehicle management unit, while an advanced **Dynamic Programming** optimization tool is used to evaluate the potential offered by the proposed hybridizing kit, and to providing a useful fuel savings benchmark.
Further work is in progress to: i) validate optimal and sub-optimal control strategies that are suitable for online implementation (i.e. real world application), ii) address both safety and functionality issues associated to car retrofitting, mainly due to the need of addressing the interaction among driver action on acceleration and brake pedal and the additional VMU; iii) improve functionality and performance of the prototype, by optimizing their components; iv) finally, develop a **Spin-Off company**, aimed to the development, production and commercialization of the solar hybridization kit to install in after-market on existing cars.

Acknowledgments

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Info and contacts

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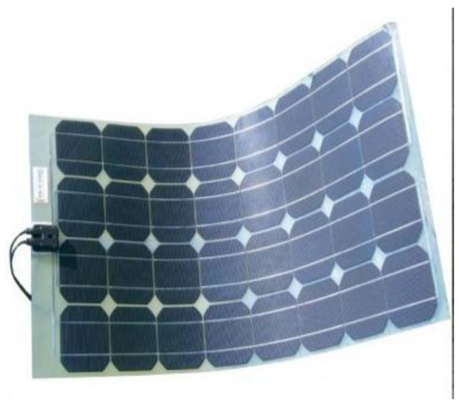
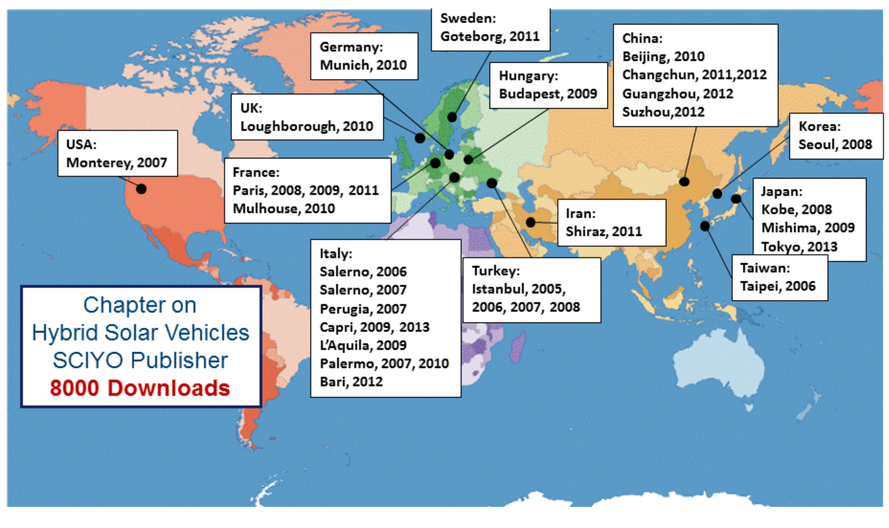
How does it work

The hybridizing equipment is installed on a **conventional car**, in which the **front wheels** are propelled by the Internal Combustion Engine (ICE) controlled by an Engine Control Unit. The vehicle is also equipped with an OBD gate (On Board Diagnostics), which allows accessing data such as pedal position, vehicle speed, engine speed and other variables.
A **Through-The-Road (TTR) parallel hybrid structure** is obtained by integrating the **rear wheels** with **in-wheel motors**. In that way, the vehicle can operate in pure **electric mode** or in **hybrid mode** (when the ICE drives the front wheels and the rear in-wheel motors operate in traction mode or in generation mode). The battery can be recharged both by rear wheels, when operating in generation mode, by **photovoltaic panels** or by **grid,** in **Plug-In** mode. The **Vehicle Management Unit** receives the data from **OBD gate**, from battery (SOC estimation) and drives in-wheel motors. A display on the dashboard may advice the driver about the actual operation of the system.



Price and payback

The **price** of the kit is estimated at about 4000 € for the pre-series production, then reducing to 3000 € or less. The payback for a consumer, in a short/medium term scenario (2-3 years) is expected to be about 3-4 years, with even lower values for the plug-in option (recharge from the grid). With respect to the purchase of a hybrid vehicle, costs are strongly lower. **Surveys on potential users** have shown that **most users are in favor of installation of such a kit on their car**. Moreover, there is a significant appreciation for car integration with solar panels.



Dissemination: The research on Hybrid Solar Vehicles has been presented in numerous conferences and seminars.
Awards: http://www.diin.unisa.it/eprolab/awards
Publications: http://publicationslist.org/grizzo