HySolarKit

Sustainable Transportation / Energy

Università di Salerno
Dipartimento di Ingegneria Industriale
ePROLAB
Energy and Propulsion Laboratory
www.eprolab.unisa.it

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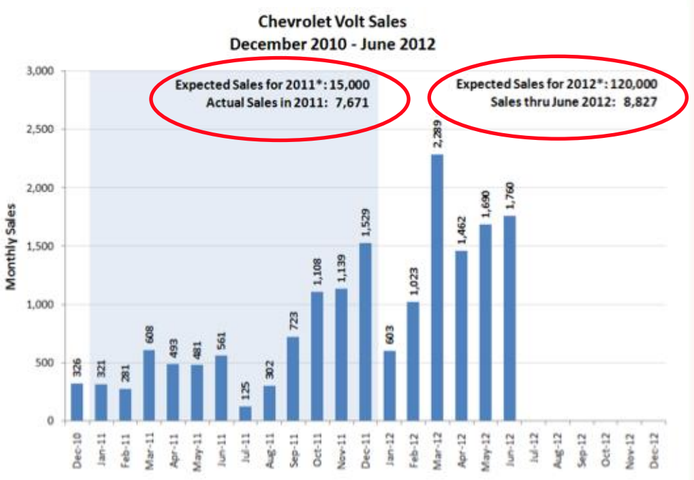
Solar Hybridization of Cars: a Short-Term Feasible Solution for Reducing Fuel Consumption and Emissions

Why car hybridization

In last decade, **Hybrid Electric Vehicles** (HEV) have emerged as a feasible solution to the reduction of fuel consumption and carbon dioxide emissions in passenger cars. 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 hour per day in urban areas (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 control strategies suitable for online implementation, 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.
A **Spin-Off company**, aimed to the development, production and commercialization of the solar hybridization kit, has been approved by the University of Salerno.

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.
Furthermore, it is worth noting that the proposed system could **augment vehicle performance**, in terms of drivability by i) **adding power to the existing powertrain**, ii) the possibility to **control each wheel separately** and iii) converting a two-wheel drive into an **all-wheel drive vehicle**.

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 is expected to be about 3-4 years for the hybrid configuration, with even lower values (1-2 years) for the plug-in option (recharge from the grid).
With respect to the purchase of a hybrid vehicle, **costs are strongly lower**.
Simulation results show that, in spite of the additional cost of the flexible PV panels, the kit configurations with **PV panels result in significantly lower payback time** for any in-wheel motor and battery configuration. Specifically, the average payback reduction that can be achieved by kit configurations including PV panels is about 20%, also partially **reducing the disadvantages due to a limited EV recharging infrastructure**.

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Market Target and Surveys

HySolarKit will aim at after-market opportunities, with typical customers being owners of conventional vehicles, who look for options to reduce fuel consumption.
HySolarKit can be installed on **most vehicles with front wheel drive** and **powered by any fuel** (gasoline, diesel, LPG, CNG, etc.) since it is not connected to the engine itself, but provides additional propulsion by means of an external device.
Furthermore, a **preliminary analysis focused on potential users** has been carried out. **Surveys on potential users** have shown that **most users are in favor of installation of such kit on their car**. Moreover, there is a significant appreciation for car integration with solar panels.
Specifically, users behavior was investigated through a stated preferences survey, which was "ad hoc" designed and carried out. The study, focused on two choice dimensions behavior - the interest towards the hybridization kit and the choice of installing or not – shows encouraging results both in terms of interest towards the kit itself and towards the **recourse to photovoltaic panels** installed on the vehicle, seen not only as a way to reduce consumption and emissions, but also as an **icon representing green mobility**.

Technical and Marketing Challenges

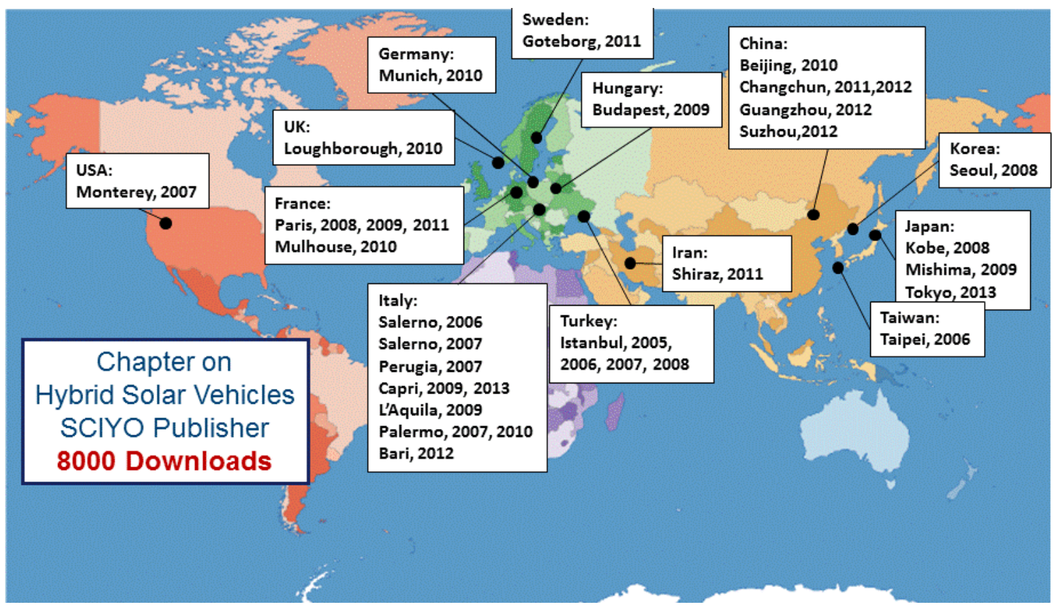
A key issue is the integration of the proposed kit into the original powertrain/structure of vehicles **without invalidating vehicle performance and safety**. A prototype of the hybridization kit has been developed and installed on a FIAT Punto, and **preliminary on-road tests have demonstrated the feasibility of the project**.
The prototype, although not yet fully optimized, represents a **successful proof-of- concept**, having allowed checking possible critical issues related to in-wheel motors, battery, photovoltaic panels and control system.
The prototype has been developed on one specific make and model (FIAT Punto), but **it could be potentially suitable for other make and models** (universal solution). If we consider the percentage of drivers willing to improve fuel economy by means of conversion kits (LPG, CNG, etc) **the market is clearly huge** (190.000 vehicles just in Italy only for FIAT Punto). Our preliminary business model proposal shows **very positive investment indexes even with 1% share of the potential market**.

Competitive Advantages and Innovation

The idea has **original and innovative characteristics** in the idea of combining photovoltaic recharge with the hybridization kit. Competitive advantages of the team are represented by i) **existing patent** on the technology and methodologies behind the development of HySolarKit, ii) **extensive expertise** in alternative automotive powertrain, and iii) **wide network of industrial partners**. The proposed solar-hybridization kit is protected by an **Italian and EU patent**, and a **working prototype has been developed**.

Staff Qualifications

The research group of the Energy and Propulsion Laboratory at the University of Salerno (**eProLab**) has a long term and **widely internationally recognized expertise in automotive and energy applications**, with numerous projects and cooperation with industry, other universities and research centres, and leading of international institutions (Chairship of **IFAC TC Automotive Control**). A former prototype of Hybrid Solar Vehicle has been developed within an European project (recipient of the DiVa Award for valorization and dissemination). Numerous **awards** have been received by the researchers of eProLab (www.eprolab.unisa.it).
A **list of publications** is available at publicationslist.org/grizzo
The research on Hybrid Solar Vehicles has been **presented worldwide** in numerous conferences and seminars: **subscribe our Newsletter** at www.hysolarkit.com.



Potential Partners

Collaboration opportunities are being considered with the following partners:

Bertone, founded in 1912, is one of the oldest and most prestigious Italian firms in the car sector and has accompanied its technological and stylistic evolution through its first hundred years. Over the years, the world's most important manufacturers have commissioned BERTONE to create vehicles on the leading edge of styling, technology and performance.
http://www.bertone.it/gruppo/stile/automotivedesign.aspx

The Research Institute of Automotive Engineering and Vehicle Engines Stuttgart (FKFS) is a public-law foundation and was founded in 1930. It is one of the best-known German research institutes and partner of the international automotive and supplier industry.
http://www.fkfs.de/english/

HySolarKit: a spin-off company of the University of Salerno, aimed to the development, production and commercialization of the after-market solar hybridization kit.
http://www.hysolarkit.com/default_EN.php

Landi Renzo, a world-leading company serving more than 30% of the market for LPG and CNG alternative automotive fuel systems and components
http://www.landi.it

"Coast to Coast E-Mobility" Program is a public-private partnership promoting knowledge and innovation exchange between US and Dutch governments, universities and private organizations, identifying new opportunities and assisting these organizations to connect within the respective E-mobility fields.
http://coast2coastev.org

Enecom is an Italian company producing lightweight, thin and highly efficient photovoltaic flexible panels based on crystalline silicon technology.
http://www.enecomitalia.com/ENG/company.html

Info and contacts

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Acknowledgments

The research on solar hybridization of cars has been financed by a grant from Ministry of Education, University and Research (MIUR), within **PRIN 2008**, in cooperation with University of Sannio.