Performance Evaluation of an Autonomous Photovoltaic System for Recharging Electrical Vehicle Batteries

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Abstract– **This paper deals with the performance evaluation of an autonomous photovoltaic system for recharging (with electrical power produced by photovoltaic panels) Lithium-ion batteries for an electrical vehicle. In this system, the power flow control is performed via a DC-DC converter using a Maximum Power Point Tracking (MPPT) technique. The performance evaluation is according to two operation modes: under degraded and optimal conditions.**

Index Terms —**Autonomous photovoltaic system, DC-DC converter, Electrical vehicle, Lithium-ion battery, MPPT control.**

I. INTRODUCTION

FOR the last two centuries, emissions of certainpolluting gases from human activities have intensified the phenomenon of green house effect leading to warmer temperatures on earth. Consequently, the international community has been mobilized to limit atmospheric concentrations of greenhouse gases with the goal ofhalving global emissions by 2050. Several solutions have been proposed by researchers and the Electrical Vehicle (EV) is one of the most promising alternatives for the transportation problem.

Unlike the conventional vehicles on road today which are major consumers of fossil fuels like gasoline, an EV is propulsed by electricity which can be stored in rechargeable batteries. The EVs are becoming more attractive with the advancement of new battery technologies that have higher power and energy density and allow matching the requested autonomy and vehicle dynamics. Electrical vehicle batteries are recharged using either the grid (G2V: Grid to Vehicle) or using renewable energies in a stand-alone recharging point (H2V: Home to Vehicle).

A battery is a device which converts chemical energy directly into electricity. It is an electrochemical galvanic cell or a combination of such cells which is capable of storing chemical energy. The first battery was invented by Alessandro Volta in the form of a voltaic pile in the 1800's.

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II. BATTERIES TECHNOLOGIES AND RECHARGING TOPOLOGIES

Batteries can be classified as primary batteries, which once used, cannot be recharged again, and secondary batteries, which can be subjected to repeated use as they are capable of recharging by providing external electric current.

TABLE I
DIFFERENT BATTERIES TECHNOLOGIES [2]

	Lead-Acid	Ni-Cd	Ni-MH	Li-Ion	Li-Polymer
Specific Power [W/kg]	80-150	150-400	200-1000	500-4000	315
Cycle Life	500	1350	1350	1000	600

Batteries are more desirable for the use in vehicles, and in particular traction batteries are most commonly used by EV manufacturers. Traction batteries include Lead-Acid type, Nickel-Cadmium (Ni-Cd), Lithium-Ion (Li-Ion), Lithium-Polymer (Li-Polymer), Sodium-Nickel Chloride (Na-Ni-Cl), Nickel-Zinc (Ni-Zn).

Although some storage technologies could work for several applications, in the most part, they are not economically applicable to different functional categories. Their assessment must be done on the basis of several parameters which establish their applicability: power level (nominal, pulsed), energy storage level (at different charge and discharge rates), memory effect, power density, energy density, overall cycle efficiency, life-time (number of cycles and performance), operative characteristics, environmental impact, recycle opportunities, investment and maintaining costs. Table I summarizes some of the commonly used batteries and their properties [3-4].

Most of EV batteries need to incorporate onboard or offboard chargers allowing the battery recharging anywhere there is an electric outlet.

The onboard chargers are limited in output power because of size and weight restrictions dictated by the vehicle design.

The output power of an off board charger is limited by the capacity of battery to accept the charge. Although these chargers are outside of the vehicle (lighter weight) and have high power (less time to recharge the batteries), adaptability to charge at different places is limited [5].