Hybrid supercapacitors contributions to intra-urban transport ecosystem based on RES for seasonal tourism

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Abstract

This poster presents a development based on batteries and hybrid supercapacitors (HSC) for their application in light electric vehicles (EV) recharging points, in tourist coastal environments.
These energy storage systems (ESS) have differentiating characteristics that are discussed in the document.
It details the main equipment and capabilities of the testing facilities, and the preliminary tests performed by INTA, the Spanish National Institute for Aerospace Technology, in the framework of the project TTUES (Urban Touristic Transport at Sustainable Environments).
System design is presented with the multi-configuration for energy supply.
The experimental results validate the HSC system for its application.

Objectives

- Promote the implementation of a sustainable transport, using specifically designed and tested light and small-sized electric vehicles, and suitable charging stations based solely on renewable energy sources (RES).
- Design, develop and validate an energy supply system for those vehicles.
- Experimentally demonstrate the capabilities of a HSC system in comparison to other ESS.
- Analyze real hybridization of a HSC system.
- Research and technological development and knowledge transfer.

System design

The complete supply and recharge system for EV is shown in Figure 1. The HSC system is contemplated for recharging from RES, as well as bidirectional charging and discharging from the grid and the DC bus.

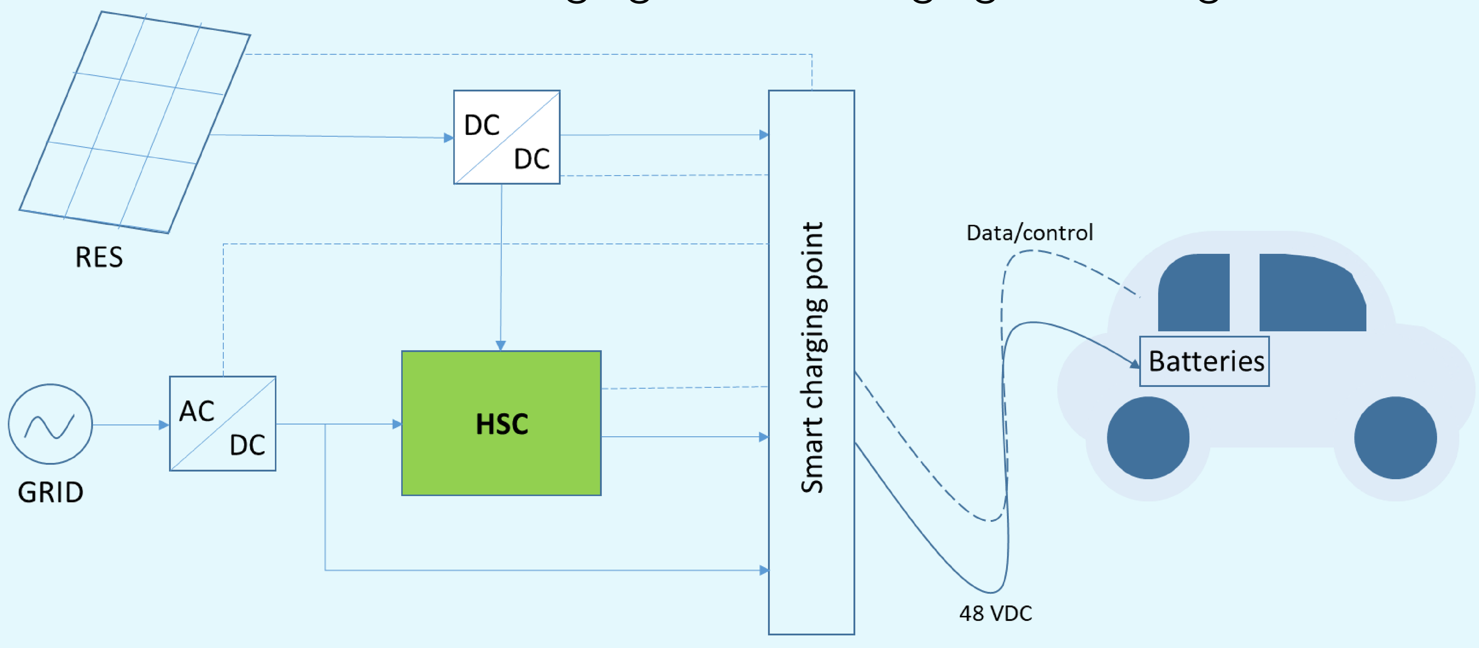

Figure 1. V2G smart charging point with HSC - TTUES

Tests

Figure 2 shows the physical implementation of the HSC system for its experimental validation. These tasks will be carried out at the Energy Laboratory that INTA owns at Huelva, SW of Spain, which includes adequate experimental testing facilities for these goals, such as a microgrid (integrates RES generation, electrical energy storage systems and several loads) that allows the testing and evaluation of components and technologies, at pilot plant scale, in real operating conditions, and batteries and super-capacitors test benches that allow the testing of energy storage equipment in controlled conditions.

Figure 2. HSC experimental system

Controlled **30 A** discharged is applied to the HSC, Figures 3,4.

- HSC energy during discharge is measured with a maximum of **2691 Wh** supplied during test, Figure 3, achieving almost rated energy (**2,8kWh**). Then specific energy is around 37 Wh/kg.
- Voltage goes from **51,77 V** (almost maximum 52 V)to **35,9 V** (cut-off voltage) during the **30 A** discharge, Figure 4. Therefore power directly supplied goes from **1,5 kW** to **1 kW**. At this power, the HSC system will fit a fully recharge of commercial HEV vehicles in around 12 hours [3], [4] while would only need around 4 hours for light HEV models [5].

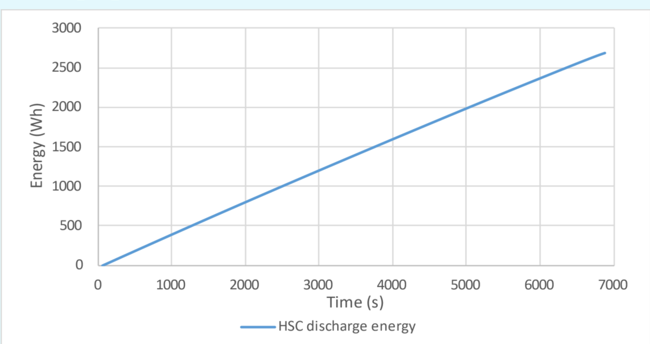

Figure 3. HSC Energy

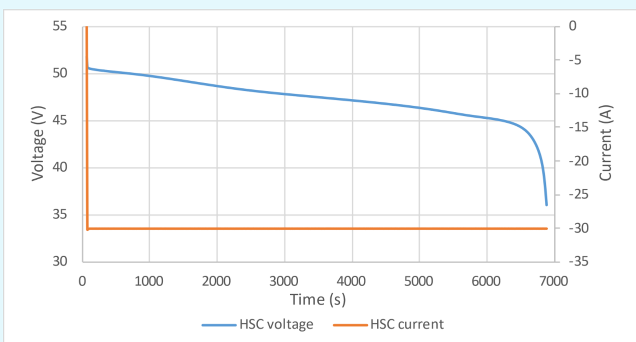

Figure 4. HSC Voltage-Current (at 30 A)

Results

Once the characterization of the EV recharging application, based on HSC, has been carried out, the implementation of the system indicated in Figure 5 is proposed. HSC and battery characteristics are showed in Table 2.

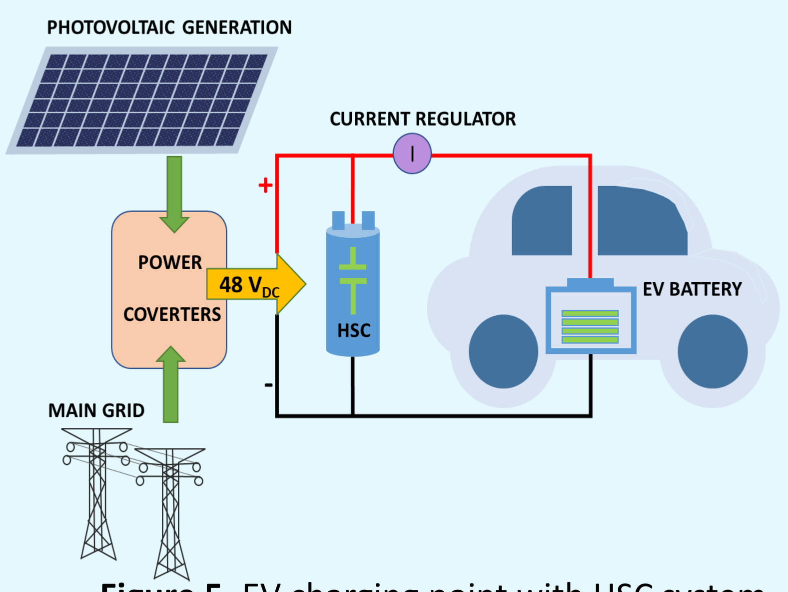

Figure 5. EV charging point with HSC system

Parameter	HSC	EV Battery
Voltage (V)	48	48
Power (kW)	36	4
Current $_{MAX}$ (A)	750	40
Energy (kWh)	2.7	2
Capacity (Ah)	56.1	40

Table 2. System Specifications

Introduction

Implementation of an intra-urban transport ecosystem, based on fleets of light electric vehicles charged from RES, could be a great solution for seasonal tourism in areas of special interest, such as tourist beaches, where main problems are usually larger traffic congestion, lower competitiveness for hotels that are not close to the beach, greater acoustics and air pollution, degradation of high-value natural environments and decrease in the citizens' comfort.
RES use at local scale reduce the environmental impact, maximizing the effect as production and consumption are carried out in the same location, limiting the losses associated with distribution networks, and minimizing the impact on the landscape for these touristic areas [1].
These local RES grids, commonly referred as microgrid, are based on ESS to maintain the energy storage and act as a buffer between the RES and the EV recharging point.
Most common ESS are compared to HSC in Table 1. Batteries provide high specific energy (Wh/kg), with limited specific power (W/kg). Supercapacitors provide high specific power with reduced specific energy, providing faster refueling but with limited quantity of EV that can be refueled since energy capacity limitation. Hybrid supercapacitors are a promising ESS alternative with higher specific energy than supercapacitors, maintaining a balanced specific power [2].

Table 1. Energy storage systems analysis

Energy Storage System	Specific Energy (Wh/kg)	Specific Power (W/kg)
Lead Acid Batteries	20-50	25-300
Lithium Ion Batteries	75-200	100-360
Supercapacitors	0,2-15	100-5000
Hybrid supercapacitors	20-30	3000-14000

Conclusions

HSC systems have great advantages for EV charging points. They combine a balance between power and specific energy, reducing the contaminating material and increasing the lifetime of batteries with which they are configured in hybridization.
The system has been validated for its application according to its specifications and compared with the needs of commercial vehicle recharging.
The following future works framed in this project will deal with its integration with the charging point based on the designed system.

References

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The project TTUES (Ref. 0517_TTUES_6_E) is co-financed by the European Regional Development Fund (ERDF), within the INTERREG VA Spain-Portugal cooperation programme (POCTEP).