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How to Develop an Energy Storage System using Electric Vehicle Second Life Batteries

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Summary

Within ELSA EU-Project [1], Renault is developing with its partners an Energy Storage System based on second life EV batteries. The design of the system is focused on the 3 essential features for a sustainable and efficient solution:

- Cost efficiency by optimizing the power electronics components and re-using the battery as it is
- Management of the battery diversity with an architecture that allows to mix different EV battery types
- Storage as a Service with several use-cases addressed to stack revenues and maximize the ROI.

Keywords: Second-life battery, energy storage, cost.

1 Header

Storage is one of the core elements of the forthcoming energy supply system to enable an increasing local production of renewable energy sources (RES) with fluctuating power output. Storage is actually a key enabler to accelerate the Smart Grid transition, as outlined by European climate and energy policy.

Renault, the leader of EV markets in Europe, has developed a specific offer where the batteries are leased. Customers benefit then from an accessible price for their Renault EVs and a lifespan warranty. In this system Renault keeps the ownership of the batteries which are carefully controlled. Thus Renault can replace for free any battery if the service provided by this battery is estimated insufficient for mobility usage.

Within the ELSA EU-Project and with all the partners involved [2], Renault does not only give additional life to electric vehicle batteries before they are recycled, but also creates stationary storage solutions that comply with the high safety standards required for electric vehicle batteries in a cost-effective manner. ELSA proposes scalable, easy-to-deploy energy storage solutions for factories, large offices and residential buildings and districts.

The goal is to design, develop and validate an industrial energy storage system based on second life batteries to reduce production, installation and maintenance costs. This enables a large penetration in the European market of local storage for electricity grid support based on used electric vehicles batteries.

The project Energy Local Storage Advanced system (ELSA) receives funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 646125.

2 Collaborative System Development

The development of the Energy Storage Systems involves Renault – already the biggest owner of EV batteries worldwide –, and major industrial companies from power electronics, electricity, construction sectors.

A collaborative engineering context is set up between the different companies. The work allocation between partners is established with regards of each one specific skills and know-how and described in the Roles, Accountability and Responsibility Matrix.

To deal with the requirements of the system, we are applying the system engineering process. It allows the identification, the quantification and the rationale of system requirements. A dedicated system engineering tool is used to lead the specifications and define the functional and physical architecture of the system. Both of these tasks are leading us to the global design of the system and the choices for the technology of each sub-system in order to respond to all requirements.

3 Low cost and scalable energy storage system

To tackle the cost optimization objective of the system the effort is made on the battery and the system architecture & components.

3.1 Second life batteries

The use of 2nd life batteries is the main asset for cost optimization of the Electrical Storage System. Price for such batteries is around 50% below price for new one. Although the batteries are not suitable anymore for EV car usage the capacity and the reliability are still high.

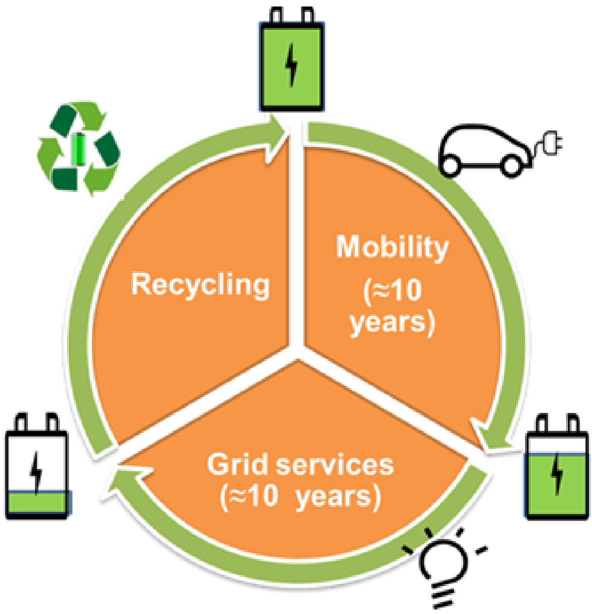

Figure1: EV battery life Cycle

The condition to preserve the economic advantage of used batteries is to exclude any modification of them. The full battery pack is removed from the vehicle and reused in the storage system with no transformation, no dismantling and no sorting.

In order to confirm the level of available storage capacity (15kWh for current Kangoo used batteries), every battery pack will be tested following a predefined quality check procedure (external aspect, connectors conformity …). Original connectors for power & signal connections are also re-used in the Energy Storage system.

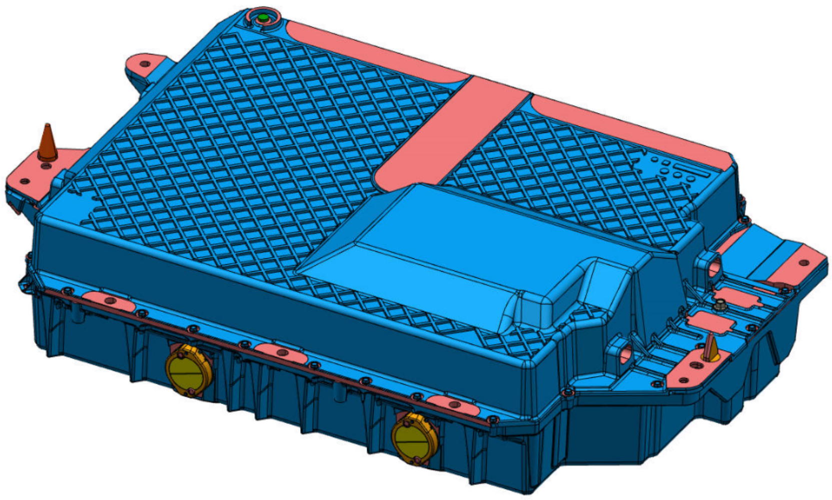

Figure 2: Example of EV battery pack

Using the battery in a Stationary Energy Storage System brings some new requirements on the component.

As an example, the arrangement of the battery in such a system needs to be flexible whereas it is not the case for a vehicle. Thus, it had to be confirmed that Renault battery pack can be set up in horizontal and vertical position.

Each specific requirement was analysed and considered in the system design. Either the battery shows full compatibility with the requirement or the requirement is handled by the other components of the system.

The detailed characteristics of the used battery and the recommendations related to safety and cycling or storage conditions are listed in a dedicated data-sheets available for each battery type.

3.2 System architecture & Power electronic components

The purpose is to design an industrialized low cost power converter with Renault EV used batteries, reducing by 30% the cost compared to storage systems with new EV batteries or non-EV batteries.

As previously mentioned, in case of using non-sorted used battery packs, some specific requirements have to be highlighted to precise the storage system specifications. One of them is the ability to handle different batteries with different voltages and different CAN message set.

Starting from the existing architecture of prototypes, a consultation with different architecture proposals is issued to several power electronics suppliers. Supplier’s feedbacks on shelf components and roadmap to adapt to EV used batteries characteristics enable us to define the TRL9 architecture. A supplier is chosen for the prototyping of the solution and the validation. The final design is compliant with the fixed cost target.

The software of the system is also a key component. Part of the development made for the vehicle is re-used for the internal control of the storage system and adapted to various specific use cases of the project.

4 Storage as a service

The electricity system is changing from a model including generators and consumers with one-way electricity flow to a model integrating renewable sources and distributed generation enabling two-way flows managed by smart technologies. This changes represent a challenge for the electricity system but also an opportunity for the customers able to provide Demand Side Response (DSR) and help balance the grid, reduce the need for new generation plants, avoid the need of reinforcement of the electrical infrastructure, contribute to the development of greener and more sustainable system.

Within ELSA project a paper study was performed on some European countries to assess the most profitable applications for the battery storage systems oriented in two main directions: Grid services and Electricity consumption cost optimisation.

Both types of services (Grid and electricity consumption cost optimisation) must be provided by the system for it to be exploited in an economically sustainable way.

The effort is currently made on developing an innovative local ICT-based Energy Management System to interface the storage with the EMS or with the distribution grid. The service provided with this system gives to the energy managers the ability to negotiate the storage capacities (local or pre-aggregated) according to their needs. The existing Web/IP based communication standards for Automated Demand Response (ADR) are also to be integrated.

References

[1] *ELSA*, http://www.elsa-h2020.eu

[2] *ELSA consortium* consists of 10 members from five EU countries: Bouygues Energies & Services, Renault SAS, Nissan West Europe SAS, RWTH Aachen University, United Technologies Research Centre Ireland Limited, Engineering Ingegneria Informatica S.p.A., B.