Hybrid energy storage systems for renewable integration in rural grids

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The challenge: To maximize the efficiency hosting capacity for renewables in LV rural networks

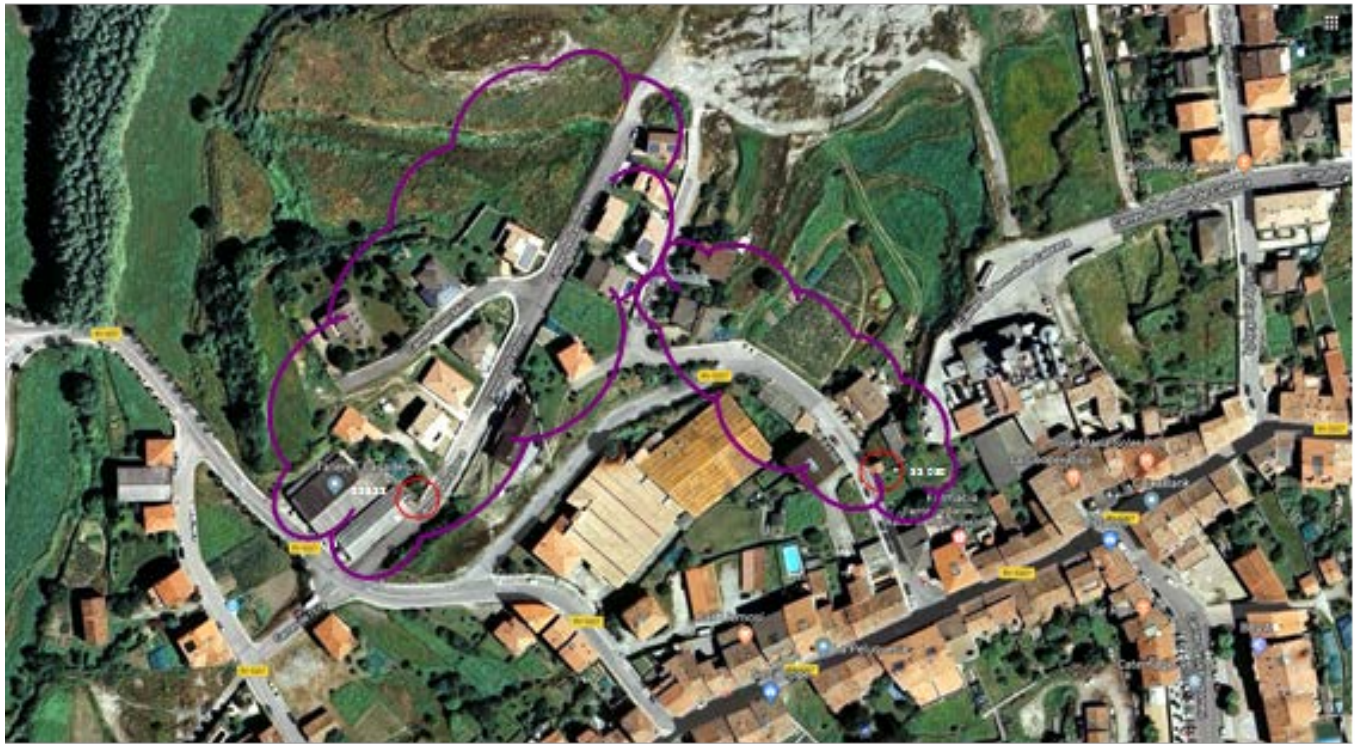

Figure. Resolvd demo site. L'Esquirol (Catalonia)

- Weak grid
- Dispersed consumption / generation
- Voltage deviations
- Current harmonics / power unbalances
- Security of supply issues
- Need for self-healing capability
- Need for enhanced monitoring and management

The solution: H2020 Resolvd project

- The objective is to **improve the efficiency and the hosting capacity of distribution networks**, in a context of highly distributed renewable generation by introducing flexibility and control in the low voltage grid.
- An **innovative advanced power electronics device, with integrated storage** management capabilities, will provide both switching and energy balancing capacities to operate the grid optimally.

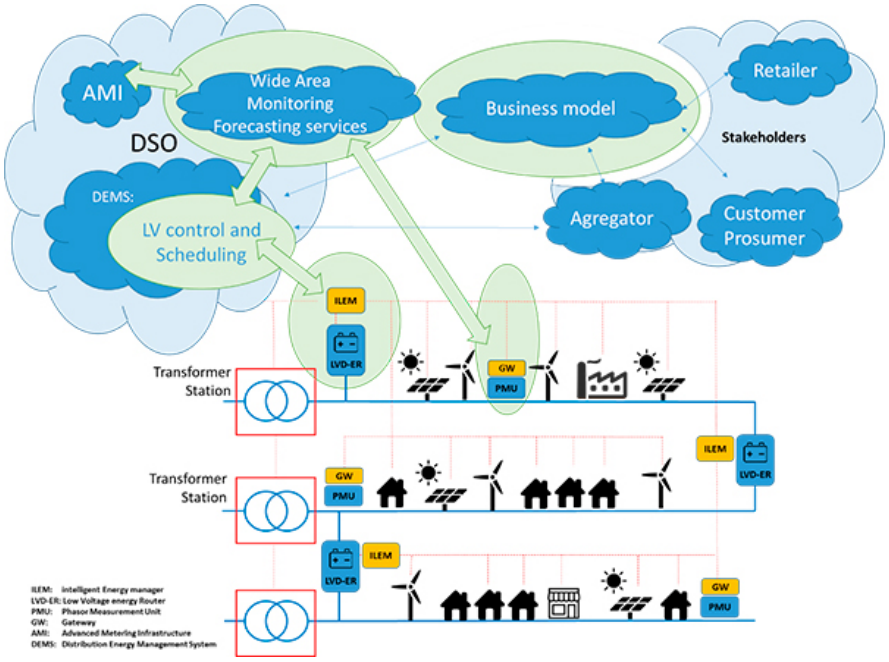

Figure. Resolvd ecosystem

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RESOLVD

LCE-01-2016-2017
European Union's Horizon 2020
Under grant agreement No 773715

Renewable penetration levered by Efficient Low Voltage Distribution grids

FACT

To store energy is expensive

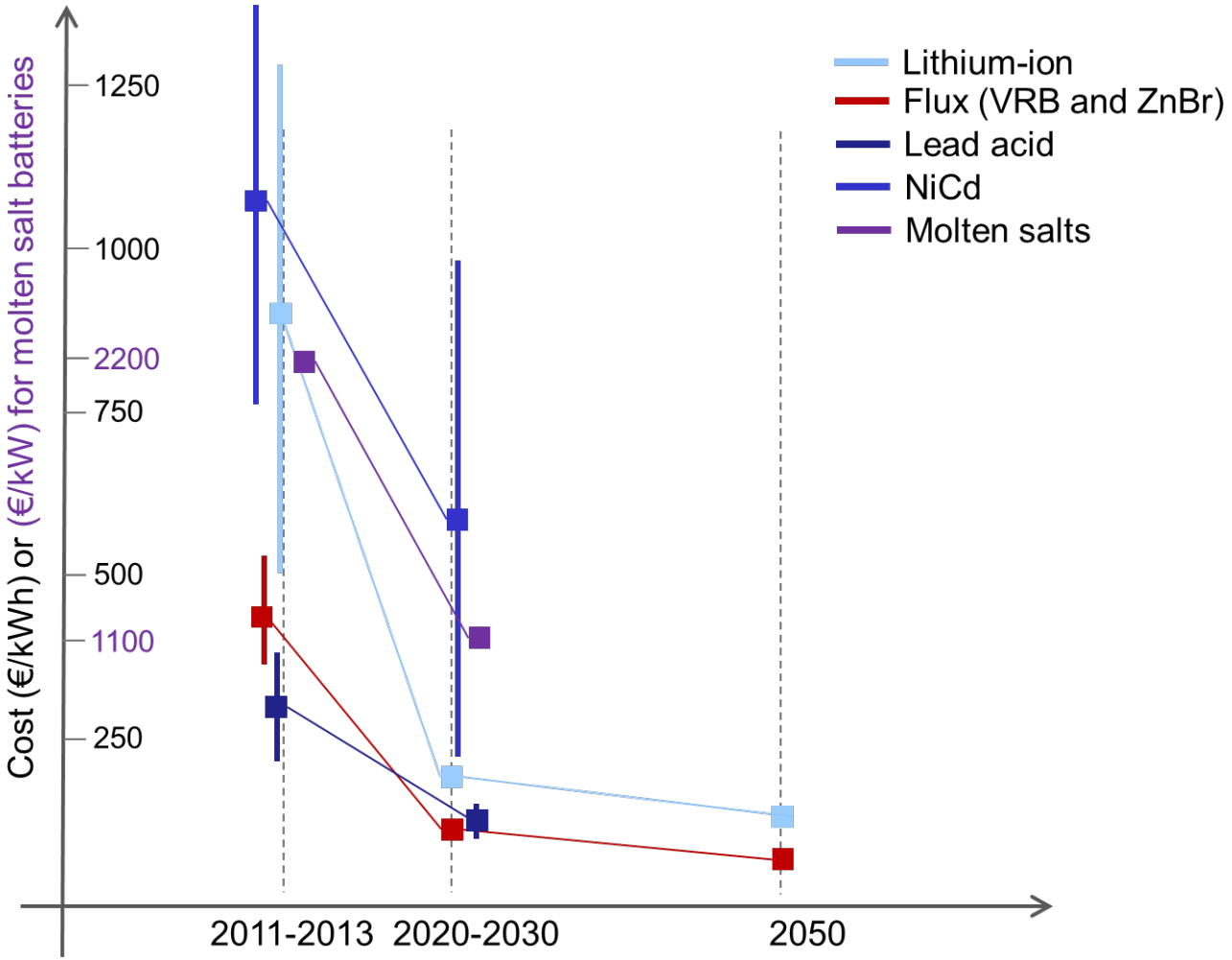


Figure. Forecasts on capital costs. Source: the author. Source of the data: (European Commission, 2011), (EASE/EERA, 2013)

FACT

Usually, a room has walls

Table. Summary of representative data for different types of batteries. Source: the author.

Type	Subtype	Nominal voltage (V)
Lead acid	LA (valve regulated)	2,00
	LA (flooded)	2,00
Alkaline	NiCd	1,30
	NiMH	1,30
Molten salts	NaS	2,10
	$Na/NiCl_2$	2,58
Lithium-ion	$C/LiCoO_2$	3,60
	$C/LiNiCoMnO_2$	3,70
	$C/LiFePO_4$	3,30
	$C/LiMn_2O_4$	3,70

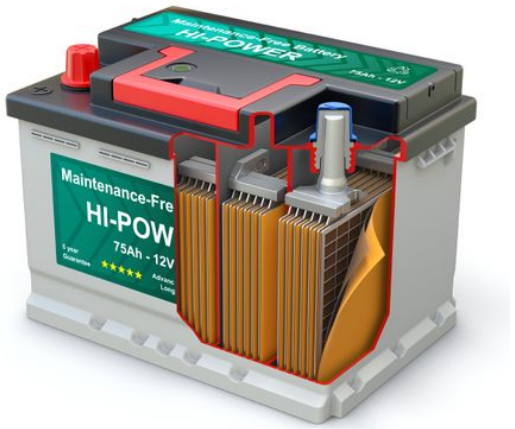
FACT

A dog is a dog, and a cat is a cat

Table. Summary of representative data for different types of batteries. Source: the author.

Type	Subtype	Nominal voltage (V)	Cyclability	Maximum rate of discharge
Lead acid	LA (valve regulated)	2,00	1200 (80% DoD; C/8)	1C cont.
	LA (flooded)	2,00	1800 (80% DoD; C/8)	1C cont.
Alkaline	NiCd	1,30	800 (80% DoD; C/8)	1C cont.
	NiMH	1,30	800 (80% DoD; C/8)	10C cont.
Molten salts	NaS	2,10	4500 (80% DoD; 1C)	1C cont. / 5C peak (30s)
	$Na/NiCl_2$	2,58	3000 (80% DoD; 1C)	1C cont. / 5C peak
Lithium-ion	$C/LiCoO_2$	3,60	3000 (80% DoD; 1C)	1C cont.
	$C/LiNiCoMnO_2$	3,70	2500 (100% DoD; C/2)	5C cont. / 30C peak
	$C/LiFePO_4$	3,30	>3000 (100% DoD; 1C)	35C cont. / 125C peak
	$C/LiMn_2O_4$	3,70	>2000 (100% DoD; 1C)	10C cont. / 40C peak

Source: http://i03.yizimg.com/



Source: http://trekwithus.com/

How could we integrate different types of batteries? Modularity & Flexibility

- Power electronics being developed in the project are modular, easy scalable and flexible in operation. These can integrate an **heterogeneous grouping of energy storages** for grid support (30 kWh lithium-ion pack + 14 kWh lead-acid)

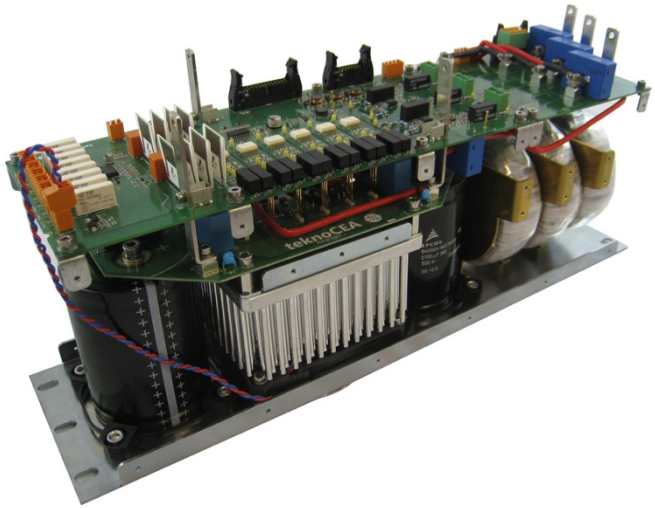


Figure. Power electronic modules of the system being designed in Resolvd Project

Capabilities of the advanced power electronics

- What are the advanced potentialities of the power electronics device?

- Current harmonics compensation
- Reactive current compensation
- Phase unbalance compensation

- Local renewable generation integration
- Energy management in grid connected / islanded mode

- Integration of variety of battery types and vendors (e.g. lithium-ion second-life batteries from Evs)
- Development of reduced cost high performance hybrid storages

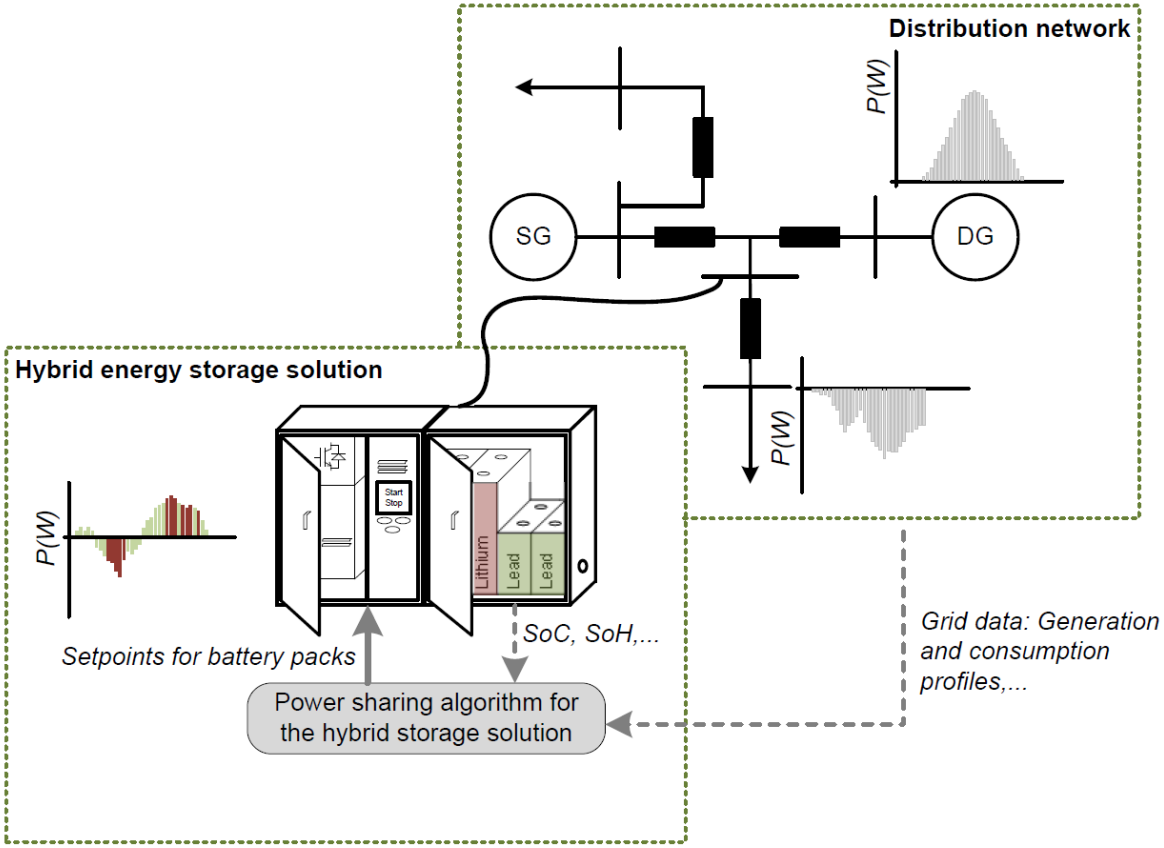
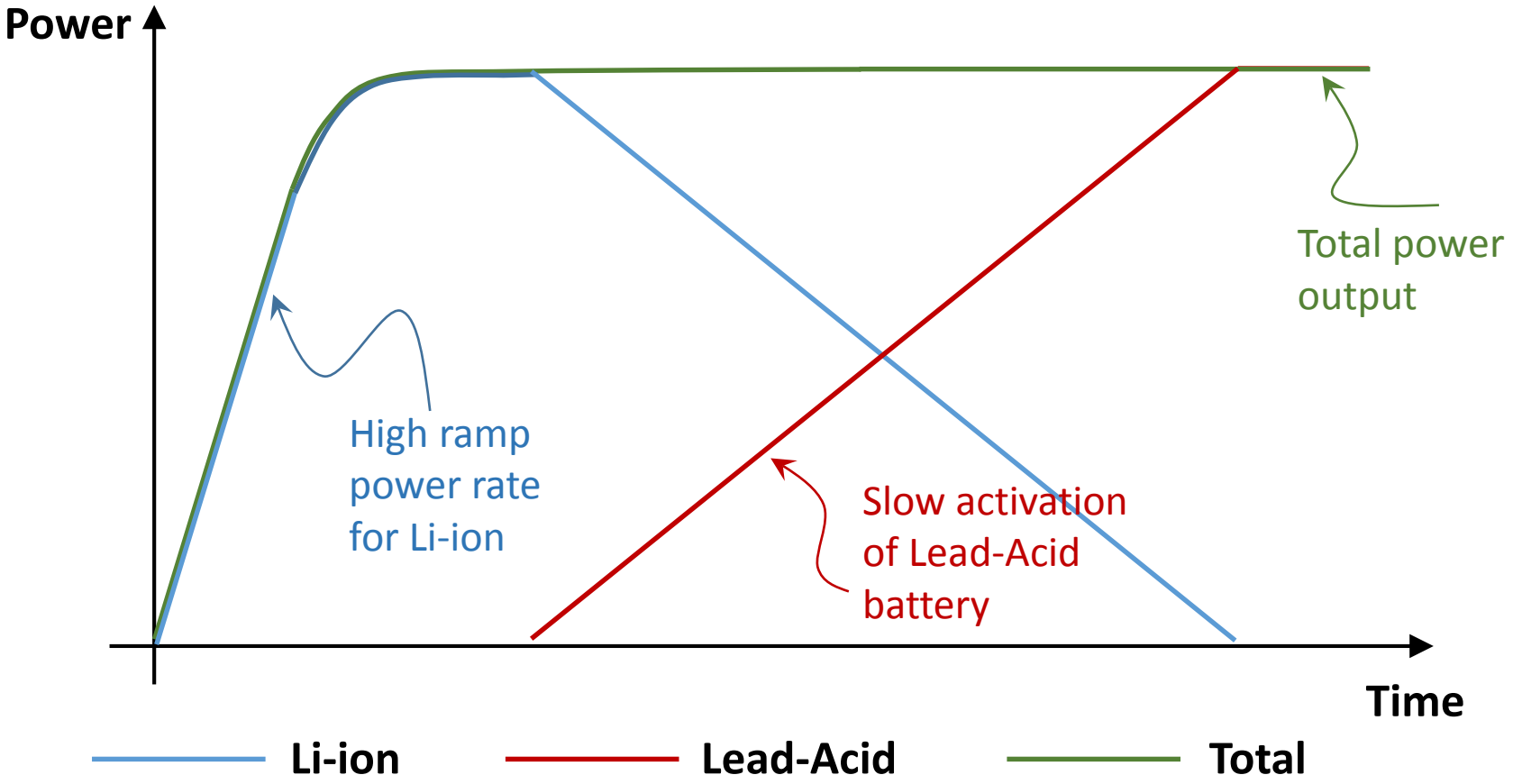


Figure. Exploitation of the hybrid energy storage system in grids

Smart operation of the hybrid battery bank

- **Power sharing strategy** for minimum operation cost



Thanks for your attention

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Questions?

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