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SUPPORTING PV:

ELECTRICITY STORAGE: REQUIREMENTS, EXPERIMENTAL RESULTS AND TOOLS

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INSTITUT NATIONAL DE L'ENERGIE SOLAIRE

WHO WE ARE ?

Atomic Energy and Alternative Energies Commission
French public establishment founded in 1945
Owns AREVA
10 research centers
16,000 specialized staff
$6bn annual budget
700 patents per year
500 industrial partners

Nuclear Energy Division

Defense Division

Fundamental Research

Technological Research Division

LITEN - Laboratory for Innovation in New Energies Technologies
1200 staff
$250m annual budget

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Requirements for higher PV grid penetration

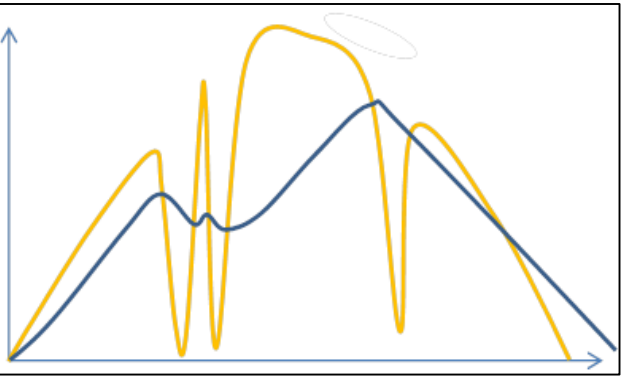
- The overwhole power grids
- The distribution networks
- The final consumers

PV INTEGRATION IN ELECTRICITY CONSUMPTION/PRODUCTION BALANCE PLANNING

Transmission System Operators: need to manage/plan consumption/production balance

Storage necessary for output control and forecast errors compensation

⇒ **Requirement to control power fluctuations and to support frequency**

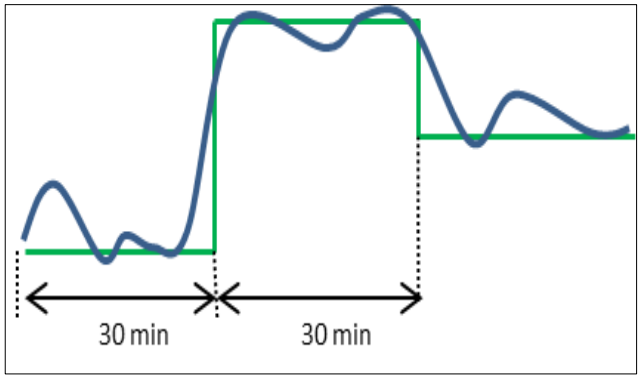


PREPA RFP

Puerto Rico

production smoothing

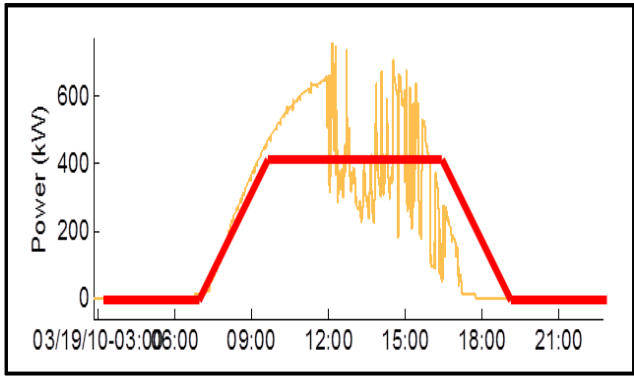
+ f/U primary regulation



French islands windpower tariff

Production forecast and limited variation of real production

+ f/U primary regulation



French islands 2012 RFP

Trapezoidal production pattern with forecast

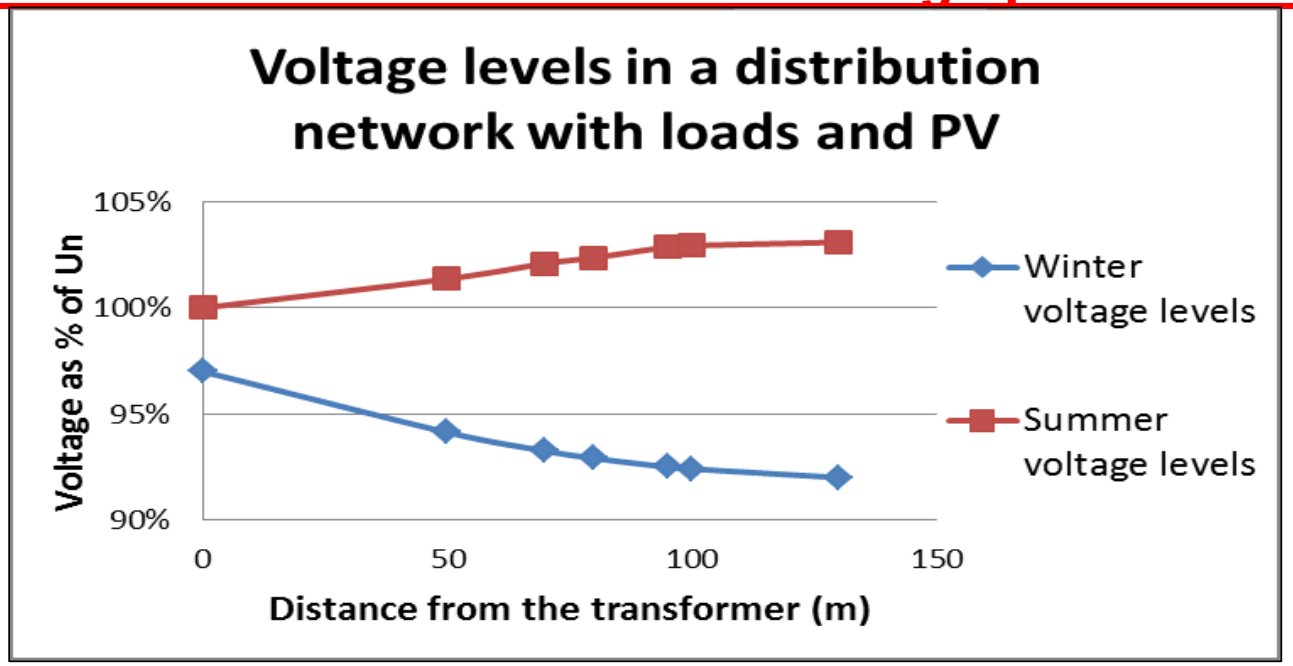
+ f/U primary regulation

Distribution System Operator: need to manage voltage levels within Un +/-10%

PV self-consumption useful by shifting energy thanks to storage

Additional storage dedicated to voltage regulation

⇒ **requirement to control PV from a voltage point of view**

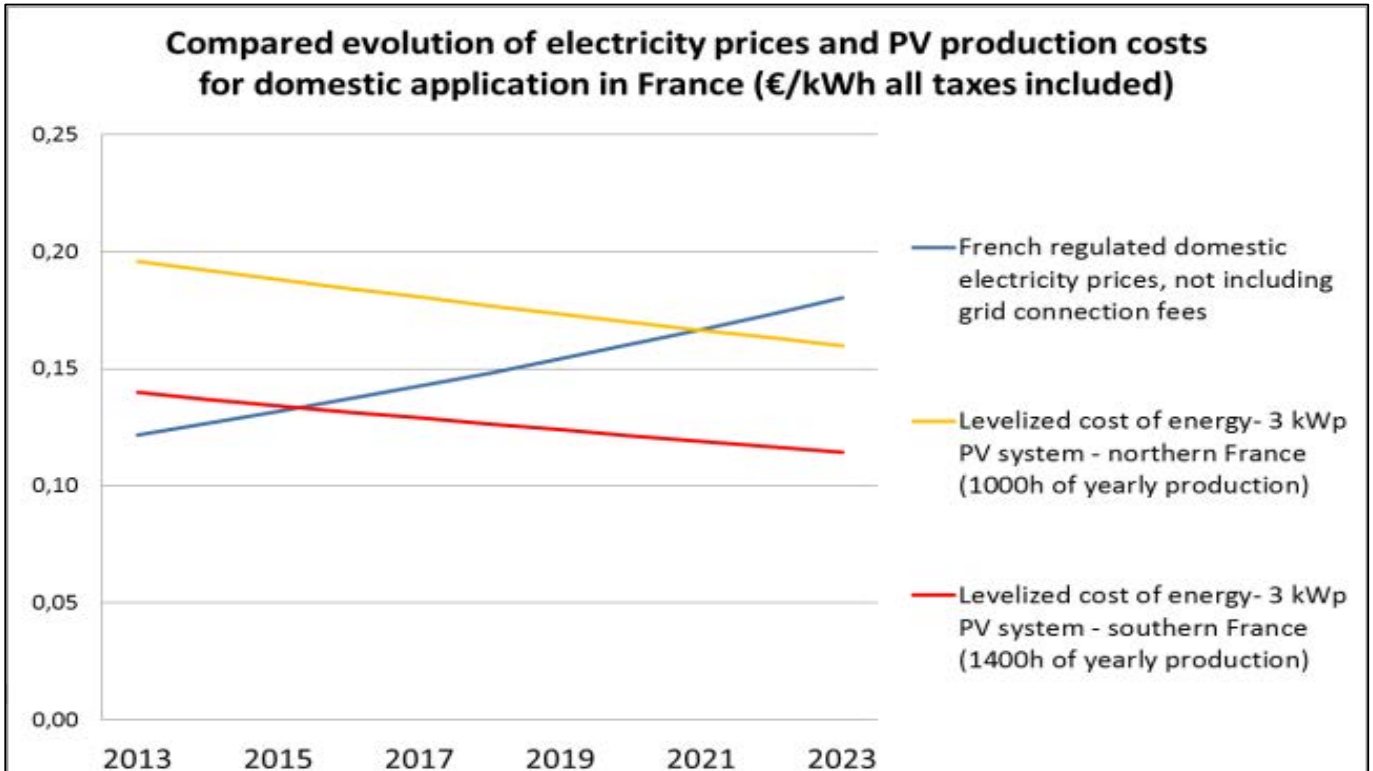


PV SELF-CONSUMPTION

Final consumer: need to reduce the electricity bill

PV cost < grid price in many countries (Germany, Italy, US, Australia,…)
With electricity storage, significant increase in self-consumption

⇒ **requirement to control PV from an energy point of view**



Experimental results and feedbacks

- 2012 CRE RFP - VrB
- 2012 CRE RFP – Zebra
- IPERD - Li
- SOLION - Li

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HYBRID SYSTEMS PV-STORAGE GENERATION COSTS IN FRENCH ISLANDS

Generation costs at peak production with diesel: 60c€/kWh

PV with storage: 30 to 45 c€/kWh

Generation costs at base load with heavy fuel oil: 23c€/kWh

PV without storage: 8 to 12 c€/kWh

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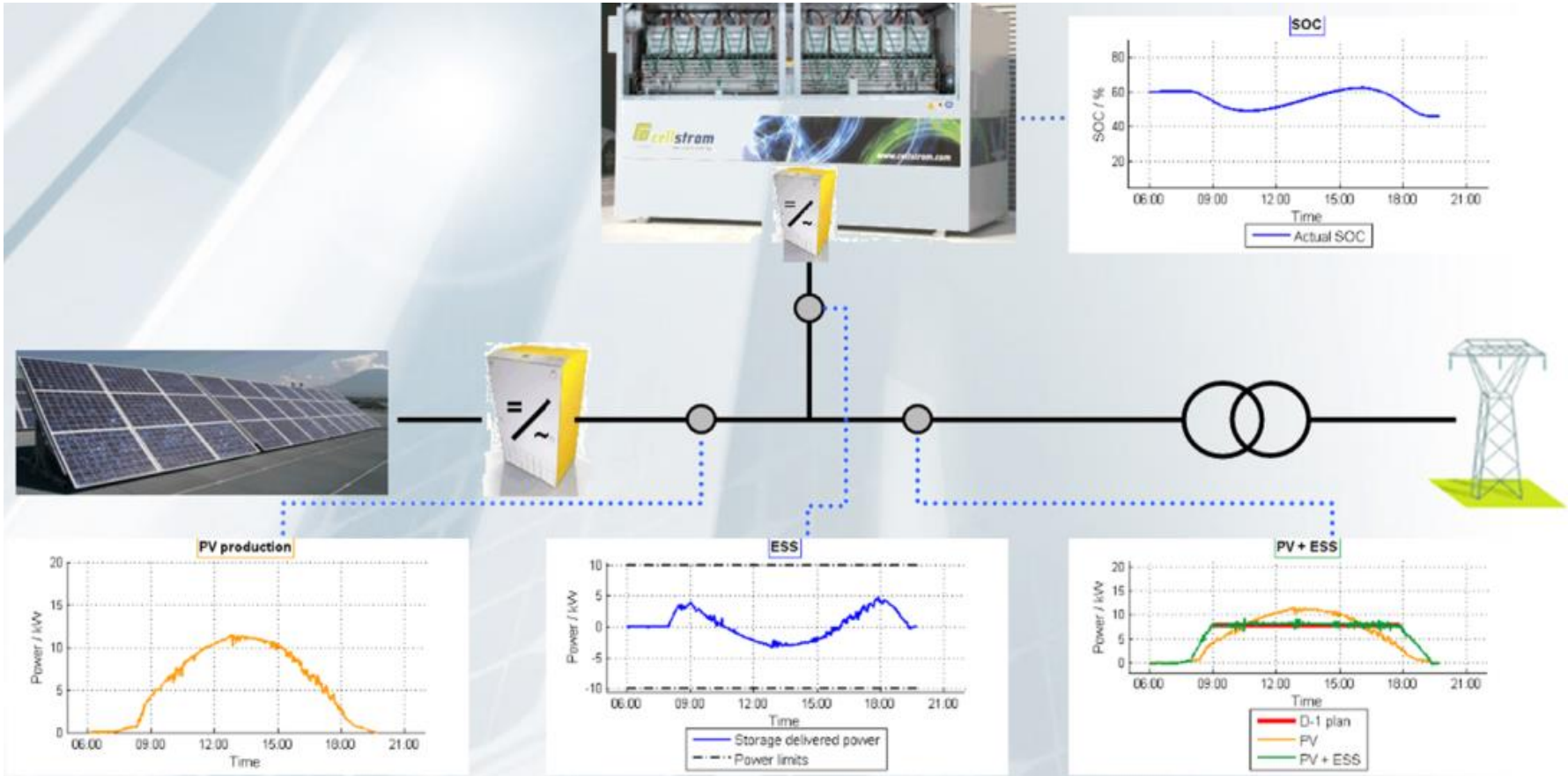
2012 CRE RFP WITH VANADIUM REDOX

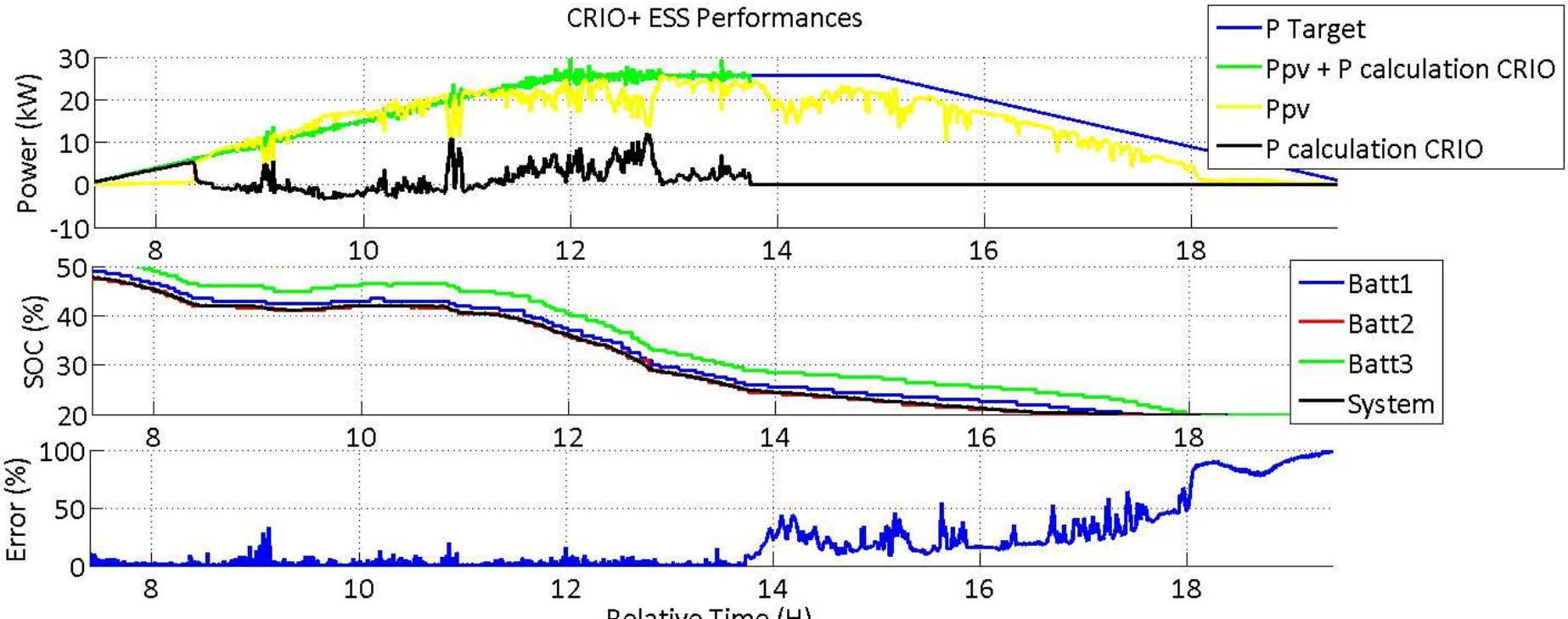
	Parameters	Values
Performances	Power	10 kW
	Nominal energy	100 kWh
Efficiency	Round trip DC efficiency	70-80%



2012 CRE RFP WITH ZEBRA (SODIUM) BATTERIES

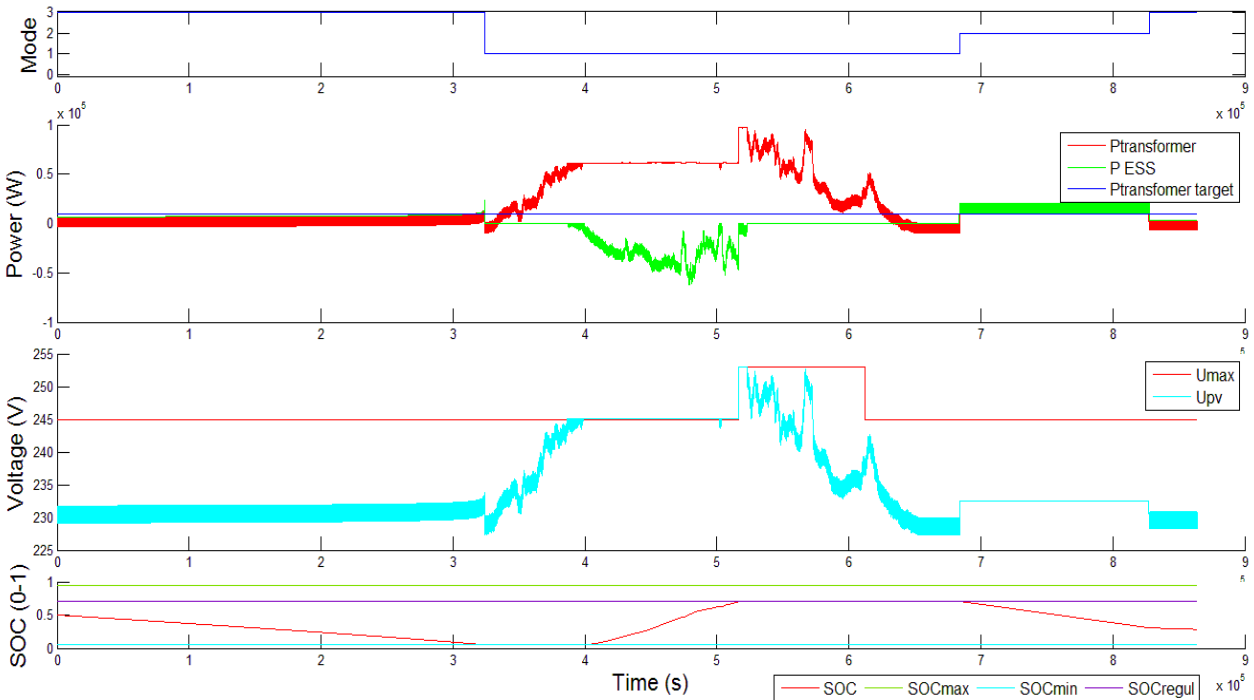
2 strings of 1 inverter-charger + 3 ZEBRA batteries

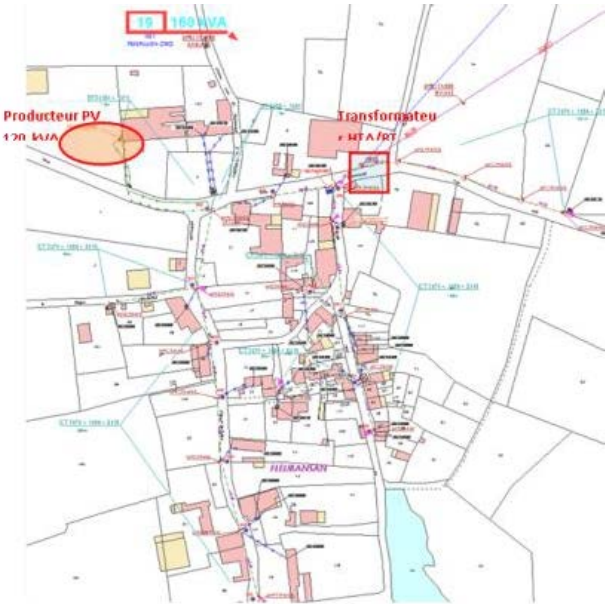
- Each battery 23.5 kWh
- Each inverter 60 kVA



IPERD PROJECT : ESS FOR LOW VOLTAGE NETWORK SUPPORT

PV	Consumer	Transformer	LiNMC
122kWp	28 (270kVA)	160kVA	50kW x 3h





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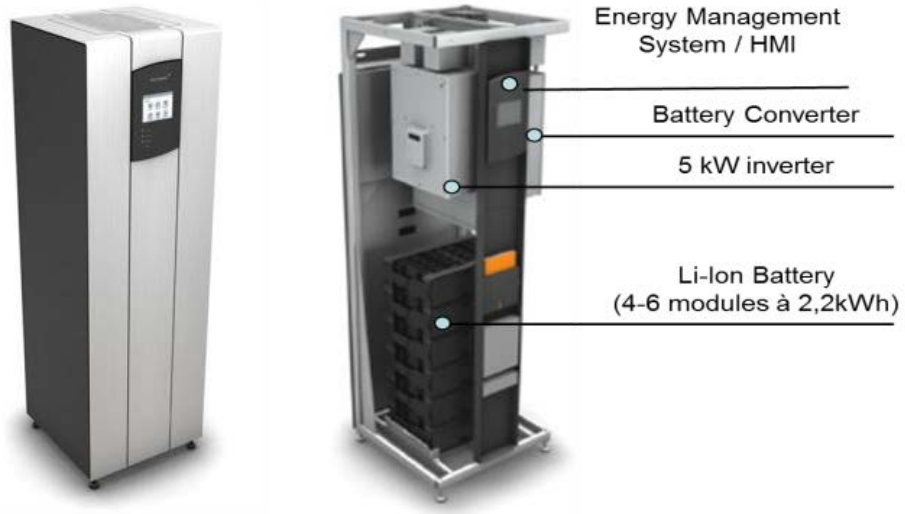
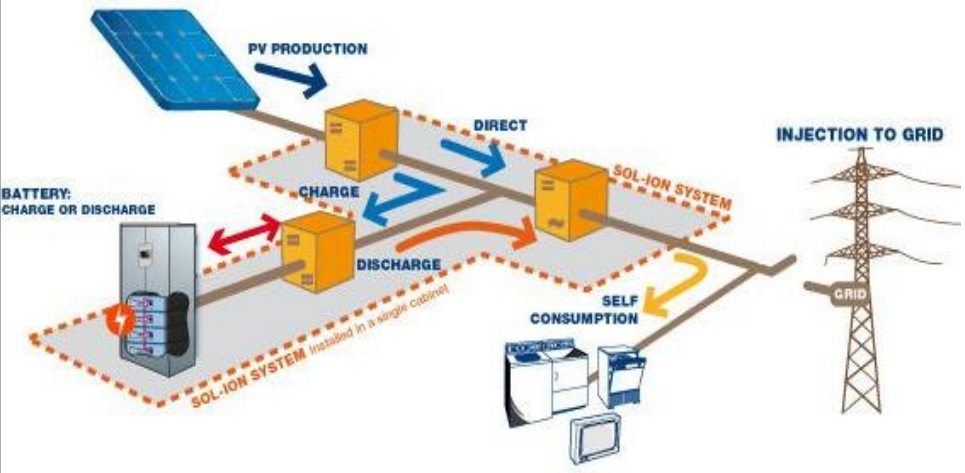
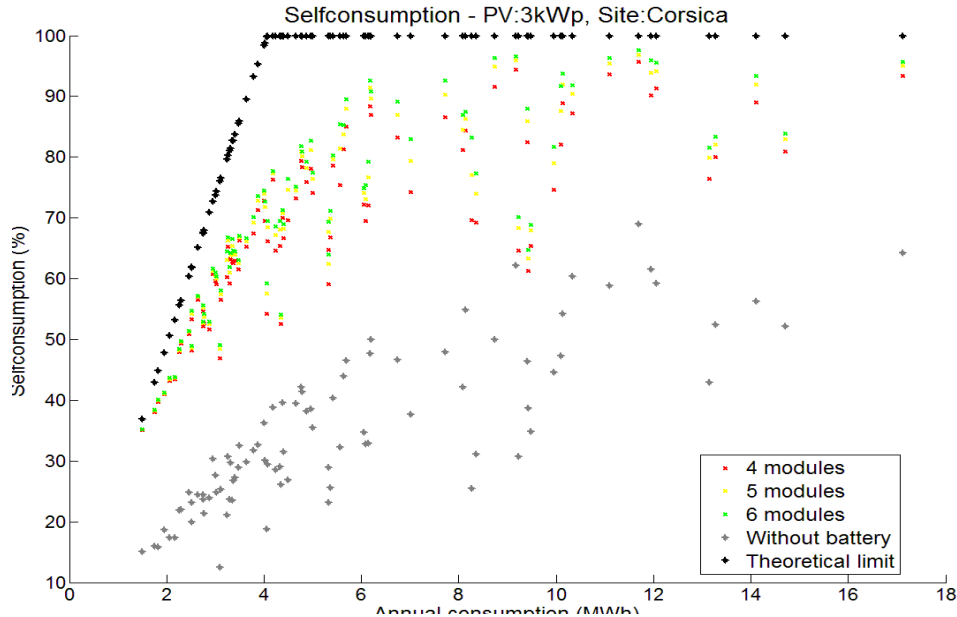
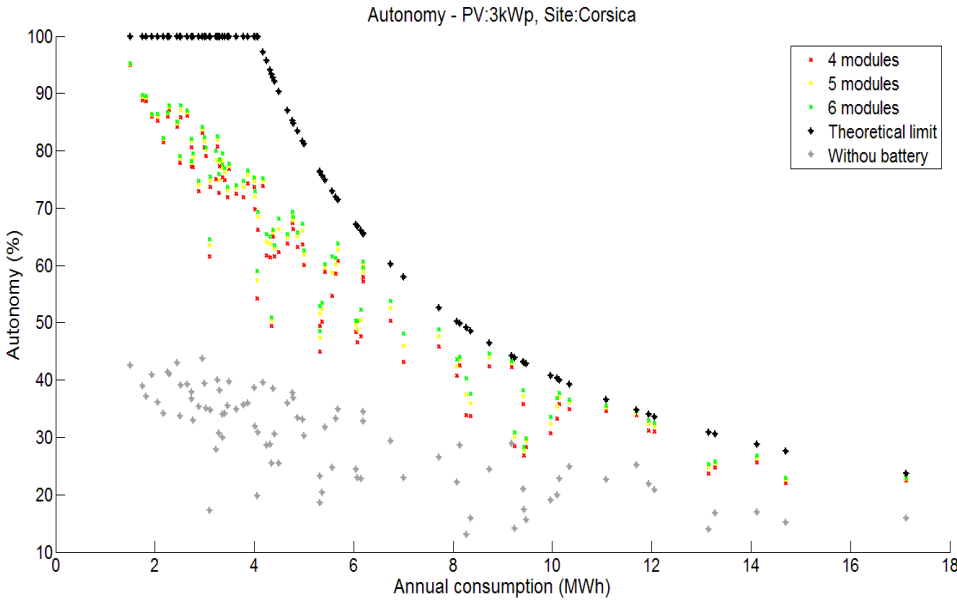
SOLION PROJECT : PV SELF-CONSUMPTION

PV	LiNCA
5kWp	4-6 x 2.2kWh









Tools for optimal coupling of PV and electrical storage

- Benchmarking
- Accurate modeling
- Energy Management System
- System testing with grid simulator

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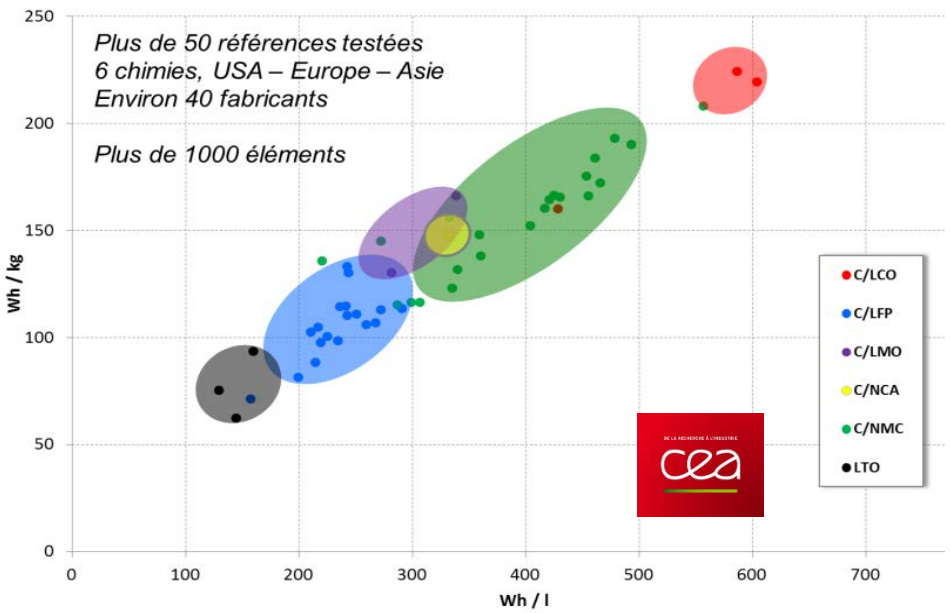
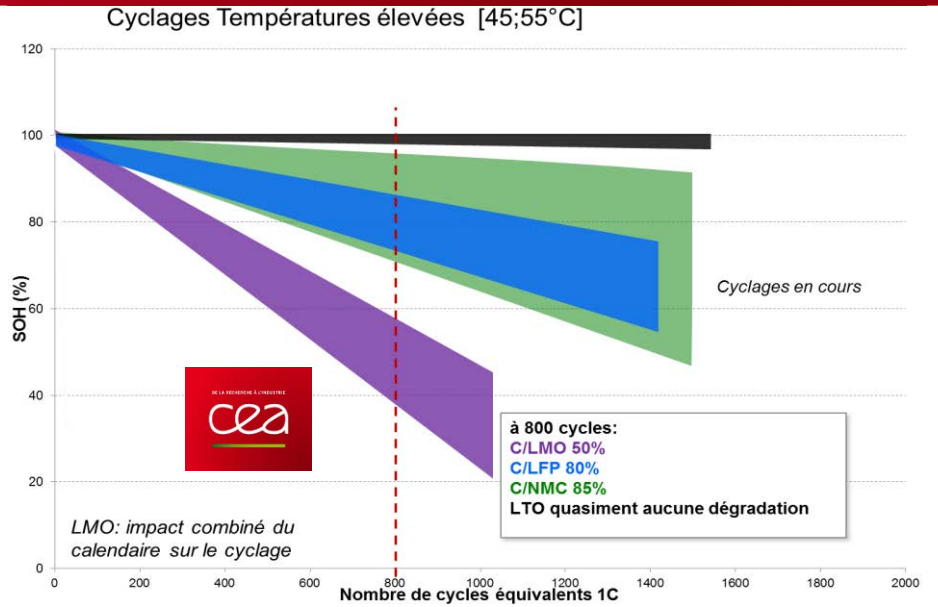
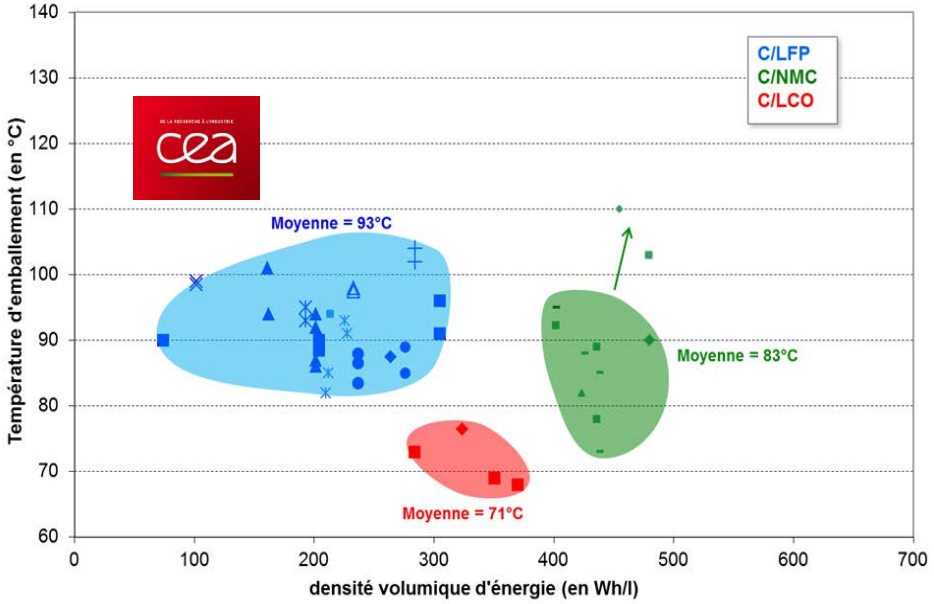
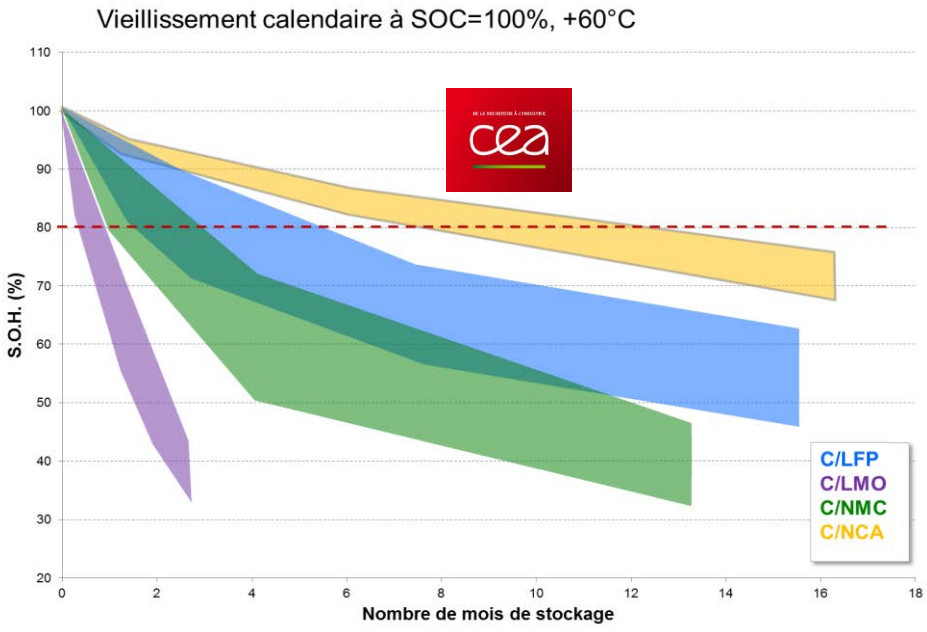
BATTERY BENCHMARKING FOR OPTIMAL TECHNOLOGY SELECTION



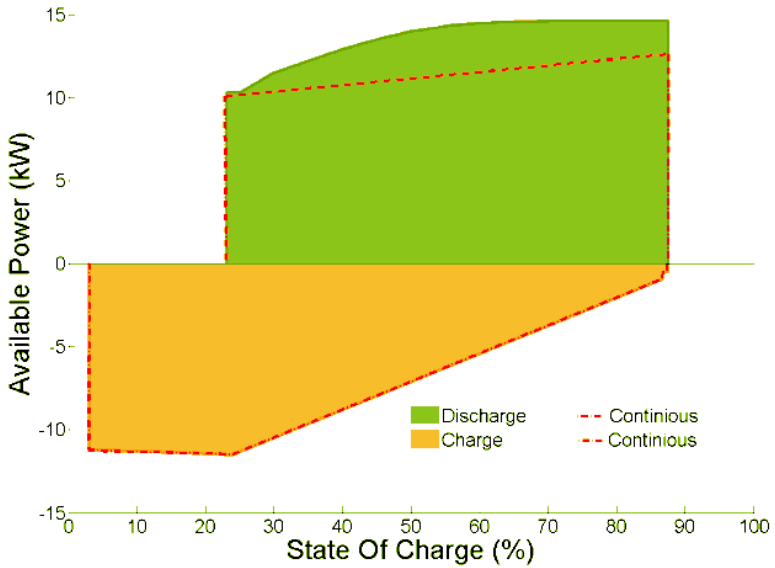


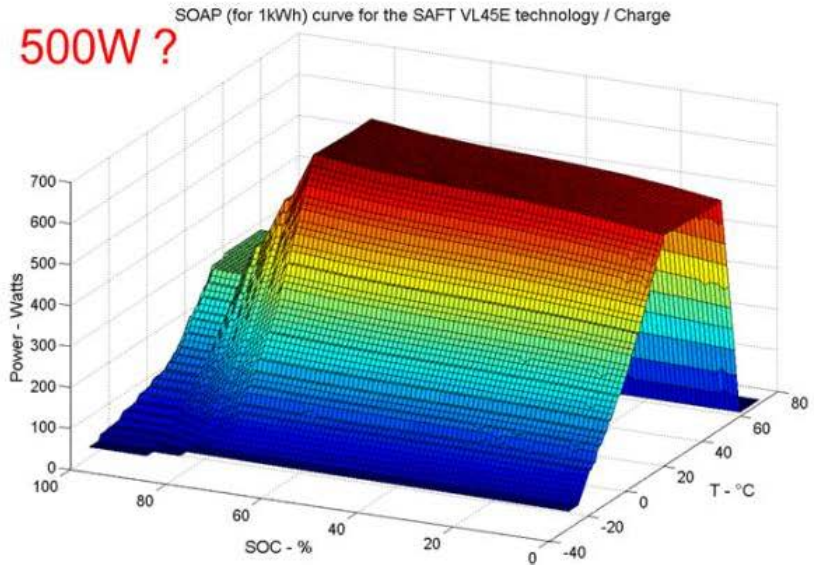


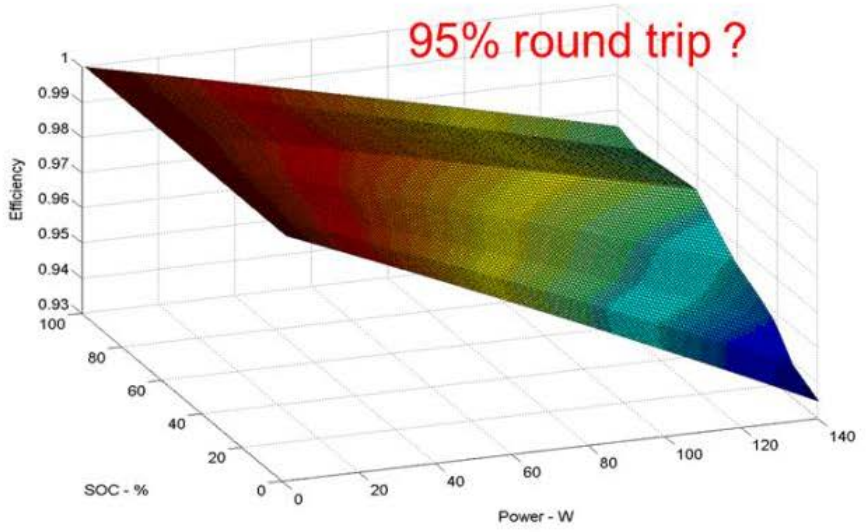


ACCURATE MODELING FOR OPTIMAL SIZING

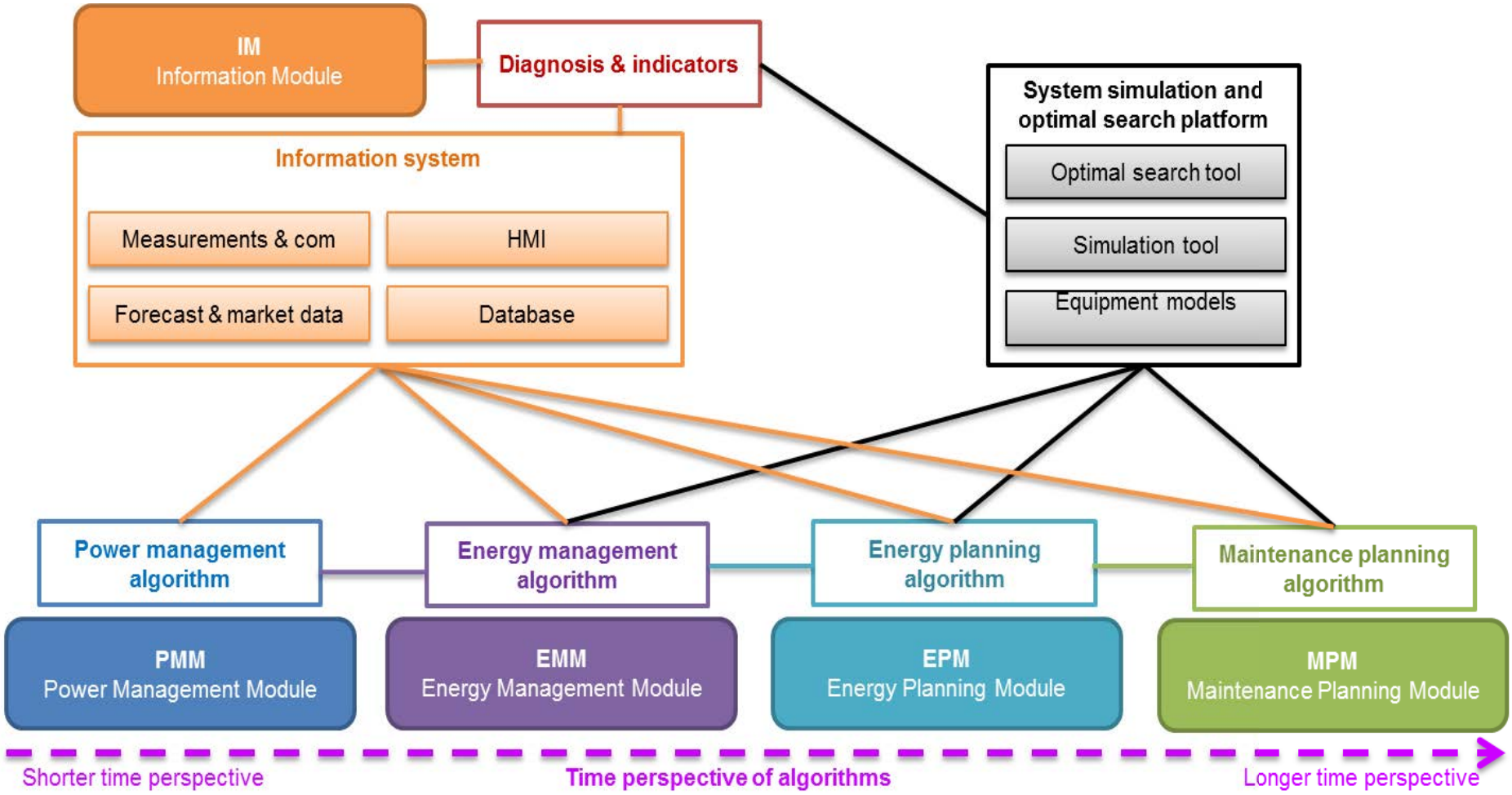
USUALLY, DATA FROM DATASHEETS ARE NOT ACCURATE ENOUGH FOR OPTIMAL SIZING





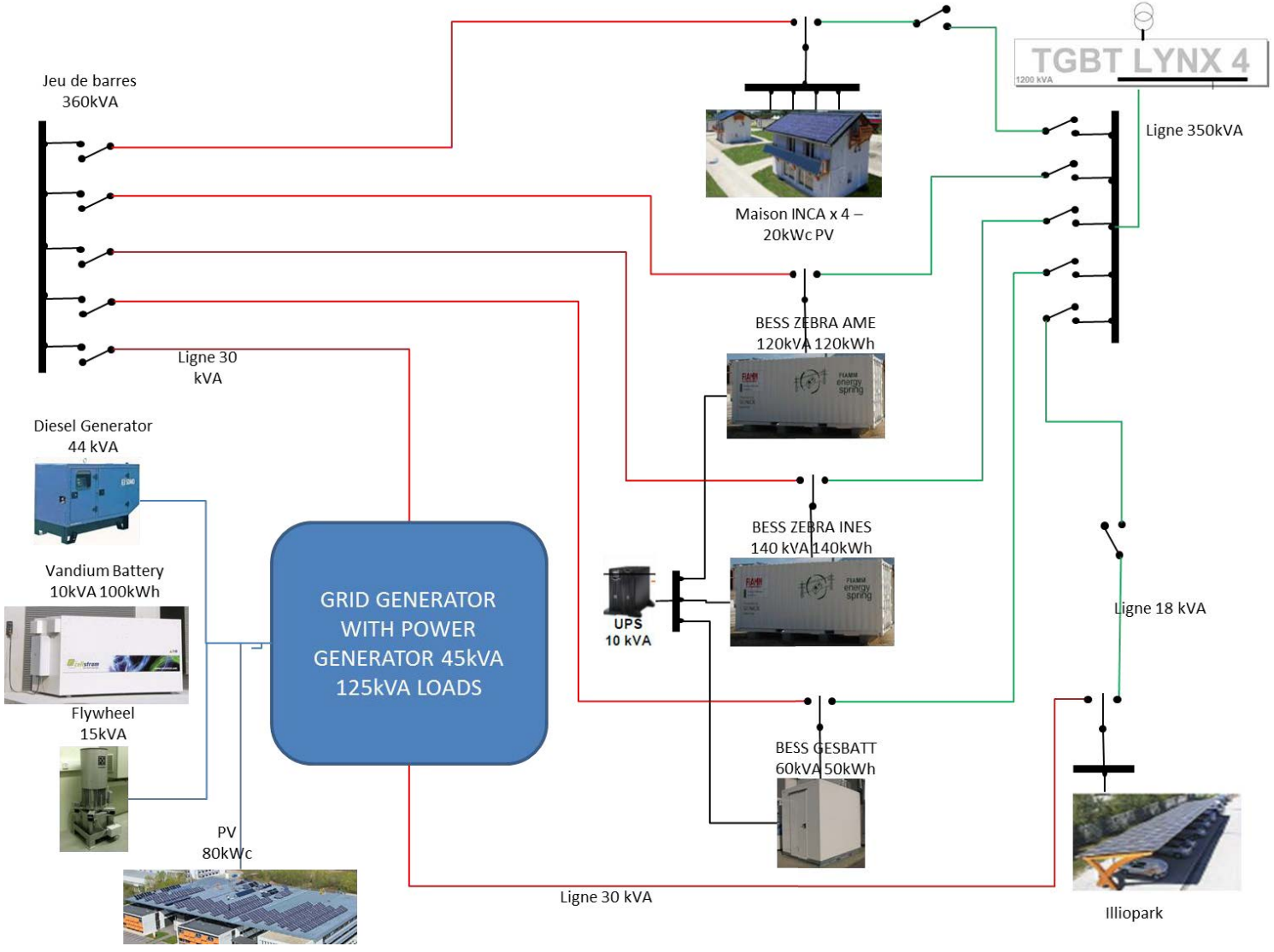


ENERGY MANAGEMENT SYSTEM FOR OPTIMAL OPERATION



BESS TESTING FOR SYSTEM VALIDATION

Performance testing including under specific grid conditions



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