



>>> **Sun'R Smart Energy**  
Agrégateur d'énergies sans CO<sub>2</sub>

## LE POMPAGE-TURBINAGE AU SERVICE DU STOCKAGE DÉCENTRALISÉ ET FLEXIBLE *ACCOMPAGNER LE DÉVELOPPEMENT DES ENR INTERMITTENTES*



9 Février 2015

**Davy Marchand-Maillet**, *Directeur des Opérations, Sun'R Smart Energy*  
[davy.marchand-maillet@sunr-sme.fr](mailto:davy.marchand-maillet@sunr-sme.fr) ; +33 (0) 682 043 170



## Agenda

- 1) Quick facts about Sun'R Smart Energy
- 2) SunHydrO - Distributed Pumped Hydro Storage
- 3) ASEO - Optimizing [RES + Storage] VPP operations



## Sun'R Smart Energy

Low-GHG energy aggregator

# SUN'R SMART ENERGY AND THE SUN'R GROUP

---

- ✓ A COMPACT TEAM OF RES & ENERGY STORAGE ENTHUSIASTS



>>> The Sun'R group develops and operates GHG-free energy assets to facilitate the transition to a sustainable electrical system

- ✓ **Sun'R Smart Energy** is part of the **Sun'R group**, evolving from a pure player in the solar PV generation to a larger position on the value chain.

In France :

Paris

Lyon

Toulouse

Montpellier

... and internationally !

  
Renouvelons nos énergies !  
**Solar PV generation**

  
**RES + Storage aggregation**

  
**Infrastructure financing**

→ **Innovation in technology:** distributed high efficiency, “grid-scale” and flexible storage units

- ✓ Flexible pumped hydro
- ✓ Isothermal CAES
- ✓ And a third undisclosed “early stage” technology

→ **Storage projects deployment:** supplying territorial/regional storage needs (~10.000s of inhabitants)

- ✓ Grid needs assessment towards renewable integration
- ✓ Units engineering with high environmental compatibility
- ✓ Fast and open financing, rigorous building
- ✓ Centralized operation et maintenance

→ **« Variable RES + Storage » aggregator:**

- ✓ Monetizing energy assets (generation & storage)
- ✓ Supplying services to the electrical system

> 20 professionals strongly involved in the energy transition

> 30M€ invested in 7 years



>>> Sun'R has developed 120+ solar PV power plants, and still currently operates 68 of these



Bardol 183 kWc  
Bardol 15450 Pauriac



Martel 182 kWc  
La Chapelle 43000 Marzyat d'aller



Portet 183 kWc  
Le Vernet 43170 Saugues





## Sun'R Smart Energy

Low-GHG energy aggregator

# SunHydro – DISTRIBUTED PUMPED HYDRO STORAGE

- ✓ SMALL IS BEAUTIFUL !

Le projet **SunHydro** est soutenu par le Fonds Unique Interministériel.





>>> The SunHydrO project is hold by flexible SmEs to bring flexibility to the electrical system

**sun'R**  
Renouvelons nos énergies !  
Solar PV generation

**QOS ENERGY**  
Data management

**Climpact-Metnext**  
Leverage climate impact. Improve performance.  
RES generation forecast

sun'R Smart Energy  
Aggregator

**SunHydrO**

**O.I.E.**  
The Energy Transition Lab  
Innovation management

**setec**  
energy solutions  
Hydro engineering

**École des Ponts**  
ParisTech  
Optimal control R&D

**ENSTA**  
ParisTech

**mhylab**  
Turbines

**EIFFAGE**  
TRAVAUX PUBLICS  
Civil engineering

**CLEMESSY**  
Electrical engineering



Context



The SunHydrO project aims to couple renewable generation with storage to supply electricity and energy services to the system

### Energy assets

Distributed renewable and variable generation sources



Electricity Storage Assets (+DSM)

Monitoring & Control

### Aggregation

Short and Very Short Term Forecast



Flexibility control

Stochastic Programming

### Electricity markets

- Wholesale market
- Balancing Market
- Capacity Market
- Ancillary Services
- Network savings (OPEX & CAPEX)

Modeling & Operation

Energy & Services sales



## >>> Why prefer small scale distributed PHS ?

- ✓ Large PHS development is inherently **limited**:
  - ✓ Strong impact on the environment (big dams)
  - ✓ Lack of possible new sites
  - ✓ Centralized storage means significant losses
- ✓ Renewables are **distributed**:
  - ✓ Most of this local generated energy has to be managed locally
  - ✓ Network deployment needs can be lowered by generation and/or demand peak shaving
- ✓ Territorial storage is the key to local **re-appropriation** of the energy policy:
  - ✓ Communities want to invest in energy assets and efficiency
  - ✓ Combined with storage , variable generation may improve local energy independence
  - ✓ Citizens are ready to invest to generate their own energy and manage it
- ✓ Small units means **risk mitigation**:
  - ✓ Investment-wise: ~30M€/unit
  - ✓ Technically: alerts on one single unit can be capitalized on the whole portfolio
- ✓ Small PHS units can be specifically adapted to onsite constraints and meet **environmental standards** (We hired an ex-WWF to make sure we do)



>>> What are the challenges with flexible distributed PHS to be coupled with renewables ?

- ✓ **Dynamics** are key to the services that can be provided:
  - ✓ To manage RES variability, turbine(s) and pump(s) must be able to adapt their power output/input.
  - ✓ Our goal is to provide ancillary services (frequency restoration reserve) to the TSO.
  
- ✓ **Siting decision** is highly multi-factorial, depending on:
  - ✓ Adapted topography (a big “step” on a short distance) and water availability
  - ✓ Network opportunities (RES installed around) and constraints
  - ✓ Environmental compatibility
  
- ✓ **Cost control** is necessary, to keep the investment low for the MW & MWh, not too far from large PHS, mainly by using “off the shelf” equipment and deployment methodologies
  
- ✓ **Operations** in uncertain conditions (renewable generation, market prices, state of the electrical system, etc.) requires advanced modeling and optimization skills



>>> A few examples of other projects based on Small PHS, proving its potential to regulate the grid



- ✓ Enel - **Dietro la Torre**: this 80 year old 4.5 MW unit has been refurbished in 2008 to cope with local constraints : it is at the very end of the line and has to be able to start pumps with only a little load on the grid.



- ✓ Gorona del Viento - **El Hierro**: coupled with 5 wind turbines, flywheels and a desalination unit, this 10 MW PHS enables the island to run on RES more than 80% of time.



- ✓ Electric Power Development Company – **Okinawa Yanbaru**: this 30MW seawater pumped storage power station is the world first to use seawater and provides some flexibility to the local utility.



- ✓ **Sun'R Smart Energy benefits from many experiences to industrialize a product to be deployed by dozens in every compatible country.**

>>> Three sites have been identified, the PHS project on the first one currently is being designed

- ✓ 10-15 MW ; 80-100 MWh
- ✓ 100-200 m head
- ✓ ~ 250.000 m<sup>3</sup> reservoirs
- ✓ 75-80% efficiency
- ✓ Environment friendly
  - ✓ No dam (out of the river)
  - ✓ Very low impact on water flows
- ✓ Highly flexible in **both** modes



*Lower reservoir inserted in the landscape*



## >>> Perspectives for distributed PHS are good

- ✓ After we have achieved technical and economical validation of the pilot unit, we expect to deploy the concept at a 100s scale in a country like France
- ✓ Islands are a propitious playground for the early deployment of such solutions
- ✓ We have already assessed the siting potential in many geographical zones and the low-head strategy we have shows many opportunities
- ✓ Business modeling shows that the price spread generated by the introduction of RES generation will reach an appropriate level in time if the government keeps the deployment pace for wind and solar
- ✓ Yet, for many reasons, that will only be part of the solutions:
  - ✓ We do not consider inter-seasonal storage (optimal capacity is in hours)
  - ✓ This kind of unit cannot be moved once built
  - ✓ Even if they are reachable, topographical and water availability requirements exclude some geographical zones to use such a solution



## Sun'R Smart Energy

Low-GHG energy aggregator

# ASEO – OPTIMIZING [RES+STORAGE] VPP OPERATIONS

---

- ✓ MODELING AND MATHEMATICAL SKILLS TO DIMENSION AND OPERATE RES+STORAGE PORTFOLIOS



Context



Storage and Variable Renewable Energy Aggregation needs a brain, that's our ASEO solution

### Energy assets

Distributed renewable and variable generation sources



Solar PV



Wind



Storage

Electricity Storage Assets (+DSM)

Muscles

Nerves

Monitoring & Control

### Aggregation

Eyes

Short and Very Short Term Forecast



Brain

Stochastic Programming

Flexibility control

### Electricity markets

Wholesale market

Balancing Market

Capacity Market

Ancillary Services

Network savings (OPEX & CAPEX)

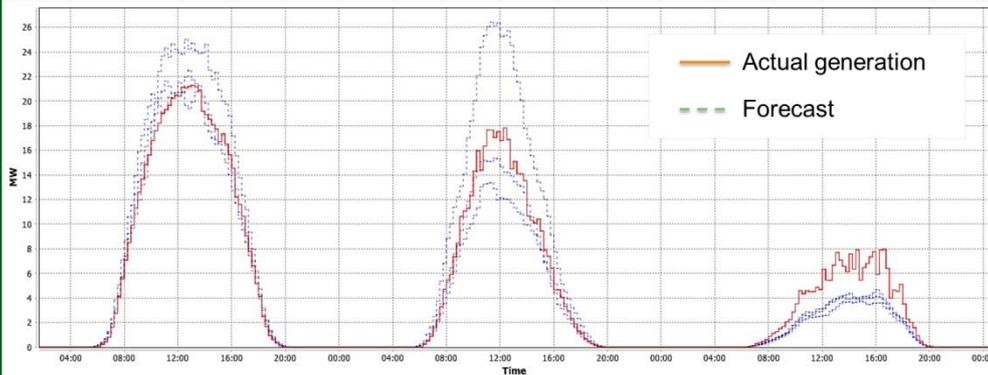
Modeling & Operation

Energy & Services sales

>>> Our « Aggregated Storage Energy Optimizer » deals with strong uncertainties to make the most reasonable decisions

RES model

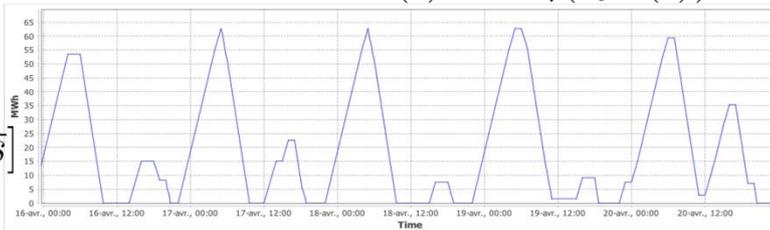
RES generation  
→ Stochastic variable  $W(t)$



Storage dynamics  $\dot{S}(t) = -\eta(Q^S(t))$

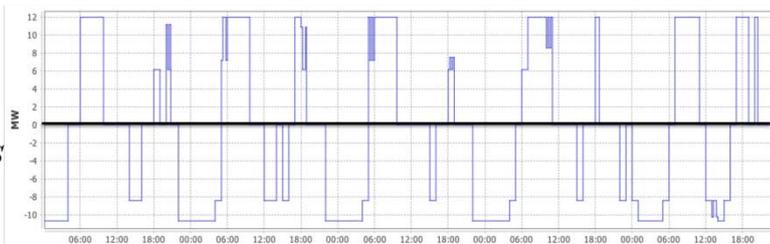
Stored energy

$$S(t) \in [0, \bar{s}]$$



Generated power

$$Q^S(t) \in Q^S$$



+ Stochastic market price model, etc.

## Long Term Portfolio Management

- Given RES portfolio, how to dimension a new storage unit ?
- Given storage portfolio, which RES units shall I contract with ?
- How to build price offers and business models ?

## Optimal Operations

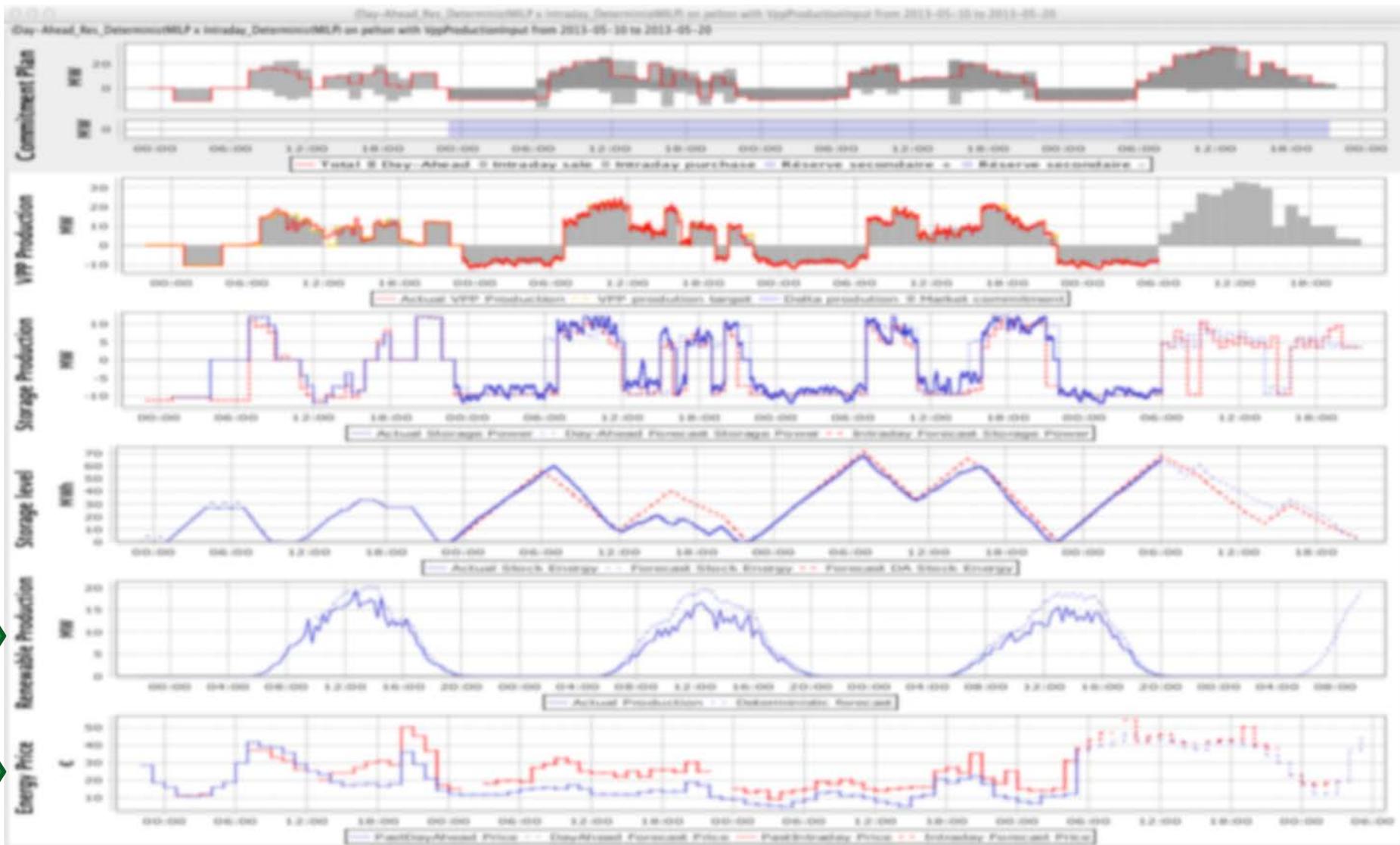
Given RES generation and price forecast uncertainties, what is the optimal strategy for:

- Market bids
- Unit commitment
- Real-time storage units operations



>>> The energy optimization dashboard is a convenient way to operate a RES+Storage portfolio

- Market commitment
- VPP output
- Energy released
- Stored energy level
- Solar PV Generation
- Price





## Sun'R Smart Energy

Low-GHG energy aggregator

## CONCLUSION

---

- ✓ WAYS FORWARD



>>> Who are the main stakeholder of such a project ?

- ✓ **Locals:** Our projects cannot exist without a full acceptance from the citizens around.
- ✓ **RES generators:** Sooner or later, they will face a Feed-In-Tariffs exit and confront with the market. With storage they can anticipate.
- ✓ **TSOs/DSOs:** The grid can benefit from the deployment of storage and Sun'R Smart Energy can provide innovative solutions.
- ✓ **Storage technologists:** Even if we develop our own, we are happy to confront with others' good ideas to constantly improve ours.
- ✓ **Investors:** Such a project needs a new kind of financing, considering long term and integrating market risks.



>>> What you should keep in mind

- ✓ Together with European countries, France has to consider **decentralized and highly flexible storage units** deployment
- ✓ Small PHS provides a positive solution for **long lasting (> 40 years) needs**
  - ✓ Both for **technical needs** (supply & demand balance, frequency reserve, local network management, etc.)
  - ✓ And **economical challenges** (time-shifting RES generation to reach sales opportunities)
- ✓ It is a **reasonable risk** to invest in such storage units
- ✓ Yet, siting, dimensioning and operations management must be supported by **tailor-made modeling and decision making tools**