Investment in Energy Storage?

The return on investment from energy storage in grids with high presence of renewable sources

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AGENDA

- NPRES growth in the National Transmission grid
- Storage as solution for grid problems
- Storage functions on the grid
- 7 Reasons to invest on Storage ON GRID
- 3 Reasons to invest on Storage OFF GRID
- Storage also for the Thermoelectrics
- CONCLUSIONS

Energy sector is on the frontline in the reduction of global heating.

To contrast the global heating, at the **Unite Nations** all the international agreements on climate and energy are identifying a target of emissions pertinent to the **control of the temperature increasing within 2°C** respect to the pre-industrial level, preferably within 1,5°C (Paris Agreement, 2015)

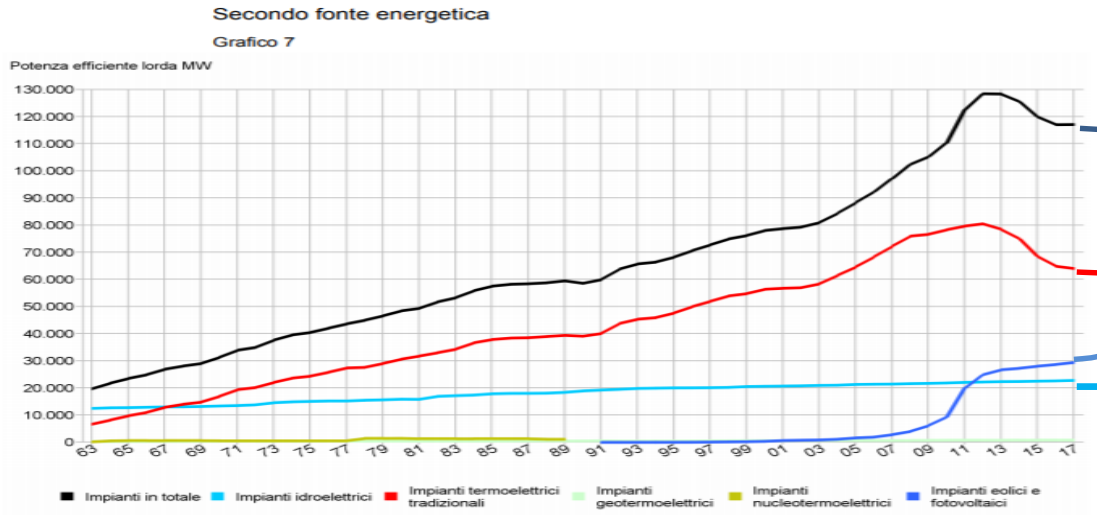
The European Union is involved in reducing CO_2 emissions of 40% at least, within year 2030, having **RES target on the total consumption of 27% at least.** In the sphere of the **Clean Energy Package** (“Cleaned Energy for all europeans”), approved at the end of year 2016, the main purposes are to strenght the energy efficiency, to mantain the world leadership on renwables and to grant the safety of the electric system.

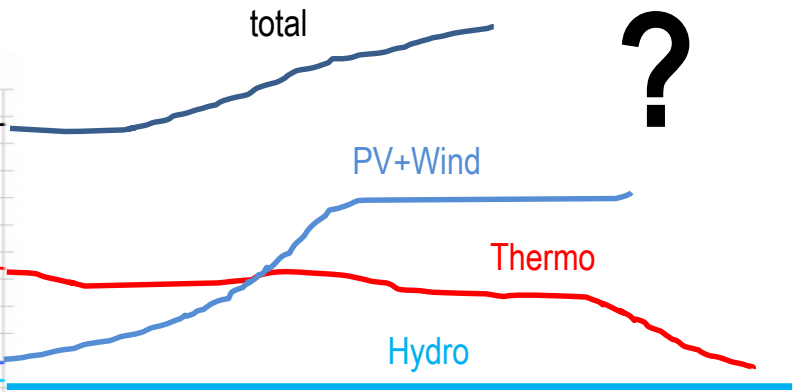
The **Integrated National Plan for Energy and Climate** (PNIEC) has updated the SEN purposes (National Energetic Strategic) – therefore **within 2030 the 30% of gross final consumptions must be covered from renewable sources (FER)** having primary energy reductions of 43%, and 39,7% on the final energy, with **riduction of greenhouse gases of 33%** for all sectors.

For such reason, the guidelines converge onto

- ➔ **Sustainable Development**
- ➔ **Decarbonisation**
- ➔ **priority for Energy from Renewable Sources**

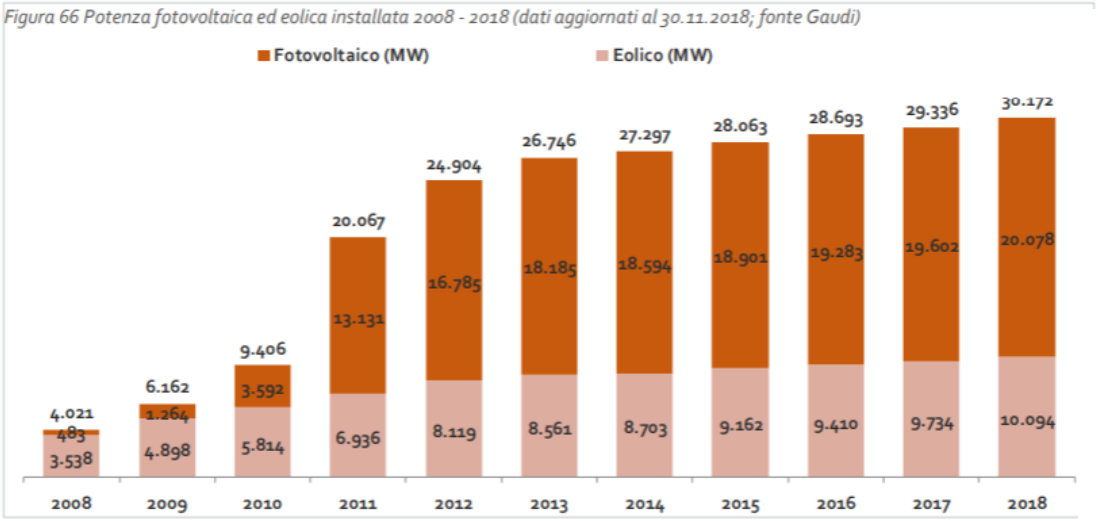
Potenza efficiente degli impianti elettrici di generazione in Italia al 31 dicembre 2017



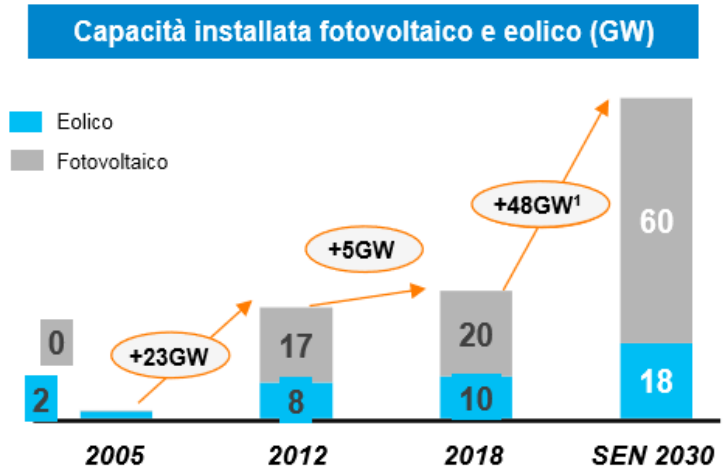


Development and possible evolution of Photovoltaic and Eolic in Italy

DEVELOPMENT @ 2018



EXPECTED EVOLUTION @2030



The capacity installed by FER has considerably grown during the last years and it's destinated to a further growth for the coming years for SEN purposes, thanks to the reduction of the costs for eolic and photovoltaic plants.

Should we invest on Energy Storage ?

WIND ~ 10 GW
Installed 10.094 MW
by the 31-12-2018

SOLAR ~ 20 GW
Installed 20.078 MW
by the 31-12-2018

The renewable intermittently not predictable energies (Wind + Solar) hugely increased in Italy - as well as the instability risk - because there is no equivalent power of primary regulation.

This is the impact of NPRES (Not Predictable Renewable Energy Sources)

Should we invest on Energy Storage ?

The renewables have hugely grown and overcame around one third of total used energy; on 319 TWh of total consumptions, during year 2017, 103 TWh are renewables.

The critical element is the percentage of instant power (during the low consumptions times).

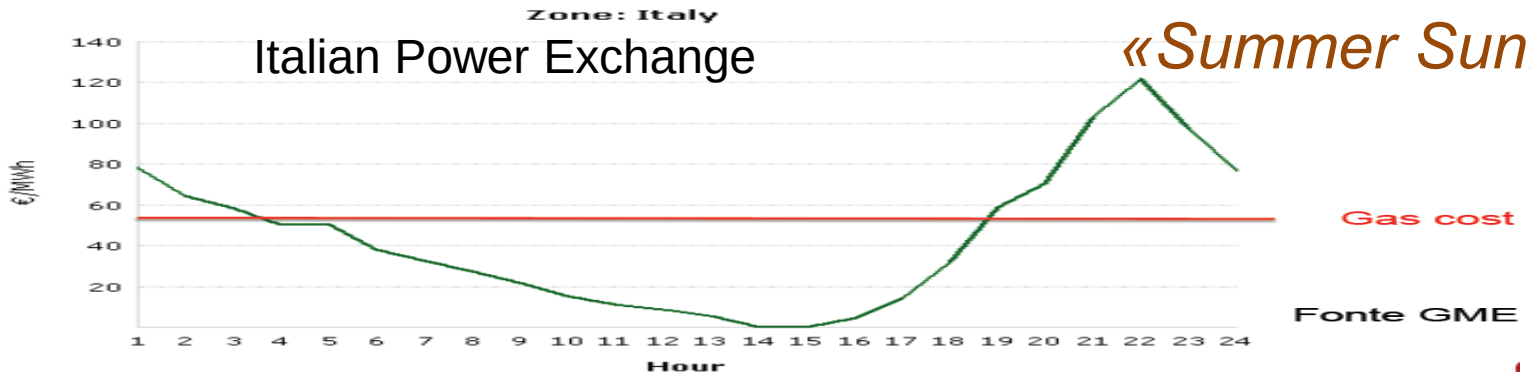
Average Penetration

$$\frac{\text{Total Renewable Energy (kWh)}}{\text{Total Energy Demand (kWh)}}$$

Istantaneous Penetration

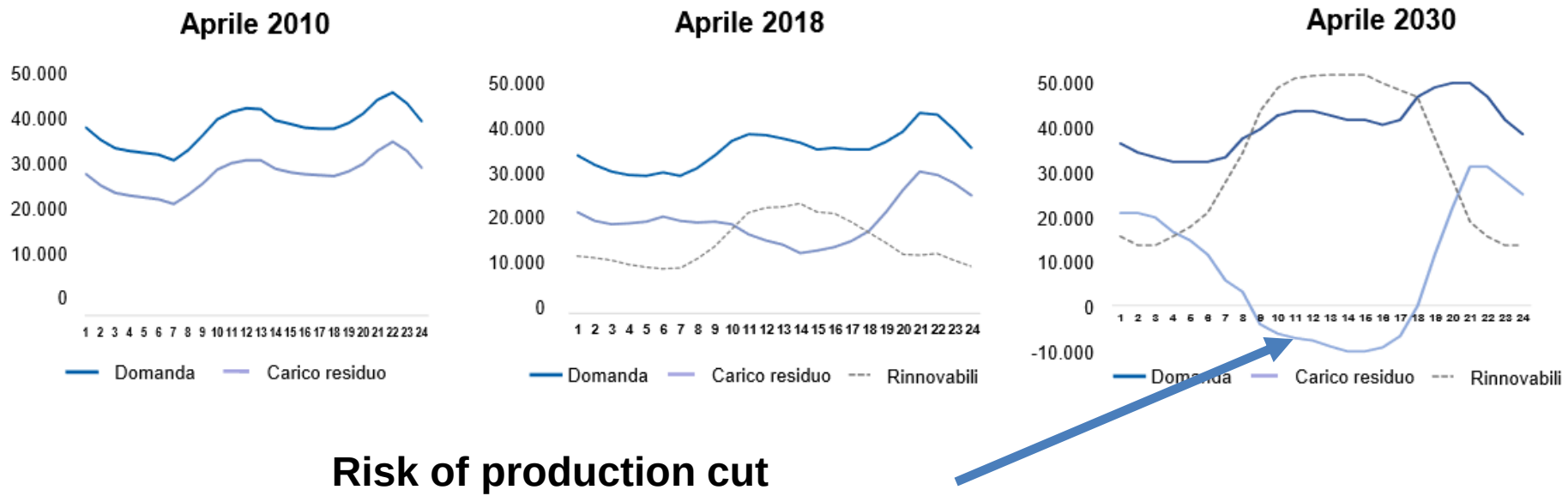
$$\frac{\text{Renewable Power Output(kW)}}{\text{Electrical Load (kW)}}$$

IPEX price in Sunday 16/6/13



«Summer Sunny Sunday»

Typical residual load profile around 24 h(GW)

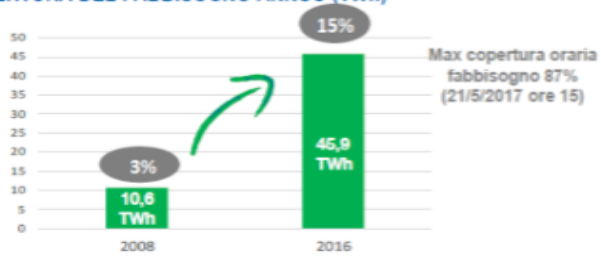


Risk of production cut

Progressive reduction of the request, which is satisfied from traditional plants, in favour of RES. Dayly hours will only be covered from renewable sources.

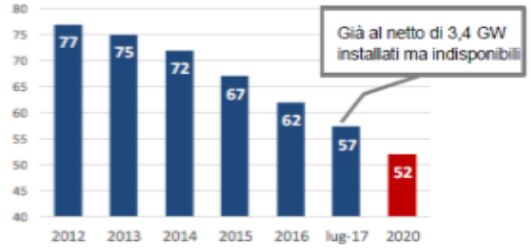
It increases the requirement of flexibility to ensure safety

PRODUZIONE DA FONTE EOLICA, SOLARE E GEOTERMICA:
COPERTURA DEL FABBISOGNO ANNUO (TWh)



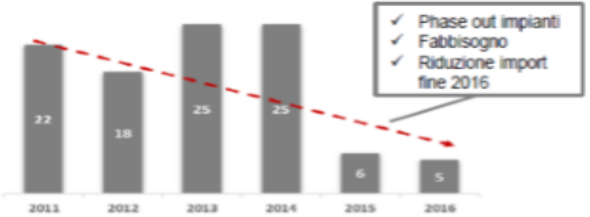
Progressiva crescita delle **FER intermittenti**

RIDUZIONE POTENZA INSTALLATA TERMOELETTRICO (GW)



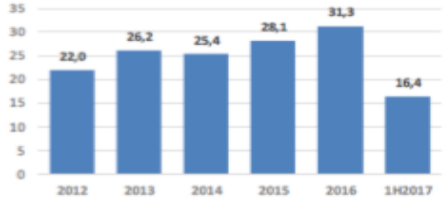
Drastica riduzione termico convenzionale

MARGINE DI RISERVA ALLA PUNTA



Progressiva **riduzione** margine di riserva alla punta

VOLUMI MSD (TWh)



Maggiori **movimentazioni MSD** per garantire sufficienti livelli di riserva rotante e per regolazione di tensione

Fonte: Terna ed elaborazioni REF-E su dati GME e Terna

Should we invest on Energy Storage ?

NPRES also involve a bigger flexibility requested to the “conventional plants” .

- Frequent stops and start-up
- Fast ramps of pickling and releasing of loads
- Miminum management (the absence of regulating capacity not only during minimum period, but also later in power plant starting).

Combined cycles are “Start-stop running”: less work, more worn

Should we invest on Energy Storage ?

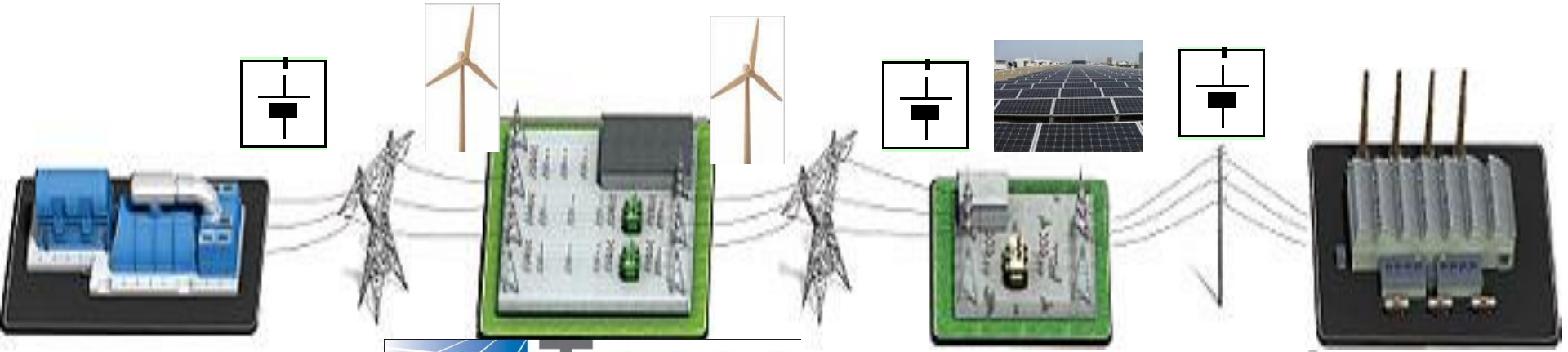
The penetration **impacts also on the inertia**: whereas the rotating masses on the traditional plants allow to overtake sudden charging variations, that means they are reducing the frequency variations, by using FRNP (static production) it's switched to zero inertia.

In case of a sudden deficit of power generation, the frequency drifts faster towards the blackout

The decay of the frequency becomes so rapid that the intervention times of the primary regulation (50% of the band in 15' and 100% in 30') may not be sufficient to avoid the loading detachments.

Should we invest on Energy Storage ?

It is therefore natural that we've tried to study suitable technological innovations to face the need to increase the capacity and flexibility of grids. Surely among these innovations **the electrochemical Storage systems have a relevant role** and pose a list of questions, also of regolatory nature.
It is about the «widespread accumulation systems", indicated from Terna and Enel Distribution as one of the instruments on which focusing to solve several criticies of transmissions and distributions grids.



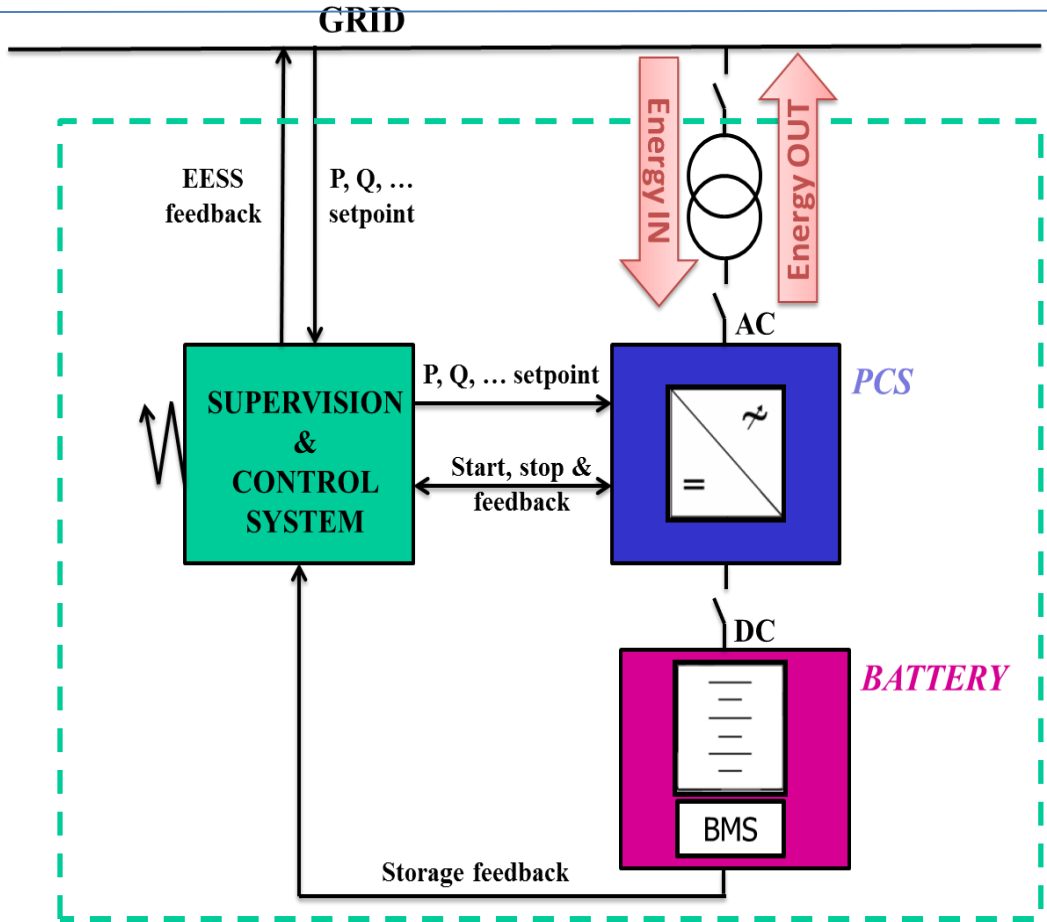
Terna
Rete Elettrica Nazionale

enel

What a Storage Energy System is?

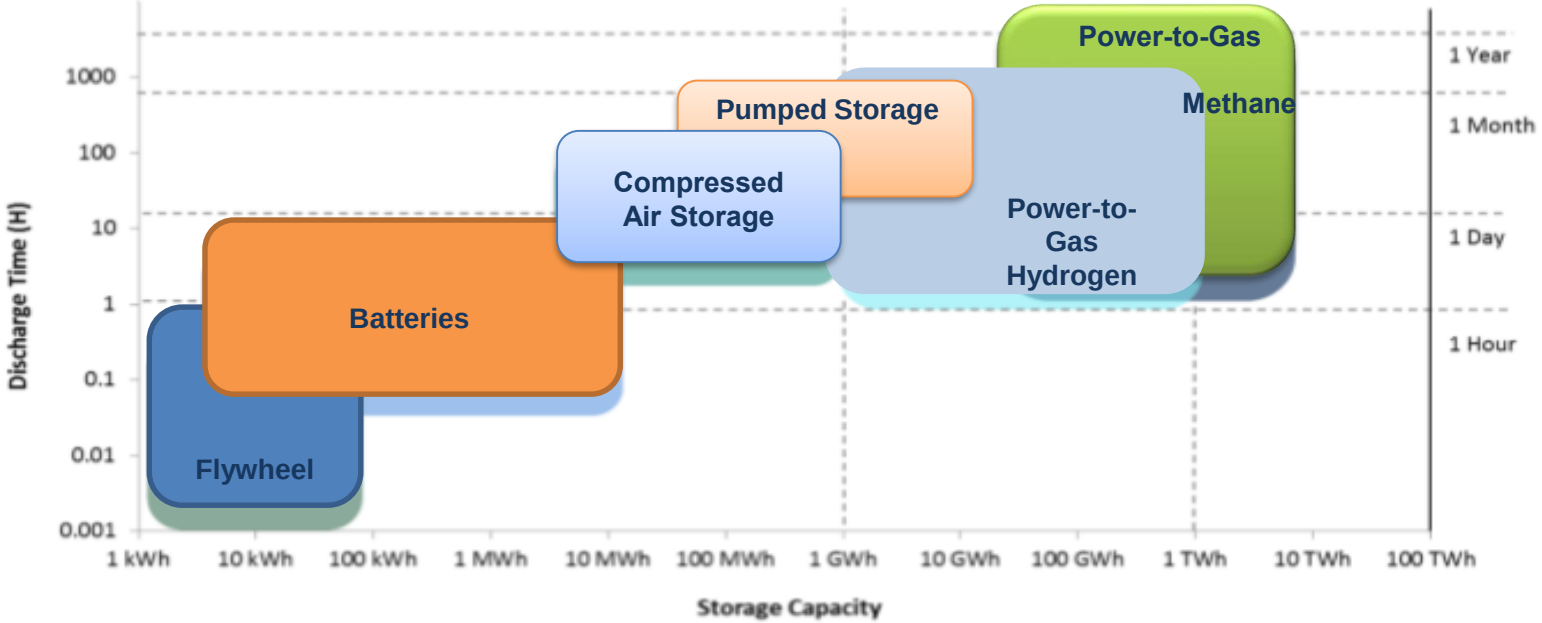
It's an electrical system capable of storing energy and releasing it in a deferred form over time (with a controllable delay) and with adjustable power.

Such possibility of modulation allows various adjustments and therefore different functions for storage.



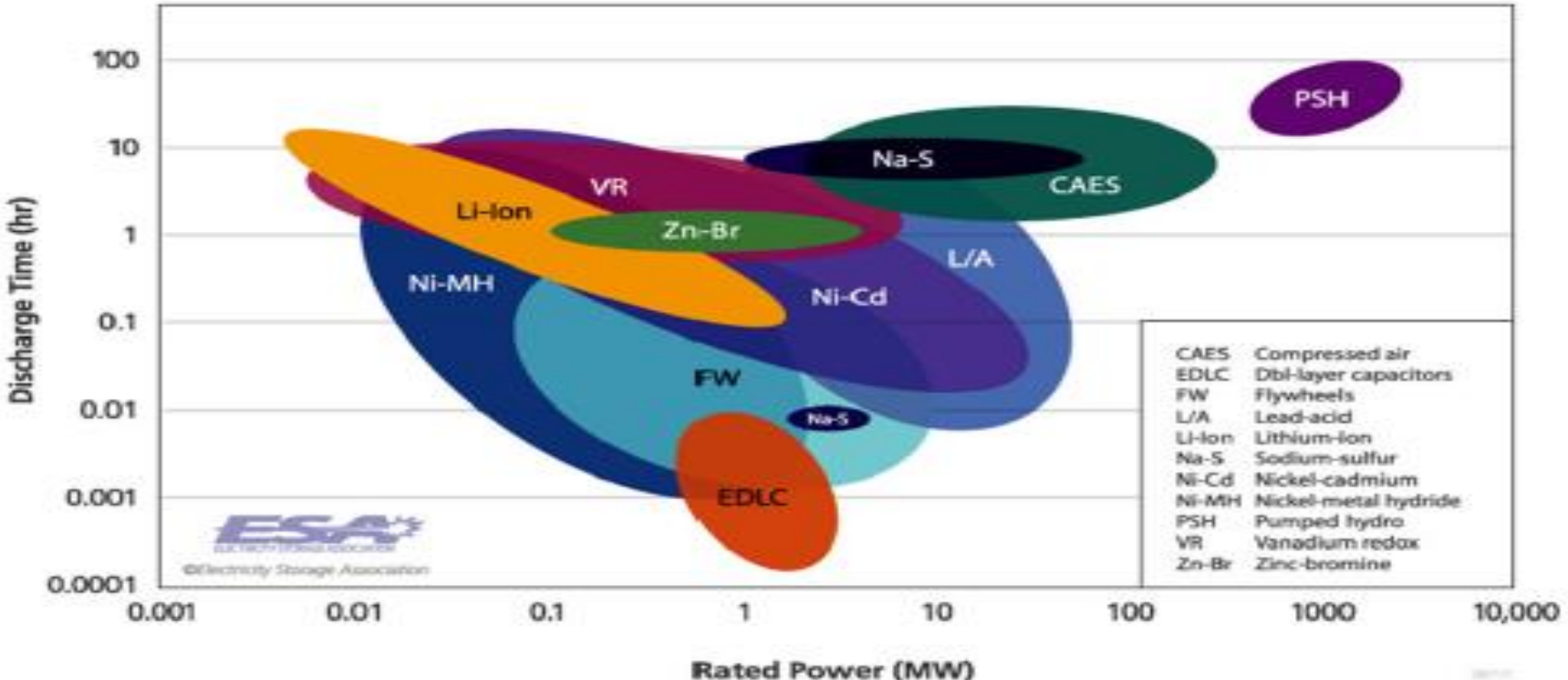
Each technology has his specific working area
Storage capacity – discharging time

Figure 15: Overview of different electricity storage technologies



Source: European Commission (2017), Energy storage – the role of electricity[178].

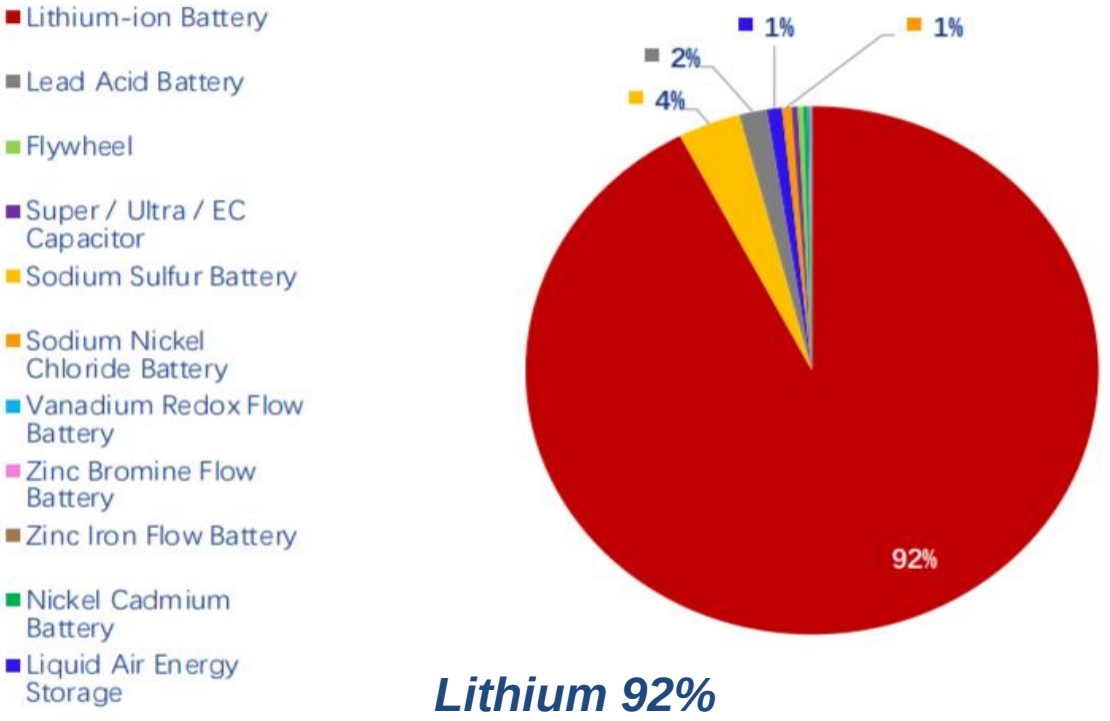
Also in the elechtrochemical field every technology owns his specificity. Storage capacity – discharging time



SAET has gained experience on several technologies

DISTRIBUTION	TRANSMISSION & RES GENERATION				
2MW/1MWh	1MW/1MWh *2 x*	60kW/120kWh *2 x* 1MW/2MWh	10,8MW/81MWh	0,45MW/1,440MWh	2,2MW/2,2MWh
Lithium (NCA)	Lithium (LiFePO4)	NaNiCl2	NaS	Vanadium flow	Lithium (NMC)
2.000 cycles	4.000 cycles	4.000 cycles	4.500 cycles	> 20.000	4.000 cycles
ή = 95% (*Battery*)	ή = 95% (*Battery*)	ή = 85% (*Battery*)	ή = 75% (*Battery*)	ή = 71% (*Battery*)	ή = 95% (*Battery*)
Energy/Power: 0.5-2	Energy/Pow	Energy/Power:	Energy/Power:	Energy/Power:	Energy/Power:
					
18,5 kg / 1,5 kWh	25 kg / 2,5 kWh	450 kg / 20 kWh	3000 kg / 225 kWh		
saft	BYD	GE FIAMM	NGK	融科储能 RONGKE POWER	LG Chem

It seems that Lithium Batteries have no competitors.



Lithium 92%

*"**Batteries with lithium ions are following the traces of solar panels** based of crystallin silicon",* says senior author Iain Staffell, college teacher of the Center for Environmental Policy. *"At the beginning they were expensive and only suitable for niche applications, but now they are produced in large amounts and their costs are getting lower much faster than competing storage technologies".*

Storage systems can be classified according to the time in which the accumulation is provided.

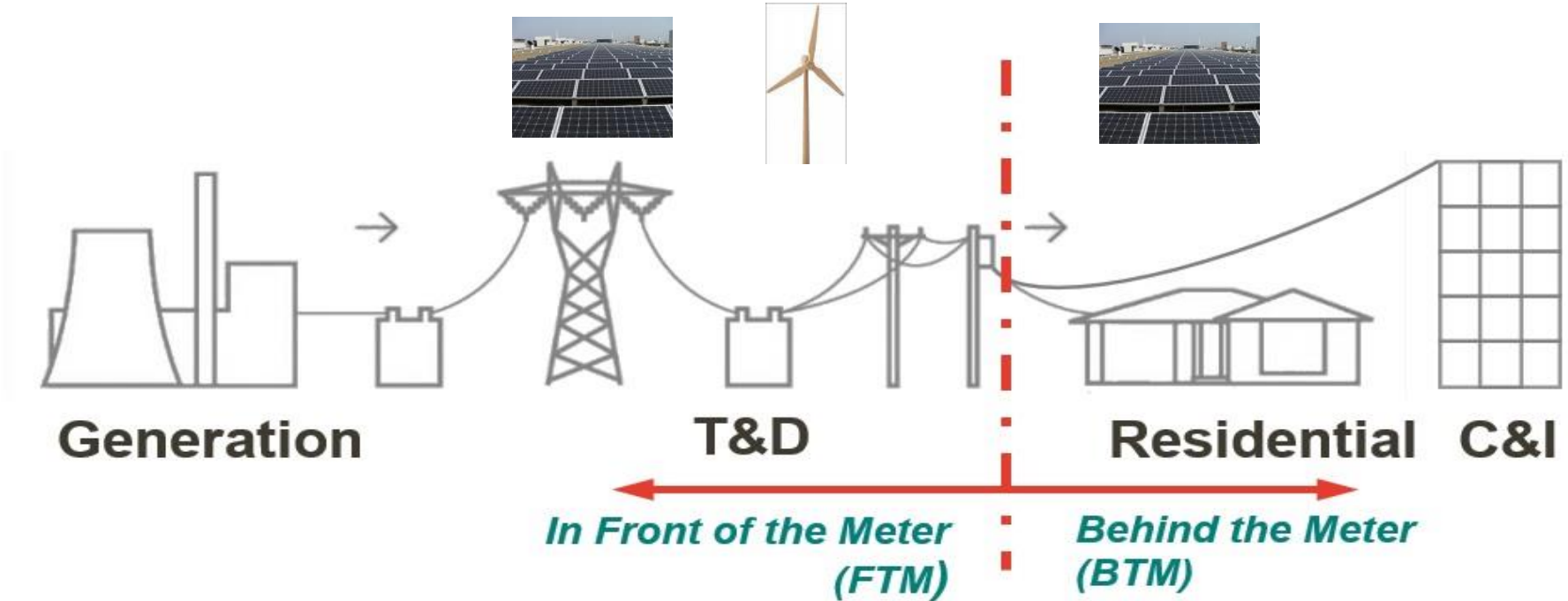
"ENERGY SERVICE"

- Time Shift
- MPE e Congestions
- Peak Shaving
- Secondary regulat.(200s/ 2h)
- Tertiary reserve (15 min- LD)
- Black Start

"POWER SERVICE"

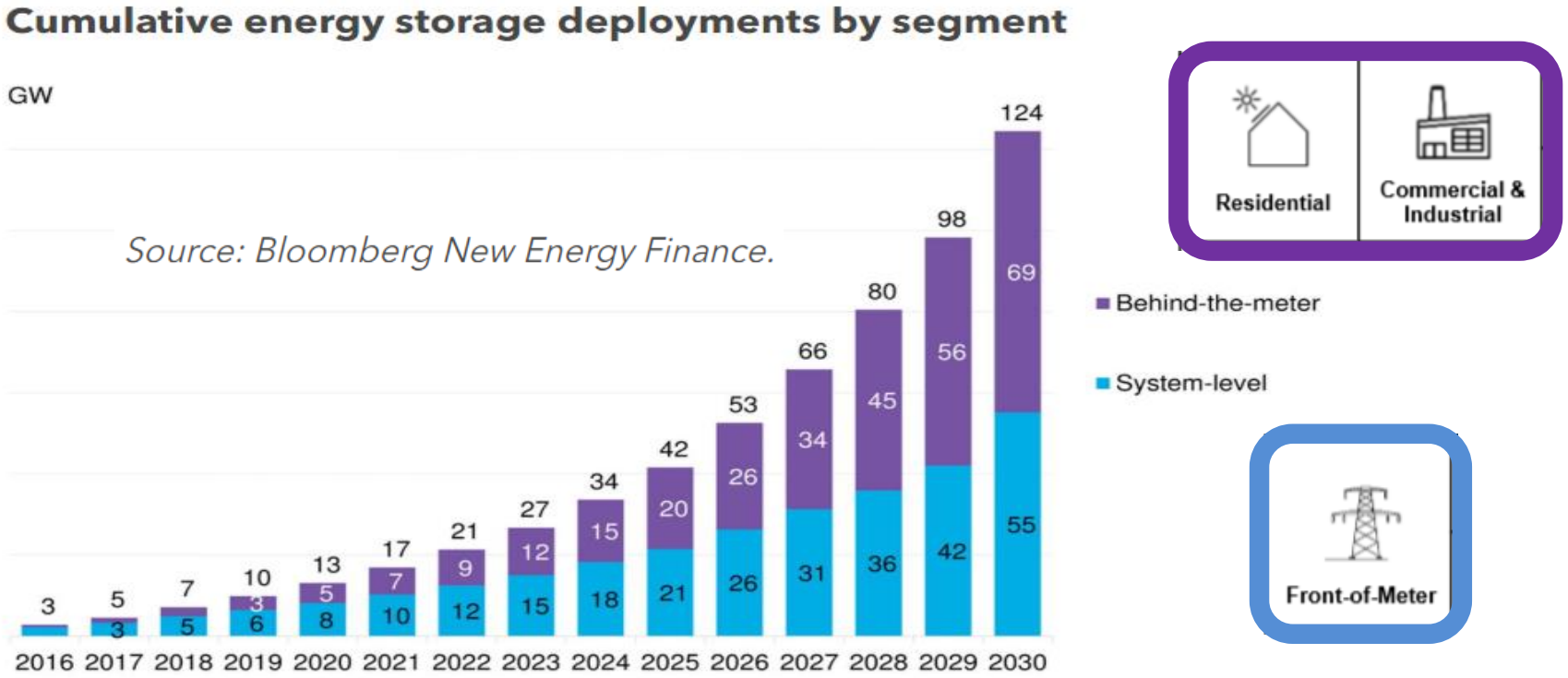
- Primary regulation 30s/15 m
- Voltage support
- Synthetic inertia
- Power Quality

At the international level, the classification in front of or behind the counter is more common.



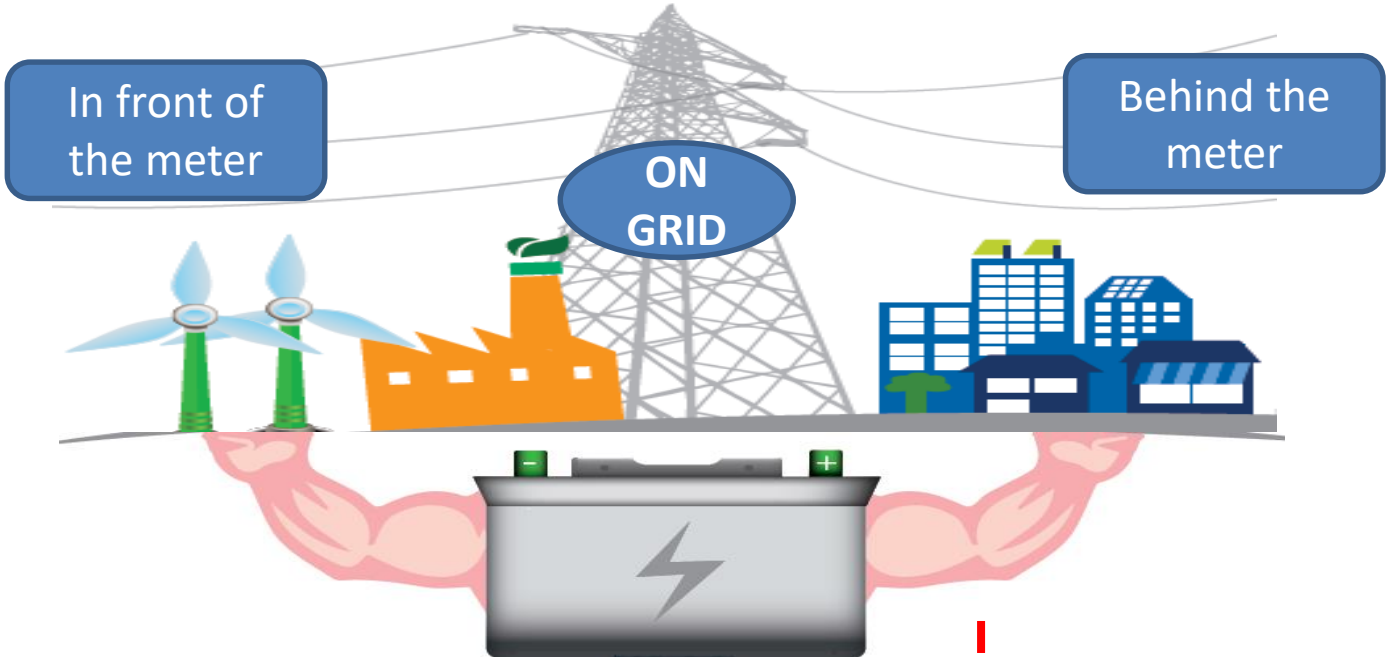
Should we invest on Energy Storage ?

And it's with this classification that Bloomberg measures a great development



Should we invest on Energy Storage ?

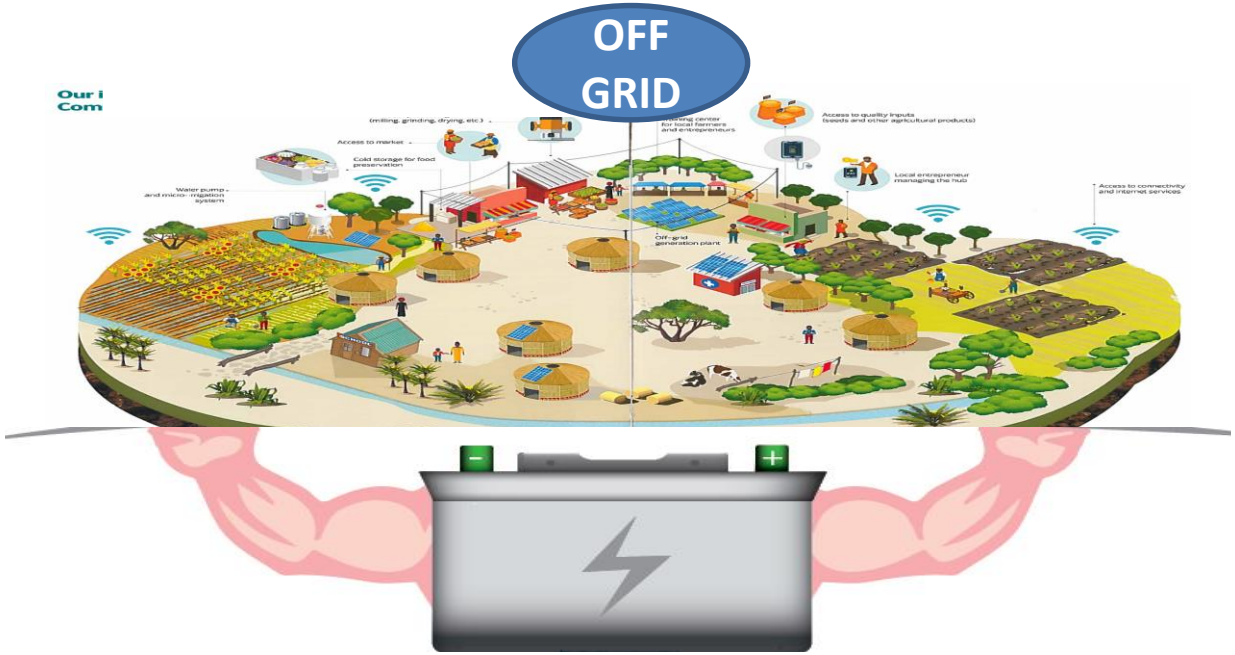
It is interesting to understand why investing on Energy Storage (On Grid)



Frequency Regulation | Power Reserve | Predictable Profile | Grid Congestion | MSD Arbitrage | Peak Shifting | **Own Consumption.** C & I and Residential

Should we invest on Energy Storage ?

….. and what about Energy Storage OFF _GRID ?



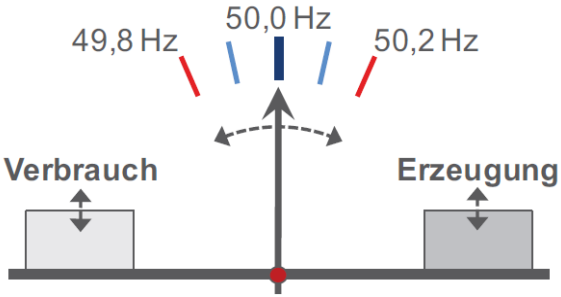
Diesel Efficiency

RES Maximization

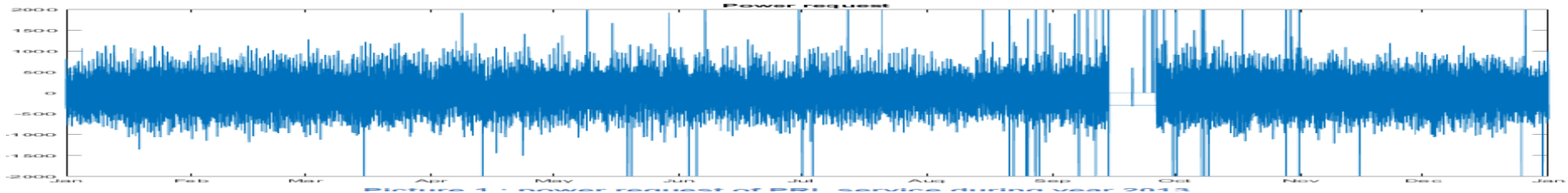
Stabilisation 4 ΔRES

1 FREQUENCY REGULATION

In order to be able to regulate the frequency of 50 hertz in western Germany (by the growth of renewables), the four german TSO + APG and Swissgrid have established an availability remuneration for the frequency regulation. Such document is the primary reserve (also called “primary control"), which must be available within 30 seconds, to avoid a transitory frequency. Therefore, the primary frequency control is the first to be activated with an immediate action on a mains frequency deviation: 49,8 Hz (full positive power) and 50,2 Hz (completely negative).



Should we invest on Energy Storage ?

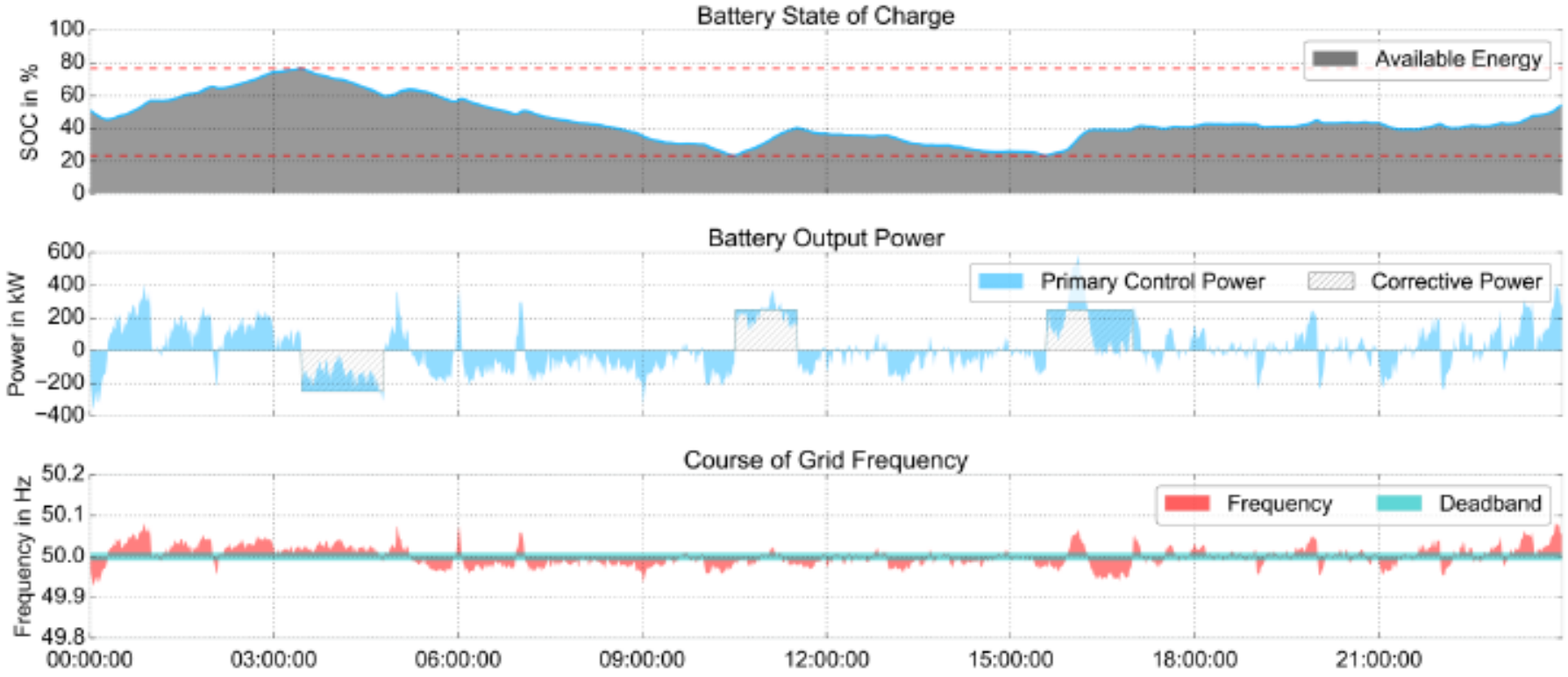


The power contributions for the regulation also have the objective of maintaining the COMPETITION WITH THE CORRECT RANGE (which allows to reply at any time to +Pmax and -Pmax for 30 minutes = around 50% of SOC).

Should we invest on Energy Storage ?

Exercise example:

The remuneration is the tariff of capacity ~ 3k€/MW weekly



2 SPINNING RESERVE

We have the examples of ENEL Global Thermo Generation: by the two carbon centrals of Litoral end Torrevaldaliga Nord, the reserve of 1,5% requested from the grid code would oblige to «stop» the groups at 98,5%, while with the storage they can work at 100% transfering the «rotating reserve» to the storage.

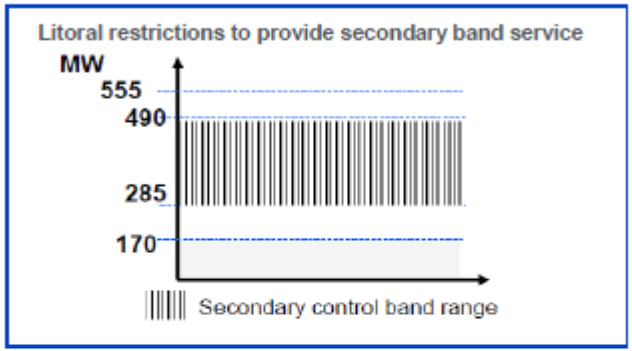
Torrevaldaliga Nord (Italy)
for 3 x660 MW coal fired pp

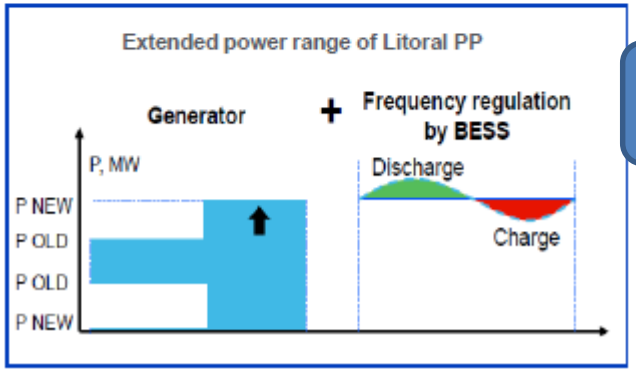
Actual Gr1 10MW/5MWh BESS
Future 3 x 20MW/10MWh BESS

LITORAL in Almeria (Spain)
for 2 x 550MW coal fired pp

20MW/11.7MWh BESS

Should we invest on Energy Storage ?





The service of primary regulation (Rotating) has the scope to contain the frequency deviation in the shortest time possible, avoiding the intervention of the defense systems with consequent disconnection of the load.

The margin of 1,5% must be considered on the maximum power of the plan declared in the RUP ➔ 1,5% x660 MW = **10 MW**
The power changement must be delivered at least 50% within 15 seconds from the start of frequency changement 100% within 30 seconds, afterwards the new generated power must be permently mantained for at least15 minutes. ➔ **C2**

The remuneration is the production increase at full power

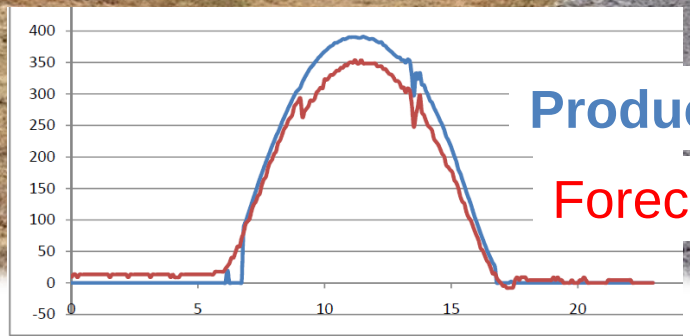
10MW - 5MWh

It is necessary to evaluate the needed time to repay the investment, considering that the Storage allows a share of producibility, which otherwise would be intended to guarantee the regulation service of the network frequency.

3 PREDICTABLE PROFILE

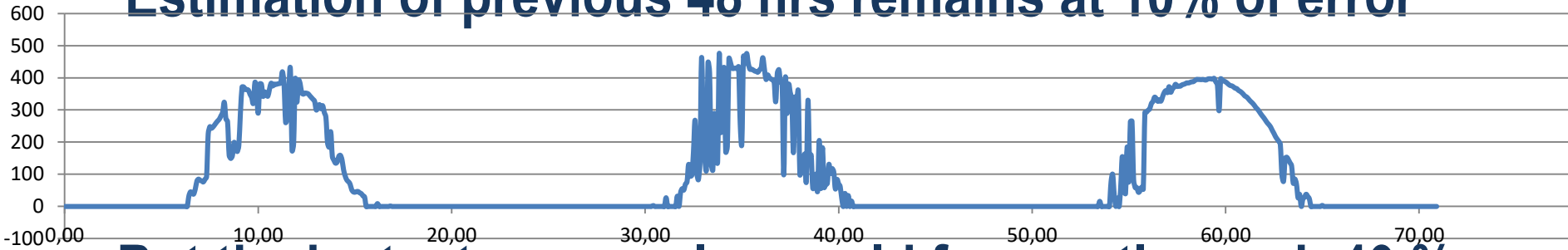
Predictable generation profile.

Storage is to balance the accuracy error of the sun forecast in order to ensure the production profile.

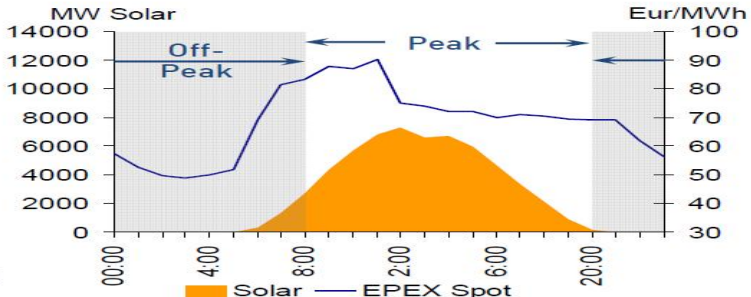


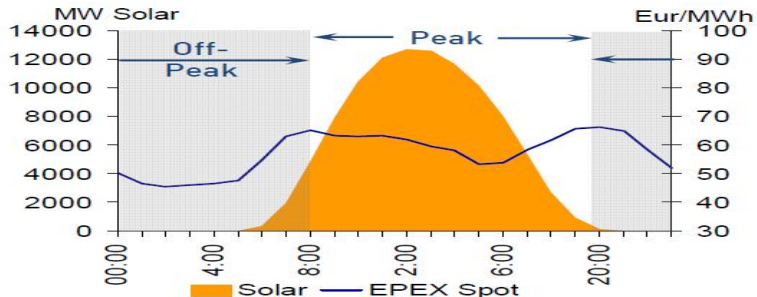
Should we invest on Energy Storage ?

Estimation of previous 48 hrs remains at 10% of error

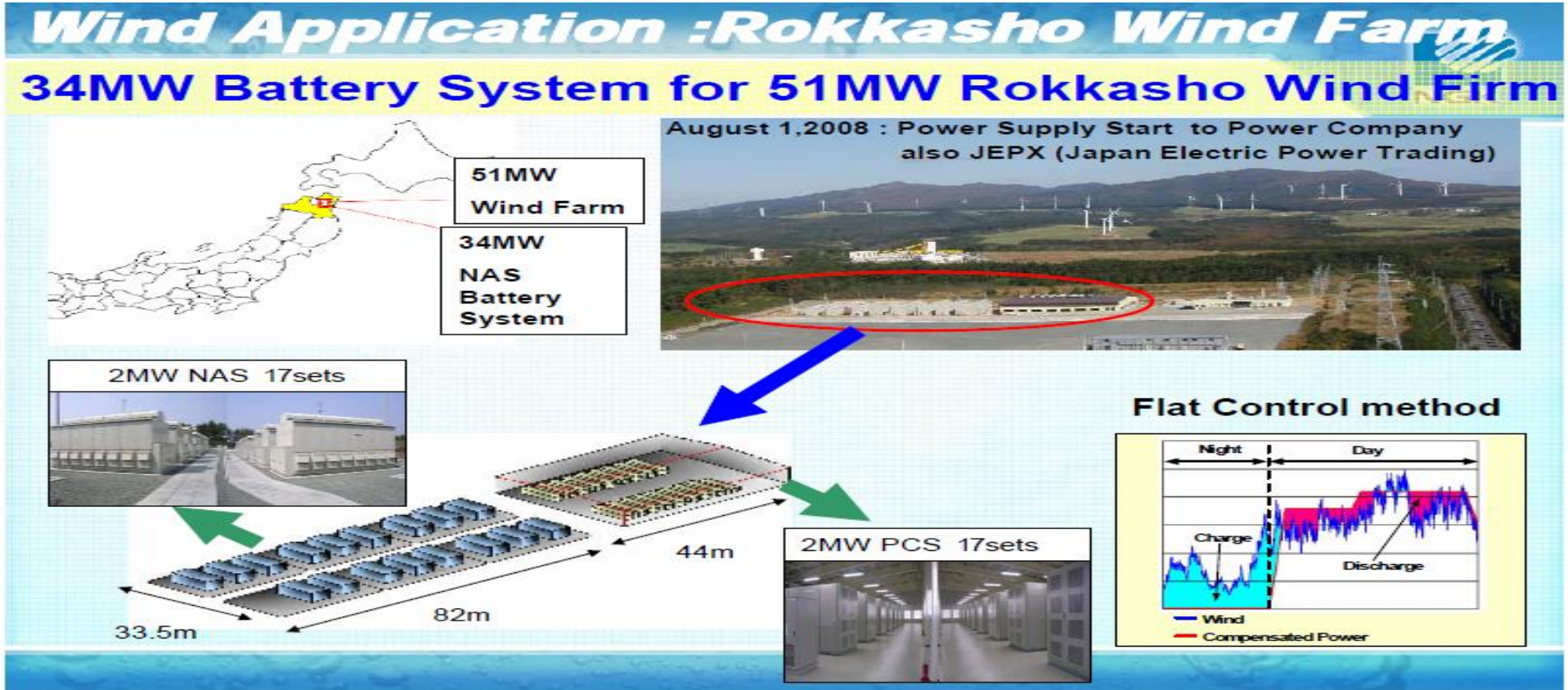


But the instantanous value could frequently reach 40 %

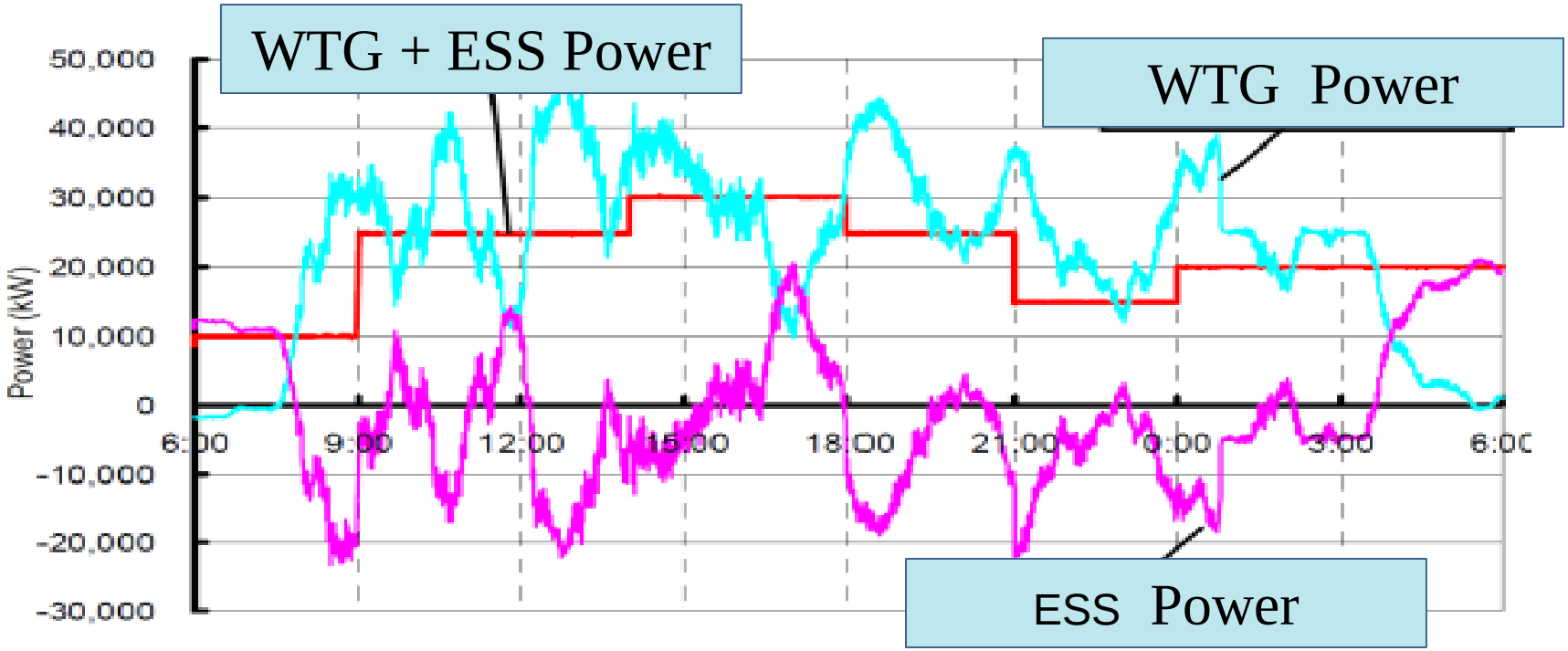




34 MW -150 MWh for an Eolic field of 51 MW



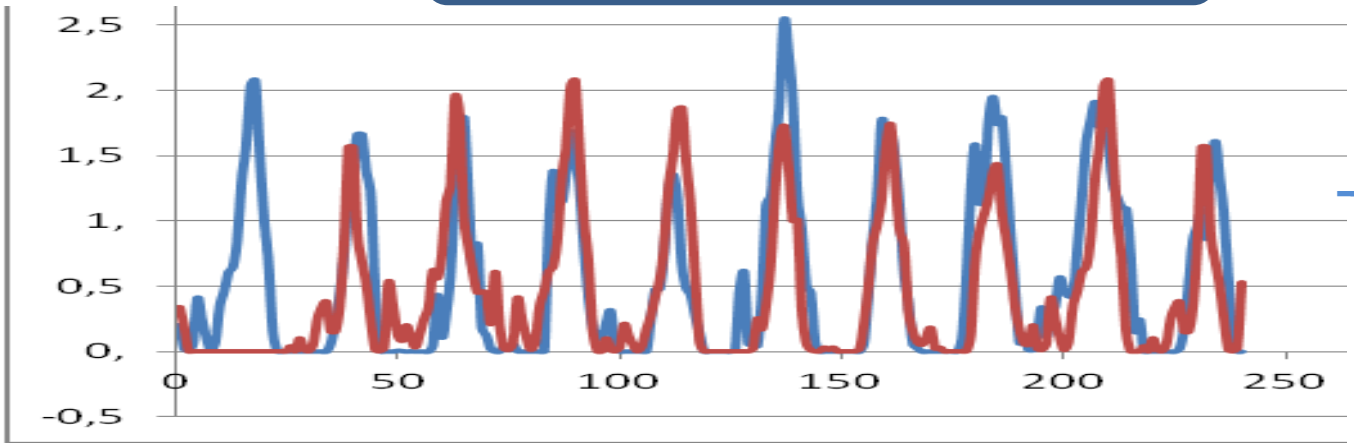
Should we invest on Energy Storage ?



The production of wind farm fits in the scheduled profile.

Should we invest on Energy Storage ?

Is remuneration intended to avoid the penalty of unbalance !! ??

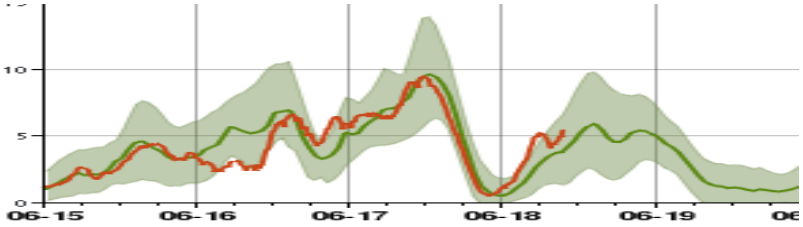


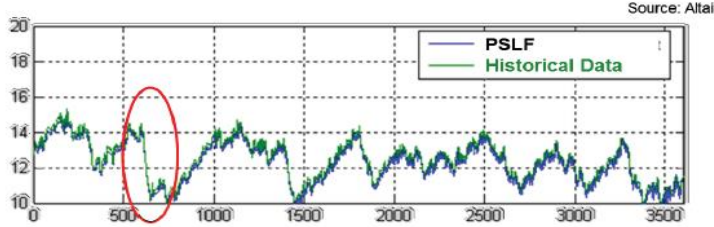
WIND Production

— Production

— Forecast

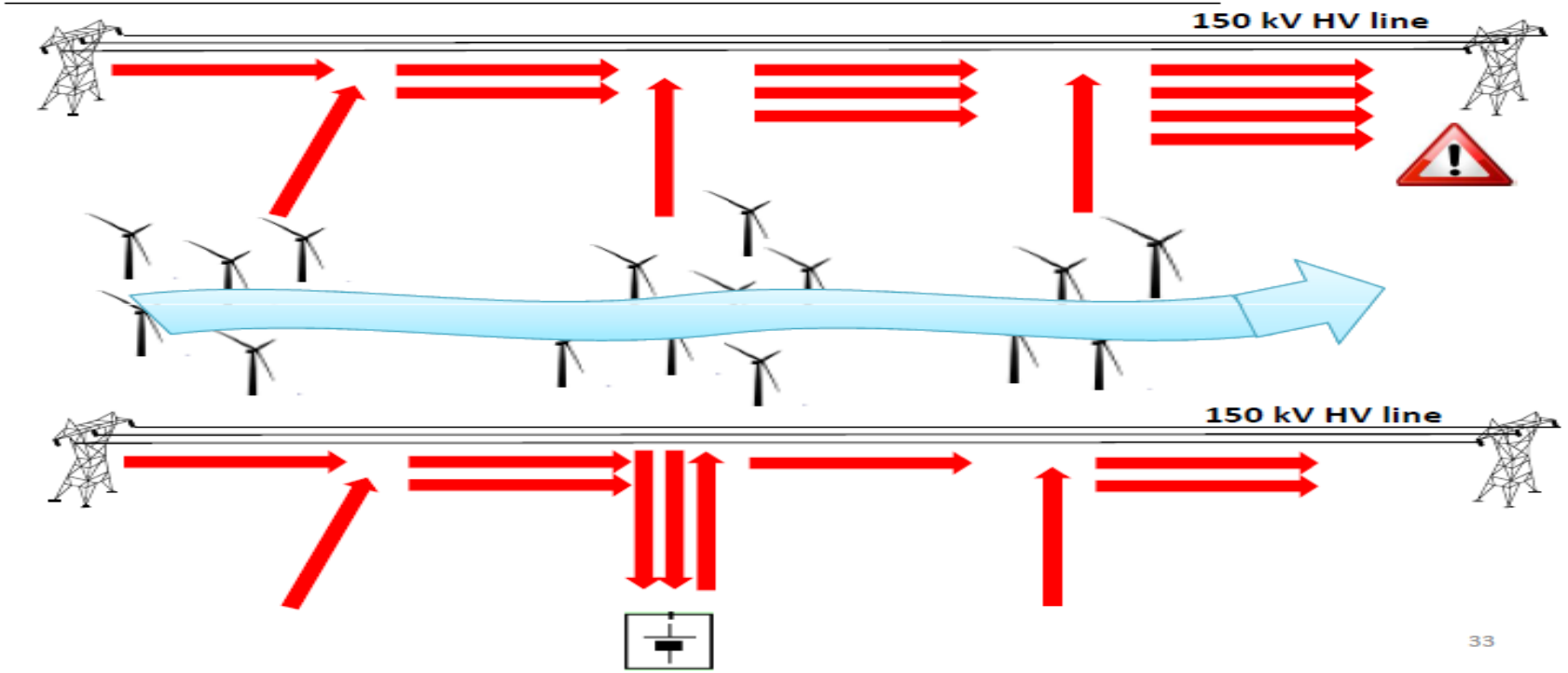
24 h in advance Wind forecast is now in the range of 10 % with 30-40% peak values



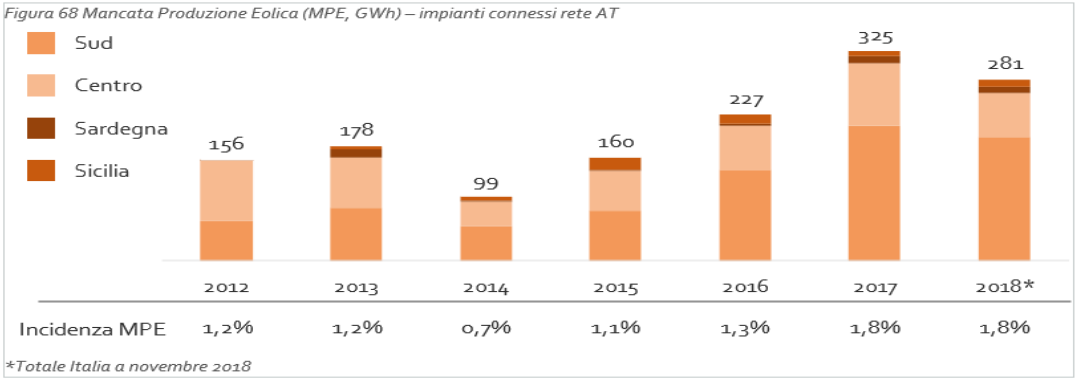


4 GRID CONGESTION

Grid congestions (obligation of RES recall)



Should we invest on Energy Storage ?

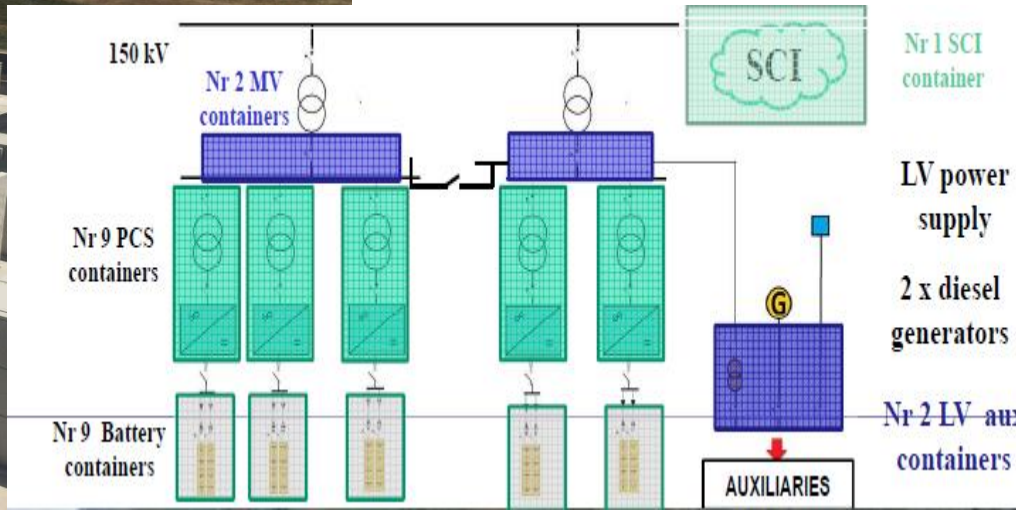


The operator, in order to ensure the safety of the system, in case of wind gusts that bring overload on the line, through UPDM communication forces the producer not to evacuate power to the grid, still guaranteeing an economic remuneration for missed production. It is in fact a mechanism that protects the producer but not the production.

Example of “grid bottleneck” Scampitella 10,8 MW-72MWh

The remuneration comes from avoiding/reducing of MPE (Missed Eolic Production)

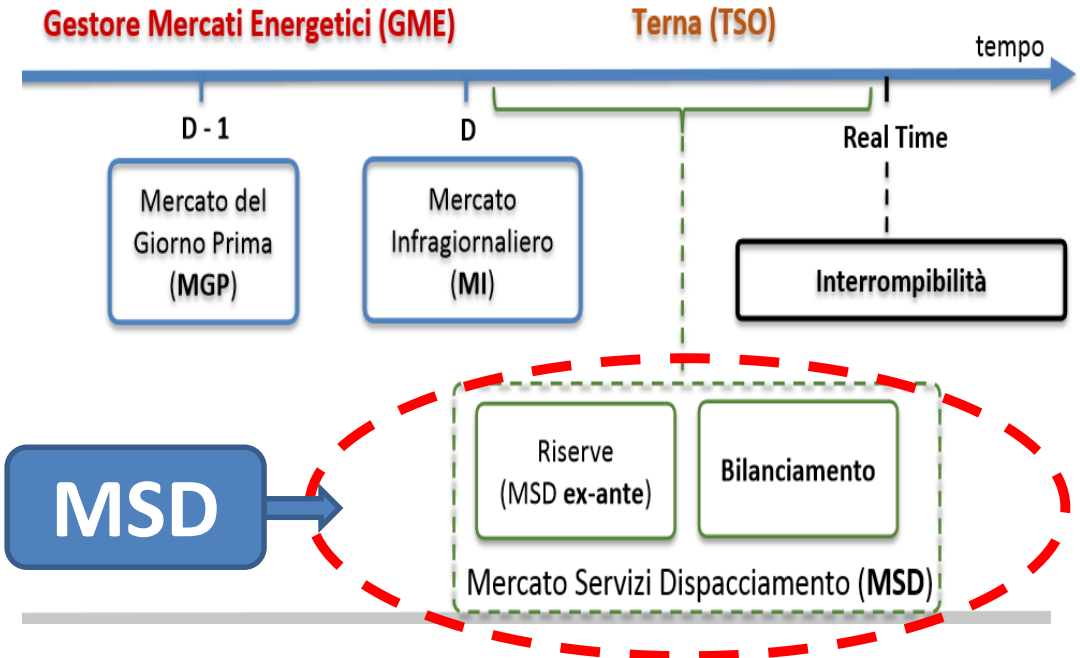
The 72 MWh capacity allows energy to be stored during overloads (wind gusts for all SS dorsal). In 2016 MPE has been reduced of 6 GWh.



5 MSD ARBITRAGE

In Italy the Electric Market forsees that Terna (TSO) has taken charge of the burden of grids balancing, there is a special market (Market of the Services of Dispaching, MSD), where Terna supplies the necessary balancing services. Interruptibility takes over as the last ratio, as a defence system, and comes only into operation if the previous mechanisms are not sufficient to recover the unbalance of grids, and only impact on customer who are partecipating to such service.

Introduction to the Market of MSD despatching Services



Flexibility – an increasingly important source

Flexibility represents the capacity to increase or reduce the production in generation plants or consumption in load, it's a precious source for the safety of the electric system and it will be even more in the future with:

- trend to ALL ELECTRIC : services powered by fossil fuels (heating, cooking, cars, etc.) become electric; the intensity of these processes will lead to more pronounced load peaks;
- trend of RES-NP: increased production quote covered by non-programmable renewable sources.

FLESSIBILITY OF GENERATORS/LOADS/STORAGES

Flexibility has therefore become unavoidable ➔ MSD

MSD ex-ante

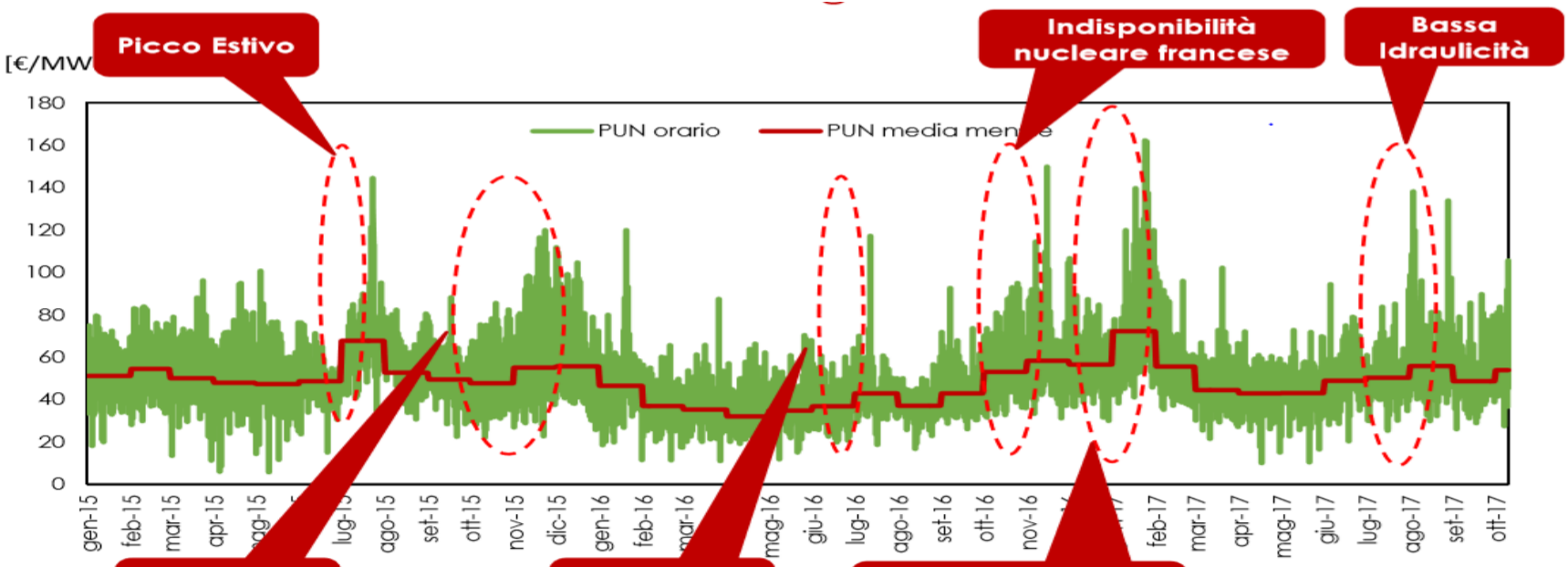
used from Terna to supply sources during programming, to avoid congestions and to guarantee safety.

Market of balancing in real time (MB)

with which Terna supplies the sources (as MSD ex-ante), but for an optimal real time management.

An increasingly flexible future

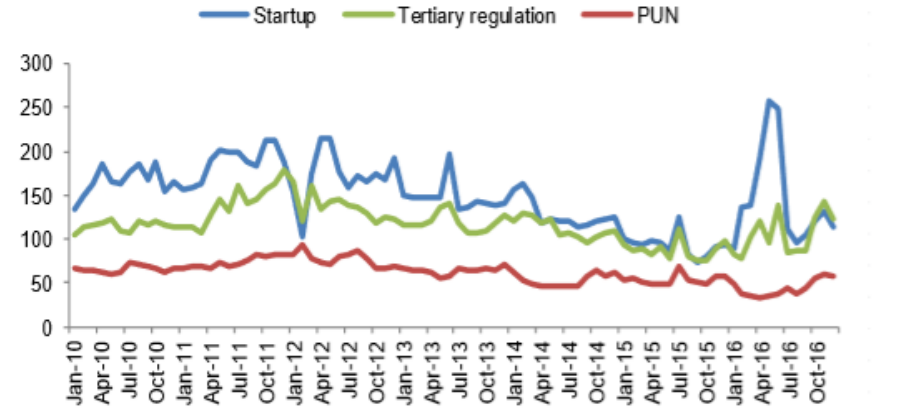
The growing request for flexibility permits to such markets to evolve also from a normative point of view.
The aim is to involve an increasing number of generation, storage and consumption units towards ancillary network services and to make a slice of users more aware of, and involved in the dynamics of the electricity markets.



MSD: volumes are constantly growing, wide price spread compared to MGP

Untill now, most of the volume traded on MDS is combined cycles, but in future….

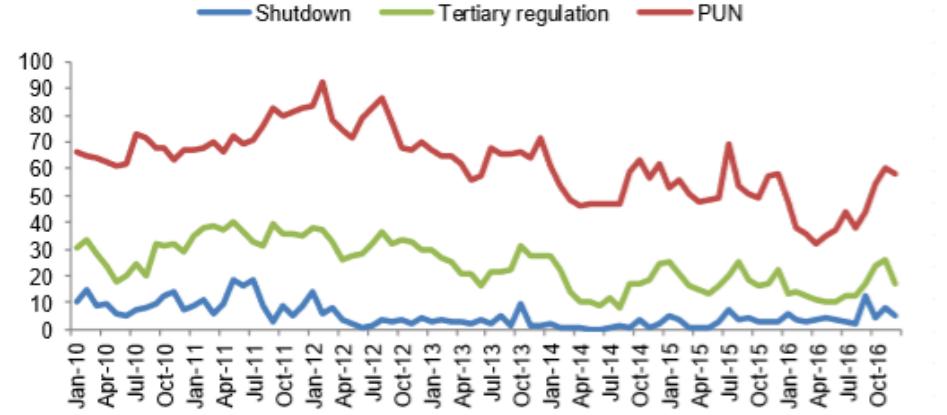
Prices to Rise
PUN< MSD ris < MSDup



Data collected up to December 2016
Source: REF-E processing on GME data

To sell at 130 – 250 €/MWh

Prices to Go Down
MSD dw < MSD ris < PUN

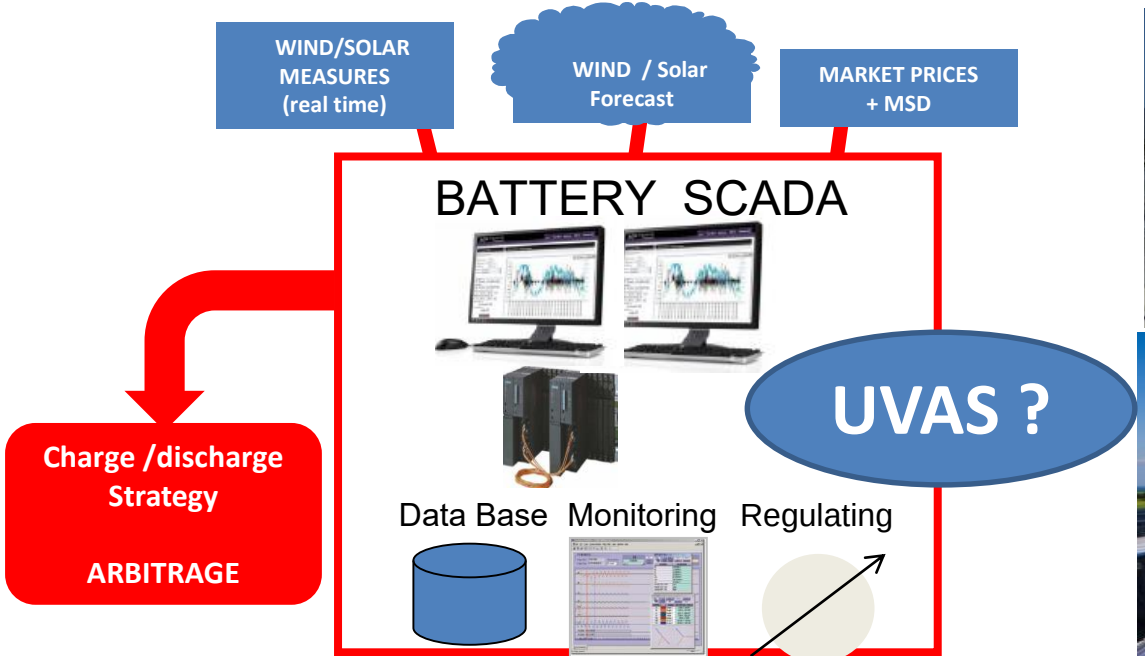


Data collected up to December 2016
Source: REF-E processing on GME data

To buy at 0 – 15 €/MWh

New opportunities for FRNP to partecipate to MSD with STORAGE

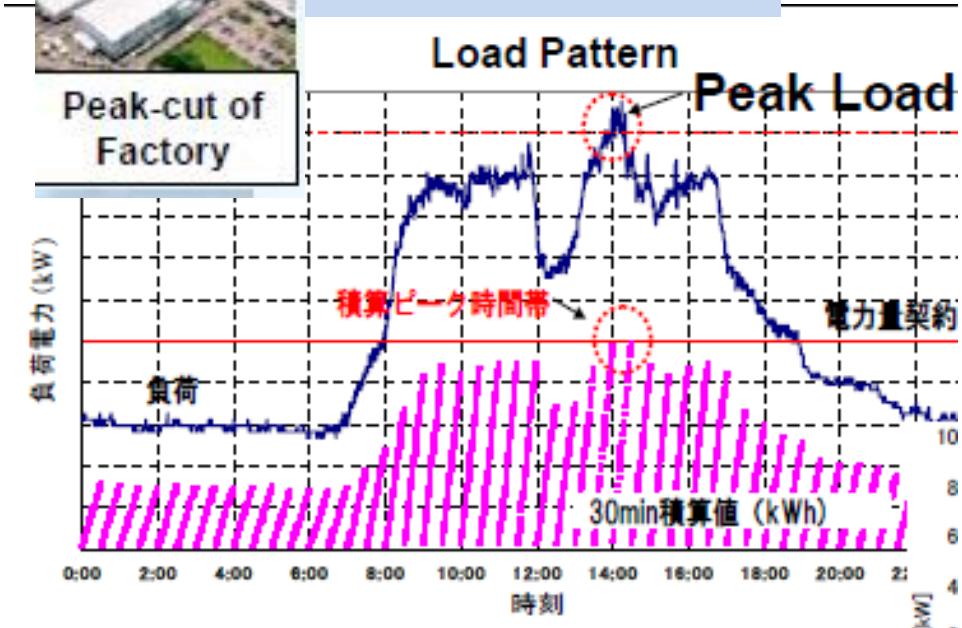
Potential partecipation of FRNP+ Storage on MSD (both relevants than in aggregate) to: solve congestions, primary, secondary and tertiary reserves, balancing: FRNPs are becoming a programmable plant that can adopt strategies on different markets.

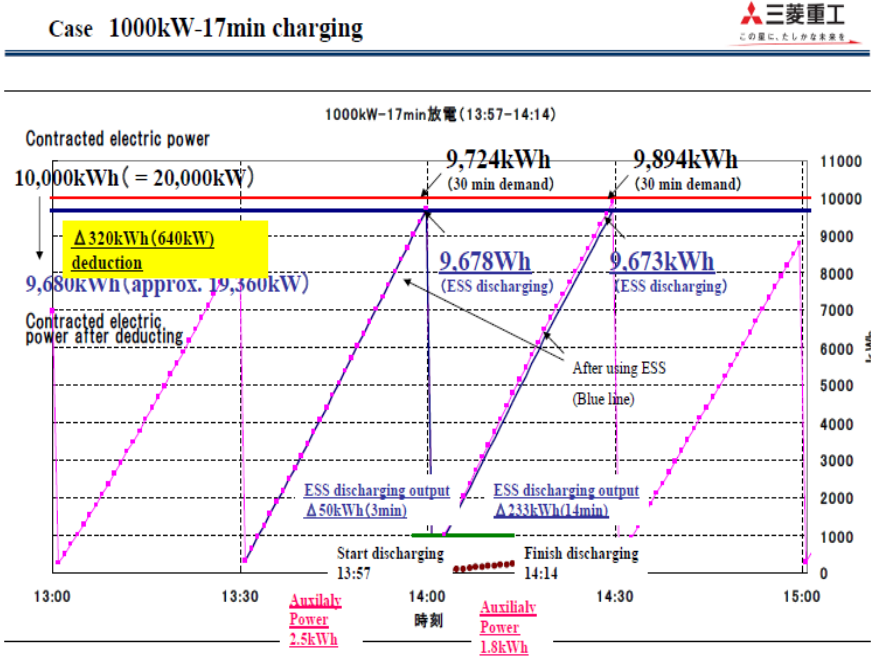


6 PEAK SHIFTING

Industrial application and residential too.

PEAK SHIFTING (or SHAVING): Reduction of a temporary peak (through preloaded storage) in order to avoid the superior power class.

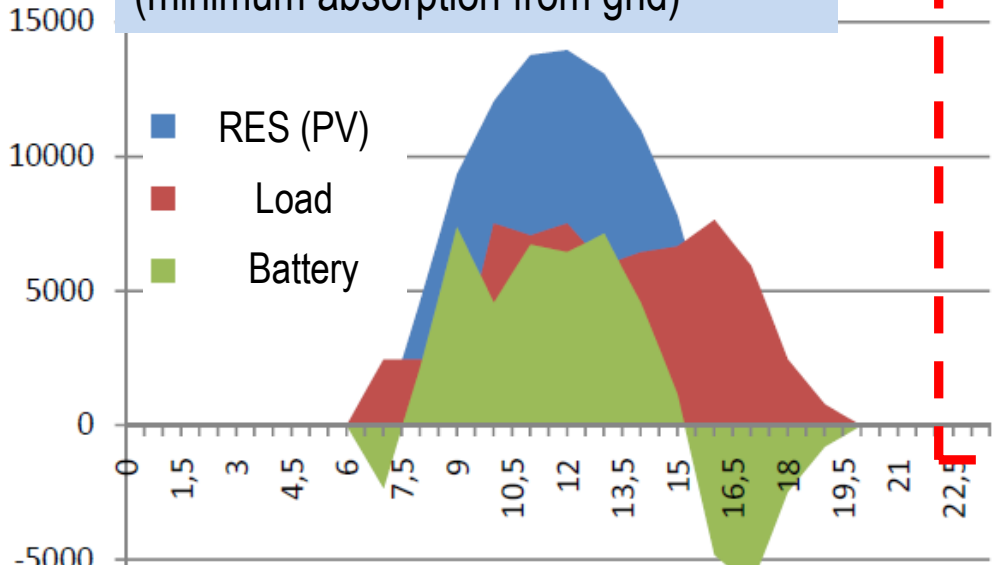




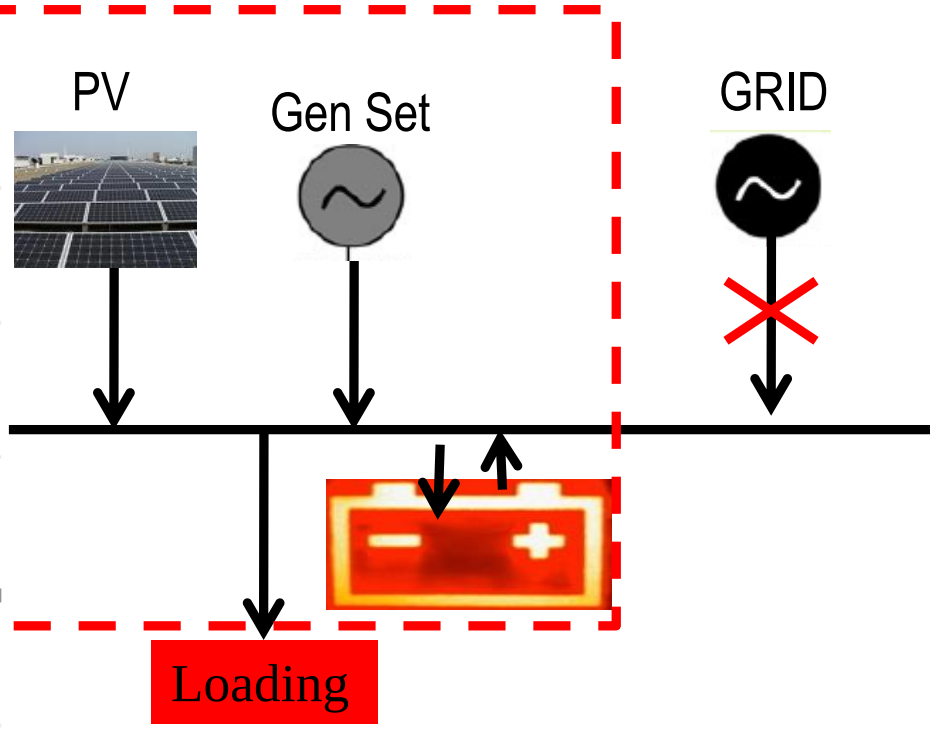
Should we invest on Energy Storage ?

7a SELF-CONSUMPTION C & I

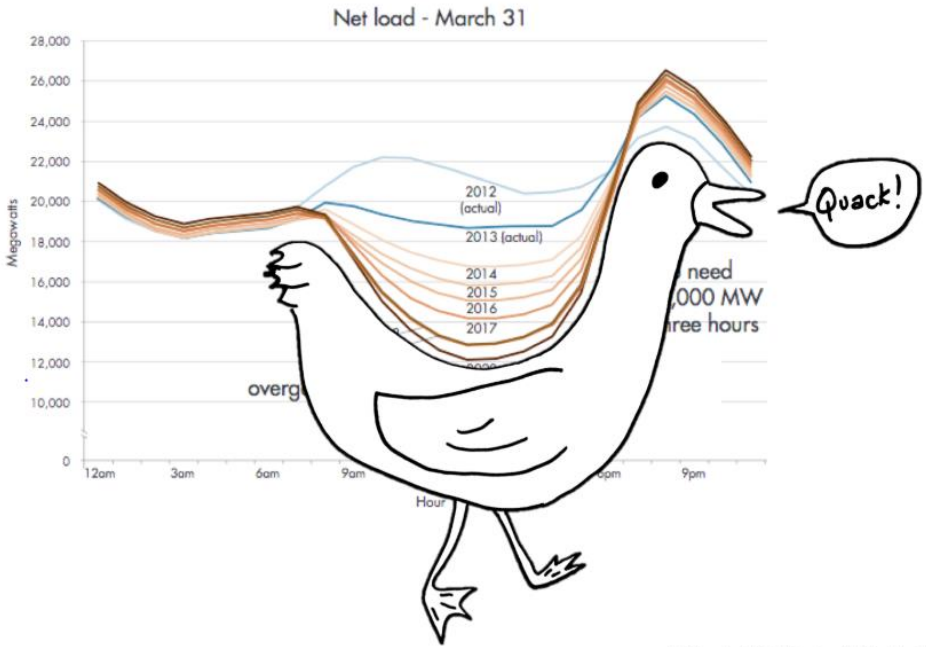
Industrial and residential applications by maximizing the self-consumption (minimum absorption from grid)



7b RESIDENTIAL SELF-CONSUMPION



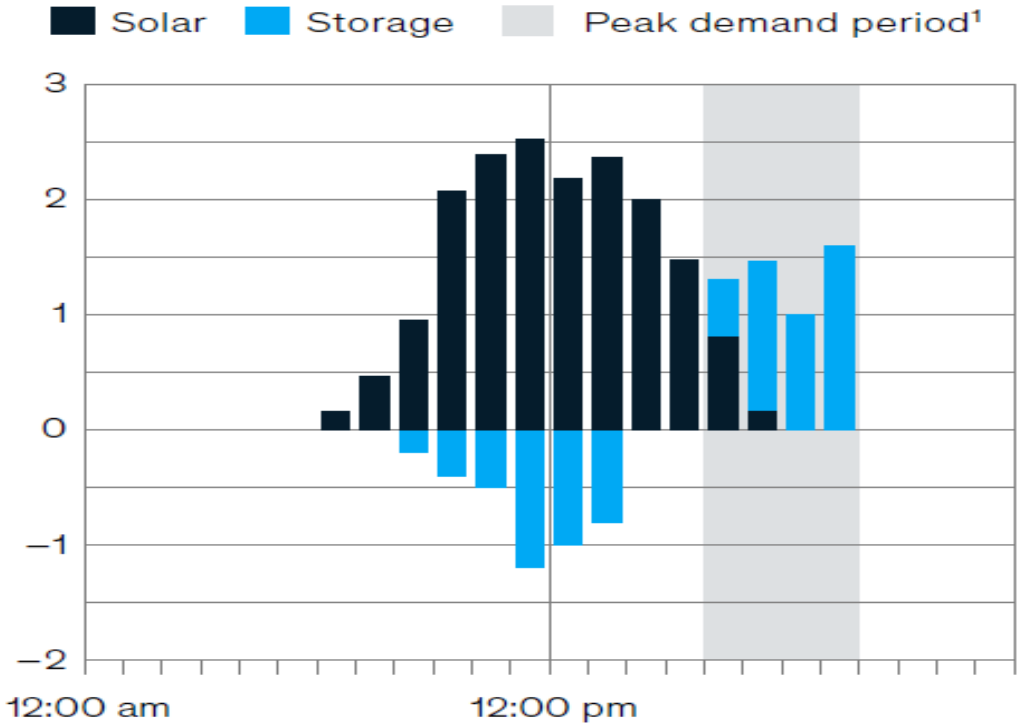
The "Californian Duck Curve» as typical situation for areas of high Photovoltaic concentration.



California ISO / Jordan Wirfs-Brock

California was one of pioneers of Photovoltaic. The Duck Curve shows how the spread photovoltaic plants reduce the residual load during middle hours of the day. Towards eveninig, however, the request increases just when solar energy production is decreasing. This leads to a significant increase of electricity withdrawn from the grid. The traditional electricity pool will therefore have to be able to quickly increase the production.

Storage makes the Californian Duck more «dispatchable»

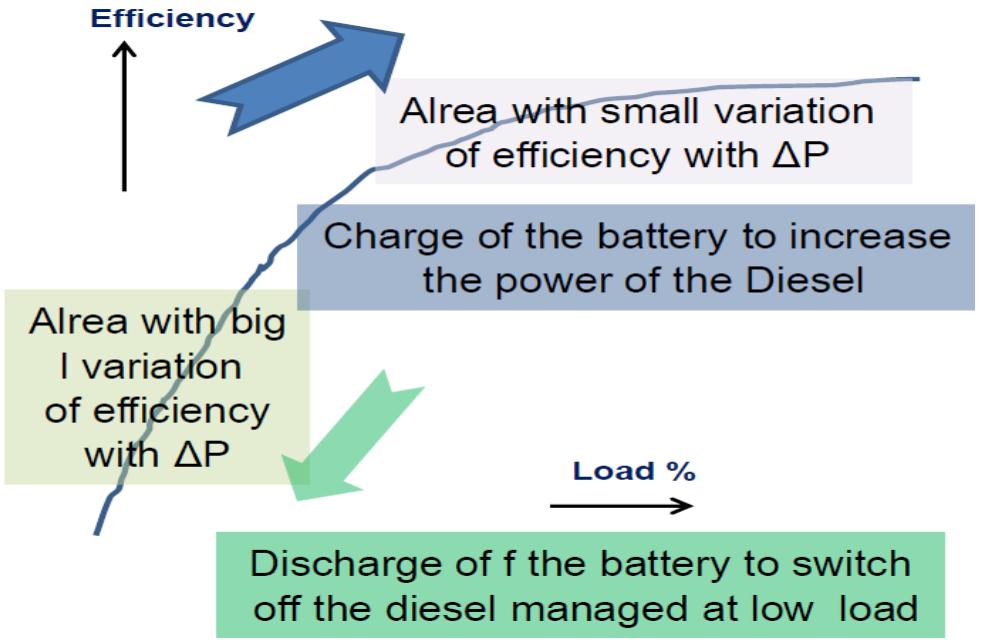


The request for power with a rapid ramp on the duck's neck is met by batteries, which can provide a rapid reaction to peak demand.

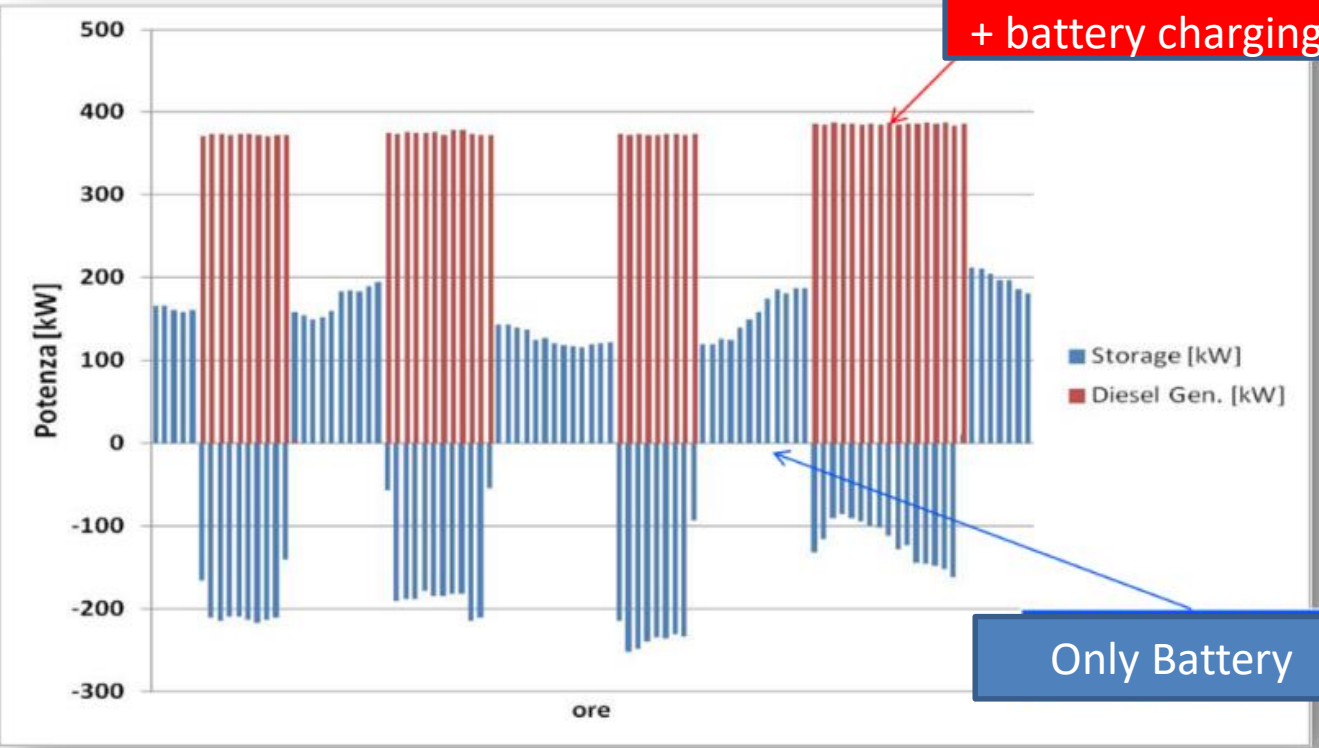
8 EFFICIENTY OF DIESEL

Efficienty of an insulated Diesel with Energy Storage

Normally the efficiency of a diesel strongly depends on the load: there is an area of functioning characterized from high variations of efficiency compared to the changement of the load (area 0-70%Pn) and operation areas where the variation of efficiency is low compared to the changement of the load (the area 70-100%): it's therefore possible to economize fuel by inserting a system of storage.

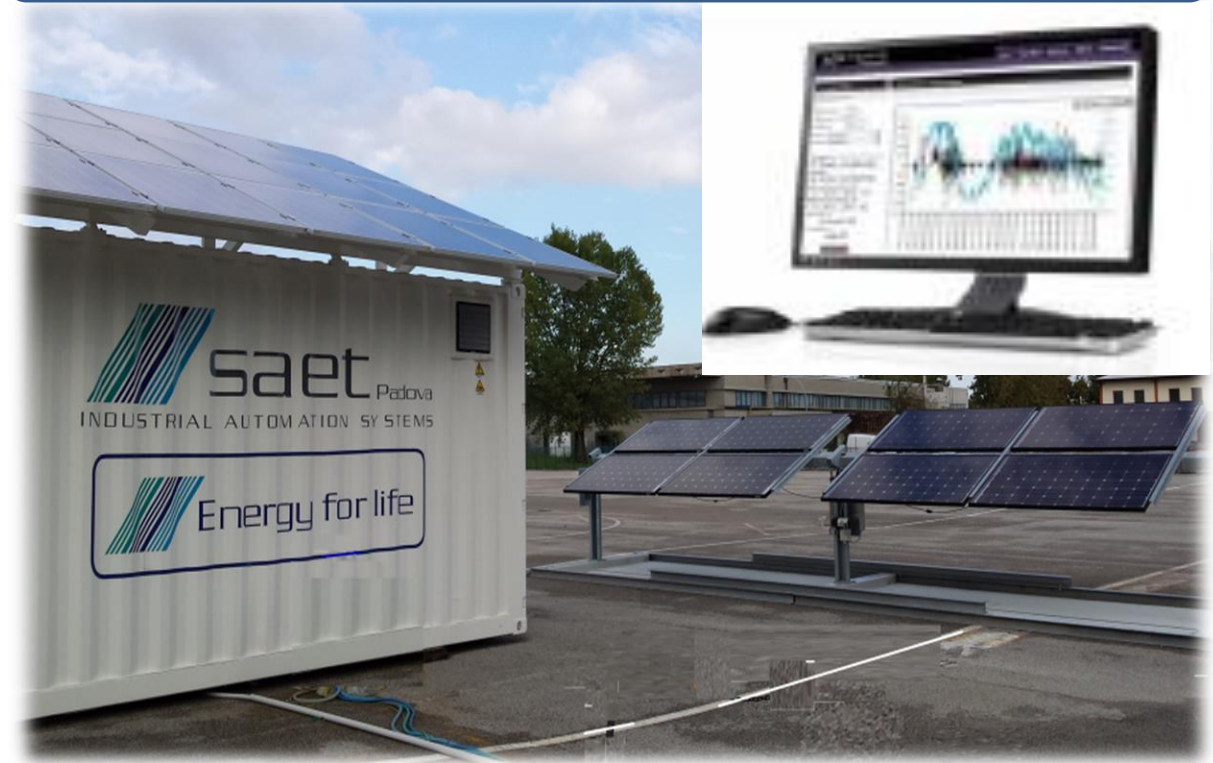


Efficiency of an insulated Diesel with Energy Storage

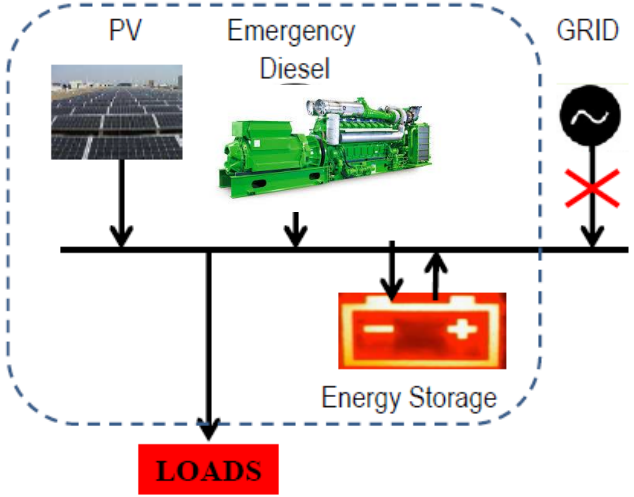


It is in fact possible to let the diesel working at constant power around the full load by accumulating the surplus to charge the battery; when the battery is close to full capacity the diesel is turned off and adjusted with the battery only. We save fuel and often transport logistics.

9 RES MAXIMIZING

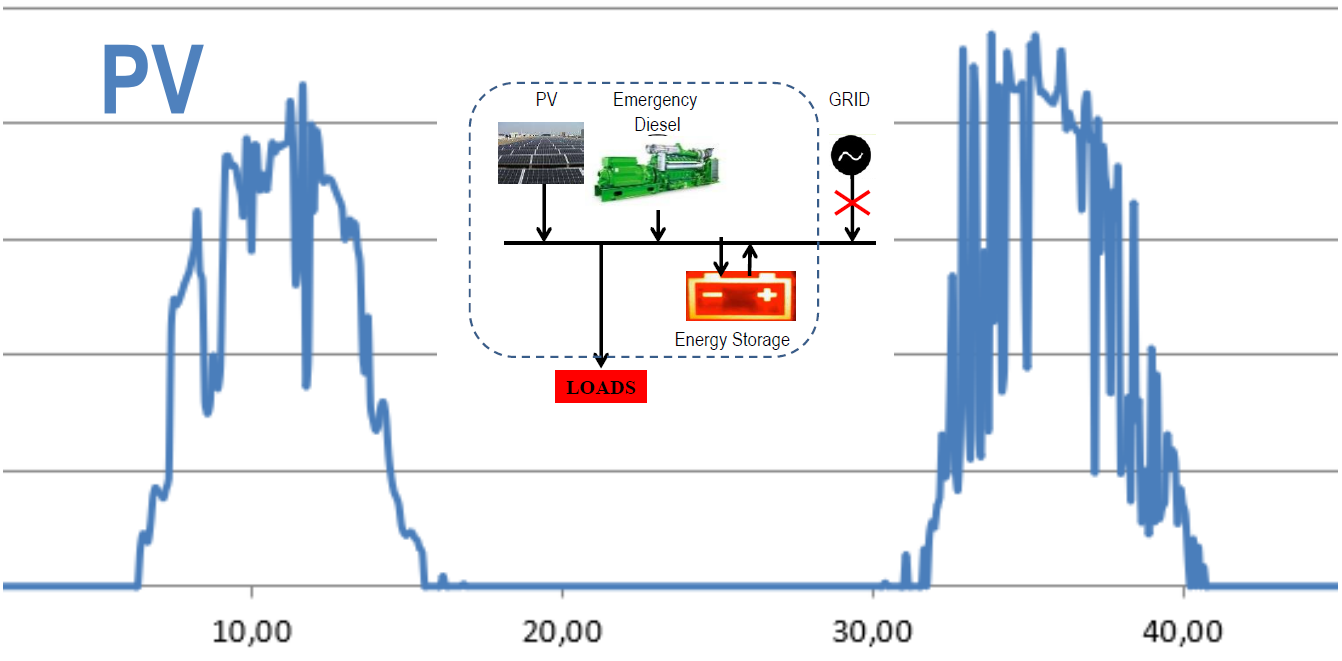


The EMS of the isolated hybrid system can maximize the RES contribution by using diesel as an emergency only; by achieving a further significant reduction in fuel consumption.



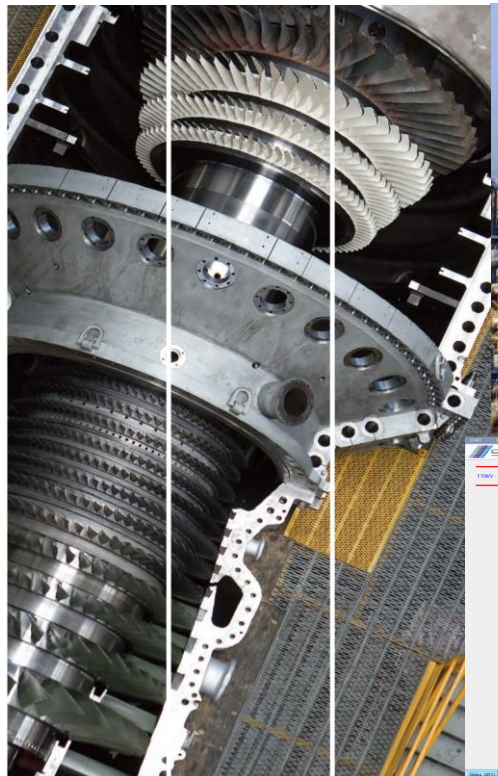
10 Stabilization of Δ RES

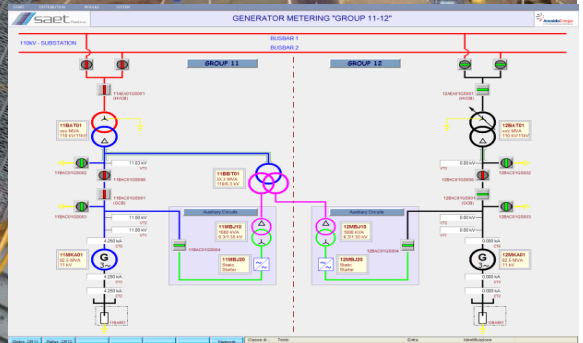
Reduction of the impact of irradiation variations(up/down ramps)



In the management of isolated PV+Diesel plants, the behaviour of the diesel is absolutely critical with the rapid falls and generation resumption due to the passage of clouds. Storage with control of off-grid frequency guarantees the stability of the grid.

Storage for thermo power plant

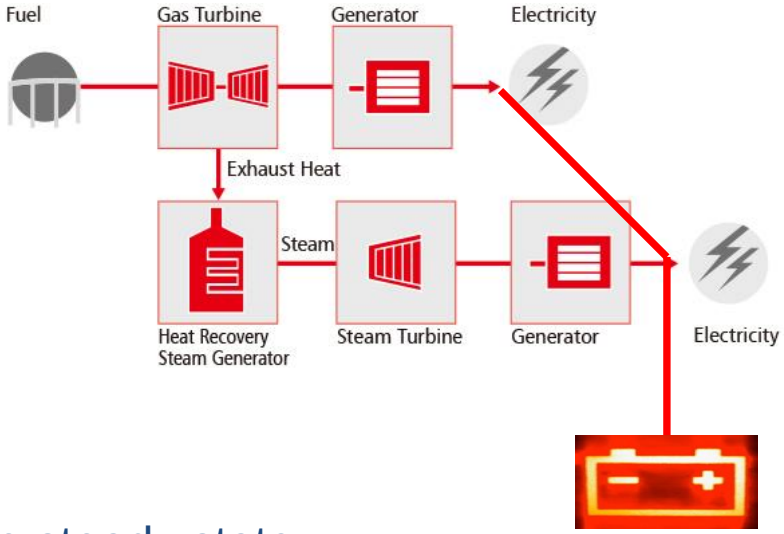




+

By combining electric energy storage systems with combined CCGT cycle power plants it is possible to provide solutions for the economic and reliable provision of balancing services, with several attractive functions used to increase the revenues of the entire power plant.

Power Plant + BESS



1. Black start
2. Primary Reserve for Freq. Reg.
3. Frequency regulation
4. Voltage regulation
5. Fast ramping support
6. Syntetic inertia
7. Accellerated Power adjustment with turbine steady state
8. Supporting demand under the minimum treshold load
9. Reduced Operation Costs

HYBRID SOLUTION: FULLY INTEGRATED BESS + POWER PLANT

CONCLUSIONS #1

The growth of NPRES and GDs has led to several management problems and the need for flexibility in the electrical system.

Among the SMART solutions for such problems there's SMART STORAGE, which has several advantages (even if the high costs of the batteries lead to returns that are still too long): it's often necessary to identify various advantages to be added up.

Storage as a solution to grid problems, but also off-grid and MICROGRID STORAGE model, both for advanced and developed countries.

STORAGE is the new solution for the integration of RES and energy decentralization with increasing of quality and efficiency.

CONCLUSIONS #2

There are several reasons to invest in storage, even if the "rush to storage" (considered by all to be the typical aspect of the electrical system of the future) has not yet begun.

The reasons of such situation are:

Battery costs (wich are, however, expected to rapidly descend…..)

The regulatory aspect that has not been adequately developed for storage in various countries.

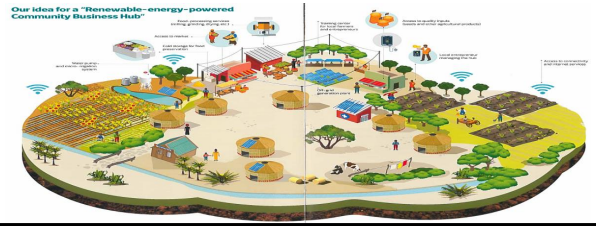
In **Italy** a regulatory evolution is expected on the **remuneration of the primary**, on **accesso to MSD**, on the **costs of imbalance** of the FRNPs.

H.V Substation provider

Energy Storage System

EPC for RENEWABLES

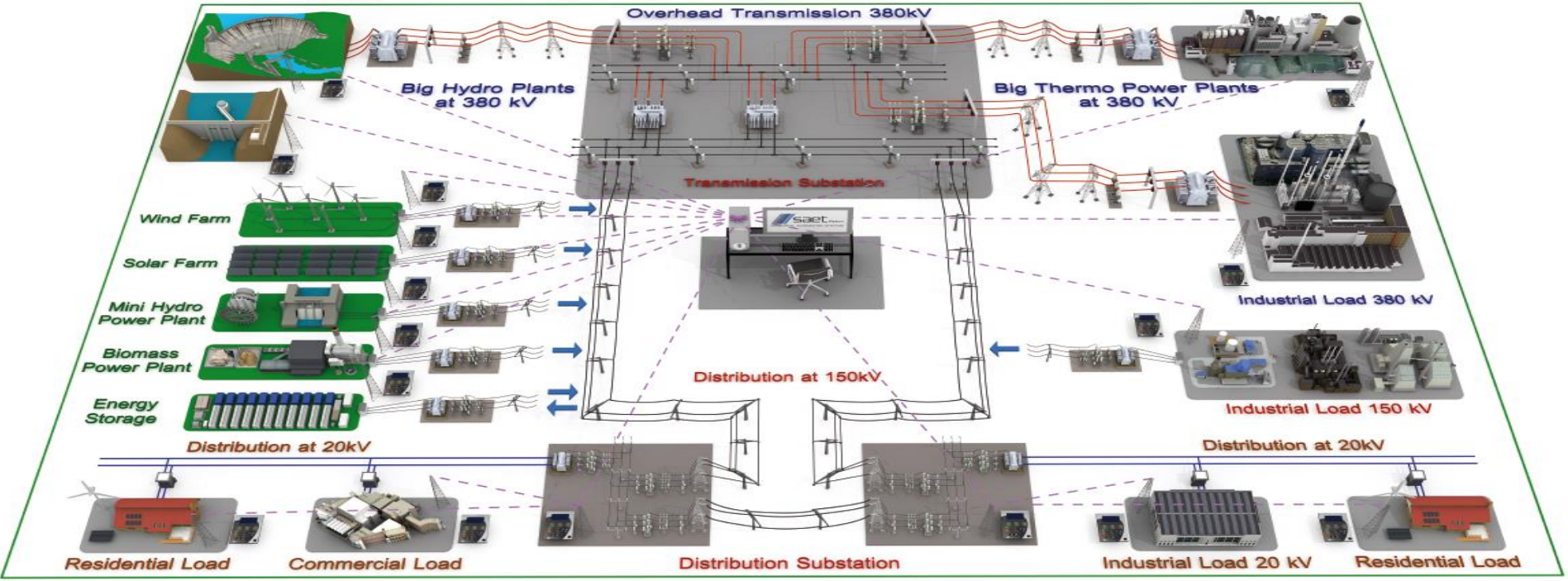
Smart Energy OFF-GRID



The role of SAET : smart energy solution provider

Should we invest on Energy Storage ?

Can We Smart Your Grid?



Thanks for the kind attention.