



# **Enel Green Power Innovative Storage Solutions**

10 May 2017 Presentazione Libro Bianco sull'Accumulo Elettrochimico - Milano



# Enel Group worldwide

Enel today: global and diversified operator<sup>1</sup>



~40 €bn Regulated Asset Base  
~62 mn distribution end users

#1 in Italy, Spain, Chile, Peru  
#2 in Argentina, Colombia



~17.5 mn free retail customers

#1 in Italy and Spain



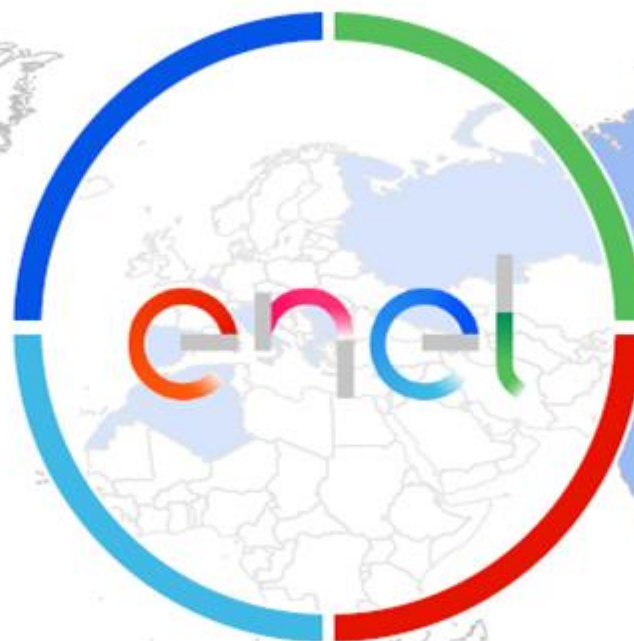
~36 GW renewable capacity<sup>2</sup>

Global leadership in  
renewables



~48 GW thermal capacity

Highly flexible and  
efficient generation fleet



1.As of 2016E

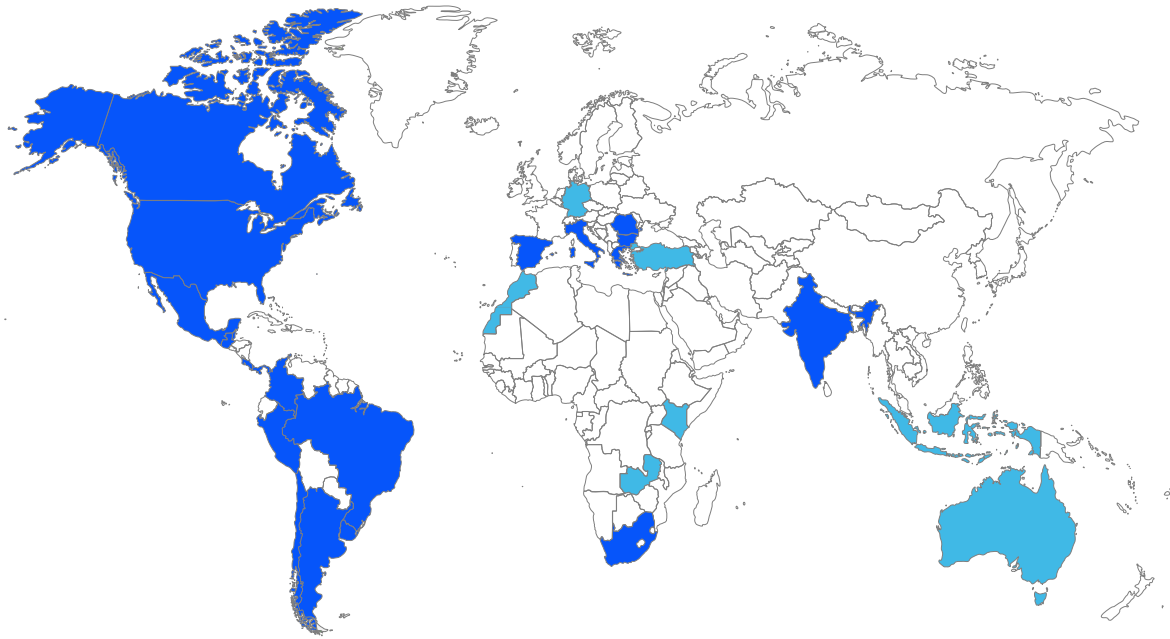
2.Consolidated capacity including 25 GW of large hydro

3.Presence with operating assets

■ Countries of presence<sup>3</sup><sup>2</sup>

# Enel Green Power

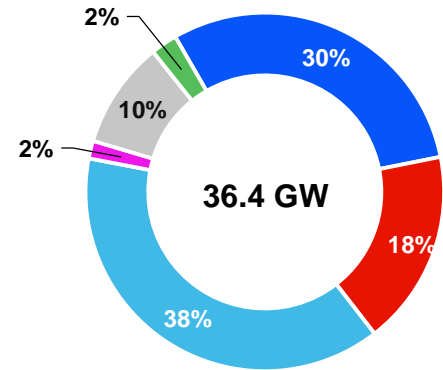
A Global leader



Countries with installed capacity

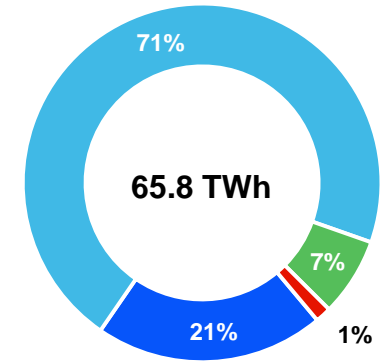
Countries with awarded capacity or other developments

### Installed capacity by geography<sup>1</sup>



- Latam
- Iberia
- Italy
- Sub-Saharan Africa & Asia
- North & Central America
- Europe & North Africa

### Net production by technology<sup>1</sup>

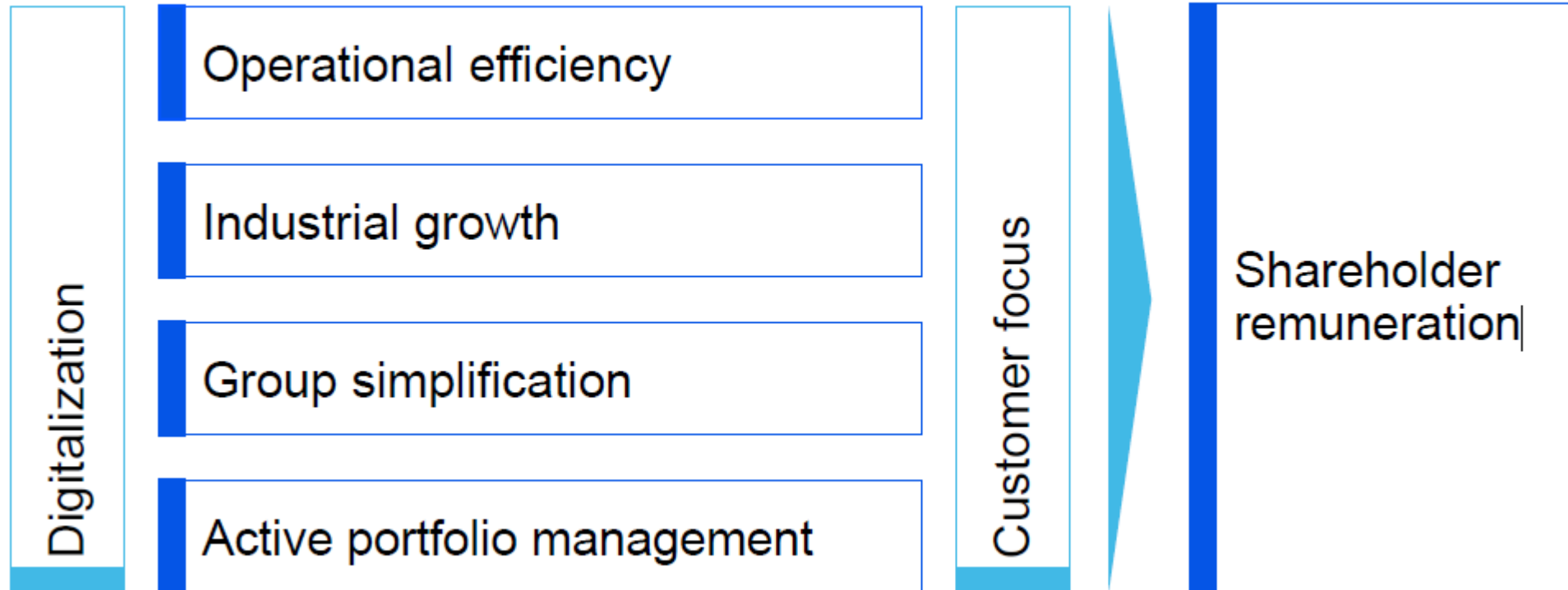


- Wind
- Hydro
- Geo
- Solar & others

1. As of 30<sup>th</sup> September 2016

# Digitalization as key factor for Enel

2016-19 Industrial plan



# Enel Green Power

Innovation Areas



A

## New Generation Technologies

Current portfolio



Wind Solar Hydro Biomass Geo

New Entries



Wave/Ocean High Altitude Wind Microgrid/Virtual PP

C

## Rural Electrification (Minigrids)



Ollagüe



India - Africa



Marcona

B

## Commercial Storage (Standalone, +Renewables, +Microgrid)



D

## Retail Energy Storage

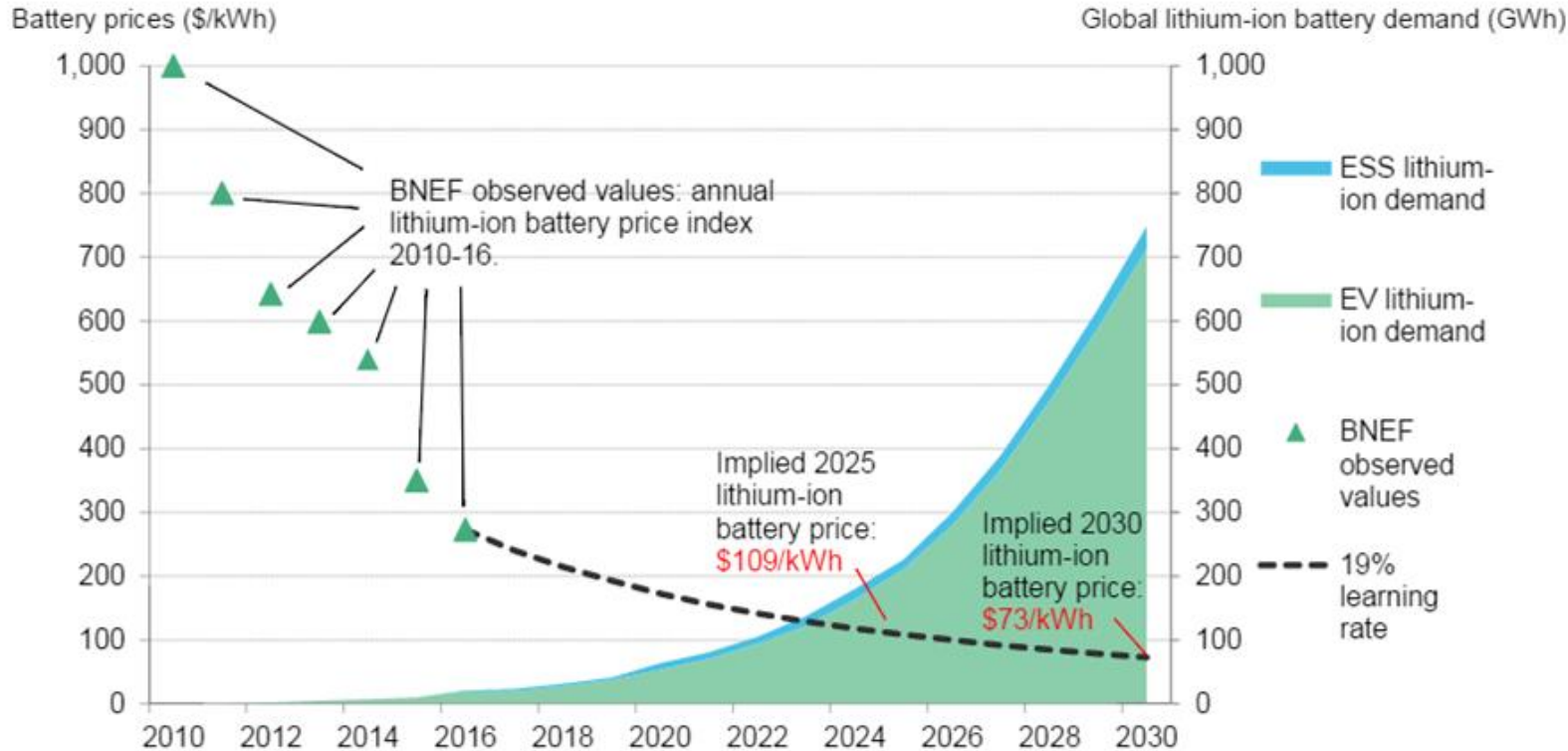


# Focus: distributed storage and renewable generation

## Market evolution and main drivers



Figure 9: Lithium-ion battery price forecast, 2010-30e (\$/kWh)



Source: Bloomberg New Energy Finance. Note: Lithium-ion battery demand is based on EV demand only, taken from our Global EV outlook to 2040 ([web](#)terminal). Prices are an average of BEV and PHEV batteries and include both cell and pack costs. Cell costs alone will be lower. We assumed the ESS capacity here is 75% of our total forecast of ESS, as our original forecast includes other technologies than li-ion.

## Storage market trends

- EVs are by far the main driver for lithium i-on demand
- Within the ESS segment, the distributed storage accounts for the majority of that segment

# Storage applications in EGP



**In operation**

**Under construction**

**In Pipeline / Under investigation**

**IPP On-grid Storage**



**Catania**  
1MW/2MWh



**Potenza Pietragalla**  
2MW/2MWh



**USA**



**North EU**



**RIMO Tender – India**



**North EU**



**Greece**



**Romania**

**Formula E**



**C&I - USA**

**IPP and integrated solutions On/Off-grid**



**Ollagüe - Chile**  
250kW/752kWh



**Peru**



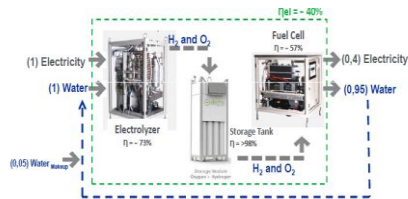
**EU - islands**



**Chile - islands**



**Minigrid India / Africa**



**Cerro Pabellòn - Chile**



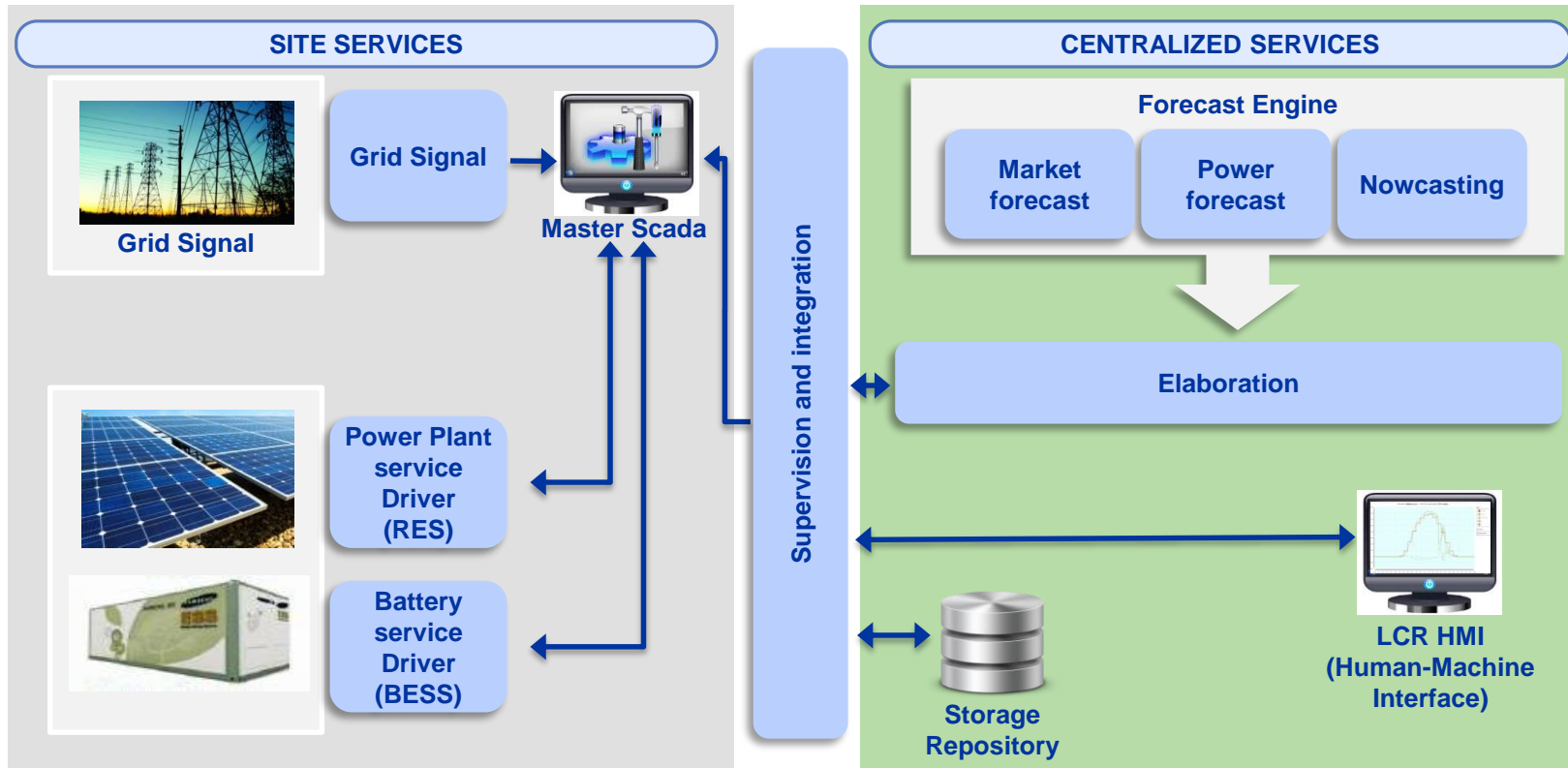
**South Africa**

**Retail Distributed Generation On/Off-Grid**



**South Africa**  
PV  
BESS

# IPP On-Grid: overview of in-house developed system architecture for Catania 1 and Potenza projects



- **In-house developed architecture**, aiming at using the system **“ESS+RES”** as a **programmable unit** allowing the implementation of **grid services and algorithms able to catch market opportunities**
- **Very good preliminary operating results**



# Projects in operation

## Storage Catania 1



### Project Description

To design, install and test a first full scale **on-grid** Battery Energy Storage System (**BESS**) integrated with the existing EGP Catania 1 PV Power plant

### Objectives

- To **assess the integration** between RES and BESS;
- To verify the BESS benefits in terms of increased RES **dispatchability** (energy shifting and peak shaving) and provision of **services for the grid** (voltage and frequency regulations);
- To acquire **first hand O&M experiences** with BESS technologies;
- To develop a **unique platform** for RES + BESS **management**.

### Peculiarities

- PV Power Plant 10MW + BESS
- Battery size: 1MW/2MWh
- Battery Technology: **sodium-metal halide** storage technology

### Timing

In full operation since September 2015

### Catania 1 PV Power Plant



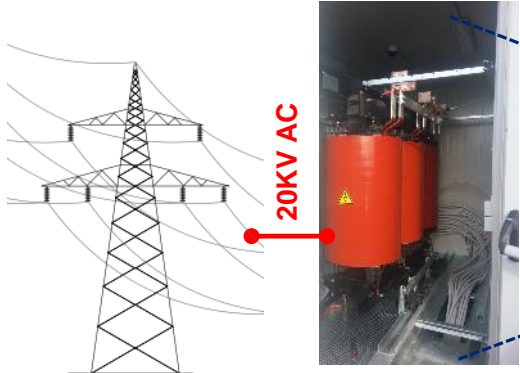
<b>Rated Power:</b>	10 MW (connection up to 8MW )
<b>Year of COD:</b>	2012
<b>Grid connection:</b>	MV
<b>Inverters :</b>	Power One (ABB) PVI-330 TL - IT
<b>PV modules:</b>	~44.000 Jinko 230W
<b>Annual Energy :</b>	~15.000 MWh

# Projects in operation

## Storage Catania 1: BESS main features



LV-MV TRASFORMER



E&C Room



1MVA Inverter



2 x 1MWh DC System



### Energy Storage System

Rated Power:	1000 kW
Delivery Capacity:	2000 kWh
Max Current:	2300 A
Max Voltage :	577 V
Operative Conditions:	-40°C + 50°C
Dimensions / Weight:	2,3x2,1x8,3m / 37Ton



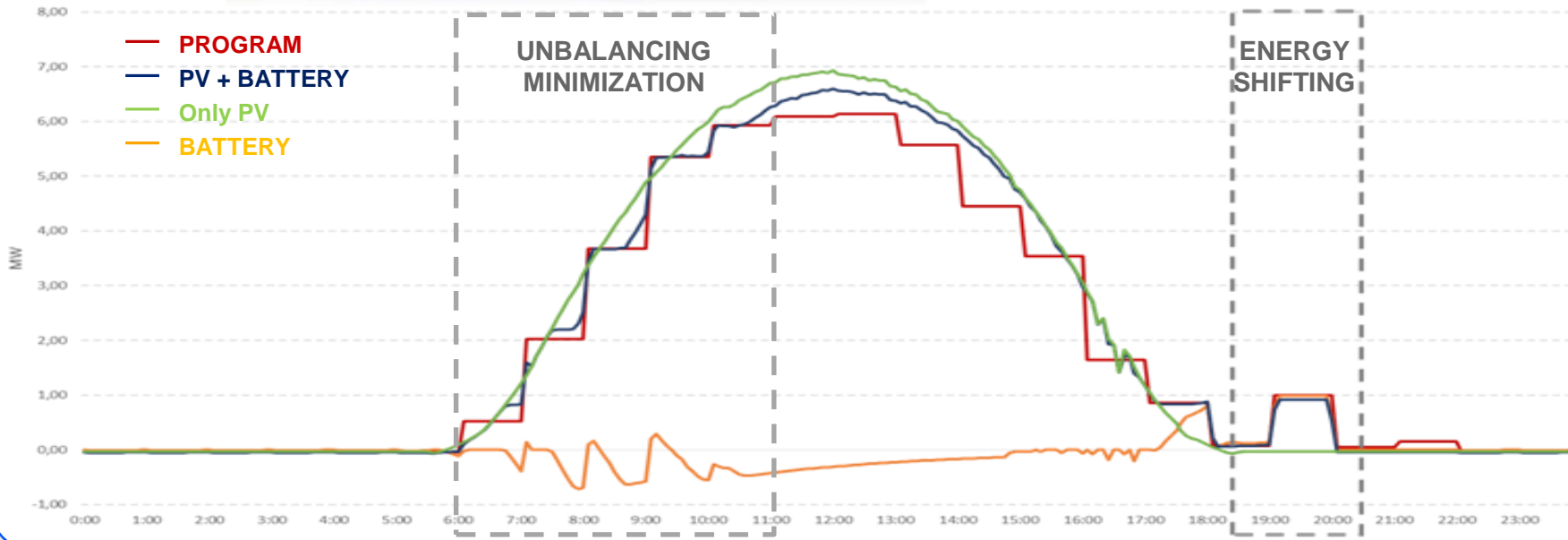
1MW-2MWh Catania 1 BESS Plant

# Projects in operation

Utility Scale Storage solutions: Catania 1 - PV & storage integration



Rated Power:	PV 10 MW (connect. up to 8MW )
PV modules:	~44.000
Year of COD:	2012
Grid connection:	Medium Voltage
Battery Tech. :	Sodium Nickel Chloride
Power/Capacity:	1MW/2MWh



## PROGRAM EXECUTION

**UNBALANCE MINIMIZATION** ✓  
Forecast Error Reduction **> 20 %** (even with reduced size battery)

**ENERGY SHIFTING** ✓

**Unbalancing minimization : IMPRESSIVE REDUCTION in production forecast error**

# Projects in operation

## Storage Potenza Pietragalla



### Project Description

To **design, install and test** a full scale **on-grid BESS** integrated with the Potenza Pietragalla WPP (18MW).

### Objectives

See Catania 1 Project

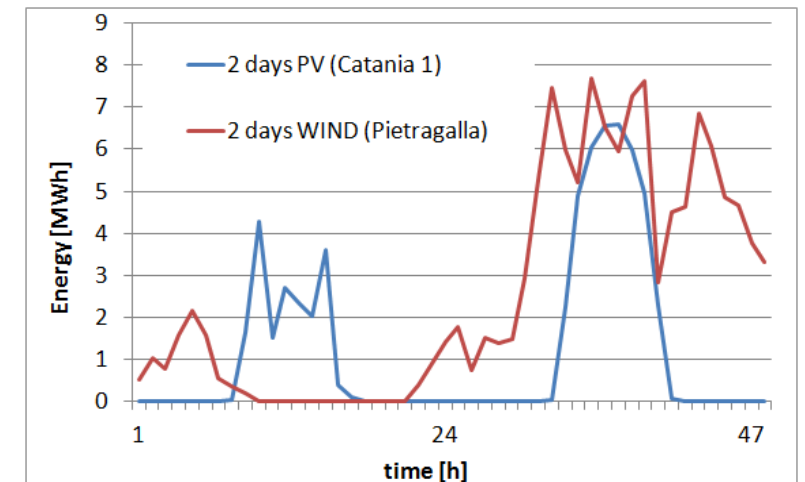
### Peculiarities

- ✓ Wind Power Plant (→ more **variable daily production profile**)
- ✓ **HV connection**: The first Wind + BESS power plant in Italy connected to HV)
- ✓ Technology: **Lithium-ion** storage technology
- ✓ Battery size: **2MW/2MWh** (power oriented, particularly suitable for frequency regulation)

### Timing

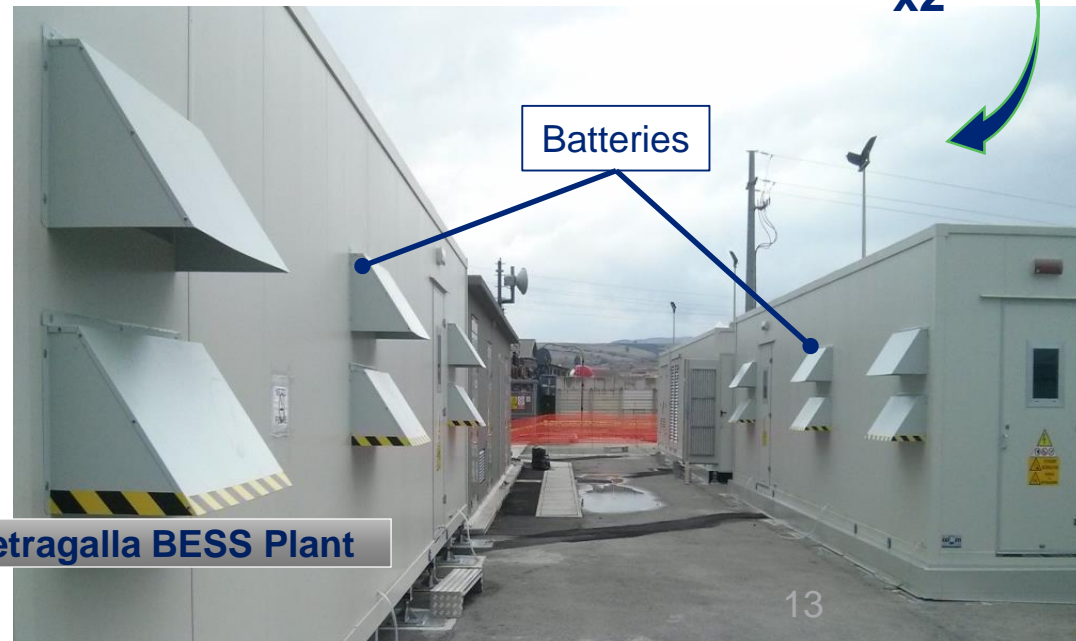
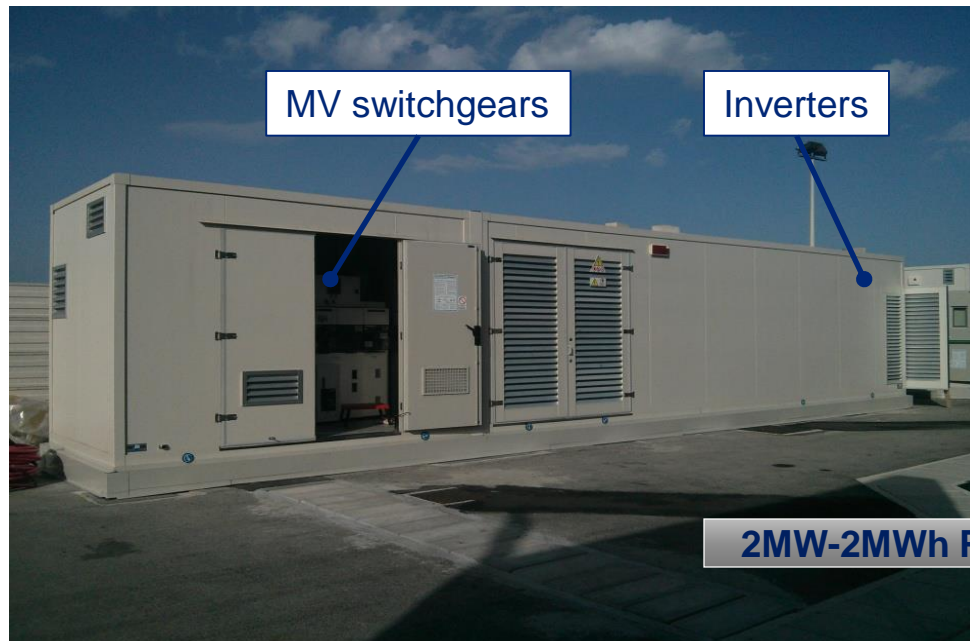
In full operation since October 2015

### EGP Potenza Pietragalla WIND Power Plant



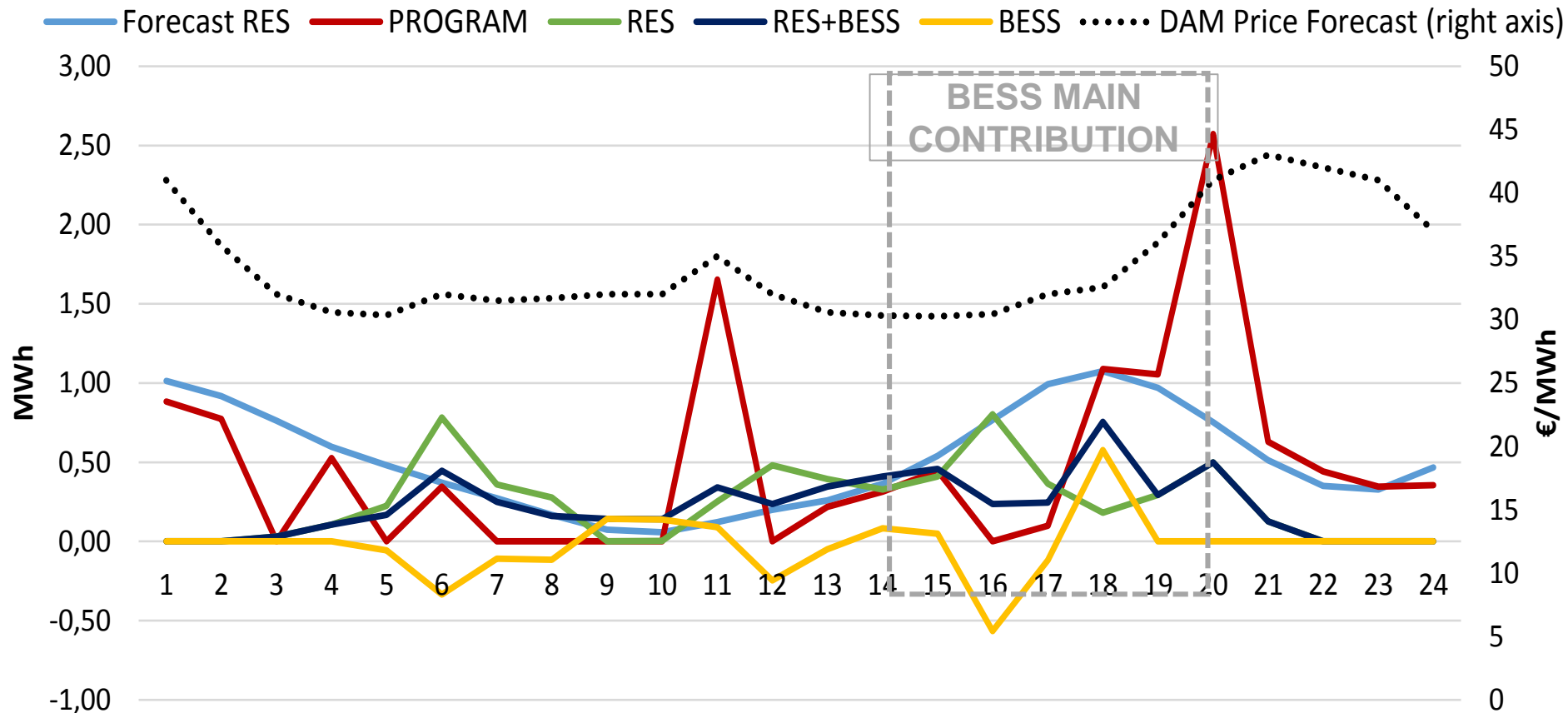
# Projects in operation

Storage Potenza Pietragalla: BESS main components



# Projects in operation

Storage Potenza Pietragalla: BESS – Unbalancing minimization and Energy Shifting



## PROGRAM EXECUTION

**UNBALANCING MINIMIZATION** ✓

**ENERGY SHIFTING** ✓

**UNBALANCING MINIMIZATION:**  
reduction by 16% during the whole day

**ENERGY SHIFTING:**  
+21% in expected revenues during the whole day

# Ollagüe

## Hybrid off-grid system



### ASSET DESCRIPTION:

- Hybrid project (**Solar PV** 205 kWp with **3Sun** Modules, PV Inverters)
- **Sodium Nickel Chloride** batteries of 752kWh
- mini **Wind** turbine 30 kW
- Backup **Diesel** 430 kW, with a further not automatized genset for redundancy
- Thermodynamic systems each one of 1 kWe +3kWt.

### AIM OF THE PROJECT:

- **Supply 24hs/day 7 days/week energy** to an off-grid village placed at **3700 AMSL** in a desert area of Chile, removing the restriction of the village to having access to energy during night time (no supply from 1 to 8 AM)
- **Minimizing the consumption of fuel** from existing diesel generator
- **Testing advanced renewable technologies** and storage system in a harsh environment, with large temperature range (down to -20°C during winter) between day and night and extreme solar radiation in rarefied atmosphere, in collaboration with project partners and research centers.
- Develop **technical solutions for fast growing market**

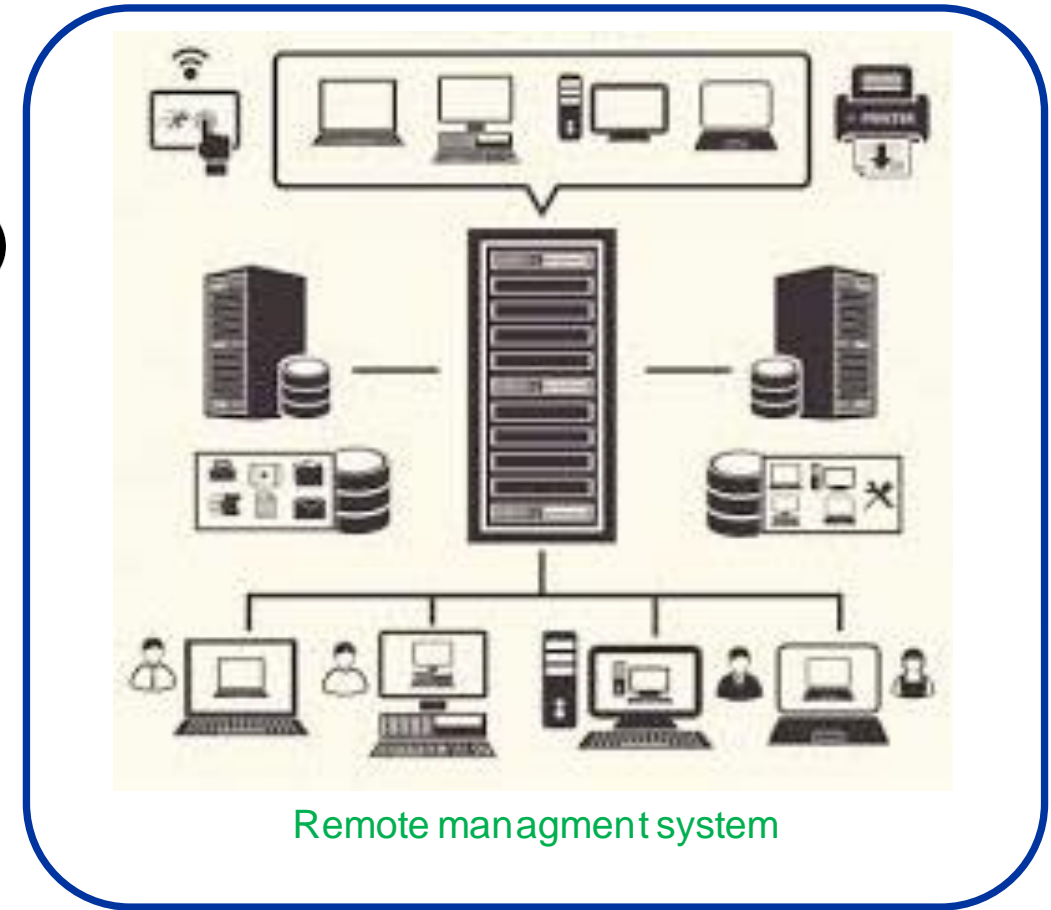
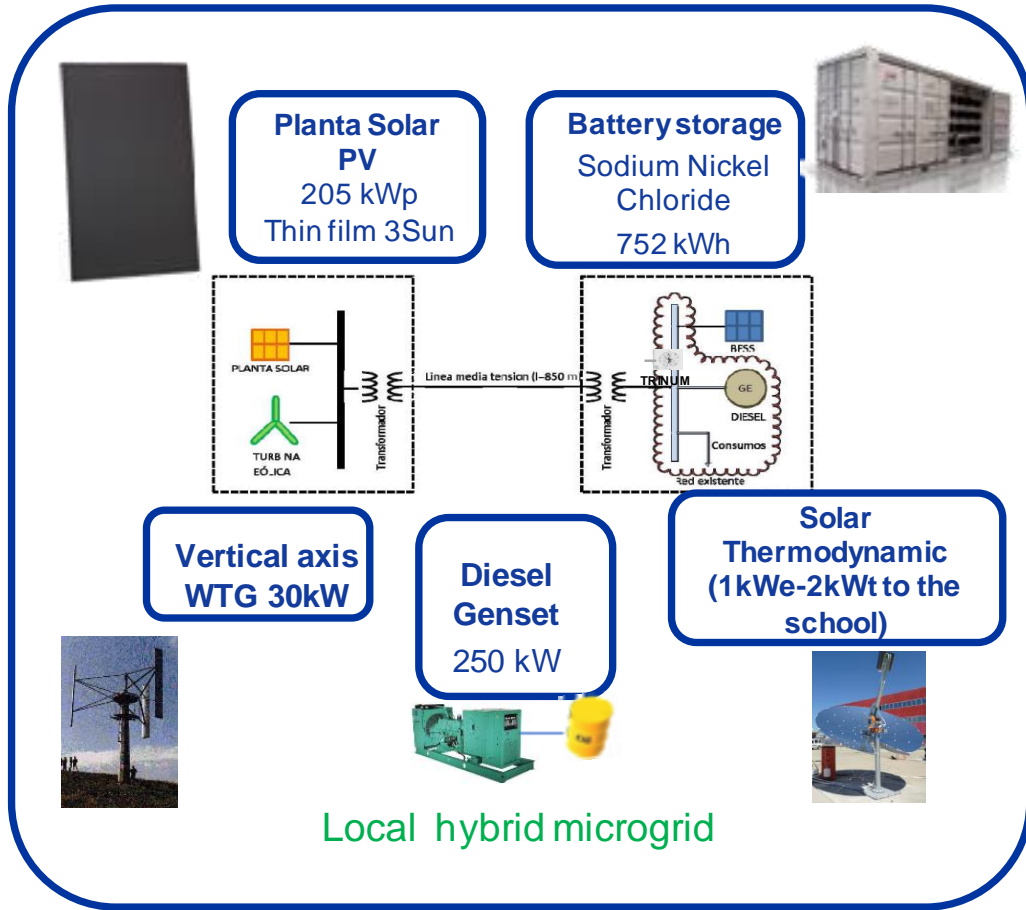
### RESULTS:

- In operation since 2015, the aim of project is completely reached
- A measurement campaign performed by CESI showed high QoS, comparable to grid, even in presence of an off-grid renewable generator
- Installed a pre-paid metering and billing system using Enel smart meters
- The installations of the hybrid system drastically changed the habits of the inhabitants, with also promising economical benefits.
- Meanwhile, the operation of such advanced plant is giving deep inside knowledge about such kind of systems and possible business model in remote area

Reliable Microgrid Operation in extremely harsh environment at high altitude

# Solar/Wind/storage/Diesel off grid system

Ollagüe, Technical solution

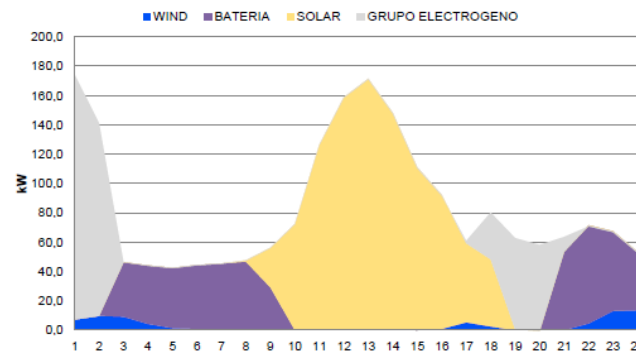
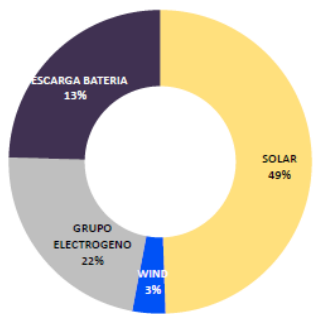
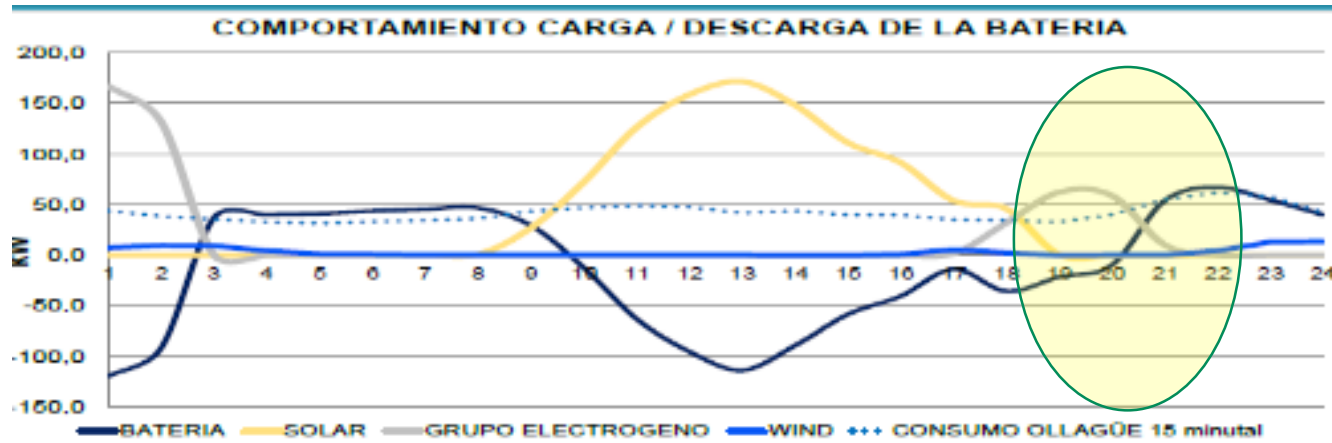


Advanced technology, fully monitored and managed remotely with local community for O&M support



# Microgrid Operation and Performance Analysis

Typical day of operation



## MAIN EVIDENCES

A full charge of the battery allows to sustain the community load during night in real operation conditions

Possible further optimizations of the Energy management system:

- Advanced weather forecast and nowcast technologies
- Real time monitoring of the loads
- Looking to possible improvements of the generation set.

Effective balance and management of the different resources for “seamless” transitions

# Distributed storage and renewable generation

Retail applications in South Africa



START  
2 kW



PLUS  
3 kW



SUPER  
4.5 kW



PREMIUM  
6 kW

KIT

## YouPower Sun

Be energy independent



PV panels



Lithium battery energetic autonomy 4/5 hours per day (considering 1.5 kW average load)



Inverter



Energy Management



Technical evaluation, consultation, system design and complete standard installation



Administrative assistance including permit requests



Security code



Energy Management



Testing and declaration of conformity



12-month maintenance and assistance program



12-month Assistance



12-month Insurance all risk



# Thank you



If you want to share with us your innovative ideas,  
please use EGP crowdsourcing platform:

<https://egp-innovation.greenapes.com/#/login>