



Gamesa Electric

Hybridization of Renewables and Storage:
the key to the energy transition in Spain



RENMAD2020 – March 2020

We are proud¹ to be
part of something big²,
building together
a better and more
sustainable world³.

①

Gamesa Electric is a worldwide leader in the design and manufacturing of electrical equipment, with extensive experience in photovoltaics, hydroelectric energy, electric traction, marine propulsion, wind power and energy storage applications, among others.

②

In April 2017, Gamesa merged Siemens Wind to form Siemens Gamesa Renewable Energy. Gamesa Electric is a 100% subsidiary of this merged company.

③

Cutting-edge technology and innovation at service of renewable energies and environment, contributing with flexible complete solutions to make clean energy more affordable and reliable. Our target is leading the global renewable energy industry driving the transition towards a sustainable world.

A Siemens Gamesa Renewable Energy company







With a worldwide installed capacity of over 95 GW, Siemens Gamesa Renewable Energy is a

global technological leader in the wind industry with a presence in more than 90 countries.

Its end-to-end value chain expertise encompasses onshore and offshore wind turbine

design, manufacturing, installation as well as cutting-edge service solutions.



	Accumulated Installed Base (Nov 19)	100 GW
	GW under O&M (Nov 19)	60 GW
	Reported Backlog (Nov 19)	>25.5 €B
	Revenue (FY 2019 pro-forma)	10.2 €B
	Market Capitalization (Nov 19)	12 €B
	Worldwide presence	+90 countries

An extensive experience in Energy

The broadest experience in photovoltaics, hydro-electric energy, marine propulsion, wind power and energy storage applications, among others.

Wind Power



More than 42.500MW of our systems world wide.

Solar



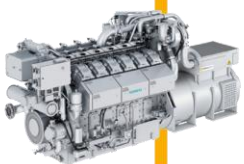
Gamesa Electric has supplied and installed more than 2.400 Photovoltaic central inverters worldwide.

Hydro-electric



Gamesa Electric has gathered a large experience (>2.000MW) in synchronous generator for small hydro power plants, including submerged generators.

Genset



With the new GaE PO 56/63 series, Gamesa Electric completes its portfolio of alternators for Genset applications, offering its customer standard products as well as the company's traditional custom solutions.

Energy Storage



Storage systems with the best possible performance leveraging on its deep knowledge of power electronics and controls.

Power Quality



Our STATCOM is a power electronics solution for fast dynamic reactive power compensation, voltage control and PF regulation.

Marine Propulsion



Gamesa Electric, as one of the industry leaders for permanent magnets technology and its capacity and technology for electric drive development, was selected for the S80 series submarine project.



Our People



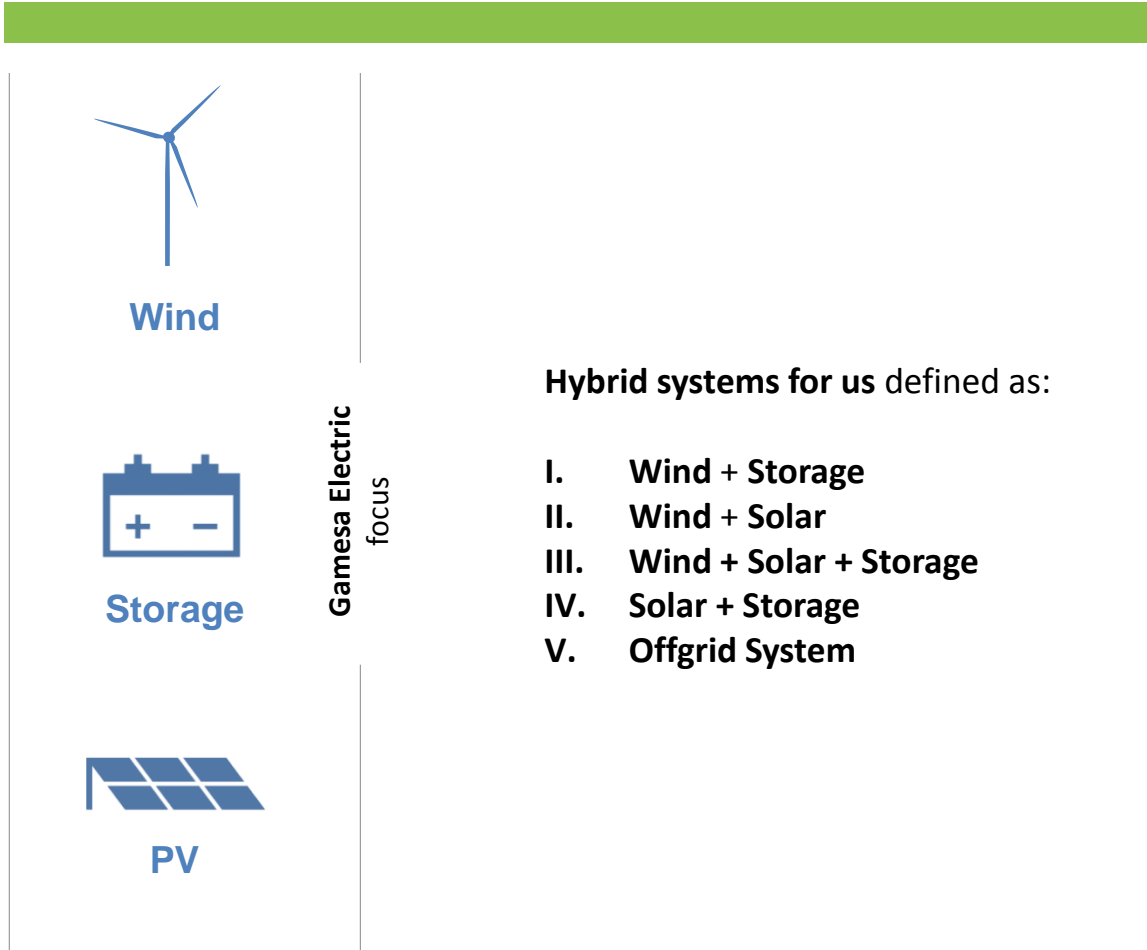
Our people are our energy and our greatest asset. What makes the difference is the result of the work and the talent of our people. People are also our ultimate goal and what makes us move forward in search of clean, affordable and accessible energy for everyone.

Occupational health & safety is an essential part of our Business Code of Conduct, internal monitoring systems, risk management work and internal controls. It is embedded everywhere in the Siemens Gamesa culture. Our company complies with prevailing legislation in every market where we have a presence, and we establish as many preventative measures as are needed.

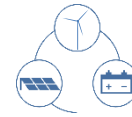
Beyond specific market requirements, we are guided at all times by the criteria of excellence and continuous improvement, and we apply an integrated health and safety, environment and quality management policy lens to all that we do. We have a zero tolerance policy towards negligent occupational health and safety conduct.

Hybrid systems

Wind integrated hybrid power plant. Definitions



Definitions:



Hybrid solutions for Gamesa Electric are combinations of wind with either solar energy or storage or both.



ON or OFF Grid: depends on whether hybrid system in **grid-connected** or runs as an **Offgrid solution**.

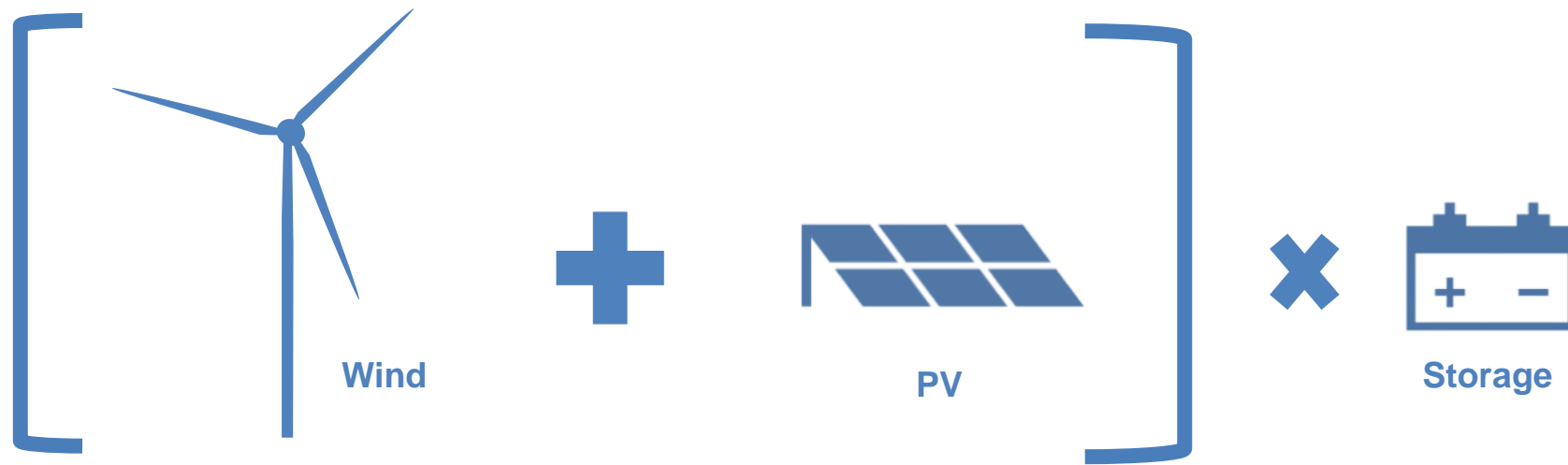


Greenfield: new hybrid plant that planned and installed together.

Brownfield: hybridization of either existing wind or solar power plant.

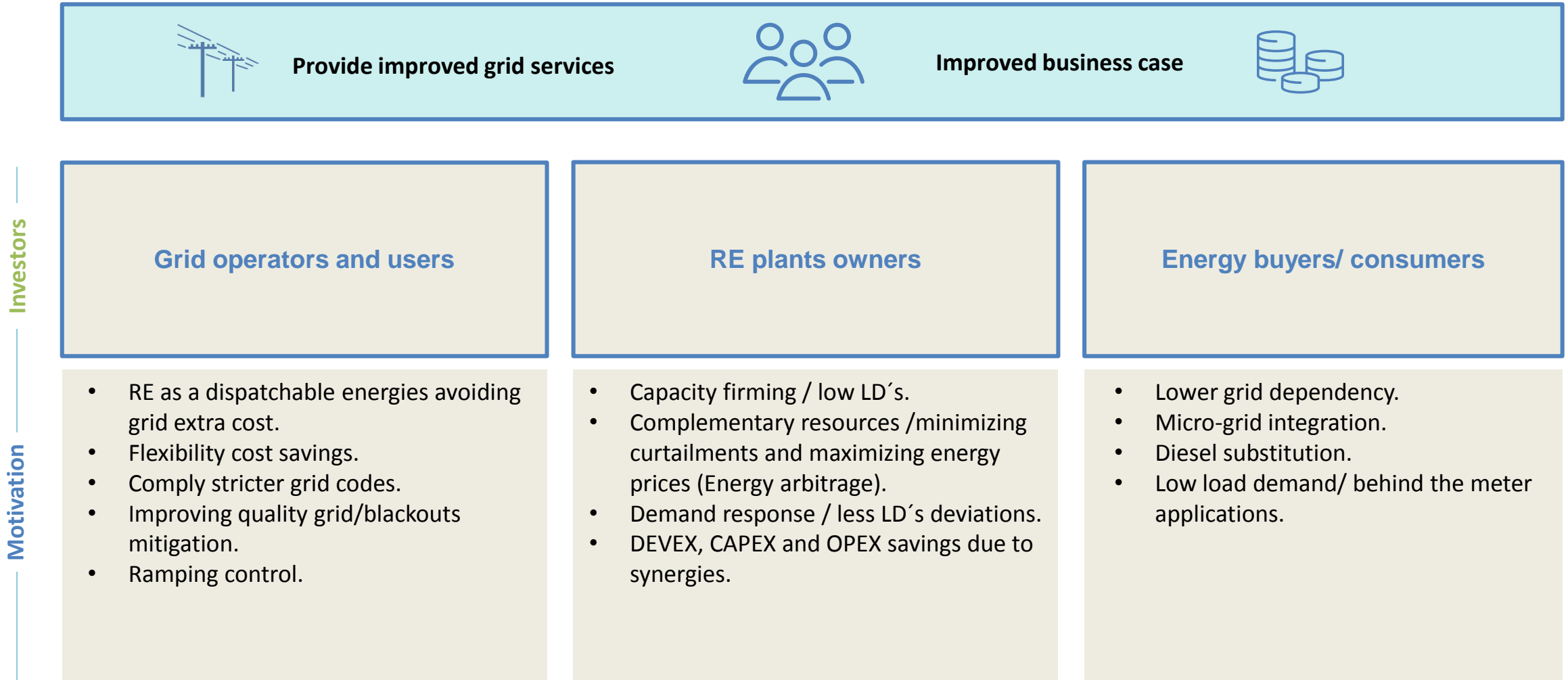
Hybrid systems

Flexible Renewable Integrated Hybrid Power Plant.



Hybrid systems

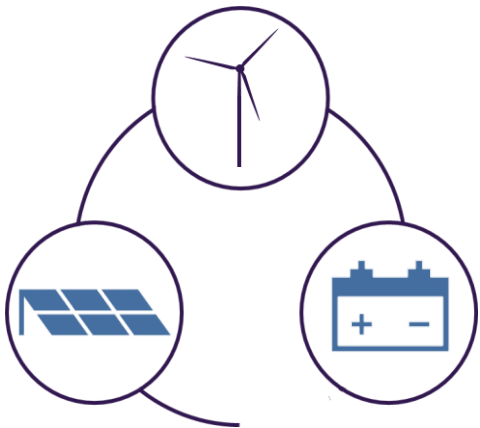
Hybridized wind projects. Investors motivation.



Project Analysis & Design

Wind integrated hybrid power plant.

Hourly generation curve models to determine the optimal contribution of technology for hybridization; **most cost-effective and profitable solution.**



SYNERGY		
CAPEX		-10
OPEX		-15
WIND %	PV %	IRR p
100	0	7.65%
100	10	7.95%
100	20	8.27%
100	30	8.55%
100	40	8.77%
100	50	9.08%
100	60	9.21%
100	70	9.31%
100	80	9.40%
100	90	9.47%
100	100	9.47%

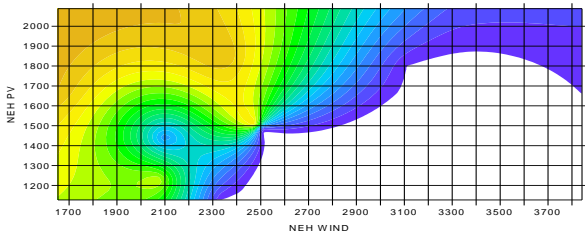
SYNERGY		
CAPEX		-20
OPEX		-25
WIND %	PV %	IRR p
100	0	7.82%
90	10	8.38%
80	20	8.79%
70	30	9.07%
60	40	9.21%
50	50	9.19%
40	60	9.00%
30	70	8.58%
20	80	8.02%
10	90	7.30%
0	100	6.43%

Fix wind capacity

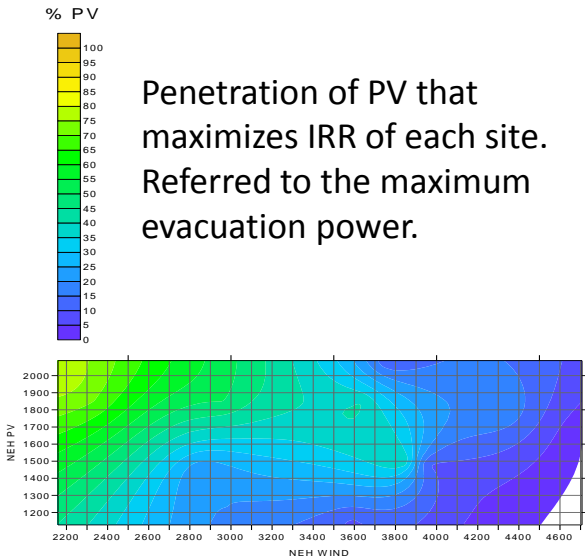
- Fix wind power.
- 11 combinations.
- 11 irr results.
- Selection of the best irr (an improvement of 1.8% regarding original wind farm).
- Pv curtailment applied.

Fix total capacity

- Fix total power.
- 11 combinations.
- 11 irr results.
- Selection of the best irr (an improvement of 1.4% regarding original wind farm).



Penetration of PV that maximizes IRR of each site. Referred to the maximum evacuation power.





One case

n cases

Project Analysis & Design

Hybrid plant Wind + BESS in USA

Co-location; 85 MW existing wind farm to which a BESS system is added

	CAPEX*	OPEX*	Performance*	Revenues*	IRR*
Technology	(\$/kWh)	(\$/kW/year)	(Cycles/year)	(M\$/year)	(%)
85 MW + 10MW/21.7MWh  	470	12.8	600-1130	1.2-1.8	11-12%

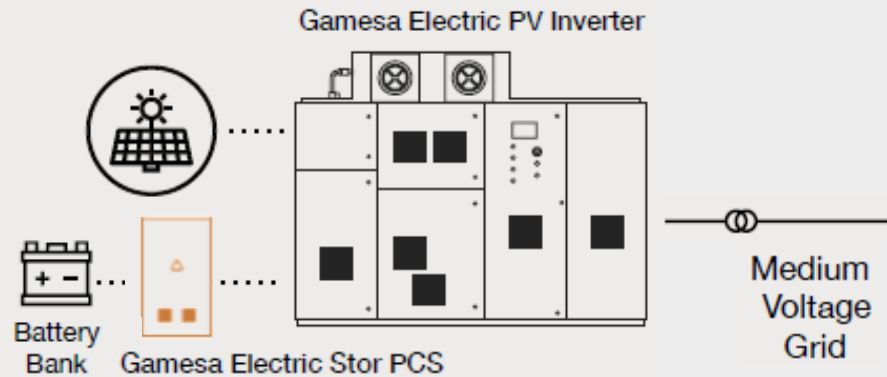
* Data only for BESS system

- Batteries of Li-ion.
- It has been simulated hourly dispatch of the battery system into the following MISO markets – Day Ahead Energy (DAE), Frequency Regulation (Reg), Spinning Reserve (SR) and Real Time Energy (RTE).
- The bidding strategy was simulated by optimizing battery dispatch to maximize revenue over day ahead energy and ancillary service markets over 24-hour horizons.
- Battery is charged from the wind farm.
- Hourly dispatch of the battery system was calculated over project lifetime of 20-years (2020-2039).
- Financial performance of the battery system was evaluated by performing cash-flow analysis using estimates of project operating revenue and costs obtained from dispatch simulation.

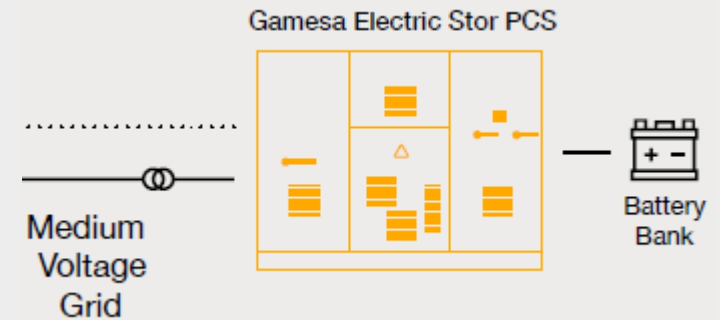
Project Analysis & Design

BESS Required Solutions

DC COUPLED



AC COUPLED



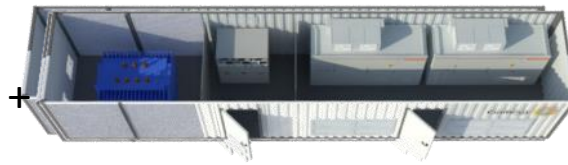
PV Power Station –DC/DC Converter

- Coupled in the DC Bus of PV Field for Clipping Energy Recovering.
- Modular and Scalable 650KW units.
- IP54



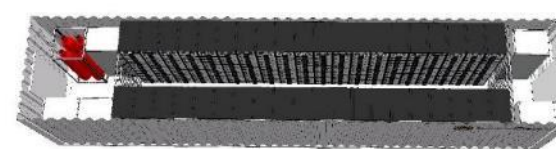
Stor-PCS Station

- 40 ft HC ISO container or Outdoor version
- Up to two (2) PCS and PCS control, up to 5MVA
- Transformer + MV Switchgear integrated



Stor-DC Station

- 40 ft HC ISO container
- Up to 6 MWh Li-Ion battery*
- DC protections, HVAC, fire detection and extinguishing integrated



System Control

- Design and Sizing for all the services and performance requirements: Energy Shifting, Frequency Response, Peak Shaving, Smoothing Intermittences, Spinning Reserve, Transmission Deferral, Energy Arbitrage...



LA PLANA - Hybrid & Offgrid Pilot Plant

General Overview

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Located in
Zaragoza

Multi-technology
at MW level.

Commissioned in
2015.

Li-ion BESS
installed in Q2 2016.

Redox-Flow Battery
under testing in 2018

The “simulated load” allows testing of the customer environment. Grid-connection is planned to further testing under different conditions.

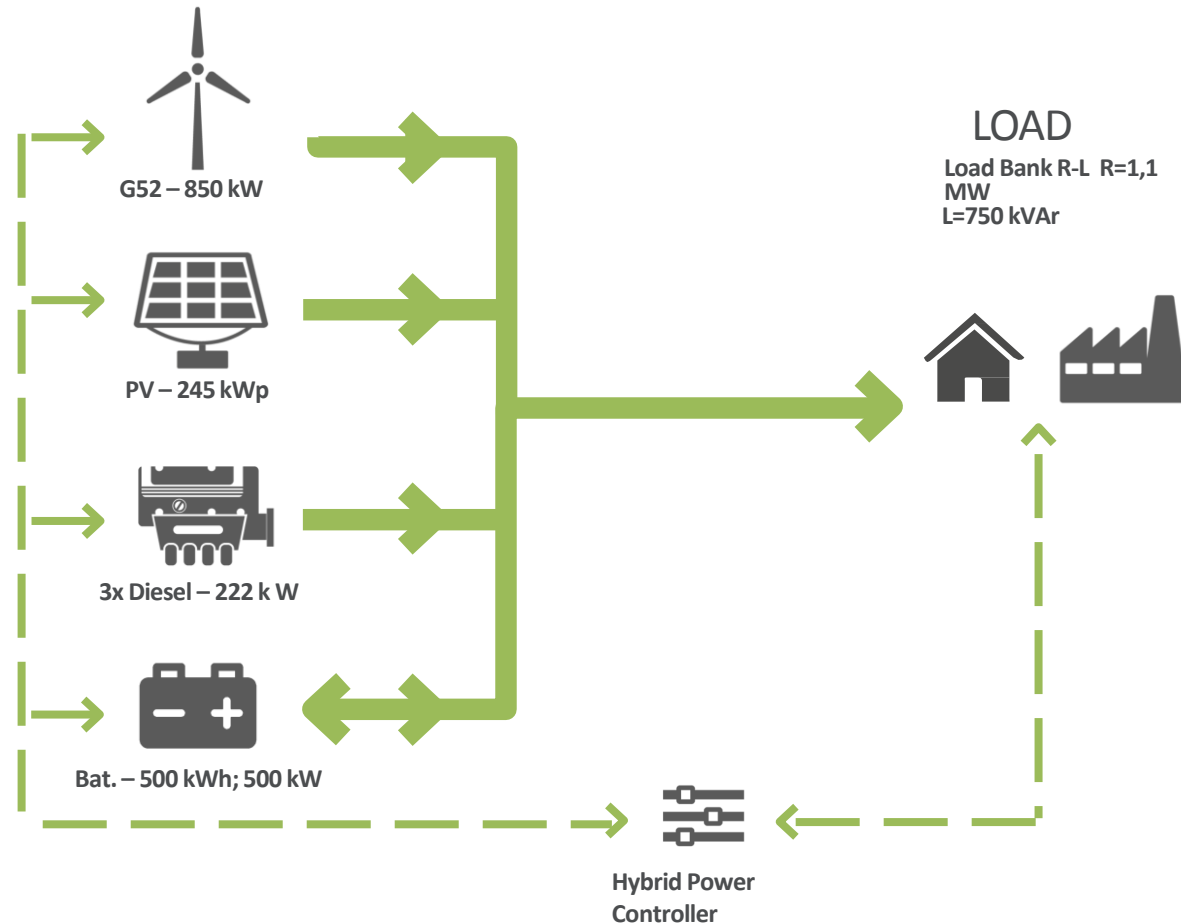


LA PLANA - Hybrid & Offgrid Pilot Plant

Wind + Solar + Batteries + Diesel

Unique Worldwide Test Plant

- > Leading global initiative combining solar and wind with diesel generation at MW level
- > The HPC “**Hybrid Power Controller**” manages, in real time, the mix of the 4 energy sources
- > The “**simulated load**” allows testing the customer load data sets on an adequate scale in a real plant.
- > Commissioned in Dec. 2015



LA PLANA - Hybrid & Offgrid Pilot Plant

Wind + Solar + Batteries + Diesel

Lithium Battery: 429 kW – 143 kWh

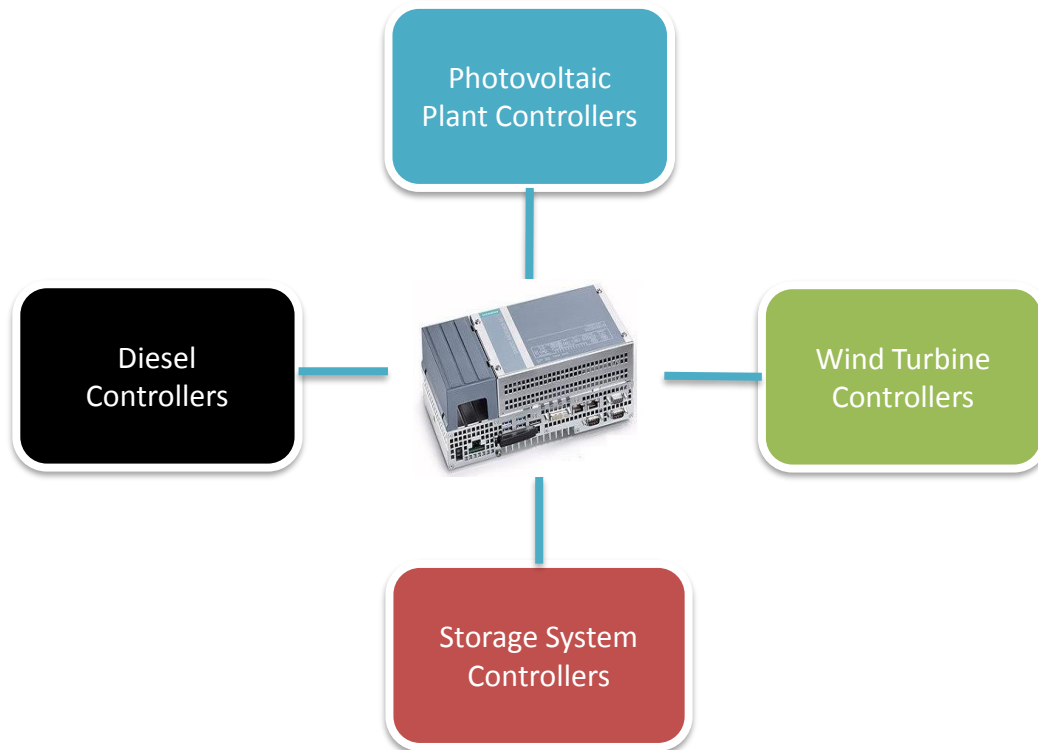


- **Chemistry:** NMC
- **Manufacturer:** SAMSUNG
- **Model:** Mega 3.3A
- **Battery with 3 racks in parallel** (429 kW, 143 kWh)
- **PCS:** Gamesa Electric (GAE 1.25 MW)
- **Rack Characteristics:**
- **Rack configuration:** 192S 1P
- **Rack voltage:** 700 V
- **Energy per rack (C):** 47,6 kWh/rack
- **Continuous discharge power:** 143 kW (1 C)/rack
- **Peak discharge power:** 572 kW (4C, 5 min)/rack
- **Response time:** < 5 ms
- **Dimension (L x W x H):** 533 x 690 x 2291 mm

LA PLANA - Hybrid & Offgrid Pilot Plant

Hybrid Control at La Plana (SCADA)

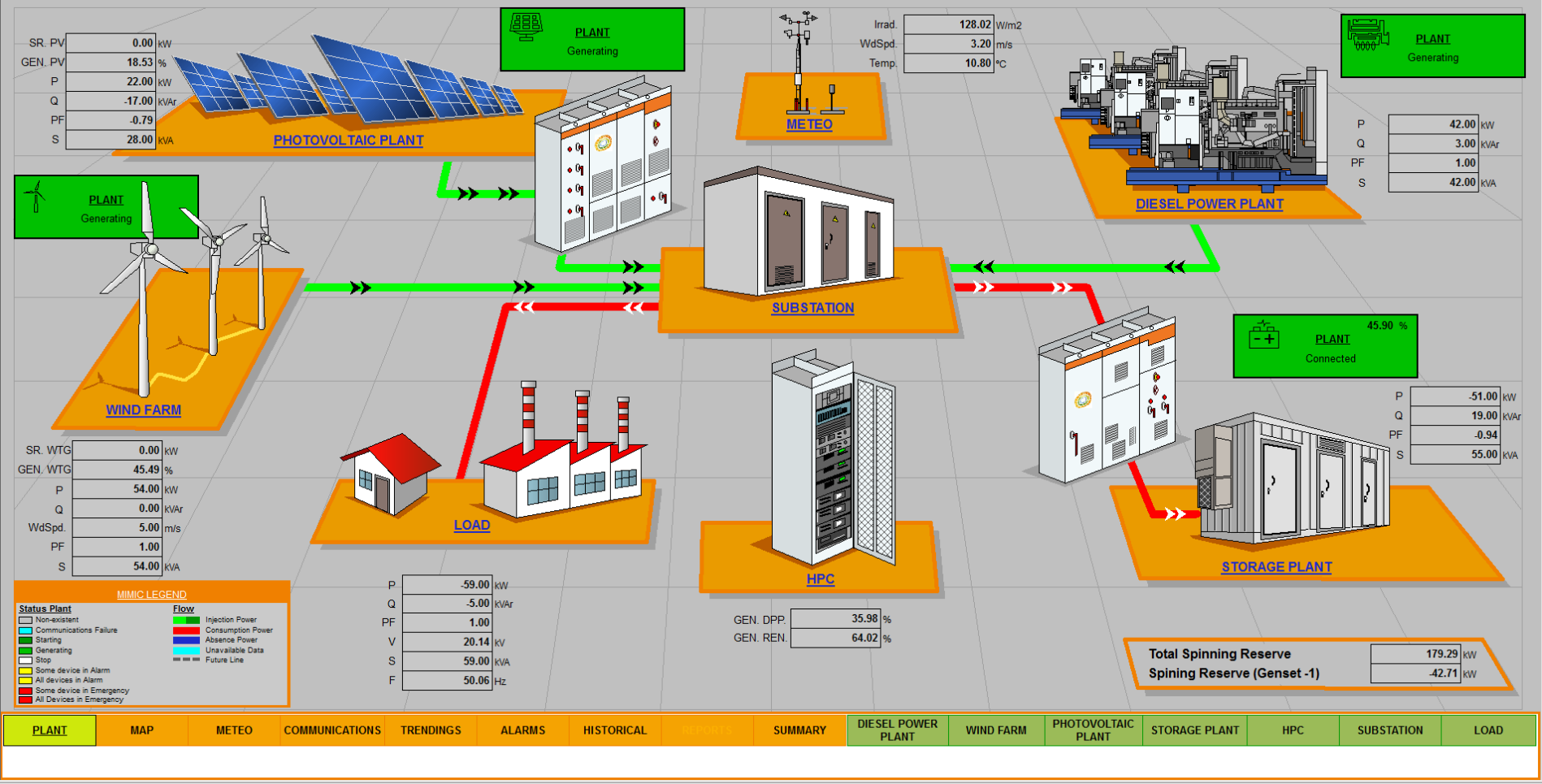
HPC – SGRE Hybrid Plant Controller



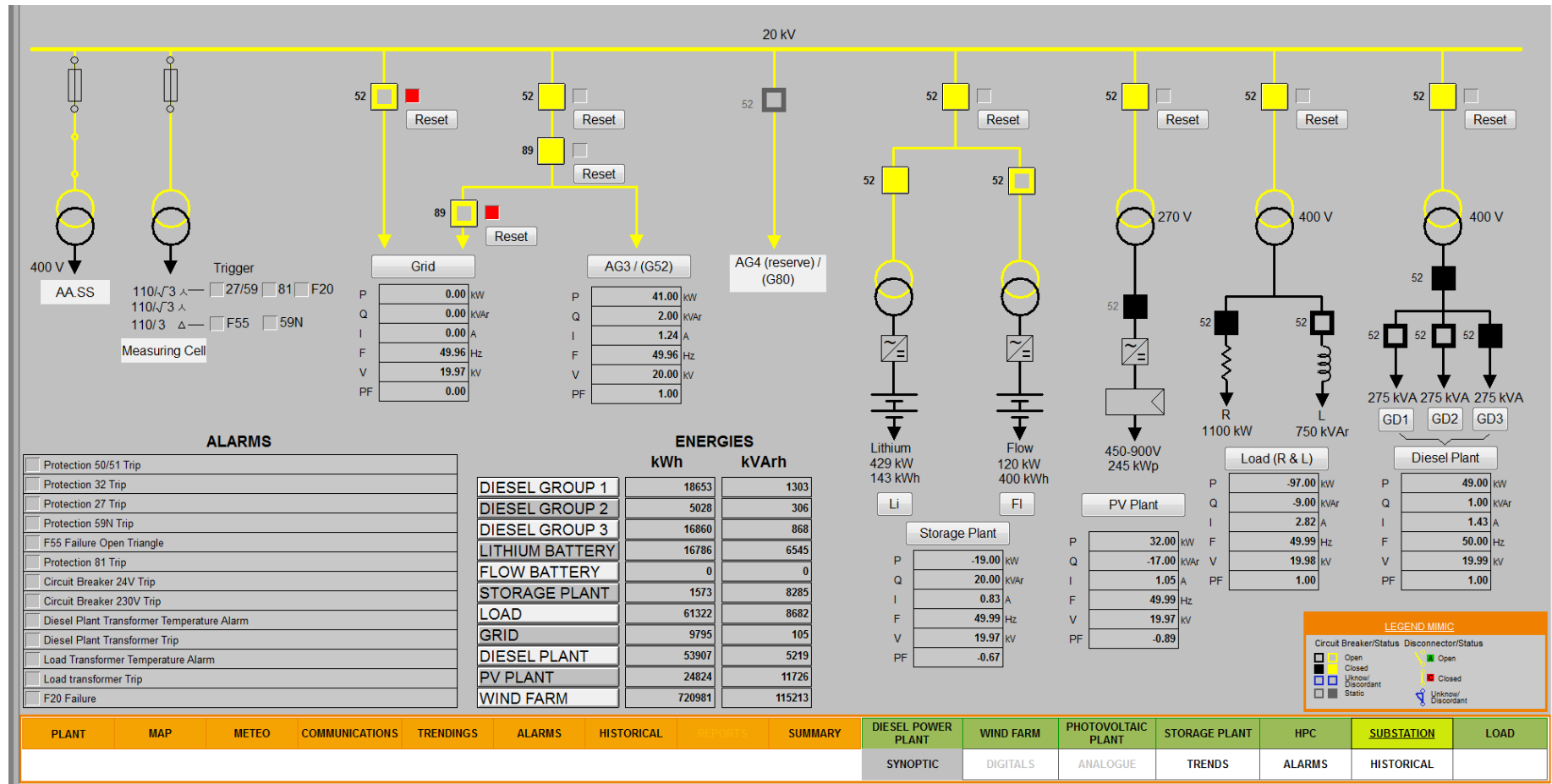
- **Algorithm Plant Control**, LCoE minimization and spinning reserve control. For Offgrid and Ongrid.
- Integration capacity of **weather forecast**.
- Able to manage **multiple devices** from each type of generation
- **Customizable** and parameter setting ad hoc.
- **Real-time communication** with all plant devices and high frequency response.
- Data **records generation** for analysis.
- Integrated **SCADA** for visualization and control (history, graphics, etc..)
- **Redundancy** possibility.

LA PLANA - Hybrid & Offgrid Pilot Plant

Hybrid Control at La Plana (SCADA)



Hybrid Control at La Plana (SCADA)



LA PLANA - Hybrid & Offgrid Pilot Plant

Features and Services

✓ Operation management:

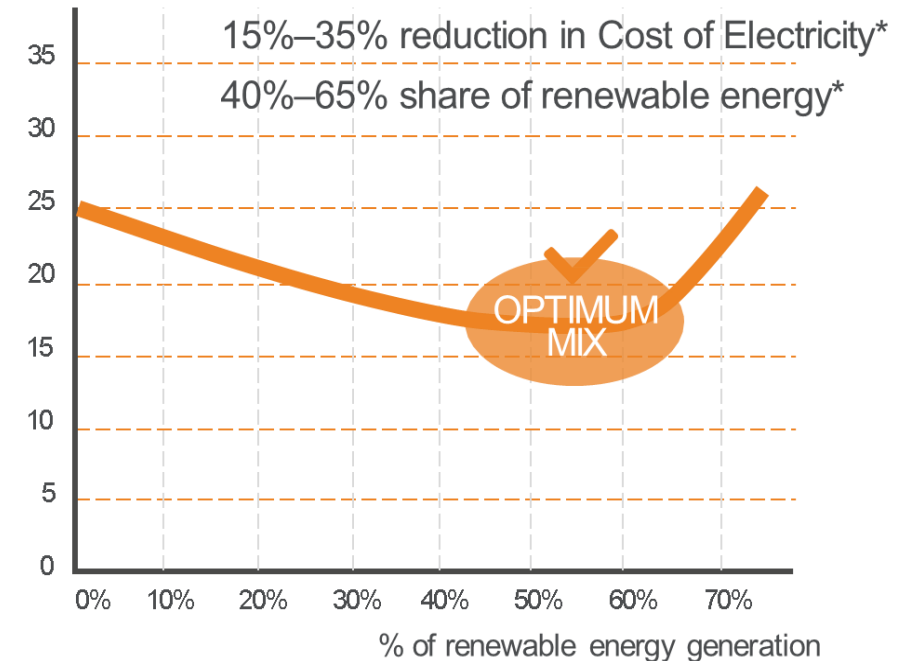
- **Integration and management** of 4 energy sources
- Starting and stopping **systems**.
- Loading or unloading **batteries**.
- Low load **diesel operation**.
- **Cloud passing**.
- Strategic planning of **spinning reserve**.

✓ Simulated load service:

With **customer load data**, the Test Plant is able to simulate and generate the necessary power for maximizing the renewable resource efficiency in a real system, achievement:

- Reducing the fuel consumption
- Reducing the CO2 emissions.
- Improve the LCOE

Cost of Electricity MIX (c\$/kWh)

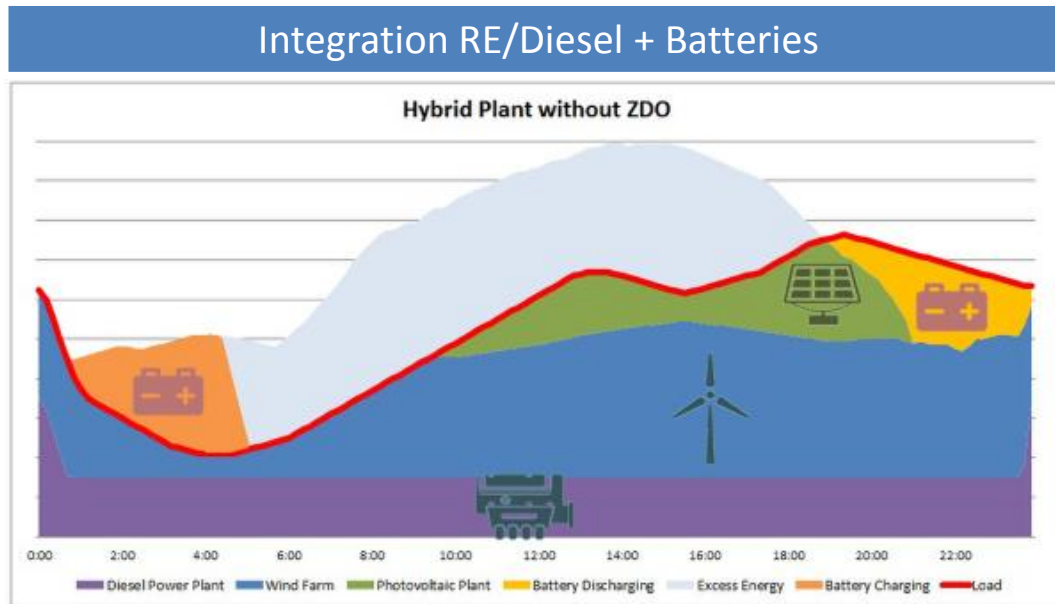


*Depending on wind/solar resource

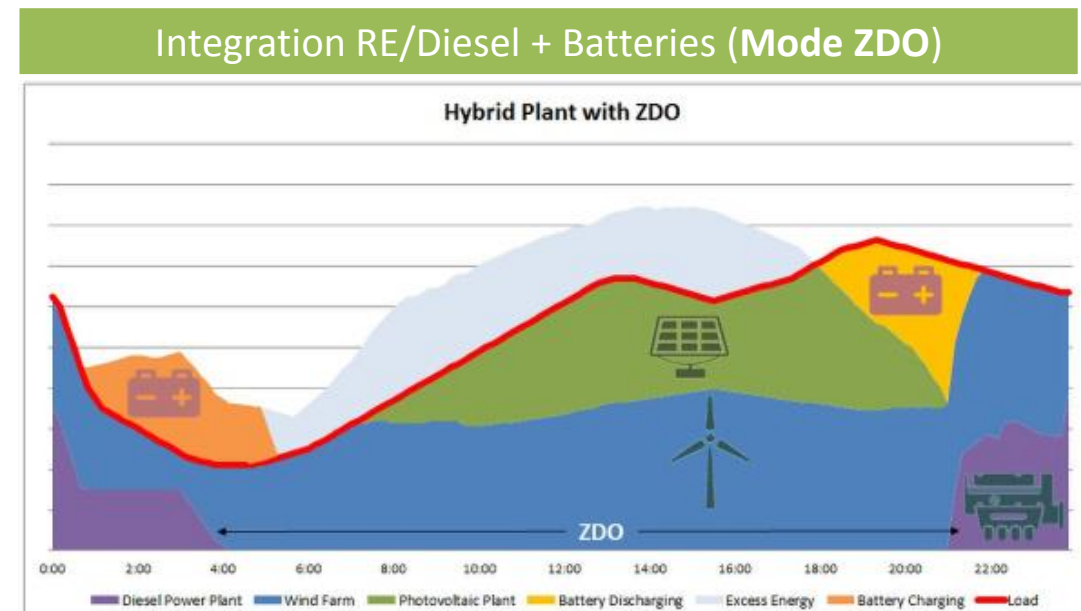
LA PLANA - Hybrid & Offgrid Pilot Plant

ZDO (Zero Diesel Operation)

Possibility of energizing the load with the diesel generators turned off thanks to the action of the storage systems.



- Diesel groups generate the grid (voltage and frequency control)
- The HPC minimizes diesel consumption, taking them to their technical minimum power (Objective: Minimize LCOE)

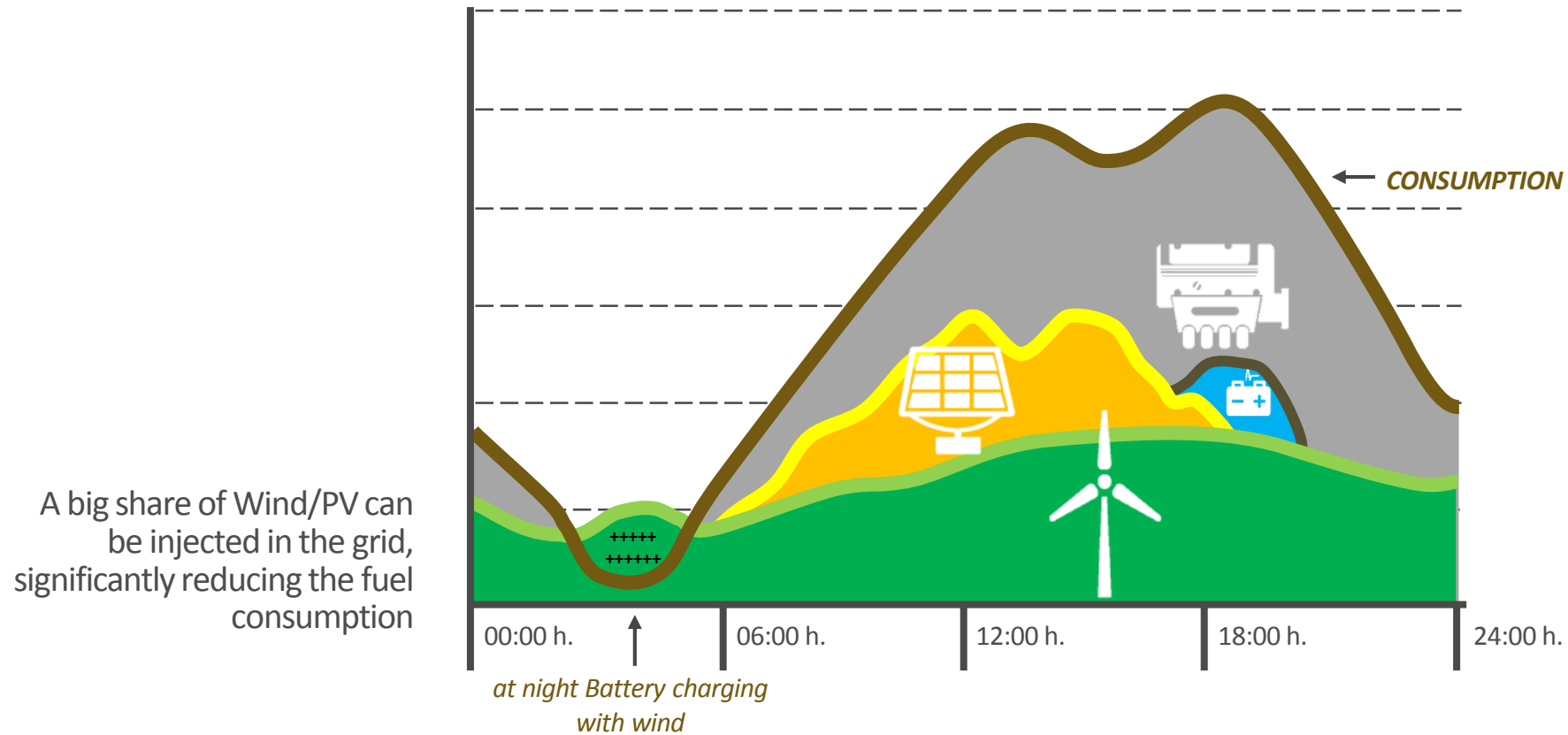


- In order to optimize the LCOE, each project studies the implementation of the ZDO mode in those time zones where the energy demand can be covered with the capacity of the batteries (including the spinning reserve necessary to assume load variations or the renewable energy produced during the period).
- In order to turn off the diesel groups for 24 hours, the batteries would have to be sized to give the peak power of the load, and the renewable would have to be oversized to produce 100% of the energy needed in time.

LA PLANA - Hybrid & Offgrid Pilot Plant

Simulation Consumption Load

- Typical daily profile: Residential electricity consumption



- Optimization of renewables vs diesel and load

LA PLANA - Hybrid & Offgrid Pilot Plant

Tailored and Competitive

- ✓ Reduced Cost of Electricity
- ✓ Decrease the CO₂ emissions
- ✓ Ensured stable grid
- ✓ Supervision, management y procurement data through SCADA
- ✓ Modular and scalable systems
- ✓ Combination of two storage technologies (Lithium & Flow)



Philippines- Hybrid wind and BESS project

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Hybrid plant Wind + BESS in Islands

Multi-technology

at MW level with Li-Ion storage.

To be commissioned in

2020.

HPC (Hybrid Plant Controller)

Pioneering central control system.

Service & EMS for 5 years.

**Complete technology
solution by SGRE**



Kabital- Hybrid wind and PV project

First commercial hybrid on-grid plant in India

Multi-technology

at MW level.

Commissioned in

2018.

Photovoltaic Inverters

made by Gamesa Electric.

India's 1st large commercial hybrid project.

Turnkey solution

(design, engineering and commissioning).

Improved generation curve and higher capacity factor.



Bulgana - Green power hub.

A large scale pioneering project with BESS

Multi-technology

at MW level with Li-Ion storage.

Commissioned in

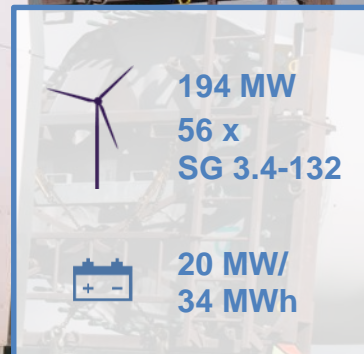
2019.

EPC solution

Design and commissioning included.

O&M for **25 years.**

Reduction of **530,000 t CO₂/a.**



Thanks for your attention!

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GamesaElectric



GamesaElectric

Shaping
new
energy