

Siemens Gamesa hybrid solutions ... applied to isolated islands Leading the way to a renewables powered future

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Who we are?

Siemens Gamesa is a global leading provider of wind power products & service solutions

- #1 in Offshore
- #2 in Onshore & Service

Founded in April 2017 as a merger of Siemens Wind Power and Gamesa

A global company, based in Zamudio (Vizcaya, Spain), listed on the Spanish Stock Exchange

Member of IBEX 35, is traded on Madrid, Barcelona, Valencia and Bilbao







Siemens Gamesa – Key Facts^{*}



+90 GW Globally Installed



+23,000 Employees



€9.1 B Annual Revenue



€10 B Market Capitalization



€23 B Order Book

* End of March 2019

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True **global**, modern and scalable **footprint**





Portfolio covering all requirements



Integrated Hybrid systems

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Technology & Innovation



• 7 Technology Centers: Bangalore (India), Boulder (USA), Brande (Denmark), Hamburg (Germany), Bilbao, Madrid & Pamplona (Spain)

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Integrated Hybrid systems

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Hybrid systems Wind, solar & storage (ON & OFF grid)



Hybrid systems

Wind integrated hybrid power plant. Definitions





Hybrid systems

Siemens Gamesa has a long track record regarding hybrid solutions



9



Siemens Gamesa's

Hybrid product offering



SGRE's hybrid portfolio

Siemens Gamesa hybrid offering. The best results on the market



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SGRE's hybrid portfolio

An optimized, streamlined product portfolio



** Designed for the North American market, but available worldwide.



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The Hybrid Plant Controller (HPC©) is the brain of a hybrid plant



Siemens Gamesa HPC©, **Controller.** Manages wind gusts, shadows, grid

requirements, etc. at WTG and inverter level.

Siemens Gamesa HPC©, SCADA

Monitors & reports the entire hybrid plant as one integrated power plant.

MEGA forecasting tool

Hybrid resource evaluation and prediction in operation to maximize energy selling price in pool markets.





HPC©: Wind & Solar Case Example. Functionalities

- Hybrid plant maximum output power limitation for not exceeding maximum design or administrative limits
- PLF (plant load factor) optimization.
- WiSH plant Control modes:
 - Wind Power priority: solar power limited for not exceeding the maximum allowed.
 - Solar Power priority: wind power limited for not exceeding the maximum allowed.
 - o Hybrid balance:

Selectable Wind production range = $(0, \frac{\text{Installed Wind Capacity}}{\text{Max. allowed Hybrid production output}} * 100\%)$ Selectable Solar production range = $(0, \frac{\text{Installed Solar Capacity}}{\text{Max. allowed Hybrid production output}} * 100\%)$

where,

Selectable Wind production + Selectable Solar production = 100%

Let's se an example in the next slide...

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HPC©: Wind & Solar Case Example.

Hybrid Balance: Possible scenarios of working conditions in Kavital with Hybrid Balance mode selected.

1 - Available generat	ion power below maxim	um allowed output – output power not limited		
Wind: • Available: 20MW • Produced: 20MW	Solar: • Available: 10MW • Produced: 10MW	Selected Wind to solar production share: 60-40% Maximum produced o/p power: 30MW (20MW from Wind + 10MW from Solar) Real Wind to solar production share: 66-33%	Hybrid Plant Total Nominal Capacity: • Wind: 50MW • Solar: 30 MW Maximum Allowed Hybrid Plant Export Power: 50 MW	
2- Output power limi	ted – insufficient resourd	ce to achieve production share		
Wind: • Available: 40MW • Produced: 35MW	Solar: • Available: 15MW • Produced: 15MW	Selected Wind to solar production share: 60-40% Maximum produced o/p power: 50MW (35MW from Wind + 15MW from Solar) Real Wind to solar production share: 70-30%		
3- Output power limi	ted – available resource	exceeding required production share		
Wind:Available: 50MWProduced: 30MW	Solar: • Available: 20MW • Produced: 20MW	Selected Wind to solar production share: 60-40% Maximum produced o/p power: 50MW (30MW from Wind + 20MW from Solar) Real Wind to solar production share: 60-40%	SOLAR PLANT WIND FARM	
			SIEMENS Gameca	

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Integrated Hybrid systems

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SGRE's hybrid portfolio

Hybrid solar PV offering





BESS offering. ReStor. SGRE proprietary BESS solution





SGRE's hybrid portfolio

Off-grid Isolated Systems







Track Record: Hybrid Systems is a fact @ Siemens Gamesa



SAN CRISTOBAL - Offgrid wind & thermal plant

Galapos Island, Ecuador

Multi-technology

penetration (monthly up to 60%).

8,3M liters of fuel replaced.

at MW level.

2007.

Commissioned in



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LA PLANA - Hybrid & offgrid prototype & test plant

Zaragoza, Spain.



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KUDGY - First hybrid plant. India

India.

Multi-technology

at MW level.

commissioned in 2017.

EPC solution (design, engineering and commissioning).

The country's first complete hybrid technology solution.

Photovoltaic inverters made by Gamesa Electric.



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KAVITAL - First commercial hybrid on-grid plant in India

Karnataka, India.



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BULGANA - Green power hub. A large scale pioneering project with BESS

Bulgana, Australia



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La Plana Offgrid Pilot Plant: Technologies



Test plant la plana: Wind + Solar + Batteries + Diesel



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Test Plant La Plana: General View



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Technologies: Generation at La Plana

Wind generation: G52 - 850 kW



52m 55 m Transformer 20 kV/690 V Contraction of the local division of the loc ► Power: 850 kW > Diameter: 52 m > Tower: 55 m (3 sections) > Rotor speed: 15-31 rpm

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Integrated Hybrid systems

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RENEWABLE ENERGY

Technologies: Generation at La Plana



Solar PV generation: 245 kWp



- > Number: 816 panels
- > 48 strings (17 panels in series, 612V)
- > **PV Inverter:** Gamesa Electric (INV-PLUS-500kW)

Panel Characteristics (for STC):

- Maximum Power: 300Wp
- **Efficiency:** 15,5%
- > 72 solar cells of multicrystalline silicon in series



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Technologies: Generation at La Plana



Diesel generation: 666 kW



- > Manufacturer: MTU
- > Model: 6R1600DS300 (222 kW, 278 kVA)
- > Number: 3
- > Cylinders: 6
- > Generator: HIMOINSA (HM 280B2) (Permanent magnets, brushless, self-excited)
- > Controller: DEIF AGC
- > Out voltage: 400 V
- > Start time: 15 s
- > Consumption (100% power): 59 l/h (0,267 l/kWh)





Technologies: Generation at La Plana

Lithium Battery: 429 kW – 143 kWh



- > **Cell Chemistry:** LMO (Lithium Manganese Oxide)
- > Cell Manufacturer: SAMSUNG
- Battery with 3 racks in parallel (429 kW, 143 kWh)
- > **PCS:** Gamesa Electric GAE 1.25 MW (SGRE)
- **Continuous discharge power:** 143 kW (1 C)/rack
- > Peak discharge power: 572 kW (4C, 5 min)/rack



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Technologies: Generation at La Plana

Flow Battery: 120 kW – 400 kWh



Chemistry: Vanadium

- > Number of electrolysers: 120 (6 series, 20 parallel)
- > **PCS:** Gamesa Electric GAE 200 kW (SGRE)
- > 2 Electrolyte storage tanks: 18.000 |

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Technologies: HPC© - Offgrid at La Plana



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Technologies: HPC© - Offgrid at La Plana



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Technologies: HPC© - Offgrid at La Plana



- 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 further optimize the LCOE, HPC© when enough Renewable & battery energy are available, the HPC can shut down the diesel gensets and create the grid with the Plant converters (mainly Storage converters).





Greek Islands



Greek Islands: Cost of Electricity – 21 islands (ex Creta, ex Rodas, ex islands < 1 MW)





- ✓ 11 island, totaling 115 MW installed (small islands), with Cost of Electricity higher than 300 €/MWh
- ✓ 6 islands, totaling 225 MW installed with Cost of Electricity between 200 and 300 €MWh
- ✓ 4 islands, totaling 356 MW installed (large islands) with Cost of Electricity between 172 €MWh and 200€/MWh



Cost of Electricity vs. Consumption (MWh)

190

178

172

401

Skyros

365

346

269

222

197

Greek Islands- LCoE (mix), IRR and curtail vs. renewables penetration



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Integrated Hybrid systems

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Thank you!

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