Energy Storage Association

StoragePLUS Wind

May 15, 2019

www.energystorage.org

Webinar Instructions

This webinar is being recorded and will be available on www.energystorage.org.

All lines will be muted during the webinar.

To submit questions, please use the chat box on the left-hand side of your screen at any time throughout the presentation.

Energy Storage Association

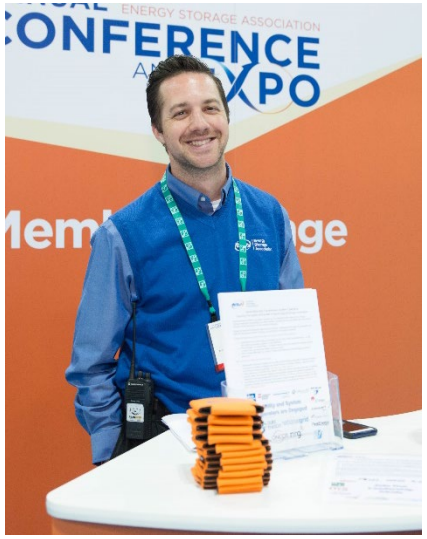
Antitrust Guidelines

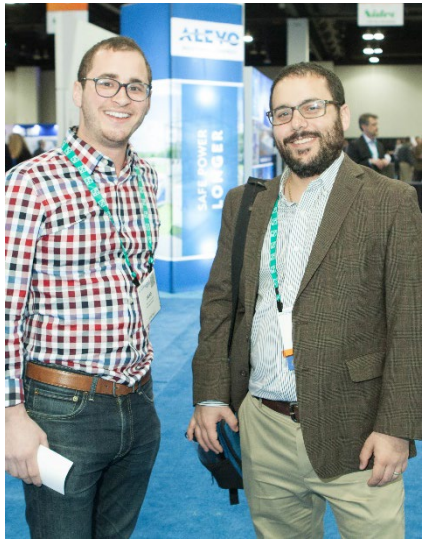
All meetings and teleconferences of the Energy Storage Association are held in accordance with our antitrust guidelines. We ask that you abide by these guidelines during today's webinar. The full guidelines are available in the Members Only area of the ESA website.

Energy Storage Association

ESA Membership

ESA works to ACCELERATE markets, CONNECT members and EDUCATE all stakeholders.





Contact **Richie O'Neill**, Membership Director
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Energy Storage Association

THE ESA STORAGE EXCHANGE

Powered by EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Alabama 110 MW Compressed Air Energy Storage Plant

October 15-16
Bellevue, WA

Energy Storage Association

Today's Speakers

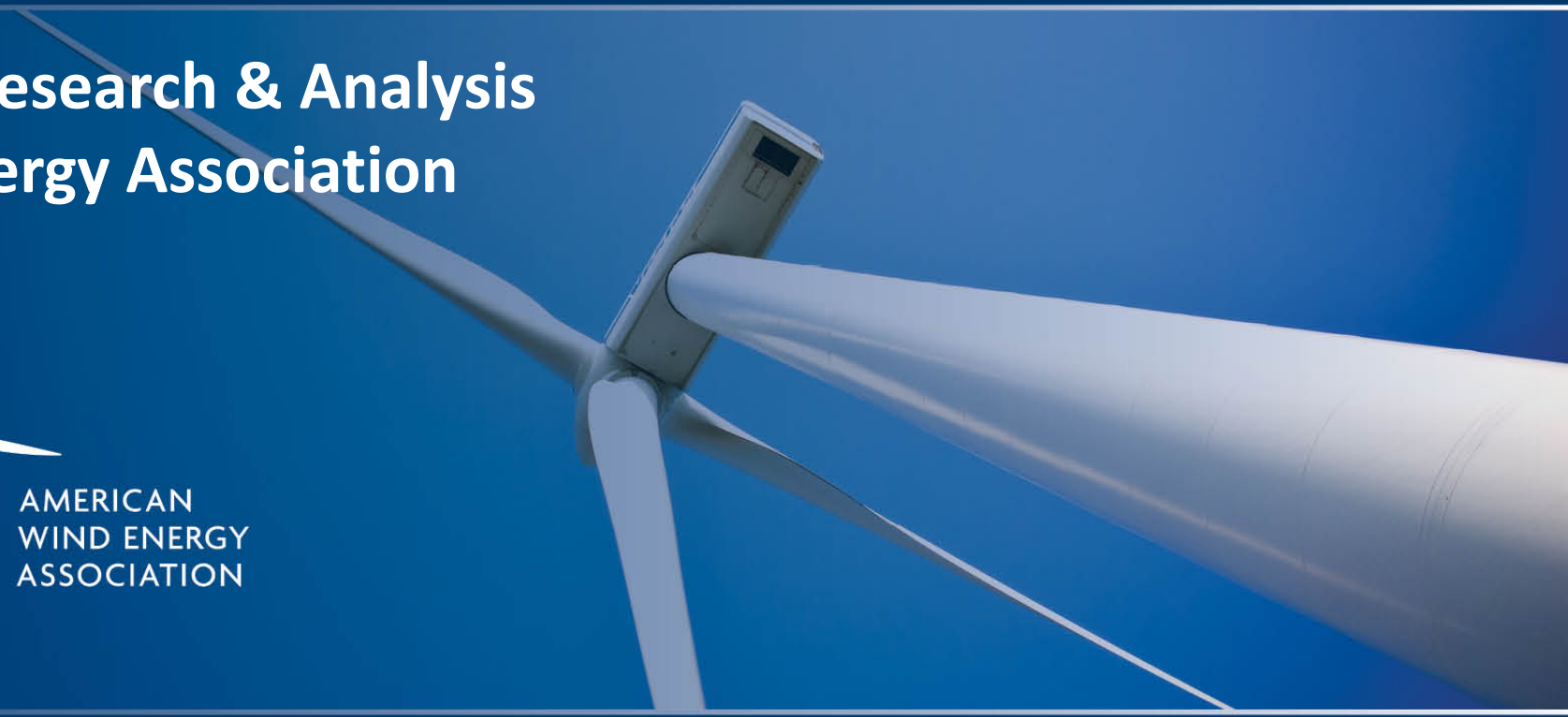
John Hensley
Vice President, Research
and Analysis
American Wind Energy Association

Christine Grey
Head of Hybrid Systems for
the Americas
Siemens Gamesa

Energy Storage Association

Wind + Storage

John Hensley VP|Research & Analysis
American Wind Energy Association



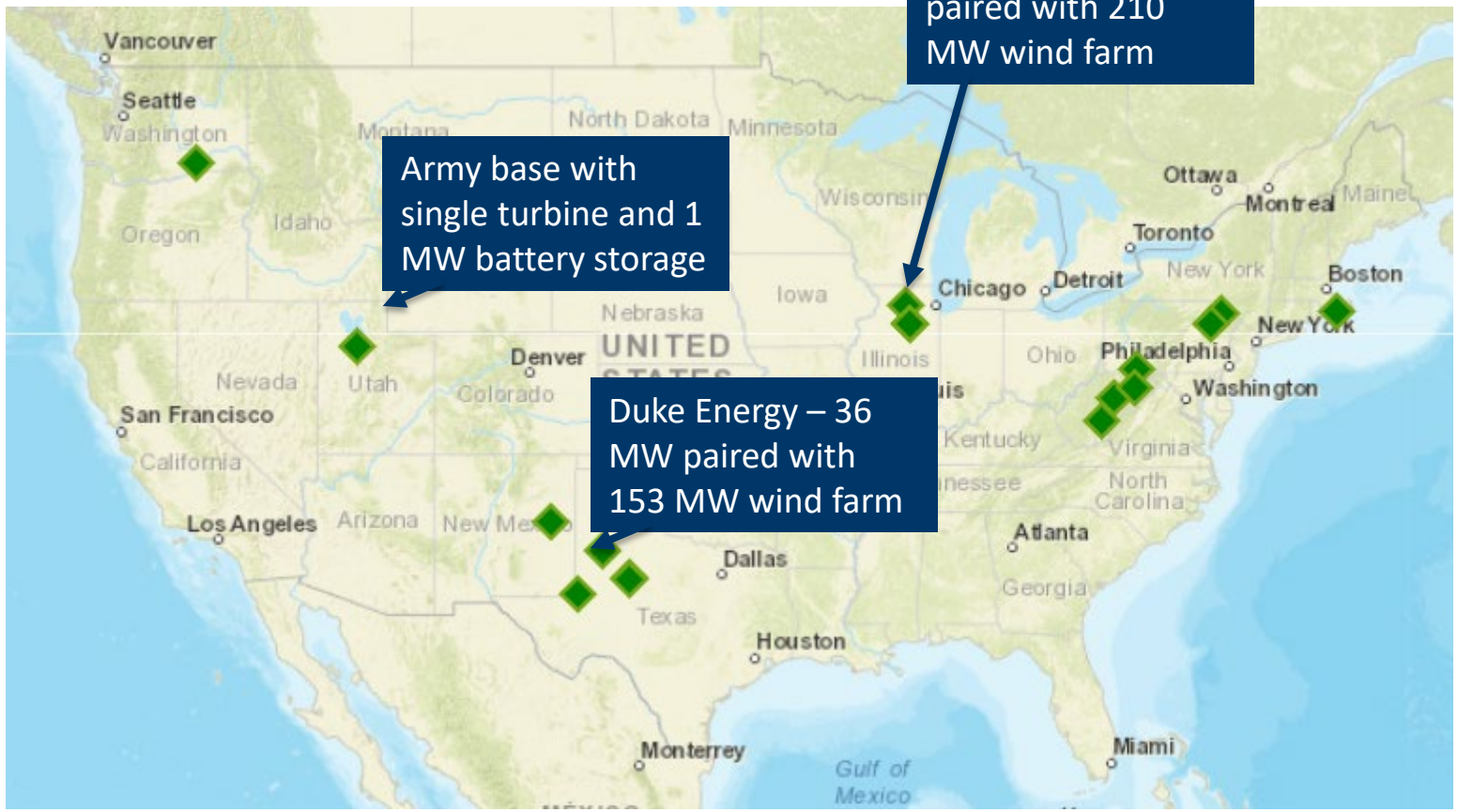
AWEA® AMERICAN WIND ENERGY ASSOCIATION

Wind + Storage History

Total wind + Solar storage deployments:

~ 80 MW operational

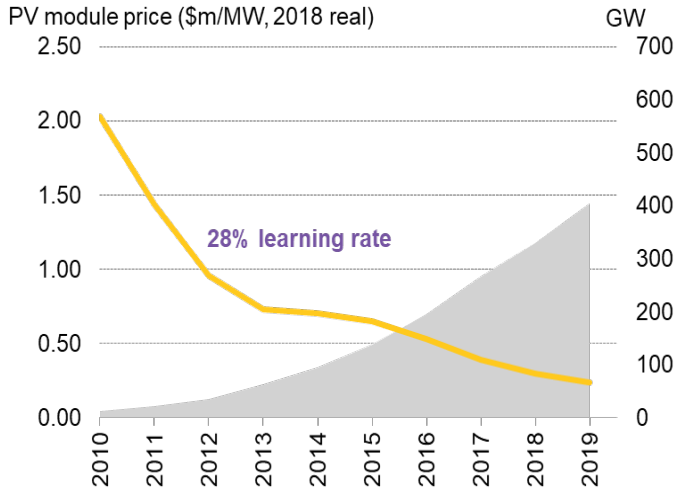
~100 MW pipeline

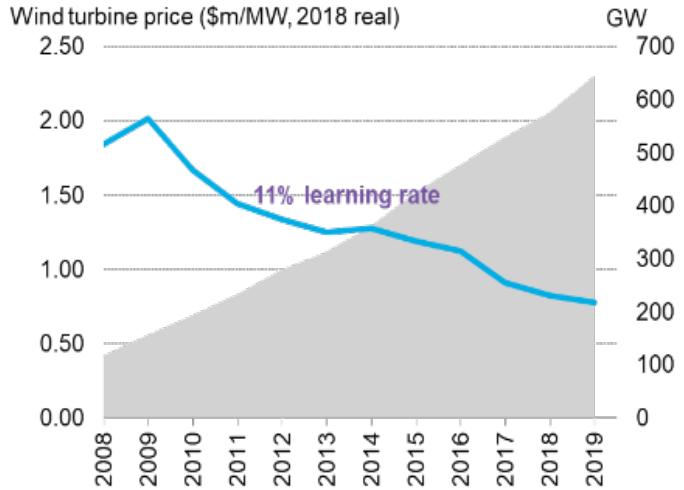


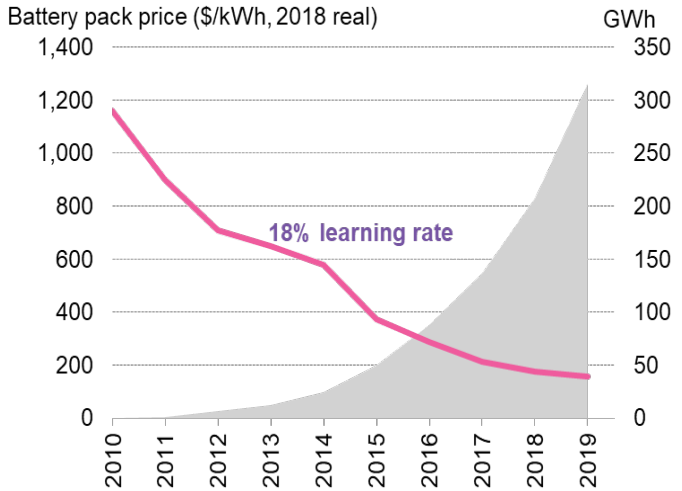
- Limited historical wind and battery storage pairing. Most paired sites are small—typically a single turbine paired with 1 MW or less battery storage.
- Three projects are paired with multi-MW battery storage
- Wind + storage pipeline remains limited as developers hunt for business case
- Clean peak standards, demand for firmed wind could accelerate market dramatically, especially as costs come down.

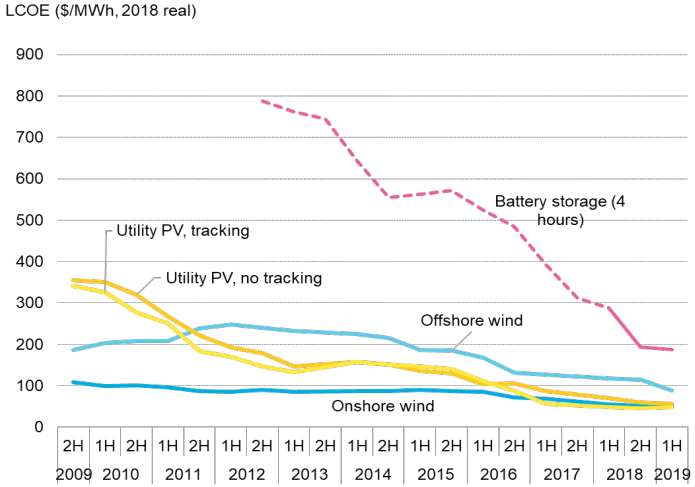
Source: Energy Acuity

Improving economics









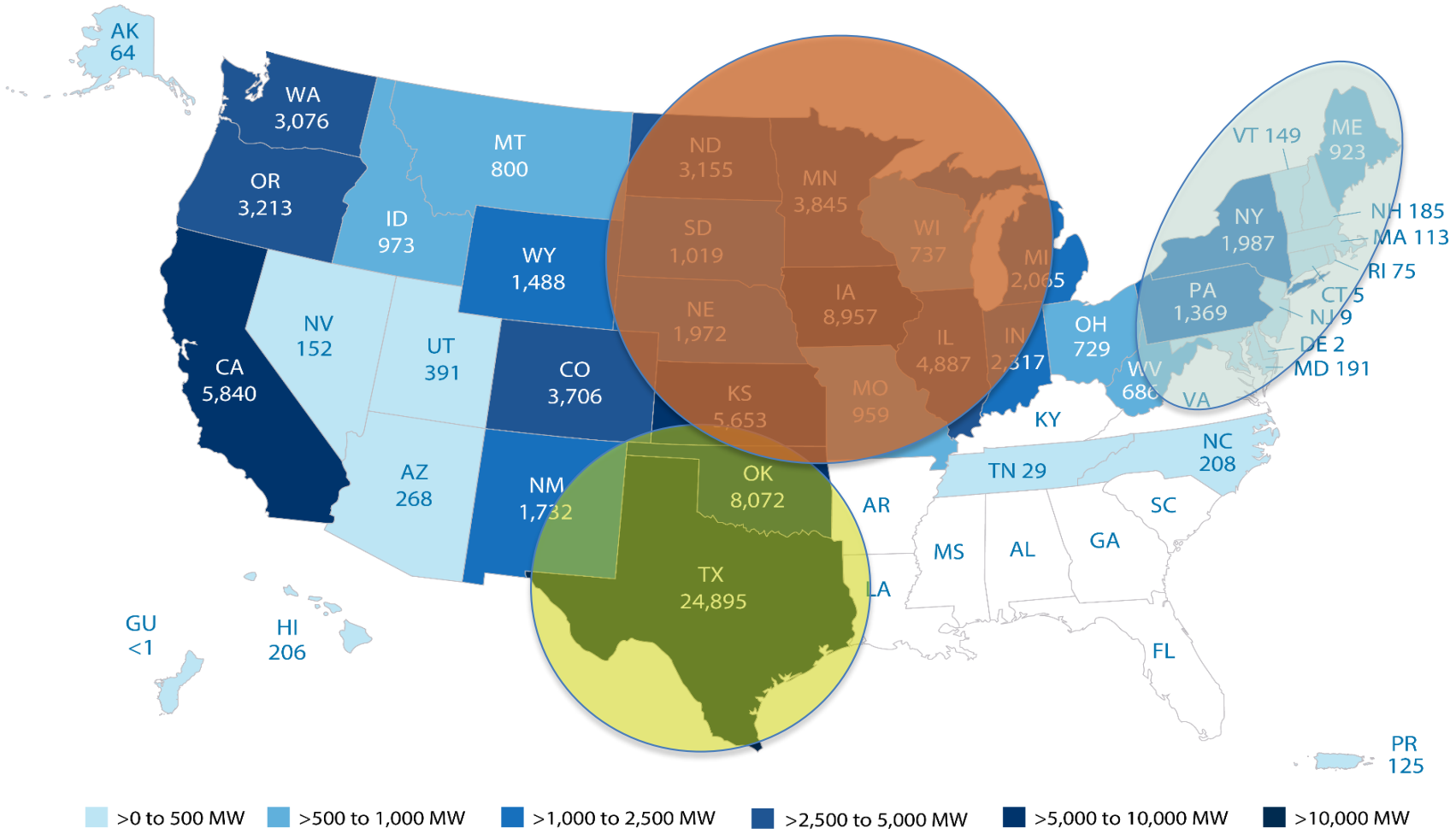
- BNEF clocks annual battery storage cost reductions at **18%.** This compares to learning rates of 11% and 18% for wind and solar, respectively, since 2010.
- Global wind + storage LCOE are estimated at $41-78/MWh, unsubsidized
- Solar + storage has advantage in U.S. due to ability to claim ITC on hybrid project.

Source: BNEF

Potential Business Cases

- Cost savings – new and existing wind farms
- Curtailment mitigation
- Price arbitrage
- Firming wind capacity
- Clean peak standards, storage mandates, legislative standards

Opportunity Areas for Pairing



Source: AWEA, Wood Mackenzie

- Texas' large install base and substantial pipeline, combined with market design and curtailment concerns, represents significant potential opportunity
- Clean Peak Standards and anticipated offshore wind presents market opportunity in New England
- Midwest offers large install base, but market rules and lack of mandates could hinder signification pairing
- California offers further opportunity, but solar + storage has market position

Challenges

- Standalone storage ineligible for ITC
- Intermittent nature of wind resource
- FERC Order 841 vague on hybrid resources
- Single point of interconnection for hybrid resource
- Capacity accreditation
- Market participation

WIND+

POWERING THE FUTURE. TOGETHER.

AWEA WINDPOWER®

Houston, TX | May 20–23, 2019

Siemens Gamesa hybrid solutions

Leading the way to a renewables powered future

May 2019

SIEMENS Gamesa
RENEWABLE ENERGY

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SIEMENS Gamesa RENEWABLE ENERGY

Company profile

SIEMENS Gamesa
RENEWABLE ENERGY

History

Siemens Gamesa Renewable Energy was created in April, 2017, with the merger of Gamesa Corporación Tecnológica and Siemens Wind Power under one roof: innovative spirit, dedication to technological excellence, and determination to provide real and lasting value to all stakeholders and customers.

Today, Siemens Gamesa Renewable Energy is a respected industry **leader committed to providing innovative and effective solutions** to the energy challenges of tomorrow.

Gamesa's history is marked by a spirit of innovation and successful expansion into new markets. What started as a small machining workshop in northern Spain quickly grew into a global company focused on new technology development.

In 1995, Gamesa expanded into wind power, installing its first wind turbine in Spain, and quickly grew into one of the leading manufacturers of wind turbines worldwide with production centers in the U.S., China, India, Brazil and Spain.

The history of **Siemens Wind Power** is equally impressive. The company has been directly involved in the wind power industry since 2004 when it acquired the Danish Bonus Energy. With the acquisition, Siemens gained a wealth of technology and proven experience stretching back to 1980. This history includes providing turbines for the world's first offshore wind farm in Vindeby off the coast of Denmark, in 1991.

Siemens Wind Power grew into the global market leader for offshore business, earning a reputation for technological leadership, strong customer service, and for offering fully integrated end-to-end energy solutions.

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Key Facts[1]

+90 GW
Globally Installed

23k
Employees

€9.1 B
Annual Revenue

11.2 GW
Order Entry

€23 B
Order Book

True global, modern and scalable footprint

Advanced digital capabilities

Portfolio covering all requirements

[1] *Figures as end of December 2018.*

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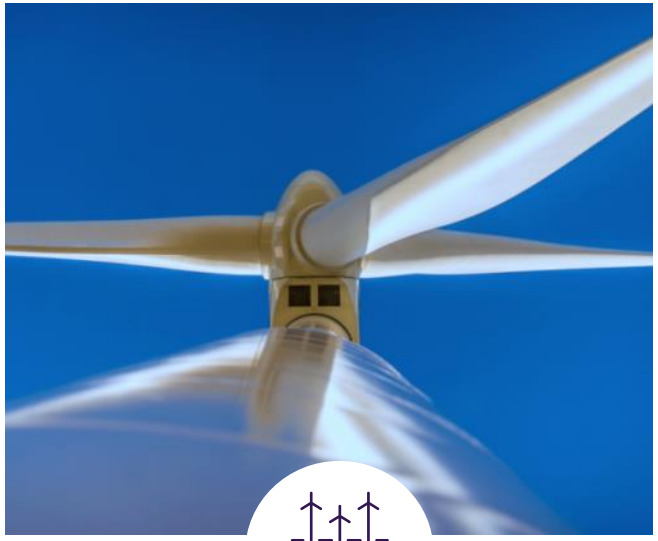
Activity



Onshore

78.5 GW installed in 75 countries.
11.2 GW of wind farm developed in 14 countries.
The perfect technology partner for your wind projects.

Offshore

+12 GW installed worldwide since 1991.
Most experienced offshore wind company with the most reliable product portfolio in the market.

Service

56.8 GW maintained.
Commitment beyond the supply of the wind turbine to achieve the profitability objectives of each project.

Three business units strongly positioned in the market

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Hybrid systems

Wind, solar & storage (ON & OFF grid)

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Energy transition. The energy sector is changing rapidly with more complex networks

Decarbonization

Decentralization

Digitalization

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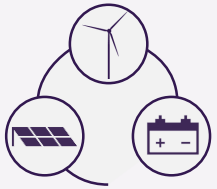
3rd Industrial revolution

Renewable energy hybrid solution

Electric vehicles
Energy buildings

Energy storage



Renewables

Prosumer

Energy trading platforms

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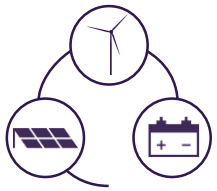
Siemens Gamesa hybrid solutions

We have a vision

Hybrid is a **proven reality** in Siemens Gamesa. Investing since 2007.



We are ready

Leading the change offering cutting edge technology and services.

Turnkey solutions with in-house **Hybrid Plant Controller HPC**, power electronics, ReStor, solar PV, micro-siting hybridation tools and financing.

Shaping the future

Promoting hybridization and guiding our clients towards a new renewable era.

Optimal prospecting

- **Advanced grid services** with technical experts teams.
- **LCoE reduction** through expertise of hybrid study expert team.

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Wind integrated hybrid power plant. Definitions

Wind

Battery

Storage

Battery

PV

Solar

SGRE focus

Hybrid systems for SGRE defined as:

I. **Wind** + **Storage**
II. **Wind** + **Solar**
III. **Wind + Solar + Storage**
IV. **Solar + Storage**
V. **Offgrid System**

Definitions:

Hybrid solutions for SGRE 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.

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Hybridized wind projects. Investors motivation.

Provide improved grid services

Improved business case

Investors

Grid operators and users	RE plants owners	Energy buyers/ consumers

Motivation

• RE as a dispatchable energies avoiding grid extra cost. • Flexibility cost savings. • Comply stricter grid codes. • Improving quality grid/blackouts mitigation. • Ramping control.	• Capacity firming / low LD´s. • Complementary resources /minimizing curtailments and maximizing energy prices (Energy arbitrage). • Demand response / less LD´s deviations. • DEVEX, CAPEX and OPEX savings due to synergies.	• Lower grid dependency. • Micro-grid integration. • Diesel substitution. • Low load demand/ behind the meter applications.

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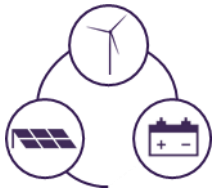
Siemens Gamesa has a long track record regarding hybrid solutions



2007

Galapagos Project
- First hybrid project with wind and diesel generators.
- Maximizing wind power penetration through Hybrid Plant Controller and saving fuel.

2014

ETES – Electro-Thermal Storage
- 1st thermal storage proof of concept in Hamburg in 2014
- Next bigger demonstrator is being built in in the Hamburg harbor for inauguration in 2019.

2015

Hybrid prototype "La Plana" test site
- Offgrid R&D plant incl. wind + PV + diesel + batteries.
- Development of first HPC controller version.

2016

Company setup for hybrids
Dedicated teams start to work on hybrid concepts and development.

1st hybrid plant in India
Wind, PV as EPC project in Kudgy.

2017

1st commercial PV-Wind hybrid
Kavital, India - turnkey project with 50 MW wind and 29 MW solar energy incl. own inverters and 1st version of HPC.

Adding a **redox-flow** battery to the "La Plana" test site.

2018

New Gamesa Electric technology center for power electronics.

2019

Next generation HPC
Next release of SGRE hybrid plant controller will be available.

Utility-scale Wind-BESS project
Bulgana, Australia – EPC solution for a green power hub incl. 194 MW of wind and 20 MW/34MWh or Li-ion battery technology.

Grid-connection planned for on-grid hybrid testing.

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Siemens Gamesa's

Hybrid product offering

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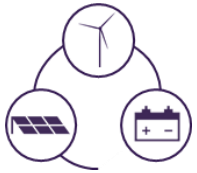
Siemens Gamesa hybrid offering. The best results on the market

Customized hybrid solutions



Feasibility studies
Engineering support

OFF & ON grid

Plug & play solutions

Hybrid Plant Controller©

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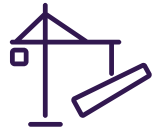
HPC

Premium in-house power electronics

Solar PV

Wind

BESS



EPC capabilities

Financing solutions through SFS

Hybrid O&M
MEGA Meteo

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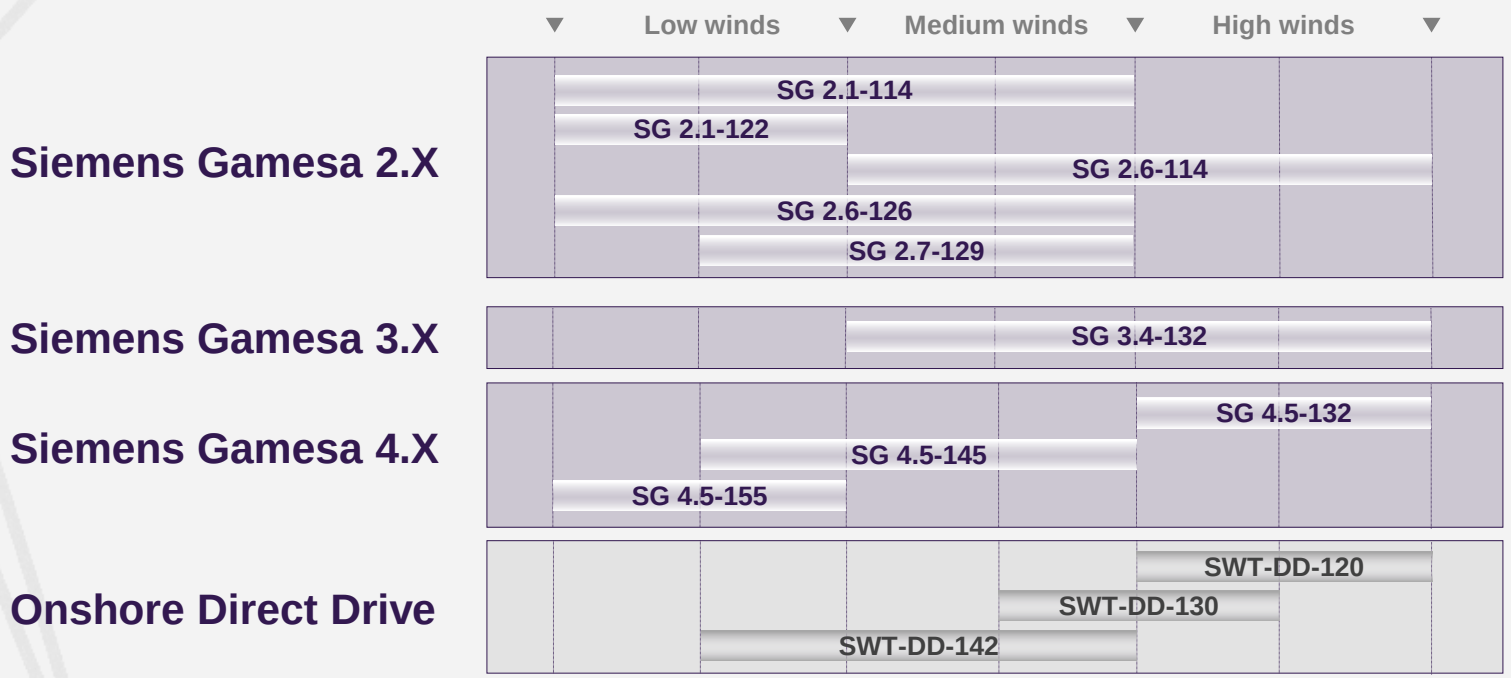
An optimized, streamlined **Product Portfolio**



Siemens Gamesa long-term reference portfolio entirely based on geared technology.

Onshore Direct Drive platform available in selected markets.

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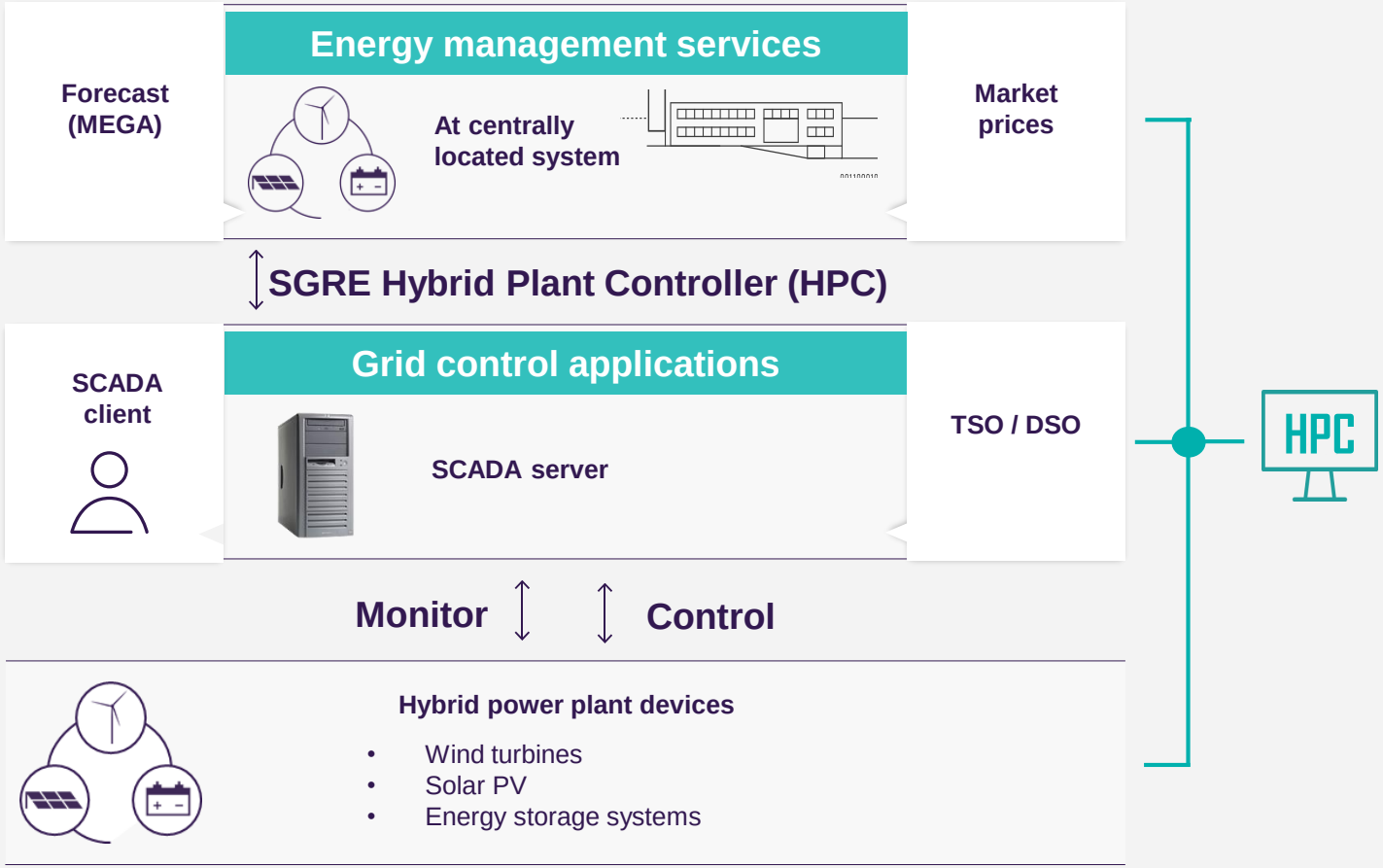
The Hybrid Plant Controller (HPC) is the brain of a hybrid plant



Siemens Gamesa HPC, Hybrid Plant 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.

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Hybrid solar PV offering

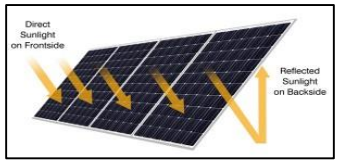
Solar technology

PV modules

- Hi-efficiency PV modules.

Trackers

- Robust, simple single axis tracker with excellent capability to minimize shading loss from the structure, with possibility of self-powered engine configuration.

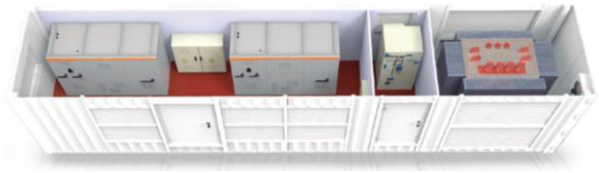


Integrated In-house

GamesaElectric

AC-Gamesa E-PCS Power Station

- 20 - 40 ft container plug & play solution.
- Gamesa Electric inverters catalogue.
- LV/MV transformer + MV switchgear integrated.

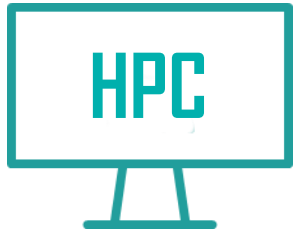


In-house

GamesaElectric

(HPC© Controller)

- Grid control applications (GCAp).
- Energy management services (EMS)
- Fast architecture included to enable the implementation of future control applications.



In-house

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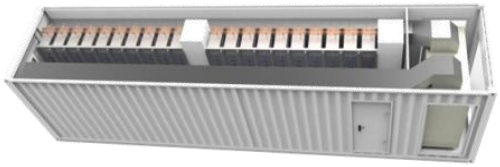
BESS offering. *ReStor.* SGRE proprietary BESS solution

Storage technology

DC Battery Container

- 40 or 20 ft container plug & play solution HC ISO.
- Up to 4.2 MWh Li-Ion battery
- DC protections, HVAC, fire detection and extinguishing integrated

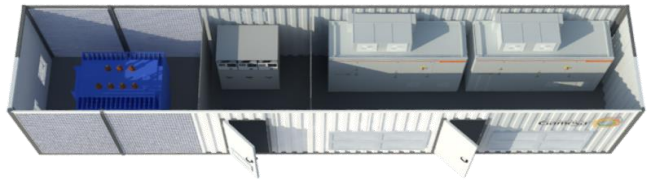


Integrated In-house

GamesaElectric

AC-Gamesa E-PCS Power Station

- 20 feet or 40 feet container plug & play solution.
- Up to 5MVA Gamesa Electric bi-directional inverters catalogue versatile and battery agnosti.
- LV/MV transformer + MV switchgear integrated.



In-house

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(HPC© Controller)

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In-house

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Storage Applications. Our solution can be tailored to your needs

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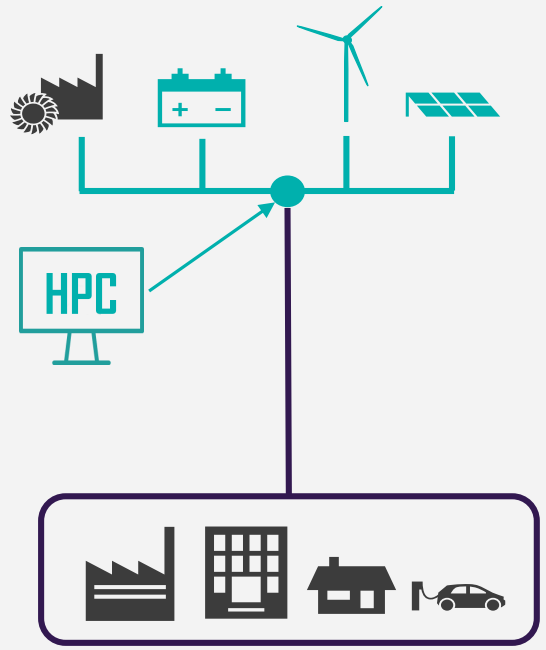
Off-grid systems

Analyzing the existing offgrid generation plant and sizing an alternative offgrid renewable plant (wind, PV & storage).
Target: optimize **LCoE**

Product offering. FULL EPC where:

- PV: tier one module & tracker suppliers.
- BESS: ReStor, SGRE proprietary battery solution.
- Fully designed for a project tailored solution.

Plant design. Starting with the analysis of the existing generation and ending with tailored Hybrid Plant Controller (HPC), which controls and operates wind, PV and BESS and sends "operation references" to the diesel/HFO plant controller.



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Siemens Gamesa's

Hybrid value proposition

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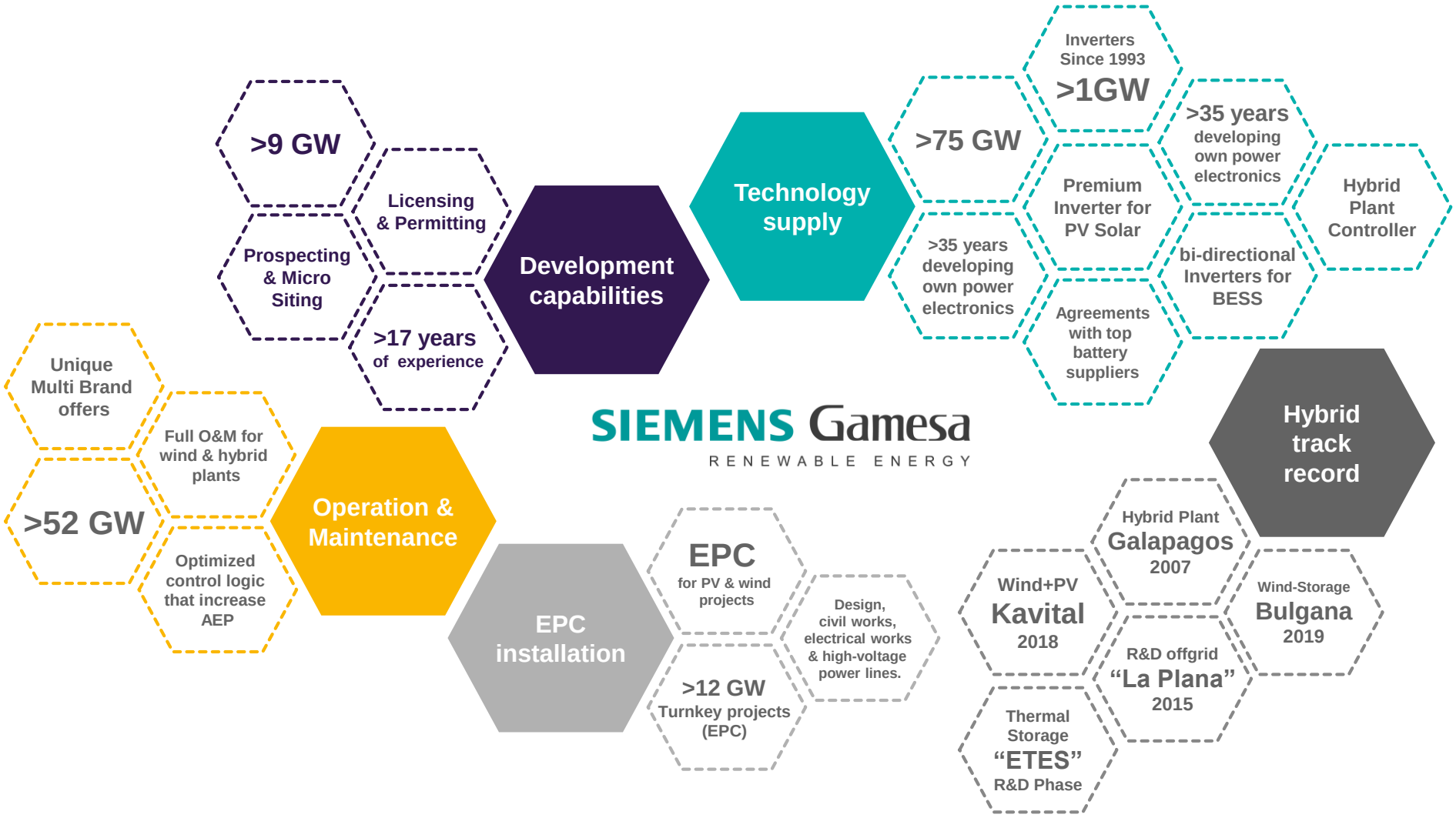
Experience throughout the whole value chain



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SGRE. The most experienced partner throughout the entire value chain of hybrid projects

Downstream | **Upstream**

Project development → **Integration EPC** → **O&M** → **Financial support** → **Technology supply** → **Power conversion** → **Software & control**

Prospecting
- Expertise in wind and solar plants.
- Hourly generation model curves to **identify the optimal contribution of technology** for hybridization.
- **Micrositing design** for the whole hybrid plant.

EPC support
- **Turnkey or supply & installation** of wind, solar, storage technology.
- Extensive experience with EPC projects.

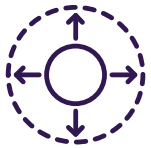
O&M for whole plant
- **Cost reduction** by sharing of resources & infrastructure.
- Company group specialized also in O&M for PV plants.

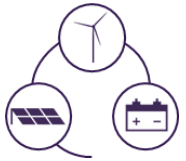
Bankability
- **Bankable** hybrid solution from most reliable supplier.
- **Financing support** possible.

Supply of Technology
- World-class wind OEM with most extensive portfolio.
- Tier-one modules and trackers suppliers.
- Modular BESS solution with tier one cell supplier.

Power conversion electronics
- State-of-the-art power converters for wind, PV and BESS.
- Fully certified.

Hybrid Plant Control
- **In-house solution** to control and supervise entire hybrid plan.
- Premium SCADA system to monitor assets.
- **Forecasting tool:** hybrid resource evaluation & prediction.





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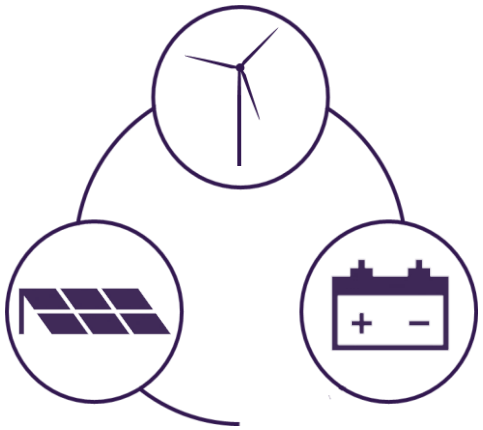
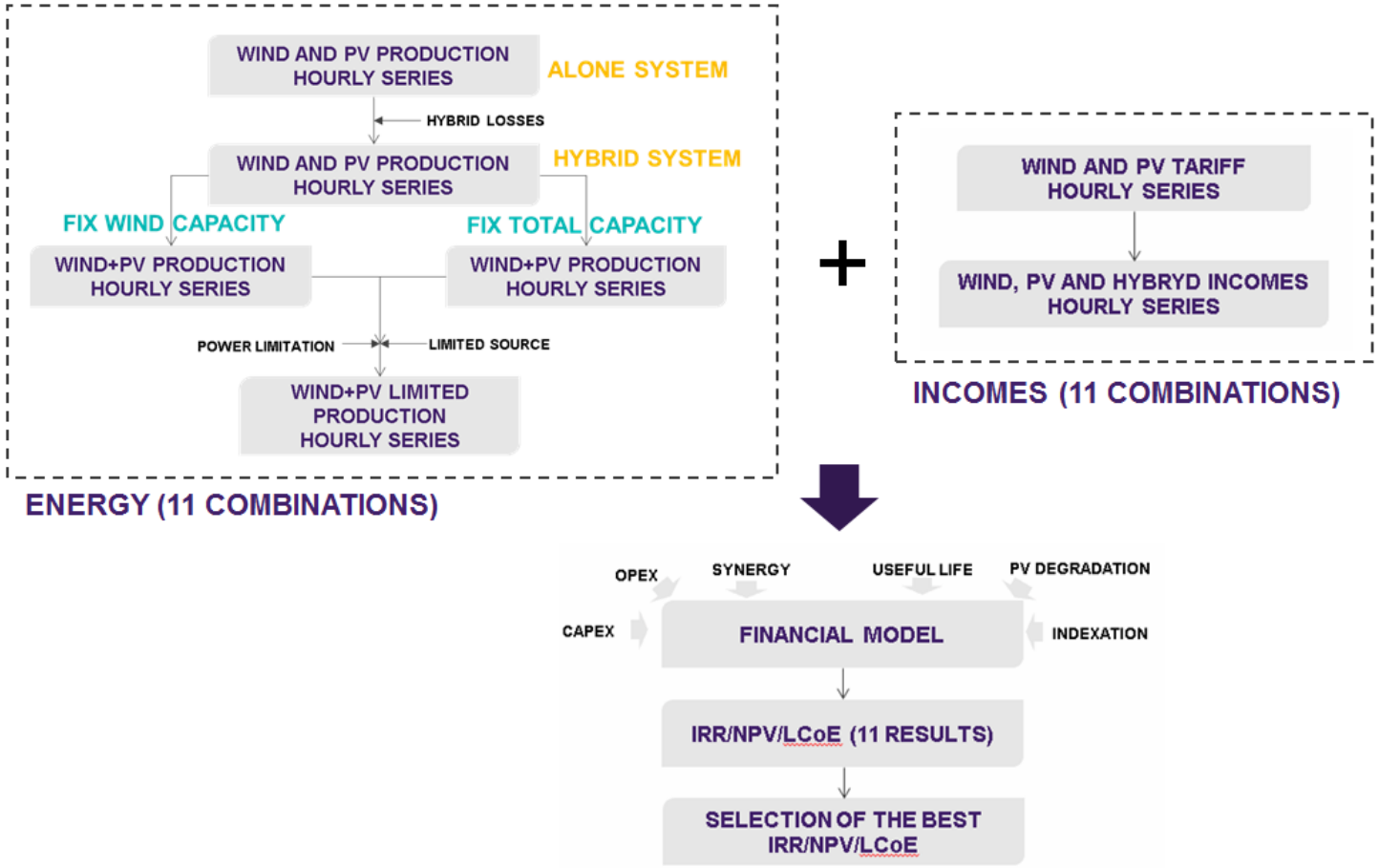
Project development. Analysis & design

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





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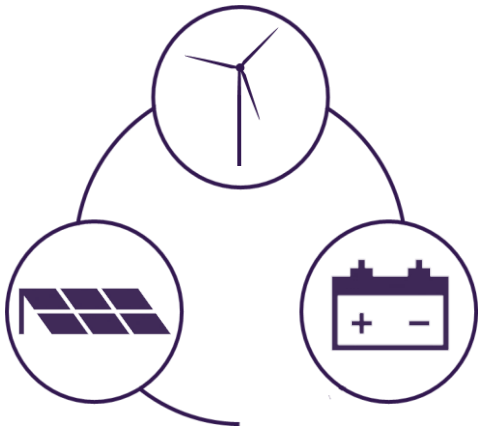
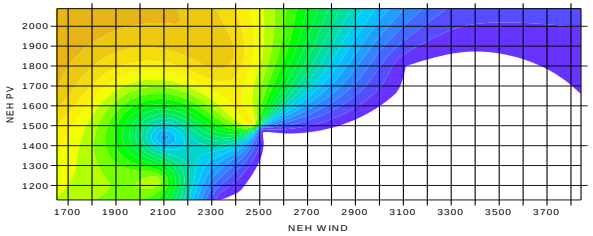


SYNERGY

	CAPEX	-10
	OPEX	-15
WIND %	PV %	IRRp
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%

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.

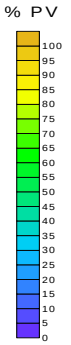


SYNERGY

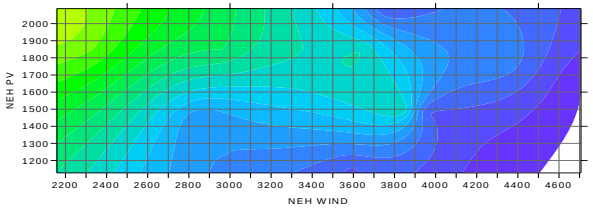
	CAPEX	-20
	OPEX	-25
WIND %	PV %	IRRp
100	0	7.82%
90	10	8.38%
80	20	8.79%
70	30	9.07%
60	40	9.21%
50	50	9.19%
40	60	9.00%
30	70	8.58%
20	80	8.02%
10	90	7.30%
0	100	6.43%

Fix 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

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

Forecast (MEGA)

Energy management services

At centrally located system

Market prices

SGRE Hybrid Plant Controller (HPC)

SCADA client

Grid control applications

SCADA Server

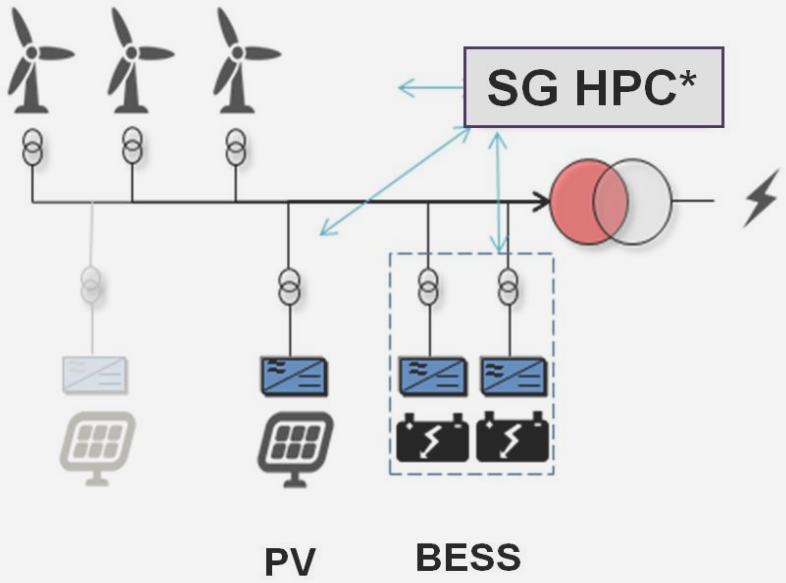
TSO / DSO

Monitor **Control**

Hybrid power plant devices

- Wind Turbines
- Solar PV
- Energy storage systems

HPC



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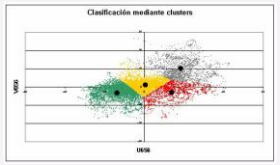
Siemens Gamesa Hybrid Plant Controller (SG HPC)

Maximization of energy production

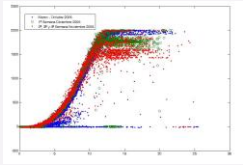
- Renewable energy forecasting (MEGA Meteo).
- Customized model of the client's wind farm: MOS (Model Output Statistic).
- Wind data treated through ARIMAS & production data with RLS filter.
- Integral customer service and wind farm communications management.

Wind power forecast

Obtaining the best accuracy for planning and market purposes.



Wind speed cluster analysis, including direction.



Dynamic power curves according to last data collected.

Continuous real-time data input from the **WF's SCADA.**

Solar Power Forecast

Obtaining the best accuracy for planning and market purposes.

Time and inclination.

Cloudiness

Type of clouds.

Radiation

Final radiation over the plant.

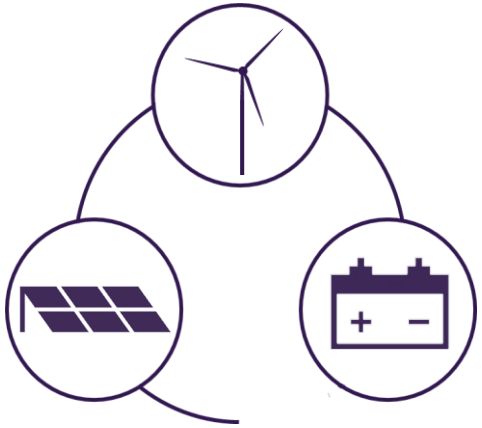
Meteo observations.

Power output.

WEB MEGA

Power electronics. Expertise for wind, PV and storage

- **Complete turn key solution**, WTG´s, PV inverters, bidirectional inverter for energy storage and batteries.
- **Solar inverters** and other power electronics, based on the same technology as the WTGs. Allows to comply with demanding grid code requirements at Hybrid plant level.



Gamesa Electric is present in the photovoltaic sector since 1993, with the design and manufacture of the first photovoltaic central inverter with 450 kW of power, as well as Europe's first photovoltaic inverter with IGBT technology and 100 kW of power, which is still in operation today.

In 2016 the company launched its new series of **central PV inverters** with 1500VDC technology, both indoor and outdoor versions and under European and American standards.

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O&M experience in wind & PV

- O&M service for the complete hybrid plant.
- Cost reduction by sharing of resources and infrastructure.
- Company group specialized also in O&M for PV plants.

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Track Record:

SGRE’s Hybrid System is a fact

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RENEWABLE ENERGY

SAN CRISTOBAL - Offgrid wind & thermal plant

Galapos Island, Ecuador

Multi-technology
at MW level.

Commissioned in
2007.

Hybrid Plant Controller
manages the plant to maximize Wind penetration (monthly up to 60%).

8,3M liters of fuel replaced.

Reduction of **20,359 tons CO_2/a.**

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LA PLANA - Hybrid & offgrid prototype & test plant

Zaragoza, Spain.

Multi-technology

at MW level.

Commissioned in

2015.

Li-ion BESS

installed in Q2 2016.

Redox-Flow Battery

under testing in 2018
(in collaboration with Hydra Redox).

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

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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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RENEWABLE ENERGY

KAVITAL - First commercial hybrid on-grid plant in India

Karnataka, 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.

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

Bulgana, Australia

Multi-technology
at MW level with Li-Ion storage.

To be commissioned in
2019.

EPC solution
Design and commissioning included.

O&M for **25 years.**

Reduction of **530,000 t CO_2/a.**

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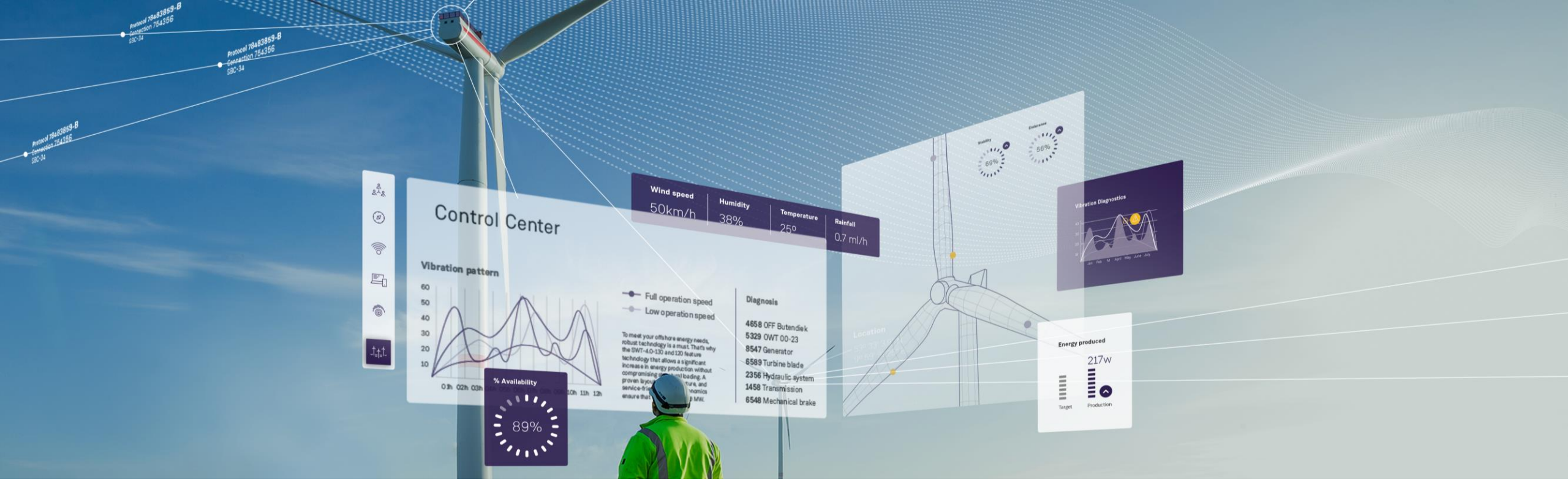

Case study

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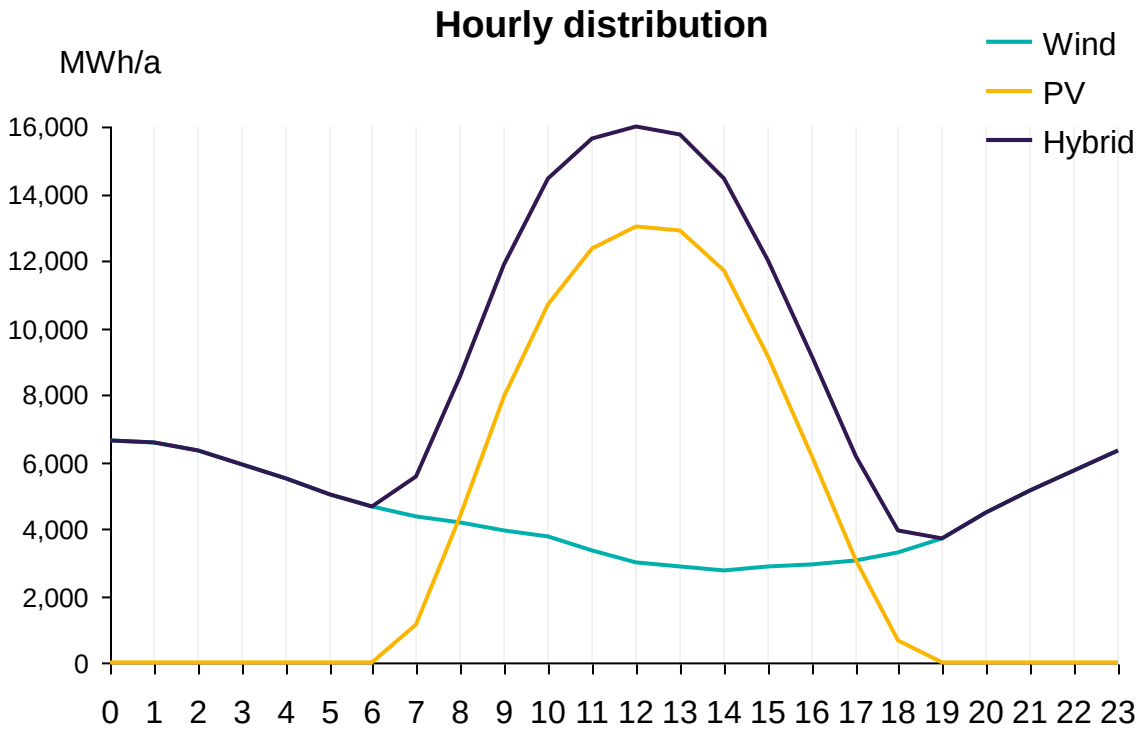
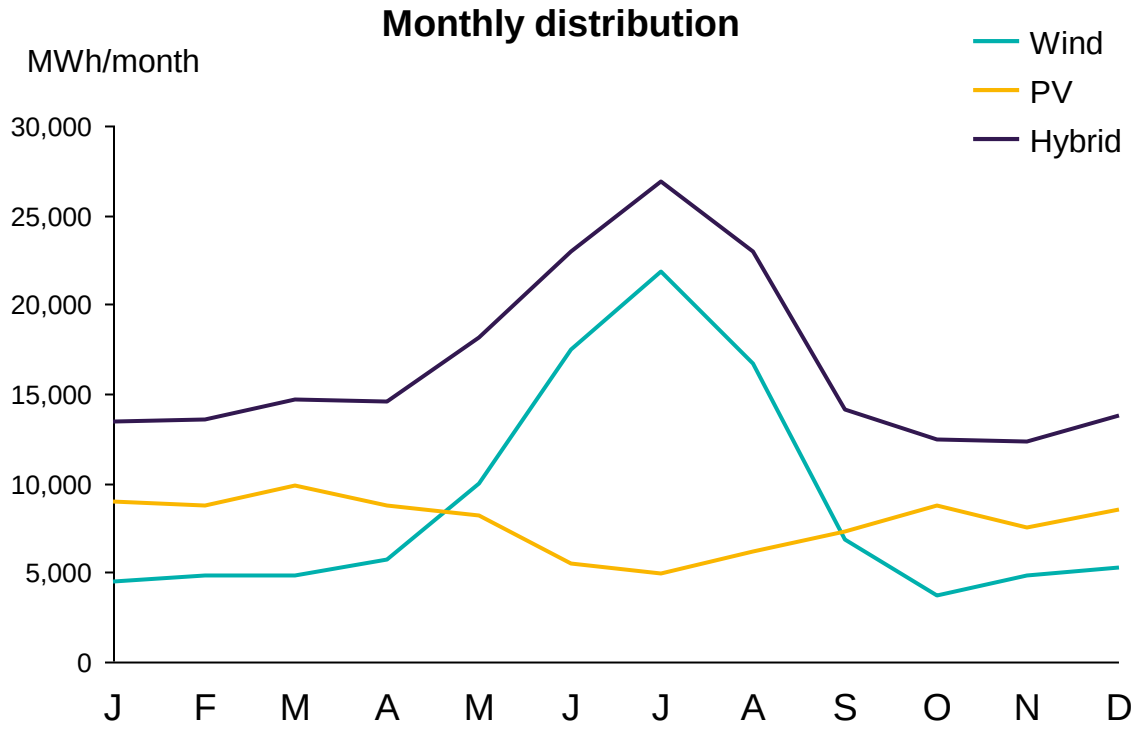
Hybrid plant Wind + Solar in India





High hourly complementarity:

- Central hours: Low wind, high solar.
- Rest of hours: High wind, low solar.

High monthly complementarity:

- May-September: High wind, low solar.
- Rest of months: Low wind, high solar .

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Hybrid plant Wind + Solar in India

Co-location; 50 MW existing wind farm, same evacuation capacity, to which a PV plant is added (+25MW and +50MW).

	CAPEX	OPEX	NEH*				IRR	Curtailment
Technology	(k€/MW)	(k€/MW/year)	WIND	PV	HYBRID	Delta	Delta	PV
50 MW	1.000	15.5	2159	0	2159	0%	0%	0%
+ 25 MW	800 **(-10%) = 720** due to synergies	8.5 **(-15%) = 7.2** due to synergies	2143	1934	3110	**+ 44%**	**+1.4%**	1.9%
+ 50 MW	800 **(-10%) = 720** due to synergies	8.5 **(-15%) = 7.2** due to synergies	2127	1863	3990	**+ 85%**	**+1.8%**	5.5%

NEH of the WIND plant assumed to be affected by PV plant. NEH of the PV plant (stand alone) = 2002. Maximum evacuation power 50 MW. Incomes 66 €/MWh for both WIND and PV. Synergies in CAPEX / OPEX based mainly on study from AECOM for ARENA (AUS). Financial model based on 20 years and discount rate of 12%. Calculation based on a hourly energy balance including PV curtailment and losses related to configuration.

*NEH = Net Equivalent hours of the hybrid plant (i.e. for case +25MW PV: (2143x50 + 1934x25) / 50 = 3110

Improvement of the IRR of aprox 1.5-2%

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Thanks

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Q & A

Questions can be submitted through the chat box in your browser.

Energy Storage Association

THE ESA STORAGE EXCHANGE

Powered by EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Alabama 110 MW Compressed Air Energy Storage Plant

October 15-16
Bellevue, WA

Energy Storage Association

Thank you

Please submit ideas for future webinars to
education@energystorage.org

Energy Storage Association