

# Hybrid Power Plants with Vestas

Leading with sustainable energy solutions complementing wind with storage and/or solar.

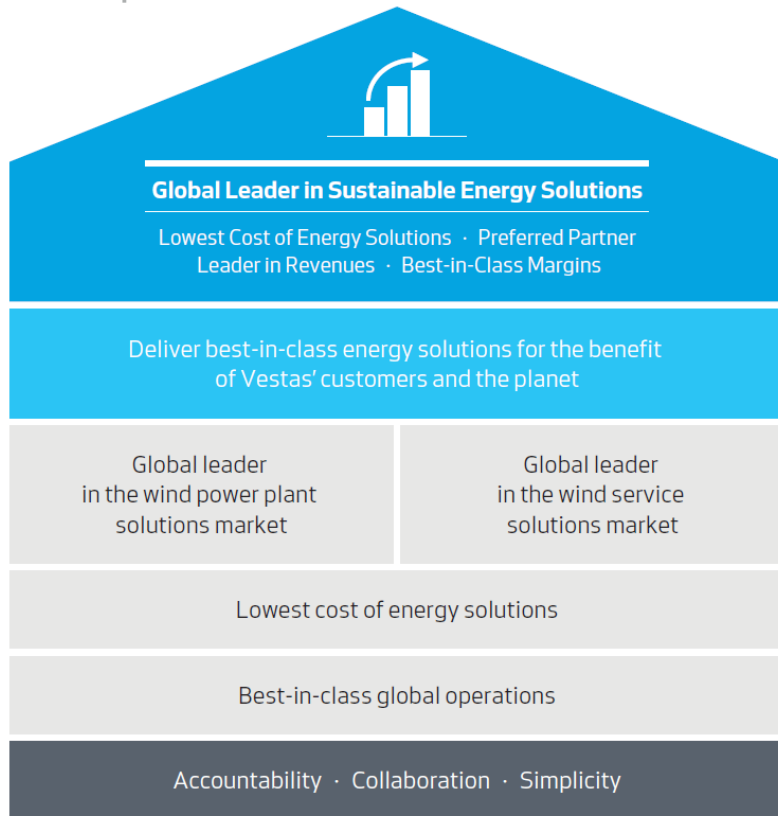
# Global leader in Sustainable Energy Solutions

Vestas' updated corporate vision shows ambition to expand focus

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**Vestas' updated vision** expands the focus to include wind working together with other energy sources and technologies in a **broader energy system context**

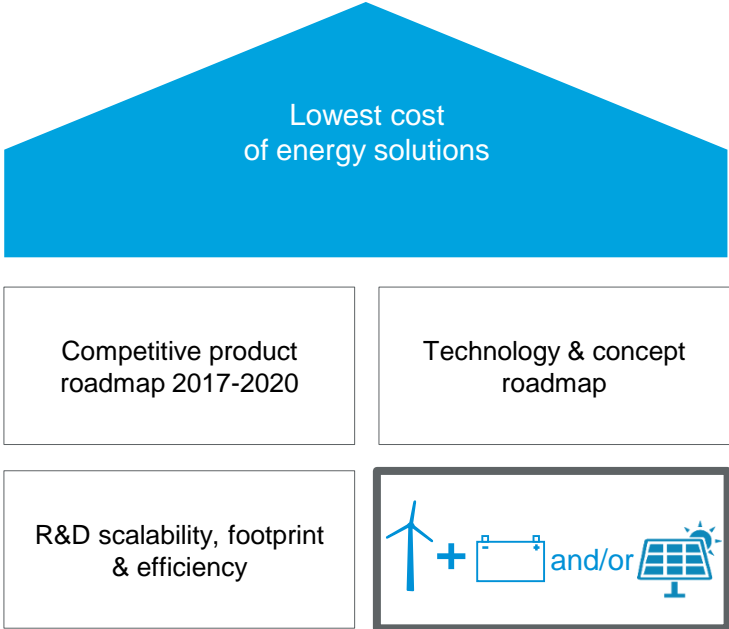
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# Lowest Cost of Energy Solutions

Expand initiatives in the area of Hybrid & Storage solutions

A key Vestas strategic objective is to **provide lowest cost of energy solutions**. To achieve this, Vestas expands initiatives in which it is already active, including **grid integration, hybrid and storage solutions**



# Evolved Energy Market: Complex Energy Network

New business opportunities arise from market developments

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Wind energy generation is part of an increasingly complex and ever **evolving energy network** with **changing technical and commercial requirements**

Sustainable Energy Solutions leverage the benefits of different energy generation and **integrates them into energy networks** on grid and micro-grid scale

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# Evolved Energy Market: Supporting technologies

Supporting technologies to wind turbine energy generation holds significant potential

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Technological advances in storage, solar, and data utilization make deployment with wind economically beneficial, depending on site specific conditions

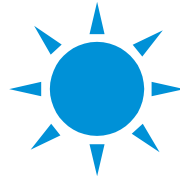
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## Supporting technologies



Storage

- Technology advancements
- Different technologies suited for either power or energy applications
- Steep cost reduction curve



Solar

- Continuous cost reduction
- Complementing wind

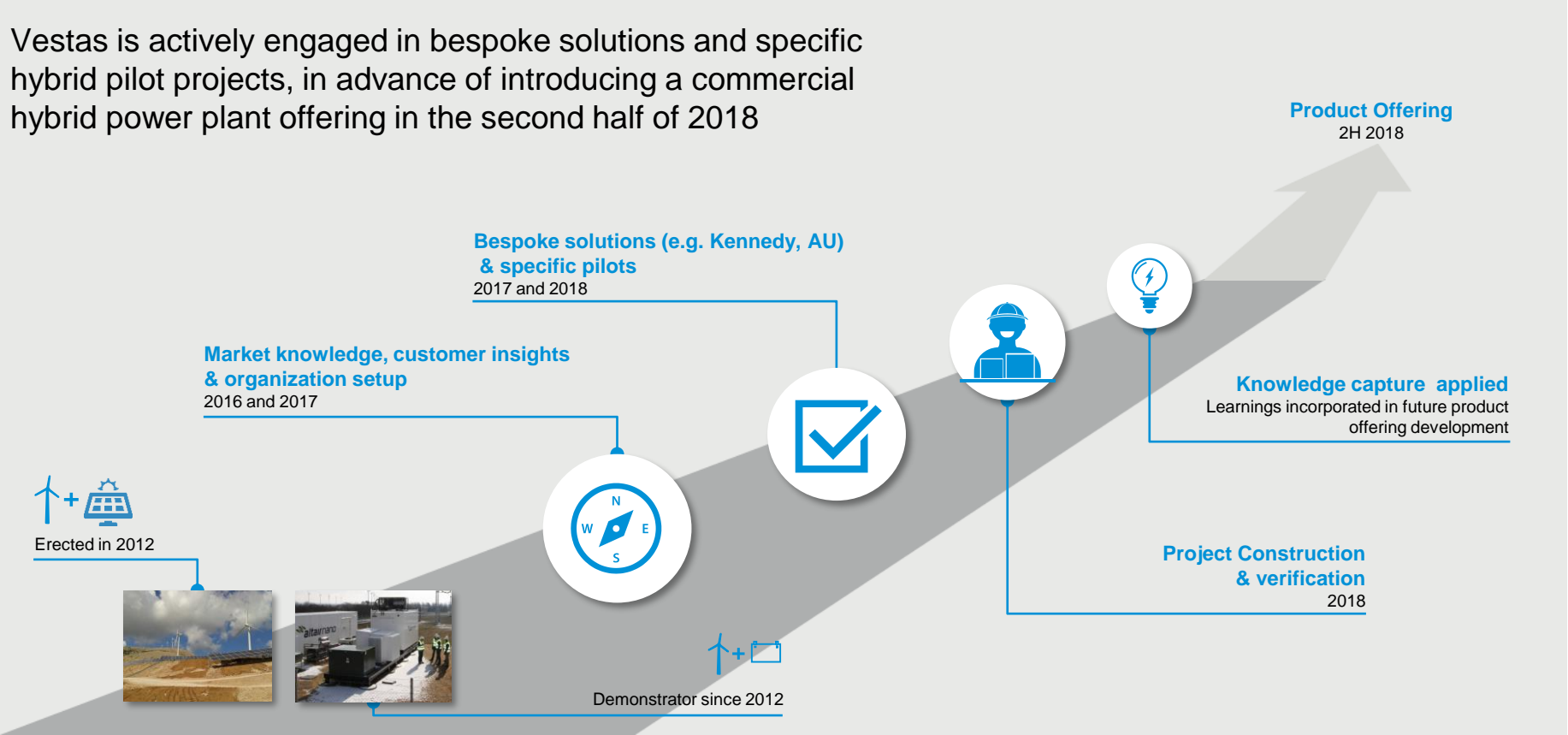


Data

- Digitalization of grid
- Understanding supply and demand

# Vestas and Hybrid Power Plants

Vestas is actively engaged in bespoke solutions and specific hybrid pilot projects, in advance of introducing a commercial hybrid power plant offering in the second half of 2018



# Hybrid system potential

Wind combined with solar and/or energy storage can help secure project realization and improve project return

secure **license to operate** and/or enter into **new markets**



## Increase Energy Production

- Use complementary generation to increase AEP and optimize supply-demand match



## Improved Capacity Factor

- Complementary generation patterns
- Mitigates physical asset-related restrictions



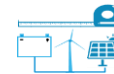
## Reduce CAPEX, OPEX and DEVEX

- Reduction from sharing & optimization of equipment and infrastructure
- Case specific avoidance of some equipment



## Fulfill grid codes and enter new revenue streams

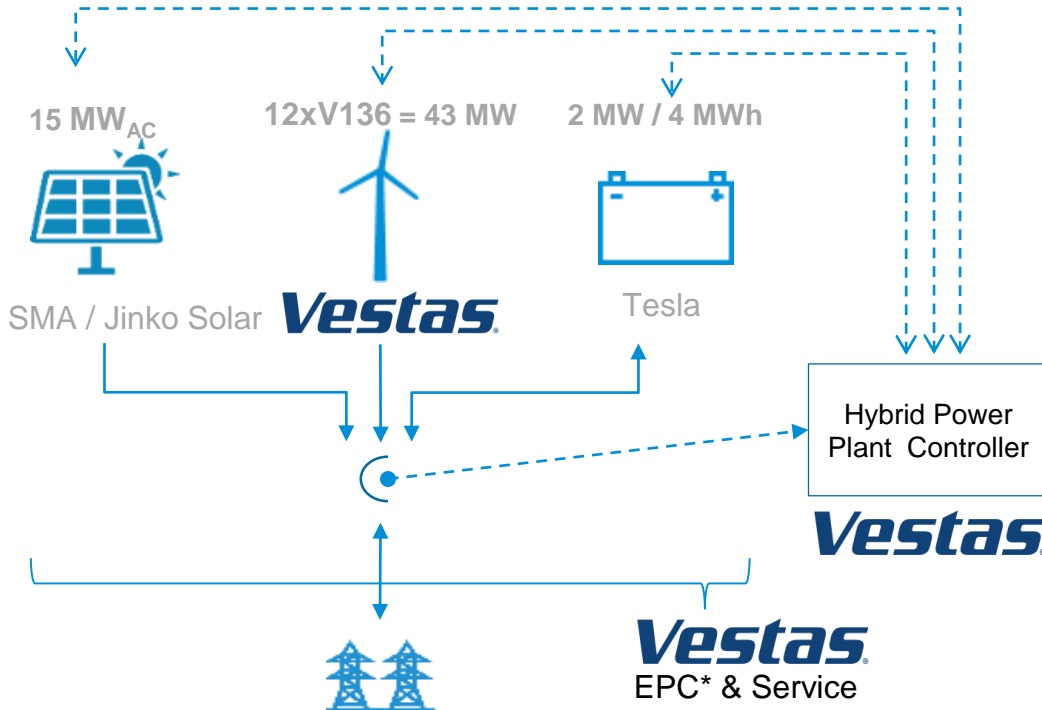
- More stable load/quality to comply with strict grid codes
- Higher price of energy and new ancillary services revenues



**Right-sized assets improve project return**

# Sustainable energy solutions: First commercial hybrid project

Kennedy Energy Park: World's first utility-scale hybrid power plant combining wind, solar & storage



## KEY BENEFITS

Vestas' Hybrid Power Plant Controller enables individual technologies to operate as one integrated facility. Combining wind with solar and/or energy storage help improve project-level economics:



Increased Energy Production



Improved Capacity factor



Reduced cost

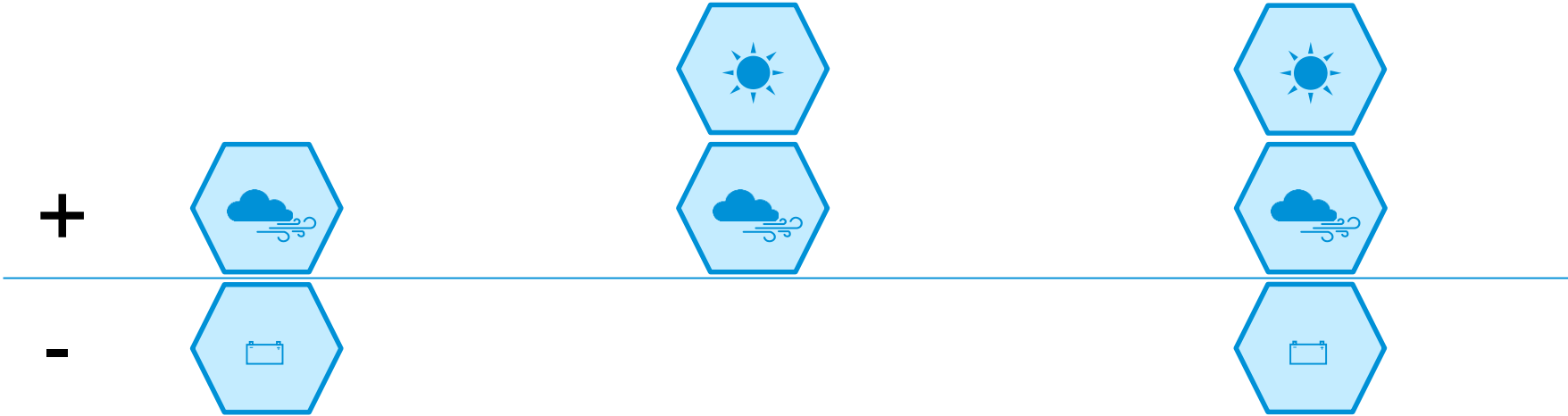


Fulfillment of Grid Requirements & enable new earning opportunities



# LCOE impact vs Hybrid Configurations

Storage is in many cases not a positive LCOE contributor



$$LCOE = \left( \frac{\text{Total cost over lifetime}}{\text{Electricity produced over lifetime}} \right)^*$$

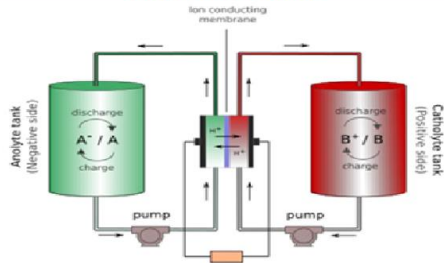
# LCOE focus remains: cost-out on storage is essential

Accelerated and rapid innovation is essential together with sub suppliers



## ORBATS

### Subject Description

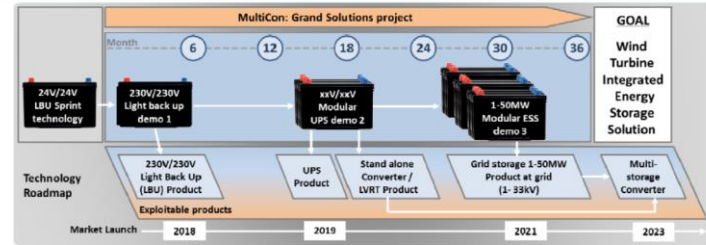


- Developing a low CAPEX and low OPEX redox flow battery energy storage solution based on safe, earth abundant, stable and inexpensive organic materials as the energy storage medium. With a cost target of < \$100/kWh, including materials, stack and balance-of-plant, widespread adoption will be feasible, and we thus provide a disruptive energy storage solution that can service markets as diverse as solar energy storage in residential applications to off-grid as well as grid-scale storage of wind power.
- Project Participants
  - DTU, AU, Harvard
  - Vestas, Visblue, Lithium Balance



## MultiCon

### Subject Description



The MultiCon project aims to foster a paradigm shift in wind energy by developing disruptive storage solutions, generating significant advantages for functionality, stability, reliability and durability, as well as lower OPEX and CAPEX for end-users.

#### Participants:

- KK Wind Solutions
- Vestas
- PowerCon
- Aalborg Universitet

The image shows a landscape with three wind turbines of varying sizes, partially obscured by a line of green trees in the foreground. The sky is filled with large, dramatic clouds, with some light breaking through. The overall scene is a natural setting with renewable energy infrastructure.

**Vestas**<sup>®</sup>

Thank you for your attention

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