QVARTZ

Emergence of hybrid renewable energy systems

New business opportunity for global renewable players

With solar becoming cost competitive with wind, towards 2020, wind and solar together are expected to impart scale to renewable electricity generation. Due to improved reliability and associated cost savings, hybrid renewable energy systems are positioned to lead this scale-up of renewables, offering new opportunities to WTG manufacturers and utilities

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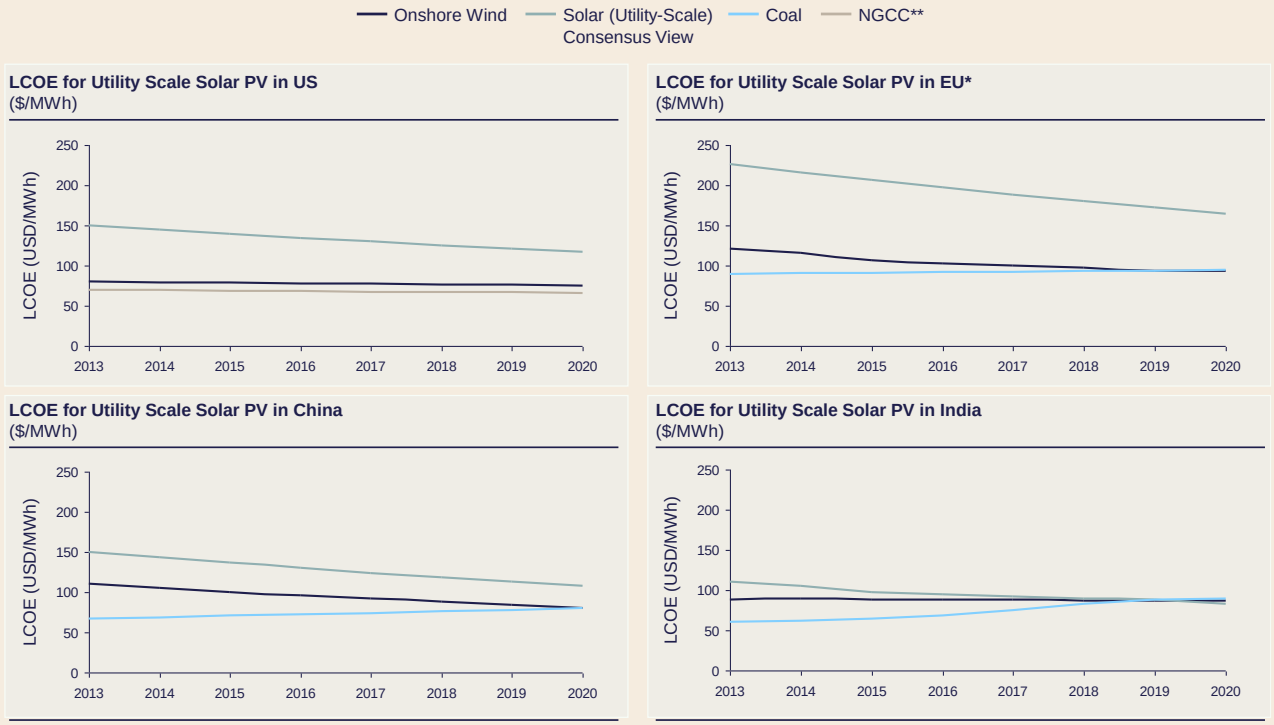
Solar is becoming the renewable technology of choice globally

Historically, wind has been the leading renewable energy source globally with around 240 GW of installations between 2009 and 2014. During the same period, solar has seen a rise in popularity ending up at installations of around 160 GW. In 2014, 43 GW capacity was added in wind compared to 39 GW in solar. Going forward, solar is expected to overtake wind as the renewable energy technology of choice. With the current outlook, the falling solar LCOEs will have the potential to attract investments worth nearly USD 300 billion [1]into solar in the next five years.

Solar is cost competitive with wind

The costs of generating electricity from solar are expected to decline by a global average of 18% between 2015 and 2020, nearly double the decline in onshore wind LCOE in the same period. The declining LCOE is primarily attributable to the declining technology costs, improving efficiencies of the PV modules. Module costs have declined by 65-70%[2] between 2009 and 2013, and in the same period, module efficiency has improved by 1.5-2%[3]. The cost of PV modules is expected to continue on a downward trend, while efficiencies will continue to improve towards 2020 due to economies of scale and technological improvements in the solar industry. Adding to this is the presence of supportive incentives for solar in selected geographies making it a highly attractive energy source. This marks the beginning of a trend where both solar and wind are going to be cost competitive and will be rapidly added to global renewable capacities. Figure 1 shows the development of utility-scale solar PV LCOE as compared to onshore wind and dominant fossil fuels in the US, the EU, China and India.

FIG 1 Solar is approaching grid party; India and China are expected to outpace EU & US in achieving parity



Note:* The consensus view gives the average LCOE for Solar PV in Germany, which has been taken to be reflective of the LCOE in EU
** NGCC- Natural Gas Combined Cycle
Source: EIA; BNEF; IEA- WEO, 2013; ISE-Fraunhofer 2013; NREL, 2015; MEC Intelligence analysis

[1] Total investment opportunity in new solar installation in the US, the EU, China, India, Japan and Australia until 2019; calculated through Capex/MW in the countries in World Energy Council, 2013 and capacity addition in the geographies forecasted by MEC (Capex projections until 2019 reduced at same CAGR (%) as LCOE reductions in the period for particular geography)

[2] IRENA, 2014
[3] Photon Internation, Feb, 2013

The IEA has for long been conservative in accepting the global shift of focus towards solar, and has consistently over-estimated the cost of electricity generation from solar, as compared to other leading industry agencies. While the IEA estimates that US solar LCOE will reach USD 175 per MWh in 2020, the broad energy research industry estimates that numbers would be in the range of USD 110-120 per MWh – a similar discrepancy could be seen in EU and China LCOE numbers, where the two numbers differ by nearly USD 20 per MWh.

Solar installations will dominate the emerging markets and overtake wind installations globally

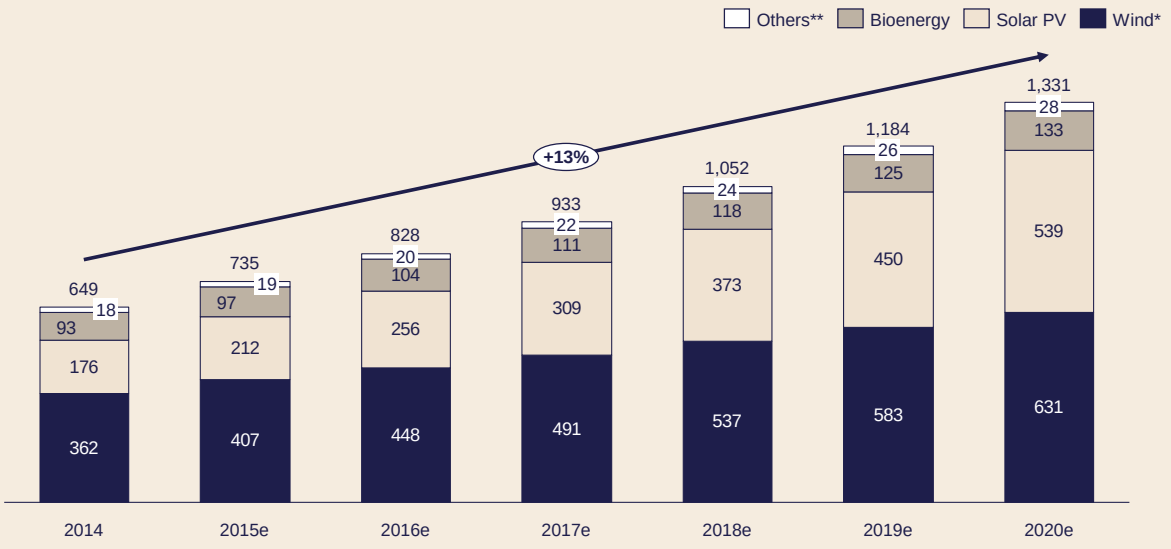
The total new installations from renewable energy (non-hydro) are expected to increase by nearly 535 GW between 2015 and 2019 to reach a total of 1,184 GW. Of this, solar is expected to account for nearly 274 GW and will overtake wind's pole position in the next five years in terms of capacity additions; wind is expected to install only 221 GW in the same period. The remaining 40 GW is expected to come from bio-energy (32 GW), geothermal (5 GW) and solar thermal (3 GW). Figure 1.2 below gives the historical and forecasted annual capacity addition of solar PV and wind.

Four geographies will be at the centre of the activity in solar, namely Europe, the United States, China and India. China and India are expected to outshine their western counterparts with highly ambitious government renewable targets. In the light of the recent announcements in both countries, they are together expected to install more than 100 GW of solar between 2015 and 2020, out of the total of 270 GW globally.

Figure 3 on page 4 gives the forecast of solar and wind capacity installations in the four geographies of the EU, the US, India and China from 2014 and 2019

FIG 2 Renewable capacity (excl. hydro) is expected to increase at 13% CAGR towards 2020 driven by solar ramp up

Cumulative renewable energy installed capacity forecast, 2014-2020
(GW)

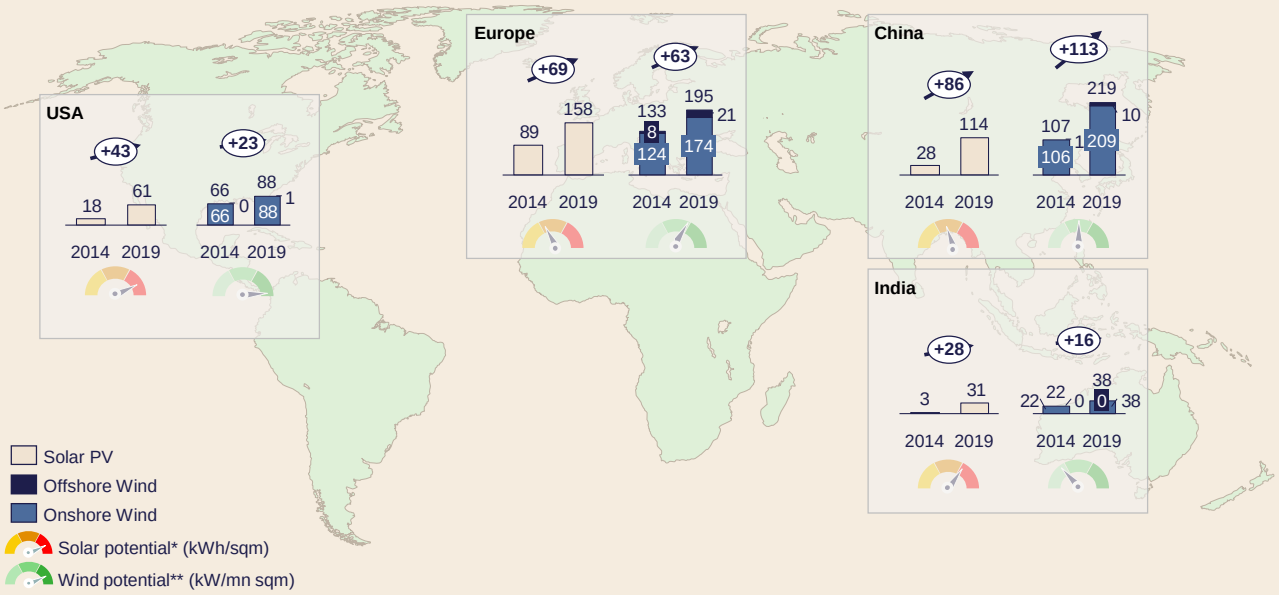


Note: *Wind includes both offshore and onshore
**Others include Solar Thermal energy, Geothermal energy and Maritime energy
Source: MEC Intelligence analysis

The development of solar capacities will be split between utility-scale and rooftop installations. In the period from 2015 to 2019, the four geographies of the US, the EU, India and China will add nearly 105 GW of rooftop solar capacity, as compared to 120 GW in utility-scale. The shift towards distributed solar in emerging economies is driven by an industrial need for cheaper power, insufficient grid connectivity and increasing cost competitiveness. On the other hand, in the EU and the US, it is facilitated by friendly tariffs, the emergence of community solar and corporate procurement of on-site solar. This ramp up of solar and wind capacities will represent a combined investment opportunity worth USD 220 billion in the four focus geographies.

FIG 3 Four key markets will drive global growth in solar

Solar PV and Wind Cumulative installed capacity 2014 vs 2019
GW

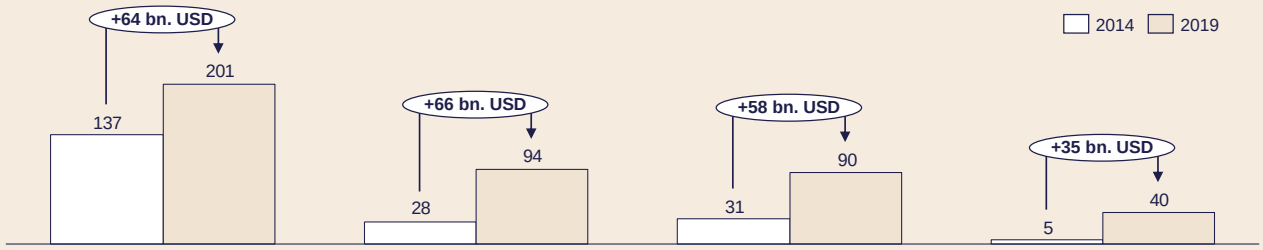


Note: *High Potential (>2000 kWh/sqm), Medium Potential (1000-2000 kWh/sqm), Low Potential (<1000 kWh/sqm)
**High Potential (>500 kW/mn sqm), Medium Potential (100-500 kW/mn sqm), Low Potential (<100 kW/mn sqm)
Source: Solar Power Europe Study; Solar Energy Industries Association/GTM Research (US); MEC Intelligence analysis

Renewables are expected to storm the energy landscape of these countries, giving rise to significant business opportunities across wind and solar supply chains. One such opportunity is the hybrid renewable energy system, which leverages synergies between the two renewable sources to benefit the producer and consumer alike. Figure 1.4 below gives the investment potential in solar PV in various geographies in the period 2014-2019

FIG 4 Global solar PV investments are expected to surpass USD 200 billion in the coming five years

Investment Potential in Solar PV 2014-19
(USD bn.)



	EU	China	US	India*
Capex 2014 (USDm/MW)*	1.53	1.00	1.71	1.47
Capex 2019 (USDm/MW)**	1.28	0.82	1.47	1.28

Note:* Conservative estimates of CAPEX range requirement for Solar PV
** Capex projections till 2019 reduced at same CAGR (%) as LCOE reductions in the period for particular geography
Source: World Energy Council – Cost of Energy Technologies Report 2013; MEC Intelligence analysis

Hybrid renewable energy systems can lead the scale-up of renewables

With the global impetus on both solar and wind, integrating storage with renewable plants is now relevant. Hybrid renewable energy systems have been in the demonstration phase and have proven the following key advantages:

1. Optimise generation costs
2. Increase system reliability
3. Provide operational flexibility over traditional renewable plants

Introduction to hybrid renewable energy systems

A hybrid renewable energy system is essentially a power generation plant that integrates two or more independent renewable technologies. Three main types of hybrid renewable plants observed in the global market are:

- Large-scale solar with energy storage
- Solar and wind hybrid
- Wind with energy storage, currently in small-scale
- Solar, wind and energy storage hybrid, mostly in demonstration phase

In addition to the above-mentioned, various hybrids combining traditional technologies like natural gas, coal, geothermal, biomass and storage exist in the global market, but solar and wind hybrids are expected to scale in size and number due to their rapidly increasing global capacity installations.

The hybrid plants would offer numerous advantages as compared to traditional solar parks and wind farms. Here is a comparison between traditional and hybrid renewable energy plants on three major parameters:

- **Generation costs:** Traditional renewable technologies have declining capital and operational expenditures while low plant availability due to intermittency affects operating revenue. On the other hand, solar + wind + energy storage hybrids would have a higher initial Capex, but increased system availability and sales of stored energy at peak prices would increase revenue and lower LCOE.
- **System reliability:** Wind and solar are intermittent sources of power generation with regional variances in power output based on wind speed and solar irradiance. A hybrid plant would address this shortcoming by complementing solar and wind generation. While daytime and summers would increase the output from solar, night time and winters would increase the output from wind. In addition, storage of surplus energy would serve as a reliable back-up source of power generation.
- **Operational flexibility:** Renewable plants can pick and drop loads in short durations; however, the ability of wind and solar plants to meet committed day-ahead schedules is subject to the availability of wind and sun. Hybrid plants would combine the flexibility of renewables and reliability of conventionals, due to provision for energy storage. In addition, they would also meet the day-ahead schedules to avoid penalties.

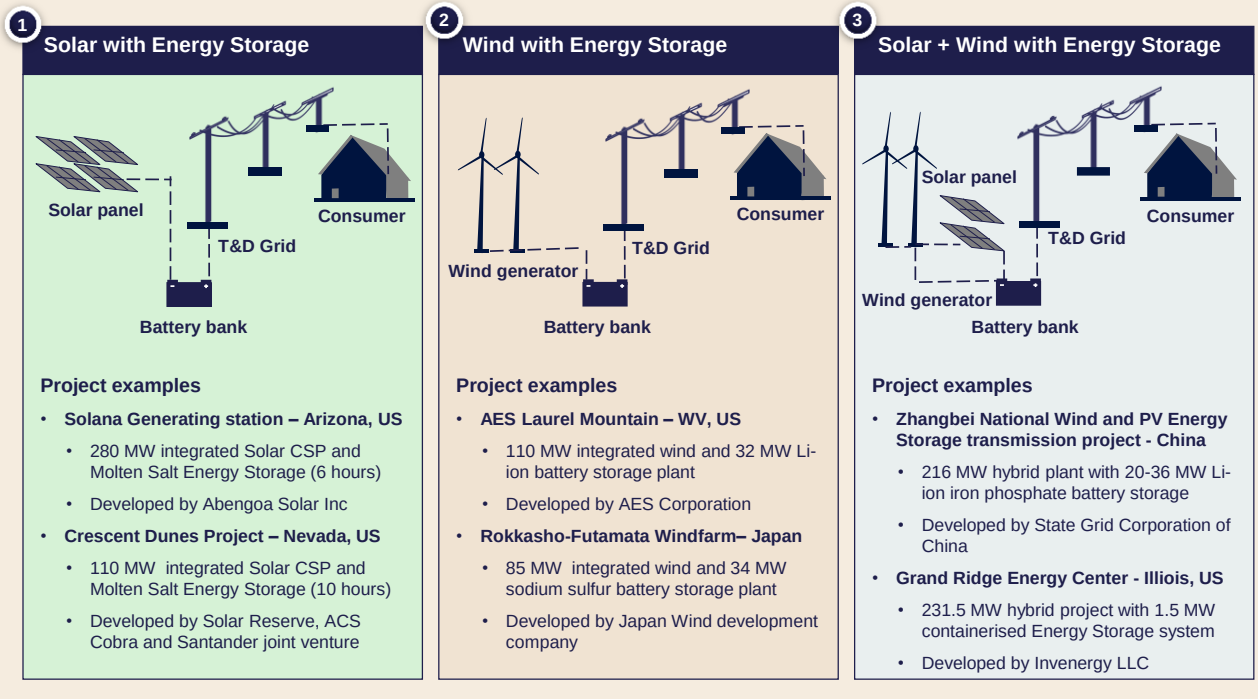
Demonstration projects of hybrid renewable energy plants are being set up globally

Hybrid renewable energy projects and integrated battery storage plants are in the demonstration phase across the world to test the viability of the various emerging business models. Figure 2.1 on the following page presents an archetype overview of hybrid renewables energy plants.

With the success of demonstration projects across the world, hybrid plants are expected to scale up in capacity and numbers. It might also give rise to new business models and integrated technology players, who could potentially disrupt the game for single-technology players. As an example of this emerging trend, global wind technology majors like Gamesa and Suzlon are entering the solar market in emerging geographies like India with EPC services, leveraging their experience in building large-scale plants.

Overall, the emerging concept of hybrids offers many opportunities to existing players and brings in new concepts to the rising global renewable market.

FIG 5 Three archetypes of Hybrid Energy Systems are available in the market



Source: Industry Articles; MEC+ Analysis

Hybrid renewable energy systems offer synergies and new opportunities to renewable players

The capabilities required to build hybrid plants can be drawn out of the synergies with traditional renewable plants. Opportunities in site development and EPC favour the existing skill-sets of WTG OEMs and utilities. In addition, such players can also leverage their plant monitoring and control skills to synchronise integrated plant operations and form a single point of control. In addition to these, both types of renewable players can combine asset management services with trading for improved output forecasting and ensure a more reliable power supply.

Hybrid plant development and integration offers maximum opportunity to renewable energy players

The hybrid renewable energy system value chain entails a number of distinct steps - from plant development to the transmission and distribution of the generated electricity. The activities linked to the construction and operation of a hybrid plant are typically similar to those in a traditional solar or wind farm. The hybrid renewable system value chain thus offers an opportunity for renewable players with existing skill-sets in renewable plant construction and operation. Refer to table 3.1 for detailed activities and the opportunities available in the respective value chain segments.

Table 1 Hybrid renewable energy system value chain and associated major opportunities

	Development	Procurement	Optimisation	Trading	Transmission	Distribution
Activities required in hybrid RES	• Site prospection • Layout based on site character-istics* and shadowing • Securing permits • Signing of PPA • Electrical predesign	• Sourcing of WTG, solar modules and batteries • Logistics and installation of WTG, PV panels, BoP** and monitoring system • Commissioning	• Software for predictive maintenance and yield maximisation • Upgrades to improve output, power quality, new functionality and life extension	• Using data, weather forecasts and analytics for day-ahead output forecasting • Real-time update of forecasts for minimising imbalances	• Installation and maintenance of efficient and robust transmission grid for renewable integration*** • T&D loss reduction through HV lines, better material, etc.	• Installation and maintenance of efficient and robust distribution grid for renewable integration • Metering, billing and collection • AT&C**** loss reduction • Demand-side management
Opportunity created within value chain segment	• Optimisation of site layout design and pre- engineering works for maximum yield and minimum O&M	• Integrated procurement and construction for cutting costs and saving efforts for developer/ investor	• Forming single point for plant monitoring and control for output maximisation and synchronised operations	• Integration of asset management services with trading for better output forecasting	• Security of supply through a more reliable hybrid farm • Meeting peak demand • Creation of flexible, bi-directional and efficient smart grids	• Security of supply through a more reliable hybrid farm • Meeting peak demand • Creation of flexible, bi-directional and efficient smart grids

* Site characteristics include solar radiance angle, wind direction and Land Topography

** Balance of Plant includes road construction, crane hard standings, HV transformer and substation protection equipment

*** Includes transmission line, transformers and substations

**** AT&C – Aggregate technical and commercial losses

Source: News articles; company websites; MEC+ analysis

Based on their current capabilities, WTG manufacturers and utilities/developers seem to be optimally positioned in the wind and solar value chain to capture parallel opportunities in the hybrid energy system value chain. The specific existing capabilities and prospects for both these renewable players are covered in the following sections.

WTG manufacturers can leverage existing capabilities within windfarm EPC and optimisation to capture hybrid market opportunities

Large wind turbine manufacturers across the globe, in general, are multi-skilled companies with diverse capabilities across the industry value chain, including turbine and associated equipment manufacturing. WTG OEMs carry out site layout design, electrical pre-design, manufacturing and installation of turbines and their associated equipment. They also optimise wind power generation through monitoring systems, component upgrades and advanced software deployment. Some are also involved in the power-trading segment through day-ahead output forecasting and updating forecasts close to real-time. They can synchronise some of their existing capabilities with the hybrid plant value chain to tap into emerging business opportunities.

WTG OEMs can integrate solar data in their existing software for site selection to pre-empt the service in the hybrid market. Similar integration of solar data can be done in software for optimal site layout and electrical pre-designing of hybrid plants.

Within procurement and construction, WTG players can draw on their experience from the construction of large-scale wind farms and existing relations with BoP contractors to impart scale to the construction of hybrid plants. Partnerships/agreements can be signed with solar panel/battery OEMs to deliver integrated sourcing.

Since the operation and maintenance of a hybrid plant mainly entails services related to wind turbines and minor services related to solar panels, WTG OEMs can leverage their existing service set-up and experience to provide an integrated O&M package for the hybrid plant developer.

Lastly, due to the superior skills in and experience with wind farm controls/electronics, WTG OEMs can integrate the output from solar, wind and energy storage to produce a single integrated output from the hybrid plant and cuts costs through the use of a single inverter.

Utilities can easily tap into opportunities in the hybrid value chain due to natural synergies with existing wind and solar portfolio

Utilities build, operate and maintain large-scale renewable energy portfolios including wind, solar and energy storage projects. They hold key competences across project planning, development, procurement and construction and commissioning for turnkey project building. Apart from asset-building activities, utilities also carry in-house expertise in asset O&M and power sales; certain vertically integrated large-scale utilities like Iberdrola and Next-Era Energy have experience with the construction and maintenance of electricity transmission and distribution assets as well.

The lowest hanging opportunity for utilities lies in integrating solar and energy storage within their existing wind farms. Wind farms occupy vast land areas and the surface as such is available for installation of solar panels, the integration would increase the per-sqm output of the farm.

The second opportunity arising out of the natural synergies with existing monitoring and control capabilities is the development of virtual plants, which integrate output from wind, solar and energy storage projects at different locations, for the plants to operate as a single asset.

Utilities can also leverage their experience in building large wind and solar farms to bring scale into hybrid RES construction, and they can streamline procurement for hybrid RES due to existing relations with WTG/solar PV/battery manufacturers and BoP providers. Within cost reduction, utilities can cut costs through using a single transmission line for electricity evacuation, and through the integration of energy storage, utilities can avoid the cost of penalties to TSO for over/under-injection.

The way forward ...

The key questions that could be of interest to WTG OEMs to tap into business opportunities across the hybrid plant value chain are:

- How can WTG OEMs leverage existing know-how in renewable plant EPC & operation to **integrate hybrid EPC & operation** into their portfolio?
- What will it take for WTG OEMs to **integrate solar offerings** into current portfolio?
- How can WTG OEMs facilitate **corporate procurement for small to medium distributed** hybrid plants?
- How can WTG OEMs leverage superior knowledge & experience in **wind services to become the service provider of choice** for hybrid plants?

For utilities to understand the opportunity in the hybrid value chain, it is recommended that they seek to answers these four key questions:

- What is the **right portfolio strategy** for utilities?
- What is the magnitude of **avoided cost of penalties** (for under/over-injection into the grid) for utilities due to Hybrid renewable energy system with energy storage?
- How can Utilities leverage existing know-how in renewable plant EPC to **optimize costs & turnaround time** for hybrid renewable energy system?
- What will it take for utilities to **integrate energy storage into their generation profile**; since this is a blind spot for them?

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