Report 2021

Task 50

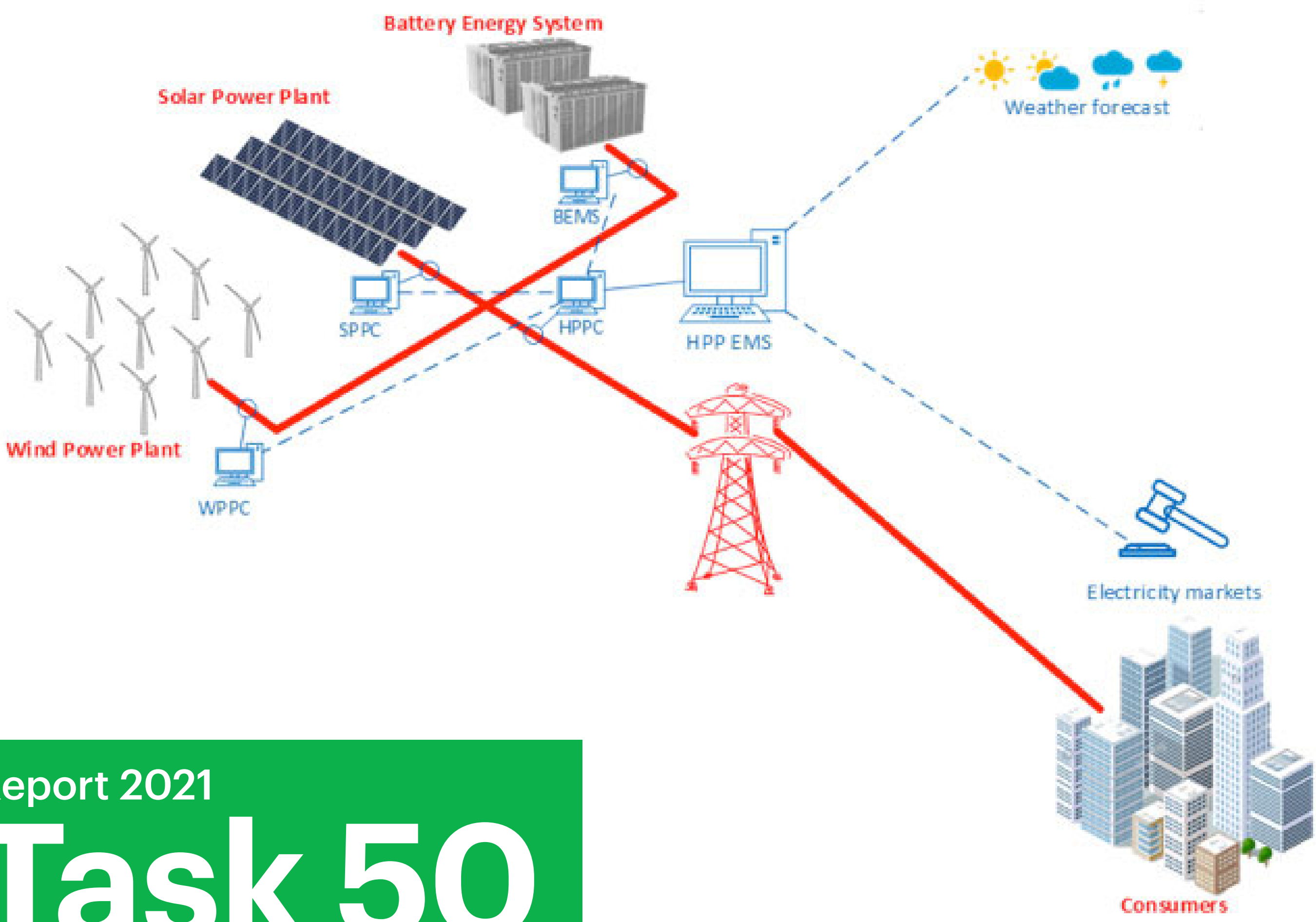

Figure 1: Example of an utility-scale grid-connected hybrid power plant with wind, solar, and battery storage. A hybrid power plant can consist of other technologies, such as a hydrogen electrolyzer.

Hybrid Power Plants

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For decades, wind, solar, and other renewable energy technologies have had minimal deployment with respect to fossil-fuel, hydropower, or nuclear-based generation assets in electric power systems.

HOWEVER, DRIVEN BOTH by consideration of environmental impacts, policy decisions, and significant cost reductions in the wind, solar photovoltaic (PV), and energy storage (particularly battery) technologies, new installations of electricity generation have been dominated by renewables in the United States, Europe, and globally (1; 2). Specifically, the cost of energy for wind and solar PV technologies has fallen to the point where these technologies are cost-competitive with conventional thermal generation in many markets (3; 4; 5) has led to integrated studies, which forecast that wind energy and solar PV technologies will each make up 30% of global electricity production by 2050 in a system with significant

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electrification of the global energy system (5). NREL's 2018 Standard Scenarios also indicate significant growth in renewable penetration of the electric sector by 2050. As we look toward the future grid dominated by renewable energy, a paradigm shift is underway where the traditional model of energy-based revenue streams for wind and solar PV using power purchase agreements or feed-in tariffs is changing (6). With renewable energy growing to 10%-20% or more of overall electricity generation (6; 7; 8; 9), design objectives are shifting from producing energy at the lowest levelized cost and using the levelized cost of energy calculator (LCOE) to also include other design objectives (which varies from market to market) that maximize profitability from revenue streams associated with time-varying energy pricing, ancillary service, and capacity markets.

The energy system of the future will be clean, sustainable (full life cycle circular economy), cost-effective, and available for all regions/communities.

This future energy system can strive to achieve clean energy across all sectors, such as transportation, buildings, industry, and agriculture. The key components needed to accomplish this are:

- Time-shifting energy system components, including demand response, capacity credit, and dispatchability at multiple timescales ranging from minutes to hourly to seasonal and everything in between.
- Grid services, including essential reliability services (ERS), grid forming and transient instabilities, and black start.
- Conversion services – including hydrogen, ammonia, methanol, liquid renewable energy-based fuels for aviation and marine, and heat to electricity.
- Electricity and fuels delivery services, including expanded long-distance electricity

Wind, solar, and storage technologies can take part in a limited way in some of these services today but, because of their uncertainty and variability, not to the same degree as traditional power plants. To ensure the profitability of these assets in the future, developers would like wind, solar, and other renewable energy plants to have the ability to operate more like a traditional power plant, in terms of capacity value, dispatch ability, ancillary services, and reliability. To ensure profitability at an individual asset level, developers/owners/operators are designing "hybrid power plants" that combines wind, solar, storage, and other renewable technologies.

By combining technologies, including storage, solar, wind, and other renewable generation, into "hybrid power plants," an individual plant owner can 1) develop economies of scope in terms of land usage, electrical and physical infrastructure, and operational expenditures, and 2) increase their system value to capitalize on revenue streams through forward capacity markets (where present), "dispatchable" operation in markets with time-varying energy pricing, and ancillary service markets (where present). Additional to these inherent benefits for power plant owners, these hybrid power plants also help in accommodating a larger volume of renewable generations behind single grid connections, allowing for a larger share of integration of renewables to meet ambitious climate goals while reducing the stress of grid reinforcement.

This is a substantial shift from historical approaches to solar and wind energy power plant development and operation. Until recently, renewable power plants in many markets had a design objective to produce as many kilowatt-hours as possible, because all were awarded the same fixed income stream (whether through a power purchase agreement or other forms of fixed energy payment). In this case, such power plants only curtail when necessary, and are commanded to do so by the system operator to support the larger grid. Looking forward, hybrid power plants act more like conventional generation, where they consistently produce less than full capacity and focus on providing energy at specific times (i.e., dispatchable energy) as well as services that support the reliability and stability of the grid system. This new paradigm creates an opportunity to critically consider how hybrid power plants should be designed—with what technology assets and in what configuration—and controlled.

In the recent Xcel "2017 All Source Solicitation 30-Day Report," 30% of the wind and solar bids included some form of hybrid plant offering by including storage (10). Vestas, one of the oldest wind turbine manufacturers still operating, has made hybrid power plants part of its core strategy going forward with a demonstration plant already in the works (11). General Electric has announced similar plans (12). This topic is highly relevant to the industry because it is intuitive to combine wind, solar, other renewables, and storage to minimize the risks of renewable energy variability and at the same time maximize revenue in evolving markets. However, after consulting the industry, it is apparent that there is still a lot of uncertainty around the economic viability of hybrid power plants in general, and under what resource and market conditions these plants may or may not make sense.

Task 50 starts operating in 2022 and based on the huge interest from the Topical Expert Meeting, participation from the following countries (either as participants or observers) is expected: Austria, Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Ireland, the Netherlands, Norway, Spain, Sweden, United Kingdom, and the United States.

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