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Whitepaper

Green Hydrogen

Meeting the challenges of increased load, intermittency and decarbonization

Siemens PTI is an economic, market, and technical consulting arm that provides expert services supporting energy suppliers, consumers, and investors.

To highlight a few long-term challenges with decarbonizing the electric grid in an era of increasing load, Siemens PTI developed a three-part white paper series reviewing intriguing new business opportunities and challenges for utilities, developers, and investors, and recent technology advancements enabling hydrogen applications. This paper represents the first of a series of three papers which will focus on the need for long-term storage to serve increasing demand. The second paper will address several storage technologies, while the third will consider the technical and economic aspects of hydrogen derived fuels in power generation applications.

Siemens PTI expects that by 2050, continental U.S. electricity load will increase substantially despite renewed energy efficiency efforts. In fact, our expected case analysis suggests that building electrification will add 124,200 GWh (2.7%) and that electric vehicles will add 272,600 GWh (5.9%) to our base forecast for 2050, which is expected to drive significant carbon reductions through 2050. While accelerated efforts to increase energy efficiency, distributed energy, and demand management may result in somewhat lower growth in electric load, Siemens PTI nonetheless expects load to increase over the forecast period. Simultaneously, while the decarbonization drive is taking different forms, each call for dramatic reductions or outright elimination of fossil fuel use within the next 15 to 30 years will in turn drive an unprecedented demand to replace fossil with renewable “green” generation.

Electrification coupled with accelerating decarbonization and intermittent renewable generation drive new opportunities

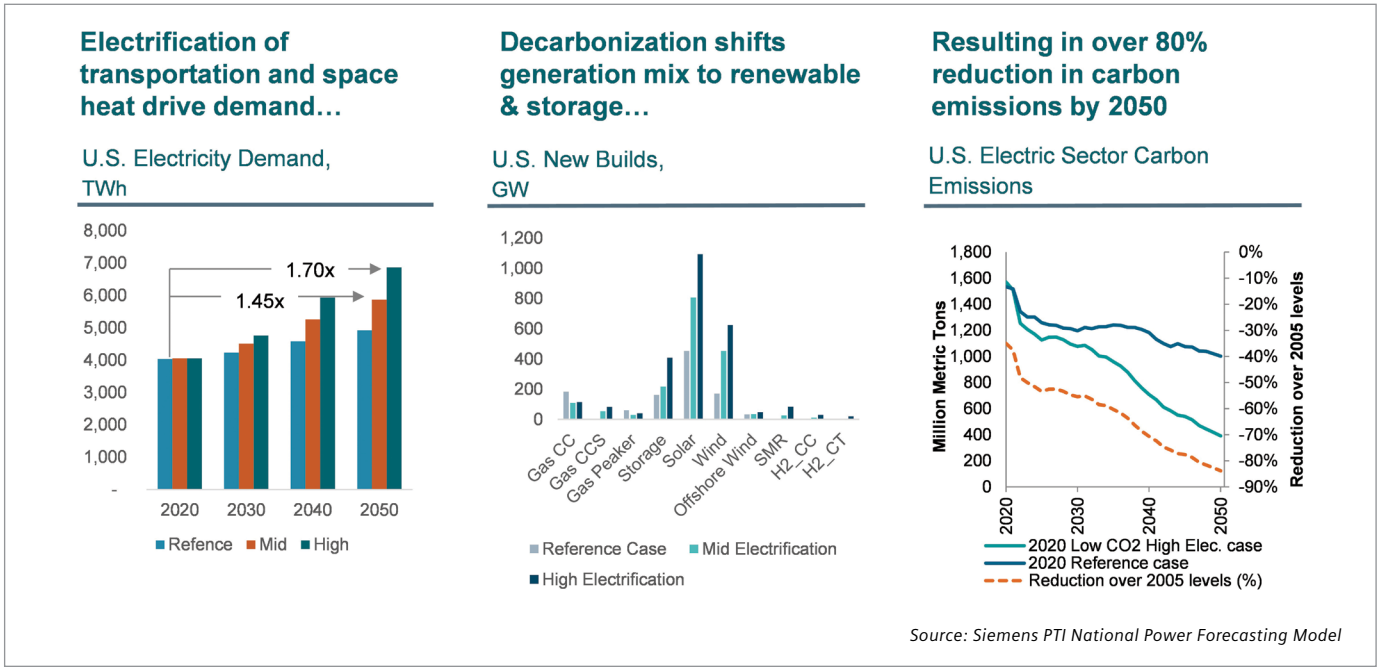
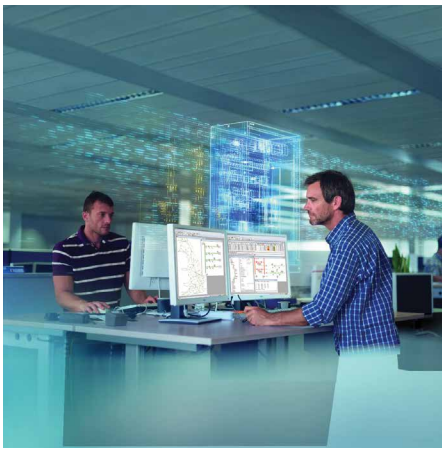
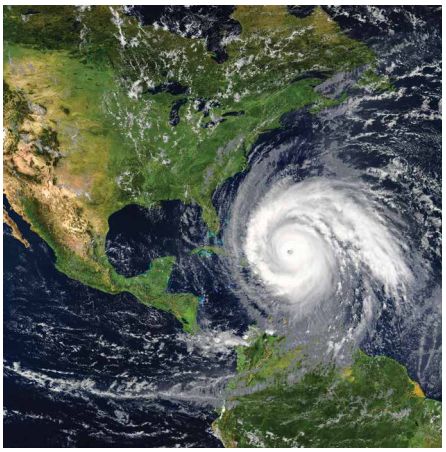


Figure 1: Electrification and electric vehicle impacts on continental U.S. load, capacity, and carbon

One significant challenge is that the wind does not always blow, the sun does not always shine, and rainfall can significantly vary year-to-year. Such events result in Intraday/ hour generation variability and multi-day generation shortfalls. The recent planned blackouts in California driven in part by wildfires and equipment outages highlight the impacts of variable generation mistimed with high load. Further, seasonal weather events like hurricanes, wildfires, and ice storms can bring several sequential days of low- to no- generation from solar, wind, and even hydro assets. It's also worth noting that solar generation in northern hemisphere declines in winter, and that markets which currently peak in the summer are likely to peak in the winter as heating load is increasingly electric. Increased winter load coupled with weather-driven supply shortfalls like that recently witnessed in Texas should get our attention. Solar generation can be reduced 75-80% from its peak during heavy cloud cover and several sequential cloudy days (weather system, hurricane, etc.) could prove catastrophic.





While often overlooked, the current system is supported during these operational fluctuations with truly massive storage resources which provide stability, resiliency, and confidence. While regionally based hydro resource are indeed substantial – today's electric system storage needs are largely met by way of fuels in the form of coal, biomass, oil, natural gas, and nuclear fuels, which can be quickly and controllably converted to electricity to meet demand.

To understand the importance these forms of storage play in the market, consider a hypothetical, though realistic example based on an October hurricane strike on the Florida panhandle similar to that of Hurricane Michael in 2018. For simplicity, assuming Gulf Power's generation was 100% solar and that extensive cloud cover limited solar generation for three days. Since hurricane induced cloud cover can extend hundreds of miles from the eye, such an event would impact neighboring utilities, but for the purposes of this simplified example, that is ignored. Under extensive cloud cover, the solar panels might generate 25% of their rating, so Gulf Power would need storage capacity of 61,782 MWh (15,446 MW of 4 hour Li-ion batteries) to meet three days of average October load at a total cost likely in excess of $18 billion. While hurricane-induced distribution system damage would reduce consumption, that is not a certainty, and planners would need to prepare for the potential the event results in greatly reduced generation with minimal reduction in consumption.

This simplified and isolated example displays the challenge of building comparably resilient system using LI-ion battery systems. Clearly meeting decarbonization with comparable resiliency as loads grow will require new forms of carbon- free/light long-term storage energy storage, whether the energy be electricity or fuel needed to generate electricity. As a result, planners are beginning to consider flow batteries, compressed air energy storage (CAES), gravity storage, thermal storage, and more recently green hydrogen and hydrogen derivative fuels. In recent systems planning engagements, Siemens PTI finds that combining longer term storage options and/or green hydrogen generation with renewable generation will prove economically viable in some markets, though much depends upon local and national carbon regimes and the importance of resiliency. Further, our research and analysis indicate that green hydrogen is a building block which opens new multi-revenue business model potential which will support larger scale, more cost competitive green energy projects. In the next white paper in this series, Siemens PTI will review some potential green hydrogen business opportunities and models.

Siemens Industry, Inc.
Siemens Digital Grid
10900 Wayzata Boulevard, Suite #400
Minnetonka, MN 55305

smartgrid.energy@siemens.com