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WHITE PAPER

How Battery-Based Energy Storage Systems Will Enable Renewables in the Philippines

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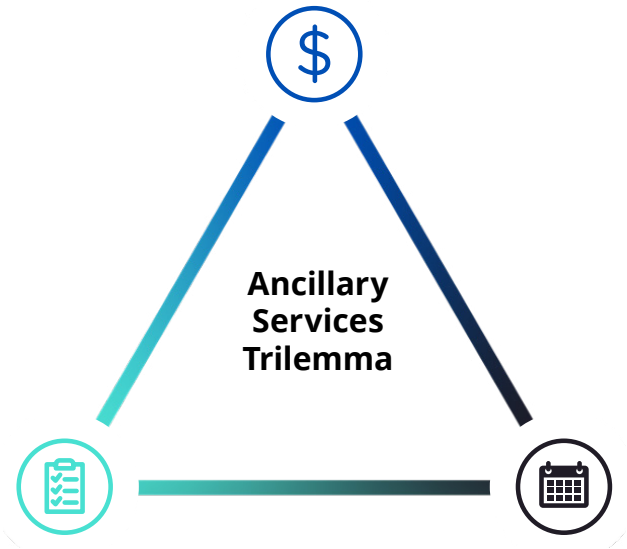
As the archipelago of the Philippines goes through an energy transition, the islands of Luzon, Visayas, and Mindanao need to ensure their grids run smoothly, and that they are stable and secure. Achieving this requires the grids to operate at a single frequency (nominally 60 Hz), but throughout the day, generation and demand fluctuations cause frequencies to rise and fall. When supply spikes, frequency rises; when demand spikes, frequency falls. While this is a characteristic of all grids, deviations as small as one percent can damage transmission equipment, and cause momentary outages, or blackouts. The effects of climate change causing storms like Agaton have led to more frequent and severe frequency swings on the nation's grids.

Why Frequency Regulation is Becoming More Difficult for the Philippines

As the Philippines pushes to hit public targets of 35 percent renewable energy generation by 2030 and 50 percent by 2040, grids are grappling with increasing system frequency variations brought about by the variability of renewables. When system frequency deviates outside the allowable threshold (±0.15 Hz deviation), grid operators rely on fast, accurate, and automated responses from power generators across the country to restore frequency balance and maintain



AFFORDABILITY

Ancillary Services Cost (Capacity Payment plus Incidental Energy Payment) should be reasonable and affordable.

CAPABILITY

Technical capability of prospective Ancillary Services providers (RR, CR, DR, etc.) should meet the minimum requirements. But better performing units/facilities should be given more merits.

AVAILABILITY

Ancillary Services should be available all the time. Selective availability should not be an option.

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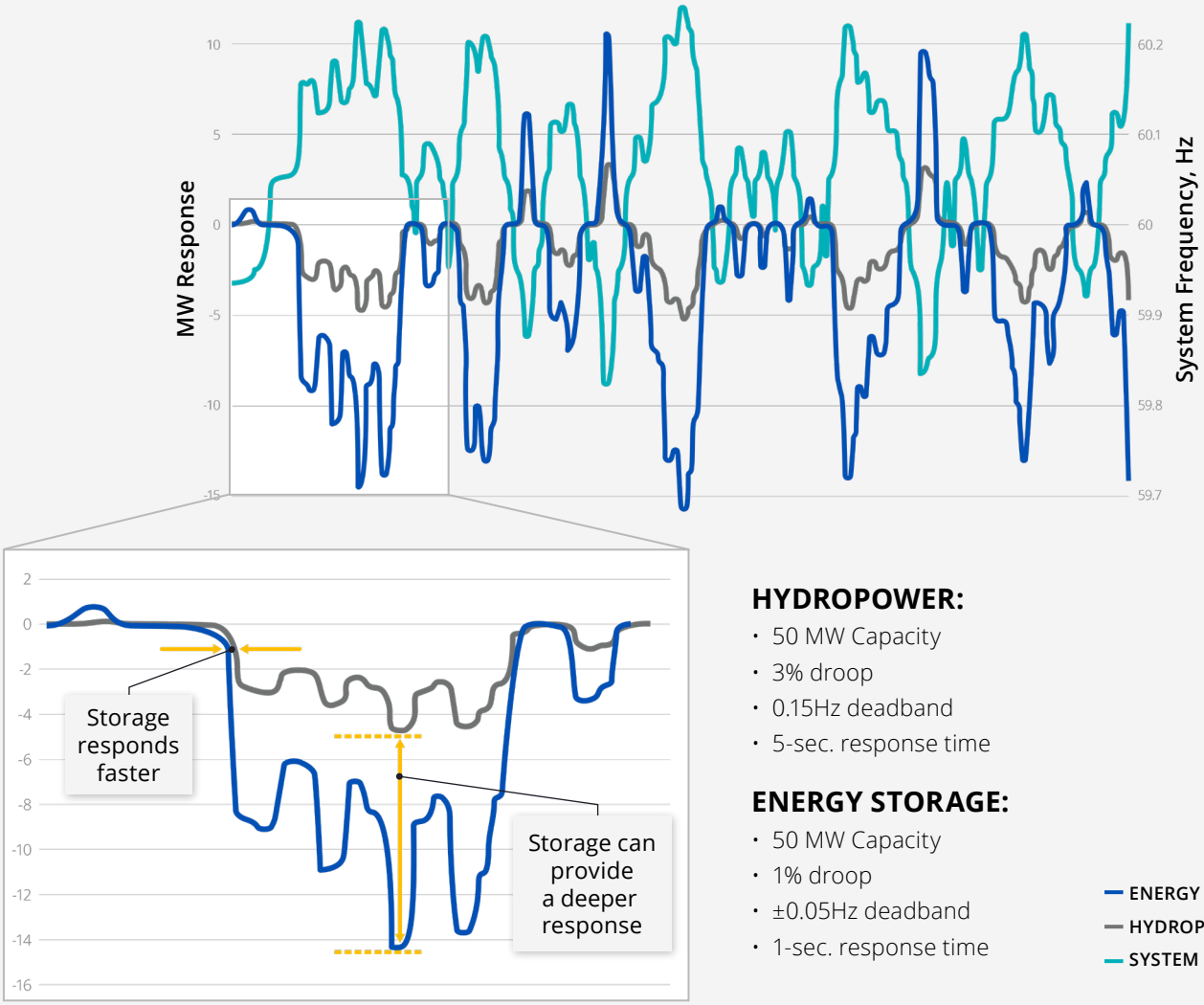
grid security and reliability. These actions are collectively called ancillary services. Despite the Philippines already paying power generators to provide such services, the nation's ancillary services market is still nascent. To ensure that power consumers can access affordable, reliable, and increasingly available renewable power, the market must quickly transition into a healthy and competitive environment for ancillary services. This transition is not simple. Developing a competitive market will require grid operators and regulators to overcome the Ancillary Services Trilemma: capability, availability, and affordability. Some jurisdictions give more weight to cost over capability and availability, others capability over cost and availability. However, one factor is common across most, if not all grids: contracts are awarded based on all three factors.

Traditional sources of this service such as hydroelectric power plants struggle to meet availability and affordability requirements. Likewise, wind and solar power generators, which rely on intermittent resources, are much more limited in availability than coal and gas generators. For instance, if demand spikes at night solar panels don't have stored energy that can be released to meet the demand. Demand-side solutions like demand response, where power consumers are paid to temporarily reduce energy consumption, require slower and manual activation, earning them low availability marks. Given the constraints of more traditional resources, battery-based energy storage systems are quickly emerging as the most cost-effective and flexible frequency regulation solution for grid operators around the world. Energy storage can provide fast and accurate response and can easily perform other vital grid services, from voltage regulation to reactive power support and power factor control, without bolting on additional hardware.

How Battery-Based Energy Storage Excels at Frequency Regulation

Contingent events such as generator or load trippings happen in seconds, making response speed critical. Here, energy storage outperforms both traditional and alternative frequency regulation products. Rapid technological advances have made storage capable of responding to frequency deviations over 2,000 times faster than a fast-starting open-cycle gas turbine—the kind of generation assets that are currently engaged in many ancillary services programs in the Philippines. Recent battery-based energy storage systems have even demonstrated faster response times than traditional ancillary service providers like hydropower and gas turbines. Below is a model illustrating how an energy storage system could respond faster and provide a higher MW response compared to a hydroelectric power plant of equal capacity. Note how energy storage's faster and more accurate response limits further frequency deviation after the initial event.

Storage resources can provide a faster and greater depth of response than hydropower



HYDROPOWER:

- 50 MW Capacity
- 3% droop
- 0.15Hz deadband
- 5-sec. response time

ENERGY STORAGE:

- 50 MW Capacity
- 1% droop
- ±0.05Hz deadband
- 1-sec. response time

ENERGY STORAGE OUTPUT
HYDROPOWER OUTPUT
SYSTEM FREQUENCY

Studies like this have been replicated around the world. In a 2015 study conducted by PJM, a U.S. Regional Transmission Organization, a battery-based energy storage asset responded to grid signals faster and with better accuracy than other technologies. The flexibility of energy storage also makes it well-suited for frequency control. Storage can be quickly and easily deployed with a smaller footprint than any other generation asset per MW. Energy storage can also be sited near load centers or adjacent to existing grid substations. In addition to regulating frequency disruptions caused by variable renewables, storage firms and smooths the inherent intermittency of these generation sources, helping clear congestion from transmission lines and storing renewable power for use during peak load times.

The Main Benefits of Energy Storage for Frequency Regulation

1. **Effective and accurate response** can act as either a load or a generation resource depending on grid requirements.
2. **Faster response time** than traditional generators helps maintain the quality, reliability, and stability of the power grid.
3. **High flexibility** provides critical grid support to facilitate smooth and coordinated system operation.
4. Capacity firming and smoothing, frequency control ancillary service, and voltage and reactive power control **enable higher penetration of variable renewable energy.**

Global Examples of Energy Storage Successfully Regulating Frequency

Success stories of energy storage regulating frequency already exist across the world, dating back a decade. In 2012, Chile installed a 20 MW system owned and operated by AES Gener that took over frequency regulation for a spinning reserve turbine, providing a more effective solution for grid stability.

In the Dominican Republic, a case relevant to the Philippines given the location on the typhoon belt, the grid boasts two 10 MW Fluence battery-based energy storage systems. When Hurricane Irma hit in 2017, grid operators requested AES Dominicana (who owns and operates the system) to keep the storage resource online during the storm. Heavy damage to power lines and forced power line disconnection sent grid frequencies fluctuating violently, yet the storage system delivered nearly 20 MW of continuous power in both directions, helping keep grid infrastructure intact and power flowing. When Irma passed, the battery infrastructure was undamaged.

In the UK, National Grid ESO has relied on storage to preserve grid infrastructure during unexpected outages. In August 2019, two large generators were disconnected from the grid, causing frequency to dip well below safe operating levels. Even after all grid reserves had been employed to raise frequency, operators couldn't make up the roughly 2 GW shortfall, forcing last resort load shedding which involved cutting power to 5 percent of the grid. Unfortunately, this caused grid frequency to spike, creating an over-frequency event. Grid operators were able to call up 472 MW of storage on the grid to pull power out of the system, return grid frequency to a safe range, and prevent system damages.

Six Steps to Building the Frequency Regulation Market in the Philippines

As the Philippines continues to integrate new solar and wind farms, small-scale frequency regulation and patchwork activity won't suffice. Instead, a master rollout plan is necessary. To help with this, we Fluence developed a six-step process called CHARGE for building an effective frequency regulation market. The CHARGE program is designed to help system operators and policymakers understand the constraints and limitations of existing resources and how they interact with the system. Then, depending on the characteristics of the grid (seasonality, interconnection, radial connection, etc.), run pilot storage projects to develop a ground-tested framework and policy that can be easily rolled up to a grid-wide ancillary services market with ample energy storage assets available to regulate frequency. The Philippines is in a critical phase of market growth and ancillary services are becoming as important to grid functioning as energy supply, yet thus far they haven't received nearly the same attention. With the right rules and protocols, willingness to innovate, and a deeper understanding of battery storage, grids can be built to reliably support a clean energy future.

The 6-Step CHARGE Process

Consider existing rules and policy

Heed and understand the need of the system

Assess, analyze, and outline possible solutions

Run simulation studies and techno-economic assessment. Accuracy and speed of response, cost and availability should all be considered in the evaluation.

Gain experience and knowledge by developing a few sizeable marquee battery-based energy storage projects.

Execute master rollout plan for energy storage.

Fluence Commissions 'First Wave' of 470 MW Grid-Scale Battery Portfolio for SMC Global Power in the Philippines

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Fluence Energy, Inc. (Nasdaq: FLNC) is a global market leader in energy storage products and services, and digital applications for renewables and storage. With a presence in 30 global markets, Fluence provides an ecosystem of offerings to drive the clean energy transition, including modular, scalable energy storage products, comprehensive service offerings, and the Fluence IQ Platform, which delivers AI-enabled digital applications for managing and optimizing renewables and storage from any provider. The company is transforming the way we power our world by helping customers create more resilient and sustainable electric grids. For more information, visit our website, or follow us on LinkedIn or Twitter.

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