Philippine Electricity Market Corporation

STUDY ON THE FRAMEWORK OF PARTICIPATION OF BATTERY ENERGY STORAGE (BES) SYSTEMS IN THE WESM

by the Technical Committee

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LIST OF ACRONYMS

CAISO	California ISO
ERCOT	Electric Reliability Council of Texas
IESO	Independent Electricity System Operator
AESO	Alberta Electric System Operator
MISO	Midcontinent Independent System Operator
ISO-NE	New England ISO
PJM	PJM Interconnection
NYISO	New York ISO
NEM	Australia National Electricity Market
SWEM	Singapore Wholesale Electricity Market

1. INTRODUCTION

A widely-used approach for classifying energy storage systems is the determination according to the form of energy used. Figure 1-1 shows the classification of energy storage systems into mechanical, electrochemical, chemical, electrical and thermal energy storage systems[1].

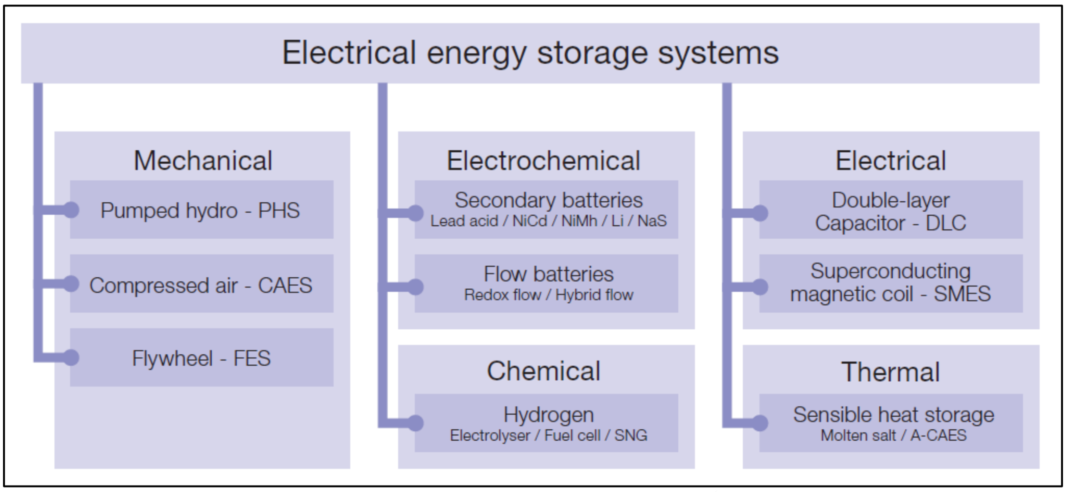

Figure 1-1 | Classification of Energy Storage Systems According to Energy Form (Source: See footnote 1)

Each of these energy storage technologies is at varying stages of development and deployment and its technical performance differs by type. Figure 1-2 shows which energy storage technology is developing, developed and mature.

[1] "Electrical Energy Storage." International Electrotechnical Commission White Paper. (2011): n. pag. http://www.iec.ch. Web.

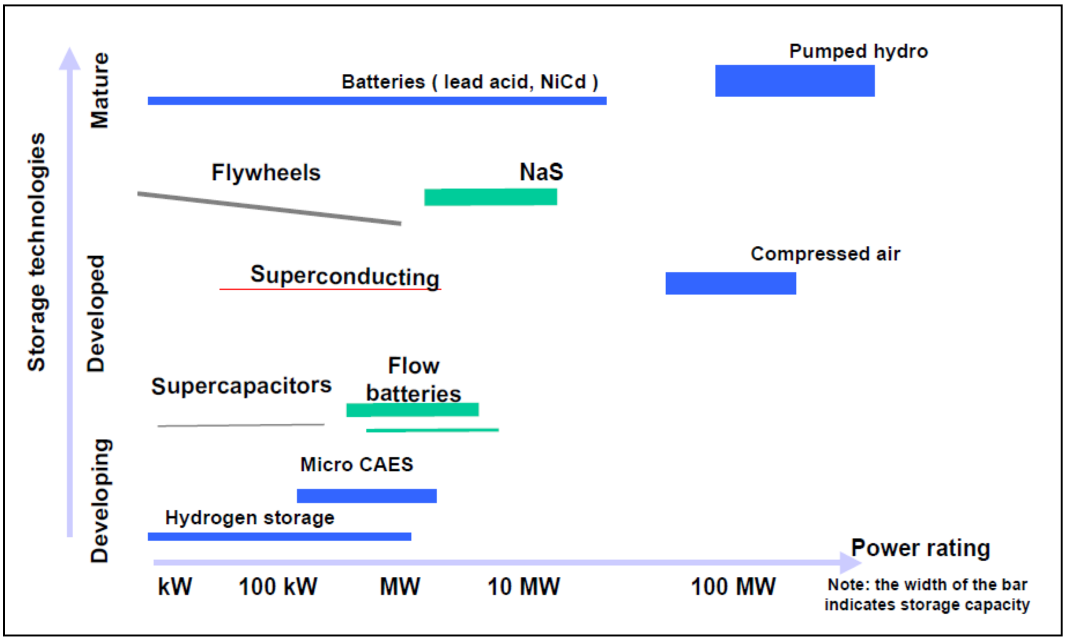

Figure 1-2 | Development Status of Energy Storage Technologies (Source: See footnote 2)

Among these energy storage technologies, pumped hydroelectric storage provides the most mature and commercially available solution to bulk energy storage. It is the most widely adopted utility-scale energy storage technology[2]. The term utility-scale energy storage refers to storage devices of sufficient power and energy rating to be of significance to the planning and operation of an electric power utility. To be of significant benefit as a generation alternative, an energy storage system should have sufficient energy storage capability[3].

Different types of energy storage are suited to different discharge times, from seconds to seasons. For a particular discharge time-frame, the suitability of an energy storage resource is determined by its power density and energy density.

> "Power density refers to the ability of energy storage technology to provide instantaneous power. A higher power density indicates that the technology can discharge large amounts of power on demand.

[2] C.J. Yang. "Pumped Hydroelectric Storage". Duke University, Durham, North Carolina 27708, USA.

[3] New Zealand Electricity Commission. "An Appraisal of New and Renewable Generation Technologies as Transmission Upgrade Alternatives". 19 December 2005.

Energy density refers to the ability of the technology to provide continuous energy over a period of time. A high energy density indicates that the technology can discharge energy for long periods." [4]

In general, technologies with the highest power densities are likely to have lower energy densities. This means that these technologies can discharge enormous amounts of power, but only for a short time. Similarly, technologies with the highest energy densities are likely to have lower power densities, meaning they can discharge energy for a long time, but cannot provide massive amounts of power immediately. This quality gives rise to a division of energy storage technologies into categories based on discharge times as shown in Figure 1-3.

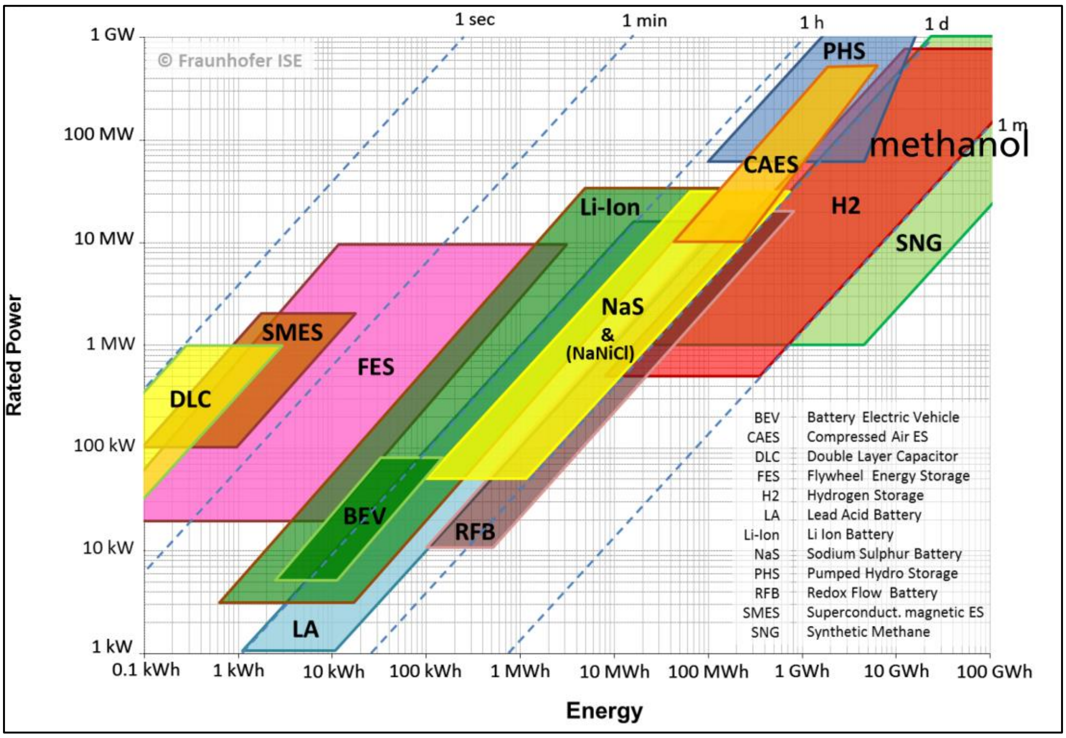

Figure 1-2 | Comparison of Rated Power, Energy Content and Discharge Time of Different Energy Storage Technologies (Source: See footnote 4)

[4] International Electrotechnical Commission. White Paper on "Electrical Energy Storage". 2011.

Energy storage technologies have different applications depending on the type of system. In general, applications for energy storage technologies include load management, spinning reserve, system stability and voltage regulation, renewable energy applications and end use applications.[5] Figure 1-4 shows the power requirement (in MW capacity) vis-à-vis the discharge duration for some application of energy storage[6].

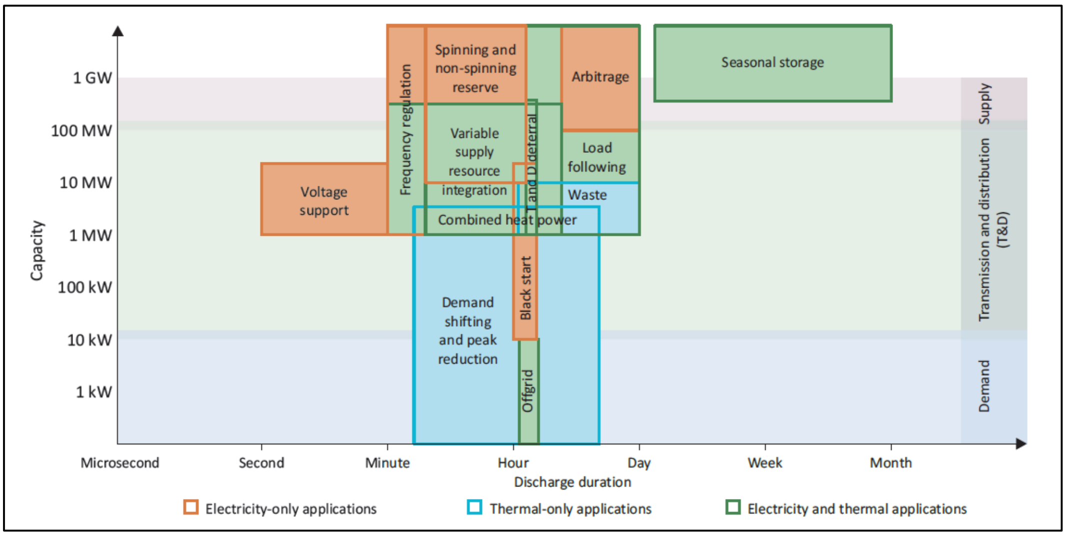

Figure 1-3 | Power Requirement vs. Discharge Duration for Some Applications in Today's Energy Systems (Source: See footnote 6)

An energy storage unit can participate in electricity markets in a number of ways, depending on its energy storage and delivery characteristics. Despite numerous advances in energy storage technologies and technical benefits offered, markets have not yet adopted energy storage applications other than pumped hydro on a large scale. At present there are several non-hydro energy storage technologies at varying stages of maturity available at the utility scale.[7]

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[5] New Zealand Electricity Commission. "An Appraisal of New and Renewable Generation Technologies as Transmission Upgrade Alternatives". 19 December 2005.

[6] International Energy Agency. "Technology Roadmap Energy Storage". 19 March 2014.

[7] Walawalkar, Rahul, Jay Apt, and Rick Mancini. "Economic of Electric Energy Storage for Energy Arbitrage and Regulation in New York." Carnegie Mellon Electrify Industry Centre Working Paper.

In the Philippines, the initial energy storage integrated in the grid and registered as generating facility in the WESM is Kalayaan pumped storage plant ("Kalayaan"). Recently, AES Philippines expressed its interest to integrate a 10-MW battery energy storage in the Luzon grid with the intent to participate in the WESM. In the Philippines, battery energy storage is a fairly new technology. On 30 June 2016, the Market Operator issued an advisory that the new 10 MW Masinloc Energy Storage Project has been modelled in the market network model, following the submission of required documents for registration in the WESM.

With the entry of new technologies such as battery energy storage systems, there is a need to review the applicability of market rules and the present policies on the same. Also, considering the objective to have a competitive market that would attract new investments for energy supply, participation in the WESM of non-conventional new technologies similar to battery energy storage is inevitable. In this regard, providing a framework of participation of battery energy storage systems in the market could open up opportunities for additional energy supply.

1.1. Background

In reference to the proposed amendments to the WESM Rules on generation company reserve/offers submitted by the AES Philippines, the Rules Change Committee requested assistance from the Technical Committee in determining the classification of a battery energy storage system, whether as: "(a) a generation company certified as ancillary service provider; or (b) purely ancillary services provider"[8]. In its response to the Rules Change Committee, the Technical Committee opined that based on the technical capability of battery energy storage systems and the current definition in the WESM Rules of a generation company, battery energy storage can function as a generation company with scheduled generating units that can provide both ancillary services and energy instead of purely ancillary services[9].

[8] TC-RSTR-2014-02 "RCC Request for Assistance". 14 October 2014. (See Appendix B.2)

[9] COR-INT-TC-14-08 "TC Response to RCC". 18 December 2014. (See Appendix B.2)

Noting the need for a policy direction on the matter in view of the imminent entry of battery energy storage systems in the grid, the Energy Regulatory Commission issued ERC Resolution No. 09 Series of 2015[10], which classified the battery energy storage system as a new source of frequency control ancillary services and exempted the same from the conduct of a system impact study[11]. In view of the said Resolution, the Technical Committee initially decided to focus its study on the role of battery energy storage systems as ancillary services providers. However, in a Rules Change Committee subcommittee meeting held on 12 January 2016, wherein the Technical Committee was invited to join, AES Philippines presented a letter from the Energy Regulatory Commission stating that battery energy storage did not fit strictly into any of the classifications defined under the current regulatory regime. The letter further stated that given the nature of its operations, the classification of battery energy storage would fall within the area of generation, in which case, a certificate of compliance may be the appropriate regulatory authorization, but noted that battery energy storage may not be able to comply with certain provisions required under the 2014 Certificate of Compliance Revised Rules due to it being a new technology. As such, while the Energy Regulatory Commission may identify applicable exceptions to the said rules, additional requirements may have to be applied for battery energy storage given the circumstances.

In view of the above, the Technical Committee decided to take into consideration in its study the role of a battery energy storage system as both an ancillary services provider and generator.

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[10] ERC Resolution No. 09 Series of 2015 -- A Resolution Adopting the Recommendations of the Grid Management Committee (GMC) Classifying the Battery Energy Storage System as a New Source of Frequency Control Ancillary Services and the Exemption thereof from the Conduct of System Impact Study. 18 May 2015.

[11] In the ERC Resolution No. 09 Series of 2015, the Grid Management Committee reasoned that the purpose for which the system impact study should be conducted is not much of a necessity in the context of a battery energy storage system considering that: (1) the power flow analysis which is conducted in order to ensure that thermal limits are not breached can be remedied by simply allocating the capacity that can be accommodated by the transmission line; (2) batteries produce direct current, which flows only in one and same direction. Hence, the possible occurrence of short circuit is slim and has negligible impact to the grid; and (3) as to the dynamics, the battery energy storage system is static and will only be used for frequency regulation, thus, it cannot cause instability to the grid.

1.2. Objective

The objectives of this report are as follows:

(1) To describe the operation of battery energy storage highlighting benefits and challenges in the adoption of this type of resource;
(2) To present a review of battery energy storage adoption in other electricity markets;
(3) To emphasize grid-related and market-related issues with this technology; and
(4) To provide recommendations for the adoption of this technology including its classification for the Philippine electricity market.

1.3. Scope

Though there are various types of energy storage, this report only specifically covers the battery energy storage system. Other types of energy storage systems are partly mentioned but not discussed in detail. In addition, only utility-scale battery energy storage is considered in this report.

2. OVERVIEW OF BATTERY ENERGY STORAGE SYSTEMS

A battery energy storage system consists of a battery device, power conversion system and associated battery monitoring and control equipment. These are in addition to the traditional switchgear and metering apparatus. Batteries use chemical reactions with two or more electrochemical cells to enable the flow of electrons. It charges when excess power from the grid is available and later discharges to the grid as needed[12]. It acts as a demand (consumer of electricity) when energy from the electricity grid is used to charge the battery, while it acts as a supply when stored energy is delivered to the grid. In general,

[12] International Energy Agency. “Technology Roadmap Energy Storage”. 19 March 2014.

energy is stored to the battery during off-peak while the battery supplies power during peak demand. With this capability, it can provide frequency regulation and voltage control.

Battery energy storage is also used as an optimum solution to store energy from renewable energy and discharge it when it is more needed on central, de-central and off-grid situations. It also offers grid services like voltage control and frequency regulation, maintain grid stability and flexibility. Aside from high speed deployment, battery energy storage can also be customized based on different system requirements.

2.1. Benefits of Battery Energy Storage Systems

The operational benefits of integrating battery energy storage systems in the grid include improved short- and long-duration voltage quality, reliable and cleaner back-up power for a limited time, reduced need for peak generation capacity, more efficient use of renewable and other off-peak generation, reduced need for transmission and distribution capacity upgrades (provide transmission support and congestion relief), increased and improved availability of ancillary services and lower greenhouse gas and other emissions.

On the other hand, economic benefits of battery energy storage systems include energy bill savings from shifting demand to off-peak, profits from selling electric energy storage into ancillary services and/or energy market, reduced necessity for dispatching expensive peaking generators during peak hours and lower electric energy storage costs as the market matures. There are studies of diesel generating sets operating in hybrid with battery energy storage system and renewable generation which showed significant fuel savings over cases without energy storage. Fuel saved is attributed to the smoothing effect of the battery, thereby allowing the diesel generator to either run at constant load, or to reduce the number of engine starts[13].

[13] New Zealand Electricity Commission. "An Appraisal of New and Renewable Generation Technologies as Transmission Upgrade Alternatives". 19 December 2005.

However, it is also acknowledged that the power conversion has inherent losses (i.e. less than 100% conversion efficiency) and may produce significant voltage and current distortion.

2.2. Battery Energy Storage Systems and Integration of Renewable Energy

Renewable energy is expected to increasingly contribute to a more sustainable energy mix. However, these resources are strongly affected by variable weather conditions. Battery energy systems which provide the necessary storage and controlled dispatch are therefore expected to provide the complementary response in order to address the challenges produced by intermittent renewable energy sources.

3. INITIATIVES ON THE INTEGRATION OF BATTERY ENERGY STORAGE SYSTEMS IN OTHER JURISDICTIONS

The participation of energy storage resources in wholesale electricity markets is not a new phenomenon. In North America, energy storage has been actively studied or commercially deployed in electricity markets such as: California Independent System Operator (CAISO), Electric Reliability Council of Texas (ERCOT), Independent Electricity System Operator (IESO), Alberta Electric System Operator (AESO), Midcontinent Independent System Operator (MISO), New England Independent System Operator (ISO-NE), PJM Interconnection (PJM) and New York Independent System Operator (NYISO)[14].

In the Asia-Pacific region, electricity markets such as Australia National Electricity Market (NEM) and Singapore Wholesale Electricity Market (SWEM) have also published their studies on the participation of non-conventional generators such as battery energy storage systems and subsequently changed their Market Rules to accommodate the participation of battery energy storage in their electricity market.

[14] In North America, independent system operators (ISO) act as both the System Operator and Market Operator

Table 3-1 summarizes the participation of energy storage, whether for ancillary services only or both energy and ancillary services, in other markets.

Table 3-1 | Participation of Energy Storage in Other Markets[15]

	NYISO	CAISO	ERCOT	IESO	AESO	MISO	PJM	ISO-NE	SWEM
Reserve	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Energy	No	Yes	Yes	No	No	Yes	Yes	No	No

The succeeding subsections will discuss the initiatives in integrating energy storage in other jurisdictions including their approach to the issues and the policy changes needed to address the issues arising from the distinct qualities of energy storage technologies. For additional details on the review of existing energy storage technologies and synopsis of the activities in other markets in relation to the integration of energy storage, see Appendix A *Energy Storage in other Jurisdictions*.

A. North America – USA and Canada

In North America, the major trigger for independent system operators and regional transmission organizations to integrate energy storage is the issuance of Federal Energy Regulatory Commission (FERC) Order No. 890, which directed grid operators to remove barriers for non-generating units to participate in the ancillary service market, and Order No. 755, which required that regulating reserve resources be compensated based on its performance.

As a result, a number of independent system operators re-evaluated and subsequently amended their rules to accommodate energy storage resources in their electricity market. Noting the unique features of energy storage, some independent system operators created a new class of resource. In CAISO, energy storage is included under

[15] In MISO and PJM, participation of energy storage facilities as energy and reserve depends on the type of energy storage. IESO, on the other hand, uses storage technologies as a source of "regulation" – a specialized service that maintains second-by-second balance on the grid. See Appendix A for further details.

"non-generator resources" while MISO classifies it as "stored energy resource" which can either be long term or short term. PJM defined two terms for storage devices – Capacity Storage Resources which participate in PJM's capacity market and Energy Storage Resources which participate in PJM's energy and/or ancillary services market. NYISO has "limited energy storage" whereas ERCOT categorizes energy storage into compressed air energy storage and "duration limited energy storage"[16]. ISO-NE on the other hand calls it alternative-technology regulation resource.

In CAISO, an energy storage pilot program was established and scenarios were simulated to observe and analyze the potential impacts of energy storage prior to its connection to the grid. Certain requirements for operating reserve provision were also revised and the 1-MW minimum capacity requirement was reduced to 0.5 MW. The 2-hour minimum continuous energy requirement was also lowered to 30 minutes in real time market (See Appendix A.1.1). The Technical Committee noted that these are important initiatives and that similar initiatives may be taken in the WESM.

B. Asia-Pacific Region – Australia and Singapore

The Australian Energy Market Commission, the Rule making body in Australia, has prepared a paper entitled "Integration of Energy Storage" which examines whether changes to regulatory frameworks are required to integrate energy storage in the electricity sector[17]. The Commonwealth Scientific and Industrial Research Organisation, the federal government agency for scientific research in Australia, also prepared a report[18] for the Australian Energy Market Commission on the assessment of the economic viability, potential uptake and impacts of electrical energy storage on the National Electricity Market[19] 2015 – 2035. One of the key findings presented in the

[16] Texas Energy Storage Alliance. "Storage Participation in ERCOT". 03 January 2010

[17] Australian Energy Market Commission. "Integration of Energy Storage – Regulatory Implications". 03 December 2015.

[18] Commonwealth Scientific Industrial Research Organisation. "Future Energy Storage Trends". September 2015.

[19] National Electricity Market is the wholesale electricity market for the electrically connected states and territories of eastern and southern Australia – Queensland, New South Wales, the Australian Capital Territory, Victoria, South

report discussed that energy storage can reduce connection costs for large customers. Battery storage co-located with a large load or small renewable generation site (<30MW) could potentially reduce the cost to connect to the grid. Also, potential savings are likely to vary dependent on the diversity of load or the generation profiles of commercial customers.[20]

In June 2015, the Australian Energy Market Operator[21] published a paper entitled "Emerging Technologies Information" to explore the potential impacts of emerging technologies such as battery storage, electric vehicles and fuel switching, and trends on operational consumption and maximum demand in the National Electricity Market, over a 20-year outlook period. The Australian Energy Market Operator observed that battery storage and electric vehicles continue to gather momentum internationally and in Australia, with industry and consumers keen to explore the opportunities and challenges presented by these new technologies. Since the market of battery storage is in its infancy and there is still no mechanism for tracking the number of installations in Australia, modelling battery storage posed a challenge. The Australian Energy Market Operator has developed the first step of its economic model to estimate the uptake of battery storage systems by residential consumers, and used this estimate to determine the impact on maximum demand forecasts. The paper thus focused on residential installation of batteries as part of a new installation of rooftop photovoltaic and battery storage together with the view of providing the economic benefit to the individual household. [22]

Australia and Tasmania. The National Electricity Market generates around 200 terawatt hours of electricity annually, supplying around 80% of Australia's electricity consumption. Western Australia and the Northern Territory are not connected to the National Electricity Market. They have their own electricity systems and separate regulatory arrangements.

[20] Ibid.

[21] The Australian Energy Market Operator operates the NEM. Much like the independent system operators in the North America, Australian Energy Market Operator also operates the System Operations and Market Operations of National Electricity Market.

[22] Australian Energy Market Operator. "Emerging Technologies Information Paper". June 2015.

On 26 May 2016, the Australian Energy Market Commission made a rule to amend the definition of a 'generating unit' in the National Electricity Rules to clarify that the rules for eligibility for registration as a generator are technology-neutral so that non-traditional generation like battery storage and solar photovoltaic can be appropriately included. The request, which arose from the findings in the Australian Energy Market Commission's Integration of Energy Storage report, was made by the Australian Energy Market Operator.

In Singapore, the Energy Market Authority[23] recently approved the market rules for battery energy storage to provide regulation service. The amendment was proposed by Energy Market Company, the Market Operator of Singapore Wholesale Electricity Market. Prior to the approval of the proposed rules, only Generation Registered Facilities (conventional generators) that can respond to automatic generation control are eligible to provide regulation in the Singapore Wholesale Electricity Market. Generation Registered Facilities dispatched by the Power System Operator to provide regulation are placed under the control of the automatic generation control subsystem of the Power System Operator's energy management system. The rules change discussion paper also referred to the experiences of U.S. markets that showed that with appropriate dispatch mechanisms, batteries are also capable of providing regulation. It also mentioned that the ability of batteries to store energy withdrawn from the transmission system and to (later) produce or release that stored energy back into the transmission system as the ancillary service of regulation is seen as "generation". Since batteries need to be dispatched to provide regulation, they have to register with the Energy Market Company as Generation Registered Facilities. Following this, the existing Market Rules for Generation Registered Facilities were then amended to make the same applicable to batteries[24]. The Rules Change Panel agreed to consider the proposal after the Power System Operator approved the first dispatch mechanism

[23] Energy Market Authority regulates Singapore's electricity and also acts as the Power System Operator (PSO) in Singapore.

[24] Singapore Electricity Market Rules. Chapter 8. July 2016. *Generation Registered Facility or GRF means a generation facility that has been registered as a registered facility to provide one or more of energy, reserve, regulation or contracted ancillary services.*

proposed for batteries providing regulation. The new rule was made effective on 28 April 2016.[25]

4. ENERGY STORAGE IN THE WESM

The Philippine WESM has no explicit provision for grid-connected energy storage equipment. However, pumped-storage hydroelectric plant has been accommodated since the initial operation of the electricity market. With a synchronous generator as its generating unit, although fitted with a pump and a reservoir for flexible operation, it was not difficult for the electricity market to treat it as a conventional generator. However with the inevitable introduction of various energy storage technologies for the transmission and the distribution networks, coupled with WESM requirement for mandatory participation for all grid users, it becomes imperative for the electricity market to accommodate such upcoming technologies taking into account their unique capabilities. The next few sections describe perceived concerns as this technology connects to the grid and participates in the electricity market.

4.1. Grid Integration and Impact

Utility-grade battery energy storage facilities of various capacities are expected to connect to the grid now and in bigger scale in the future. With its capability to deliver energy into the grid, albeit with limited duration, the initial response is for this technology to be treated similar to a conventional generator. In addition, with its fast response, it is also expected to perform as an ancillary services provider. However in both cases, this technology does not perform in the same way as conventional generators.

[25] Energy Market Company. Notice of Market Rules Modification. EMC/RCP/80/2015/321. Effective Date: 28 April 2016.

4.1.1 Battery Energy Storage Performance and its Capability compared to a Conventional Generator

Conventional generators convert energy from one form, usually mechanical, to electrical effectively in real time. As such these equipment are rated in terms of the rate of energy conversion such as joules per second, or more commonly MW-hr per hr or simply, in MW. The amount of energy converted or produced by the equipment is limited only by the primary energy resource or the fuel. Battery energy storage systems on the other hand is a limited energy resource, wherein the amount of energy produced is equal to the finite energy pumped into it minus the conversion loss. As such these equipment are rated in terms of energy in MW-hr. Still, the rate at which the battery energy storage delivers energy to the grid is rated in MW.

To illustrate, a 10 MW-hr battery energy storage system can produce a constant 10 MW of power for a full hour. If so desired, it can produce a fraction of this power for a corresponding longer period (e.g. 5 MW for two hours, or 2.5 MW for four hours, etc.). Apparently, a battery energy storage system's power-time characteristic sits well with a shortened dispatch interval. That is, the same 10 MW-hr system, may be dispatched at a fraction of an hour for a large capacity (e.g. 20 MW for half-hour, 40 MW for quarter-hour, etc.).

If a battery energy storage is classified as a Generator, it has to undergo the required test for its minimum stable load or Pmin. At present, conventional generators are tested with continuous output for four hours which may not appropriate for battery energy storage. In fact, the System Operator has come up with a one-hour test to evaluate the power rating of a battery energy storage[26]. Conventional generators are also characterized in terms of its ramping rates. The battery energy storage however, performs excellently in this area. In fact, *ramping* is not even an appropriate measure for this type of technology since it is capable of almost step-change in output. A new set of test procedures has been formulated by the System Operator and has been

[26] Test Procedure on Battery Energy Storage System presented by the System Operator and approved by the Grid Management Committee. See Appendix B.

presented and subsequently approved by the Grid Management Committee (GMC). This alternate testing procedure acknowledges this facility's unique characteristics compared to conventional generators.

4.1.2 Battery Energy Storage Capability to Provide Ancillary Service

The battery energy storage's unique characteristic to inject finite amount of energy almost instantaneously supports frequency regulation which is critical in System Operation. ERC Resolution No. 9 Series of 2015, upholds this by declaring battery energy storage as Frequency Control Ancillary Services (FCAS) provider. Technically, the battery still has finite charge and discharge rates, however, compared to a typical dispatch interval, this charging and discharging intervals are significantly shorter.

On the other hand, its actual capability to provide ancillary service is heavily affected by the battery's state of charge (SoC) which varies throughout the operation. A discussion in Singapore's Energy Market Company rules change proposal best clarifies the technicalities on the SoC of battery energy storage:

> "Batteries are not able to provide regulation (in both directions) when they are fully charged or discharged because the output range of a battery, bounded by its maximum rates of charge and discharge, is dependent on its level of stored energy, as measured by its SoC. When the battery is empty (i.e. SoC of 0%), its maximum rate of discharge is 0 kW as an empty battery has no stored energy to discharge at all if the system requires it to provide up-regulation. When the battery is full (i.e. SoC of 100%), its maximum rate of charge is 0 kW as a full battery has no unused capacity to charge at all if the system requires it to provide down-regulation. Due to the limited storage capacities of batteries, they may not be able to provide regulation continuously throughout a dispatch period. They could easily be fully charged or discharged when providing regulation, especially when the deviations in grid frequency are large, causing

the required regulation associated with either direction to be high and for a prolonged period of time"[27] .

Due to this, scheduling of battery energy storage as an ancillary service provider has to take into account the batteries' SOC. This can be done by real-time measurement, or by a sophisticated prediction algorithm, or both.

4.1.3 Battery Energy Storage Installation and Variable Renewable Energy Resources

In all economies throughout the world, target energy mix maximizes contribution from renewable energy resources which include conventional hydro in various configurations coupled with increasing penetration of wind and solar energy. Even in the Philippines, the proposed renewable energy technology installation targets of the Department of Energy for wind and solar are both 500 MW each and shall be made effective until December 31, 2018 or until installation targets are fully prescribed, whichever comes first[28]. However, available capacity from renewable energy sources such as wind, solar and even run-of-the-river hydro are highly variable. An IEC white paper[27] acknowledged that in order to accomplish significant renewable energy integration, storage technologies should play a vital role. Referred to as electrical energy storage (EES), the same paper categorized EES participation into (a) grid-side, (b) generation-side, or (c) demand-side.

Grid-side participation of battery energy storage refers to the use of grid-connected storage, independent from a specific generator or load. The System Operator is able to harness this technology's profound capabilities to meet grid objectives via load shifting, load following, reactive power supply or even emergency power. Again, with

[27] Energy Market Company. Notice of Market Rules Modification. Paper No. EMC/RCP/80/2015/321. 28 April 2016.

[27] International Electrotechnical Commission. White Paper on "Grid Integration of Large-Capacity Renewable Energy Sources and Use of Large-Capacity Electrical Energy Storage". 2012.
[28] Draft National Renewable Energy Board (NREB) Resolution No. 3, Series of 2016.

multiple intermittent energy sources throughout the grid, the flexibility afforded by battery energy storage is most welcome.

Generation-side participation refers to battery energy storage installations operated in conjunction with a specific generator. With the intermittent characteristic of RE sources, battery energy storage connected in this manner will significantly reduce RE's adverse effect to the network.

Demand-side participation refers to large-quantity battery energy storage equipment connected to direct users. Typical example of this is massive electric vehicle charging referred to as grid-to-vehicle (G2V), or the other way, electric vehicle power plant also referred to as vehicle-to-grid (V2G). Similarly, these systems address the intermittent characteristic of RE sources.

Since battery energy storage facilities are utilized for voltage and frequency regulations to maintain grid stability and flexibility, it thereby provides solutions at generation, transmission, distribution and customer levels. The TC is of the opinion that battery energy storage's contribution to various sectors of the power system has to be acknowledged accordingly. In particular, grid impact studies should reveal the benefits of this technology to complement intermittent renewable energy sources.

In the Philippines, both grid-side and generation-side participation can immediately be realized. Some of the most legitimate installation of battery energy storage facilities can be in areas with large installed VRE resources in a grid with thin reserves. As an illustration, with the influx of solar farms in Negros, among the issues encountered by the System Operator is the limited ancillary service providers in the Visayas grid. Hence the grid will experience automatic load dropping (ALD) whenever there is a sudden reduction in solar plant output. A battery energy storage facility of suitable capacity can participate either as part of the generation facility or as a grid component in order to support the integrity of the grid.

However, consideration must also be made on the transmission capacity of delivering its output to the interconnected island/s where large Distribution Customers are connected. Though battery energy storage can serve as replacement power for the variability of VRE Resources (i.e., solar farms especially during daytime), transmission line constraints could also occur with the additional output from battery energy storage.

Currently there is no specific directive from the DOE related to VRE and battery energy storage. The closest issuance that can be considered on this matter is DOE Circular No. DC2015-07-0014[29], wherein there is a provision for replacement power. Specifically, the Circular states that "deviations outside the prescribed range set per FIT-eligible technology, the RE developer shall be responsible for procuring replacement power". Without prejudice, any generating facility, new energy sources or conventional, can utilize battery energy storage facilities as an option.

4.1.4 Impact of Battery Energy Storage Facilities as a Function of Capacity and Location

The TC is also of the opinion that the impact of a battery energy storage facility in the grid is affected by its location, its capacity, and the characteristic of the grid. To illustrate, a 10-MW battery energy storage facility in Luzon will not have the same impact as a 10-MW battery energy storage facility in Visayas. The same capacity will have a different impact whether or not it is located adjacent or away from a VRE resource. In addition, transmission voltage levels together with line and substation capacity constraints within the region may also affect the contribution of battery energy storage facilities. Having said that, a system impact study should be done prior to battery energy storage installation. However, in light of the ERC Resolution No. 09, Series of 2015[30], allowing exemption for battery energy storage from the system impact study, the TC recommends that this exemption be qualified depending on the size of

[29] Department Circular No. DC2015-07-0014 *Prescribing the Policy for Maintaining the Share of Renewable Energy (RE) Resources in the Country's Installed Capacity Through the Holistic Implementation of the Pertinent Provisions of Republic Act. No. 9513 or the RE Act on Feed-in Tariff (FIT) System, Priority and Must Dispatch, Among Others.* 26 June 2015

[30] ERC Resolution No. 09, Series of 2015 *A Resolution Adopting the Grid Management Committee's Recommendations Classifying the Battery Energy Storage System as a New Source of Frequency Control Ancillary Services and the Exemption thereof from the Conduct of System Impact Study.* 18 May 2015.

the battery energy storage. This is consistent with the current practice for differentiating between large and small generators. A more comprehensive study may have to be performed to differentiate between large and small battery energy storage.

4.2. Market Participation

Electricity markets in other jurisdictions, as surveyed in Appendix A, also recognized the unique capabilities of battery energy storage participating as ancillary service provider and even as energy provider. In addition, short dispatch intervals in other jurisdictions permitted wider battery energy storage participation. The following terms were used to identify battery energy storage:

- NYISO - Limited Energy Storage Resource
- CAISO - Non-Generator Resources
- ERCOT - Duration Limited Energy Resource
- MISO – Stored Energy Resource (Short Term and Long Term)
- ISO-NE - Alternative Technology Regulation Resource

Some of the terminologies, such as *Limited Energy Storage Resource* and *Duration Limited Energy Resource* emphasize its finite energy capability. However, the TC is of the opinion that the limited-energy characteristic of this technology gets obscured with the ever increasing energy capacity of various battery technologies coupled with a shortened dispatch interval. On the other hand, the term *Non-Generator Resource (NGR)* emphasizes that this equipment does not operate as a *Generator* which is the rotating machine converting mechanical to electrical energy. As such characterization and models for rotating generators does not apply to this resource. The TC prefers this appellation. Again, this is preferred over *Non-Generating Resource (*also, *NGR)* which is not consistent with this technology's capability to inject energy into the electrical network.

As a Non-Generator Resource (NGR) with fast response, a battery energy storage can participate in the Philippine WESM both as an energy source and as an ancillary service provider. In the following sections, its participation to the market including registration and modelling is presented.

4.2.1 Battery Energy Storage Market Participation and Registration

As an additional resource and market participant, the battery energy storage is beneficial to the market. As a resource capable of injecting energy into and withdrawing energy out of the grid, a battery energy storage registers to the market both as a generator and as a load. In due time, when the reserve market is activated, it has to register as an ancillary service provider as well.

Prior to registration as a generator, it has to undergo a set of tests which is distinct from tests applied to conventional generators in order to establish its capabilities in terms of minimum and maximum power (i.e. Pmin and Pmax, respectively), albeit for a shorter period compared to conventional generators as described in **Sec. 4.1.1**.

For its participation as a generator, it will be subjected to the Must Offer Rule (MOR). However as a storage technology, it is not capable to deliver energy continuously particularly for the WESM's hourly dispatch scheduling. Its finite storage may however be considered as a technical constraint in order to de-rate its Maximum Available Capacity. The battery energy storage facility has to provide monitoring signals regarding its state of charge.

In addition, as a generator it is also expected to comply with the dispatch tolerance limit. This technology affords large ramping rate (that is, a finite change in the output at a very short interval), hence compliance to the dispatch tolerance limit will not be an issue.

With its ability and requirement to charge from the grid, this installation shall also register and participate in the market as a load.

In the upcoming regime of co-optimized energy and reserves market, this installation shall register and participate as an ancillary service provider as well. Prior to registration, it has to undergo proper testing to establish its capability in terms of power rating (or the rate at which it delivers or draws energy) and response time in order to determine its suitability to provide various ancillary services to the grid.

4.2.2 Battery Energy Storage Modelling in the Market

As a market participant, its actual operation has to be properly modelled in the Market Management System (MMS). During consultation with the PEMC-TOD on 16 June 2016, it was discussed that with battery energy storage's two modes of operation, it is modelled both as a generator (discharging mode) and as a load (charging mode). Even if remote terminal units (RTU) can read both positive and negative injections, the current MMS has limitations such that negative reading from generators are automatically adjusted to zero. To circumvent this, two co-located market trading nodes (MTN) are assigned to each battery energy storage facility: a generator and a load. The TOD further advised that the new MMS scheduled in 2017 is capable to capture these various modes with a single MTN. This flexibility suits not just battery energy storage but other bi-directional network components as well.

An even more important modelling consideration is the location of the battery energy storage power meters with respect to nearby installations. As presented in **Sec. 4.1.3**, battery energy storage participation can either be on the generation-side or the grid-side; as far as the market is concerned, this participation is strongly affected by the metering connection. For generation-side participation, the battery energy storage is located adjacent to a generator, mostly but not necessarily, a Variable Renewable Energy (VRE) resource. The generator-battery system coordinately participate in the market. In case of a VRE, the battery minimizes the variability in energy production. Even for a conventional source, there should be mutual benefit between these two resources (a) operation-wise to meet dispatch and charging requirements and (b) financial-wise to meet contracted obligations. The battery energy storage charges during the period that will maximize the benefit for the generator that it supports. In which case, the RTU of the MTN reads the net power flow between this generator-battery system and the grid.

On the other hand for grid-side participation, the battery energy storage location supports the requirements of the grid which include the transmission network or even a group of generators in a particular region. In terms of metering and market participation, the battery energy storage installation is assigned its own MTN with its own RTU.

5. SUMMARY AND RECOMMENDATIONS

Based on the preceding discussions, the Technical Committee is of the opinion that battery energy storage is beneficial to the market, and acknowledges that battery energy storage can be used as fast responding regulating reserve. However, its capacity as reserve is a function of its state of charge which has to be continuously monitored by the System Operator for timely reserve dispatch, and by the Market Operator in the eventual market-based reserve scheduling. The Technical Committee also emphasizes that the new MMS should be able to accommodate the peculiar behavior of battery energy storage, such as its bidirectional power injection to the grid and periodic monitoring of the state of charge. The TC further recognizes that even as it introduces additional computing and communication burden to the MMS, the shorter dispatch interval provides a better environment for storage technologies such as this to participate in the market.

In view of the above, the Technical Committee thus recommends that:

a. Battery energy storage be classified as Non-Generator Resource emphasizing its distinct characteristics compared to rotating machine-based generators. As such, Non-Generator Resource modelling, characterization and performance testing are distinct from conventional generators. As a generation resource, its maximum available capacity may be de-rated based on technical constraints;
b. Grid impact study be conducted based on the size of the battery energy storage facility; the size of small battery energy storage to be exempted from such GIS may vary across grids. In addition, such study shall take into account the installation's impact as it participates as either grid-side or generation-side in the light of variable renewable resources nearby; and
c. Relevant market rules be revised accordingly, establishing the requirement for the classification of battery energy storage as Non-Generator Resource and requirement for registration and offer submission.

ABOUT THE TECHNICAL COMMITTEE

Under Clause 1.7.2 of the WESM Rules, the Technical Committee shall from time to time as necessary and appropriate, and whenever the PEM Board directs: *(a) monitor technical matters relating to the operation of the spot market; xxx (c) Assist the PEM Board by providing expertise in relation to: xxx (3) any other matter of a technical nature relating to the spot market; and (d) from time to time if the Technical Committee in its discretion deems necessary or appropriate, propose amendments to the WESM Rules in relation to technical matters, in accordance with chapter 8 with a view to: (1) improving the efficiency and the effectiveness of the operation of the spot market; and (2) improving or enhancing the prospects for the achievement of the WESM objectives.*

Further, Section 4 of the Technical Committee Market Manual (TCMM) provides that the Technical Committee shall conduct technical reviews and studies in relation to (a) power plant technical parameters; and (g) any other matter of technical nature relating to the sport market.

The TC is currently composed of three (3) members, namely, Prof. Jordan Rel C. Orillaza; Engr. Jaime V. Mendoza, Distribution Management Committee (DMC) Representative; and Engr. Fidel D. Dagsaan, Jr., Systems Operator (SO) Representative. Engr. William C. Alcantara was with the TC as Independent Member and was part of the initial stages of the study until July 2016.[31]

This report is prepared with the assistance of the Market Assessment Group of the Philippine Electricity Market Corporation.[32]

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[31] The term of appointment of Engr. William C. Alcantara as independent member of the TC expired effectively on 31 July 2016.

[32] The MAG acts as the Technical and Administrative Secretariat of the TC.

APPENDIX

A. REVIEW OF ENERGY STORAGE IN OTHER JURISDICTIONS

The following sections present the participation of battery energy storage in other jurisdictions, especially where ancillary services are managed in the electricity market. In the Philippines where ancillary services are not yet managed in the electricity market, the participation of battery energy storage may have to be reviewed after an initial roll-out of the Reserves Market.

A.1. NORTH AMERICA – USA and Canada

A.1.1. California Independent System Operator (CAISO)

In 2008, CAISO examined the energy storage technologies in the process of integrating renewable resources. CAISO anticipated the flexibility of energy storage technologies that would lead to improved management of the volatility of the grid due to the integration of additional renewable resources to the grid. Pending the approval of the standards on contingency reserve, CAISO filed an application with the Federal Energy Regulatory Commission to allow Non-Generator Resources to supply regulating reserve and operating reserve.[33]

An Energy Storage Pilot Program was established and scenarios were simulated to observe and analyze the potential impacts of energy storage prior to its connection to the grid. Certain requirements for operating reserve provision were also revised and the 1-MW minimum capacity requirement was reduced to 0.5 MW. The 2-hour minimum continuous energy requirement was also lowered to 30 minutes in real time market.

Pursuant to the California Assembly Bill passed in 2010, an Energy Storage Roadmap was developed with the objective of identifying needed policy, regulatory actions, and

[33] WECC Standard BAL-002-WECC-1 – Contingency Reserves

technology and process changes needed to address challenges and facilitate expansion of energy storage in California. In the same year, the Federal Energy Regulatory Commission revised the definition of Small Generating System in the interconnection procedures and agreement to explicitly include storage devices.

In an anticipation of receiving interconnection requests from energy storage and to provide a forum for identification of issues and solutions, CAISO launched the interconnection initiative in 2014. CAISO also conducted an Energy Storage Roadmap Workshop to review and solicit feedback from stakeholders on barriers facing energy storage in California and potential solutions for addressing those barriers, which was considered in mapping out the key building blocks required to facilitate energy storage in California.

In CAISO, energy storage resources are eligible to qualify as sellers in the energy and ancillary service markets consistent with the technical requirements applicable for other resource types. Generally, energy storage resources participate in the CAISO markets as Non-Generator Resources, Pumped Storage Hydro or as one of CAISO's two demand response entities: Proxy Demand Resources or Reliability Demand Response Resources. CAISO applies the same minimum capacity requirements and minimum offer sizes to all resources seeking to participate in its market. CAISO's tariff identifies a minimum resource capacity size of 0.5 MW, although resources can meet this minimum resource capacity size requirement through aggregation[34].

A.1.2. Pennsylvania-New Jersey-Maryland Interconnection (PJM) [35]

In PJM, there are mainly two types of storage resources, i.e. pumped hydro and advanced energy storage which includes compressed air energy storage, flywheel and

[34] "Response of the California Independent System Operator to Data Request". Federal Energy Regulatory Commission Docket No. AD16-20-000 Electric Storage Participation in Regions with Organized Wholesale Electric Markets. May 2016.

[35] The regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia.

battery storage technologies. Pumped hydro storage resources have been operating as capacity, energy, and ancillary service resources in the PJM wholesale market. However, new forms of energy storage particularly battery and flywheel technologies have recently advanced technologically and commercially[36].

PJM recognized that these energy storage are physically limited energy resources. For instance, most advance energy storage typically can only sustain their full output for less than six hours while PJM's pumped storage hydro plants are typically able to keep at full output for more than six hour but some less than ten hours.[37] PJM defined a new type of resource, Energy Storage Resource such as flywheel or battery storage facility that are able to participate in the PJM energy and/or ancillary services markets as a Market Seller.[38]

PJM acknowledged the clear benefits of utilizing Energy Storage Resources to enable greater penetration of intermittent resources, such as wind, solar, landfill gas, run-of-river hydroelectric power and other renewable resources[39]. Noting the potential increase in the entry of Energy Storage Resource in its system, PJM recognized the importance of updating and establishing market rules to accommodate the participation of Energy Storage Resources into PJM markets, i.e. capacity, energy and ancillary services, and to ensure the comparability of those rules with other similarly situated resources[40].

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[36] PJM. "Limited Energy Resources in Capacity Market: Problem Statement". 05 August 2010.

[37] Ibid.

[38] PJM. "Energy Storage in PJM: Overview of Rules and Requirements". Clean Energy States Alliance Webinar. February 23, 2016.

[39] In PJM, Intermittent Resources are generation capacity resources with output that can vary as a function of its energy source. Source: PJM. M18 Updates for Capacity Performance Filing. March 26, 2015.

[40] PJM's capacity market is called the "Reliability Pricing Model" while PJM's energy markets are the Day-ahead Energy Market and Real-time Energy Market. References to PJM's energy market shall refer to both of these markets. On the other hand, PJM's ancillary services markets are Regulation, Synchronized Reserve and Non-synchronized Reserve. Collectively, PJM's capacity, energy and ancillary services markets shall be called PJM wholesale market.

Energy Storage Resource continues to demonstrate its value in PJM as a resource that helps smooth the integration of renewable energy and provides frequency regulation service. In 2014, more than 100 MW of storage was in service in the PJM footprint and included battery and flywheel facilities and commercial electric vehicles. Regulation resources were paid for their performance – how quickly and how accurately they respond to PJM's signal. This performance-based approach rewarded faster and more accurate resources with higher compensation.[41]

Considering the changing functionality and market activity associated with these energy storage devices, it was however noted that the definition of Energy Storage Resource does not cover all energy storage devices or the manner in which it may participate in PJM's wholesale market. Energy storage devices, particularly batteries and flywheels, have commercial and technological limitations that currently restrict its participation in PJM's wholesale markets such as the costs associated with providing energy for longer periods of time and the requirement that resources must be available to provide capacity with very limited excuses on a year-round basis.

In PJM, Market Sellers can submit offers for storage resource in PJM's wholesale markets as either generation resource[42] or demand-side resource[43]. Within these broad categories of generation and demand-side resources, there are different eligibility and performance requirements for each of the PJM wholesale markets in which Market Sellers participate. Table A.1-1 below summarizes how these different types of storage resources currently participate in PJM's wholesale markets, by type and amount[44].

[41] PJM Annual Report 2014. p. 17

[42] Energy Storage Resources that are directly interconnected to the transmission system, or interconnected to the distribution system and inject power past the applicable customer meter.

[43] Energy Storage Resources that are located behind customer's meters.

[44] "Response of PJM Interconnection, L.L.C". Electric Storage Participation in Regions with Organized Wholesale Electric Markets. Federal Energy Regulatory Commission. Docket No. AD16-20-000. May 2016.

Electric Storage Resource by Technology	Installed Capacity/Qualified Rating (MW)	Capacity	Energy	Ancillary Services
Pumped Storage Hydro (Generation)	5,537	Yes	Yes	Yes
Battery (Generation)	245	No	No	Yes
Flywheel (Generation)	20	No	No	Yes
Battery (Demand-side Resource)	12	Yes	No	Yes

Table A.1-2 | Participation of Energy Storage in PJM, 2016 (Source: See footnote 46)

To further differentiate the storage devices, PJM defined two terms specific to storage devices – Capacity Storage Resource and Energy Storage Resource. The latter as earlier defined while the former defined as any hydroelectric power plant, flywheel, battery storage, or other such facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and /or ancillary services markets and which participates in the capacity market or "Reliability Pricing Model" (RPM)[45]. Capacity Storage Resources are exempt from the RPM must-offer requirement as a Capacity Performance Resource that applies to all types of generation resources. Energy Storage Resource on the other hand, as earlier defined, are offered into the energy and/or ancillary services market only, not RPM.

A.1.3. New York Independent System Operator (NYISO)

In NYISO, flywheels, compressed air energy storage and batteries are recognized as new and emerging energy storage technologies that represent a new class of resource that has the potential to create a more robust power system.

These technologies have energy capacity limitation that precludes them from participating in the energy market. To provide these technologies access to the market, NYISO defined a new type of regulation service provider referred to as Limited Energy Storage Resource.

[45] Open Access Transmission Tariff, Attachment DD, Section 2.13A.

Limited Energy Storage Resource is characterized by its ability to provide continuous six-second changes in output with its inability to sustain continuous operation at maximum energy withdrawal or maximum energy injection for a period of one hour[46].

Traditionally, all resources which provide regulation service also participate in the energy market. Considering that flywheels, compressed air energy storage and batteries are energy limited technologies, NYISO developed new market rules and related market software to accommodate the unique characteristics of Limited Energy Storage Resources and to specifically support its integration.

New rules were put in place to allow these devices to participate in the market as regulation-only providers. As such, Limited Energy Storage Resources are offered as ancillary service and are limited to providing Regulation Service in the NYISO market. Market software was also revised to allow Limited Energy Storage Resources to be economically scheduled on the basis of its regulation availability bid only.

NYISO also modified the real-time dispatch and automatic generation control software to evaluate the capability of Limited Energy Storage Resources in sustaining withdrawals and injections over the five-minute scheduling horizon and to help maximize the amount of regulation it can provide.

If its storage capability allows, Limited Energy Storage Resources will be dispatched first to take advantage of its fast response capabilities and to avoid energy deployments of slower moving generators. On another note, if Limited Energy Storage Resource is insufficient to provide regulation, another resource will be dispatched by real-time dispatch. The real-time dispatch can calculate the upper and lower regulation capability of the device and accordingly schedule the regulation capacity of Limited Energy Storage Resource by monitoring its energy storage. In the event that the capacity of Limited Energy Storage Resource is below the scheduled day-ahead capacity for the five-minute interval due to its energy storage limitation, the Limited

[46] NYISO. White Paper on "Energy Storage in the New York Electricity Markets". 2010.

Energy Storage Resource will be required to purchase replacement Regulation Service similar to that of the requirement for all Regulation Service providers.

Limited Energy Storage Resources are being paid the market clearing price as compensation for the value of its regulation service similar to the manner of how traditional suppliers are compensated. Other than this, its service is compensated differently from that of traditional regulation providers such that, Limited Energy Storage Resources are not yet subject to the “performance adjustments” applied to traditional regulation providers noting its more rapid responsiveness as compared to other regulation service providers.

In addition, Limited Energy Storage Resources are not compensated for the energy provided to the system while providing Regulation Service. Rather, the energy they provide is netted against the energy they use over each hour with the product of that calculation multiplied by the average energy locational based marginal pricing over the hour to produce an hourly energy charge or payment[47]. While Regulation Suppliers are scheduled using both its Regulation Service availability bids and its Energy bids, Limited Energy Storage Resources are scheduled only on the basis of its Regulation availability bids.

A.1.4. Electric Reliability Council of Texas (ERCOT)

In September 2011, a legislation was enacted on the entry of the energy storage in the Texas market which covered the energy storage equipment and systems that intended to provide energy and ancillary services. The legislation classified the energy storage as generation assets and required the owner of generation assets to register.

Projects which deal with issues around the integration of the energy storage and emerging technologies were launched to address entry of the energy storage in Texas

[47] Ibid.

market. ERCOT conducted pilot projects and granted temporary exemptions from ERCOT rules as necessary to effectuate the purposes of a pilot project.

Rules changes were adopted defining the "wholesale storage" as occurring when electricity is used to charge a storage system. Wholesale storage (i.e. charging an energy storage system) is exempted from the transmission service rate, retail tariffs, rates and charges or fees in relation with the retail purchase of electricity, among others.

ERCOT settles the wholesale storage by requiring that storage systems be treated like other generation systems in the sale of energy and ancillary services at wholesale. Energy acquired to charge a storage system is to be treated as wholesale and settled at nodal price. Also, electric storage equipment or systems will not make purchases of electricity for storage during a system emergency declared by ERCOT unless directed.

In March 2012, it was ruled that an energy storage has the option of receiving "wholesale storage load" treatment[48]. An energy storage is not subject to ERCOT charges associated with ancillary service obligations or credits associated with the revenue of Congestion Revenue Rights if an energy storage chose to be a wholesale storage load.

However, in order to receive wholesale storage load, generation from an energy storage must be "returned to the grid" and the energy storage system must be separately metered from all other systems. Wholesale storage load pays the nodal price instead of the zonal price and treated as a wholesale storage load.

In ERCOT, energy storage resources are categorized as compressed air energy storage and Duration Limited Energy Storage which include flywheel and battery energy storage. Duration Limited Energy Storage can alternate between charge and discharge within 5 minutes.

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[48] The Public Utility Commission of Texas. "Rule Making on Energy Storage Issues".

With the increased penetration of renewable energy in its system, ERCOT looked into the benefits of a “Fast Responding Regulation Service”. Fast Responding Regulation Service is expected “to increase the reliability of the ERCOT system at a lower total cost to Load as compared with solely relying on conventional Regulation Service”[49]. Fast Responding Regulation Service is intended to complement current regulation service. It can be ramped to its full output within 60 cycles and it is intended to respond first and help slow down the frequency decay while other resources start to respond. _ ERCOT explored Fast Responding Regulation Service through a pilot project open to energy storage and noted that the introduction of Fast Responding Regulation Service improves ERCOT's ability to arrest frequency decay during unit trips. Fast Responding Regulation Service Pilot Resources generally followed ERCOT Fast Responding Regulation Service deployments and responded automatically using local frequency detecting techniques. When deployed, Fast Responding Regulation Service reduces the rate of change of frequency and regulation deployed to conventional Resources. There was also an observed lower quantities offered for FRRS-down and an overall lower performance for FRRS-down[50].

A.1.5. Midcontinent Independent System Operator (MISO)

The major driver of the energy storage program in MISO is the need for greater flexibility in order to address the challenges in grid operation stemming from increased renewable energy generation. MISO undertook an energy storage study together with Manitoba Hydro focusing on compressed air energy storage, pumped hydroelectric storage and battery energy storage for the analysis.

In MISO, energy storage resource refers to Stored Energy Resource further categorized as either “long term storage” (compressed air energy storage and pumped hydroelectric storage) or “short term storage” (battery energy storage). Short term and long term storage are treated differently in MISO. Long-term Stored Energy Resource

[49] ERCOT. “Governing Document for Fast-Responding Regulation Service Pilot Project”. 13 November 2013.

[50] ERCOT. “Pilot Project for Fast Responding Regulation Service”. 15 April 2014.

can participate in both day-ahead market and real time market similar to generators and loads. On the other hand, Short-term Stored Energy Resources are only eligible in the day-ahead market and real time Operating Reserve Market[51]. Stored Energy Resources provide frequency control and regulating reserves. This was the focus for MISO in the first phase of the study[52].

MISO focused on testing regulating, spinning, and supplemental reserve supply for short-term Stored Energy Resource. MISO lifted the requirement of providing the service for a continuous 60 minutes and developed a 'pay-for-performance' tariff that will allow resources to be paid a 'regulation mileage payment' in addition to the marginal clearing price. Stored Energy Resources have the option to identify themselves with other types of resources when providing energy or ancillary service, in which case participants need to model energy storage as a generator to represent the discharging state and a load to represent the charging state.

Short-term Stored Energy Resources can only be bid as regulation and the resource offer includes parameter values describing the resource storage level and ramp rate, etc. Stored Energy Resources are then dispatched as energy by the real time Security Constrained Economic Dispatch model.

Dispatch MW is limited to a value that is the mean of the maximum and minimum operating level in MW at which the resource can operate (varying hourly if required), based on the latest data from the Stored Energy Resource. Dispatch MW value indicates whether Stored Energy Resource requires charging (-MW) or has available stored energy to dispatch (+MW). Stored Energy Resource energy penalty variable is set at the current cleared regulation demand price. Penalty screens out charging the Stored Energy Resource when the current energy price is above the penalty or discharging the Stored Energy Resource when the current energy price is below the penalty. This screening variable is designed to minimize uneconomic use of the Stored Energy Resource.

[51] MISO. Energy and Operating Reserve markets Business Practices Manual. 01 March 2015.

[52] MISO Energy Storage Study Phase 1 Report. November 2011.

As for its market participation, long-term Stored Energy Resources participate in both day-ahead market and real-time market. In the day-ahead market, a participant can submit bids or schedule load, to purchase energy from the market to store in hours of its choice, or submit offers or self-schedules to reduce demand to provide energy or reserves the demand side resource. Participants may adjust its bids, offers and/or schedules in the real-time market.

On the other hand, Short-term Stored Energy Resources are only eligible to be bid as regulation resources in the ancillary services day-ahead market and real time operating Reserve Markets. They supply Regulating Reserve, but not Contingency Reserve or Energy. Its minimum offer per hour is 1MW.

A.1.6. New England Independent System Operator (ISO-NE)

In 2008, ISO-NE initiated a pilot program for Alternative Technology Regulation Resources which allowed participants to provide regulation reserve in its real-time Regulation market. The pilot program is "pay-for-performance", so a resource that does not perform will receive no compensation during the interval of non-performance. In ISO-NE, Alternative Technology Regulation Resources must have at least 1MW of capacity and can be aggregated for multiple sites under single control[53].

In March 2011, the redesigned Regulation market went into effect with key features including a conventional signal and new type of dispatch signal to enable Alternative Technology Regulation Resources to provide frequency regulation services.

The new type of dispatch signal however did not accommodate non-generation resources. A new type of dispatch signal was thereafter defined specific for non-generation resources based on a storage technology such as battery energy storage and flywheels.

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[53] ISONewswire, *Redesigned Regulation Market Now in Effect*. April 7, 2015.

ISO-NE changed its automatic generation control dispatch to provide three dispatch signals: energy-neutral trinary, energy-neutral continuous, and continuous[54]. Energy-neutral signal directs energy storage to cycle between electricity production and consumption over a short period.

Alternative Technology Regulation Resource of various types can now choose among two versions of the energy-neutral signal, as well as the conventional regulation dispatch signal used by generators. To improve performance monitoring, modifications were made to communications between the independent system operator and remote terminal units of resources to support the coordinated dispatch of generation and non-generation resources.

A.1.7. Independent Electricity System Operator (IESO)

To support Ontario's efforts to better understand the integration of energy storage in Ontario's electricity system and market, the IESO explored how energy storage can be integrated into the day-to-day operation of Ontario's electricity system and market.

Back in 2012, IESO conducted a project on Alternative Technologies for Regulation. This project was designed to evaluate the ability of alternative technologies to provide regulation service relative to existing providers of regulation service in Ontario. Most of the respondents to the IESO's Request for Proposal proposed to employ energy storage technologies. The ATR project sought technology diversity and resulted in three different technologies being selected: a battery system; a flywheel system; and a load aggregation arrangement. All three projects have been commissioned and are currently providing the contracted regulation service.

[54] Dynapower Energy Management, *5 Things to Know About the ISO-NE Frequency Regulation Market*. May 20, 2015.

In January 2014, IESO, in coordination with the Ontario Power Authority, released the Energy Storage Procurement Framework in compliance with the direction of the Ontario Ministry of Energy. The framework covered Ontario's Long- Term Energy Plan which provided for 50 MW of energy storage to be procured by the end of 2014. The same also covered the review of regulatory barriers to the participation of storage in the market, and options to address said barriers. The procurement of the energy storage aimed for open, fair and transparent procurements, value to ratepayer, being responsive to storage industry readiness; and integration of storage into the IESO Administered Markets.

Beginning in the fall of 2014, the IESO conducted a two-stage process for the second phase of the energy storage procurement, including a Request for Qualifications (RFQ) followed by Request for Proposals (RFP).

In the first phase, the IESO selected storage technologies from five companies to provide ancillary services to support increased reliability and efficiency of the grid. The second phase of the procurement was open to energy storage technologies with a range of performance characteristics. This phase was focused on two specific aspects of energy storage: its capacity value – the ability to be available to store energy and provide it back when called upon – and its arbitrage value – the ability to store energy during lower priced periods and inject it back into the electricity system when prices rise, and the value of energy increases.

On 23 September 2014, the Ontario Power Authority hosted a webinar to provide an opportunity for stakeholders to learn about the proposed procurement process, to ask questions and to provide the Ontario Power Authority with feedback. The Ontario Power Authority posted the draft Energy Storage RFQ with commenting period until 02 October 2014.

In March 2016, the IESO issued a technical report on energy storage focusing on the reliability needs of the Ontario power system and the potential for energy storage technologies to address those needs.

Presently, the IESO is using storage technologies as a source of "regulation" – a specialized service that maintains second-by-second balance on the grid (alternative technologies for Regulation). It can be provided by generators, fast-responding loads, or fast-responding storage resources.

By helping to correct small, sudden changes in power system frequency, regulation balances power flows and maintains the reliability of the power system. This quick response is becoming increasingly important to facilitate more renewable resources like wind and solar, whose output is variable in nature.

In a report prepared by IESO, energy storage technologies are classified as Type 1, Type 2 and Type 3[55]. Type 1 are energy storage technologies capable of withdrawing electrical energy from the grid, storing such energy for a period of time and then re-injecting this energy back into the grid. This include, but are not limited to, flywheels, batteries, compressed air and pumped hydroelectric[56].

A.1.8. Alberta Electric System Operator (AESO)

In 2011, the Alberta Market conducted a study on the integration of the energy storage in conjunction with integration of wind energy. AESO solicited issues and comments from the stakeholders on legislation concerning the integration of the energy storage project. The main issues that were identified include the development of technical and operating requirements to connect and operate energy storage systems, identification of the appropriate tariff rates to apply to energy storage systems and the review of

[55] Type 2 – Energy storage technologies that withdraw electricity from the grid and store the energy for a period of time. However, instead of injecting it back into the grid, they use the stored energy to displace electricity consumption of their host facility at a later time. Ex. heat storage or ice production for space heating or cooling;

Type 3 - Energy storage technologies that only withdraw electricity from the grid like other loads, but convert it into a storable form of energy or fuel that is subsequently used in an industrial, commercial or residential process or to displace a secondary form of energy. They're generally integrated with a host process that uses that secondary form of energy directly or are connected to a transmission or distribution network for their secondary form of energy. Ex. Fuel production (hydrogen or methane), steam production and electric vehicles.

[56] IESO. Energy Storage Report. March 2016.

technical requirements for the provision of Operating Reserves considering the characteristics of energy storage technologies.

In September 2012, AESO launched an Energy Storage Integration Initiative which initially assessed possible ways of integrating energy storage by identifying and prioritizing issues that may exist within the current market design in relation to energy storage integration.

In collaboration with AESO, Alberta Innovates Technology Futures conducted a study on using energy storage to support dispatch of wind systems. The final report suggested that wind systems could benefit from energy storage through profit shifting by creating energy arbitrage and energy firming. The same report also suggested the possibility of enabling wind participation in the operating reserves market through energy storage.

Driven by the funding initiative of the Climate Change and Emissions Management Corporation, interest in integrating energy storage systems into the Alberta Market increased. North American Electric Reliability Corporation approved the new reliability standards for contingency reserves which allowed non-generating resources to provide regulating reserve and spinning reserve.

In June 2013, the AESO launched an energy storage initiative in which AESO explored how energy storage can improve the grid without compromising reliability and efficiency[57].

In 2014, AESO released a discussion paper which explored the key considerations regarding the top priorities to advance the integration of storage technologies in Alberta[58].

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[57] AESO. Energy Storage Initiative Issue Identification. 13 June 2013.

[58] AESO. Energy Storage Integration. 13 May 2014.

Afterwards, AESO released a recommendation paper on Energy Storage Integration regarding the identified priorities. AESO recommended the complete drafting and filing of ISO Rules to address technical and operating requirement for battery energy storage systems ("Proposed Battery System Rules") which was also consulted with the industries in 2015[59].

Rules were filed with the Alberta Utilities Commission and became effective on 25 April 2016 on Battery Facility Energy Storage Operating Requirements[60] and Battery Facility Energy Storage Technical Requirements[61].

AESO is currently working to determine rate treatment for energy storage facilities. Consultation began in 2016 and filing of proposal with the regular tariff is in 2017.

The AESO is also currently consulting on Operating Reserve rules to allow technology neutral participation in regulating, spinning and supplemental reserves to allow technology such as storage to provide these services.

A.2. ASIA-PACIFIC – Singapore

A.2.1. Singapore Wholesale Electricity Market (SWEM)

In SWEM, the ability of batteries to store energy withdrawn from the grid and to later release that stored energy back into the grid as ancillary service or regulation is seen as "generation". As such, batteries are classified as generation facilities. This is in reference to the definition of "generate" and "generating station" in the Singapore's Electricity Act. According to Singapore's Electricity Act, "generate" means *to produce*

[59] AESO. Energy Storage Integration. 18 June 2015.

[60] ISO Rules. Part 500 Facilities. Division 502 Technical Requirements. Section 502.14 Battery Energy Storage Facility Operating Requirements.

[61] ISO Rules. Part 500 Facilities. Division 502 Technical Requirements Section 502.13 Battery Energy Storage Facility Technical Requirements.

electricity by means of generating station for the purpose of giving a supply to any premises or enabling a supply to be so give and “generating station” means *any installation used for, or for purposes connected with the production of electricity*[62].

Since batteries need to be dispatched for regulation, it will have to register as Generation Registered Facility[63] with Energy Market Company. In order to accommodate batteries in the market, the existing Market Rules for Generation Registered Facilities were thereafter revised to make the same applicable to batteries.

With regard to scheduling, similar to existing Generation Registered Facilities, the minimum offer requirement of 0.1 MW will apply to batteries in the regulation market. Multiple generating units at the same generating station can register as one facility to meet the 0.1 MW minimum offer requirement. All offers from batteries will be qualified by the Market Clearing Engine as long as the aggregate offered quantity of each battery do not go beyond its PSO-approved maximum regulation capacity. The Market Clearing Engine will then schedule adequate regulation from batteries and conventional generators based on its offer prices, to meet the requirement for regulation.

Settlement for the capacity offered by batteries will be paid based on scheduled quantity of regulation as provided in the Market Rules. Regarding its dispatch, batteries are eligible for regulation provision via dispatch mechanisms approved by the Power System Operator[64]. A more detailed discussion on dispatch mechanism (output range setting, basepoint setting, multiple types of regulation signal, deadband, etc.) is provided in the discussion paper of the rules change proposal by Energy Market Company.[65]

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[62] Singapore Electricity Act Revised Edition 2006.

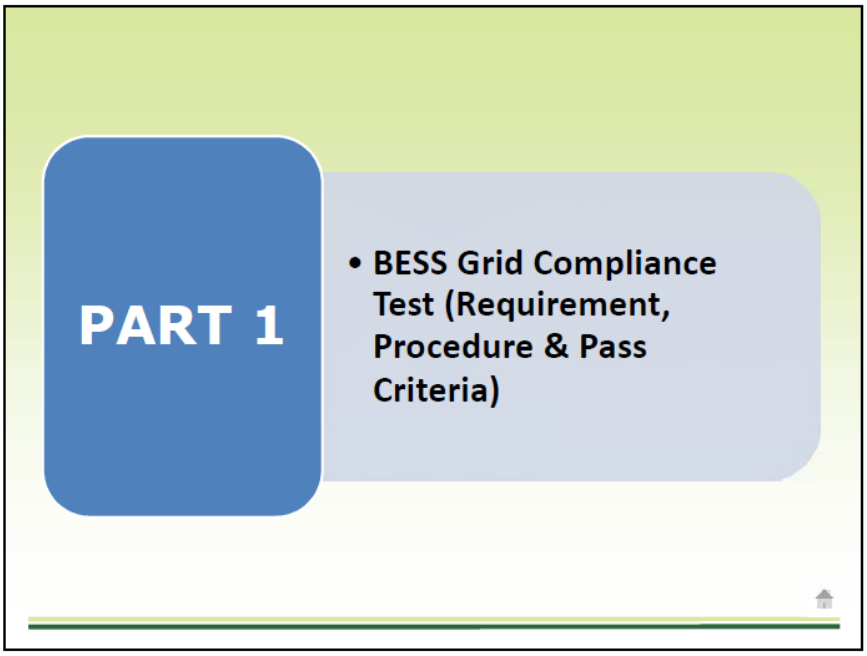
[63] Singapore Electricity Market Rules. Chapter 8. July 2016. *Generation Registered Facility or GRF means a generation facility that has been registered as a registered facility to provide one or more of energy, reserve, regulation or contracted ancillary services.*

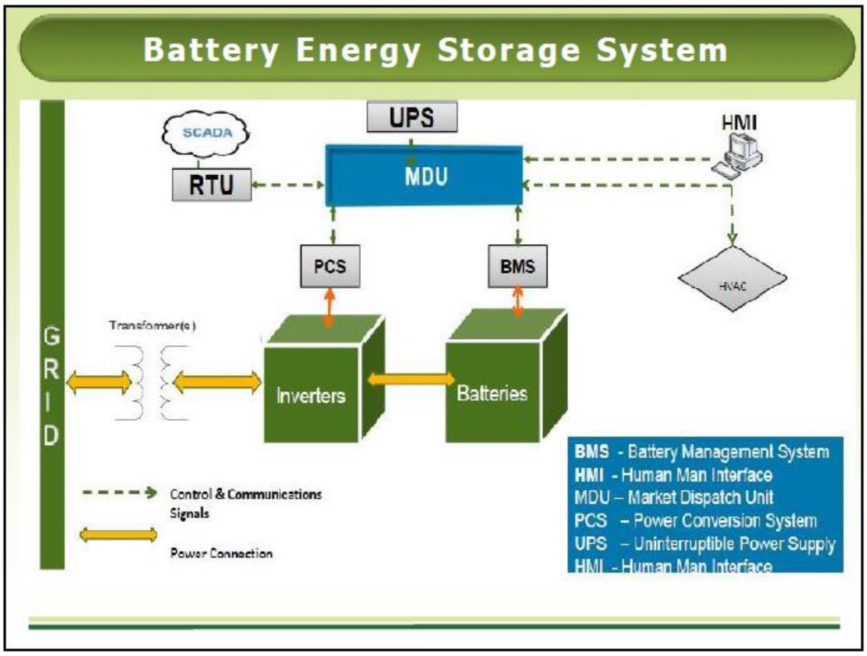
[64] Energy Market Authority regulates Singapore’s electricity and also acts as the Power System Operator (PSO) in Singapore.

[65] Energy Market Company. Notice of Market Rules Modification. Paper No.: EMC/RCP?80/2015/321

B. REVIEW OF RELATED LITERATURE, RELEVANT RULES AND PROVISIONS

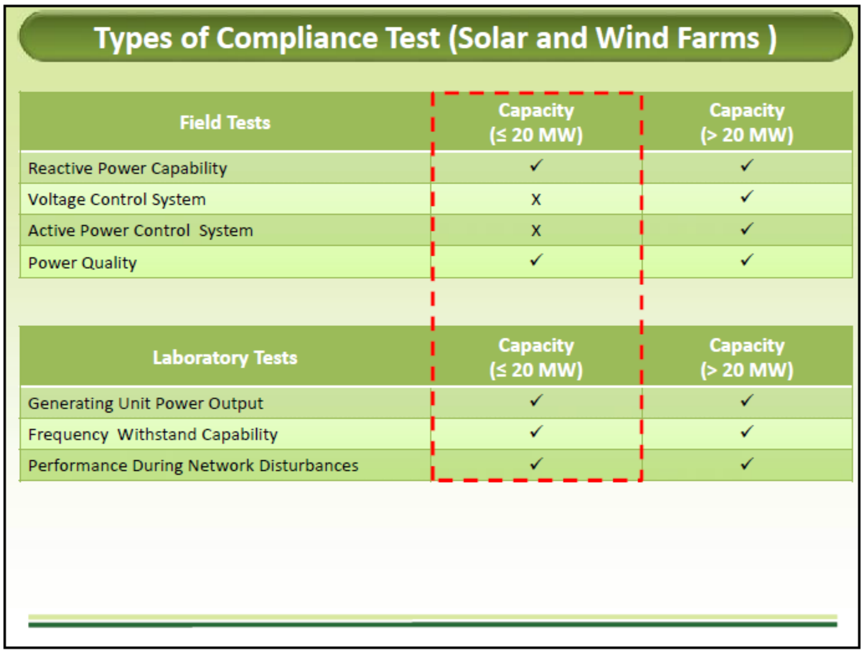
B.1. Test Procedure on Battery Energy Storage System





Types of Compliance Test (Conventional Plants)

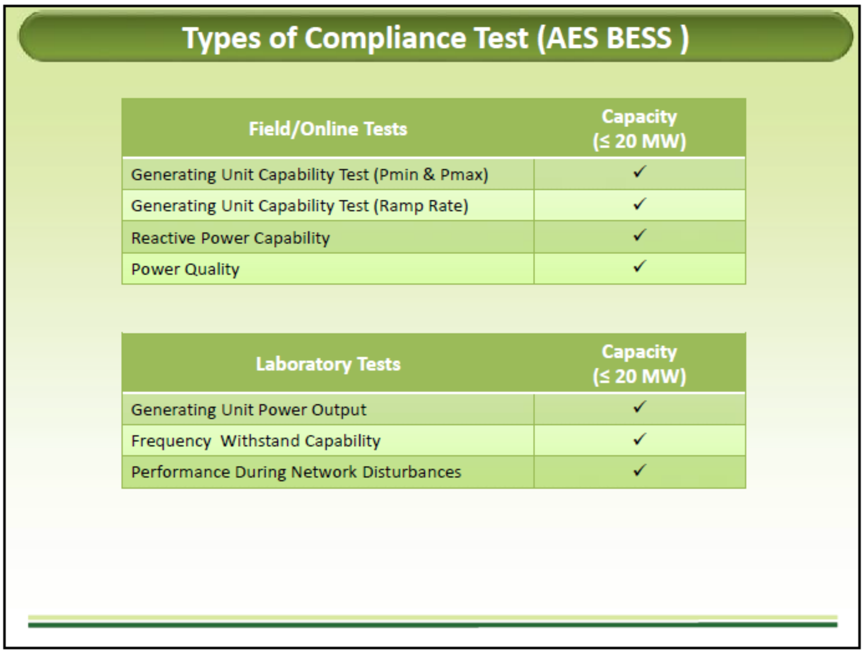
Online Tests	Small Generators (≤ 20 MW)	Large Generators (> 20 MW)
Reactive Capability	x	✓
Governor and Load Controller Response	x	✓
Frequency Withstand Capability	x	✓
Unbalance Loading Withstand Capability	x	✓
Load Rejection	x	✓
Generating Unit Capability Test (Pmin & Pmax)	✓	✓
Generating Unit Capability Test (Ramp Rate)	✓	✓
Excitation System On-Load	x	✓
Excitation System Under Excitation Limiter	x	✓
Excitation System Over Excitation Limiter	x	✓
Offline Tests	**Small Generators (≤ 20 MW)**	**Large Generators (> 20 MW)**
Excitation System Open Circuit Step Response	x	✓
Open and Short Circuit Saturation Characteristics (Laboratory)	x	✓



Types of Compliance Test (Solar and Wind Farms)

Field Tests	Capacity (≤ 20 MW)	Capacity (> 20 MW)
Reactive Power Capability	✓	✓
Voltage Control System	X	✓
Active Power Control System	X	✓
Power Quality	✓	✓

Laboratory Tests	Capacity (≤ 20 MW)	Capacity (> 20 MW)
Generating Unit Power Output	✓	✓
Frequency Withstand Capability	✓	✓
Performance During Network Disturbances	✓	✓



Types of Compliance Test (AES BESS)

Field/Online Tests	Capacity (≤ 20 MW)
Generating Unit Capability Test (Pmin & Pmax)	✓
Generating Unit Capability Test (Ramp Rate)	✓
Reactive Power Capability	✓
Power Quality	✓

Laboratory Tests	Capacity (≤ 20 MW)
Generating Unit Power Output	✓
Frequency Withstand Capability	✓
Performance During Network Disturbances	✓

AES WESM Registration

Market Participant Name	**Masinloc Power Partners Co.Ltd**
Market Participant Short Name	**MSNLOBAT**
Membership Category	**Generation Company**
Membership Type	**Direct WESM Member and Trading Participant**
Application Type	**Additional Facility**
Facility	**10 MW Masinloc Energy Storage Array**
Market Trading Node/s	**1MSNLO_BATG**
Location	**Masinloc, Zambales**
Registered Maximum Capacity (P_{max})	**10 MW**
Registered Minimum Capacity (P_{min})	**0 MW**
Maximum Ramp Rate (MW/min)	**600 MW/min**
Classification	**Scheduled**
Membership Effective Date	**2 July 2016**
Condition/s	**Submission of the following documents prior to WESM Commercial Operations:** • Certificate of Compliance from the ERC with complete attachments; • Transmission Service Agreement ; and • Formal notice on MSNLOBAT's WESM Participation date should be given to PEMC and NGCP at least nine (9) days before the start date.

Generating Unit Capability Test (Pmin & Pmax)

Requirement	Procedure	Passing Criteria
• Unit should demonstrate capability to be scheduled and dispatched based on its declared data and in accordance with Generation Scheduling and Dispatch parameters.	• Request clearance from RCC to conduct the test. • Let the plant control operator adjust the output of the unit on its minimum and maximum operating capacity. • Sustain at minimum and maximum loading for at least 60 minutes each (based on AES WESM Registration). *Please note that based on ERC directive, conventional plants should sustain both test at minimum and maximum loading for at least 4 hours each.* • Record loading of the plant hourly and observe the operating condition of the plant. If available, download the alarms and events from the event logger of the BESS control system.	• Pmax and Pmin should be within ±1.5% of declared values or 1MW whichever is lower (PGC 6.10.2). • The Pmax shall be allowed provided that it can be supplied within the rated Power Factor limits specified in PGC Section 4.4.2. • Test procedure should require commencing the test from the existing registered Pmax & Pmin and not from the proposed new value. • Results Required: ✓ Pmin (MW) – Minimum stable power output ✓ Pmax (MW) – Maximum stable power output

Generating Unit Capability Test (Ramp Rate)

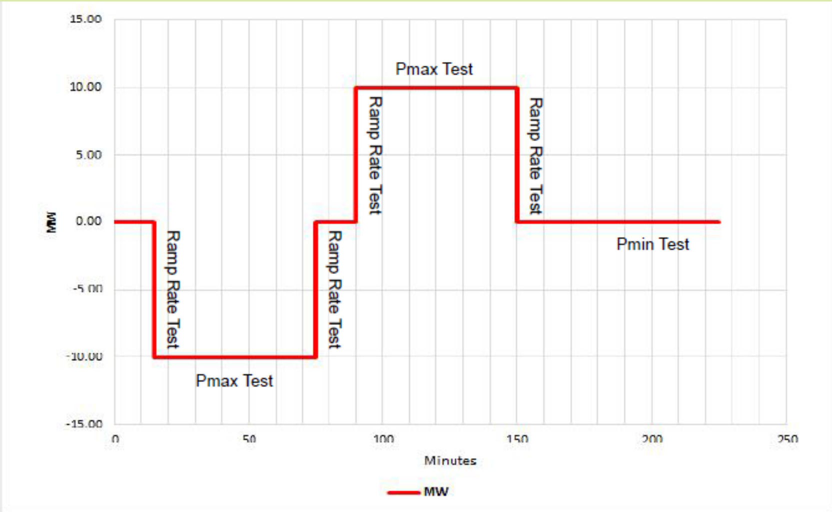
Requirement	Procedure	Passing Criteria
• Unit should demonstrate capability to be scheduled and dispatched based on its declared data and in accordance with Generation Scheduling and Dispatch parameters.	• Request clearance from RCC to conduct the test. ➢ Let the plant control operator adjust the output of the unit on its Minimum to its Maximum operating capacity. • Sustain at least 15 minutes at maximum load. If available, download the alarms and events from the event logger of the plant's/unit's control system.	• Ramp rate should be ±10% of registered ramp rate (PGC 6.10.2). • Results Required: ✓ MW/min – Ramp Rate

Generating Unit Capability Test for AES BESS (Pmax/Pmin/Ramp Rate)

The test shall have the following details:

- Request clearance from RCC to conduct the test.
- Set the BESS to Manual Mode.
- Bring the BESS State of Charge (SOC) to approximately empty.
- Sustained approximately 0% SOC for 15 minutes before conducting Ramp Rate Test.
- A -10MW (as load) is issued to the BESS. This portion of the test is used to verify BESS full capacity at -10MW performance.
- Sustained -10MW for 60 minutes to conduct Pmax Test.
- Command BESS to issue 0MW BESS. Prior to this command, conduct the Ramp-Rate Test.
- Sustained 100% SOC for 15 minutes before conducting Ramp-up Rate Test.
- A +10MW (as generator) is issued to the BESS. This portion of the test is used to verify BESS full capacity at +10MW performance.
- Sustained +10MW for 60 minutes to conduct Pmax Test.
- Before putting BESS to an approximately 0% state of charge, conduct the Ramp-Rate Test.
- Sustained the approximately 0% SOC for 15 minutes then conduct Pmin @ 0MW for 60 minutes.

Generating Unit Capability Test for AES BESS (Pmax/Pmin/Ramp Rate)



Round Trip Efficiency

energymag

Storage technologies	Round trip efficiency
Hydro	from 65% in older installations to 75-80% for modern deployments
Flywheels	80% to 90%
Batteries	75% to 90%
Electrothermal (ETES)	65% to 75%
Compressed air (CAES)	65-75%

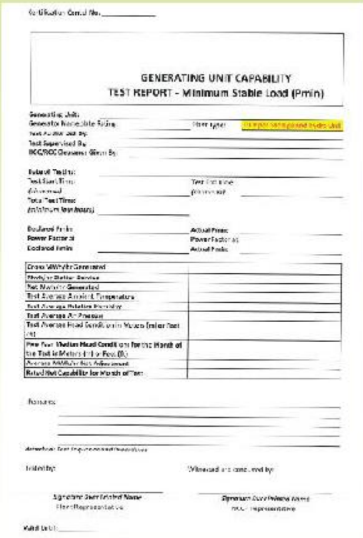
Generating Unit Capability Test – ERC Directive (Pmax, Pmin & Ramp Rate Tests)

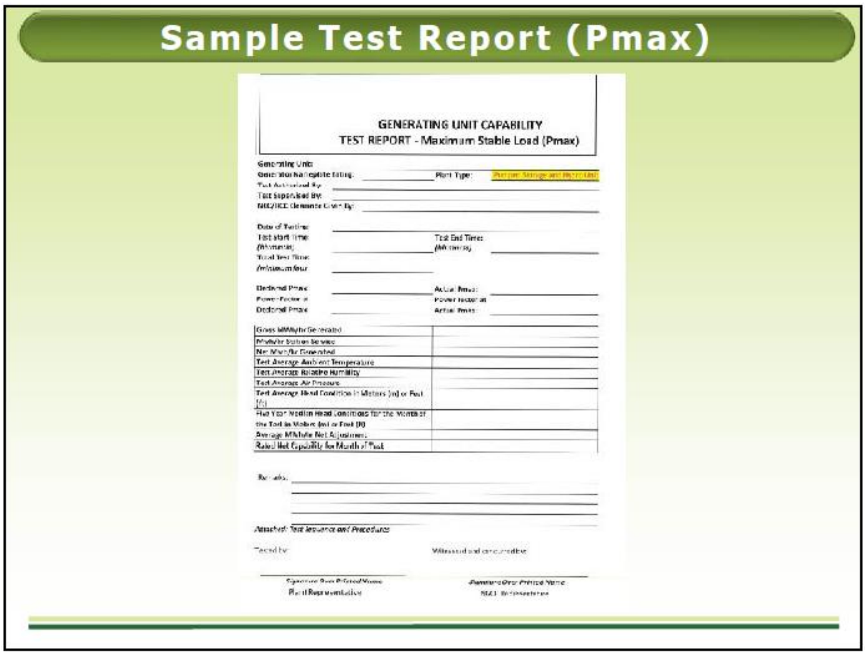
ARTICLE IV
OBLIGATIONS OF A GENERATION COMPANY

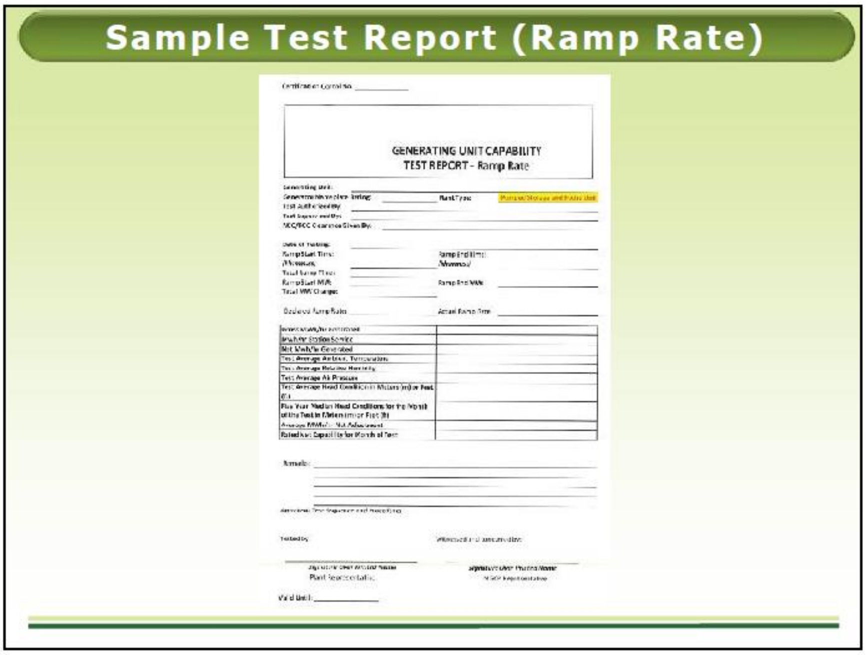
Section 10. **ERC Reportorial Requirements. –**

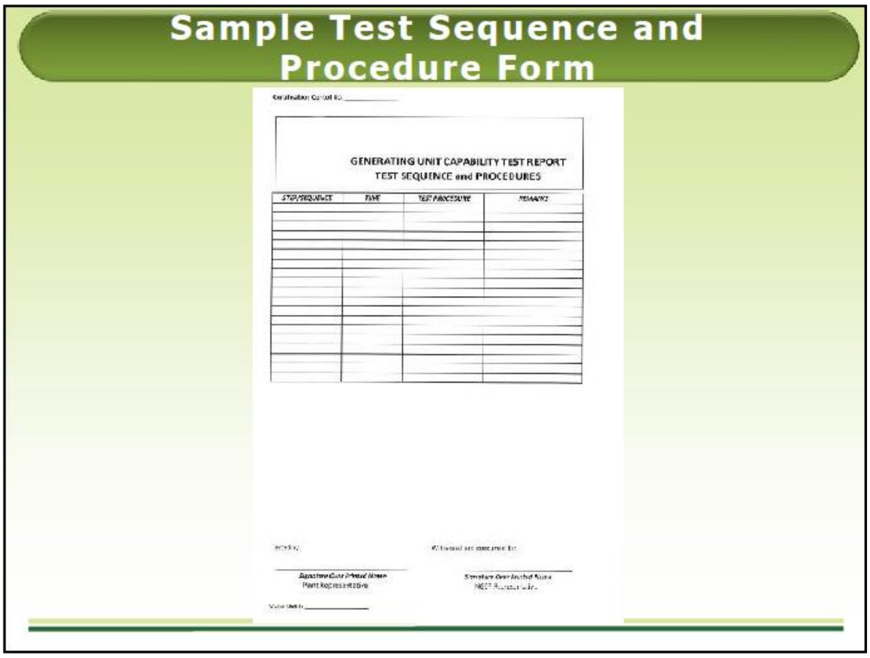
(d) A Generation Company shall inform the ERC in writing of any changes in the individual unit's registered Pmax, Pmin, Ramp Up Rate and Ramp Down Rate as provided in Section 10 (a)(iv), Article IV hereof which should be supported by capacity and performance tests conducted by a third party acceptable to the ERC. Thereafter, the Generation Company shall apply for the amendment of the technical description of its Generation Facilities.

Sample Test Report (Pmin)




Sample Test Report (Pmax)
GENERATING UNIT CAPABILITY
TEST REPORT - Maximum Stable Load (Pmax)

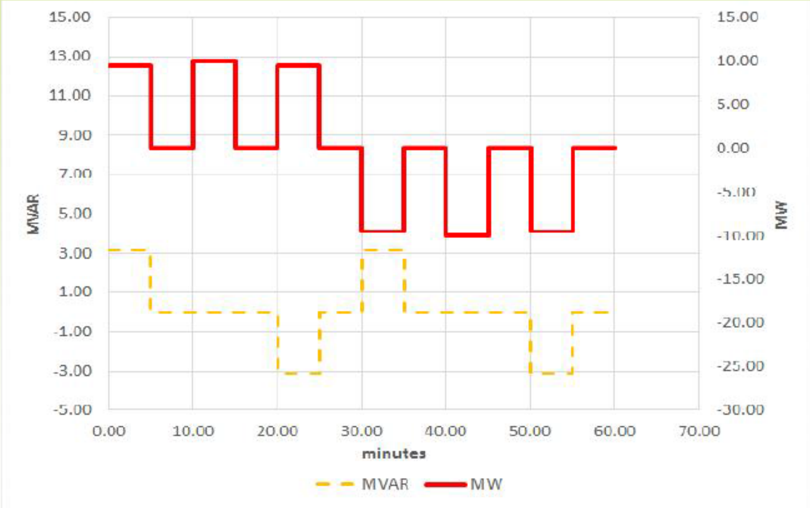

Sample Test Report (Ramp Rate)
GENERATING UNIT CAPABILITY
TEST REPORT - Ramp Rate



Reactive Power Capability

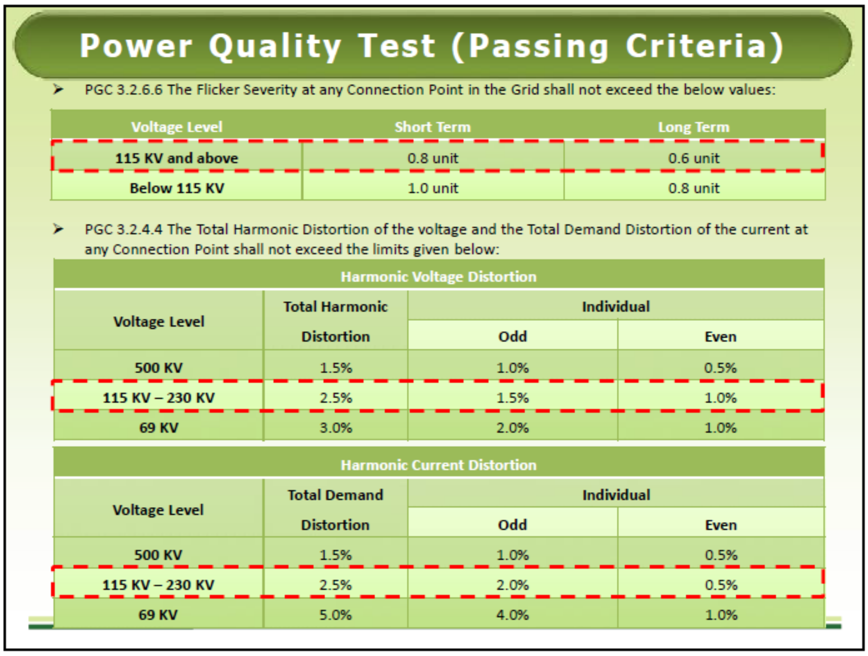
Requirement	Procedure	Passing Criteria
• BESS is capable of supplying 0.95 lag and 0.95 lead.	Pre requisite of the test: Conduct simulations as basis for the test values and the time of test to prevent voltage problem. • Request clearance from RCC to start the conduct of test. • Start from Unity Power Factor (1.0 pf). Then record initial readings. • Set the power plant controller to manual power factor mode then adjust PF in step of 0.01. 1 + 0.99 - 0.99 + 0.98 - 0.98 + 0.97 - 0.97 + 0.96 - 0.96 + 0.95 - 0.95 *-For AES BESS, propose test will be from 0.95PF (lag) to unity then 0.95PF (lead) considering the slight expected MVAR delivery or absorption.*	• At any Active Power Output Levels, the unit must be capable of continuous operation at any point between the limits of 0.95 lagging and 0.95 leading power factors (ERC Resolution 7). • Results Required: ✓ MW – Active power ✓ MVAr – Reactive power ✓ HV – High Voltage ✓ LV – Low Voltage ✓ Ambient Conditions (Temperature, Pressure), if available

Reactive Capability



Power Quality Test

Requirement	Procedure	Passing Criteria
• With the system in Normal State, upon the connection of the BESS, the Flicker severity at the Connection Point shall not exceed the values established in Article 3.2.6.6 of the PGC. • Upon the connection of BESS, the Total Harmonic Distortion (THD) of the voltage and the Total Demand Distortion (TDD) of the current at the Connection Point shall not exceed the limits established in Article 3.2.4.4 of the PGC. The maximum harmonic current injection from a BESS to the grid shall be determined as the maximum allowed harmonic current injection at the Connection Point, multiplied by the ratio of BESS Installed Capacity to the total capacity of all power generation/supply equipment with harmonic source at the Connection Point.	• Install Power Quality Analyzer (PQA) at the connection point of BESS 1 week before and after energization. • During the commissioning period, BESS will be operated under Governor Control Mode. • Evaluate the downloaded data in PQA for flicker severity and harmonics.	• Please refer to next slide



Power Quality Test (Passing Criteria)

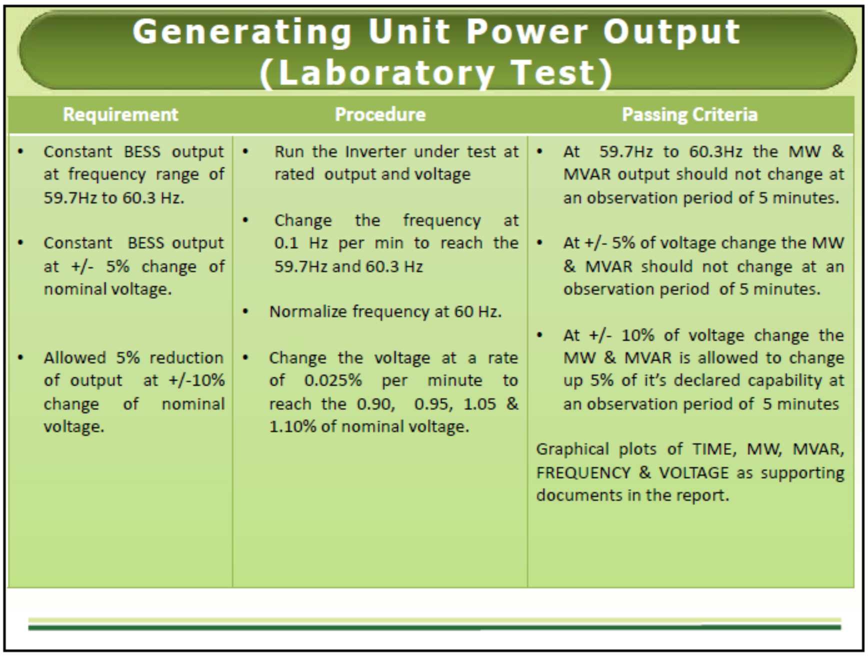
- PGC 3.2.6.6 The Flicker Severity at any Connection Point in the Grid shall not exceed the below values:

Voltage Level	Short Term	Long Term
115 KV and above	0.8 unit	0.6 unit
Below 115 KV	1.0 unit	0.8 unit

- PGC 3.2.4.4 The Total Harmonic Distortion of the voltage and the Total Demand Distortion of the current at any Connection Point shall not exceed the limits given below:

Harmonic Voltage Distortion			
Voltage Level	Total Harmonic Distortion	Individual	
		Odd	Even
500 KV	1.5%	1.0%	0.5%
115 KV – 230 KV	2.5%	1.5%	1.0%
69 KV	3.0%	2.0%	1.0%

Harmonic Current Distortion			
Voltage Level	Total Demand Distortion	Individual	
		Odd	Even
500 KV	1.5%	1.0%	0.5%
115 KV – 230 KV	2.5%	2.0%	0.5%
69 KV	5.0%	4.0%	1.0%



Generating Unit Power Output (Laboratory Test)

Requirement	Procedure	Passing Criteria
• Constant BESS output at frequency range of 59.7Hz to 60.3 Hz. • Constant BESS output at +/- 5% change of nominal voltage. • Allowed 5% reduction of output at +/-10% change of nominal voltage.	• Run the Inverter under test at rated output and voltage • Change the frequency at 0.1 Hz per min to reach the 59.7Hz and 60.3 Hz • Normalize frequency at 60 Hz. • Change the voltage at a rate of 0.025% per minute to reach the 0.90, 0.95, 1.05 & 1.10% of nominal voltage.	• At 59.7Hz to 60.3Hz the MW & MVAR output should not change at an observation period of 5 minutes. • At +/- 5% of voltage change the MW & MVAR should not change at an observation period of 5 minutes. • At +/- 10% of voltage change the MW & MVAR is allowed to change up 5% of it's declared capability at an observation period of 5 minutes Graphical plots of TIME, MW, MVAR, FREQUENCY & VOLTAGE as supporting documents in the report.

Generating Unit Power Output (Sample Data)

Condition setting			Measured Parameters			
Grid FREQ	Inverter Output	PF	Active Power	Tested PF	Reactive Power	Apparent Power
59.7	10% Rated Power	Lagging0.95	62.990	0.94634	21.499	66.542
		1	62.955	0.98304	11.706	64.046
		Leading0.95	62.983	0.95004	-20.691	66.296
	70% Rated Power	Lagging0.95	443.062	0.95539	136.905	463.748
		1	441.937	0.99930	7.775	442.248
		Leading0.95	439.600	0.95139	-142.268	462.061
60	10% Rated Power	Lagging0.95	63.585	0.94624	21.732	67.198
		1	63.774	0.98289	11.937	64.885
		Leading0.95	63.519	0.95474	-19.786	66.530
	70% Rated Power	Lagging0.95	443.133	0.94677	147.519	467.058
		1	442.271	0.99927	7.929	442.595
		Leading0.95	442.399	0.94925	-146.537	466.049
60.3	10% Rated Power	Lagging0.95	63.855	0.94597	21.885	67.503
		1	63.779	0.98257	12.057	64.910
		Leading0.95	63.488	0.95381	-19.994	66.563

Frequency Withstand Capability (Laboratory Test)

Requirement	Procedure	Passing Criteria
• Continuous operation range of 58 Test values of F F = > 61.8-62.4 F = > 62.4 Hz F = 57.6 - < 58. F = < 57.6 Hz		BESS should onnection is and beyond n is allowed onnection is s and below is allowed W, MVAR & documents

Frequency		Time
Hz	P.U.	
>62.4	>1.04	Automatic disconnection allowed, if so decided by the BESS operator
>61.8 – 62.4	>1.04 – 1.04	5 minutes
58.2 – 61.8	0.97 – 1.03	Continuous operation (Test for 58.2Hz, 60Hz and 61.8Hz will be sustained for at least 5 minutes prior to recording).
57.6 - <58.2	0.96 - <0.97	60 minutes
<57.6	<0.96	5 seconds

Performance During Network Disturbances (Laboratory test)

Requirement	Procedure	Passing Criteria
• For BESS, a voltage sag at connection point = 0.0pu (150ms), 0.30pu (600ms) and 0.90pu (3s). • No absorption of reactive power during fault and recovery period.	• Run the Inverter under test at rated output and voltage . • Change the voltage at the connection point as per PGC requirement.	• For BESS, at zero voltage, 0.30pu and 0.90pu the inverter should not disconnect at t = 150ms, 600ms and 3000ms, respectively. • Graphical plots of TIME, MW, MVAR & VOLTAGE as supporting documents.

Performance During Network Disturbances (Laboratory test)

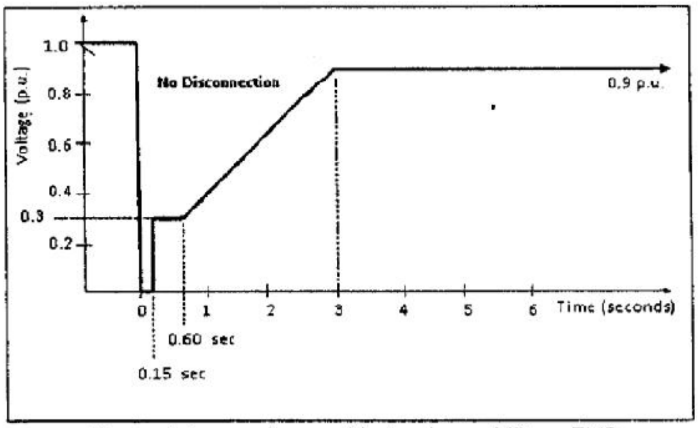
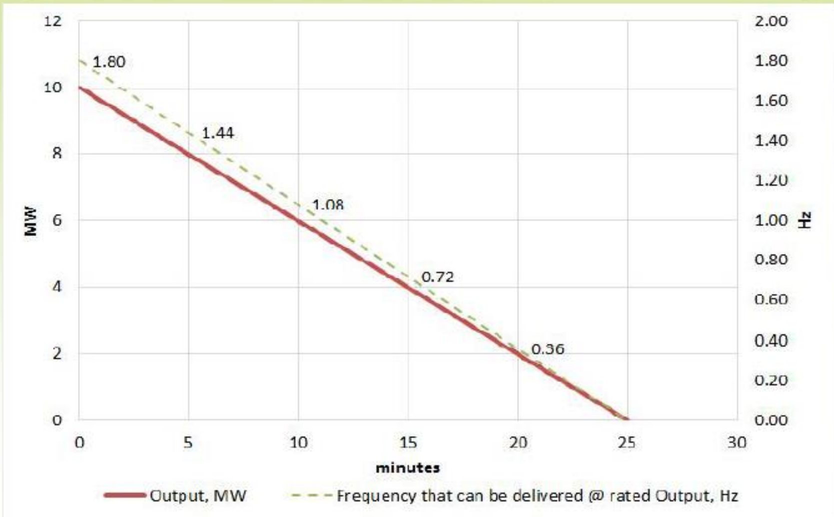


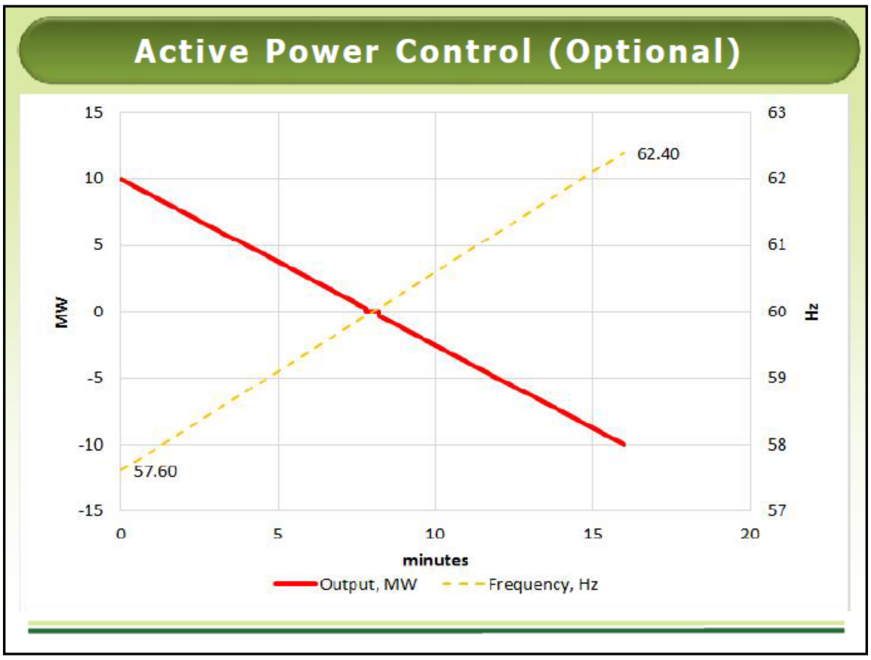
Figure 4: Low voltage withstand capability – PVS

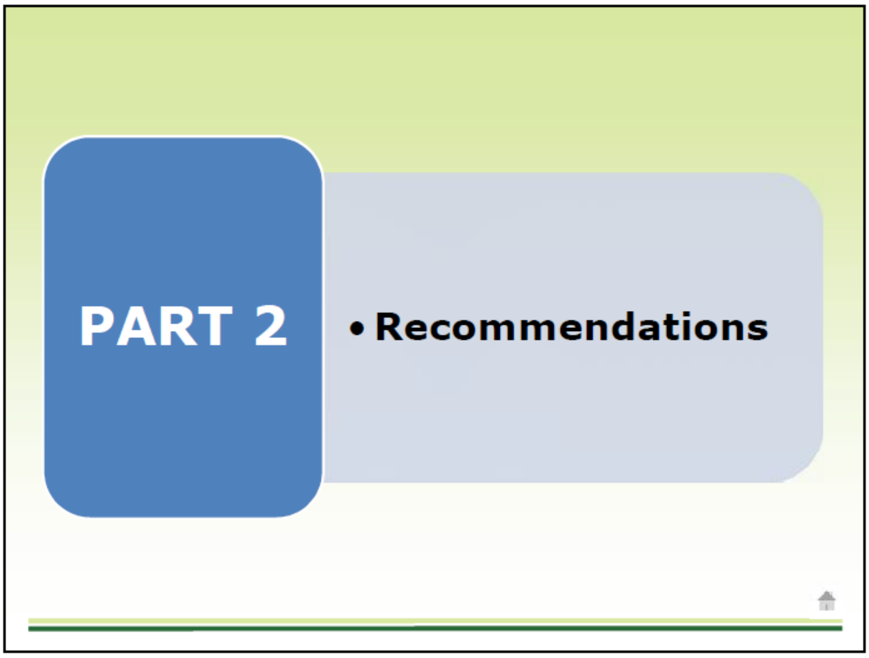
Active Power Control (Optional)

Requirement	Procedure	Passing Criteria
Active power regulation at frequency range of 59Hz to 61Hz. Active power control modes: • Active power constraint (set points) • Active power gradient (ramps)	• Request clearance from RCC to conduct the test. • Set the control mode to Active power constraint (set point) and reduce the output in step 20% reduction then increase back to the pre test value. Record the values every time set point was attain. • Change the control mode to Active power gradient (ramps) then adjust the output and record the pre and post MW value to check the desired minimum ramp rate. • Disable the Active power control by returning to free active power production.	• For active power constraints and active power gradient the changed should commenced after 2 secs and completed not later that 30 secs (ERC Resolution 7). • Results Required: ✓ MW – Active power ✓ MVAr – Reactive power ✓ HV – High Voltage ✓ LV – Low Voltage ✓ Ambient Conditions (Temperature, Pressure), if available

Active Power Control (Optional)




Active Power Control (Optional)
MW
Hz
62.40
57.60
minutes
Output, MW
Frequency, Hz


PART 2
• Recommendations

Recommendations

- **Seek approval from GMC on the proposed test requirements of BESS (grid compliance).**
- **To formulate a separate test requirement of BESS for its certification as Frequency Control Ancillary Service.**

Frequency Regulation Ancillary Service Accreditation Test Protocol

1. The Frequency Regulation (FR) Test (i.e. Regulating Reserve) shall be performed with the objective of confirming that the BESS is able to provide an output power change in response to frequency deviations, within ±1% of the expected response within 5 seconds.
2. The FR Test conditions to be considered for the BESS shall be the following:
    1. Speed droop setting: 1%
    2. Dead band setting: ±0.06 Hz
3. The BESS shall be allowed to charge and discharge to regulate the state of charge if the system frequency is within the deadband. Let the BESS operator adjust the output of the unit to 50% of regulating range and set the unit on Governor Control Mode (GCM). Take note of the unit's frequency deadband of ±0.06 Hz.
4. The BESS shall be connected to the grid and run freely for 24 hours for each condition.
5. During the test, NGCP will record the real power output (charge/discharge) every second.
6. The BESS shall be deemed to have passed the FR Test if the objective of the Test in item 1 above has been satisfied. There shall be 90 qualified samples in analyzing the GCM response. Samples shall be taken every 5 seconds. For a single sample, the generating unit shall establish 80% or higher response with respect to the speed droop setting otherwise failed. Out of gathered samples, at least 90% shall be in compliance with the latter criteria otherwise failed.

B.2. TC Correspondences

a. TC-RSTR-2014-02 "RCC Request for Assistance"

ANNEX 'A'

Philippine Electricity Market Corporation

TC-RSTR FORM A

TC-RSTR-20[14]-[02]

REQUEST FOR TECHNICAL STUDY/REVIEW

Requests made only under this prescribed form shall be accepted and considered as submitted.

This request for technical study or review can be submitted to:

TECHNICAL COMMITTEE
Thru: **Market Assessment Group**
Philippine Electricity Market Corporation
18/F Robinsons Equitable Tower
ADB Avenue, Ortigas Center
Pasig City, 1605 Philippines
Email addresses: mag@wesm.ph
Fax Number: (+632) 395-2704

I. Requesting Party

Name	Rowena Cristina L. Guevara
Designation	Chairperson , Rules Change Committee
Signature	[signature]
Company	c/o Philippine Electricity Market Corporation (PEMC)
Company Address	18th Floor, Robinsons Tower, ADB Avenue, Ortigas Center, Pasig City
Telephone Number	c/o Market Assessment Group, PEMC - 02-261-8734
Fax. No.	c/o Market Assessment Group, PEMC - 02-395-2704
Email address	gev@eee.upd.edu.ph; gevguevara@gmail.com

II. Request Information

Topic : Request for Assistance in Determining Classification of Battery Energy Storage System
Nature of Request*(please indicate with **x**)* ☐ Rule/ Manual Review ☐ Incidents/Case Study ☐ Position Paper ☒ Others Please Specify : Request for Classification of Battery Energy Storage System
Details of the Request: *Please provide the purpose, scope and details of the study/review. Attach supporting documents if any. Use additional sheets if necessary.* As a background, the AES Proposed amendments to relevant sections of the WESM Rules to provide a distinction between a Generation Company certified as Ancillary Service Provider and a purely Ancillary Services Provider, such as the Grid Energy Storage System, in submitting offers for energy and reserve. The Proposal widens the scope of Participants that can submit reserve offers. The Proposal went through the usual RCC processes. During the RCC's discussion of the proposal, the RCC noted that the Battery Energy Storage System (BESS) can only operate at a maximum of 30 minutes to address primarily the frequency problem encountered in the grid. It was likewise noted that the BESS has a fast response but can sustain provision of its capacity only for a limited time. However, during said RCC deliberations on the matter, issues were also identified by the RCC relative to the Proposal, among others, the classification of the Grid Energy Storage System or the Battery Energy Storage System of the AES. Noting that there was no consensus on how the same can be classified, the RCC agreed to defer its decision on the Proposal and first seek the TC's assistance in identifying how such technology can be classified based on the provisions under the WESM Rules and the Grid Code. The RCC acknowledges that new technologies such as the Grid Energy Storage Systems may contribute in enhancing the capacity for reserve and energy in the Market and thus should be given a chance to participate in the Market. However, the RCC at the moment cannot make a decision on the AES' Proposal until we are able to ascertain the identity of such technology type. In this regard, the RCC herein submits this request to the TC for the appropriate classification of such technology.

ANNEX 'A'

Urgent Request : ☒Yes☐No

Date Received by MAG:

Philippine Electricity Market Corporation

For MAG use only

TC-RSTR FORM B

TC-RSTR-20[14] [07]

Date of Endorsement to the TC: OCT 16 2014 - HADD

Actions Taken By TC:
TC Resolutions:

Philippine Electricity Market Corporation

15 October 2014
COR-INT-RCC-14-24

MEMORANDUM

HADD
OCT 16 2014

To	:	**The WESM Technical Committee**
Thru	:	**Chrysanthus S. Heruela**, VP-- PEMC-MAG
From	:	**The Rules Change Committee**
Subject	:	**Request for Assistance in Determining Classification of the Battery Energy Storage System**

The Rules Change Committee (RCC) is writing with reference to the Proposal for Amendments to the WESM Rules on Generation Company Reserve Offers/ Battery Energy Storage System as received by the RCC from AES Philippines.

As a background, the AES Proposed amendments to relevant sections of the WESM Rules to provide a distinction between a Generation Company certified as Ancillary Service Provider and a purely Ancillary Services Provider, such as the Grid Energy Storage System, in submitting offers for energy and reserve. The Proposal widens the scope of Participants that can submit reserve offers.

The Proposal went through the usual RCC process. However, during the RCC's deliberations on the matter, issues were identified by the RCC relative to the Proposal, among others, the classification of the Grid Energy Storage System or the Battery Energy Storage System of the AES. Noting that there was no consensus on how the same can be classified, the RCC agreed to defer its decision on the Proposal and first seek the TC's assistance in identifying how such technology can be classified based on the provisions under the WESM Rules and the Grid Code.

The RCC acknowledges that new technologies such as the Grid Energy Storage Systems may contribute to enhancing the capacity for reserve and energy in the Market and thus should be given a chance to participate in the Market. However, the RCC at the moment cannot make a decision on the AES' Proposal until we are able to ascertain the identity of such technology type. With this, we hope that the TC can assist the RCC in this regard.

Attached herewith are the matrix of the AES' Proposal and the discussion paper on the matter, as well as its presentation to the RCC, for your reference.

Thank you.

For the Rules Change Committee,

Dr. Rowena Cristina L. Guevara
Chairperson

Wholesale Electricity Spot Market

WESM-WR-CN-_____

REQUEST FOR WESM RULES AMENDMENTS

Proposals made only under this prescribed form shall be accepted and considered as submitted.

This request for amendments to the WESM Rules can be submitted to:

PEM Board
Attention: **PEM Committee Secretariat**
Philippine Electricity Market Corporation
18/F Robinsons Equitable Tower
ADB Avenue, Ortigas Center
Pasig City, 1605 Philippines
Email addresses: rcc@wesm.ph
Fax Number: (+632) 395-2704

I. Proposer's Information

Name	**GONZALO B. JULIAN, JR.**
Designation	DIRECTOR, MARKETS
Company	AES PHILIPPINES, INC.
Company Address	18TH Floor, Bench Tower Building, Rizal Drive, Cor 30th St.
	Bonifacio Global City
Telephone No.	+6324592649
Fax. No.	+6324592695
Email Address	gonzalo.julian@aes.com

II. WESMRules Amendment Information

Topic : PROPOSAL AMENDMENT ON THE GENERATION COMPANY RESERVE OFFERS

Nature of Request (please indicate with **x**)

III. Proposed Amendment

Title	Section	Provision	Proposed Amendment	Rationale
3.5 SUBMISSION OF OFFERS, BIDS, AND DATA	**3.5.7 Generation Company Reserve Offers**	3.5.7 Generation Company Reserve Offers	3.5.7 ~~Generation Company~~ **Ancillary Services Provider** Reserve Offers	The existing provisions only allows the **Scheduled Generator and/or Generation Company** to submit a reserve offer. To acknowledge the technical limitation of facilities like Grid Energy Storage System (i.e. Battery Energy Storage System, Compressed Air Energy Storage System, Flywheel Energy Storage System, Pumped-Storage Hydroelectricity, etc.) in dispatching energy on a continuous basis that will result to non-compliance to energy RTD which means these technologies are technically incapable of being Scheduled Generators. Thus, allowing such technologies to offer their capacities to Ancillary Services (i.e. Reserve Market) only but not to energy.

Title	Section	Provision	Proposed Amendment	Rationale
3.5 SUBMISSION OF OFFERS, BIDS, AND DATA	**3.5.7 Generation Company Reserve Offers**	3.5.7.2 When applicable, subject to clause 3.3.4.2, each *Scheduled Generator* registered as an *Ancillary Services Provider* in respect of a *reserve facility* in a particular *reserve region* shall submit a standing *reserve offer* for each of its relevant *reserve facilities* in respect of that *reserve region* for each *trading interval* for each day of the week in accordance with the *timetable*.	3.5.7.2 When applicable, subject to clause 3.3.4.2, each ~~*Scheduled Generator*~~ **of the** registered ~~as an~~ *Ancillary Services Provider* in respect of a *reserve facility* in a particular *reserve region* shall submit a standing *reserve offer* for each of its relevant *reserve facilities* in respect of that *reserve region* for each *trading interval* for each day of the week in accordance with the *timetable*.	
3.5 SUBMISSION OF OFFERS, BIDS, AND DATA	**3.5.7 Generation Company Reserve Offers**	3.5.7.3 Each *reserve offer* submitted by a *Generation Company* under clause 3.5.7.2 shall: (a) Correspond to response capability of the relevant *reserve facility* which has been certified as meeting the relevant reserve response standards, for that *reserve facility category,* in accordance with the *Grid Code and Distribution Code;* and (b) Include the information specified in Appendix A1.2.	3.5.7.3 Each *reserve offer* submitted by ~~a *Generation Company*~~ **an Ancillary Services Provider** under clause 3.5.7.2 shall: (a) Correspond to response capability of the relevant *reserve facility* which has been certified as meeting the relevant reserve response standards, for that *reserve facility category,* in accordance with the *Grid Code and Distribution Code;* and (b) Include the information specified in Appendix A1.2.	

Title	Section	Provision	Proposed Amendment	Rationale
3.5 SUBMISSION OF OFFERS, BIDS, AND DATA	**3.5.7 Generation Company Reserve Offers**	3.5.7.4 *Generation Company* registered as an *Ancillary Services Provider* in respect of a *reserve facility* shall, in consultation with the *System operator*, submit check data to be used by the *Market Operator*, in accordance with clause 3.5.12, to assist in determining the validity of any *reserve offer* which it submits.	3.5.7.4 ~~*Generation Company* registered as an~~ **<u>A registered</u>** *Ancillary Services Provider* in respect of a *reserve facility* shall, in consultation with the *System operator*, submit check data to be used by the *Market Operator*, in accordance with clause 3.5.12, to assist in determining the validity of any *reserve offer* which it submits.	
APPENDIX A1. INFORMATION TO BE SUPPLIED WITH OFFERS TO SUPPLY AND TO BUY ELECTRICITY	**Appendix A1.2 Reserve Offers "Regulating Reserve"**	Regulating *reserve offers* from Generators shall consist of:	Regulating reserve offers from ~~Generators~~ **<u>Ancillary Services Providers</u>** shall consist of:	
APPENDIX A1. INFORMATION TO BE SUPPLIED WITH OFFERS TO SUPPLY AND TO BUY ELECTRICITY	**Appendix A1.2 Reserve Offers "Regulating Reserve"**	(e) Monotonically increasing prices starting from zero for the first offer block, which shall correspond to the mandatory *reserve* capability required from that *Generation Company* under its connection agreement; and	(e) Monotonically increasing prices starting from zero for the first offer block, which shall correspond to the mandatory *reserve* capability required from that ~~*Generation Company*~~ **<u>Ancillary Services Provider</u>** under its connection agreement; and	

Title	Section	Provision	Proposed Amendment	Rationale
APPENDIX A1. INFORMATION TO BE SUPPLIED WITH OFFERS TO SUPPLY AND TO BUY ELECTRICITY	**Appendix A1.2 Reserve Offers "Contingency Reserve"**	Contingency *reserve offers* from Generators shall consist of:	Contingency reserve offers from ~~Generators~~ **Ancillary Services Providers** shall consist of:	
APPENDIX A1. INFORMATION TO BE SUPPLIED WITH OFFERS TO SUPPLY AND TO BUY ELECTRICITY	**Appendix A1.2 Reserve Offers "Contingency Reserve"**	(e) Monotonically increasing prices starting from zero to the first offer block, which shall correspond to the mandatory *reserve* capability required from that *Generation Company* under its connection agreement.	(e) Monotonically increasing prices starting from zero to the first offer block, which shall correspond to the mandatory *reserve* capability required from that ~~*Generation Company*~~ **Ancillary Services Provider** under its connection agreement.	

Note: For convenience, please underline and put in bold letters the proposed changes to the WESM Rules.

IV. Referral

Date Received by MAG : ____________________

Proposed Amendment: ☐ Urgent ☐ Minor ☐ General

A. For Urgent Amendment (For the use of PEMC President only)

Date Referred to PEMC President	
Certifies as urgent	☐Yes ☐No
Convene the RCC within 48 Hrs.:	☐Yes☐No
Remarks:	

B. For Minor and General Amendment (For the use of RCC only)

Date Referred to RCC:	
Remarks:	

Action taken:	
Request for comments:	☐ Yes ☐ No
	Request written comments from: ☐ DRG ☐ MSC ☐ PA ☐ TC ☐ MO ☐ ECO ☐ MAG ☐ Other PEM Board Committees ☐ Other Interested Parties
For further review of the Technical Sub-Committee/s:	☐ Yes Assigned to: ☐ SO Sub-Committee ☐ MO Sub-Committee ☐ Metering Sub-Committee ☐ Billing and Settlement Sub-Committee ☐ Legal and Regulatory Sub-Committee
	☐ No
For public consultation:	☐ Yes ☐ No
RCC Resolution:	☐ Approved ☐ Disapproved
RCC Resolution Number:	
Date of Resolution:	
RCC Meeting No.:	
Date of endorsement to the PEM Board:	

Wholesale Electricity Spot Market

PROPOSAL AMENDMENT ON THE GENERATION COMPANY RESERVE OFFERS

AES Philippines, Inc.

[July 1, 2014]

I. SUMMARY OF THE PROPOSED RULES CHANGE

The AES Philippines, Inc. proposes amendments to the WESM Rules to have a distinction between a Generation Company certified as an Ancillary Services Provider and a purely Ancillary Services Provider such as the Grid Energy Storage System in submitting offers for energy and reserve. This will acknowledge the technical limitation of the Grid Energy Storage System in the WESM in view of the directive of the Department of Energy ("**DOE**") in its Department Circular ("**DC**") No. DC 2010-06-0007 "Preparations for the Trading of Ancillary Services in the WESM".

II. BACKGROUND

The WESM Rules under section 3.5.7 "Generation Company Reserve Offers" only allows Generation Company and/or Scheduled Generators to submit Reserve Offer. A registered Generation Company pursuant to WESM Rules section 2.3.1 "Generation Company" shall submit Energy Offer pursuant to WESM Rules section 3.5.5 "Generation Offers and Data" and if a Generation Company is also certified as an Ancillary Services Provider pursuant to WESM Rules section 2.3.5 "Ancillary Services Provider" shall also submit Reserve Offer. Thus, submitting an Energy Offer alongside its Reserve Offer. A registered Generation Company meanwhile which is not a registered Ancillary Services Provider shall only submit an Energy Offer. A mechanism or rule should also be established for a registered Ancillary Services Provider only (not a registered Generation Company/Scheduled Generator) to submit Reserve Offer only.

Emerging technologies such as Grid Energy Storage System, provide a valuable augmentation of today's need for Ancillary Services. However, such technologies have a technical limitation to continuously dispatch energy which will result to non-compliance to Energy Real-Time Dispatch if scheduled based on the result of the Market Dispatch Optimization Model (MDOM). In view of the abovementioned technical limitation, to optimize the capabilities of such technologies, given that a certain facility is certified by the System Operator and Market Operator pursuant to section 2.3.5 "Ancillary Services Provider", Grid Energy Storage System shall be allowed not to provide an Energy Offer while participating in the Reserve Market.

III. THE PROPOSED RULES CHANGE

The WESM Rules require an independent registration for a grid-connected facility/trading participant to be a Generation Company/Scheduled Generator and/or Ancillary Services Provider. Thus, imparting that an Ancillary Services Provider may or may not be a registered Generation Company/Scheduled Generator. Emerging technologies like Grid Energy Storage System registered as Ancillary Services Provider pursuant to WESM Rules section 2.3.5 "Ancillary Services Provider" may or may not be registered as a Generation Company/Scheduled Generator pursuant to WESM Rules under section 2.3.2 "Generation Company" bound by the germane technical limitation of the technology.

The proposed amendment widens the scope of the participants that can submit reserve offers. The existing WESM Rules under sections: ***(1st) 3.5.7.2*** *"When applicable, subject to clause 3.3.4.2, each Scheduled Generator registered as an Ancillary Services Provider in respect of a reserve facility in a particular reserve region shall submit a standing reserve offer for each of its relevant reserve facilities in respect of that reserve region for each trading interval for each day of the week in accordance with the timetable.",* ***(2nd) 3.5.7.3*** *"Each reserve offer submitted by a Generation Company under clause 3.5.7.2 shall: (a) Correspond to response capability of the relevant reserve facility which has been certified as meeting the relevant reserve response standards, for that reserve facility category, in accordance with the Grid Code and Distribution Code; and (b) Include the information specified in Appendix A1.2.", and* ***(3rd) 3.5.7.4*** *Generation Company registered as an Ancillary Services Provider in respect of a reserve facility shall, in consultation with the System operator, submit check data to be used by the Market Operator, in accordance with clause 3.5.12, to assist in determining the validity of any reserve offer which it submits.",* only allow Scheduled Generators and/or Generation Company registered under WESM Rules section 2.3.1 "Generation Company" that is also registered as Ancillary Services Provider pursuant to section 2.3.5 "Ancillary Services Provider" of the WESM Rules, to submit Reserve Offer. The proposed amendment will allow emerging technologies such as the Grid Energy Storage System registered as Ancillary Services Provider pursuant to WESM Rules under section 2.3.5 "Ancillary Services Provider", to participate in the Reserve Market but not in the Energy Market.

Generally, the proposed amendment effectively replaces the *Generation Company, Scheduled Generator, and Generator* with **Ancillary Services Provider** in the sections 3.5.7, 3.5.7.2, 3.5.7.3, 3.5.7.4, and Appendix A1.2 to capture the provisions to apply to a registered Ancillary Services Provider only.

IV. BACKGROUND AND DESCRIPTION OF THE PROPONENT

The proponent is the AES Philippines, Inc. As one of the world's leading power companies, AES owns and operates a diverse and growing portfolio of generation and distribution businesses that serves 100 million people worldwide. In the Philippines, the company started in April 2008 with the acquisition of the 600-megawatt coal-fired thermal power plant in Masinloc, Zambales.

It now supplies its 600-MW capacity to distribution utilities (private utilities and electric cooperatives), large industrial end-users, and the wholesale electricity spot market (WESM) in Luzon. It is able to provide safe and reliable supply to both wholesale and retail customers who also benefit from programs that AES Philippines uniquely provides.

AES Corporation through its subsidiary AES Energy Storage has the technology to provide emissions-free capacity to improve the performance and reliability of today's power grid in the form of Battery Energy Storage System (BESS). We are currently conducting a study to build a BESS in our Masinloc, Zambales plant. This technology is efficient and has the fastest operating reserve response for frequency regulation and contingency reserve as well. It can also provide support for the integration of renewable energy sources into the grid.

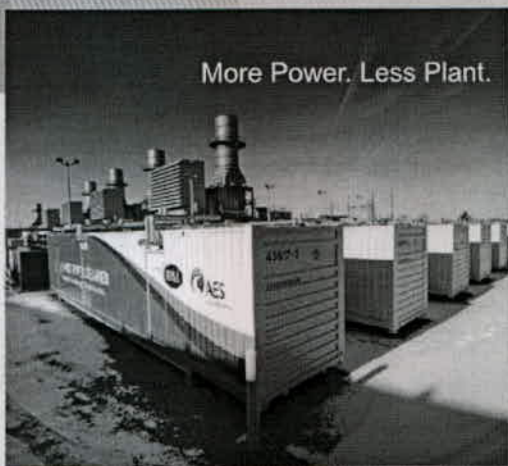
V. CONCLUSIONS AND RECOMMENDATIONS

The existing provisions on WESM Rules under section 3.5.7 "Generation Company Reserve Offers" only allow Generation Company/Scheduled Generator registered as Ancillary Services Provider to submit a Reserve Offer alongside its Energy Offer. The proposed amendments acknowledges the technical limitation of facilities like Grid Energy Storage System (i.e. Battery Energy Storage System, Compressed Air Energy Storage System, Flywheel Energy Storage System, Pumped-Storage Hydroelectricity, etc.) in dispatching energy on a continuous basis that will result to non-compliance to energy RTD which means these technologies are technically incapable of being Scheduled Generators. Thus, allowing such technologies to offer their capacities to Ancillary Services (i.e. Reserve Market) only but not to energy.

VI. REFERENCES

WESM Rules
DC 2010-06-0007

AES
we are the energy



AES Battery Energy Storage (BES)

RCC Presentation

August 2014

Topics

1. Service capabilities and added benefits
2. AES's experience with energy storage
3. Services and project preview

BES is a smart alternative with added benefits

Ancillary services Provides safe, reliable and secure balancing of energy on the grid.

Reserve capacity Sell more power from the same plant when you let BES meet your reserve requirement.

Operational flexibility Acts as both generation and load to enable more than twice the flexible range of a peaker plant on the same interconnection.

Resource adequacy Always available, helping load serving entities to meet system and local capacity requirements.

Energy Can meet peak energy demands by storing cleaner, more efficient off-peak energy and delivering it during peak periods.

Demand response Provides clean, cost-effective, reliable power from a grid-dedicated resource

Energy efficiency Designed with the ability to tap into existing unused capacity from efficient combined cycle power plants and renewables. Utilities can make their power procurement more energy efficient by adding BES to their mix.

Emissions reduction No direct emissions, no water usage, BES is a clean alternative.

Renewable integration Can help level the variability of all generators and demands on the grid.

Transmission/Distribution efficiency Allows it to be sited closer to load (modular and no local emissions), reducing the need for transmission and distribution build out in congested areas while improving local reliability.

24x7x365 service Always on and synchronized to the grid with no minimum set point and no fuel requirement allowing it to deliver value every day.

AES serves utility markets with around 200 MW of power plant grid scale equivalent resource serving globally recognized customers

Customers: pjm bhpbilliton SQM KGHM Teck

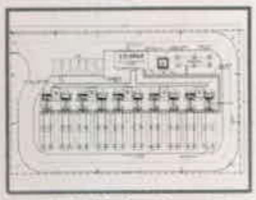
Chile

AES Carina @ IPL
World's first grid Lithium-ion battery
Feb 2008

USA

24 MW Los Andes, Chile
2009

40 MW Angamos, Chile
2012



40 MW Cochrane
(Approved)
2015 COD

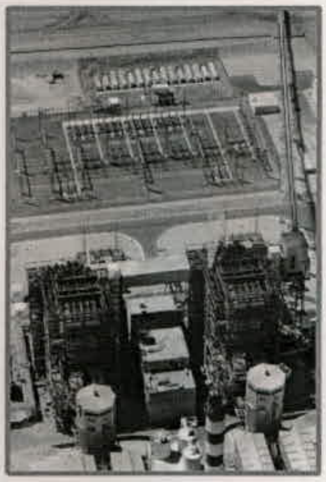
16 MW Johnson City, NY
2010

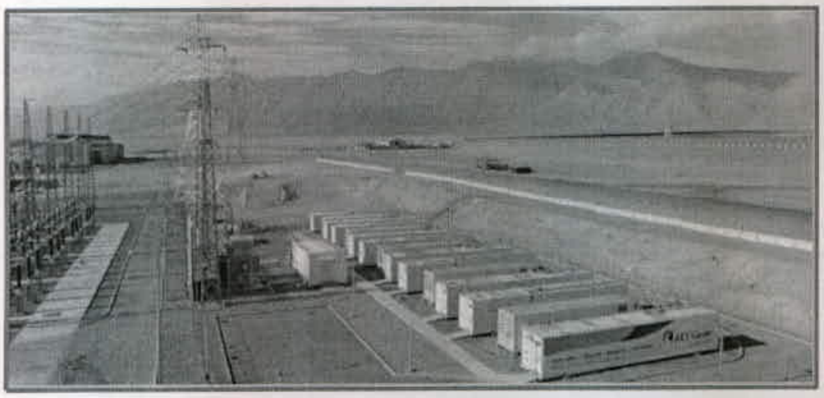
64 MW Laurel Mtn, WV
2011

40 MW, Dayton Ohio
Sep 2013

Storage providing spinning reserves in N. Chile since 2009, Los Andes and Angamos (64MW total resource)

Angamos in 2012: Winner of the Edison International Award and "Plant of the Year" by Power magazine.

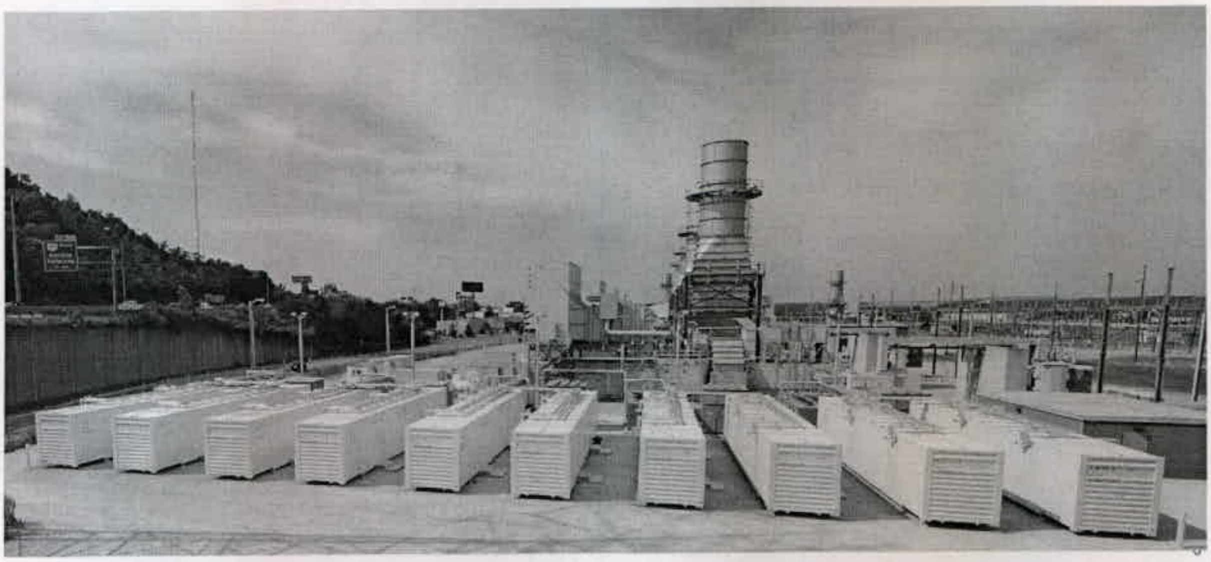




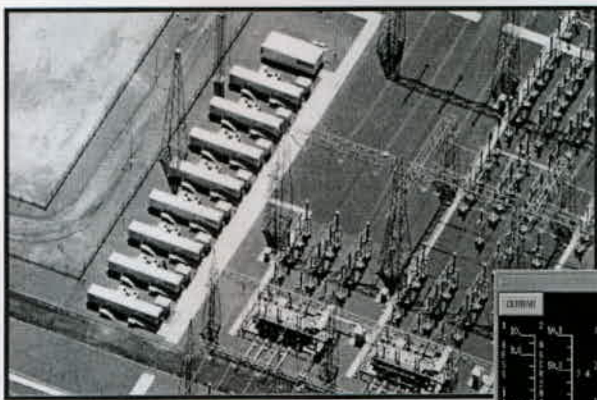
Tait: 40 MW of Frequency regulation reserves serving PJM Interconnection markets

Frequency Regulation	
COD:	Sep-2013
Size:	40 MW
Revenue Model:	Freq Reg. ($/MW-Hr)
Equivalent Availability:	97%

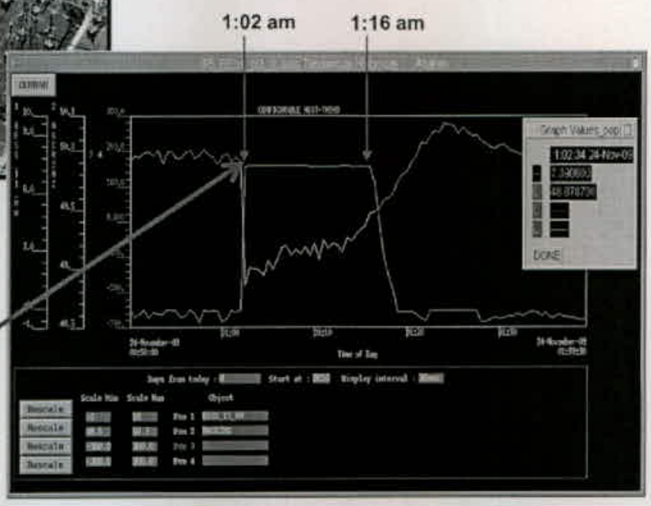
- Frequency Regulation resources
- Operating range of +20MW to -20MW
- Precise response to 4 second AGC
- 800,000 Battery Cells
- Location: Ohio, USA



Synchronized Reserve: 12 MW Los Andes in isolated Chile grid is among the most reliable reserve resources



Capacity Release for Generators	
COD:	Dec-2009
Size:	12 MW
Revenue Model:	94 GWh/year
Commercial Availability:	100%

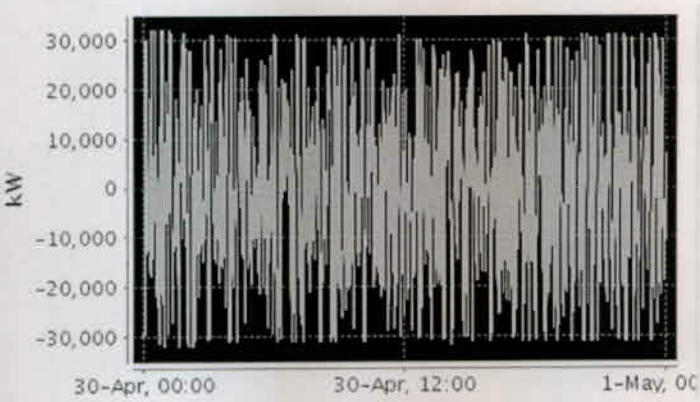


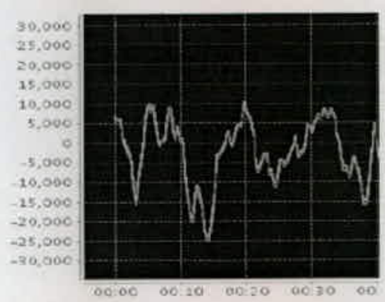
Loss of 200 MW in SING: November 24th

Pre-programmed digital response when frequency dropped below 50 Hz

Effectively providing simulated inertia

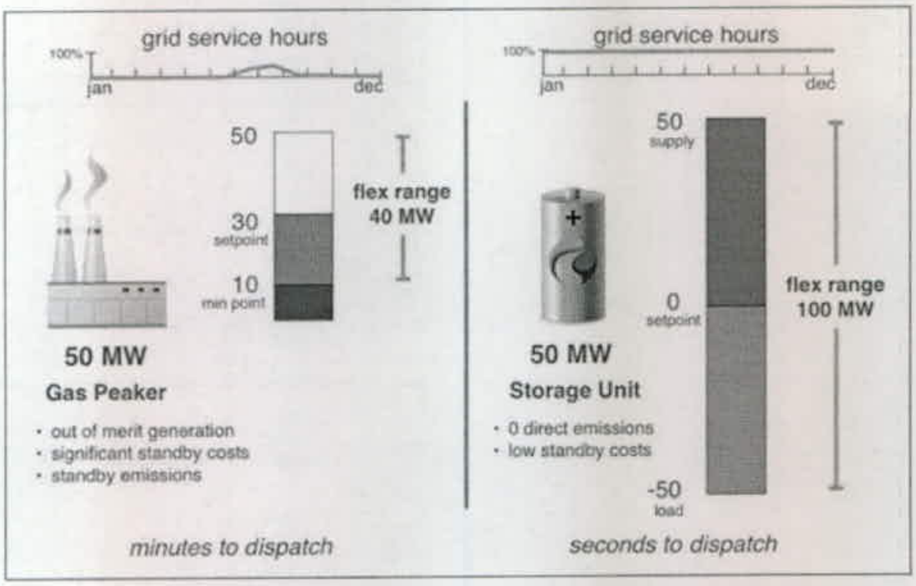
Laurel Mountain 64 MW battery resource operating commercially in PJM since 2011



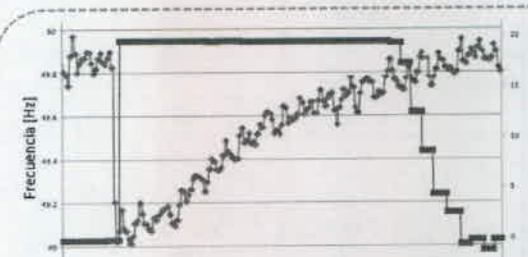


- Operating range of +32MW to -32MW
- Precise response to 4 second AGC
- Ramp rate mitigation
- Economic, daily bid in PJM power market

Flexibility: a 2X operating range, low standby cost, and nearly instantaneous power

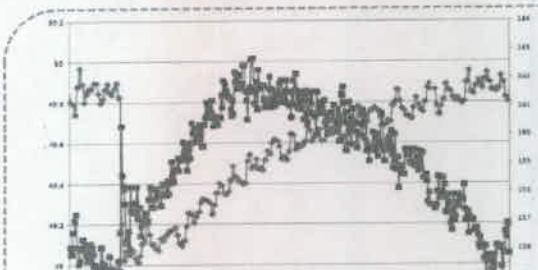


Angamos 40MW resource quick, precise response to system event on 4/9/12 to maintain grid



Angamos BESS Response

- ✓ Angamos BESS responds with rapid increase of output from 0MW to 20MW
- ✓ Autonomous response according to programmed profile
- ✓ Output sustained until stability restored

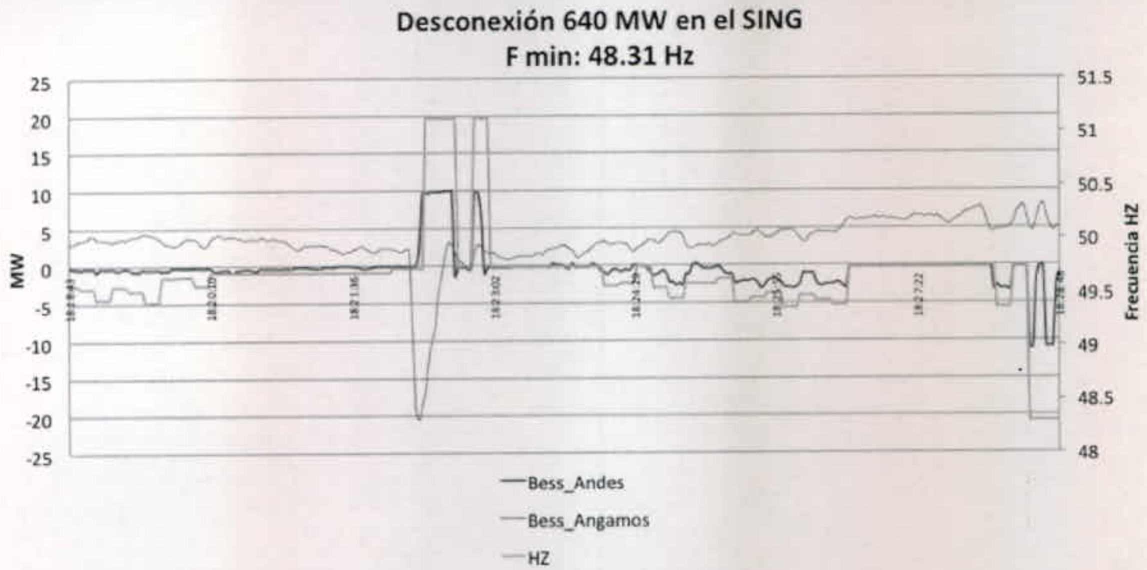


Thermal Units

- ❖ Thermal unit responds with 4MW burst, then output drops off
- ❖ Gradually ramps up in oscillating manner to 7MW output increase over 4 minutes

Source: CDEC-SING, AES

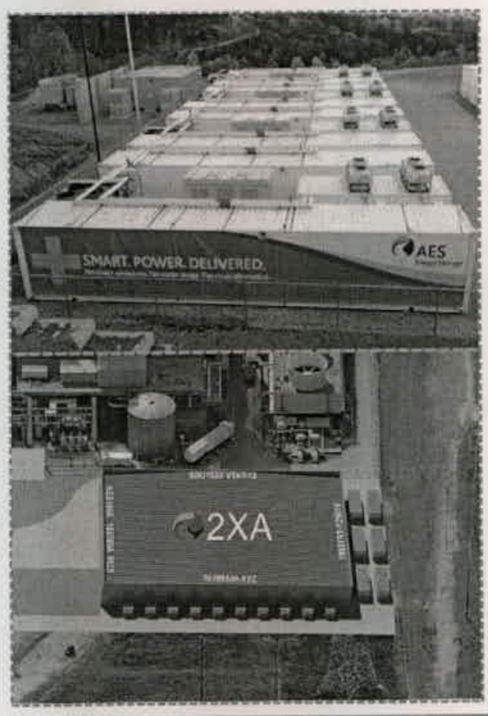
Event from May 8, 2013, when the SING lost 640 MW (2,000 MW peak demand) due to a substation trip



The AES units BESS_Andes and BESS_Angamos both responded immediately and this rapid injection of power helped stabilize the system frequency so that the other thermal units could replace the lost power without tripping.

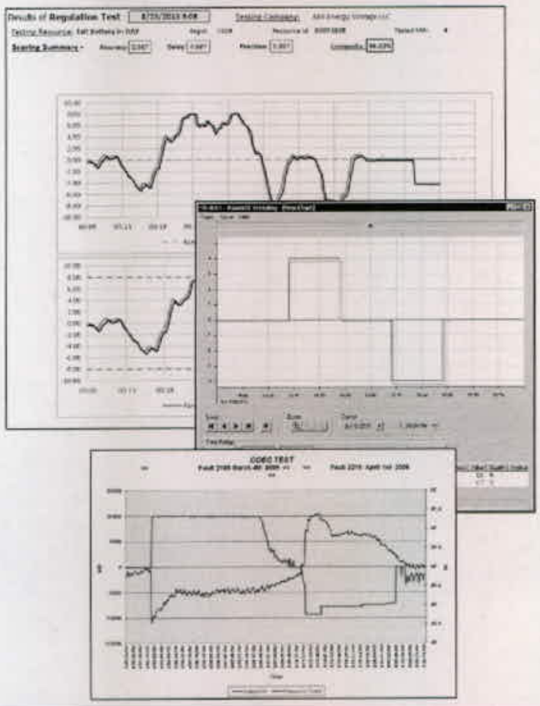
AES' PowerCenter™ architecture enables best in class technology and maximizes performance

System Characteristics	AES's PowerCenter™ Flex
Fast Reserve Capacity	Modular, 10MW up to 400MW
Round Trip Efficiency	85%-90% (based on dispatch)
Operating Range	+/- full nameplate e.g. +40MW to -40MW
Availability	97% weighted annual equivalent availability
Operating Temperature	-20 C to 40 C
Power Factor	± 0.95 at full load
Ramp-Up/Down Rate	0% to 100% output in 200ms
Voltage Support	Voltage Droop Settings < 50ms response time
Automatic Generator Control	< 50ms response time after control latency
Ride Through	Low Voltage Ride Through (settable thresholds) Low Frequency Ride Through (settable thresholds)
Standards	IEEE 519, 1547, UL 1741, NEC
Start-up time	<1 second, continuously synchronized
Dispatch	PLC-SCADA, Modbus TCP
Minimum generation	No minimum to remain synchronized
PCS Technology	IGBT-based inverters
Storage Technology	Advanced Lithium-Ion Batteries or similar
Emissions	No air emissions, no water use



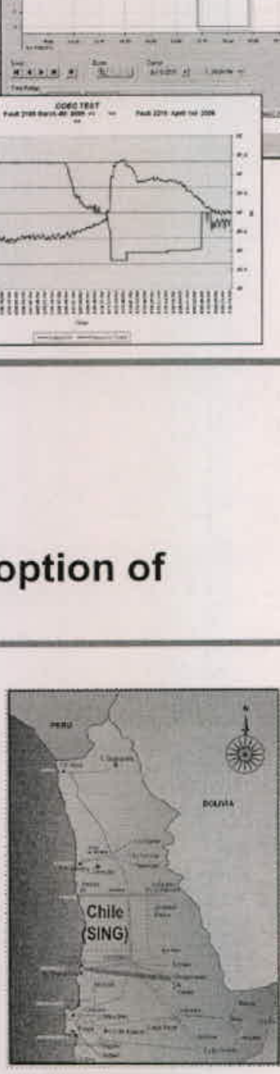
AES storage systems completed existing performance qualification for ancillary services in power systems

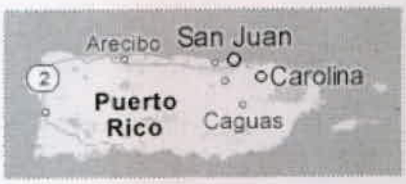
- AES storage projects passed qualification tests in:
  - USA PJM (3 projects)
  - USA New York ISO (1 project)
  - USA California ISO (1 project)
  - USA MISO Indiana (1 project)
  - USA ERCOT Texas (1 project)
  - Chile SING Northern Grid (2 projects)
- Storage projects passed the standard qualification tests for the ancillary service.
- Qualification tests have included performance with Automatic Generation Control (AGC) signals and autonomous frequency detection.



Islands are the natural leaders for the adoption of advanced energy storage

- Power system size, resource types, and fuel availability are unique in island power environments.
  - Puerto Rico, renewable projects must be able to manage ramp rate, reactive power, and frequency
  - Hawaii, RFI for 10-80MW of storage for 2014 procurement to support system reserves. Wind project with storage.
  - UK/Ireland, new ancillary services for grid management, storage introduced in UK.
  - N. Chile, islanded SING system has two energy storage systems for secondary reserves.

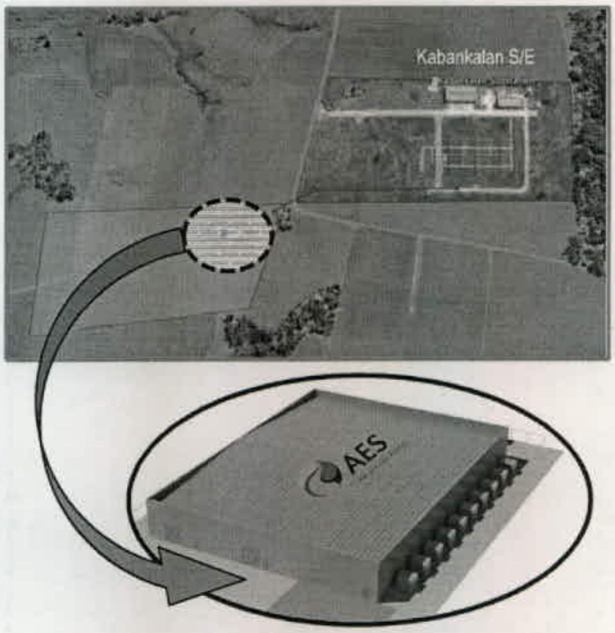




AES brings BES offering to the Philippines

40 MW Project at Kabankalan, Negros Occidental – Target 2015 COD

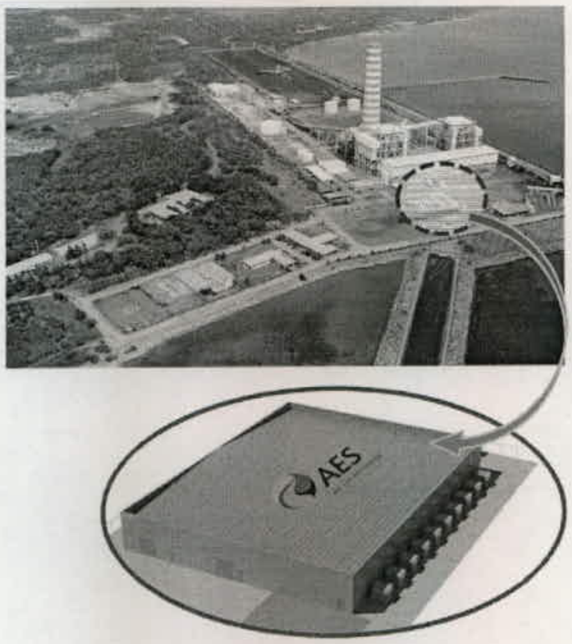
- Load Following and Frequency Regulation Service contract under discussion with NGCP.
- Identified Kabankalan substation in Visayas for initial project (40MW interconnection, 80MW flexible range).
- SIS with NGCP.
- Reviewing firms for Facilities Study.
- Black & Veatch for core engineering; local Owner's Engineer in selection.
- On-going permitting from EMB
- Discussed financing with various institutions.

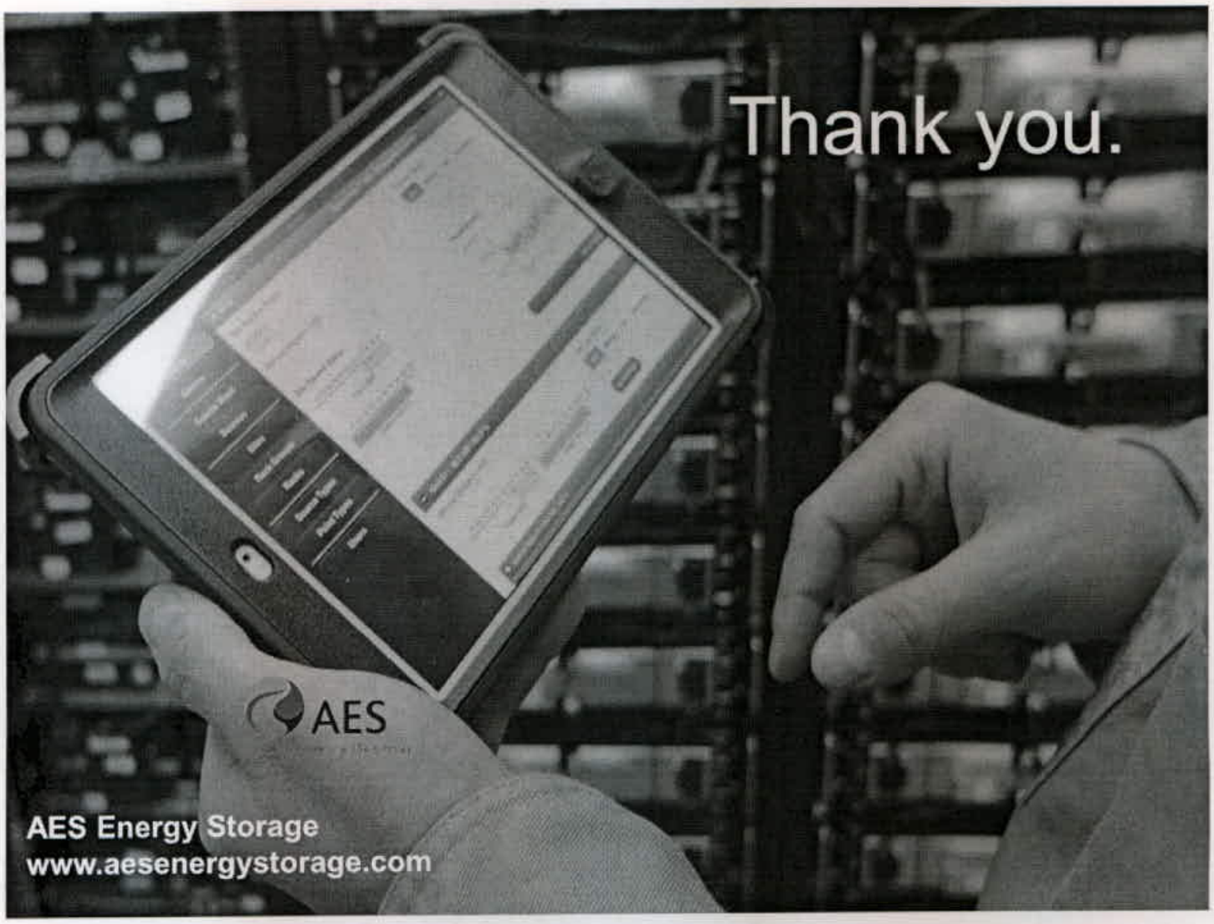


AES brings BES offering to the Philippines

Planned 10 MW Project at Masinloc – Target 2015 COD

- Can be scaled up to 20 MW
- Load Following and Frequency Regulation Service contract for discussion with NGCP.
- Participation in the upcoming Reserve Market.
- Identified location inside the existing Masinloc Coal Fired Power Plant.
- Identified permits and legal support.




Thank you.
AES
AES Energy Storage
www.aesenergystorage.com

b. COR-INT-TC-14-08 “TC Response to RCC”

Philippine Electricity Market Corporation

18 December 2014
COR-INT-TC-14-08

MEMORANDUM

To	:	**Dr. Rowena Cristina L. Guevara** Chairperson, Rules Change Committee
Thru	:	**Chrysanthus S. Heruela**, VP-MAG
From	:	**Technical Committee**
Subject	:	**Request for Assistance in Determining Classification of the Battery Energy Storage System**

This is with regard to the request for assistance of the Rules Change Committee (RCC) in determining the classification of the Battery Energy Storage System (BESS) whether as a Generation Company certified as Ancillary Service Provider or as a purely Ancillary Services Provider.

The RCC request dated 15 October 2014 referenced its request to the Proposed Amendments to the WESM Rules on Generation Company Reserve/Offers submitted by the AES Philippines. The TC recognizes that the result of the TC's opinion will assist the RCC in its deliberation of the proposal.

The TC invited the Market Assessment Group (MAG) and AES Philippines to provide the references and additional information regarding energy storage technologies particularly the battery energy storage systems (BESS)

Following its discussions on the matter, the TC hereby provides its comments as follows:

(1) BESS is a generation resource and should be capable to offer in the energy market. The TC however, recognizes the limitation of such technology in terms of energy capacity. We were informed that AES is designing a 40MW power available for 1 full hour. As such they have serious limitation if required to offer full capacity for our energy market's hourly trading interval. However, the TC emphasizes that with the same energy capacity, smaller amount of power can be delivered for a longer period (or for multiple hourly trading intervals). In fact, as the WESM looks forward to shortening this trading interval (e.g. 15 min), a BESS will even be in a better position to offer energy in such regime.

(2) The TC further recognizes that for this type of generation, the Maximum Available Capacity as defined in the Dispatch Protocol Manual (DPM) may be seriously limited. Since the DPM provides instructions, regarding the limitations of other generation

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technologies such as hydro power plants and steam power plants, the TC believes that a similar provision can be made for BESS.

(3) The TC notes that a BESS' limitation in terms of availability is similar to the case of a pumped storage power plant, which is currently able to offer in the energy market.

(4) Classifying some resources as purely Ancillary Service Provider is not consistent with the envisioned energy-reserve co-optimized market. For the market to realize maximum economic gain, all available resources should be made available for both energy and reserve.

(5) Based on the WESM Rules' definition of a Generation Company, together with the expected capacity of a BESS, the TC agreed that a BESS falls under the category of a Generation Company with scheduled generating units. In addition, these generating units may be capable to offer Ancillary Services subject to ERC's approval.

In summary, based on the technical capability of a BESS as presented by AES, and the current definition in the WESM Rules of a Generation Company, the TC's opinion is that a BESS can function as a Generation Company with scheduled generating units that can also provide both Ancillary Services and energy instead of purely Ancillary Services.

Thank you.

For the Technical Committee,

Jordan Rel C. Orillaza
Acting Chairperson

B.3. List of Prospective Proponents with Battery Energy Storage Systems Projects[66]

The list below is presented to highlight the current situation that there is a significant number of proponents for battery energy storage technology in the Philippines.

Proponent	Projects	Installed Capacity MW	Location	Issuance
AES Philippines Power Partners Co. Ltd.	APPCL's Battery Energy Storage Solution Project	60	Mexico, Pampanga	1/31/13
	Battery Energy Storage Plant Project	40	Masinloc, Zambales	6/5/15
	Battery Energy Storage System	40	Laoag, Ilocos Norte	2/18/16
	Battery Energy Storage System	40	Bantay, Ilocos Norte	2/18/16
	Battery Energy Storage System	40	Villanueva, Misamis Oriental	8/7/14
Masinloc Power Partners Co. Ltd.[67]	Battery Energy Storage Plant Project	40	Toril, Davao del Sur	9/30/15
	Battery Energy Storage Plant Project	40	Maco, Compostela Valley	9/30/15
SunAsia Energy Inc.	Enerhiya Central Battery Energy Storage Project	40	Concepcion, Tarlac	4/8/16
	Enerhiya Sur I Battery Energy Storage Project	40	Lemery and Tuy, Calaca, Batangas	4/8/16
	Enerhiya Sur II Battery Energy Storage Project	40	Lumban, Laguna	4/8/16
	Enerhiya Delas Islas I Battery Energy Storage Project	15	Amlan, Negros Oriental	4/8/16
	Enerhiya Delas Islas II Battery Energy Storage Project	15	Ormoc, Leyte	4/8/16
	Enerhiya Delas Islas III Battery Energy Storage Project	15	Compostela, Cebu	4/8/16
EQ Energy Storage, Inc.	Cadiz Energy Storage	15	Cadiz City, Negros Occidental	5/24/16

[66] Based on the DOE's list of companies with BES projects issued with clearance for Grid Impact Study as of November 2016.

[67] Formerly AES Power Partners Ltd. Co, issued last January 2015

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