Nel Consulting Limited

IES Intelligent Energy Systems

# Upgrading Design and Implementation of Energy Battery Storage Market Mechanism of the Philippines Electricity Market Mechanism

## Final Report

## October 2022

**Prepared for:**

ENERGY TRANSITION PARTNERSHIP

Powering Prosperity and Enabling Sustainability in South East Asia

Philippine Electricity Market Corporation

UNOPS | AFD Agence Française de Développement | Federal Ministry for Economic Affairs and Climate Action | Department for Business, Energy & Industrial Strategy | Environment and Climate Change Canada / Environnement et Changement climatique Canada | Children's Investment Fund Foundation | IKEA Foundation | Windward Fund

## LIST OF ACRONYMS

| | |
|---|---|
| ACE | Area Control Error |
| AEMO | Australian Energy Market Operator |
| AGC | Automatic Generation Control |
| ANEM | Australian National Electricity Market |
| AP | Administered Price |
| APC | Administered Price Cap |
| AS | Ancillary Service |
| AS-CRM | Ancillary Services Cost Recovery Mechanism |
| ASP | Ancillary Service Provider |
| ASPA | Ancillary Services Procurement Agreement |
| ASPP | Ancillary Services Procurement Plan |
| AU$ | Australian Dollar |
| BCQ | Bilateral Contract Quantity |
| BESS | Battery Energy Storage System |
| BMS | Battery Management System |
| BSAS | Black Start Ancillary Service |
| BSS | Black-Start Service |
| CAISO | California Independent System Operator |
| CONE | Cost of New Entry |
| CPUC | California Public Utilities Commission |
| CSP | Competitive Selection Process |
| DA | Day-Ahead |
| DAP | Day-Ahead Projection |
| DARD | Dispatchable Asset-Related Demand |
| DC | Direct Current |
| DCC | Directly Connected Customer |
| DCS | Dispatch Conformance Standard |
| DDMT | Dispatch Deviation Monitoring Tool |
| DDP | Distribution Development Plan |
| DER | Distributed Energy Resource |
| DOD | Depth of Discharge |
| DOE | Department of Energy |
| DPM | Dispatch Protocol Manual |
| EC | Electric Cooperative |
| ECO | Enforcement and Compliance Office |

| | |
|---|---|
| EE | Energy Efficiency |
| EMS | Energy Management System |
| EPIRA | Electric Power Industry Reform Act |
| ERC | Energy Regulatory Commission |
| ERCOT | Electric Reliability Council of Texas |
| ESS | Energy Storage System |
| ETP | Southeast Asia Energy Transition Partnership |
| FCAS | Frequency Control Ancillary Services |
| FERC | US Federal Energy Regulatory Commission |
| GEAP | Green Energy Auction Program |
| GIS | Grid Impact Study |
| GPI | Generator Price Index |
| GWAP | Generator Weighted Average Price |
| HAP | Hour-Ahead Projection |
| HHI | Herfindahl-Hirschman Index |
| Hz | Hertz |
| IEMOP | Independent Electricity Market Operator of the Philippines |
| IRP | Integrated Resource Provider |
| IRR | Implementing Rules and Regulations |
| ISO-NE | Independent System Operator - New England |
| ISO | Independent System Operator |
| IT | Information Technology |
| kV | kiloVolt |
| kW | kiloWatt |
| kWh | kiloWatt-hour |
| LDA | Locational Deliverability Area |
| LMP | Locational Marginal Price |
| LSE | Load-Serving Entities |
| MAG | Market Assessment Group |
| MAR | Market Assessment Report |
| MAS | Market Assessment System |
| MDOM | Market Dispatch Optimization Model |
| MISO | Midcontinent Independent System Operator |
| MMS | Market Management System |
| MO | Market Operator |
| MOMT | Must-Offer Monitoring Tool |
| MOPS | Market Operator Performance Standard |
| MRR | Market Re-Run |

| | |
|---|---|
| MRU | Must Run Unit |
| ms | Milliseconds |
| MSC | Market Surveillance Committee |
| MTN | Market Trading Node |
| MW | MegaWatt |
| MWh | MegaWatt-hour |
| NEM | National Energy Market |
| NEO | National Electricity Objective |
| NGCP | National Grid Corporation of the Philippines |
| NMAS | New Market Assessment System |
| NPC | National Power Corporation |
| NREP | National Renewable Energy Program |
| NSR | Non-Spinning Reserves |
| NSS | Network Settlement Surplus |
| NYISO | New York Independent System Operator |
| OATS Rules | Open Access Transmission Services Rules |
| OCC | Offered Capacity Compliance |
| OR | Operating Reserve |
| PCS | Power Conversion System |
| PDM | Price Determination Methodology |
| PEM Board | Philippine Electricity Market Corporation Board |
| PEMC | Philippine Electricity Market Corporation |
| PEP | Philippine Energy Plan |
| PGC | Philippine Grid Code |
| PJM | Pennsylvania, New Jersey, and Maryland |
| PPA | Power Purchase Agreement |
| PRAS | Primary Reserve Ancillary Service |
| PSH | Pump Storage Hydropower |
| PSI | Pivotal Supply Index |
| PSM | Price Substitution Methodology |
| PV | Photovoltaics |
| QTP | Qualified Third Party |
| RCOA | Retail Competition and Open Access |
| RE | Renewable Energy |
| REM | Renewable Energy Market |
| RPSAS | Reactive Power Support Ancillary Services |
| RSI | Residual Supply Index |
| RT | Real-time |

| | |
|---|---|
| RTD | Real-Time Dispatch Schedule |
| RTDT | Real-Time Display Tool |
| RTO | Regional Transmission Organizations |
| SCADA | Supervisory Control and Data Acquisition |
| SCED | Security-Constrained Economic Dispatch |
| SIPS | System Integrity Protection Scheme |
| SIS | System Impact Study |
| SO | System Operator |
| SOC | State of Charge |
| SOCM | State of Charge Management |
| SOH | State of Heath |
| SPC | Secondary Price Cap |
| SR | Spinning Reserve |
| SRAS | Secondary Reserve Ancillary Service |
| SVC | Static Var Compensation |
| SVG | Static Var Generator |
| TDP | Transmission Development Plan |
| TNP | Transmission Network Provider |
| TRAS | Tertiary Reserve Ancillary Service |
| T&D | Transmission and Distribution |
| US | United States |
| VRE | Variable Renewable Energy |
| WAP | Week-Ahead Projection |
| WESM | Wholesale Electricity Spot Market |
| WESM PDM | Price Determination Methodology for Philippine Wholesale Electricity Spot Market |

# EXECUTIVE SUMMARY

## PROJECT AIMS

1. To broaden and strengthen the PEMC's governance functions to encompass emerging technologies participating in the WESM, which include BESS and other ESS as part of the country's energy transition program.

2. To determine the completeness of market policies with respect to BESS and other ESS.

3. Recommend possible enhancements to the market design and protocols, as and where applicable.

## PROJECT OUTPUTS

The outputs of the study are detailed below:

- **Output 1**: Conformance standards applicable to BESS and other ESS; and inception planning and preparation of the reports.

- **Output 2**: Introduction of protocols for BESS and other ESS for their scheduling and dispatch in the energy-only, and eventually in the co-optimized market for energy and reserves.

- **Output 3**: Achievement of satisfactory compliance rating by the market participants who operate BESS and other ESS, determined by PEMC's ECO.

- **Output 4**: Increased levels of competitiveness in the spot market in terms of BESS and other ESS ownership.

## OUTPUT 1: RECOMMENDATIONS ON CONFORMANCE STANDARD

Based on an analysis of WESM practices against international practices, several recommendations that relate to enhancing the existing framework for the WESM were identified. These are tabulated as follows:

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 1 | Market Registration | Generation company can register BESS units as battery energy storage. | BESS facilities registered as "bidirectional units" to be more technology neutral (in US and Australia). | • Explicitly list parameters that BESS units are to provide upon registration – which should include rated capacity (MW), rated energy (MWh), maximum charge rate, maximum discharge rate, and maximum Depth of Discharge (DOD). |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | | | • Define annual process for updating them over the lifetime of the BESS (the current IEMOP process used for updating registration data is suitable).<br>• Indicate whether the BESS is providing AS for NGCP SO, as there are implications for dispatch. |
| 2 | Market Registration | Generation company registering the PSH as a generator with an associated load . | PSH facilities registered as a dispatchable load & dispatchable generator. | • Provision PSH to be able to register loads as demand side bidding facilities.<br>• A PSH registering its pumping load would follow the same process as any dispatchable load. |
| 3 | Market Registration | PSH and BESS are specifically named as storage technologies that can be registered. | Technology neutral approach is taken where a market participant can register a dispatchable load, generation unit, or bidirectional units without reference to a particular technology. | Make registration more technology-neutral by allowing market participants to register units as bidirectional units, dispatchable loads, generating units without primary reference to the underlying technology; the latter (chemical battery, flywheel, etc to be recorded as a secondary criterion). |

## OUTPUT 2: RECOMMENDATIONS ON WESM PROTOCOLS

Assessments and analysis of the WESM Protocols, with a particular focus on the WESM's Dispatch Protocol Manual was conducted. A summary of the recommendations that have been proposed is set out in the following table:

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 4 | Scheduling & Dispatch (of AS) | Interim AS Market is managed by SO separately to the WESM, with day-ahead scheduling of AS Providers for CR | Provision of AS for BESS has higher priority than energy dispatch for system security reasons. | • NGCP-SO needs to provide the reserve capacity and SOC requirements based on its grid assessment. The BESS reserve is responsible for ensuring enough SOC to comply with the reserve requirement.<br>• Modifications may be required to the interface to IEMOP for |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | (PRAS), RR (SRAS) and DR (TRAS). | | declaration of AS schedules by SO.<br>• A Demand Bid option is voluntary for loads that wish to operate that way. There is no need to enforce all loads connected to the WESM to be dispatchable, particularly if they are not controllable loads that can respond to a dispatch instruction.<br>• The list of information required is set out in Section 7.3. |
| 5 | Dispatch / Market Projections | WESM MMS accounts for SOC, capacity limits and energy storage limits of BESS in RTD, HAP, DAP and WAP; however, WESM rules do not specify this. | Physical capability of ESS / BESS represented in all market dispatch processes and specified in the market rules. US markets explicitly model SOC, efficiency, and other parameters of BESS in all dispatch related market processes. | WESM rules describing the MDOM and market processes (RTD, HAP, DAP, WAP) adjusted to ensure that the requirement to represent ESS / BESS in terms of SOC, and charging / discharging, and bidirectional bids are included. This is important for ongoing IEMOP compliance to WESM rules. Also require that the SOC has a minimum level (which is specified as required for Interim AS market) – this can be provided with participant offers as well. |
| 6 | Dispatch / Market Projections | PSH units could not register as a bidirectional unit because it takes time for PSH to go from loading / pumping. | PSH use demand-side bids to manage this issue, so that the loads could set the price if the market is marginal on loading. | As with earlier recommendations, requiring PSH to register pumping loads as dispatchable demand and using a demand-side bid will address this issue. If the PSH takes a long time to go from pump to generator or vice versa, this can be reflected in its offer/nomination management. |
| 7 | ESS Bids / Offers | PSH providing load forecasts rather than offers / bids which means that PSH loads will not be reflected if their dispatch is marginal. | PSH use demand-side bids so that the loads could set the price if the market is marginal on loading. | Require PSH to register loads as dispatchable loads and submit demand-side bids for loading. This ensures that BESS and PSH are on an equal footing when operating in the market.<br><br>The above requirement should be understood in the context of a Demand-Side bidding regime that is optional for PSH. Under optional participation, demand-side bids can be constructed in a way that allows the PSH to operate according to an optimal plant maintenance regime, |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | | | respecting any contractual obligations that constrain the role of the PSH. |
| 8 | ESS Bids / Offers and Must-Offer Rule | WESM allows for 10 prices / quantities that can be specified as monotonically increasing and prices / quantities can be negative or positive. | Provides for same number of prices / quantities as generators and loads to ensure bidirectional units are treated equally with demand-side bidders & generator offerors. | Increasing the number of pricing bands from 10 to 20 would ensure bidirectional (BESS) are on equal basis with both generators & demand side players.<br><br>Aside from increasing the number of offer blocks, BESS is required to comply with the Must-Offer Rule; in addition to the determination of its maximum available capacity for BESS, the SOC must also be accounted for, when the Must-Offer Rule is invoked. Moreover, a certain threshold of the BESS current SOC must also be set when BESS will be allowed to submit negative bids for purposes of charging (typically 10%). |
| 9 | Dispatch / Market Projections | PSH units could not register as a bidirectional unit because it takes time for PSH to go from loading / pumping. | PSH use Demand-Side Bids to manage this issue, so that the loads could set the price if the market is marginal on loading. | As with earlier recommendations, requiring PSH to register pumping loads as dispatchable demand and using a demand-side bid will address this issue. |
| 10 | System Security / Directions | As the SO can call units for the purpose of must-run, the must-run regime in the WESM would need to ensure that the SOC information is available to the SO to ensure that they make informed decisions when calling BESS at short notice in emergencies. | SOC is considered when calling ESS for directions. Requirement to ensure that the ESS facility is staffed / manned in a way that would allow for directions to be immediately responded to. | Ensure existing must-run procedures and manuals set out the consideration of SOC for BESS. We understand this is already operationally the case but need to ensure it is explicit.<br><br>It is understood that the SO monitors SOC of BESS to ensure that they can deliver any ancillary services for which the SO has assigned them the responsibility to provide. |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 11 | System Security / Directions | General emergency regime & system directions provide SO with the right to issue directions to participants that they must respond to. | Require ESS to respond to a no-charging declaration that may be issued on a market-wide basis by SO or SO+MO if there is an emergency or a need. | Ensure rules / framework are in place to allow the SO to require all ESS / BESS to stop charging in emergencies.<br><br>Also ensuring that the WESM rules places an obligation on ESS / BESS participant to respond to such a notification / instruction.<br><br>In addition, the Philippine Grid Code to be amended to include this requirement to ensure the practice is followed. |

### OUTPUT 3: RECOMMENDATIONS ON COMPLIANCE MONITORING

An assessment was made of the WESM compliance monitoring arrangements against international practices. This resulted in the following enhancements to the compliance framework to handle ESS.

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 12 | Compliance Monitoring / Conformance Standard | Dispatch conformance standard extended to cover the PSH and BESS in dispatch conformance standard. | All technologies have their conformance to dispatch instructions and provision of AS monitored / checked including PSH / BESS. | Apply the same threshold/dispatch tolerance (1.5% or -3% of the target schedules or +/-1MW, whichever is higher) is applicable to BESS.<br><br>It is noted that at present Kalayaan PSPP is already being monitored under the existing conformance standard for conventional generators. While the general conformance standard should apply, there may be a need to expand the standard to cover demand-side bids and/or load nomination accuracy (the PSH can decide whether to DS bid or nominate its load profile). |
| 13 | Compliance Monitoring / Conformance Standard | BESS can respond very rapidly to high / low prices within a 5-minute period, which will not be considered in the existing dispatch | Monitoring & compliance regime considers within dispatch interval monitoring to ensure adherence to a maximum ramp rate (except for when the | Monitoring the BESS to ensure it adheres to its dispatch targets and a maximum ramp rate for system normal operations. If the BESS is providing frequency regulation or responding to a contingency, then monitoring against a maximum ramp limit can be relaxed for those situations. Note: requires real-time SCADA data of BESS power output or 5-minute metering data |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | compliance regime in the WESM, which is more concerned with ensuring the endpoint lies within + 1.5% / -3.0% of previous period dispatch target. | ESS/BESS is providing a rapid response to a contingency event) – this is done with SCADA data or 5-minute metering data. Dispatch target monitoring & compliance regime for all generating units and dispatchable loads[1]. | or the use of its real-time SOC information. |
| 14 | Compliance Monitoring / Conformance Standard (Must-Offer Rule) | Must-Offer Rule for generating units would apply to the BESS which does not consider the SOC. However, the dispatch optimization accounts for maximum SOC in determining dispatch targets for BESS. | Capacity withholding is routinely monitored and analyzed, particularly during high price events or instances where market power is suspected to have been exercised. | Adjust the Must-Offer Rule to account for capacity that is not made available by a BESS as a result of the current state of SOC for the BESS. An explanation of the logic is set out in Section 8.3.4.1. |
| 15 | Compliance Monitoring / Conformance Standard | Extend data collection of MAS on daily and real-time basis to cover additional indicators of BESS units. | Key indicators are generally monitored by system and/or market operators, or units responsible for market monitoring. | Daily data collection in MAS modified to collect the following information (provided by SO for each BESS): (i) SOC (MWh), (ii) Availability (MW), (iii) Efficiency (%), (iv) SOH (%) and (v) contracted reserves as determined by the SO – for each dispatch period.<br><br>Real-time data collection (and monitoring interface) enhanced to collect / monitor: (i) SOC (MWh) and (ii) Availability (MW). |

[1] Where real-time / monitored data is used, standard checks on data quality will be required or ensuring that the data has already come out of a state-estimator to ensure its accuracy.

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 16 | Compliance Monitoring / Conformance Standard and Market Monitoring | Post Market Analysis Assessment implements catalogue market monitoring indices. | Market monitoring includes monitoring of the general operation of the ESS in the market. | Market monitoring enhanced to consider additional charts to focus on the operation and performance of ESS in the WESM. (The details are specified in Section 8.3.5.). |
| 17 | Compliance Monitoring / Conformance Standard (NMAS Software System) | Existing MAS has not considered ESS at this stage. | Update software to collect the data and implement the calculations necessary for ESS compliance monitoring. | Implement enhancements in NMAS to allow ECO to undertake compliance monitoring of BESS (further details set out in Section 8.3.6.). |

**OUTPUT 4: RECOMMENDATIONS ON COMPETITIVENESS**

An assessment was made of the WESM competitiveness with a focus on market power mitigation and market power monitoring arrangements. The findings were as follows:

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 18 | Market Power Monitoring / Mitigation | EPIRA concentration limits applied to a firm level. | Concentration limits triggering regulated pricing or anti-competitive laws in place to intervene in the market and break up a dominant monopoly organization. | Additional clause added to appropriate legislation to apply the EPIRA competition limits to ensure that no single technology by a single firm dominates ESS supply as single technology. Note that it is suggested that this apply for a period of time and be relaxed once it was clear that there was adequate diversity in ESS suppliers. |
| 19 | Market Power Monitoring / Mitigation | PSI, RSI, and HHI | BESS / ESS capacity is considered part of a generator portfolio's generation resources for supply. | Include ESS capacity that is registered in the WESM in these computations in the ongoing market monitoring and surveillance reporting and monitoring of MAG. |
| 20 | Market Power Monitoring / Mitigation | PSI, RSI, and HHI | Consider both firm level (portfolio-level) indicators for pivotal supply and technology indicators. | Compute the RSI, PSI and HHI metrics for technologies, as well as for firms. Monitor these to keep track of the operation of BESS playing an increasing dominant role in the market. |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 21 | Market Power Monitoring / Mitigation | Market price cap | Formal price cap in place, and transparent methodology for reviewing and resetting the price cap from time to time. | Put in place a formal price cap and methodology for periodic review and setting. |
| 22 | Market Power Monitoring / Mitigation | Market price floor | Formal price floor in place, and transparent methodology for reviewing and resetting the price floor from time to time. | Put in place a formal price floor, and methodology for periodic review and setting. |
| 23 | Market Power Monitoring / Mitigation | Secondary price cap and triggering mechanism | Mechanism in place to periodically review and update the settings of a secondary price cap (or its equivalent). | Recommend having a process to periodically review the settings in light of ESS technology and its penetration in the WESM. |
| 24 | Market Power Monitoring / Mitigation | Market Monitoring Procedures | Monitoring of price spreads. | Monitor price spreads and compare to business case / profitability for ESS. |

## OTHER RECOMMENDATIONS

During the assessments carried out on the existing WESM framework two more general, longer-term areas of improvement were identified. These relate more to longer-term policy settings the Philippine energy industry and are beyond the scope of this report to consider in detail but are important to the ongoing integration of ESS into the WESM. The two areas were: (1) provisions for hybrid facilities – where ESS and other technologies are combined to operate as an overall generation system, and (2) the longer-term development of an integrated energy and reserves market in the WESM. The former will enable greater participation in the WESM, the latter will provide ESS with a more transparent and efficient framework for participation in energy and reserves markets.

These recommendations are summarized in the following table:

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 25 | Market Registration, Dispatch, | No provisions for registration of hybrid | Hybrid systems / Integrated Energy Resources can be registered and | It is proposed that this be done as an extension to the stand-alone ESS enhancements. There are implications for conformance |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | Scheduling, Settlement, | facilities (or IRPs). | managed in the market. | monitoring and the approach adopted for dispatch. |
| 25 | AS Market | Integration AS market not yet in place in the WESM | Market-based (AS) markets that allow for participation of ESS. | Important to implement AS markets in the WESM as it supports the business case and hence promotes the investment in ESS in the WESM. |

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|---|---|
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# 1 INTRODUCTION

## 1.1 BACKGROUND

The increased focus on the adoption of RE over the recent years has not only led to a rapid development of new and alternative energy generation technologies, but also to a steady transformation in the electric grids worldwide, offering consumers and providers with increasing options for generating, using, and managing energy. The changing nature of energy consumption and generation is leading the grid to transition from a centralized, static system of energy generation to one that is adaptable, dynamic, and one that can more effectively respond to changes. Energy storage technologies have been coming to the forefront lately with system operators realizing that a total dependence on traditional sources of energy, while obviously harmful for the environment is also quite unreliable and the commonly sought renewable sources of PV and wind are unreliable in certain situations because of their intermittent nature.

In countries with electricity markets, energy transition requires changes to market operations because, unlike conventional generation, RE technologies are (i) intermittent, (ii) zero marginal cost, and (iii) have no (or limited) inertia[2].

Today's electricity systems can and do handle a moderate share of solar and wind. This is because there are sufficient other resources to step in when wind and solar output is low, and sufficient inertia from the thermal resources. However, as the penetration of RE increases, a point is reached where the power system tends to become unstable if there is an emergency disconnection of a generator or transmission line. As inertia falls and supply uncertainty increases, more reserves and faster responding reserves are required. BESS have proven to be well well-suited to perform these functions in view of their very rapid response capability.

An example of a BESS used primarily to stabilize the grid is the Hornsdale BESS in South Australia (Figure 1 below). As is typically the case, for BESS, the Hornsdale BESS earns revenue by providing more than one service – stabilizing the grid through the provision of ancillary services, and through price arbitrage (buying energy at a low price and selling at a high price).

[2] Intermittent renewable energy is given an acronym VRE (Variable Renewable Energy)

*Figure 1: Hornsdale 100MW / 129 MWh BESS (Fast Acting Stabilizer & Energy provider)*

Another issue that arises with increasing penetration of VRE is that the second-by-second balance between supply and demand tends to become less predictable. As VRE increases, the conventional generators used to balance supply and demand may not be capable of meeting an imbalance that has significantly more fluctuation. Again, BESS is well-suited to perform the balancing function, particularly in conjunction with a specific VRE plant (a hybrid power plant). PSH can also perform the balancing function but requires a more advanced turbine design.

BESS can be applied centrally (serving more than one VRE power plant) or can be distributed at each VRE power plant. The international trend is towards the distributed model as the approach is (i) technology neutral, (ii) financed by the VRE plant owner, and (iii) offers the VRE plant owner flexibility of operation, and (iv) allows the VRE plant owner to make best use of storage and inverter technology.

The AES Los Alamitos BESS is an example of an ESS that provides a capacity reserve (Figure 2 below). As is the case for the Hornsdale BESS, the Los Alamitos BESS also earns revenue through price arbitrage.

*Figure 2: Los Alamitos 100MW / 400MWh BESS (Capacity Reserve and Energy provider)*

There are energy storage technologies other than BESS and PSH, but at the present time these technologies are not commercial. A description of the range of energy storage systems and their characteristics is provided as Appendix A.

In terms of the impact of energy storage on electricity markets, the conformance standards that apply to conventional generators and loads do not apply to ESS because ESS capability varies as it charges and discharges. The nature of ESS means that market rules are needed that reflects the nature of ESS.

## 1.2 ESS & THE PHILIPPINES

The future role of ESS in the electric power industry is well-recognized by the DOE. In August 2019, the DOE issued Department Circular No. DC2019-08-0012 entitled, “Providing a Framework for Energy Storage System in the Electric Power Industry”, establishing a policy on the operation, connection, and application of ESS among others. It recognizes that the ESS technologies can be applied to serve a variety of functions in the generation, transmission, and distribution of electric energy, which include AS, energy generation and peak shaving.

### 1.2.1 BESS Projects in the Philippines

BESS project developers have responded to the opportunities in the Philippines. Two grid-scale BESS projects equalling 60 MW were commissioned in May 2021. The 20 MW system in Toledo and 40 MW system BESS operating in Bataan are expected to be followed by a third with a larger capacity of 100 MW. The AES Corporation has installed an energy storage array in Masinloc to provide fast response ancillary services and a 10 MW power capacity to the Luzon grid, in addition to a 40 MW BESS in

Kabankalan to improve the Visayas grid's ability to accommodate solar power that is available in the region.

The NGCP has assessed the need for AS by 2040[3], in response to the expected increase in VRE capacity. NGCP is planning for the AS capacity to be provided by BESS. The total capacity need has been assessed to be 450 MW, mostly connected at the standard sub-transmission voltage of 69kV.

*Table 1: Ancillary Service BESS Capacity Forecast to 2040*

| Substation | Voltage Level | Recommended BESS Capacity (MW) |
|---|---|---|
| **LUZON GRID** | | |
| Masinloc | 69 kV | 20 |
| Daraga | 69 kV | 40 |
| Laoag | 69 kV | 40 |
| San Rafael | 69 kV | 20 |
| Labo | 69 kV | 20 |
| Mexico | 69 kV | 20 |
| San Manuel | 69 kV | 20 |
| Bay | 69 kV | 20 |
| Labrador | 69 kV | 20 |
| Lamao | 230 kV | 30 |
| Lumban | 69 kV | 40 |
| **Total Capacity** | | 290 |
| | | |
| **VISAYAS GRID** | | |
| Kabankalan | 138 kV | 10 |
| Ormoc | 69 kV | 20 |
| Samboan | 69 kV | 10 |
| Sta. Barbara | 138 kV | 10 |
| Compostela | 230 kV | 20 |
| **Total Capacity** | | 70 |
| | | |
| **MINDANAO GRID** | | |
| Villanueva | 138 kV | 10 |
| Davao | 69 kV | 20 |
| Maco | 69 kV | 20 |
| Kibawe | 69 kV | 20 |
| Butuan | 69 kV | 20 |
| **Total Capacity** | | 90 |

As of 31st of October 2021, the DOE had committed to BESS projects totalling 900 MW for Luzon, 343 MW for Visayas, and 280 MW for Mindanao. These projects include AS and VRE firming BESS projects. A full list of the committed projects is provided as Appendix B.

With BESS projects already in operation, and with such a large capacity of BESS projects in the pipeline, the Philippines' electricity market (WESM) faces the same challenge faced by electricity markets in the US, United Kingdom and Australia. In these markets, the MOs have taken steps to re-design their

[3] Transmission Development Plan 2020-2040 Volume 1, pp65-66

markets to encourage ESS on a technology-neutral basis. New conformance standards, protocols and compliance measures have been introduced in recognition that ESS technologies have different operating characteristics to conventional generators.

As mentioned above, the DOE issued circulars DC2019-08-0012 and DC2018-08-0022 to facilitate the entry of ESS.

In response, PEMC has made modifications to conformance standards, protocols, and business support systems to align with the intent of the DOE directives, e.g.

- WESM_RULES_as_of_24Mar2022_(PR)_final.pdf
- WESM-DPM, Dispatch Protocol – WESM Manual, Issue 16.0
- Market Assessment System – Business Requirements Document, 2020
- PEMC-MOPS, Market Operator Performance Standard (MOPS)

However, compared to other electricity markets, the changes made to PEMC's market system are a 'light-touch'. PEMC has created a study project with the purpose of broadening and strengthening energy storage governance to encompass emerging technologies.

# 2 PROJECT OBJECTIVES & OUTPUTS

## 2.1 SPECIFIC AIMS

1. To broaden and strengthen the PEMC's governance functions to encompass emerging technologies participating in the WESM, which include BESS and other ESS as part of the country's energy transition program:

   *"The WESM is the market where trading of electricity will be made. The PEMC, which is a private, non-stock, non-profit corporation whose functions shall be performed through its Board of Directors, which shall hereafter be referred to as the PEM Board, shall be the Governance Arm of the WESM and shall provide the policies and guidelines of the WESM contained in the Implementing Rules and Regulations of the Act, WESM rules, and such other relevant laws, rules and regulations"*

   While governance is a broad term, for the purpose of the project, governance is considered as a system of rules, protocols and support systems. The WESM rules, PEMC market protocols and PEMC's ECO are all part of the governance system.

2. To determine the completeness of market policies with respect to BESS and other ESS

   We understand that the existing market policies that are particularly pertinent to the project are as follows:

   - Wholesale Electricity Spot Market Rules
   - DC2019-08-0012: Providing a Framework for Energy Storage System in the Electric Power Industry and ensuring that the ESS/BESS connected to the network is pursuant to the standards defined in their respective guidelines.
   - WESM-DPM, Dispatch Protocol – WESM Manual, Issue 16.0
   - Market Assessment System – Business Requirements Document, 2020
   - PEMC-MOPS, Market Operator Performance Standard (MOPS)

3. Recommend possible enhancements to the market design and protocols, as and where applicable.

   The need for enhancements is largely determined by deficiencies in the wholesale market rules in relation to the following principles as BESS and ESS capacity increases:

   - Promotes competition: Does the rule remove barriers to entry and lead to reduced operating costs?
   - Promotes transparency: Will the clarifications to the obligations and charges in the rules reduce information asymmetry and improve the decision-making of participants?
   - Creates a level playing field: Are the obligations in the rule proportional, technology-neutral and do they provide participants efficient incentives across categories?
   - Appropriately allocates risks: Will the appropriate parties be assigned responsibility for costs under the approaches in the final rule for cost recovery?
   - Minimizes administrative and regulatory burden: Will the changes reduce the administrative burden on DOE, ERC, PEMC and participants?
   - Enhances system reliability and security: Will the obligations on storage improve reliability and security?
   - The possibility of gaming the market: Could the increasing number and usage of BESS/ESS in the network lead to indirect influence on the market and prices? Enhancements might be needed to prevent any form of undue advantage in an open market.

   These principles offer a set of tests that we will use to prove that changes proposed to market design and protocols, in relation to BESS and ESS, are optimal.

## 2.2 PROJECT OUTPUTS

The outputs of the study are detailed below:

- **Output 1**: Conformance standards applicable to BESS and other ESS; and inception planning and preparation of the reports. Conformance standards are taken to mean the Dispatch Conformance Standards specified in Clause 3.8.5 of the WESM rules.
- **Output 2**: Introduction of protocols for BESS and other ESS for their scheduling and dispatch in the energy-only, and eventually in the co-optimized market for energy and reserves.

  The pertinent protocols include:

- WESM Dispatch Protocol Manual – Defines functions and responsibilities among the MO, the SO, and WESM members with respect to the scheduling and dispatch of reserve capacities.

- Protocol for Central Scheduling and Dispatch of Energy and Contracted Reserves – This protocol covers specific guidelines in the scheduling and dispatch of reserve capacities during normal and emergency conditions during the central scheduling of energy and reserves.

- **Output 3**: Achievement of satisfactory compliance rating by the market participants who operate BESS and other ESS, determined by PEMC's ECO.

  The compliance rating would be achieved when the ECO gives awards/recognitions to the most compliant participants, while the ECO monitors the assessment, validation, and/or investigation of alleged breaches by trading participants, particularly the OCC and DCS. Also, the energy contributed by the ESS/BESS to the grid should be monitored similarly to how a conventional generator is monitored.

  The MOPS are a key setting in ensuring achievement of satisfactory compliance ratings, and the PEMC's MAG is involved in the MOPS. The ECO enforces the offer capacity compliance, dispatch conformance, and forecast accuracy standards.

- **Output 4**: Increased levels of competitiveness in the spot market in terms of BESS and other ESS ownership, though they can be difficult for PEMC to directly control. Hence, the baseline values for market assessment can be determined after the development of certain initial measures.

  Increased levels of competitiveness are indicated in terms of increasing efficiency and long-term investment. Additionally, the HHI is a commonly accepted measure of market concentration and is used to determine market competitiveness. As the popularity of ESS/BESS increases, the HHI would reduce in the country, thus increasing the competitiveness of the market.

Efficiency depends on market rules that are performance-based and that promote market transparency.

Sustained investment in BESS or other ESS technologies is a function of market confidence. To a large extent such confidence relies on a set of market rules that are technology-neutral, in addition to reduced barriers to entry and the general ease of business in the energy sector.

# 3 WHOLESALE ELECTRICITY SPOT MARKET (WESM) OF THE PHILIPPINES

## 3.1 WESM OBJECTIVES

The EPIRA and its IRR form the framework for power industry reforms in the Philippines. EPIRA establishes the industry structure and measures to achieve reform objectives including the regulatory framework, restructuring of the power sector, private sector participation, development of competitive power markets and open access to gradually introduce retail competition. EPIRA was established to increase efficiency, enhance investment, broaden ownership, encourage competition in the power sector and to provide for the orderly and transparent privatization of the assets and liabilities of the Philippines' NPC.

EPIRA provides the broad parameters for the WESM, which is defined in detail in the WESM rules. The WESM rules set out the design principles of the electricity spot market, roles and responsibilities of the MO and the SO, governance of the market, registration of market participants, the procedures for dispatch and pricing, settlements and provision of information and processes for rules changes, disputes and enforcement.

The overriding objectives of the WESM are[4]:

1. Promote competition
2. Provide an efficient, competitive, transparent, and reliable spot market
3. Ensure efficient operation of the WESM by the MO in coordination with the SO in a way which:
    a. Minimizes adverse impacts on system security,
    b. Encourages market participation, and
    c. Enables access to the spot market.
4. Provide a cost-effective framework for resolution of disputes among WESM participants, and between WESM participants and the MO, and between the WESM participants and the Governance arm
5. Provide for adequate sanctions in cases of breaches of the WESM rules
6. Provide efficient, transparent and fair processes for amending the WESM rules.

[4] WESM Rules (Unofficial), 24 June 2021, available: https://www.wesm.ph/library/downloads/view-download/documents/market-rules-and-market-manuals-for-1-hr-market/wesm-rules-and-amendments

7. Provide for the terms and conditions to which entities may be authorized to participate in the WESM

8. Provide the authority and governance framework of the Governance arm and the PEM Board, and

9. Encourage the use of environment-friendly renewable sources of energy in accordance with the EPIRA

## 3.2 WESM GOVERNANCE

The overall governance structure of the WESM is as illustrated in Figure 3.

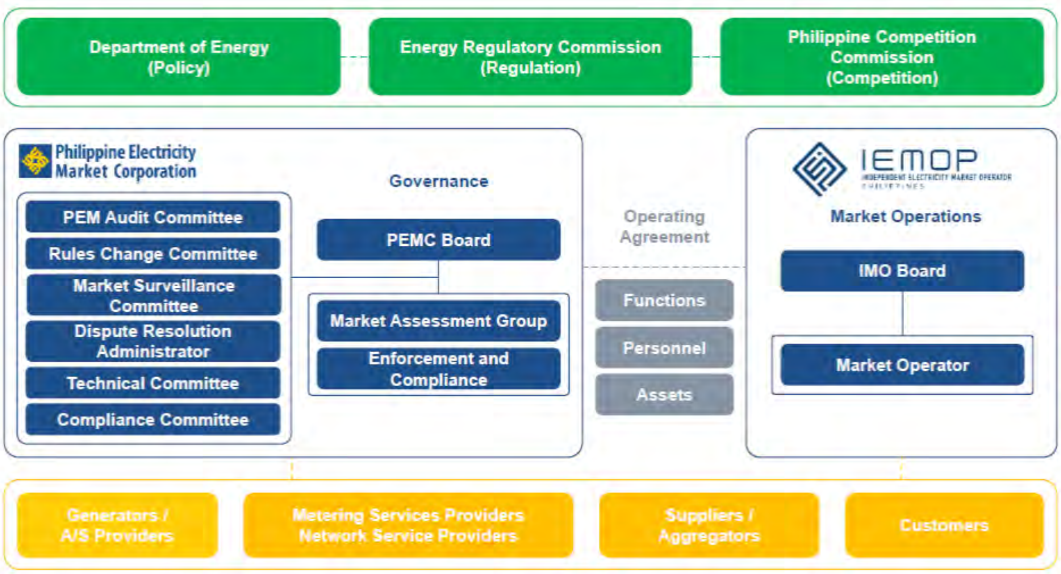


*Figure 3: WESM governance structure*[5]

The DOE is composed of the following bureaus:

- Energy Resource Development Bureau,
- Energy Utilization Management Bureau,
- Energy Policy and Planning Bureau,

[5] B-I-G Capacity Building Program for Connectivity – "Learning from the Philippine WESM," 12 November 2017 - http://www.bigconnectivity.org/beta/sites/default/files/2018-03/Session_2.5_PEMC_ADB%20Presentation%20of%20CLCJ%20OLMEDO_11152017%20final.pdf

- Oil Industry Management Bureau,
- Electric Power Industry Management Bureau, and
- Renewable Energy Management Bureau.

Under Section 43 of the EPIRA, the ERC is tasked to promote competition, encourage market development, ensure customer choice, and penalize abuse of market power in the electricity industry.

Section 30 of the EPIRA mandated the formation of an independent entity to which the MO functions, assets, and liabilities will be transferred. With this, the DOE, along with the electric power industry market participants, endorsed the transfer of the WESM operations from PEMC to the IEMOP on 26 September 2018.

The PEMC remains as the governing body of the WESM primarily through the PEM Board of Directors and the WESM Governance Committees.

The various participants in WESM and their relations with each other are shown in Figure 4 below.

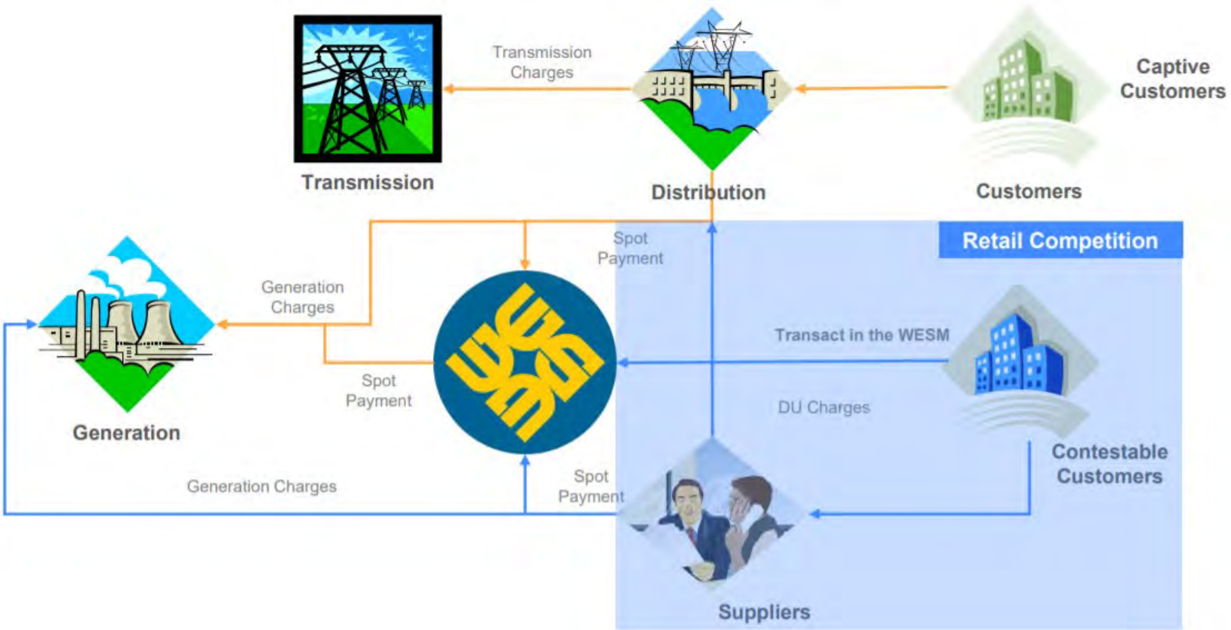


Figure 4: WESM participants and their connections

### 3.3 WESM DESIGN PRINCIPLES

The guiding design principles of WESM are as follows:

1. Gross Pool: Maximum available capacity is offered
2. Net Settlement: Bilateral contract quantities are netted out and settled outside the spot market

3. Co-optimized Energy and Reserves: Employs principle of co-optimization of energy and reserves
4. Self-commitment: Maximum capacity and ramp rates are the only generator constraints
5. Real-time Market: Nodal prices and schedules are determined near real-time
6. Transparency: Timely and accurate market information

## 3.4 AS AND THE WESM

### 3.4.1 Background

The key documents that guide the management of AS in the Philippines include:

- The Electric Power Industry Reform Act (EPIRA),
- The Grid Code,
- Ancillary Services Procurement Plan (ASPP),
- Ancillary Services Cost Recovery Mechanism (AS-CRM),
- Price Determination Methodology for Philippine Wholesale Electricity Spot Market (WESM PDM),
- Wholesale Electricity Spot Market (WESM) Rules,
- Open Access Transmission Services Rules (OATS Rules), and
- DOE Circular No. DC2021-03-0009 'Adopting a General Framework Governing the Operationalization of the Reserve Market in the Wholesale Electricity Spot Market and Providing Further Policies to Supplement DC2019-12-0018'.

### 3.4.2 Interim Arrangements for AS

In the original WESM rules, in 2006, it stated that 'When reasonably feasible, the MO, in coordination with the SO, shall establish and administer a spot market for the purchase of certain reserve categories. To date this has yet to be implemented, and the AS markets are operated under Interim arrangements where the SO, NGCP, contracts all reserves and there is a protocol in place for managing the services in the WESM, which only considers scheduling and dispatch for energy. The reason this is important is because there are implications for BESS that provide AS and their dispatch in the WESM.

The remainder of this section describes the interim arrangements as it has implications for the conformance standard / dispatch protocols of ESS.

### 3.4.3 Categories of AS

Under the Interim Arrangements, the reserves procured by the SO are defined as follows:

- **CR: Contingency Reserve** – a reserve procured to provide the generating capacity needed to respond to infrequent, but usually large, failures of generating units and/or transmission tie lines. failures of generating units and/or transmission tie lines.

- **RR: Regulating Reserve** – a reserve procured to provide primary response RR operating in an automatic frequency sensitive mode or Free Governor Mode with dead band of +/ -0.15Hz with maximum response time of 5 seconds and sustainable for 25 seconds

- **DR: Dispatchable Reserve** – is a reserve procured to provide generating units that have fast start capability which can synchronize within 15 minutes upon dispatch instruction of SO and can sustain its output for a minimum period of 8 hours.

The ultimate Philippines AS arrangements comprise the following services, as defined in the PGC:

- **PRAS**: which is an AS to stabilise the system frequency and to cover the loss or failure of a synchronized generating unit or a transmission line or the power import from a single circuit interconnection.

- **SRAS**: is an AS to restore the system frequency from the quasi-steady state value as established by the PRAS of Generating Units back to the nominal Frequency of 60 Hz. The SO, through AGC, shall use the secondary reserve to supply demand balance during small deviations, and restore the system frequency from the quasi-steady state value back to the nominal frequency of 60 Hz during contingent event.

- **TRAS**: is an AS required to replenish the SRAS and to cover variations of VRE generation. If and only if, the PRAS and SRAS have been exhausted, the SO shall make use of the tertiary reserve to return/ maintain the system frequency to 60 Hz, under a number of predefined scenarios: (a) unplanned tripping of generating units / transmission lines, (b) unplanned loss of power imports, (c) unplanned disconnection of load and/or load blocks, (d) un expected increases or reductions of VRE generation, or significant errors in forecasts, or (e) system frequency rises above 60.1 Hz or falls below 59.9 Hz and PRAS and SRAS are inadequate to return frequency to nominal values.

- **RPSAS**: is the capability of a generating unit to supply reactive power to, or absorb reactive power from, the transmission network to maintain the bus voltage within five percent (5%) of its nominal voltage. The purpose of RPSAS is to supplement reactive power resources of the static and dynamic type, depending on the location and network loading conditions, and to contribute to network voltage control when dispatched.

- **BSAS**: The need for this AS arises when event or significant incident will result in a partial or total system blackout. This is the ability of a generating unit, without assistance from the grid or other external power supply, to recover from a shutdown condition to an operating condition to energize the grid and assists other generating units to start. The objective is to energize a section of the network without the use of external power sources, allowing further connection of transmission circuits, and demand to be progressively connected, until the network is re-integrated.

### 3.4.4 Determination of Requirements

The requirements, types of providers and conditions for provision of "CR or PRAS", "RR or SRAS" and "DR or TRAS" are set out in Table 2. The table also summarizes any key requirements or constraints on providers of the said services. Collectively PRAS, SRAS and TRAS are reserves that support frequency control. This has been based on PGC and AS procurement rules of ERC for the interim AS market.

*Table 2: Summary of PRAS, SRAS and TRAS Requirements*

| Service | System Requirement | Providers / Provision Mechanism(s) | Conditions on Scheduling of Providers | Other constraints or requirements |
|---|---|---|---|---|
| PRAS | Determined by NGCP based on the most heavily loaded generating unit online and its scheduled reserve (i.e., largest credible generator outage) | Provided by generating units (i.e., conventional types), operating under governor control mode and new technologies (e.g., BESS, flywheel, etc.) as certified and contracted by the SO, or offering in the WESM | Providers must operate in governor control mode – which is a mandatory requirement for connection. Providers will be assigned PRAS requirements if: (1) it has sufficient headroom, and (2) it has a contract to provide PRAS with SO | Capacity offered for PRAS shall not be used in the regular energy supply. No generating unit shall be assigned a PRAS level greater than 20% of the total required amount of PRAS, subject to availability of sufficient PRAS providers, for any dispatch interval to avoid a single point of failure |
| SRAS | Set to 4% of the hourly system demand | SRAS is provided by generating units (i.e., conventional types) and new technologies (such as BESS or flywheel, etc.) both if they are contracted and certified by the SO or offering in the WESM. The providers must be capable of operating on AGC | SRAS shall be controlled by the SO through AGC with auto regulation, auto assistant emergency, or auto emergency settings to regulate the system frequency. The speed governing system shall be capable of accepting raise and lower signals or set point signals from the control centre of the SO | Generating unit contracted to provide secondary reserve shall not override the AGC mode or AGC setting as set and controlled by SO. Where the AGC function of the SO is not fully operational, dispatcher shall instruct the generator to transfer to manual control mode. The capacity offered for SRAS shall not be |

| Service | System Requirement | Providers / Provision Mechanism(s) | Conditions on Scheduling of Providers | Other constraints or requirements |
|---|---|---|---|---|
| | | | | used in the regular energy supply |
| TRAS | Based on the second most heavily loaded generating unit online and its scheduled reserve (second largest most credible generation contingency) | TRAS is provided by generating units (i.e., conventional types), new technologies (e.g., BESS, flywheel, etc.) and Qualified Interruptible Loads contracted by the Transmission Network Provider and are certified by the SO or offering in the WESM | TRAS providers are AS providers that are synchronized to the grid and those which are offline. TRAS providers must provide a committed uniform load throughout the Dispatch Period. Interruptible Loads should also be able to stay off-line until ordered by the SO to re-connect to the grid | The capacity offered for TRAS must not be used in the regular energy supply. TRAS providers must provide real time data (MW readings and status of load) to the NGCP SCADA/EMS. The total TRAS quantity for the system is to be 50% synchronized to the grid, and 50% offline |

*PRAS - Primary Reserve Ancillary Service*
*SRAS - Secondary Reserve Ancillary Service*
*TRAS - Tertiary Reserve Ancillary Service*

For RPSAS, all generating units shall be capable of supplying its active power output, as specified in the generator's declared data, within the limits of the power factor prescribed as per PGC, at the generating unit's terminals. The generators shall be dispatched by the SO to operate within this range as the need arises to manage voltage.

For BSAS, the SO determines "restoration highways" and black start capability is procured from strategically located generating units. Sufficient black start and fast start capacity must be made available at strategic locations to facilitate the restoration of the grid to the normal state following a total system blackout. Further conditions on BSAS providers are set in the PGC.

### 3.4.5 Contracting and Payment for AS

The SO procures and enters into an ASPA with qualified AS providers to ensure sufficient levels of AS will be always provided to the grid. Prior to the start of the WESM reserve market, based on DOE Circular DC2019-12-0018 "Adopting a General Framework Governing the Provision and Utilization of Ancillary Services in the Grid", the SO is assigned the responsibility of procuring AS via firm contracts for ASPA. As such AS providers have a contract with the SO for the provision of AS at prices and rates that are determined by NGCP and approved by ERC. AS providers that have ASPAs with NGCP are required to manage their operations in the WESM to satisfy the conditions in the ASPA to provide AS. The SO is responsible for finalizing the AS providers for PRAS, SRAS and TRAS on a day-ahead basis using the methodology specified in Section 3.4.6.

The cost of minimum loading for PRAS, SRAS and TRAS providers is not to be considered part of the AS payment and should be recovered via the WESM or through bilateral contracts with load customers.

The cost of start-up or shutdown outside the scheduled intervals shall not be part of the AS payment. It is the obligation of the AS provider to ensure it is synchronized at the start of its scheduled interval when providing PRAS, SRAS or TRAS.

The maximum AS capacity and energy dispatch must not exceed the scheduled AS capacity. Any excess shall not be part of the AS payment. It is the obligation of the AS provider to ensure that it provides only up to its maximum scheduled capacity. AS provider must limit its AS provision within its scheduled intervals. Capacity and energy provided outside the scheduled intervals shall not be paid under AS.

All payments are subject to the approval of the ERC.

### 3.4.6 Scheduling AS

The AS Procurement document of ERC sets out the scheduling arrangements for pre-WESM reserve market, and post-WESM reserve market. This section summarizes the pre-WESM reserve market arrangements, as this study does not consider the longer-term AS market arrangements.

Most importantly, the ASPs are required to ensure that the contracted generators are as and when required to be dispatched to provide their services. This is done with the implementation and enforcement of the AS dispatch protocol which helps with the scheduling and dispatch of the AS. The AS dispatch protocol helps schedule the dispatch of the ancillary services as follows:

1. Time intervals for scheduling and dispatch are to be in accordance with the dispatch intervals defined under Clause 3.4.1 of the WESM rules.
2. The ASPs are required to submit the following to the SO daily:
    a. Day-ahead capacity nomination as per the time intervals
    b. Status of the black start equipment if the ASP is a black start provider
2. The SO generates a daily, day-ahead AS schedule based on:
    a. Reserve requirement per time interval
    b. Nominated ancillary capacity
    c. Merit order of each ancillary service
    d. Black start units available
    e. Reactive power support required
3. The SO is required to provide instructions to the ASPs for the dispatch of their generators based on the schedule. Re-dispatch procedures can be undertaken by the SO in case of any of the conditions mentioned under Section 3.1.8 of the AS procurement document.

4. The SO is required to monitor the performance of the ASPs and the compliance of the services that they provide and include penalties, in case of any non-compliance, in the statement of accounts that is sent to the ASPs.

5. Additionally, the SO is also required to generate and submit a monthly report on the AS schedule and performance to the ERC.

#### 3.4.7 Longer-Term AS Arrangements

In the longer-term, once the commercial operation of WESM reserve market has commenced, then according to DOE Circular DC2019-12-0018 'Adopting a General Framework Governing the Provision and Utilization of Ancillary Services in the Grid' and PGC, the SO shall procure AS based on the following:

- PRAS, SRAS, and TRAS, are envisaged to be:
    - 50% of the reserve requirement through firm contracts of ASPA
    - 50% of the reserve requirement through WESM Reserve Market
- RPSAS will be managed through firm contracts of ASPA, provided that the payment for such shall be on a per-occurrence basis, and
- BSAS will also be managed via firm contracts of ASPA, provided that the payment for such shall be on a per-occurrence basis.

Note that the longer-term AS arrangements are not considered in this study, only the arrangements prior to the above have been considered.

### 3.5 RECENT DEVELOPMENTS

In recent years, WESM has undertaken multiple measures to enhance its structure and design, some of which include:

1. Addressing the limitations caused by central scheduling such as dispatch scheduling of FCAS in the WESM and limiting the dispatch schedules of renewable energy in constrained zones.

2. Strengthened coordination among the policy-making bodies, regulators, implementing agencies, and the market participants.

3. Phased-in and integrative implementation of market mechanisms.

4. Increasing the involvement of the market participants in the implementation of market mechanisms.

## 3.6 RECENT CHANGES TO WESM TO SUPPORT ESS

The Philippines DOE, through its Department Circular DC2018-08-0022, made amendments to the WESM rules in late 2018. The crux of this amendment was the expansion of the possible classifications of a generation unit from the original four which included two types of scheduled units and dispatch units to include two types of ESS under Clause 2.3.1.2 of the WESM rules:

1. BESS: Defined by DOE as a facility that can store electrical energy through chemical reactions via charging and discharging processed to generate or consume energy as required.

2. Pumped-storage Unit: Defined by the DOE as a facility that can store water from a reservoir at a lower elevation to one at a higher elevation to produce electrical power.

The above definitions make it clear that the DOE has acknowledged and accepted the bidirectional nature of the operation of ESS units, being capable of generation as well as consumption. As a result, the following changes have been made to WESM to accommodate and integrate ESS units:

1. A generation company is required to operate the ESS units under its purview as a “generation” unit within the provisions of the dispatch conformance standards set forth in the Market Manual.

2. ESS facilities are now considered in the load forecast to meet the net load by the generation system.

3. The pumped storage units in the generation system are required to submit a weekly forecast of when the unit would be operating as a load to transport the water from the lower reservoir to the higher reservoir. Every interval where the pumped storage unit is not acting as a load is considered as it being available to operate as a generation unit.

4. Being eligible generation units in the system, the ESS facilities are now required to follow all the instructions from the System Operator in accordance with the Grid Code and WESM rules.

5. In addition to the information mentioned under the Section 2.5.4.4 of the Manual on Registration, Suspension and De-registration, the generation company is required to:

    a. Include the energy storage efficiency and the maximum storage capacity, in case of a battery energy storage unit

    b. Include the facility’s maximum pump load, in case of a pumped-storage unit

The amendments have also made provisions in relation to the energy market and the trading operations:

1. The MO is required to approve the classification of a generation unit as either of the four earlier categories, or one of the two new ESS categories, subject to the relevant prevailing rules and regulations under Section 2 of the Market Manual on Registration, Suspension and De-registration.

2. The MO is required to publish the dispatch schedule for the ESS facilities in each dispatch interval in the settlement intervals for the previous trading day, as it does for the other generation units.

3. Generation companies with or without bilateral contracts are now required to submit standing market offers for their scheduled generation units, battery energy storage units, and pumped storage units for all dispatch intervals in accordance with the market trading schedule.

4. Pumped storage units are required to submit their generation offers with the same information that is asked of the scheduled generation units, mentioned under Appendix A1.1 of the Market Rules.

5. Battery energy storage units are required to provide the information asked of the other generation units as mentioned above, along with additional information mentioned in Appendix A1.4.

6. The MO is required to provide electronic confirmation of receipt and acceptance of valid market offers, nomination of load levels, demand bids or projected output to the respective trading participant. If the offer, bid, or projected output are invalid, the market operator is required to inform the participant to allow them time to correct and resubmit the valid offers, bids, or projected outputs.

The market operator and system operator formulate a market dispatch optimization model to simultaneously determine multiple values of the market as defined under Clause 3.6.1 of the Market Rules. The ESS facilities are now considered in the formulation of the market dispatch optimization model. The market operator has the authority to restrict the dispatch targets in case of potential security concerns in accordance with a hierarchy, that has been amended to include the ESS units and is defined under Clause 3.6.1.8 as:

1. Scheduled generation units, battery energy storage systems, and pumped-storage units operating on generation mode beyond its minimum level

2. Non-scheduled generation units

3. Priority dispatch generation units

4. Must dispatch generation units

The DOE also recognized the need to accommodate changes to the Market Network Model, as defined under Section 4 of the WESM Market Manual. The complex nature of the interaction between components of the network model was expanded to include the ESS facilities, namely, battery energy storage systems and pumped-storage units.

MTN are the points in the load flow model that are set out for the settlement of energy and reserves of the Trading participants. ESS facilities were included in the market trading nodes by modelling the MTNs as the trading points of generation units, battery energy storage systems, and pumped-storage units (or a load corresponding to its connection point). The classification of MTNs was amended in under Section 6 of the Market Network Model Development and Maintenance manual to add the following two:

a) BESS nodes: nodes representing a battery energy storage system directly connected to a network operated by the SO, and where power is injected or withdrawn through the transmission network.

b) Pumped-storage Unit nodes: nodes that represent a registered pumped-storage unit directly connected to a network operated by the SO, and where power is injected or withdrawn through the transmission network.

Accommodating the abovementioned changes in the market rules, protocols and procedures have impacted only a small number of key documents. A clause-by-clause list of ESS changes in WESM documentation is provided as Appendix C.

*Table 3: WESM Documents Impacted by ESS*

| Protocol | Document Reference | Modified for ESS? |
|---|---|---|
| WESM rules | WESM_RULES_as_of_24Mar2022_(PR)_final.pdf | **Yes** |
| Disclosure and Confidentiality of Retail Customer Information | RCOA-DCRCI-2.1_as_of_25_Nov_2021_final.pdf | No |
| Green Energy Option Program Procedures | RCOA-GEOPP-0.0_as_of_25_Nov_2021_final.pdf | No |
| Metering Standards and Procedures | RCOA-MSP-5.1_as_of_25_Nov_2021_final.pdf | No |
| Market Transactions Procedures | RCOA-MTP-3.1_as_of_25_Nov_2021_final.pdf | No |
| Registration Criteria and Procedures | RCOA-RCP-3.1_as_of_25_Nov_2021_final.pdf | No |
| Rules for Competitive Retail Electricity Market (Retail Rules) | RETAIL_RULES_as_of_25_Nov_2021_final.pdf | No |
| Billing and Settlement | WESM-BSM-10.1_24Mar2022_final.pdf | No |
| Constraint Violation Coefficients and Pricing Re-Runs | WESM-CVC-7.0_27_Aug_2021_(DC2021-07-0022)_final_1.pdf | No |
| Dispatch Protocol Manual | WESM-DP-16.0_26_Jun_2021_(EWDO)_(FINAL).pdf | **Yes** |
| Dispute Resolution | WESM-DRM-8.0_07Jan2022_(final).pdf | No |
| Enforcement and Compliance | WESM-ECM_1.0_23Oct2021.pdf | No |
| Procedures for the Monitoring of Forecast Accuracy Standards for Must Dispatch Generating Units | WESM-FASMD-2.0_26_Jun_2021_(EWDO)_1.pdf | No |
| Guidelines Governing the Constitution of the PEM Board Committees | WESM-GDL-4.0_23Oct2021.pdf | No |
| Guidelines on Significant Variations in and between Trading Intervals | WESM-GSV-4.0_26_Jun_2021_(EWDO).pdf | No |
| Market Operator Information Disclosure and Confidentiality Manual | WESM-IDC-5.1_26_Jun_2021_(EWDO).pdf | No |
| Load Forecasting Methodology | WESM-LFM-4.0_26_Jun_2021_(EWDO)_1.pdf | No |
| Market Network Model Development and Maintenance – Criteria and Procedures | WESM-MNMCP-5.1_26_Jun_2021_(for_reposting).pdf | **Yes** |

| Protocol | Document Reference | Modified for ESS? |
|---|---|---|
| Market Surveillance | WESM-MSM_1.0_23Oct2021.pdf | No |
| Metering Standards and Procedures | WESM-MSP-15.0_07Jan2022_(final).pdf | No |
| Protocol for Central Scheduling and Dispatch of Energy and Contracted Reserves | WESM-PCSD-3.0_26_Jun_2021_(EWDO)_1.pdf | **Yes** |
| Price Determination Methodology | WESM-PDM-3.0_26_Jun_2021_(EWDO)_(FINAL).pdf | **Yes** |
| PEM Audit Market Manual | WESM-PEMAUD-2.0_26_Jun_2021_(EWDO).pdf | No |
| Procedures for Changes to the WESM rules, Retail rules and Market manuals | WESM-RCM-5.0_26_Nov_2021.pdf | No |
| Registration, Suspension and De-Registration Criteria and Procedures | WESM-RSDCP-10.1_25_Nov_2021_reposted.pdf | **Yes** |
| System Security and Reliability Guidelines | WESM-SSRG-1.0_26_Jun_2021_(EWDO).pdf | No |
| Technical Committee Market Manual | WESM-TCMM-3.0_23Oct2021.pdf | No |
| WCO Certification and Registration Manual | WESM-WCR-1.0_15Jan2022_(DC2021-12-0041)_fin.pdf | No |
| Penalty Manual | WESM_Penalty_Manual_1.0_23_Oct_2021_(final).pdf | No |

# 4 STAGES OF ESS MARKET INTEGRATION

## 4.1 CHALLENGES IN THE INTEGRATION OF ESS

The integration of BESS/ESS is the next step for the WESM and PEMC. One of the key issues in electricity markets is that energy storage is a relatively flexible technology that can provide energy and non-energy related services (e.g., AS), but unlike conventional electricity generation resources, it operates with bidirectional energy flow. This results in several challenges:

1. Typically, storage and hybrid schemes (RE + storage) must register in two registration categories (as a generator and as a consumer). This is not only an issue in the registration process, but also for participation in dispatch, where storage units must provide two separate bids – one from each registration category.

2. The requirements for DC coupled hybrid facilities are unclear. It is important to clarify the scheduling requirements for hybrids that are DC coupled to facilitate the entry and participation of those configurations, which can also deliver benefits to the system.

3. The existing framework for the recovery of non-energy costs does not ensure that there is a consistent approach across participation categories and technology types considering increasing bi-directional flows. It is expected that improved AS arrangements will address any design deficiencies in the current arrangements.

Moreover, in markets with high levels of RE where innovation is desired, it has been accepted that electricity market rules should embrace a technology neutral approach wherein the market accommodates a variety of participants with bi-directional energy flows that may offer (and consume) energy and AS. Given the DOE's NREP, if executed correctly, Philippines will be heading in the direction of high level of renewable energy with presence of BESS/ESS in the grid, which would require upgrading of the WESM rules. A technology neutral approach means that a power system performance standard or connection requirement is specified in a way that does not reference the specific nature of a given technology. For example, a voltage standard or frequency standard does not need to make reference to a given technology. So long as a technology – whether it is an ESS, conventional generator or VRE farm can demonstrate compliance with the required standard, then it would be accepted for either grid-connection or operation in the power system.

ESS OPERATIONS IN AN ELECTRICITY MARKET

The following are important concepts for ESS operation in electricity markets:

- ESS power capacity (kW) cannot be less than energy storage capacity
- There are power applications where energy use is small e.g., frequency regulation, large ramp management

- There are energy applications where energy is delivered over 1 to 4 hours at a constant power, e.g., solar and wind firming, small ramp management, capturing price arbitrage opportunities
- The SOC of an ESS is important to the SO as it determines the capability of the ESS to support (or not) the security of the power system

Figure **5** shows a BESS example where SOC falls with discharge to about 15% of rated capacity and rises to about 70% while charging. The smaller SOC range the longer the BESS life.

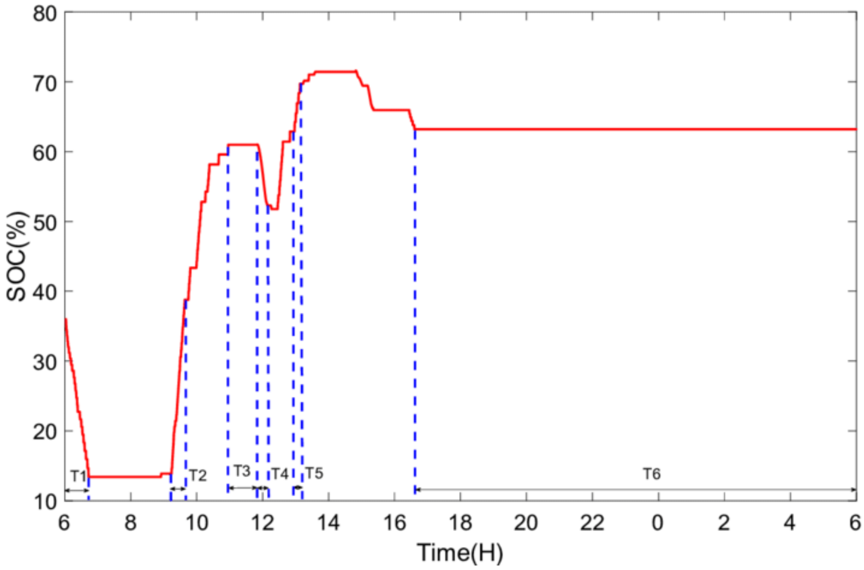


*Figure 5: Illustration of a BESS Maintaining its SOC between 15% and 70%*

## 4.2 CASE STUDY: HORNSDALE POWER RESERVE

Hornsdale Power Reserve, when it first came into operation in December 2017 in South Australia, was the world's largest Lithium ion and first of its kind utility-scale battery system in Australia with a capacity of 100 MW/129 MWh. It was expanded to 150 MW/194.5 MWh in 2020. Hornsdale Power Reserve is in a region that is highly susceptible to load variations due to its transition towards renewable developments, with ambitions of delivering electricity from 100% renewable sources by 2030. Hornsdale Power Reserve has made a significant impact in addressing the region's major energy security and reliability challenges.

Since its inception, the Hornsdale Power Reserve has been instrumental in delivering fast frequency response to address grid frequency fluctuations and in stabilizing inertia services that were previously addressed by large synchronous generators in the region. During the planning stage the expansion was expected to support the system in providing up to 3,000 MWs of inertia for the region which is about half of the requirement of 6,000 MWs identified by AEMO to maintain a secure operating level of inertia.

When commissioned, South Australia Government reserved 70 MW (out of 100 MW) and 10 MWh (out of 129 MWh) of battery capacity with the objective of improving system security and reliability in South

Australia and put downward pressure on the FCAS prices. These objectives were to be met through providing FCAS services, fast frequency response as well as participation in the SIPS, a special scheme developed by the AEMO and ElectraNet, the transmission network service provider in South Australia, designed to prevent a loss of the Heywood interconnector between South Australia and Victoria in the event of a loss of multiple generators in South Australia. The owner of Hornsdale Power Reserve can participate in the commercial market with the balance of power and energy.

An illustration of Hornsdale Power Reserve price arbitraging in the ANEM is illustrated in Figure 6 and in Figure 7. As per a pumped storage or any other energy storage device, BESS arbitrages in the NEM between times of high price and low price. It should be noted that in the ANEM, the price cap is set high (15,300 AU$/MWh presently) and price floor negative (-1000 AU$/MWh). 30 MW of the Hornsdale Power Reserve battery is registered as a market participant (the rest operates under an out-of-market AS contract 70 MW). The 30 MW of BESS from Hornsdale Power Reserve is in competition with all other generators and dispatchable loads.

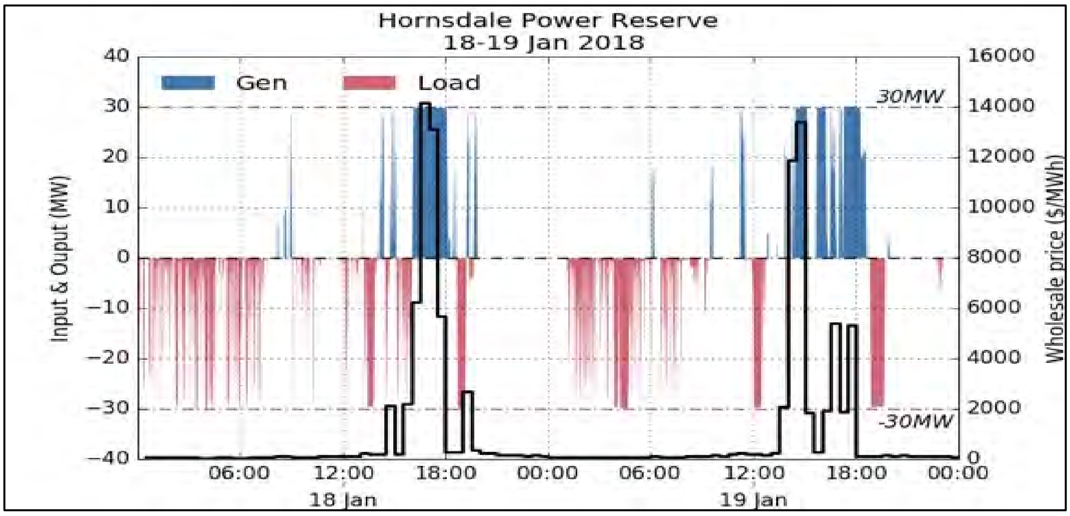


*Figure 6: Illustration of HPR discharging when spot market prices are high*

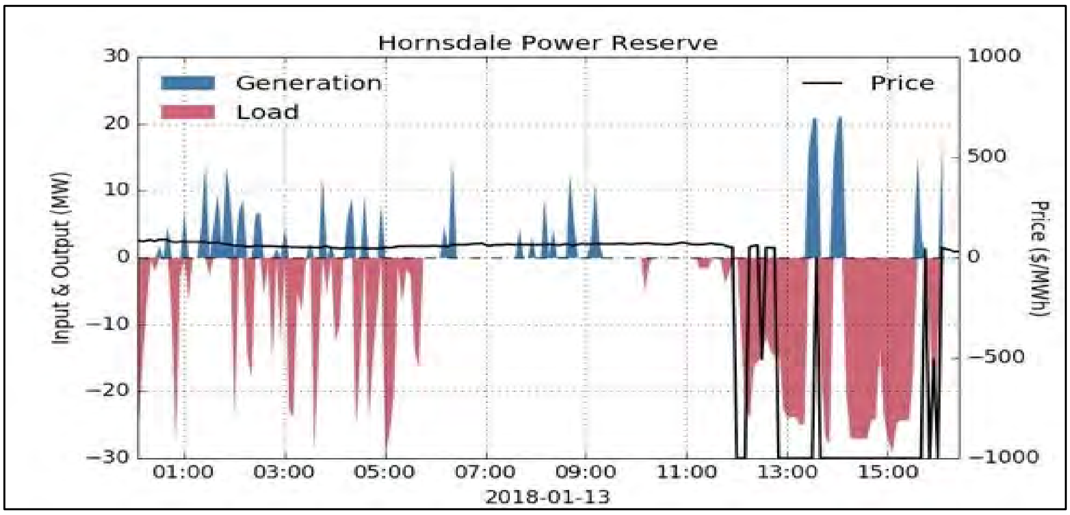

*Figure 7: Illustration of HPR charging when prices are low (and negative)*

Hornsdale Power Reserve can respond to system events rapidly, within 100 to 150 ms. Simulation studies by independent consultants of a hypothetical contingency event of the loss of 200 MW due to a trip of the Heywood interconnector connecting South Australia and Victoria, showed that Hornsdale Power Reserve's fast response prevented load shedding in the simulated event[6]. In addition to improving system reliability Hornsdale Power Reserve has also reduced system FCAS cost. In its first year of operation, the battery system is estimated to have provided more than AU$50 million in cost savings to consumers[7]. Below are instances of cost savings attributed to Hornsdale Power Reserve.

- AEMO has historically procured 35 MW of regulation FCAS in South Australia when it deemed the loss of Heywood was credible. The cost of Regulation FCAS services for the market is estimated to be AU$40 million in each of 2016 and 2017. AEMO advised in October 2018 that it will no longer need to procure the 35 MW.

- For example, in an event on 14 January 2018 AEMO estimated that Hornsdale Power Reserve reduced costs by around AU$3.5 million. The average price of regulation FCAS during that event was AU$248/MWh compared to historically being above AU$9,000/MWh. The lower price (and cost) is attributed to the presence and performance of Hornsdale Power Reserve.

- Modelling by an independent consultant estimates that HPR reduced Regulation FCAS costs by approximately AU$35 million in 2019. After Hornsdale Power Reserve started operating, annual average Regulation FCAS price in SA fell from AU$470/MWh to less than AU$40/MWh, which is at a similar level to the other NEM regions[8].

- In contingency FCAS, Hornsdale Power Reserve is modelled to have saved approximately AU$62 million with the highest proportion of savings coming from the 6-second FCAS service.

- It is also expected that the availability of an additional capacity and bidding across the energy and FCAS markets contributes to additional cost reduction which is not quantified. Before expansion, Hornsdale Power Reserve had 30 MW that it can bid into the energy and FCAS markets. This has increased to 80 MW after the expansion from 100 MW to 150 MW.

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[6] Aurecon, "Hornsdale Power Reserve - Year 1 Technical and Market Impact Case Study," Aurecon, 2019.

[7] Hornsdale Power Reserve, "Hornsdale Power Reserve to Be Expanded," Hornsdale Power Reserve, 19 November 2019. [Online]. Available: https://hornsdalepowerreserve.com.au/hornsdale-power-reserve-to-be-expanded/. [Accessed 19 June 2022]

[8] Aurecon, "Hornsdale Power Reserve - Year 2 Technical and Market Impact Case Study," Aurecon, 2020.

## 4.3 STAGES OF ESS INTEGRATION

An assessment of market maturity regarding the integration of ESS facilities into the market is set out in Table 4. The following are the definitions for the five stage of market maturity:

- **Initial**: building awareness
- **Managed**: implementing best practices
- **Defined:** standardisation and continuous improvement
- **Integrated:** integration and alignment
- **Optimized**: continuous innovation

The following definitions have been used in the terminology used in the table:

- ESS refers to energy storage system, including PSH and BESS,
- "Stand-alone ESS" facility – a single ESS that is greater than some minimum size, and
- IRP is a hybrid system, which are facilities that are the composite of numerous technological components.

The purpose of the table is to illustrate the stages of evolution that wholesale electricity markets undergo in terms of integration of ESS.

*Table 4: Stages of ESS Integration*

| **Market Design Process** | **Stage 1: Initial Design (ESS not accommodated)** | **Stage 2: Managed (Pilot ESS)** | **Stage 3: Defined (Stand-alone ESS)** | **Stage 4: Integrated (VRE+ESS)** | **Stage 5: Optimized (IRPs)** |
|---|---|---|---|---|---|
| Level of participation of ESS in electricity market | ESS / IRPs not able to participate in the electricity market | Support for the connection / operation of stand-alone ESS in electricity market on a limited basis | Full support connection / operation of stand-alone ESS in electricity market for energy and ancillary services | Support for full connection / operation of stand-alone ESS and limited participation[9] of IRPs in electricity market – in energy & | Support for full connection / operation / flexibility[10] in stand-alone ESS and IRPs in electricity market – in energy & ancillary service |

[9] For example, there may be tight limits or restrictions on the nature of the hybrid facilities – e.g., solar / wind + ESS only, or limits in terms of the sizing etc.

[10] Flexibility means that market participants have greater freedom over the composition of their hybrid facilities – e.g., integration of BESS, distributed generation sources, wind, solar and other technologies – so long as they can demonstrate that they comply with requirements for registration. It also means within this context, having more than 1 facilities located at different connection points.

| Market Design Process | Stage 1: Initial Design (ESS not accommodated) | Stage 2: Managed (Pilot ESS) | Stage 3: Defined (Stand-alone ESS) | Stage 4: Integrated (VRE+ESS) | Stage 5: Optimized (IRPs) |
|---|---|---|---|---|---|
| | | | | ancillary service markets | markets. IRPs can be located at > 1 connection point. |
| Registration | ESS / IRPs not recognised as a category of market participant | Stand-alone ESS facilities can be registered to participate in generation market only | Stand-alone ESS facilities can be registered to participate in generation, load and ancillary service markets | Stand-alone ESS and IRPs can be registered as market participants to participate in generation, load and ancillary service markets | Stand-alone ESS and IRPs can be registered as market participants to participate in generation, load and ancillary service markets. Market participants have greater flexibility over the composition and treatment of their IRPs in the market |
| Scheduling | Market clearing engine does not schedule ESS facilities or IRPs | Market clearing engine schedules ESS on stand-alone basis for generation only, but loads are scheduled separately (not optimised in the market) | Market clearing engine schedules ESS for generation and loads based on bidirectional bids/offers. Market clearing engine also schedules ESS for AS so long as ESS is registered to provide the given AS and submits offers to provide AS | Market clearing engine schedules ESS and IRPs[11] for generation and loads based on bidirectional bids/offers. Market clearing engine also schedules ESS / IRP for AS so long as ESS / IRP is registered to provide the given AS and submits offers to provide AS | Market clearing engine schedules ESS and IRPs for generation and loads based on bidirectional bids/offers. Market clearing engine also schedules ESS / IRP for AS so long as ESS / IRP is registered to provide the given AS and submits offers to provide AS |

[11] Note that IRP scheduling is potentially quite complex as there is a combination of forecast information for VRE components, and dispatch could be done at an aggregate level, or it could be done at a sub-connection point level.

| Market Design Process | Stage 1: Initial Design (ESS not accommodated) | Stage 2: Managed (Pilot ESS) | Stage 3: Defined (Stand-alone ESS) | Stage 4: Integrated (VRE+ESS) | Stage 5: Optimized (IRPs) |
|---|---|---|---|---|---|
| Dispatching | Any ESS would be dispatched outside of the market | ESS follows dispatch instructions from Market Clearing Engine in real-time | ESS follows dispatch instructions from Market Clearing Engine in real-time | ESS / IRP[12] follows dispatch instructions from Market Clearing Engine in real-time | ESS / IRP follows dispatch instructions from Market Clearing Engine in real-time |
| Bidding | No facilities to accept bids / offers from an ESS facility (it could be managed as must-run load / generation outside the market) | Offers to schedule ESS for generation. Loads treated as must-run (does not accept load bids) | Bi-directional offers for generation and load of ESS, i.e., demand-side bidding. Offers for AS markets also accepted for AS the ESS is registered to provider. | Bi-directional offers for generation and load of ESS and IRPs, i.e., demand-side bidding. Offers for AS markets also accepted for AS the ESS is registered to provider. | Bi-directional offers for generation and load of ESS and IRPs, i.e., demand-side bidding. Offers for AS markets also accepted for AS the ESS is registered to provider. |
| Pricing | Not subject to market prices | Only generation is subject to market prices – load charging costs on same basis as any other customer | Can set prices based on offers / bids for generation / load, and subject to those prices | Can set prices based on offers / bids for generation / load, and subject to those prices | Can set prices based on offers / bids for generation / load, and subject to those prices |
| Settlement – for energy | No treatment of ESS in settlements | ESS injections and offtakes are handled in the settlement logic | ESS injections and offtakes are handled in the settlement logic | ESS / IRPs injections and offtakes are handled in the settlement logic[13] | ESS / IRPs injections and offtakes are handled in the settlement logic |
| Settlement – for AS markets | No treatment of ESS in settlements | No treatment of ESS in settlements | ESS is paid for AS it provides and charged for AS under AS cost recovery rules | ESS / IRPs are paid for AS they provide and charged for AS under AS cost recovery rules | ESS / IRPs are paid for AS they provide and charged for AS under AS cost recovery rules |

[12] Note that logic for dispatching IRPs may be at the aggregate level or at the sub-connection point / unit level. This would need to be determined as part of the registration process. Sub-connection point units would need to be able to receive dispatch instruction signals for example.
[13] For IRPs the arrangement and locations of meters is important for settlements.

| **Market Design Process** | **Stage 1: Initial Design (ESS not accommodated)** | **Stage 2: Managed (Pilot ESS)** | **Stage 3: Defined (Stand-alone ESS)** | **Stage 4: Integrated (VRE+ESS)** | **Stage 5: Optimized (IRPs)** |
|---|---|---|---|---|---|
| Compliance | Not needed | Compliance regime only considers ESS for generation and has some measures for checking compliance of scheduled loads | Compliance regime covers both energy and AS markets for ESS | Compliance regime covers both energy and AS markets for ESS and IRPs | Compliance regime covers both energy and AS markets for ESS and IRPs |

*ESS – Energy Storage Systems*
*IRP – Integrated Resource Provider*
*VRE – Variable Renewable Energy*
*AS – Ancillary Services*

## 4.4 WESM MARKET MATURITY

The following table considers the five stages of market maturity for the treatment and integration of ESS into the selected international markets. Note that we have included Singapore as well, as an example of a market that presently has no processes to address ESS just as a comparison. The review of international experience shows that the US and Australian markets have had facilities for the management of ESS in place long before the recent surge in BESS. As shown, the WESM is has a basic implementation of facilities for ESS by virtue of the need to address the operation of the Kalayaan PSH facility and the market is presently focused on the implementation of stand-alone arrangements for ESS more generally, which we term "Stage 3".

*Table 5: Market Maturity Assessment*

| ***Market Design Process*** | ***Stage 1: Initial Design*** | ***Stage 2: Managed (stand-alone ESS simple model)*** | ***Stage 3: Defined (stand-alone ESS more advanced)*** | ***Stage 4: Integrated (IRPs – basic implementation)*** | ***Stage 5: Optimized (IRPs – fully flexible implementation)*** |
|---|---|---|---|---|---|
| PJM (USA) | | | | | |
| CAISO (USA) | | | | | |
| ERCOT (USA) | | | | | |
| ANEM (Australia) | | | | | |

| ***Market Design Process*** | ***Stage 1: Initial Design*** | ***Stage 2: Managed (stand-alone ESS simple model)*** | ***Stage 3: Defined (stand-alone ESS more advanced)*** | ***Stage 4: Integrated (IRPs – basic implementation)*** | ***Stage 5: Optimized (IRPs – fully flexible implementation)*** |
|---|---|---|---|---|---|
| United Kingdom (UK) | | | | | |
| NEMS (Singapore) | | | | | |
| WESM (Philippines) | | | | | |

**Legend:**

| | |
|---|---|
| | Current implementation |
| | In process of transitioning towards |

## 4.5 FOCUS ON STAND-ALONE ESS INTEGRATION AND INTERIM AS ARRANGEMENTS

As described in the previous section there are numerous stages of ESS integration that could be targeted for in a power market. In the case of the Philippines WESM, while it is recognized that there is a growing need to allow for the integration of hybrid facilities (or Integrated Energy Resources), it is necessary to ensure that the implementation of the standalone ESS installations in the WESM is consistent with the requirements of Stage 3. This becomes a precondition before transitioning to integration of IRP and hybrid systems as per Stages 4 and 5. This requires consideration of market registration, dispatch, scheduling, compliance, and market monitoring procedures. It also requires consideration of rules and protocols to address the issue in the Philippines of the Interim ancillary services market. This requires as a condition for BESS to be able to satisfy the conditions of their AS contracts with NGCP system operator while also being able to register and participate in the WESM energy market.

The consideration of ESS that form part of a hybrid facility and the longer-term approach that the WESM takes for its ancillary service markets needs to wait until the DOE's policy framework for Ancillary Services has been finalized and implemented.

## 4.6 WESM TREATMENT OF ESS

The WESM presently has in place an Interim AS market that co-exists with the wholesale electricity market. The SO determines the amount of contracted AS capacity for each reserve provider, and the reserve provider is required to offer into the WESM taking this into account. The SO also provides IEMOP with scheduled reserves on a day-ahead basis. The treatment that is assumed in this project for stand-alone ESS is the Interim AS market as illustrated in *Table **6***.

*Table 6: WESM Treatment of ESS by market development stage*

| ESS Application | Description | Current Treatment in WEM | Interim AS Market Treatment of ESS | Longer-Term Treatment of ESS |
|---|---|---|---|---|
| Arbitrage / Peak Load Shaving Service | Purchasing low-cost off-peak energy and selling during periods of high prices | Presently, BESS are not able to operate in the WESM as they provide AS. | Energy dispatch is determined considering SOC and contracted capacity as determined by the SO, but no joint optimisation between AS and energy. | Capability between energy and FCAS would be co-optimised – i.e., an integrated energy and reserves market approach is taken. |
| VRE Firming | Firm up intermittent output of a VRE farm / facility such as wind or solar. | Rules for hybrids in the WESM are required but beyond the scope of this project – further discussion provided in Section 11. | | |
| Operating Reserves (FCAS): | Different categories of frequency control services to maintain the frequency standard | All AS are contracted separately with the SO, and exist outside the market, except that contracted reserves are accounted for in the WESM's dispatch processes. Reserves are settled between the AS provider (an ESS facility owner) and the SO. | | Integrated energy-reserves co-optimization market will determine reserve providers. |
| Primary Frequency Response | Very fast response to unpredictable variations in generation and demand (typically due to forced outages) | Managed and settled by SO under the AS provider contracts. | | These services are planned in the long-term to be scheduled under an integrated energy-reserves co-optimization and the service providers will be paid via WESM settlements rather than under an AS contract with the SO. |
| Regulation | Fast response to random, unpredictable variations in generation and demand | | | |
| Contingency Spinning | Fast response to a contingency such as a generator failure | | | |
| Ramping/ Load Following | Follow longer-term (hourly) changes in electricity demand | 5-minute market provides for load following and ramping from one 5-minute period to the next. | | |
| Black-Start | Start system after system-wide failure (black start) | ESS contracted to provide these services by the SO | ESS contracted to provide these services by the SO | ESS contracted to provide these services by the SO |
| Voltage Support | Provide voltage regulation in a location | ESS contracted to provide these services by the SO | ESS contracted to provide these services by the SO | ESS contracted to provide these services by the SO |

# 5 DEVELOPERS SURVEY

## 5.1 INTRODUCTION

It is important to understand where developers of ESS projects are encountering obstacles and barriers in terms of participating in the Philippines WESM. This section summarises the key findings of the survey to ensure that the project targets issues and barriers that they are presently encountering.

## 5.2 SURVEY

The survey covered the following areas:

- Generation Companies
- VRE Companies
- Distribution Utilities
- ESS Developers

It was issued to:

- Target market(s) for energy storage
- What role would ESS play in the power system
- Are the rules and regulations hindering energy storage from providing the services sought to be provided?
- What issues are encountered in making an ESS business model work?
- What issues arise from permitting and siting of ESS?
- What policies could Department of Energy enact to promote ESS investment?
- What improvements to the regulatory framework could ERC enact to enable ESS investment?
- What could IEMOP do to make ESS investment easier?
- What could NGCP do to make ESS investment easier?
- What could distribution companies do to make ESS investment easier?

- Other comments / suggestions to remove barriers for ESS technology investment?

A full copy of the survey is provided in Appendix D. A total of 11 survey responses were collected by PEMC in support of the project. It should be noted that all responses were related to BESS, rather than PSH or other forms of energy storage. Nevertheless, BESS is a good “test case” for revealing issues within existing frameworks for electricity markets and regulations for the electricity sector.

## 5.3 TARGET MARKETS FOR ENERGY STORAGE

The survey asked developers to indicate what were their target markets in the Philippines for ESS out of the following options:

- WESM participation – meaning registering as a market participant and operating the wholesale electricity market processes,
- Augmentation or to complement an existing generator – where a BESS is fitted to the same connection point to enhance the operational performance of an existing generator, making it more flexible,
- Distribution Utility PPA, meaning a PPA with a distribution company to provide ESS services as required to improve the performance of the distribution network,
- Transmission Company PPA, meaning a contractual arrangement with the transmission company (NGCP) – where the main product is generally considered to be ancillary services,
- Other Entity PPA – an entity other than those listed above having a PPA of some kind for ESS services,
- Another application other than those listed above, or
- Target market is not applicable.

The findings are illustrated in Figure 8 which shows the percentage of responses that listed the stated target market for ESS services. The key finding from this is that the most sited applications were participation in the WESM and having a PPA with NGCP (for AS). Other common and important applications were augmentation of existing facilities and having a PPA with a distribution company. While this is not surprising, it highlights that firstly ancillary services are considered an important target market for ESS which means that the further development of the AS market is key to supporting ESS. Secondly, the reference to WESM participation, highlights the importance of having the WESM being able to support and accommodate ESS is very important.

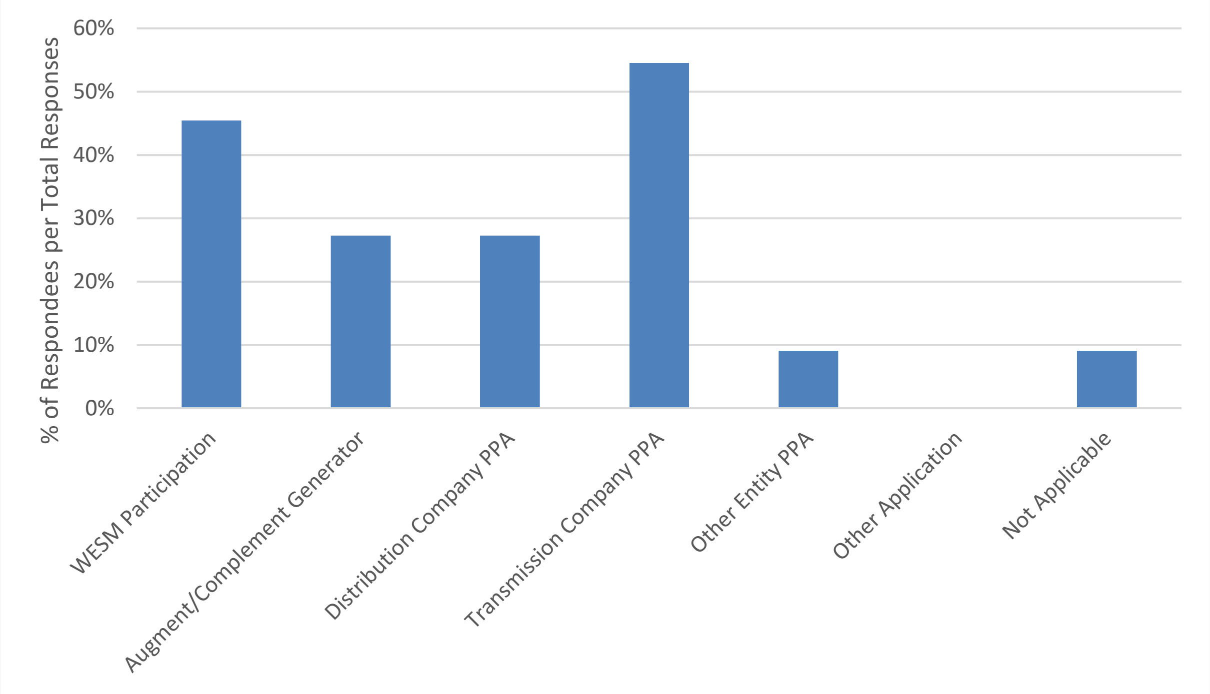


*Figure 8: Target Markets for Energy Storage*

## 5.4 ENVISAGED ROLE OF ENERGY STORAGE

The surveyed organizations were asked about the services or envisaged role that they saw for ESS, with the following being presented as options:

- Energy,
- Capacity,
- AS,
- Capital (T&D or generator) deferral,
- Smart grid / micro grid application,
- Load management,
- Distribution services,
- RE Firming, and
- Hybrid Systems.

The results are illustrated in Figure 9. It is not surprising to see that the majority of responses saw ancillary services as being a key application for ESS as this is the role that BESS entering into markets has typically been providing. The other popular applications included: capacity, energy, deferral of capex in transmission, load management and smart grid applications were also expected. The main implication is that for the present project, it is important to note that all the applications for ESS need to be considered in the WESM – and as noted earlier, AS markets and hybrid facilities are important, but not well catered to at present in the WESM.

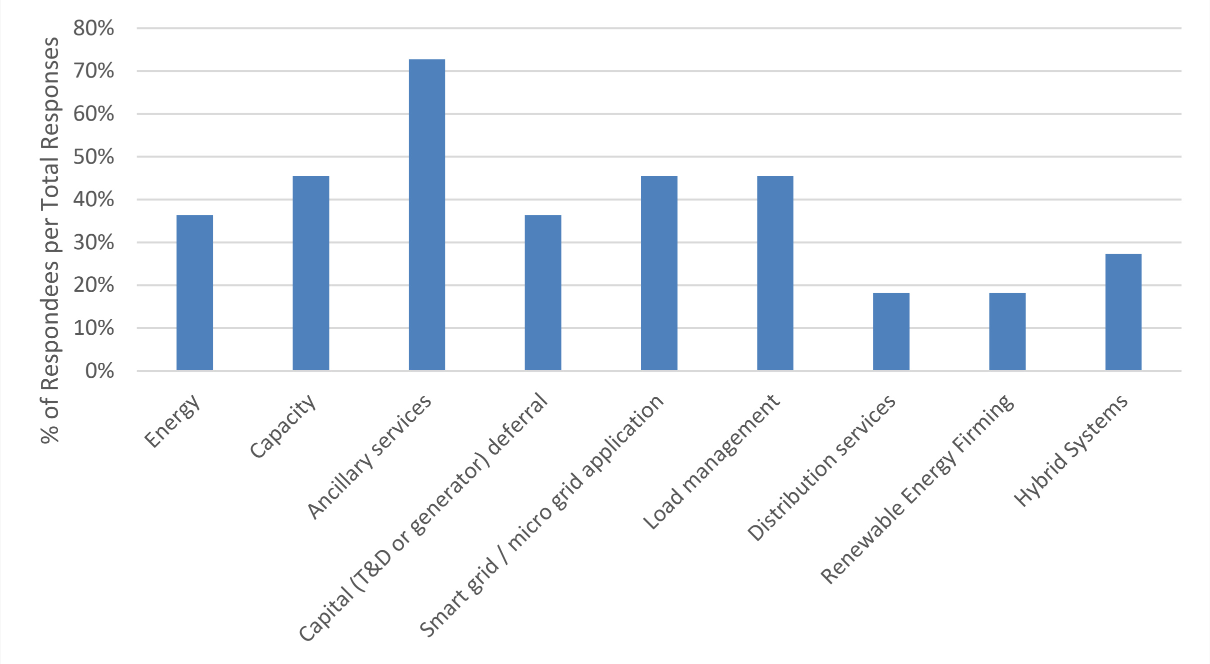


*Figure 9: Envisaged Role for ESS*

## 5.5 LIST OF COMMON ISSUES RAISED IN RESPONSES

The following are important issues for the existing regulatory and policy framework that were identified by survey respondents.

- Regulations for cost recovery for an ESS are not clearly defined in the case of ESS
- A lack of clarity around the cost of charging an ESS – whether it is liable for transmission charges
- Application of transmission charges in general – noting that ESS both generates and loads
- ESS not recognised as a category of participation in the Philippines WESM
- Long queues and wait times for system impact studies to be completed for ESS
- Treatment and registration of BESS as augmentation to existing generator

- Permitting and siting generally problematic because ESS has not been considered in the framework
- Long-terms plans not defining a master plan for ESS development
- Market rules need to be improved / made clearer in terms of treatment of ESS
- Need for greater public awareness and consultation on the benefits of BESS technologies
- Lack of incentives / pricing mechanisms to encourage BESS investment
- Land availability, permitting and acquisition mechanism to support ESS
- Put a compendium of all existing laws and regulations that support ESS to make it easier to under the applicable laws
- Cost recovery mechanisms for the reserve market need to be better defined so that the SO recover the costs efficiently
- In relation to the WESM:
    - Rules need to add clarity on how ESS participates in the market – e.g., Must-Offer Rule, dispatch compliance, additional compensation claims, etc.
    - having tight (low) market price caps inhibit recovery of investment for ESS (which are dependent on price arbitrage between periods of low prices and high prices)
    - Limited contracting opportunities if not selling to the WESM, hence lenders are hesitant to grant loans to ESS
    - The above factors make it hard for securing loans for ESS development
- Determine and publish the amount of BESS capacity / storage required in the system
- Determine the amount of AS required for the system to facilitate BESS participation
- Limited connection points for grid access – forward looking plans to consider and identify these would be very useful to guide ESS investments
- Long process of getting permits and clearances with common choke points including completion of SIS and GIS
- Actions the DOE could pursue to improve ESS deployment:

- Reinforce existing policies. Supplement with detailed implementation guidelines of the DOE Department Circular No. DC 2019-08-0012 Providing A Framework for Energy Storage Systems in the Electric Power Industry.

- Promote power system studies to identify the generation mix, including storage requirements int the future,

- Policies to recognise the contribution of BESS makes to quality of supply

- Facilitate an ESS master plan (to guide investment)

- Require ESS treatment across all regulations, including hybrid systems

- Develop policy to encourage investment on ESS (similar to GEAP)

- Push transmission and distribution network readiness for connection of ESS

- Progress AS rules and regulations consistently across the market

- Require a detailed study into the AS requirements and feasibility of BESS providing AS

o Actions the ERC could pursue to improve ESS development:

- Recognise ESS as a distinct facility that acts only as a load on an interim basis that is different to an end-use consumer,

- Address the issue of transmission charges for ESS

- Conduct an investigation into the long-term benefit of higher price caps in the WESM to create incentive on new entrant ESS

- Capex filing of ECs and distribution companies need to account for ESS

- Conduct information drive to explain the role, nature and positive impact that ESS could have

- Approval of PDM for Reserve Market

- Ensure harmonised and consistent regulations on the AS market

o Actions IEMOP could pursue to improve ESS development:

- Carry out training and capacity building on ESS treatment and operation in electricity markets and market rules / models

    - Benchmark rules against the rules in other jurisdictions
    - Enhance WESM rules, procedures, and systems to accommodate the participation of BESS in the market considering SOC.
    - Adopt best international practices in the integration of BESS in the power market processes
    - Revise price caps to make the WESM more attractive to ESS.
- Actions NGCP could pursue to improve ESS development:
    - Have more resources available to carry out SIS and GIS to reduce the time they take,
    - Provide greater guidance to developers on connection points that could accommodate ESS projects,
    - Tighter coordination with IEMOP to facilitate more efficient use of BESS resources for both system and market operations,
    - Improve transparency in processes requiring SO clearance,
    - Capacity building on BESS simulation studies with focus on hybrid generation set-up (such as ESS and coal),
    - Identify locations where ESS is viable to guide investment under its TDP. Locations is open and it should undergo auction on the locations under the CSP policy of the DOE,
    - Develop ESS master plan anticipating entry of variable renewable energy plant. Immediate improvement of transmission channels including switching stations, transmission lines, and SVC substations that will be owned and developed by NGCP in anticipation of transmission developments that are required for uptake in VRE and ESS in the system,
    - Provide technical support to distribution utilities and adopt the latest technology of ESS,
    - Commence auctions for AS from ESS under the CSP policy of the DOE,
    - Improve the processes for the testing and commissioning of BESS to be better defined and more efficient.

- Actions Distribution Utilities could pursue to improve ESS development:
  - Require distribution companies to consider the role of the ESS in the DDPs,
  - Conduct study on power quality improvement ESS. Immediate improvement of distribution channels including switching stations and sub-transmission lines that will be owned and developed by NGCP in anticipation of transmission development that will include VREs and ESS in the system,
  - Determine suitable offtake contracts with BESS in mind to promote this technology,
  - Commence upgrading distribution networks and systems to make way for ESS and even other new technologies,
  - Fast track the implementation of smart grid and upgrading of systems to better monitor delivery/consumption of power.

## 5.6 CONCLUSION

The conclusion from the survey in relation to the areas that are relevant to the scope of this study are:

- Importance of having the WESM rules and manuals being able to accommodate participation of ESS across all market processes,
- Importance of ensuring the dual role of BESS in providing AS while also wanting to participate in the WESM needs to be accommodated,
- Accommodating the hybrid facilities – including generator augmentations and VRE firming appears to be growing in importance.

# 6 OUTPUT 1: ESS & MARKET CONFORMANCE STANDARDS

## 6.1 INTRODUCTION

Conformance standards (Output 1) relate to the dispatch conformance standards that are specified in Clause 3.8.5 of the WESM rules. This section benchmarks WESM practices against international electricity markets where ESS integration has occurred. The section focuses on services that ESS provides – providing an assessment of ancillary services, capacity markets and energy markets. It concludes with a summary of the recommendations related to conformance standards, thereby addressing the requirements of Output 1.

## 6.2 ENERGY MARKETS

AS provides grid services for short-term reliability. Capacity markets serve long-term reliability requirements. Energy markets fit between the two in terms of planning horizon.

An energy market forms the mechanism through which sellers and buyers transact electricity at prices referred to as LMPs. The LMP calculation incorporates the full marginal cost of serving an increment of load at each bus in the power system. The cost has three components – system energy price, congestion price, and loss price. System energy price is the cost of an additional increment of energy from the marginal generator. Congestion price occurs when a demand resource is located in a zone with transmission capacity constraints; a premium is placed on the use of congested power lines to signal the need for strengthening.

In the US, the procurement of electricity supply is carried out on two timescales - the first is the DA or the forward market in which ISO/RTOs calculate hourly LMPs for the next operating day based on the previously mentioned parameters. Hourly LMPs help meet the estimated energy required by consumers. The operators also run a market power mitigation test to ensure that the bids made by different generator classes are fair and within predetermined limits.

Even though electricity consumption is fairly price-inelastic, and consumers have mostly consistent consumption patterns, it is still impossible to make error-free predictions 24 hours in advance. To mitigate this gap in knowledge in actual aggregate demand and to account for dynamically changing zonal grid conditions with respect to transmission constraints, the market operators run a SCED model on a short timescale of 5 minutes. This 5-minute interval is called the RT balancing market. LSEs pay RT LMPs for any demand that is above the forecasted energy schedule and receive corresponding revenue if real demand falls short of forecasted demand.

In Australia, the ANEM is structured as a gross pool, with mandatory registration of all generators or dispatchable loads exceeding 5 MW, with all resources of 30 MW and above being centrally either centrally dispatched or semi-dispatched (in the case of VRE). A real-time 5-minute ahead security constrained pricing and scheduling process determines the 5-minute spot prices for energy and 8 categories of FCAS. Like the WESM, the ANEM is based on the principle of self-commitment, which means that unit commitment decisions are made by market participants, based on cleared bids and offers. To facilitate commitment decisions, the 5-minute ahead market is complemented by several market processes which project dispatch and pricing outcomes – most notably, a 1-hiour ahead 5-minute dispatch, an “up to 30 minute “rolling pre-dispatch process and a large number of pre-dispatch sensitivities to assist market participants to understand sensitivity of price to demand over a 48 hour-ahead period of time and revise bids / offers in response.

## Energy Market International Practices

### a. Performance and Compensation

The mechanism for performance and compensation is important for levelling the playing field in the wholesale market.

In the US, the FERC Order 841 set five rule changes intended to achieve this outcome.

1. Provision of Make Whole Payments: Make whole payments are supplemental payments to the energy lender in a scenario when economic dispatch solution does not provide enough revenue to cover total costs.
2. Sales and Purchase of Energy to be at Locational Marginal Pricing
3. ESS can set the wholesale market clearing price when it is the marginal resource, as both a wholesale seller and wholesale buyer.
4. Provision to exempt payment of Wholesale Charging Energy Settlement Exemption twice during charging and discharging.
5. Treat all storage the same as generators when assessing Non-Performance Charges and Bonus Performance Credits.

*Table 7: Performance & Compensation Payments in US Markets*

| Parameter | CAISO | ISO-NE | MISO | NYISO | PJM | SPP |
|---|---|---|---|---|---|---|
| Make Whole Payments | Yes | Yes | Yes | Yes | Yes | Yes |
| Sales and Purchase at LMP | Yes | Yes | Yes | Yes | Yes | Yes |
| ESSs can set the wholesale market clearing price as both a seller and buyer | Yes | Yes | Yes | Yes | Yes | Yes |

| Parameter | CAISO | ISO-NE | MISO | NYISO | PJM | SPP |
|---|---|---|---|---|---|---|
| Wholesale Charging Energy Settlement Exemption to prevent paying twice | Yes | Yes | Yes | Yes | Yes | Yes |
| Treat all storage exactly the same as generators when assessing Non-Performance Charges and Bonus Performance Credits | Yes | Yes | Yes | Yes | Yes | Yes |

*CAISO - California Independent System Operator*
*ISO-NE - Independent System Operator - New England*
*PJM - Pennsylvania, New Jersey, and Maryland*
*MISO - Midcontinent Independent System Operator*
*NYISO - New York Independent System Operator*

In Australia, the general approach for ESS integration principles was to ensure ESS treatment in line with the principles of the NEO which is “to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to: price, quality, safety and reliability and security of supply of electricity, and the reliability, safety and security of the national electricity system." This effectively means ensuring that ESS treatment in the ANEM is on an equal basis to other technologies that participate in the market.

*Conformance Standards*

A greater commitment period or an auction closer to the start of the commitment period provides revenue certainty, making an ESS or any other capacity resource attractive for investors.

**b. State of Charge Management**

An ESS’s SOC is the amount of energy the ESS currently has stored relative to the limit on the amount of energy that can be stored. SOC is typically expressed as a percentage.

In the US, FERC Order 841 directed the ISOs/RTOs to allow ESS the option of self-managing their SOC, rather than mandatory ISO-managed SOCM. By allowing self-SOCM, private actors and ESS owners/operators can directly control the charge cycles occurring in a given time period. For batteries, this operational control can potentially mitigate the risk of the ESS “wearing out” or losing the capability to hold sufficient charge before scheduled retirement, i.e., the lifecycle is optimised.

MISO, PJM, and SPP allow only self-SOCM; ISO-SOCM is not an option. However, to participate in the energy market, ESS operators in these wholesale markets must submit several bidding parameters, such as SOC, minimum and maximum SOC, and economic charge and discharge limits. Therefore, ESSs are allowed to self-schedule and will be dispatched as scheduled rather than in an economically determined fashion by the market operator. However, ESSs may also submit a dispatchable range as a bidding parameter instead of a strict schedule, which would allow the market operator greater flexibility to guide resource dispatch during a given time period.

CAISO and NYISO both provide options for ESSs to either have SOC managed by the ESS or by the grid operator. CAISO allows ESSs to self-manage their SOC through submitted bidding parameters or to have the market optimization software manage SOC through bidding and ESS-specific parameters. For ISO-SOCM in NYISO, an ESS's SOC will be directly accounted for in NYISO's optimization software; for self-SOCM in NYISO, an ESS's SOC will not be directly accounted for since ESSs will self-manage their dispatch.

ISO-NE is unique in that it has taken a hybrid approach to SOCM, relative to the other ISOs/RTOs. While the other ISOs/RTOs treat SOC a bidding parameter, it is only a telemetry value in ISO-NE. A telemetry value is a recording made by an instrument and relayed to the grid operator rather than manually communicated by an ESS operator. This telemetry value is used as an input by ISO-NE software to automatically determine "Maximum Consumption Limit" and "Economic Maximum Limit" values, which contrasts with the other energy markets in that these values are determined by the ESS itself and submitted as a bidding parameter. In short, ISO-NE uses real-time telemetry to enforce SOC feasibility for ESSs; the only other ISO/RTO to do this is SPP.

While self-SOCM may help storage owners/operators mitigate project risk and enhance resource ownership, flexibility, revenue streams, and control, the grid operators may prefer ISO-SOCM to increase market financial and operational efficiency and take over scheduling responsibility.

In Australia, submission of bids and offers for energy (generation or loading) and offers for up to 8 different categories of FCAS, can be revised in real-time and as required by the market participant for inclusion in the next 5-minute dispatch interval. The revision of bids / offers of market participants including ESS, can be based on the projections of outcomes from various hour-ahead and 48-hour ahead market projection processes. In the ANEM, because there is a real-time market and because the market provisions for both energy and FCAS, then the responsibility for the management of SOC is an issue that is self-managed by the ESS market trader through bidirectional bids, which allow for the simultaneous submission of an offer to charge or discharge.

*Conformance Standards*

Self-SOCM flexibility is more likely to encourage ESS.

**c. Minimum Run Time – Dispatch Signal & Timeline to Self-Dispatch**

Minimum run time is defined as the minimum set time that an ESS would be able to follow a dispatch signal as prescribed by the system operator. Self-dispatch is defined as the ability of an ESS to dispatch on its own in case it is unable to keep up with a minimum run time requirement particularly for reserves.

In the US, ISO-NE has a minimum run-time requirement of 15 minutes for consumption and 1 hour for the provision of energy and reserve. However, ISO-NE does not have a bid parameter for minimum run time to run a dispatch signal in the energy market. It is instead input during the operational phase through telemetered values. On the other hand, NYISO and CAISO consider minimum run-time as an optional bid parameter, giving ESS flexibility for devising offer curves. Additionally, an ESS that cannot operate for a least 1 hour in a single state (injection or withdrawal) can still participate in NYISO's markets as a Limited Energy Storage Resource. ESS in ISO-NE is allowed to self-dispatch to a MW level that is higher than the minimum MW level required to meet the 1-hour reserve. However, this is only such that the MW level is sustained for at least 15 minutes. As a result, reserves are not considered for the ESS in question. This is because dispatch above the MW level required to meet the 1-hour duration requirement will not be sustained for an hour.

The co-optimization of energy and reserves plays a crucial role in overall revenue collection for ESS. Markets that restrict access by setting minimum run times may increase the opportunity cost of participating in other services. Hence, ISO-NE and SPP are categorized under the basic criterion while NYISO and CAISO are defined under the advanced criterion since they allow for minimum run times to be input as optional parameters. PJM and MISO do not mention minimum run times that are needed as bid or input parameters.

In Australia, achieving a minimum run time is an issue that is self-managed by market participants through their bids and offers most of the time.  A market participant seeking to stay online for a minimum period has the option to make a negatively priced offer to generate, which normally guarantees the unit will be dispatched and stay online for the required period of time.

In the WESM it is up to the market participant to submit offers that will keep them online for the required minimum time - whether a slow-start generator or a BESS or any other technology.  ESS is not a special case as all generators in the market have to manage this kind of issue under a de-centralised unit commitment philosophy, which is clearly started in the PDM and consistent with the Market Rules.

*Conformance Standards*

If a minimum run time is defined by the market and there is a bid parameter associated with it, then the market is classified in the basic maturity category. If ESS is allowed to define a minimum run time as a result of its operational and physical constraints or submit this as an optional bid parameter to the market, then the market can be considered as advanced since it allows for enhanced flexibility of operations of ESS.

### d. Restrictions to Set LMPs

This is a self-defined parameter that concerns whether there is any kind of restriction or limitation to an ESS participating and/or submitting a bid and setting an LMP.

In the US, most ISOs have restrictions in simultaneous participation of an ESS as a supply resource and a demand resource.

In MISO and NYISO, an ESS can only be cleared as either a supply or a demand resource at a given interval and only be cleared at a single energy target MW per interval. As a result, an ESS is not permitted to bid both withdrawal and injection in the same market hour.

In NYISO, an ESS with non-continuous dispatch ranges may have to opt out of their position in case it is dispatched to a level that is outside its feasible range. PJM does not allow ESS with a minimum charge limit (as well as resources that are self-scheduled without dispatchable range) to set an LMP.

ISO-NE has some limitation at the self-dispatch level of ESS as a demand resource. A generator asset when self-dispatched is done so at the requested MW level at the Energy Offer Floor. A DARD when self-dispatched is done so at the requested MW level regardless of the LMP.

CAISO has no restriction. Additionally, CAISO does not assess transmission access charges as a result of a ‘negative generation parameter’ in their ESS participation model, which allows ESSs to increase their price bids. CAISO is also set to remove transmission charges for pumped hydro storage as well.

In Australia, ESS have bidirectional bids for energy, and unidirectional bids for FCAS offers. The prices are allowed to vary from the market price floor up to the market price cap, as is the case for any other market participant participating in the energy and FCAS markets of the ANEM. The main controls on spot market pricing are applied on a market-wide basis and include the cumulative price threshold, which when breached, imposes an APC which is a secondary price cap that is lower than the market price cap, and intended to reduce systemic risk of high prices in the ANEM.

*Conformance Standards*

The basic criterion is defined by restrictions in setting bids such as that for ESSs with non-continuous dispatch ranges. An advanced criterion is defined by no restrictions.

*WESM*

The WESM has a secondary price cap that comes into place if market prices are too high for a sustained period, in a similar way to the Australian market. The main difference between the US and Australia/Philippines in this area is that there are some system-wide mechanisms to manage high prices (and deter gaming) while in the US markets they process bids and run checks on pivot suppliers and revert their bids / offers to short-run marginal costs if they are detected as being able to exercise market power.

## 6.3 RECOMMENDATIONS (OUTPUT 1)

At the present time the WESM does not have an Ancillary Services Market or a Capacity Market. Therefore, the market conformance standards in place in electricity markets in the United States and Australia do not yet apply. Nevertheless, these standards are very likely to apply in the future as the WESM continues to evolve.

The conformance standards that apply to energy markets, observed to apply to ESS in international electricity markets, have been partly adopted by the WESM. The gaps that have been identified are summarized in Table **8**.

*Table 8: Recommendations for Output 1: Conformance Standards*

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 1 | Market Registration | Generation company can register BESS units as battery energy storage | BESS facilities registered as “bidirectional units” to be more technology neutral (in US and Australia) | • Explicitly list the parameters that BESS units are to provide upon registration – which should include rated capacity (MW), rated energy (MWh), maximum charge rate, maximum discharge rate, and maximum Depth of Discharge (DOD)<br>• Define annual process for updating them over the lifetime of the BESS (the current IEMOP process used for updating registration data is suitable)<br>• Indicate whether the BESS is providing AS for NGCP SO, as there are implications for dispatch |
| 2 | Market Registration | Generation company registering the PSH as a generator with an associated load | PSH facilities registered as a dispatchable load & dispatchable generator | • Provision PSH to be able to register loads as demand side bidding facilities<br>• A PSH registering its pumping load would follow the same process as any dispatchable load. |
| 3 | Market Registration | PSH and BESS are specifically named as storage technologies that can be registered | Technology neutral approach is taken where a market participant can register a dispatchable load, generation unit, or bidirectional units without reference | Make registration more technology-neutral by allowing market participants to register units as bidirectional units, dispatchable loads, generating units without primary reference to the underlying technology; the latter (chemical battery, flywheel, etc to be recorded as a secondary criterion) |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | | to a particular technology | |

# 7 OUTPUT 2: WESM PROTOCOLS

## 7.1 INTRODUCTION

Output 2 is concerned with the Introduction or enhancement to protocols for BESS and other ESS for their scheduling and dispatch in the energy-only, and eventually in the co-optimized market for energy and reserves.

## 7.2 ASSESSMENT

The following protocols have been assessed against the requirements for BESS and ESS:

- WESM-PDM – defines functions and responsibilities among the MO, the SO, and WESM Members with respect to the scheduling and dispatch of reserve capacities

- Protocol for Central Scheduling and Dispatch of Energy and Contracted Reserves – This Protocol covers specific guidelines in the scheduling and dispatch of reserve capacities during normal and emergency conditions during the Central Scheduling of energy and reserves

These have also kept in mind the Interim AS arrangements, that are in place in the Philippines until an Integrated energy-reserves market is introduced in the WESM.

## 7.3 WESM SCHEDULING AND DISPATCH MECHANISM FOR BESS IN INTERIM AS MARKET

### 7.3.1 Concept

As described in Section 3.4, under the Interim AS arrangements in the WESM, the SO is responsible for determining the amount of each AS that is required and allocating the AS providers. This includes PRA, SRAS and TPAS, which in effect relates to spare capacity that is set aside for responding to a contingency. This is done on a day-ahead basis, and the information on AS providers is submitted to IEMOP to be accounted for in the market processes: RTD, HAP and DAP, the latter two of which are continuous rolling-processes.

A critical issue for a BESS that is an AS provider is that it must have its SOC set to a level that would enable it to deliver PRA, SRAS and TPAS. Therefore, in the dispatch of BESS in the WESM, it is necessary to ensure that the BESS would not be discharged for the provision of energy which would subsequently compromise its ability to deliver the services that the SO has already. In other words, IEMOP would need to ensure that the SOC does not fall below a minimum level for each BESS that is an AS provider.

### 7.3.2 Information Exchange Requirement

The SO would need to provide the following information to the IEMOP to enable the IEMOP to be able to dispatch the BESS for energy in a way that will respect their pre-determined AS obligations for each hour in the day-ahead AS schedule:

- Pmax – maximum output of the BESS (in MW), which the IEMOP should have already from registration, but adjusted for any outages,
- SOCmax – maximum storage capability of the BESS in MWh,
- SOC-AS dedicated to provision of ancillary services (in MWh) which the IEMOP would need to ensure is always respected in the RTD, DAP and HAP market optimisation processes,
- SOC available for energy dispatch, which will usually be SOCmax – SOC-AS in MWh,
- Capacity (MW) dedicated to AS – which is not available for dispatch in the energy market, and
- Maximum offer capacity (MW) – which is the maximum offer that can be submitted to the energy market for dispatch, which will normally just be computed as Pmax – Capacity dedicated to AS.

### 7.3.3 Worked Example of Information Exchange Requirement

To illustrate how this would work, we provide a simplified numerical example, showing how two different BESS units, that have SOC max and Pmax as defined in *Table **9***, would be hypothetically handled by the SO and the information that the SO would transfer to the IEMOP to incorporate in their dispatch and pricing processes.

*Table 9: BESS parameters*

| BESS | Parameter | Unit | Value |
|---|---|---|---|
| BESS #1 | Pmax | MW | 50 |
| BESS #1 | SOC max | MWh | 100 |
| BESS #2 | Pmax | MW | 30 |
| BESS #2 | SOC max | MWh | 60 |

An example of the AS dispatch done on a day-ahead basis by the SO is set out in *Table **10***. This shows the PRAS and SRAS that has been allocated to the two BESS units which varies by hour of the day. For simplicity only hours 1 to 12 are shown. Each BESS has a total allocation of MW for each service, which is shown in the bottom two rows of the table.

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*Table 10: Example of AS dispatch for BESS and computation of the min SOC requirements*

| BESS | Parameter | Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BESS #1 | PRAS Capacity Reserved | MW | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| BESS #2 | PRAS Capacity Reserved | MW | 10 | 10 | 10 | 20 | 25 | 25 | 20 | 20 | 20 | 20 | 10 | 10 |
| BESS #1 | SRAS Capacity Reserved | MW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BESS #2 | SRAS Capacity Reserved | MW | 0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 0 |
| BESS #1 | Capacity Dedicated to AS | MW | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| BESS #2 | Capacity Dedicated to AS | MW | 10 | 15 | 15 | 25 | 30 | 30 | 25 | 25 | 25 | 25 | 15 | 10 |

Table 11 and Table 12 respectively show the information that the SO would compute and provide to the IEMOP for each BESS following the day-ahead dispatch of AS providers. The information includes as a specification for the minimum SOC by hour that the SO would be required to ensure is respected in the dispatch of the BESS for energy. It also shows the amount of SOC that is available for energy dispatch and the maximum offer capacity by time of day considering the AS obligations for each BESS.

*Table 11: BESS 1 information provided to IEMOP by SO for AS dispatch*

| BESS | Parameter | Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BESS #1 | Min SOC | MWh | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| BESS #1 | SOC available for energy | MWh | 100 | 100 | 100 | 100 | 70 | 70 | 70 | 70 | 100 | 100 | 100 | 100 |
| BESS #1 | Registered Pmax | MW | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| BESS #1 | Capacity for AS | MW | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| BESS #1 | Max Offer Capacity | MW | 50 | 50 | 50 | 50 | 20 | 20 | 20 | 20 | 50 | 50 | 50 | 50 |

*Table 12: BESS 2 information provided to IEMOP by SO for AS dispatch*

| BESS | Parameter | Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BESS #2 | Min SOC | MWh | 10 | 15 | 15 | 25 | 30 | 30 | 25 | 25 | 25 | 25 | 15 | 10 |
| BESS #2 | SOC available for energy | MWh | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| BESS #2 | Registered Pmax | MW | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| BESS #2 | Capacity for AS | MW | 10 | 15 | 15 | 25 | 30 | 30 | 25 | 25 | 25 | 25 | 15 | 10 |
| BESS #2 | Max Offer Capacity | MW | 20 | 15 | 15 | 5 | 0 | 0 | 5 | 5 | 5 | 5 | 15 | 20 |

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## 7.4 WESM SCHEDULING AND DISPATCH MECHANISM FOR BESS IN LONG-TERM AS FRAMEWORK

The longer-term AS framework is for the IEMOP to implement energy and reserves co-optimization, and AS providers that participate in the AS market would provide offers for each of the reserve services. While this is beyond the scope of work for this report and the final framework for AS is yet to be finalised, it means that the SO would be responsible for nominating to the IEMOP only the total amount of each service is required, and would no longer need to nominate the AS providers to IEMOP as the IEMOP's dispatch processes (RTD in particular) will determine the providers of PRAS, SRAS and TREASS directly on the basis of the reserve offers that AS providers participating in the WESM submit to IEMOP.

The protocol described in the previous section would therefore need to be revised at this stage and would likely involve the SO providing the IEMOP with the real-time status of BESS units only, along with the required MW amounts of each AS.

## 7.5 RECOMMENDATIONS (OUTPUT 2)

The recommendations for WESM's dispatch protocols and on the assessment of this section are presented in Table **13**.

*Table 13: Recommendations for Output 2: WESM Protocols*

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 4 | Scheduling & Dispatch (of AS) | Interim AS[14] procurement (of reserves) is managed by SO separately to the WESM, with day-ahead scheduling of AS Providers for CR (PRAS), RR (SRAS) and DR (TRAS) | Provision of AS for BESS has higher priority than energy dispatch for system security reasons | • NGCP-SO needs to provide the reserve capacity and SOC requirements based on its grid assessment. The BESS reserve is responsible for ensuring enough SOC to comply with the reserve requirement.<br>• Modifications required to the interface to IEMOP for declaration of AS schedules by SO.<br>• A Demand Bid option is voluntary for loads that wish to operate that way. There is no need to enforce all loads connected to the WESM to be dispatchable, particularly if they are not controllable loads that can respond to a dispatch instruction.<br>• The list of information required is set out in Section 7.3. |
| 5 | Dispatch / Market Projections | WESM MMS accounts for SOC, capacity limits and energy storage limits of BESS in RTD, HAP, DAP and WAP; however, WESM rules | Physical capability of ESS / BESS represented in all market dispatch processes and specified in the market rules. US markets explicitly model SOC, efficiency, and other parameters of BESS in all | WESM rules describing the MDOM optimization model and market processes (RTD, HAP, DAP, WAP) adjusted to ensure that the requirement to represent ESS / BESS in terms of SOC, and charging / discharging, and bidirectional bids is included. This is important for ongoing IEMOP compliance to WESM rules. Also require that the SOC has a minimum level (which is specified as required for Interim AS market) – |

[14]It is noted that there are plans to transition the AS market in the Philippines to have energy-reserves co-optimization and cost-recovery for provision of reserves based on a causer pays principle.

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | do not specify this. | dispatch related market processes | this can be provided with participant offers as well. |
| 6 | Dispatch / Market Projections | PSH units could not register as a bidirectional unit because it takes time for PSH to go from loading / pumping | PSH use demand-side bids to manage this issue, so that the loads could set the price if the market is marginal on loading | As with earlier recommendations, requiring PSH to register pumping loads as dispatchable demand and using a demand-side bid will address this issue.<br><br>If the PSH takes a long time to go from pump to generator or vice versa, this can be reflected in its offer/nomination management. |
| 7 | ESS Bids / Offers | PSH providing load forecasts rather than offers / bids which means that PSH loads will not be reflected if their dispatch is marginal | PSH use demand-side bids so that the loads could set the price if the market is marginal on loading | Require PSH to register loads as dispatchable loads and submit demand-side bids for loading. This ensures that BESS and PSH are on an equal footing when operating in the market.<br><br>The above requirement should be understood in the context of a Demand-Side bidding regime that is optional for PSH. Under optional participation, demand-side bids can be constructed in a way that allows the PSH to operate according to an optimal plant maintenance regime, respecting any contractual obligations that constrain the role of the PSH. |
| 8 | ESS Bids / Offers and Must-Offer Rule | WESM allows for 10 prices / quantities that can be specified as monotonically increasing and prices / quantities can be negative or positive | Provides for same number of prices / quantities as generators and loads to ensure bidirectional units are treated equally with demand-side bidders & generator offerors | Increasing the number of pricing bands from 10 to 20 would ensure bidirectional (BESS) are on equal basis with both generators & demand side players.<br><br>Aside from increasing the number of offer blocks, BESS is required to comply with the Must-Offer Rule; in addition to the determination of its maximum available capacity for BESS, the State of Charge must also be accounted for when the Must-Offer Rule is invoked. Moreover, a certain threshold of the BESS current state of charge must also be set when BESS will be allowed to submit negative bids for purposes of charging (typically 10%). |
| 9 | Dispatch / Market Projections | PSH units could not register as a | PSH use Demand-Side Bids to manage | As with earlier recommendations, requiring PSH to register pumping loads as dispatchable demand and |

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | bidirectional unit because it takes time for PSH to go from loading / pumping | this issue, so that the loads could set the price if the market is marginal on loading. | using a demand-side bid will address this issue. |
| 10 | System Security / Directions | As the SO can call units for the purpose of must-run, the must-run regime in the WESM would need to ensure that the SOC information is available to the SO to ensure that they make informed decisions when calling BESS at short notice in emergencies | SOC is considered when calling ESS for directions. Requirement to ensure that the ESS facility is staffed / manned in a way that would allow for directions to be immediately responded to | Ensure existing must-run procedures and manuals set out the consideration of SOC for BESS. We understand this is already operationally the case but need to ensure it is explicit.<br><br>It is understood that the SO monitors SOC of BESS to ensure that they can deliver any ancillary services for which the SO has assigned them the responsibility to provide. |
| 11 | System Security / Directions | General emergency regime & system directions provide SO with the right to issue directions to participants that they must respond to | Require ESS to respond to a no-charging declaration that may be issued on a market-wide basis by SO or SO+MO if there is an emergency or a need | Ensure rules / framework are in place to allow the SO to require all ESS / BESS to stop charging in emergencies. Also ensuring that the WESM rules places an obligation on ESS / BESS participant to respond to such a notification / instruction.<br><br>In addition, the Philippine Grid Code to be amended to include this requirement to ensure the practice is followed. |

# 8 OUTPUT 3: COMPLIANCE MONITORING

## 8.1 INTRODUCTION

Achievement of a satisfactory compliance rating by market participants is determined by PEMC's ECO. The ECO gives awards/recognitions to the most compliant participants. The ECO also assesses, validates, and/or investigates alleged breaches by trading participants, particularly the OCC and DCS.

These compliance practices are pertinent to ESS / BESS. The energy contributed by the ESS/BESS to the grid should be monitored in a similar manner to a conventional generator.

We understand this output to refer to the satisfactory performance of market participants who operate BESS and other ESS. The ECO enforces offer capacity compliance, dispatch conformance, and forecast accuracy standards.

## 8.2 PEFORMANCE INDICATORS FOR BESS

Generally, performance indicators for a BESS can be divided into the following categories:

- Installation characteristics,
- Operational indicators,
- Performance indicators,
- Ageing indicators, and
- Safety indicators.

Some of these categories relate to information that is only relevant to the owner / operator of a BESS, drawing attention to issues that must be addressed as part of ongoing operations and maintenance of a BESS facility. However, some indicators are pertinent to the interests of PEMC ECO / IEMOP because they concern compliance and/or market operations.

A summary of the indicators is provided in Table 14; indicators that need to be monitored by PEMC ECO / IEMOP are highlighted. It can be seen from the table that most of the parameters are dynamic, changing frequently, introducing complexity in 1) maintaining a realistic model of each ESS installation in the Market Dispatch Optimization Model's database for IEMOP, and 2) in accurately assessing the ESS's physical status which has implications for compliance monitoring. These issues are considered further in the sections that follow.

In the case of BESS, advanced BMS are designed to interface to SCADA system, providing needed dynamic data. Figure 10 below is a schematic of an advanced BMS/SCADA system.

*Table 14: BESS Performance Indicators and Implication for WESM Monitoring*[15]

| Aspect | Indicator | Definition | Need to Monitor (by PEMC ECO / IEMOP)? | Rationale |
|---|---|---|---|---|
| Technical Parameters | Rated Power Capacity (MW) | Manufacturer provided a rated MW (or kW) capacity for the BESS installation. | Yes | Required for registration and should be compared over time with respect to the available capacity |
| | Rated Energy Capacity (MWh) | Manufacturer provided a rated MWh (or kWh) capacity for the BESS installation. | Yes | Required for registration and should be compared over time with respect to SOC |
| | Maximum Recommended DOD (%) | Most BESS manufacturers also provide a maximum DOD. Staying within maximum recommended DOD is important for optimal performance and lifespan of the battery. | Yes | Useful to know the maximum DOD that is recommended because it may assist in monitoring to understand the operation of a BESS. |
| Operational Indicators | SOC (MWh) | SOC quantifies the volume of charge available within an element. | Yes | Impacts the availability of the BESS to provide energy services |
| | Balance (using voltage level as a proxy) | BMS balance the voltage levels of individual battery packs (typically wired in parallel – refer to *Figure **10***) based on the overall BESS control mode and seek to: (1) manage voltage, current and temperature, (2) estimate SOC and SOH, (3) fault detection, and (4) storage of monitored data. Balance is measured by monitoring differences in voltage within a BESS's battery packs. | No | This is the responsibility of a BESS operator for the ongoing management of the facility – to increase its lifetime and identify the need for maintenance. |
| Performance Indicators | Efficiency (%) | For any storage system, the energy efficiency quantifies the energy lost between the charge and the discharge. In the case of BESSs, the overall efficiency of an electrochemical assembly (cell, module, rack, bank …) can be further divided into the voltaic and the coulombic | Yes | Since IEMOP would need to model the charging / discharging operation of ESS in the market processes, the efficiency would need to be considered in the corresponding scheduling models. |

[15] Adapted from: "Key Performance Indicators for the monitoring of large-scale battery storage system", by Brun Emeric, source: http://www.diva-portal.org/smash/get/diva2:1371050/FULLTEXT01.pdf.

| Aspect | Indicator | Definition | Need to Monitor (by PEMC ECO / IEMOP)? | Rationale |
| --- | --- | --- | --- | --- |
| | | efficiencies – however, an overall number is of primary importance for market operations. | | |
| | Availability (MW) | A BESS facility has a modular configuration that must be considered when assess the availability (in MW) of the facility. The Live Level Availability represents the MW capacity that is available given the current state of the BESS | Yes | This is a key indicator to understand the availability of a BESS installation and compare to offered capacity in the WESM |
| Ageing Indicators | Number of Cycles (Number) | The number of equivalent cycles performed by the BESS in as a measure of the total charge throughput. The number of cycles is a cumulative indicator that can be measured cumulatively over time. | No | This is primarily an indicator that is of interest to the BESS owner / operator and used for the purpose of lifecycle management – it is a primary indicator of the BESS's age. |
| | State of Health (%) | Refers to the ratio (in %) of the maximum battery charge against its rated energy capacity. Essentially this is the maximum SOC for the BESS can achieve, given that it declines over time. | Yes | This impacts the BESS availability, and it would be beneficial to monitor. |
| Thermal Indicators | Temporal temperature indicators | Variation of the maximum temperature recorded of the facility over a period – defined by min / max. | No | Monitoring the thermal performance of the BESS is the responsibility of the BESS owner / operator |
| | Physical dispersion | Monitoring / comparing the temperature of each module or battery pack, to identify outliers or battery packs that are operating out of the normal range. | No | |

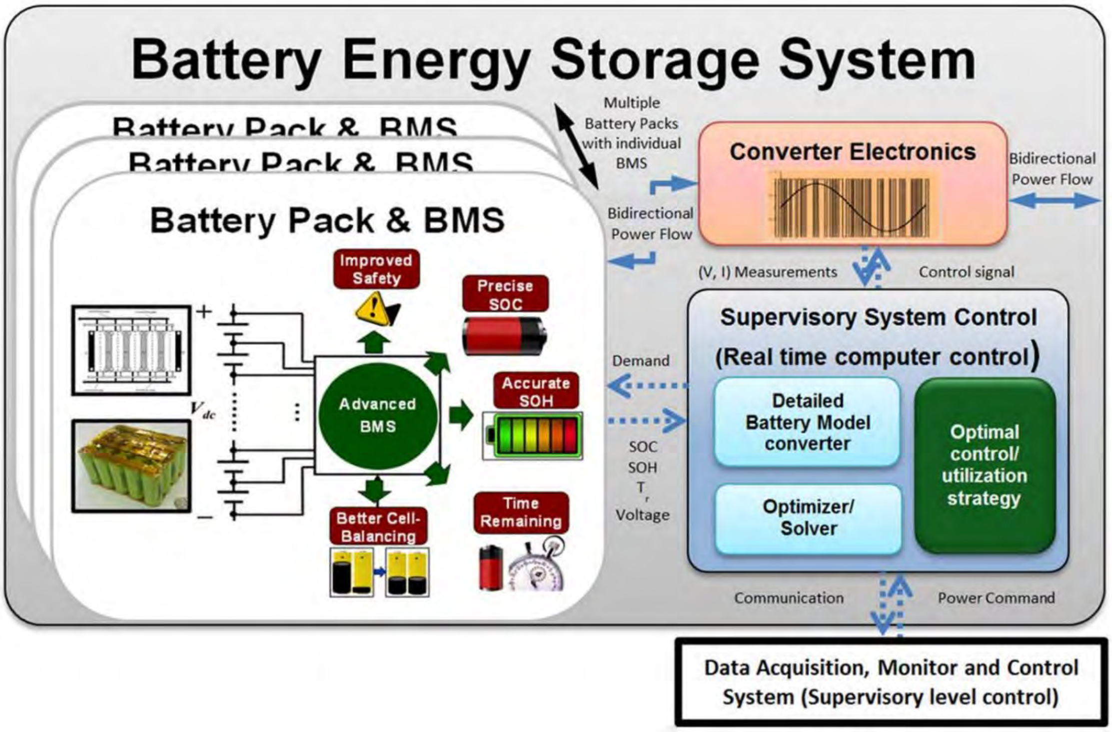



*Figure 10: Schematic of BESS and BMS for Grid-Scale Applications*

# 9 OUTPUT 4: INCREASED LEVELS OF COMPETITIVENESS

## 9.1 INTRODUCTION

Output 4 is defined as increased levels of competitiveness in the spot market in terms of BESS and other ESS ownership.

A high level of competitiveness will ensure sustained investment in BESS or other ESS technologies as investors will have confidence in their assessment of risk and reward. To a large extent such confidence relies on a set of market rules that are technology-neutral, in addition to reduced barriers to entry and the general ease of business in the energy sector. Another consideration is that market power must be seen to be measured and if necessary mitigated to ensure a level playing field at all times. In this regard there are short-term measures and medium-to-long term indicators that are applicable. A transparent governance structure with performance reporting will go a long way to satisfying market participants that market outcomes are fair and reasonable. Importantly, a market that has adequate measures to mitigate market power will generally have a higher degree of competition and will deliver better outcomes for society with efficient prices.

The objective of Output 4 is to ensure that the WESM's market power monitoring and mitigation measures are sufficiently adapted to address the challenge of having a high level of ESS participating in the market so that the issue of market power is properly managed.

## 9.2 MARKET POWER AND MARKET POWER MITIGATION IN ELECTRICITY MARKETS

A standard definition for market power market power in electricity markets that implement SCED models and determine real-time wholesale spot market prices (as done in the WESM) is defined as the ability of, or the potential for, a buyer or seller of electricity to significantly, and sustainably alter market prices away from a competitive price.

The main approaches that have been implemented in practice to mitigate market power in electricity markets are:

- Competition policy or laws that prevent a single firm from owning or controlling a substantial amount of capacity – a direct way to combat this is to impose concentration limits on registration of generation capacity, or defining anti-competitive laws that prevent single firms from becoming too large.
- Price control on the electricity market, including market price caps, market price floors, or secondary price caps or other measures that are triggered if market spot prices become too high for too long a period – in this way systemic failure of the market can be avoided.

- Compliance and penalty regime – where non-compliance with a rule that results in a penalty – often the rule defines a boundary between allowed behaviour and disallowed behaviour with dispatch compliance being one example.

- Market monitoring – to assess and check for the presence of anti-competitive behaviour. In practice, several common market monitoring indices are used, although market participants may be able to readily circumvent detection by such indices through tacit collusion or other behaviour, and so it is often necessary to have a deep data set of market outcomes that can be systematically analysed to assess behaviour.

Often the role of the entity doing the market monitoring (MO, Market Regulator, or other body) is to identify market outcomes that appear to point to the presence of market power and subsequently investigate the situation in more detail. If the evidence continues to point to an issue of market power, then the matter is often referred to another body who can investigate further, take legal action or issue a penalty. If a market suffers from being dominated by too few market players, then it is possible that actions could be taken to break up the dominant portfolio, or to have the dominant player make generation offers at estimates of their actual costs or have other limitations imposed to curb their market power. An example of this may be that a large player with > 20% of capacity ownership and control is required to make cost-based bids only until they sell off part of their portfolio.

## 9.3 HOW ESS CAN EXERCISE MARKET POWER IN ELECTRICITY MARKETS

An important observation about ESS is that their business case in an energy market (excluding revenue for providing ancillary services) relies on price arbitrage – meaning that the greater the difference between high prices and low prices, the greater the revenue they can potentially earn. Therefore, unlike a conventional generator – thermal plant, a VRE farm, or a hydro without storage – they have an incentive to drive low prices lower and high prices higher.

Under normal (competitive) operation ESS tends to drive low prices up (because ESS increases demand for electricity for charging) and higher prices down (because ESS wants to be dispatched to take advantage of price arbitrage). A higher penetration of ESS in the market will tend to reduce the price differential.

However, as ESS profits according to the price spread, they have an incentive to try to manipulate the spread. In theory this is difficult to do as a stand-alone ESS. It is more likely to occur when ESS and other generation (conventional or VRE) has a common owner. Under such an arrangement a ‘strategic’ generator could be willing to generate more, thereby reducing the low price further and losing revenue; the generator would later withhold capacity from the market to drive up the price received by the ESS for discharging. A simulation based on game theory shows this is feasible. The simulated market outcomes for a 5GW ESS operating in a 60GW market, are shown in Figure 11.

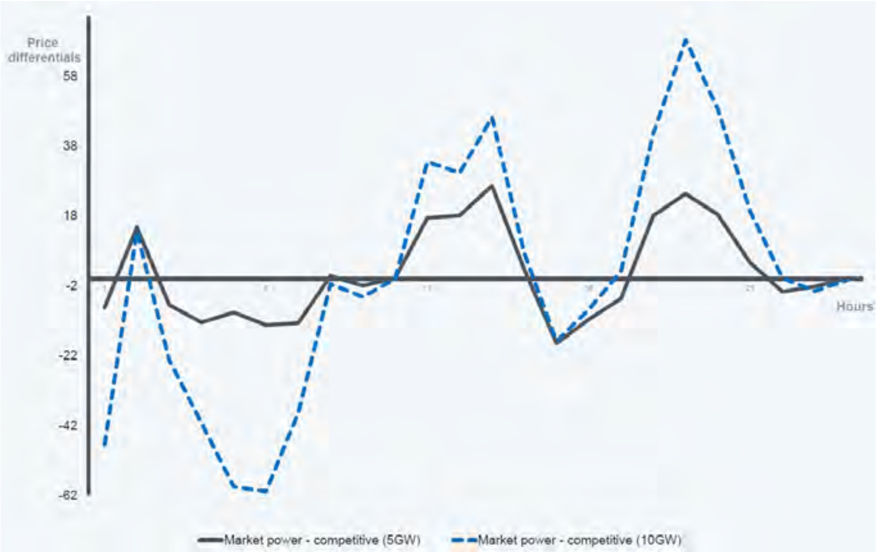



*Figure 11: Price differentials with strategic behaviour[16]*

Figure 12 extends the simulation to illustrate how an increasing amount of ESS capacity (5 GW vs 10 GW) can increase price differentials for strategic gain. It shows predictions from the simulation across price duration curves to show the effect – again it can be seen from the scenarios where BESS operates strategically (i.e., exercises market power) how such behaviour will tend to increase higher prices and reduce lower prices.

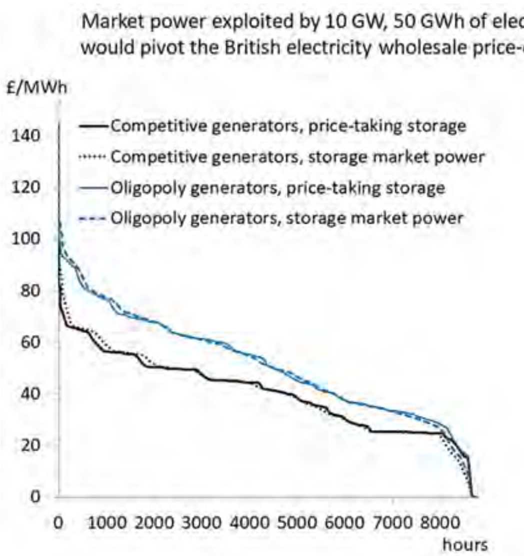



*Figure 12: Price duration curves showing impact of BESS in British electricity wholesale market[16]*

[16] Source: Olayinka Williams and Richard Green, "Welfare effect of market power in Storage", Imperial Business College.

With the above background in mind, the behaviors of ESS that are of concern in power markets include:

- Price-spread manipulation,
- Displacement of other generators to require the start or stop of less responsive generators,
- Rapid ramping to respond to violate dispatch compliance requirements (discussed in 8.3.4.2), and
- Other forms of collusion, as is observed with generation portfolios.

Analysis carried out by Williams and Green[16], based on the UK market, suggests that if ESS capacity reaches around 10% of peak demand, then there is potential for an oligopoly to influence market prices to their benefit, in the absence of there being adequate competition in ownership of the ESS capacity.

A review of the US ISO's shows that CAISO recognizes that BESS operators may be able to manipulate default energy bids because some costs related to State of Charge are difficult for the market operator to determine independently. However, broader concerns re market price manipulation are in the form of warnings that BESS participants (particularly hybrids) will be monitored for strategic behavior. It is thought to be the case that market manipulation concerns are low because the ISO's control very large power markets and BESS capacity offering energy time shifting is small relative to total market capacity.

## 9.4 EXISTING MEASURE IN WESM TO MITIGATE MARKET POWER

The WESM has in place numerous measures that have been implemented to address the issue of market power. These are briefly summarized here.

### 9.4.1 Concentration Limits in EPIRA

The EPIRA of 2001 or Republic Act 9136 forms the basis of liberalization of the Philippines electricity sector. The law provides the basis for: (1) deregulation and introducing competition into the generation sector, (2) the WESM, and (3) liberalization and introduction of competition into electricity distribution through RCOA.

Importantly, EPIRA requires: "A Generation Company shall comply with Rule 11 on Cross Ownership, Market Abuse and Anti-Competitive Behavior" where Rule 11, Section 4 on "Limits on Concentration of Ownership, Operation or Control of Installed Generating Capacity", specifies in clause (a) that:

> *"No person, company, related group or IPP administrator, singly or in combination, can own, operate or control more than thirty percent (30%) of the installed capacity of a grid and/or twenty-five percent (25%) of the national installed generating capacity…"*

Further, in clause (b) it is stated that:

*"The capacity of such facility shall be credited to the entity controlling the terms and conditions of the prices or quantities of the output of such capacity sold in the market in cases where different entities own the same Generation Facility.*

*In cases where different Persons own, operate or control the same Generation Facility, the capacity of such facility shall be credited to the Person controlling the capacity of the Generation Facility."*

The grids referred to in Rule 11 Section 4 (a) in practical terms relate to Luzon, Visayas and Mindanao.

The concentration limits are in place to safeguard the WESM from a company from becoming too dominant, although industry commentators will often suggest that ownership limitations alone are not sufficient to prevent the exercise of market power[17], and that industries dominated by 3 to 5 major firms do not lead to competitive outcomes – concentration limits such as 15% or lower have tended to be preferred as that implies the industry would have least 6 firms in competition.

### 9.4.2 Market Monitoring

Pursuant to the WESM rules and the Market Surveillance, Compliance and Enforcement Market manual, the PEMC MAG prepares and submits to the MSC periodic MARs, that assess market behaviour, including the evolution and analysis of the market monitoring indices. These are the outworking of the MAS that was described previously in Section 8.3, which is also used for compliance monitoring.

The MAG processes the indices based on the market monitoring data that has been collected mainly from IEMOP and NGCP SO. The reports include:

- Monthly market assessment reports,
- Quarterly market assessment reports, and
- Annual market assessment reports.

Among other assessments, the reports have an emphasis on monitoring three indices as a flag to indicate the presence of market power[18]. These are so called, "dynamic indices" because they measure market power (and potential benefit of exercising market power) taking into consideration variables that change depending on the market conditions, such as: demand, required spinning (or operation) reserves and generation availability. The measures that are monitored include:

- PSI,

[17] Helena Agnes S. Valderrama. "Market Structure Issues in the Philippine Power Generation Sector", Philippine Management Review 2007, Vol. 14, 23-37.
[18] PEMC, "Catalogue of Market Monitoring Data and Indices Issue 1.0", 17 May 2006.

- RSI, and
- HHI as a measure of overall market concentration.

These are summarized for reference:

### *9.4.2.1 **Pivotal Supply Index (PSI)***

PSI is a binary variable where 1 indicates “pivotal” and 0 indices “not pivotal”. It measures a plant for a particular dispatch period whether, given the market conditions of demand and generation, the demand could have been supplied without that generator being available.

The following defines the computation[18]:

#### Pivotal Supply Index

$$RDem_i^h = GenTot^h + Res^h - (\Sigma GenCap^h - GenCap_i^h) - IntCap^h$$

$$PSI_i^h = 1, \text{ if } RDem_i^h > 0$$

$$PSI_i^h = 0, \text{ if } RDem_i^h <= 0$$

Where:

- $RDem_i^h$ = residual demand of generator “i” in hour “h”
- $PSI_i^h$ = the pivotal supplier index for generator “i” in hour “h”
- $GenTot^h$ = total generation required in hour “h” to supply the load (energy withdrawn plus transmission losses)
- $Res^h$ = the operating reserve in hour “h”
- $\Sigma GenCap^h$ = total offered capacity of all generators in the hour “h’
- $GenCap_i^h$ = offered capacity of generator “i” in hour “h”
- $IntCap^h$ = available import capacity from interconnection in hour “h”

The pivotal supplier frequency index measures the frequency that a plant is pivotal over a given period. This is given by the following[18]:

#### Pivotal Supplier Frequency Index

$$PSI_i^t = \frac{\Sigma\, PSI_i^h}{(\text{No. of hours in period “t”})}$$

Where

- $PSI_i^t$ refers to the percentage of time that generator “i” is pivotal in the period “t”

An example of the PSI from a recent annual market report is illustrated in Figure 13. It identifies the plant that have been flagged as pivotal suppliers in the WESM the most frequently. The data is conditioned on whether the plant is setting the price to a level that exceeds 10,000 PhP/MWh.

| Plant | Major Participant Group | Cool Dry | | Hot Dry | | Rainy | |
|---|---|---|---|---|---|---|---|
| | | Frequency | % of Time | Frequency | % of Time | Frequency | % of Time |
| LIMAY CCGT | MEI | 4 | 0.18% | | | 6 | 0.14% |
| SAN ROQUE HEP | SMC | 7 | 0.32% | | | 2 | 0.05% |
| BAUANG DPP | VEC | 3 | 0.14% | | | 6 | 0.14% |
| CALUMANGAN DPP | Other IPPs | | | | | 4 | 0.09% |
| PPC DPP | GBPC | | | | | 3 | 0.07% |
| BATANGAS DPP | Other IPPs | | | | | 1 | 0.02% |
| PANAY DPP III | SPC | | | | | 1 | 0.02% |
| PANAY DPP I | SPC | | | | | 1 | 0.02% |
| ANDA CFTPP | APC | | | | | 1 | 0.02% |
| KALAYAAN PSPP | PSALM | | | | | 1 | 0.02% |

*Figure 13: Example of Pivotal Supplies and Price Setters for >= 10,000 PhP / MWh Periods[19]*

#### *9.4.2.2 Residual Supply Index (RSI)*

RSI is a continuous index measured as the ratio of the available generation without that generator to the total generation required to supply demand. The market RSI is measured as the lowest RSI among all generators in the market. A market RSI less than 100% indicates the presence of a pivotal generator(s) or supplier(s).

RSI This is given by the following[18]:

[19] PEMC MAG, "Annual Market Assessment Report: 26 November 2019 to 25 November 2020", July 2021

## Residual Supply Index

### a. Residual Supply Index by Generating Plant

$$RSI_i^h = \frac{(\Sigma GenCap^h - GenCap_i^h) + IntCap^h}{GenTot^h + Res^h}$$

Where:

- $GenTot^h$ = total generation required in hour "h" to supply the load (energy withdrawn plus transmission losses)
- $Res^h$ = the operating reserve in hour "h"
- $GenCap_i^h$ = offered capacity of generator "i" in hour "h"
- $\Sigma GenCap^h$ = total offered capacity of all generators in hour "h'
- $IntCap^h$ = available import capacity from interconnection in hour "h"

A variation on the RSI is to compute a whole of market measure as follows:

### Residual Supply Index of the Whole Market

$$RSI\_Market^h = min\ (RSI_k^h)$$

Where "k" refers to all generating plants in the market

The RSI as computed by PEMC MAG are presented in the annual market reports and an example of the RSI computation in a recent annual market assessment report is provided in Figure 14. These charts flag the extent to which there have been pivotal suppliers across different periods.

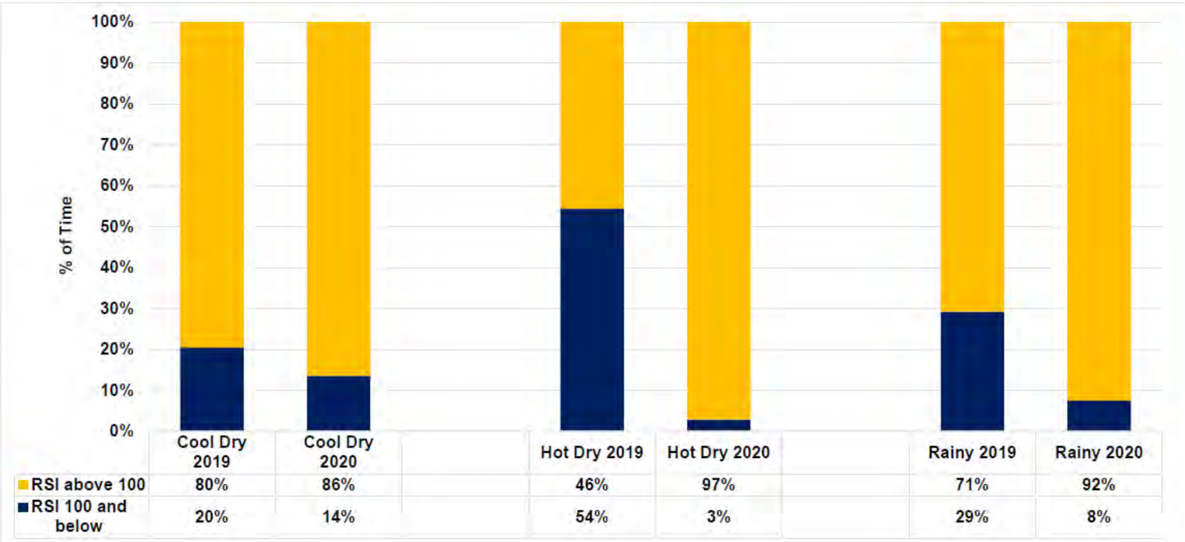



*Figure 14: Example of RSI from 2020[20]*

#### *9.4.2.3 Herfindahl-Hirschman Index (HHI)*

The HHI measures the degree of market concentration, considering the relative size and distribution of participants in the monitored market. It is calculated as the sum of squares of the participant's market share[18]:

Herfindahl-Hirschman Index

$$HHI^t = \Sigma (S_k^t)^2$$

Where:

- $S_k^t$ = generating plant/customer/trading participant "k" market share in the period "t", where $\Sigma S_k^t = 100\%$
- "k" = all generating plants/customer/trading participants

Note that the HHI approaches zero when the market has very large number of participants each having a relatively small market share. In contrast, the HHI increases as the number of participants in the market decreases and the market starts to become dominated by a small number of major players, which is undesirable.

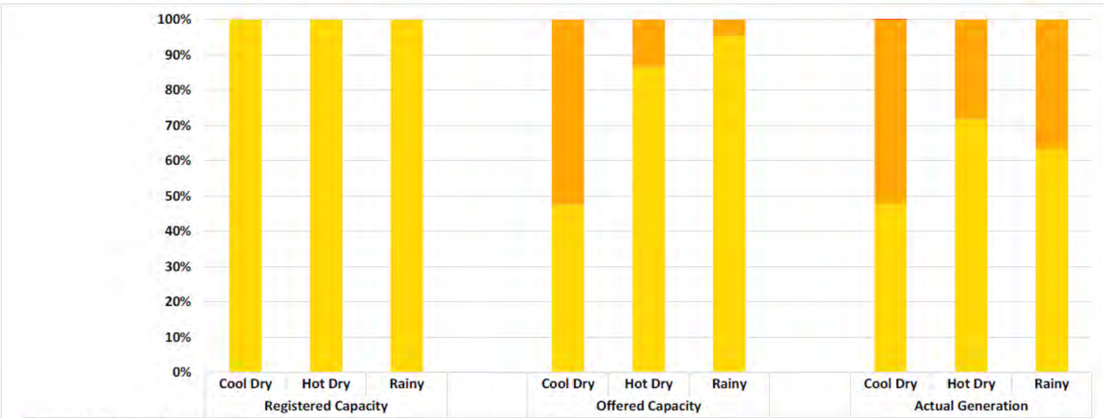
Widely used HHI ranges are adopted to assess the level of market concentration:

- o HHI < 1000 indicates that the market is not concentrated,
- o HHI from 1000 to 1800 indicates the market is moderately concentrated,

[20] PEMC MAG, "Annual Market Assessment Report: 26 November 2019 to 25 November 2020", July 2021

- o HHI from 1800 to 2500 indicates a concentrated market, and
- o HHI > 2500 indicates it is highly concentrated and signals a lack of competition in the market.

Note that often the HHI will be computed based on capacity that is made available to the wholesale market or it is computed based on generation in the market. To some extent, concentration limits being imposed on market participants by EPIRA (see Section 9.4.1) is an indirect way to manage HHI to ensure a competitive market, although installed capacity by itself is fixed whereas the issue for market monitoring is attempting to identify periods of time when market concentration is too high under certain conditions – such as periods of high demand. An example from the annual market reports of the application of HHI in the WESM is provided in Figure 15. the measure used is "offered capacity" rather than installed capacity, as offered capacity is a better measure of capacity available in real-time.




| | Registered Capacity | | | Offered Capacity | | | Actual Generation | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cool Dry | Hot Dry | Rainy | Cool Dry | Hot Dry | Rainy | Cool Dry | Hot Dry | Rainy |
| Highly Concentrated | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Concentrated | 0% | 0% | 0% | 53% | 13% | 4% | 52% | 28% | 37% |
| Moderately Concentrated | 100% | 100% | 100% | 47% | 87% | 96% | 48% | 72% | 63% |
| Not Concentrated | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

*Figure 15: Example of HHI for 2020[21]*

### 9.4.3 Compliance Monitoring and Penalties

Compliance monitoring and penalties are implemented in the WESM. Note that compliance monitoring acts as a way of diminishing undesired behavior by detecting clear breaches of market rules and issuing penalties. Compliance monitoring is an important part of ensuring market behavior is reasonable, but it often it is not possible to detect more complex behaviors where market power is being exercised or be able to distinguish between a legitimate problem – such as a plant outage vs. an attempt to manipulate prices (such as a capacity withdraw). Two important areas in the WESM for compliance monitoring are:

[21] PEMC MAG, "Annual Market Assessment Report: 26 November 2019 to 25 November 2020", July 2021

(1) Must Offer Rule, and (2) Dispatch conformance standard. These were discussed in relation to Output 3 – see Section 8.

### 9.4.4 Market Price Controls

The WESM also has in place a number of controls on prices, which include the following:

- SPC of 6,245 PhP/MWh is imposed if a rolling 3-day period (72 hours) average price exceeds 9000 PhP/MWh[22]. This has the effect of capping prices if the spot prices become too high over a rolling period and has some effect to limit the financial consequences of systemically high spot prices on market participants. While this does not necessarily remove market power, it limits the impact that extreme pricing events on customers (the extreme pricing events may have been driven by market power or they may have been driven by other factors), and

- An offer price cap is imposed on generator offers of 32,000 PhP/MWh, which has the effect of capping spot market prices to 32,000 PhP/MWh, although technically there is not a cap on the prices.

- Price Substitution Methodology (PSM) is another measure that is in place – where if the difference in nodal prices between locations exceeds a threshold, logic is imposed to reduce the difference in prices differences.

While it has been previously recommended to introduce a market price cap and market price floor to the WESM, to date this has not been officially done[23]. The market price cap is effectively 32,000 PhP/MWh, the market price floor is understood to be determined by a setting the market clearing engine software, to -1000 PhP/MWh.

## 9.5 RECOMMENDATIONS (OUTPUT 4)

The recommendations for compliance monitoring and on the assessment of this section are presented in Table 15.

*Table 15: Recommendations for Output 4: Competitiveness*

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 18 | Market Power Monitoring / Mitigation | EPIRA concentration limits applied | Concentration limits triggering regulated pricing or anti-competitive laws in | Additional clause added to appropriate legislation to apply the EPIRA competition limits to ensure that no single technology |

[22] This was set in place in July 2021 – refer to: https://www.philstar.com/business/2021/07/01/2109246/erc-amends-wesm-price-setting-system/

[23] See for example: PEMCStudyontheInterimMitigatingMeasureintheWESM_FINAL.pdf

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| | | to a firm level. | place to intervene in the market and break up a dominant monopoly organization. | by a single firm dominates ESS supply as single technology. Note that it is suggested that this apply for a period of time and be relaxed once it was clear that there was adequate diversity in ESS suppliers. |
| 19 | Market Power Monitoring / Mitigation | PSI, RSI, and HHI | BESS / ESS capacity is considered part of a generator portfolio's generation resources for supply. | Include ESS capacity that is registered in the WESM in these computations in the ongoing market monitoring and surveillance reporting and monitoring of MAG |
| 20 | Market Power Monitoring / Mitigation | PSI, RSI, and HHI | Consider both firm level (portfolio-level) indicators for pivotal supply and technology indicators | Compute the RSI, PSI and HHI metrics for technologies as well as for firms. Monitor these to keep track of the operation of BESS playing an increasing dominant role in the market. |
| 21 | Market Power Monitoring / Mitigation | Market price cap | Formal price cap in place, and transparent methodology for reviewing and resetting the price cap from time to time. | Put in place a formal price cap, and methodology for periodic review and setting. |
| 22 | Market Power Monitoring / Mitigation | Market price floor | Formal price floor in place, and transparent methodology for reviewing and resetting the price floor from time to time. | Put in place a formal price floor, and methodology for periodic review and setting. |
| 23 | Market Power Monitoring / Mitigation | Secondary price cap and triggering mechanism | Mechanism in place to periodically review and update the settings of a secondary price cap (or its equivalent) | Recommend having a process to periodically review the settings in light of ESS technology and its penetration in the WESM. |
| 24 | Market Power Monitoring / Mitigation | Market Monitoring Procedures | Monitoring of price spreads. | Monitor price spreads and compare to business case / profitability for ESS. |

# 10 LOOKING AHEAD: HYBRIDS & ANCILLARY SERVICES

## 10.1 THE TREND TOWARD HYBRID SYSTEMS

Widescale and rapid uptake in deployment of VRE, such as wind and solar, have occurred as the result of lowering costs, technology improvements and often from favorable policies. The variability and uncertainty associated with VRE has put an emphasis on increasing the flexibility of power systems to complement the evolving technology mix. ESS is one strategy to increase flexibility and to complement a power system that has significant level of VRE generation.

Apart from stand-alone ESS connection and operation, as considered in this report, another important trend is that of the emergence of hybrid facilities or integrated resources. An example of an integrated resource is a BESS that is co-located with a VRE farm or other types of traditional generators, to improve its overall operation and performance characteristics. In the case of VRE farms, provision of “VRE firming” services are becoming commonly deployed. In the case of traditional generators, such as combined cycle gas turbines or open cycle gas turbines, coupling the power station with a BESS can provide a rapid start and rapid response capability, with sustained power output delivered by the conventional thermal resource.

Electricity market integration of such hybrids is recognized as a significant emerging challenge that is needing to be addressed with high priority given the proliferation of potential applications.

### 10.1.1 Hybrids and IRPs

A Hybrid Resource is a facility that comprises a mixed-fuel type power generation facility or a combination of different generation technologies physically and electronically controlled by a single owner/operator. A major advantage of hybrid power systems is the fuel savings that it can offer, which also helps with the reduction in the emissions and use of non-renewable sources. The use of complementary power sources can help increase the reliability of the power system as well. For instance, combining a solar PV source with a fossil fuel-based generator eliminates the primary disadvantage of solar PV – the intermittency of the power supply. At the same time, the use of solar PV reduces the use of fossil fuels. These systems can be “hybridized” further by the integration of energy storage systems into the mix. This practice has been gaining traction, especially with the reduction in the cost battery energy storage systems due to the reduction in costs of Li-ion batteries. Utilizing a renewable energy source and energy storage along with a fossil fuel generator for emergency or peak demand use helps further reduce the use of fossil fuels and thus the emissions associated with them. Despite these advantages, utility-scale hybrid systems can be difficult to install as the capex involved can be relatively high. End-users who have renewable power systems installed, such as rooftop solar installations on their premises can much more easily hybridize their installation with the installation of lower capacity batteries to increase the utilization of the solar power and reduce their dependence on the electric grid.

### 10.1.2 Philippines Policy for Hybrid resources

The Philippines Department of Energy defines Hybrid Power Systems in its Department Circular DC2019-08-0012 as "any power or energy generation facility which makes use of two or more types of technologies utilizing both conventional and/or renewable fuel sources." Typically, hybrid power systems are facilities that are a combination of one (or more) type of conventional or renewable generation source with an ESS which can be inter alia, a battery energy storage system, compressed air energy storage, pumped-storage unit, or flywheel energy storage.

While most of the generation facilities are owned by the generation companies, this can also apply to facilities owned and operated by QTPs who play a vital role in the missionary electrification process by providing basic electricity services to remote areas where the generation companies find it difficult to reach. Furthermore, the DOE has also included customers/end-users who own and/operate energy storage systems. For instance, a residential rooftop PV system connected to a BESS would be a hybrid power system.

The DOE has recognized the potential of ESS-based systems, and requires the operators of the hybrid systems to register their systems to provide one or more of the following[24]:

- Energy through bilateral supply contracts or trading in the WESM
- Ancillary Services
- Auxiliary load management for generation companies
- Distribution utility demand management
- Distribution utility power quality management

The DOE has set out the following stipulations regarding the operation of hybrid systems, in addition to their requirement of obtaining a certificate of compliance from the ERC:

- Generation companies are permitted to own and operate integrate ESS in their existing generation facilities to create hybrid systems. However, they are required to register the ESS separately in the WESM and shall have separate metering and monitoring.
- Generation companies with hybrid systems are required to provide the RE Registrar with certified estimates of the RE generated[25].

[24] The Philippines DOE – Department Circular DC2019-08-0012 [ https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2019-08-0012.pdf]
[25] PEMC – Market Development [https://www.wesm.ph/market-development/re-market/frequently-asked-questions]

- DCC and end-users are permitted to own and operate ESS as part of a hybrid system, subject to obtaining permits from relevant authorities. The following information is to be provided to the TNP, SO, and MO, by the DCCs and to the DU by the end-users:
    - Type of ESS used its proposed application/purpose
    - Capacity and rate of charge/discharge
    - Any additional information as required
- QTPs are permitted to own and operate ESS in conjunction with RE-based generation facilities to provide electricity to households in remote areas, in the form of a local micro-grid that is compatible with the government's electrification program.
- TNPs, Small Grid owners, and SOs are not permitted to own and operate ESS facilities, among other reasons as mentioned under Section 4.7 and Section 4.8 of DC2019-08-0012, to avoid any conflict of interests.
- The hybrid systems connected to the grid are required to comply with the connection and operational requirements that are asked of all other generation facilities as well, including compliance with the PGC, PDC, WESM rules, and any other relevant policies.

### 10.1.3 Hybrid resources in the Philippines

The Department of Energy in its Energy Plan 2020-2040 had acknowledged the hybridization of power systems or renewable facilities as a way to increase their reliability. They had mentioned that the use of battery storage in the grid, or solar PV systems with other fuels would make help balance the intermittency of the renewable energy sources, while also staying on course for reducing the emissions and the dependence on fossil fuels.

The following hybrid power systems are currently operational in the Philippines:

*Table 16: Operational hybrid power systems in the Philippines*

| Location | Technologies Used | Scale |
|---|---|---|
| Alaminos, Laguna, Luzon | Solar PV: 120 MW<br>Battery Storage: 60 MWh | Utility-scale |
| Sabang, Palawan, Luzon | Solar PV: 1.4 MW<br>Diesel: 1.2 MW<br>Battery Storage: 2.3 MWh | Microgrid |
| Lahuy Island, Camarines Sur, Luzon | Solar PV: 250 kWp<br>Diesel: 400 kW<br>Battery Storage: 210 kWh | Microgrid |
| Haponan Island, Camarines Sur, Luzon | Solar PV: 100 kWp<br>Diesel: 100 kW<br>Battery Storage: 210 kWh | Microgrid |

| Location | Technologies Used | Scale |
|---|---|---|
| Quinasalag Island, Garchitorena, Camarines Sur, Luzon | Solar PV: 400 kWp<br>Diesel: 500 kW<br>Battery Storage: 210 kWh | Microgrid |
| Poblacion, Dumaran, Luzon | Solar PV: 132.8 kWp<br>Diesel: 144 kW<br>Battery Storage: 351.1 kWh | Microgrid |
| Port Barton, San Vicente, Luzon | Solar PV: 200 kWp<br>Diesel: 609.5 kW<br>Battery Storage: 200 kWh | Microgrid |

## 10.2 INTEGRATED AS MARKET

### 10.2.1 WESM Situation and Challenges

While the WESM rules define the basis for a competitive ancillary services market and assigns the role to the MO, the WESM's AS market implementation remains in an early stage of development with Interim arrangements in place. In the near-term, market-based mechanisms to procure ancillary services PRAS, SRAS and TRAS (see definitions in 3.4) are planned[26]. Specifically, the WESM would integrate these services and centrally dispatch them in real-time jointly with the energy market. Furthermore, there would be mechanisms established to recover the cost of these services from market participants, with under the principle of "causer-pays".

Having an integrated energy-reserves market will improve upon the Interim AS arrangements, because ESS providers of these services will be able to participate directly in the energy and AS spot markets together and their capacity will be utilized in the most efficient way. Whereas, at present, with the AS providers being separately nominated by the SO on a day-ahead basis, it means that some portion of capacity is "netted out" of the energy market and will not be available for dispatch.

Challenges to the development of an integrated energy and AS market include:

1. Harmonization of the PGC 2016 definitions of AS with those used in the WESM rules

2. Defining the respective roles and interfaces between the MO (or the IEMOP) and SO in setting service requirements and procurement of the needed ancillary services

3. Implementation of the ancillary services markets in the Market Information Technology (IT) Systems.

[26] It is understood that PEMC recently filed with ERC the application for the approval of the Price Determination Methodology for the Reserves Market/Co-optimized Market. The Reserves Market design follows the DOE DC on Reserves Market, wherein in the interim, Regulating, Contingency and Dispatchable Reserves are used. Moreover, it has a single buyer mechanism (SO).

### 10.2.2 Integrated AS Markets and ESS

These issues are beyond the scope of this project; however, the general recommendation is made that progressing the development of the AS market will be to the benefit of greater integration of ESS in the WESM within the next few years.

## 10.3 RECOMMENDATIONS

The near-term recommendations related to the WESM are summarized in Table 17. These are issues that relate more to near-term policy change in relation to the WESM Reserve Market are beyond the scope of this report to consider in detail.

*Table 17: General Recommendation for Looking Ahead*

| No. | Electricity Market Area | WESM Practice | International Practice | Recommendation(s) |
|---|---|---|---|---|
| 24 | Market Registration, Dispatch, Scheduling, Settlement, | No provisions for registration of hybrid facilities (or IRPs) | Hybrid systems / Integrated Energy Resources can be registered and managed in the market. | It is proposed that this be done as an extension to the stand-alone ESS enhancements. There are implications for conformance monitoring and the approach adopted for dispatch. |
| 25 | Ancillary Services Market | Integration ancillary services market not yet in place in the WESM | Market-based ancillary service markets that allow for participation of ESS. | Important to implement ancillary service markets in the WESM as it supports the business case and hence promotes the investment in ESS in the WESM. |