MONASH
ENERGY
INSTITUTE

NATIONAL ELECTRICITY AMENDMENT

(INTEGRATING ENERGY STORAGE SYSTEMS INTO THE NEM) RULE

A reply to a consultation paper of the AEMC prepared by

Guillaume Roger, PhD
Associate Professor, Monash Business School
Associate Director, Monash Energy Institute
Co-Director (Economics), Grid Innovation Hub

with the assistance of
Ross Gawler, PhD
Associate Researcher, Monash University

This submission:

On 20 August 2020, the AEMC issued a consultation document (NATIONAL ELECTRICITY AMENDMENT (INTEGRATING ENERGY STORAGE SYSTEMS INTO THE NEM) RULE) seeking input from stakeholders on a rule-change request initiated by AEMO to prepare for the integration of grid-scale storage into the NEM.

In this submission we answer almost all 40 questions contained in the consultation document. In an opening section we also specifically attract the attention of the AEMC to three important aspects of integration of storage into the NEM: (*i*) the bidding process for devices that may either buy or sell at any point in time and using dynamic strategies, (*ii*) the dispatch algorithm that must now solve a dynamic optimization problem and (*iii*) the industrial organization of the storage market.

Guillaume Roger

9 October 2020

Disclaimer:

The views expressed herein are our professional opinion as experienced academics. In no way should they be construed as a policy position adopted by Monash University.

Part I: Three important remarks.

Before answering the questions raised by the Commission we draw attention to three important points, the treatment of which we believe critical to the successful integration of storage services into the NEM. These elements are largely neglected in the consultation document prepared by the Commission and in the request prepared by AEMO. However, they implicitly elevate the rule-change request from a level of administrative change to one of profound market design.

1) Market Design.
   With the introduction of storage, two aspects of the bidding process must be modified. The first aspect is that, at any point in time, storage can buy or sell; therefore, a bid may be expressed as an offer to buy (ask) or to sell (bid). This is correctly identified in the consultation document however the consequences seem to have been neglected. First, the double auction generates a *unique* clearing price; it must be then determined whether the storage unit wants to buy or sell at this price. Second, there typically is a spread between bid and ask, even at the market-clearing quantity. Any clearing prices in that bid-ask interval is admissible, but how that price is set must be specified. Third, the welfare-maximising price-quantity pair is known to typically induce a *loss* to the market maker – here, AEMO. Therefore price-setting is sensitive in this new environment.
   The second aspect pertains to the *dynamic* nature of decisions made when dealing with storage. Storage presents a new important characteristic: its optimal strategy depends on the state of charge and its anticipation of future circumstances. Of course, this includes its bidding strategy – whether buying or selling – of a storage unit. This state of charge is a state variable in a *dynamic optimization* problem; an optimal strategy is not just a single bid-ask offer but a sequence of such offers, which depends on the *future* environment. This is a *new class* of problems in market design that has not been studied yet.
   We also remark that keeping track of the state of charge is important: if it is kept private, it introduces *asymmetric information* between the storage operators and the market operator. Asymmetric information greatly complicates market design, and entails significant welfare costs. It is however easy to mandate the monitoring of this information at the time of developing new market rules, and easy to implement with current technology via telemetry.

   We believe a detailed study of this problem is warranted.

2) Dynamic dispatch.
   As mentioned above, an optimal strategy is the solution to a *dynamic problem* for each storage operator as they compete with each other. The dispatcher faces a similar problem, however dealing not with one unit but the entire fleet of storage units. NEMDE is utterly unable to tackle such a dynamic optimization problem. Hence integrating storage into the NEM requires to completely update the NEMDE algorithm, in addition to keeping track of the state of charge of all registered units at all times.

3) Industrial organization

Finally, market power is an important concern for the Commission to consider. Just as for large generators, large battery operations do hold unilateral market power. However, we observe there are no significant economies of scale in battery operation: capacity scales up linearly. That is, unlike large generation plants, which feature economics of scale, there is *no social benefit* from large scale of operation for a battery; instead there is only the cost associated with the exercise of market power.

To the extent that entry can be controlled by AEMO, the entry of many *small(er)* players should be encouraged and the concentration of capacity should be discouraged in order to foster competition in the provision of storage services. It is especially important to favour the entry of small-scale operation early in the development of the market to avoid pre-emptive entry of large players. Karaduman (2020) even makes the case that entry by a large-scale operator is not even (privately) profitable with current technology because of the so-called price effect: a large operator moves prices, to the point where the realised spread may not cover costs.

There is a second benefit to fostering a competitive market. When there are a few large players, the only avenue to model the market for the purpose of market design, for example, is to use a game-theoretic approach. With batteries, the market design problem becomes a *dynamic game* – not just a problem of dynamic optimization. These models are typically very difficult to solve. When the market is competitive instead, the dynamic game can be reduced to a dynamic optimization problem, which is easier to handle.

In conclusion, there is much more to integrating storage into the NEM than AEMO even raised. We believe the reforms required to successfully integrate storage are eminently achievable; we also believe there is no time to lose to start with this important work.

Part II: Questions.

QUESTION 1: PROPOSED ASSESSMENT FRAMEWORK

Do you agree with the proposed assessment framework or are there any additional assessment criteria the Commission should use when assessing identified issues and possible solutions?

N/A

QUESTION 2: CURRENT ISSUES CAUSED BY THE TREATMENT OF STORAGE (AND HYBRIDS) UNDER THE NER

1. Do you agree with AEMO that there are currently significant issues for storage units and hybrid facilities being caused by the rules not including a storage definition? Why, or why not?

   Being registered either as a scheduled generator or as a load carries obligations that a battery, and even more so a hybrid system, may not be able to carry out. For example, the battery of a hybrid system that is fully charged cannot be used as a load by AEMO. This should be clearly identified. If penalties as a stake, it is understandable that storage owners may be worried of such misunderstandings, which may lead to delays in registration.
   There appears to be little to lose by recognising that batteries are a different technology and that their ability to act as a load or a generator depends on their state of charge. This is indeed novel, and something that neither generators nor loads had to contend with previously.

2. Has AEMO identified all the current issues for storage and hybrid facilities that arise from its primary issue that the NER does not recognise and adequately define storage? If not, what are the other issues?

   Nowhere does AEMO mention that the use of a battery is *state-dependent*. An empty battery can only be a load and a full battery can only be a generator. It is very important to keep track of this state, especially as AEMO (i) attempts to find an optimal dispatch using batteries and (ii) may wish to direct battery operators in some instances to control grid stability.

QUESTION 3: IMPLICATIONS OF STORAGE FORECASTS

Do you agree that storage and hybrid facilities are likely to play a significant role in the future market? If so, do you agree that this indicates that the issues AEMO has identified in its rule change request, arising from the current treatment of storage under the NER, are likely to become worse over time? Why, or why not?

There is little doubt that storage will play an increasingly important role in the NEM as generation transitions from thermal to renewable. Given the characteristics of VRE, storage

likely is the most important instrument of this transition. It is therefore important to clarify the role of storage in the system. Storage can be many things: a source of price arbitrage, a device to implement intertemporal substitution of generation, a source of grid and frequency stability, or a device to assist with congestion management (especially with the forthcoming introduction of LMP). It may be particularly important as a complement to VRE generation, that is, in hybrid installations. If there is confusion today with a handful of installations, things are likely to become only worse as the number of hybrid plants increase.

QUESTION 4: AEMO'S RATIONALE FOR DEFINING STORAGE AND HYBRIDS IN THE NER

1. Do you agree with AEMO that there is a strong rationale for defining storage and hybrid facilities in the NER (as different to load and generation)? Why or why not?

   There is a definite case to clarify the distinction between generator/loads and storage facilities, even though storage unit can operate under current NER and arrangements thereof. The reasons are (i) there is a contradiction in being be bound to the obligations of both generators and loads *simultaneously*, (ii) the state of charge is an essential variable of a storage device and (iii) some facilities, such as hybrid installations, may not be really loads open to the market, but rather dedicated to their own generation source. On (i) in particular, a storage unit cannot simultaneously charge and discharge. If the dispatch engine does not recognize this, the optimal dispatch may ask of the same unit that it acts as load and generator at the same time.

2. Bearing in mind that the two-sided market reforms (as discussed in section 2.2.4) propose to move towards service-based requirements (rather than technology-based requirements), are there differences in the nature of the services provided by or to storage facilities that require these services to be distinguished from generation and load?

   As outlined in 1) above, there is a case for this distinction to be made – given current NER. Specifically, the storage installations of hybrid facilities may not be appropriately registered as loads, for example. The reason is that their role may be to soak up excess supply from the generation facility and to firm up that facility, rather than act as load. It is also important to collect essential information, such as the state of charge, which is based on technology.

QUESTION 5: AEMO'S PROPOSED WORDING FOR DEFINING STORAGE AND HYBRID FACILITIES IN THE NER

Do you have any comments on AEMO's wording for its proposed definitions of storage and hybrid facilities?

It may be helpful to not presume of hybrid facilities that they can accept inflow or outflow at any time. For hybrid facilities the price arbitrage may differ from stand-alone batteries because the source of energy is different. In addition, the battery of a hybrid facility may have other functions that assist in the operation of the generation unit and in its connection to the grid.

A technology-neutral definition of a bi-directional unit does not define the mechanism or technology for stored energy as means to control the consumption and production of electricity.

QUESTION 6: ALTERNATIVES TO AEMO'S PROPOSED SOLUTION TO INTEGRATION ISSUES FOR STORAGE

In light of the alignment issues between AEMO's rule change request and the direction the ESB's two-sided market reforms are taking, which of the following approaches do you support and why?

1. Waiting for the implementation of the two-sided market reforms to address the integration issues facing storage and hybrid facilities

   No, for at least four reasons. First, whatever reforms may emerge from the efforts of the ESB, they are years away from being implemented. In the meantime, batteries are in operation now, new projects are in the pipeline and inviting more batteries to rapidly enter the market would help with the firming of VRE generation.

   Second, a highly decentralised market as envisioned by the ESB is neither desirable nor viable.[1] It is not viable because of the central coordination problem that exists between generation and demand. That is, with a broad brush, there is ample supply (of VRE) but no demand at 2PM and a large demand but no supply at 7PM. A market requires both demand and supply to be *simultaneously* present. The clear path to solve this problem is intertemporal "arbitrage", that is, batteries. This is a third reason to proceed with whatever reforms are necessarily to accommodate batteries. A completely decentralised market is not desirable because it is the source of a significant externality on the grid. Such a decentralised market is likely not under the control of AEMO, which implies that AEMO would have difficulties in forecasting both supply and demand. There are remedies, of course. The most effective one is to not encourage a disruptive decentralised that arises out of expensive subsidies to households.

   Fourth, the "two-sided market" envisioned by the ESB is really a double auction for decentralised resources. At a high level it is a similar design to the one required to handle storage. Hence there is no or little waste in proceeding now.

2. Introducing AEMO's rule change proposal as an interim step prior to the implementation of the two-sided market reforms

   Yes, for the very same reasons as in 1. above.

3. Implementing certain aspects of the two-sided market reforms through this rule change project, such as combining the different types of market participants and imposing obligations based on services rather than assets

   In light of the comments in 1. above, it may be sensible to adopt certain aspects of the ESB's work, especially when it comes to designing a double auction. However this is not advocating delay.

4. Taking an alternative approach (please specify)

   N/A

[1] The "two-sided market" of the ESB is in fact a double-auction: any agent may buy or sell. A two-sided market, as defined by Nobel prize-winning Jean Tirole and his colleague Jean-Charles Rochet, is in fact a very different object. More details available upon request.

QUESTION 7: UNDERSTANDING THE INTEREST IN REGISTERING HYBRID FACILITIES AND THE CHALLENGES THAT EXIST

1. Why would you consider aggregating different technologies together in a hybrid facility? Which technologies do new participants propose to combine in hybrid facilities?
   There is much merit in combining storage with intermittent generation. It obviously smooths "production" over time: energy in excess of demand can be stored until it is required, or it can be stored and sold for a higher price later. It also smooths the injection of energy into the grid and so may assist in solving the stability and frequency control issues usually associate with VRE. Finally it may turn a semi-scheduled generator into a scheduled generator.

2. Are you considering using storage to minimise causer-pays liabilities by balancing the output of your units across multiple connection points under the current NER? What are the challenges of this approach?
   We are not a market participant but this seems to be an obvious thing to do.

3. Would you prefer to balance output and consumption across multiple connection points or combine technologies behind an individual connection point?
   N/A

4. Are you considering aggregating renewable plant and batteries together as a scheduled generating unit under the current rules? What regulatory challenges do you see with this approach?
   N/A

5. Do you consider that the lack of clarity in the NER on whether different technologies can be aggregated is a significant issue for registering hybrid facilities? If so, why?
   Yes, this may be problematic. For example, a battery that is combined with a VRE generator with the express purpose of charging from the VRE generator may not be able to act as a scheduled load because it is already charging from the VRE, and so could not be directed by AEMO. There may be many other scenarios like this one, where the actual usage may differ from the usage anticipated by the NER for either loads or generators.

QUESTION 8: REGISTRATION PROCESS ISSUES

N/A

QUESTION 9: ISSUES WITH SMALL STORAGE UNITS

The role of small storage units should be clarified as soon as they aggregate in a portfolio, such as an SGA. This may become important as investment in storage increases, especially if AEMO has to direct some storage units at time. It may also help enhancing the participation of small units in the FCAS market, where small and fast units are ideal.

Furthermore, a sensible definition of "small" needs to be provided, in the following sense. Market power is a definite concern with any generator, and storage is no exception. However, with storage there is no benefit to large-scale operations: the fixed costs are low and operations scale up linearly in the number of battery units. Therefore, to the extent that is can be controlled, one should favour a collection of small batteries over a large battery (supplying

the same energy). There are *some* fixed costs however (e.g. connection costs), which imply there exists an optimal unit size, where average cost are low but this benefit is not outweighed by market power. This is should guide the definition of small (and large). Finally, the regulators should monitor the aggregation of small batteries into a large operation so as to pre-empt the bypassing of the "large" hurdle.

QUESTION 10: PROPOSED APPROACH TO REGISTRATION CATEGORIES AND CLASSIFICATIONS

1. Do you consider that AEMO's proposed solution will make the registration process simpler and less expensive for intending participants seeking to classify storage units and hybrid facilities?

   It will certainly make the process more transparent in that it will clarify the role and obligations of storage units. The cost of registration seems trivial compared to the investment and the operating revenue.

2. In relation to the registration of hybrid facilities, do you agree that the NER should provide that participants cannot aggregate units with different classifications or different technology types (unless AEMO approves it on a case-by-case basis)?

   Not aggregating units provides a more comprehensive picture of the generation/storage fleet. This information is likely to be useful to AEMO, now and in unforeseen contingencies. For example, there may be instances in which a solar farm produces at full capacity and discharges its battery at the same time. On the other hand, the same solar farm may prefer that its battery not be treated as a scheduled unit, so that it can use it at its will. For example, it may want to charge, rather than discharge, in anticipation of higher prices into the future.

   There may be a more flexible approach, which consists in not aggregating units for the purpose of registration and classification, so that AEMO has an accurate inventory of storage units and of their current state of charge. However, on any given day, two or more units could declare themselves aggregated for the purpose of dispatch. If a battery and a VRE generator declare themselves aggregated they become a single unit and the storage unit cannot participate as a(n) (independent) scheduled unit. The details of such an approach would have to be worked out, including whether AEMO may have capacity to override or reject the dispatch declaration of the supplier.

QUESTION 11: REGISTERING PUMPED HYDRO FACILITIES

1. Do you support AEMO's proposed approach to registration and classification for pumped hydro facilities?

   Broadly, yes.

2. Is a storage unit's ability to ramp linearly from production to consumption the best way to determine whether it should classify as a bi-directional unit, or classify as a scheduled generating unit and scheduled load?

   Batteries possess a defining feature that set them aside: they can switch on and off (and revert) almost instantaneously. This defining feature renders them very adept to provide FCAS, and to combine them with an unscheduled generating unit – which then may become scheduled. Pumped hydro possesses technical characteristics that are different to that (i.e. fast, rather than instantaneous, ramp up and down) and so it should not be lumped with batteries. In particular it cannot be (meaningfully) combined with a VRE to firm up the VRE dispatch; that is, pumped hydro is likely to always be a stand-alone

facility. It seems therefore more sensible for pumped hydro to remain classified as both load and generator, which more closely corresponds to its technical characteristics.

QUESTION 12: PROPOSED APPROACH FOR TRANSITIONAL ARRANGEMENTS
N/A

QUESTION 13: AEMO'S SOLUTION TO CLARIFY WHAT SMALL UNITS SGAS CAN AGGREGATE

1. Do you agree with AEMO's proposal to clarify how an SGA can include storage units in its portfolio?
   Yes. At the very least this provides for a clearer inventory of storage units, and of their state of charge.

2. Does AEMO's solution provide flexibility for an SGA to include DER, other than storage, that may have bi-directional energy flows?
   N/A

QUESTION 14: ADDING FURTHER REGISTERED PARTICIPANT CATEGORIES
N/A

QUESTION 15: ALTERNATIVE SOLUTIONS FOR REGISTERED PARTICIPANT CATEGORIES
N/A

QUESTION 16: BIDDING IN SCHEDULED STORAGE FACILITIES

1. How complex are the current arrangements for bidding for a scheduled storage facility compared to bidding for a scheduled generator or load?
   It may be concerning that a storage unit may receive conflicting dispatch instructions, i.e. simultaneously charge and discharge.
   Because storage can buy or sell at any point in time, it must be able to *simultaneously* express a supply and a demand schedule, and depending on the clearing price, decide whether to discharge or charge.
   Finally, a storage unit bidding is in fact a sequence of bidding decisions (to buy or sell) that depend on its state of charge and its expectation of the future. That is, it solves a dynamic optimization problem, which the rules of the market must accommodate.
   The details of this *dynamic,* true double auction must be worked out. The implementation may, broadly speaking, take the form of a day-ahead market.

2. If available and if you had storage facilities, would you opt to change from the existing arrangements to a single DUID model, with 10 price bands rather than 20?
   This does not come across as a great concern. It is always possible for a unit to ignore a price band on either side – generating or load. In light of this, it is preferable to have a richer bidding space. It is also necessary to have a rich bidding space for arbitrageurs (like storage) to act effectively.
   There are much more concerning issues with bidding and dispatching that we comment on below.

QUESTION 17: DISPATCH CONFLICTS

To the extent that the current arrangements for scheduled storage units results in conflicting dispatch instructions, we would like to understand:

1. How often these conflicts occur in relation to energy and FCAS, and how material are they for the operators of scheduled storage units and other market participants?
   N/A

2. To what extent can these conflicts be, or to what extent have they already been, remediated through experience and through improved bidding systems? Would moving to a single DUID model be an appropriate and proportionate response?
   Market participants will continue to learn to bid using storage devices. Dispatch conflict are more likely to arise *across* markets than *within* market. The reason is simply that an arbitrageur either sells high or buys low; it does not seek to sell low and simultaneously buy low. So, unless the bidder makes a mistake, its storage unit cannot be dispatched to buy and sell at (approximately) the same price in the same market at the same time. This rests on the ability to not only express distinct offers to buy and offers to sell at the same time, but to also express a willingness to inject or withdraw depending on the unique clearing price of the double auction.
   However, a unit could be dispatched to act as load in the energy market and simultaneously inject energy in the FCAS market for a short period. If this is a realistic scenario, it can be remediated. For example, a priority order may be established, to, for example, favour the FCAS market. In this case, the unit may be directed to operate in the FCAS market and simultaneously be released of any obligation in the energy market.

QUESTION 18: AGGREGATION AND RAMP RATES

1. What problems arise under the current arrangements in relation to the application of minimum ramp rates?
   Ramp rates are largely irrelevant to batteries. This, of course, makes them very useful for FCAS.

2. Do you agree with AEMO's proposal to rely on the aggregation approach set out in Chapter 3 of the NER (rather than the one set out in Chapter 2 of the NER)?
   This seems to be sensible. Even though battery response varies from very fast to almost instantaneous, it may be advisable to constrain their rate of change to enforce the scheduled dispatch, especially as the market moves towards a 5-minute settlement interval.

QUESTION 19: FORECASTING AND ENERGY AVAILABILITY

1. Are there problems arising from energy-limited plant not being reflected in forecasts?
   Yes, of course. It is simply inaccurate information that can be very costly, especially in times of tight supply. The state of charge of the fleet of battery is an essential state variable of the system and *must* be taken in account in forecast and in dispatch.
   It also is reported that the AEMO forecast for VRE is inaccurate and costly to suppliers. A solution around it is for the VRE to supply their own forecast and apply a penalty for deviations from the forecast.

2. Could this problem be addressed by requiring storage facilities to provide additional information on energy limits in their bids, as proposed by AEMO?
   It may be sufficient to fix the problem of forecasting. At any rate it is *essential* that the state of charge of batteries be reported for accurate dispatch, and as part of the bidding process. When it comes to batteries, there is no reason for AEMO to not have access to this information directly and in real time by telemetry. This resolves the pernicious problem of *asymmetric information* – information known to the market participants but not the market operator.
   This is in fact a *critical* point that requires some elaboration beyond what the question asks. For a single battery, its charge/discharge strategy depends on the state of charge -- as well as the forecast market conditions. The same applies at the aggregate level, that is, for AEMO. So, AEMO's optimal dispatch depends on the (aggregate) state of charge of the entire system, as well as its forecast of future conditions. **Therefore, the optimal dispatch becomes a *dynamic optimization* problem. This is *not* something that NEMDE can handle at present. To be clear, integrating storage in the NEM requires also updating the dispatch engine in a very significant and difficult way.**

QUESTION 20: PERFORMANCE STANDARDS

1.
   a. Are the current rules unclear on how performance standards should apply in facilities with a mix of asset types?
      These rules do not seem to be so complicated. However they may leave the door open to argument by market participants, especially if they happen to be hurt occasionally by the application of these rules.

   b. Do the current rules create barriers for storage hybrid facilities?
      N/A

   c. To maintain power system security, should AEMO have greater visibility of the assets behind a connection point?
      Yes, AEMO should absolutely have greater visibility behind a connection point. In a nutshell the reason is that incidents behind a connection point may generate significant externalities on the system, which individual suppliers have no incentive and no capacity to internalise. Only AEMO can have the system-wide perspective to take appropriate action.

2. Could these challenges be mitigated by having a single set of performance standards for each asset, as proposed by AEMO?
   It certainly would simplify things, especially when it comes to hybrid systems. Batteries typically have symmetric characteristics when charging and discharging but that may not be true of a hybrid system where a battery is used to complement the VRE. In such a case, the battery may privilege charging from the VRE and so not be available to charge from the NEM, even if its characteristics are symmetric.

QUESTION 21: ISSUES WITH HOW FEES AND CHARGES, AND NON-ENERGY COSTS ARE RECOVERED.

1. Do you agree that there is an inconsistency with how fees and charges and non-energy costs are recovered from Market Participants?

   Yes.

2. What is the impact of this issue? Does it create an uneven playing field and does it create (or has it the potential to create) perverse behaviours and outcomes?

   The impact is threefold: a) it over-values installation such as pumped hydro, which only pays charges according to the netted output, b) it increases cost recoveries elsewhere in the system at the expense of other participants (cross-subsidy) and c) it may alter the incentives of market participants. Perverse outcomes, such as splitting storage devices into smaller units for example, should be reasonably anticipated. In addition, net metering completely fails to capture the real cost of dealing with a market participant. If it is deemed reasonable that costs be somehow allocated according to energy consumption or delivery, then it must be allocated according to the *gross* consumption and delivery. This may require installing multiple metering device, which is a small cost and a small amendment to the NER. Metering at each connection point also has benefits further discussed below.

3. Do you consider the burden of costs will be exacerbated as exempt generating units increase behind the meter?

   Absolutely. New units may in fact be designed and installed to take advantage of these arrangements, while simultaneously increasing the burden of dispatch on AEMO – see question 19. It also shifts the burden of the cost of the grid to other market participants, and so distorts their responses.

4. Are there any other issues that the Commission should consider with respective to fees and charges, and non-energy cost recovery?

   Yes. Prices need not be set to only cover AEMO's costs. They may be set according to demand elasticity to steer behaviour; this is incentive design. Any surplus collected by AEMO could be used to invest in upgrades or rebated to users as lump-sum payment.

QUESTION 22: SOLUTIONS FOR ISSUES WITH FEES AND CHARGES AND NON-ENERGY COSTS RECOVERY

1. Do stakeholders agree with AEMO's proposed solution that MSGA and the proposed bi-directional resource provider participant categories should pay non-energy cost recovery and NEM Participant fees and charges based on consumed and sent out energy separately (as is the current practice for a grid-scale battery registered as both a Market Generator and Market Customer)?

   If it is considered reasonable to apportion these costs according to energy consumed or produced, then it seems reasonable to apply this principle to bi-directional providers.

2. Will AEMO's proposed solution level the 'playing field' between existing grid-scale batteries, MSGAs and participants under the proposed new category bi-directional resource provider? That is, will AEMO proposed solution more efficiently allocate fees and charges and non-energy costs between these Market Participants categories?

Yes, as long as all suppliers pay according to gross metering, as indicated in question 21. Other market participants should be supportive of this shift; the alternative is to continue with net metering, in which case batteries pay almost zero fees.

3. For hybrid facilities are further requirements needed, for example, should each asset in a hybrid facility be required to have a revenue meter or is supervisory control and data acquisition (SCADA) data appropriate?

   Yes, each asset that can independently inject or withdraw energy should be metered and charged accordingly. While gross metering on the grid should be implemented, it should not extend beyond. For example, it would be inappropriate to charge a facility for transporting energy from a solar farm to its own storage device on its own network.

4. Are there practical or implementation issues associated with charging MSGAs non-energy costs and NEM Participant fees based on consumed and sent out energy?

   It is not clear at all to me that this practice is cost reflective; it is only if the cost incurred by AEMO is linear in the energy traded on the NEM. However, some of the most disruptive market participants are in fact not even registered with AEMO – such as households and small generators. Others are registered but generate problems and disruptions (so, costs) that are not proportional to their metered output – for example, VRE that do not operate at capacity. So, this whole practice may need to be reviewed.

QUESTION 23: ALTERNATIVE SOLUTIONS FOR ISSUES WITH FEES AND CHARGES AND NON-ENERGY COSTS RECOVERY

1. Do you consider it appropriate to recover non-energy costs from Market Customers and Market Generators in the same way AEMO recovers costs form grid-scale batteries? That is, should participant fees, charges and non-energy costs for Market Generators and Market Customers be calculated on energy consumed and energy sent out separately, not on netted energy as is the current practice?

   Absolutely, as long as there is no double-counting. Please see questions 20-22 above.

2. If changes are made to how participants' fees, charges and non-energy costs are recovered, do you consider creating a new participation category, bi-directional resource provider, is the best way to do this? Or could it be appropriate to make changes to existing market participant categories to achieve the same outcome?

   The question of fees is almost orthogonal to the question of a new category, which has been addressed elsewhere in this submission (Questions – 2 to 15). The rationale for a new category thus remains.

3. Do you consider that there are other changes that could be made to Participant fees and non-energy cost recovery that would create a more consistent and level the playing field across Participant categories?

   Yes, as alluded to in Questions 21 and 22 above. First setting prices for the sole purpose of cost recovery may not be efficient; prices should be set according to demand elasticity. AEMO is in a position to allocate the cost of its services according to their respective marginal value – that is, demand elasticity. Second, the source of the most cost need not be the source of the most revenue. For example, a large baseload generator or a large battery may pay disproportionally more than a troublesome solar farm – even though the causer pay principle ought to capture these differences.

QUESTION 24: ISSUES WITH TUOS AND DUOS CHARGING ARRANGEMENTS

1. Do you agree that there is ambiguity and uncertainty around how transmission and distribution network businesses calculate and charge TUOS and DUOS for battery systems?

   There may be ambiguity: is a battery a generator or a load? If it both, is it sensible to net out charges? These questions need to be addressed.

2. Does this ambiguity and uncertainty create a material issue for investment in battery storage projects now, or in the future as the number of energy storage projects increase across the NEM?

   It may become material, especially for the more marginal battery projects, especially under zonal pricing, which ignores congestion. All this may result in batteries being located in the wrong part(s) of the NEM.

3. What are the pros and cons to allowing each NSP discretion in developing and applying TUOS and DUOS charges? On balance, should the approach and method to applying TUOS and DUOS charges be harmonised among NSPs?

   TNSPs and DNSPs are regulated assets because they are considered natural monopolies and may otherwise exercise their market power. This market power may go as far as pre-empting the use of their network – if not by refusing connection (open access), by simply setting a very high price. This is the rationale behind both mandating access and regulating access charges on telecommunication networks, for example.

   With batteries, NSPs may be tempted to pre-empt the market and install their own devices with sole access to their network, and engage in trading in the energy and FCAS markets. There are good technical reasons for NSPs to deploy and operate batteries for the purposes of stability or frequency control on their assets. However they should not be in a position to pre-empt the market by setting any TUOS or DUOS they wish. There absolutely is a case for regulation of these charges. Harmonisation may not be possible, nor desirable, because of different costs. Some of these cost difference may be truly exogenous – for example, geography or topography.

4. Is there a regulatory risk when NSPs interpret how to apply the current rules to battery systems?

   Yes, there is, as alluded to in point 3. above.

QUESTION 25: SOLUTIONS FOR CLARIFYING THE APPLICATION OF TUOS AND DUOS CHARGING

1. Do you agree with AEMO's proposal to exempt all energy storage systems from TUOS charges? If you agree with an exemption, should the exemption of TUOS charges also apply to energy used on site (auxiliary load) i.e. energy that is not stored and sent out into the network?

   There is a strong case not to charge TUOS and DUOS to storage demand as long as it does not cause flow constraints in the network. In so doing, it does not increase network costs. In addition, Locational Marginal Pricing will give storage operators the correct price signals so that they will be very unlikely to contribute to congestion on the network.

   Keeping storage within network constraints may need local controls which could be implemented as part of the design and paid for as part of the connection cost. There may need to be a penalty regime equivalent to TUOS/DUOS charges if storage demand is not operated within network capacity.

It is not clear why consumption of energy for a battery should attract DUOS charges if it operates within the network capacity, or contracts for additional connection capacity to allow import when the external network is not constrained. These costs should be covered under the connection agreement.

Furthermore, there may be good reasons to subsidize storage devices since the bring significant positive externalities to the grid, and other market participants may benefit. For example, it is a very good complement to VRE, who do not pay TUOS but generate disruptions on the network. If so, this should be articulated.

2. If battery systems are exempt from TUOS charges does this:
   a. create a subsidy for battery technology and therefore an advantage over other generation technologies?

      No, as long as the battery does not contribute to congestion. We know from congestion pricing that the price of using an uncongested network – like a road – is zero.

   b. remove the ability to provide an efficient location and/or price signal to potential battery system proponents, and therefore impact on the efficient entry and location of new battery system participants?

      As long as the removal or application of TUOS is geographically uniform, there is no reason to expect that it affects location choice. In comparison, the implementation of nodal pricing is much more important in giving the correct price signal for location choices. The exemption may affect entry decisions, although this likely is a second-order consideration. In addition, storage may generate sufficient positive externalities to justify this exemption. But, again, this should be articulated.

3. If battery systems are not exempt from TUOS charges does this:
   a. create double charging of TUOS /DUOS for end use customers?

      There is a distinct risk, but it is easily dealt with. It is enough to revise end-user charges, which the AEMC and the AER could mandate.

   b. distort investment signals and not align with the need for significantly more storage investment across the NEM?

      Yes, it would distort the investment signal, as explained above. In addition, in light of the positive externalities generated by storage (smoothing, stability, FCAS, arbitrage), subsidizing entry of storage may be desirable. If so, it should be made explicit.

4. How should TUOS and DUOS charges apply to hybrid facilities? Should TUOS and DUOS charges be based on metered data at the network connection point, or another option? Are there technical or implementation issues with this?

   In the same way as for stand-alone storage in order to not give an edge to the storage unit of a unit facility, which could compete with the stand-alone storage.

5. Do you agree that battery systems should pay DUOS charges for consumed energy? Please explain why or why not.

   No, see comments above. As long as storage contributes to smoothing electricity flows, and not to increase congestion, there is no reason to charge DUOS.

QUESTION 26: ALTERNATIVE SOLUTIONS FOR ISSUES WITH TUOS AND DUOS CHARGING

1. How would charging all Market Participants TUOS and DUOS, based on the services received by participants (energy consumed) rather than based on the asset type, impact participants' behaviour and market outcomes? This would mean that all Market Participants would be liable for TUOS and DUOS charges for the energy that is consumed at their network connection point.
   This description seems to be pretty close to the current arrangements, probably because currently assets are specific to usage. Going forward, this is equivalent to labelling storage as just a market participant, and charge them accordingly. That said, there are other dimensions specific to storage that this approach does not capture. Therefore, distinguishing storage from other assets remains important.

2. If all Market Participants were charged TUOS and DUOS, would this have any impact on existing external arrangements?
   It is not clear what is meant by "external arrangements"; however there seems to be little reason at face value to not charge all market participants for their use of the network. There may be other valid reasons, such as promoting the entry of storage, but these have not been articulated.

3. Is a definition for storage technologies needed to clarify TUOS and DUOS charging, or could AEMO's proposed solution or an alternate solution be implemented using the existing Market Participant categories, such as a scheduled load?
   Yes, a definition of storage is needed so as to not charge TUOS and DUOS. It is important for other reasons, in particular to keep track of the charging state of a battery, which affects the optimal dispatch decisions.

4. Are there technical issues or complications with implementing AEMO's proposed solution or an alternative solution?
   N/A

5. Do stakeholders consider there is an inconsistency in the approach NSPs use to calculate network prices? If yes, would a more harmonised approach to network pricing provide clearer investment signals across the NEM and reduce costs for battery system proponents?
   There is a case to be made to harmonise the methods, which need not equate harmonising outcomes. There may be very good reasons for some NSPs to be more expensive than others, such as terrain, access, population density and so on. These characteristics ought to be reflected and accounted for. NSP regulation is notoriously poor, but this is a different issue altogether.
   Energy prices, rather than network charges, are likely more important for storage to decide whether to invest. The opportunities for arbitrage are an order of magnitude more relevant than network charges.

6. Does the introduction of LMP and FTRs as contemplated through transmission access reform impact whether storage should face TUOS?
   TUOS and LMP are completely independent matters. It is paramount to not confound them nor to confuse the issue. Network assets are compensated using TUOS and DUOS, which are regulated prices. LMP is about the marginal value of energy at a node, not about the cost of transmission; LMP prices *congestion*, not the use of a network. Regardless of its marginal value (that is, regardless of the congestion status), that energy still needs to

be transported on the network: the price of energy may be zero, it still needs to be transported. LMP is the price received by generators when they inject power at a given node, and paid by loads when they withdraw at a given node.
Upon the transition to LMP, a storage operator will buy and sell power at a given node that is at, or the closest to, its connection point. That price remains independent of the cost of investing in, and maintaining, network assets.

7. Are there any other approaches that could be considered to address the issues raised by AEMO?
This may need to be further investigated. It is not at all clear that linear prices based on consumption are adequate to pay for the cost of fixed assets. It may be that lump-sum payments such as registration fees are more efficient instruments.

QUESTION 27: TECHNOLOGY SPECIFIC DRAFTING IN THE NER - ISSUES

1. Are you concerned that the terms relating to load and generation, or other terms in the NER, are not sufficiently technologically neutral? If so why?
No. A technology-neutral formulation of the NER is important to not needlessly discriminate between technologies that offer essentially the same service. However, batteries for example, can offer new services that no generator or no load can offer – such as response times in the order of milliseconds rather than seconds. There is a benefit in acknowledging this physical reality.

2. Do you consider key terms in the NER such as 'generation' and 'load' are ambiguous when applied to storage and hybrids? If so, why?
There seems to be little ambiguity as to what these terms are and about the reality that a storage unit can be both a load and a generator – however not at the same time – and has a state of charge. That is why, as mentioned earlier, a distinction should be made and a new category defined.

QUESTION 28: TECHNOLOGY SPECIFIC DRAFTING IN THE NER - PROPOSED SOLUTION

1. Would AEMO's proposed changes to these key terms in the NER assist with the effective integration of storage and hybrids in the NER? Are there other terms or definitions that are more appropriate than those suggested by AEMO?
Yes, this may matter in removing ambiguity in what a "bid" is. At present there is no such issue because the only participants bidding are generators that can only offer to sell. Storage can bid as a generator, but also as a load when charging. An appropriate market design should allow for this new reality and allow storage units to bid as *buyers*. This requires collecting a two-sided bidding schedule.

   The suggested definitions are fine.

2. Do you think the benefits of this proposed drafting solution would likely outweigh the costs, given the scale of the changes?
Yes, this is a much more substantive change than may appear. With market participants expressing buy and sell bids, one should expect a spread between the bid and the offer – as on financial markets. This has further implications for market design: how is a clearing

price defined when there is a bid-ask spread? What is the optimal "ticker" size (the amount by which a bid or an offer can vary)? This also implies the clearing mechanism must include an offer (to buy) curve in addition to the selling offers.

3. Would changes to these fundamental terms in the NER affect related external documents such as contracts, procedures and guidelines (other than AEMO's), and if so would the changes cause you to incur costs or other difficulties? What implementation period would be needed to address these issues?

   The changes implied by the introduction of storage are much more profound than documentation. Storage implies a complete market redesign, as suggested by point 3. above, as well as Question 19 before.

   It is difficult to estimate the implementation period, except to say it is not short given a complete market redesign.

QUESTION 29: TECHNOLOGY SPECIFIC DRAFTING IN THE NER - OTHER OPTIONS

N/A

QUESTION 30: INTERVENTION COMPENSATION - ISSUES

1. What other specific issues relating to storage and hybrid assets need to be considered in formulating appropriate intervention compensation arrangements?

   There are at least two issues specific to batteries when formulating intervention compensation. The first one is the fact that a storage device cannot always respond; for example, an empty battery cannot discharge, while an idle generator can turn on. The second one pertains to the price differences that lie at the core of a battery operation. Consider the example of a battery that is charging in anticipation of discharging at a higher price in the future. If it is directed to start *discharging* instead, it foregoes revenue in the future. However, when *exactly* in the future, that is, at what price? It is impossible to know what the discharge strategy would have been, and therefore what the revenue would have been. It becomes difficult to evaluate compensation, and an appropriate mechanism must be thought through.

2. Are the current arrangements for applying the market suspension framework and administered price period compensation framework to storage and hybrid appropriate in light of the increasing numbers of these facilities in the NEM? If not, what changes do you consider are required?

   No, please see point 1. above.

3. Should changes be made to clause 3.15.7B to create consistency with the existing definition of direct participant and address the omission of scheduled loads?

   N/A

QUESTION 31: INTERVENTION COMPENSATION - SOLUTIONS

1. Do you consider that a separate compensation framework should be developed for storage and hybrid assets, or should they continue to be compensated in line with existing intervention compensation frameworks in order to minimise market distortions, subject to the amendments currently under consideration?

In light of point 1. above the current framework is likely not appropriate to compensate storage units. Hence a new framework should be developed – along many other new institutional arrangements to accommodate the rise of storage. In particular, estimating the counterfactual required to evaluate compensation is essential.

2. If you consider a separate compensation framework should be developed, how should it differ from the existing frameworks?
   In light of the characteristics of storage, the framework likely needs to be rebuilt completely – see point 1. above. The compensation framework should account for the state of charge of storage – that is, their ability to comply with directions. It should also include a method of computing the counterfactual analysis that is necessary to estimate the opportunity cost of complying with directions (and thus deviating from the privately-designed strategy of the storage operator).

3. If you consider that the current frameworks should continue to apply to storage and hybrid assets, are any additional amendments required?
   The current framework cannot be used for storage.

QUESTION 32: RRO - ISSUES

1. Is it appropriate for the electricity imported from the grid for the purposes of energy storage to form part of a liable entity's liable load under the RRO?
   If the question asks "Consider a liable entity under the current regime; suppose it adds a battery. Should the energy stored be part of the liable load?", then the answer is probably not. There are at least two reasons for this. First, the liable load that installs a battery may contribute to smoothing operations by drawing on its stored energy in times of high demand, rather than from the grid. Second, it may also contribute to stability by discharging into the grid from time to time – to arbitrage prices, or at AEMO's direction. This is hardly making things worse for the system. This need not exempt the load from its own liability with appropriate metering of both battery and load.
   Finally, storage can be considered largely a "discretionary" load: it can be scheduled when it does not impose constraints on the system.

2. Should operators of storage assets be liable entities under the RRO?
   No, for at least two reasons. First, a storage facility is essentially an arbitrageur. If it is made to contract in the forward market with a generator to satisfy the RRO, the arbitrage in the physical market becomes redundant. Second, the RRO is meant to encourage investment in generation. Storage is a substitute to generation in that it allows for intertemporal shifting of generation capacity. In its own right it already contributes to reliability of supply.

QUESTION 33: RRO - SOLUTIONS

1. Do stakeholders agree with AEMO that the RRO should apply to storage only when the storage system is co-located with a separate load in a hybrid facility (this does not refer to the battery's own load)?
   No, this is not even necessary. Please see point 1. of Question 32 above.

2. Would alternative or additional changes to the application of the RRO to load for storage be more appropriate?

   Yes, definitely. While a battery may charge in times of stress – say, because the forecast anticipates even more stress in the system – it can be directed by AEMO not to, and to discharge instead. But then the storage unit should not be treated as load. This is possible, even in a hybrid facility, with independent metering of the load and the battery.

QUESTION 34: RRO - STORAGE CONTRIBUTION TO RELIABILITY ISSUES

1. What are your views on the issues outlined above which relate to whether or not storage contributes to reliability issues?

   The scenario that is painted in the consultation document is definitely possible but it is unlikely and can be controlled through appropriate market design and directions from AEMO in periods of disruption.

2. Are there any other issues to consider when evaluating the treatment of load used for storage under the RRO?

   To deter loads from investing in storage for the purpose of window-dressing and to escape the RRO it is important to meter storage and load independently.

QUESTION 35: RRO - IMPLEMENTATION ISSUES

Should RRO liabilities for hybrid facilities continue to be calculated at the connection point? If not, where?

There should be two connection points.

QUESTION 36: RRO - OTHER OPTIONS

Can the issues (if any) related to the application of the RRO to storage and hybrids be resolved without establishing a new market participant category for these facilities?

No, this category is essential. If a storage unit is a load (and a generator), how can it be exempted from the RRO, unless it is clearly identified as storage? Hence a new category.

QUESTION 37: MARGINAL LOSS FACTORS - ISSUES

Are the current arrangements for calculating and applying MLFs to storage and hybrids appropriate in light of the increasing numbers of these facilities in the NEM? If not, what changes do you consider are required?

Loss factors should be dynamic and forward looking. With improved weather and demand forecasting, and more powerful computers, MLF can be computed frequently as the situation changes. This is all the more important with storage, where arbitrage is a primary motivation of investment.

QUESTION 38: MARGINAL LOSS FACTORS - SOLUTION

Do you agree with AEMO's proposed solution of applying the existing arrangements for applying MLFs to its proposed new market participant category (if this category were to be established)?

Only partially. This new definition of a category (bi-drectional units) is an opportunity to also update the MLF methodology.

QUESTION 39: RELIABILITY PANEL REPRESENTATION
Is it appropriate to require that the Reliability Panel include a member to specifically represent storage and hybrid asset proponents, or are the current mandatory and discretionary membership provisions adequate?

Completely. Storage is substitute to many alternative sources of energy (generation, spinning reserves,…) and so stands in competition with these technologies. The interests of investors in storage must be represented on this Panel.

QUESTION 40: OTHER DRAFTING ISSUES - ISSUES
N/A