Aussie Rules on batteries tightened

Discussion Paper

renew.

Document information

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Enabling, inspiring and advocating for people to live sustainably in their homes and communities.

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1. Introduction

Many Renew members already have solar batteries helping to power their home, often installed many years ago as part of an off-grid solar system at a remote property. Many more are watching the battery market, waiting for economics to improve before adding a battery to their grid-connected solar system in the suburbs. Some have installed small DIY solar systems in sheds. All these people are affected by a new Australian Standard published on the 11th of October 2019 which significantly tightens the rules on where, how and by whom batteries can be installed and maintained.

NOTE: this article discusses the contents of standards documents but these are only brief descriptions and are no substitute for reading the actual standards.

1.1. The old rules

Until now the installation and maintenance of home solar batteries has been covered by Australian Standard AS 4086.2, last published in 1997. This predates the widespread uptake of grid-connected solar systems and lithium batteries – for example the first lithium cordless tool battery only appeared in 2005. A 40-page document, the old standard was written with off-grid properties in mind and presumed that the battery's chemistry was lead-acid or nickel-cadmium. Such batteries are very heavy and typically assembled on-site from individual cells, e.g. twenty-four cells each weighing 50kg. As well as electrical fuses etc, the standard specified how such batteries should be enclosed to exclude vermin while allowing the safe escape of flammable hydrogen gas which lead-acid batteries can emit.

Non-electricians have always been allowed to work on batteries and their wiring provided they are a "competent person" and the voltage isn't too high. Until now the Aussie wiring rules have defined Extra Low Voltage (ELV) to have a maximum of 120 volts for direct current (DC) electricity[1] or 50 volts for alternating current (AC).[2] State regulations have required that work at a voltage higher than ELV be carried out by a licenced electrician.[3]

1.2. Lithium batteries arrive

Since around 2015 a great variety of home solar batteries has emerged, mostly using a lithium chemistry. Lithium batteries are well-suited to grid-connected residential solar systems since they are relatively small and light, efficient and responsive. These batteries are quick to install since they're typically supplied as a self-contained appliance so there's no need to assemble a battery or construct a battery enclosure onsite. They don't emit hydrogen gas or spill acid, but on the other hand some models can burst into flames in the unlikely event of a severe electrical fault or being caught up in a house fire that started elsewhere. In the course of such an event it's possible that some models may emit toxic smoke or explode. There is considerable diversity of chemistry within the "lithium" category.

Until now lithium battery installations have proceeded in the absence of a suitable Australian Standard. As a stop-gap measure, industry bodies have published documents to guide installers. [4]

2. The new rules

To fill the gap in regulating solar batteries a new standard AS 5139[5] was published on the 11th of October 2019. It's a 172-page document and like any other Aussie standard it's not free – you can purchase it from the private company SAI Global for A$336.[6] It also applies in New Zealand so you can also purchase it from Standards New Zealand as an electronic document for NZ$149.40.[7]

2.1. A difficult gestation

Work on AS 5139 commenced in 2015. Each Australian Standard is produced by volunteer experts in the relevant field; for a list of organisations represented on this committee please see Appendix 1. Agreement was elusive within the committee due to the variety of perspectives and interests represented. For example, fire safety authorities tended to have a different view to renewable energy organisations. A draft standard was released for consultation in 2017 but failed to progress to a published standard. After the process was restarted a new first draft was released for consultation on the 31st of January 2019. Following many submissions critical of its stringency, a second draft was released on the 11th of March.

2.2. Scope

This standard applies to batteries installed in a fixed location whose voltage is at least 12 Volts and whose energy storage capacity is at least 1 kilowatt-hour (kWh). For reference, a lead-acid battery with a rated capacity of 1 kWh would typically weigh around 27kg. The standard applies to homes, garages, sheds and commercial properties but not to caravans, tiny homes with wheels, electric vehicles, uninterruptible power supplies or telecommunications applications.

2.3. Battery categories

AS 5139 groups batteries into three categories. The standard doesn't provide handy labels so in this document we'll refer to them as categories 1, 2 and 3.

2.3.1. Category 1

A battery such as the Tesla Powerwall 2 is a self-contained appliance. It includes internal safety switches[8] as well as an inverter so it can deliver standard 240V AC power to a house switchboard via standard 240V household wiring. This is called a "pre-assembled integrated battery energy storage system".

This category has the fewest installation requirements. It's covered by ten pages of the standard which mostly relate to restricted locations, testing, commissioning and documentation and frequently defer to the manufacturer's manual.

2.3.2. Category 2

A battery such as the LG Chem RESU 10 includes internal safety switches but no inverter since it's designed to be connected to an inverter via a power cable. It's called a "pre-assembled battery system".

The standard devotes 26 pages to installation requirements for this category. In addition to the items noted for category 1 it includes detailed requirements for wiring, fusing, earthing etc.

2.3.3. List of approved batteries

For categories 1 and 2 the Clean Energy Council (CEC) maintains a list[9] of "approved" batteries which have been tested to comply with electrical safety requirements in the Best Practice Guide.[10] These are all lithium batteries marketed for solar energy applications.

2.3.4. Category 3

The third category covers batteries that are not on the CEC's approved list. This includes:

- All non-lithium batteries.
- Pre-assembled lithium batteries not listed by the CEC.
- Lithium batteries that are not pre-assembled.

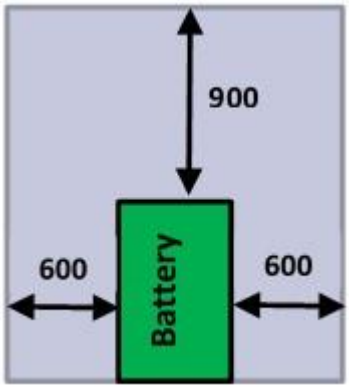
The standard dedicates 44 pages to installation requirements for category 3 including items such as battery enclosure design, ventilation, voltage drop and arc flash.

Where batteries may be installed

The new standard is more restrictive than previous rules and guidelines, making it harder to find a suitable location for a home battery. The most likely battery locations are on an external house wall or in a garage.

Batteries aren't allowed:

- In habitable rooms [11]
- In ceiling spaces or wall cavities
- Under stairways or access walkways
- In an evacuation route or escape route
- Near combustible materials



The standard requires clear space between the battery and any windows, doors and appliances such as hot water units and air conditioners. This clear space must extend at least 600 mm to either side and 900 mm above the battery.

If the battery is wall-mounted with a habitable room on the other side, the wall must have a non-combustible[12] barrier extending the same dimensions as noted in the previous paragraph. Most likely the installer will add a thick cement sheet unless the wall is already made of cement sheet, brick or concrete.

A battery in a garage may need a bollard to protect it from cars.[13]

2.3.5. Extra requirements for category 3

A battery in category 3 (as described above) isn't allowed under the floor of a habitable room. Further, it is restricted to a structure detached from the house such as a shed if either of two conditions apply:

- Its chemistry is lithium.[14]
- It's a powerful battery that can create a dangerous arc (arc flash) in the event of a short circuit.[15]

3. Maintaining an old, off-grid battery

Many off-grid householders are experienced in performing regular maintenance on lead-acid batteries such as topping up water levels, cleaning and tightening battery terminal bolts and checking cell voltages. Such maintenance is recommended by the Australian Standard for off-grid power systems, AS 5409.[16]

The main safety risk mentioned in the previous battery standard AS 4086.2 was spillage of acid from the batteries. That document states that someone doing routine inspection and maintenance should wear goggles or a face shield plus overalls or a dust coat, and tools used during maintenance should be insulated to help prevent an accidental short-circuit.[17]

3.1. Calculating the potential danger

Under the new battery standard, protective clothing requirements have in many cases escalated dramatically. They depend on the potential danger from a short-circuit known as "arc flash incident energy" (AFIE[18]), which in turn depends on how much current the battery could push through the cables in the event of a short-circuit, its voltage and the distance from the battery at which you are working.
AS 5139 requires that anyone working on a battery calculates the AFIE value using a formula[19] and then looks up a table[20] listing the protective clothing necessary for that value.

Unfortunately, this leaves many off-grid households in a difficult position because they probably don't have a copy of the standard. Even if they purchase the document, they may lack the technical skills to understand the complicated AFIE formula or to select appropriate input values for it. Their battery is an expensive investment and must be maintained to conserve its lifespan and fulfil warranty requirements. Many people will be unaware of the new standard's existence and may be inadvertently violating state regulations by not following it.

3.2. What clothing is needed to maintain a typical off-grid battery?

Let's consider a typical existing off-grid battery for a household. Combined, its twenty-four lead-acid cells have a rated energy storage capacity of 48 kilowatt-hours at a voltage of 48 volts. If the battery's positive and negative cables accidentally touched, the battery could push a current through those cables as high as 6,000 amps for two seconds.

If a person is working on this battery at an arms-length distance of 45 centimetres then the calculated AFIE is 4.67 and the new battery standard requires them to wear[21]:

- Arc-rated long-sleeve pants and long-sleeve shirt
- Arc-rated face shield and balaclava, plus safety glasses
- Hearing protection
- Leather work shoes and leather and voltage-rated gloves (as needed)

A kit supplying such protective clothing (minus the shoes) costs over $600 to purchase.[22]

3.3. What should off-grid householders do?

To comply with the new battery standard, one option for off-grid householders is to calculate what protective clothing is required, obtain and wear it when maintaining the lead-acid battery.

Another option is to engage an electrician to upgrade the battery system, aiming to reduce its potential risk in the event of a short circuit. A simple solution mentioned in the standard is to install a fuse between two of the battery cells that were originally connected by a simple cable.[23] This dramatically reduces the battery's potential risks because in the event of a short-circuit the fuse will disconnect quickly (for example in 0.1 seconds) so the electrical arc doesn't have time to fully develop. For the hypothetical battery noted above, installing such a fuse reduces the AFIE to 0.21 and it appears that the standard doesn't require special clothing to protect against arc flash.

A third option is to have a professional perform maintenance on their battery. This might be expensive and inconvenient, especially for flooded batteries that require regular topping up with water. For such batteries it's possible to install an automatic watering system which should remove the need to regularly work close to the battery cells.

4. DIY solar systems in sheds

Many solar enthusiasts and handy-people have installed small off-grid solar systems in sheds on a do-it-yourself (DIY) basis. For example, the battery in such a system might be connected via direct current to a light globe, a water pump for gardening and a small removable inverter for charging power tools. In the past it was possible for such systems to comply with standards if the installer was a “competent person” and the solar and battery voltages stayed below 120 volts which was the limit for “extra low voltage” ELV.

4.1. New maximum voltage allowed

The new battery standard abolishes ELV, instead defining three ranges of Decisive Voltage Classification (DVC).[24] These are categories used in some overseas standards. Non-electricians are now restricted to DVC-A[25], which includes DC voltages up to 60 Volts and AC voltages up to 35 Volts.

At first glance this limit wouldn’t affect a 12, 24, or 48-volt battery. However, small solar systems often include a solar array with a higher voltage, connected to the battery via a charge controller using Maximum Power Point Tracking (MPPT) technology.

For example, two solar panels might be connected on the roof in series so the cable leading to the charge controller carries a voltage up to 90 Volts. An example of such a controller is the Victron 100/30 pictured to the right.
Since this voltage exceeds DVC-A, under the new standard this is no longer allowed for non-electricians.[26] Even working on the connected 48-volt battery may not be allowed since the charge controller might only use electronics to convert the voltage, which can’t be sufficiently trusted to isolate the battery from the higher voltage, according to AS 5139.[27]

Apart from the voltage level, AS 5139 includes many other requirements for battery installation – please refer to the standard for details.

4.2. What should a DIY person do?

To comply with the new standard, a shed-mounted existing solar system with voltages above 60 Volts shouldn’t be worked on by a non-electrician. If work must be done, options include:
- Contract an electrician whenever work is required.
- Reduce solar voltages to below 60 Volts. This probably entails using a different charge controller.[28]
- Reduce the battery size to below 1 kilowatt-hour of energy storage so the new standard doesn’t apply.
- Make the installation portable so the new standard doesn’t apply.

5. Upgrading a battery

Many batteries were installed before publication of AS 5139 in locations that don't comply with the new standard, for example within 600mm of a window.

As with most safety standards, this one is not immediately retrospective and thus won't necessarily require existing systems to be brought up to current standards. However, if an existing system is expanded (adding more batteries or replacing existing batteries) then it would likely trigger the requirement for the whole system to be brought up to current standards.

Some batteries have been marketed as "expandable" but achieving this could be difficult if the battery must be moved, or the wall it's mounted on must be made fire-proof.

6. Are the new rules too onerous?

The new battery standard aims to improve public safety by minimising the risks posed by batteries. These risks are real, as proven by several incidents involving hoverboards[29], electric bicycles[30] and mobility scooters.[31]

On the other hand, some countries even allow batteries in habitable areas. Sonnen says that tens of thousands of its batteries are installed this way in Germany[32], as illustrated to the right.

Long life spans must be considered as it's possible that an Aussie home battery may sit with minimal attention for two or three decades spanning multiple home occupants. Electronic and chemical components degrade over time, reducing confidence in the battery's safety. Perhaps German regulations ensure inspection and maintenance to a higher standard than in Australia.

One problem with the new standard is that it doesn't differentiate between different lithium chemistries. For example, lithium iron phosphate (LiFePO4) batteries are generally regarded to be safer than those using lithium nickel manganese cobalt (NMC) as it's quite hard to make them burn. It also doesn't differentiate between the quality of manufacture of different products on the Clean Energy Council list. In the absence of guidance by the standard, these factors are the responsibility of consumers to consider.

In our view, clearances required from windows etc. are insufficiently flexible, as they don't consider that risks vary according to a battery's energy storage capacity, its chemistry and the fire resistance of its cabinet. For some batteries smaller clearances should be allowed.

The new restrictions on DIY solar systems in sheds are quite harsh. For comparison, New Zealand has some lenient rules, even allowing some DIY wiring for grid-voltage appliances in houses.[33]

In Renew's view some of the new standard's provisions are too onerous. However, it's better to have an imperfect standard than no standard at all, which was the case up until October 2019. Hopefully future editions of the standard will strike a better balance.

7. Broader implications of the new rules

Solar batteries attached to grid-connect solar systems have become more difficult to install. Many homes have no location that can meet the requirements of AS 5139, and many more need fire proofing for the battery location costing perhaps around $1,000. This will suppress the uptake of solar batteries.

7.1. Consumers and installers

Before the new standard was published, uptake of these batteries had been slow since they're economic for only a small subset of households. With these poor economics, it's not a major issue for consumers that they are harder to install.

In off-grid applications the publication of AS 5139 has accelerated the shift from lead-acid to lithium batteries. As noted earlier in this document, pre-assembled lithium batteries on the CEC list have much easier installation requirements so nowadays they tend to be favoured by off-grid solar installers. An example is the BYD B-Box Pro battery in the following picture.

In both off-grid and grid-connected battery applications, the new standard may steer installers toward ac-coupling of solar arrays rather than dc-coupling, because the new standard has few changes for ac-coupled solar inverters.[34]

7.2. Local electricity networks

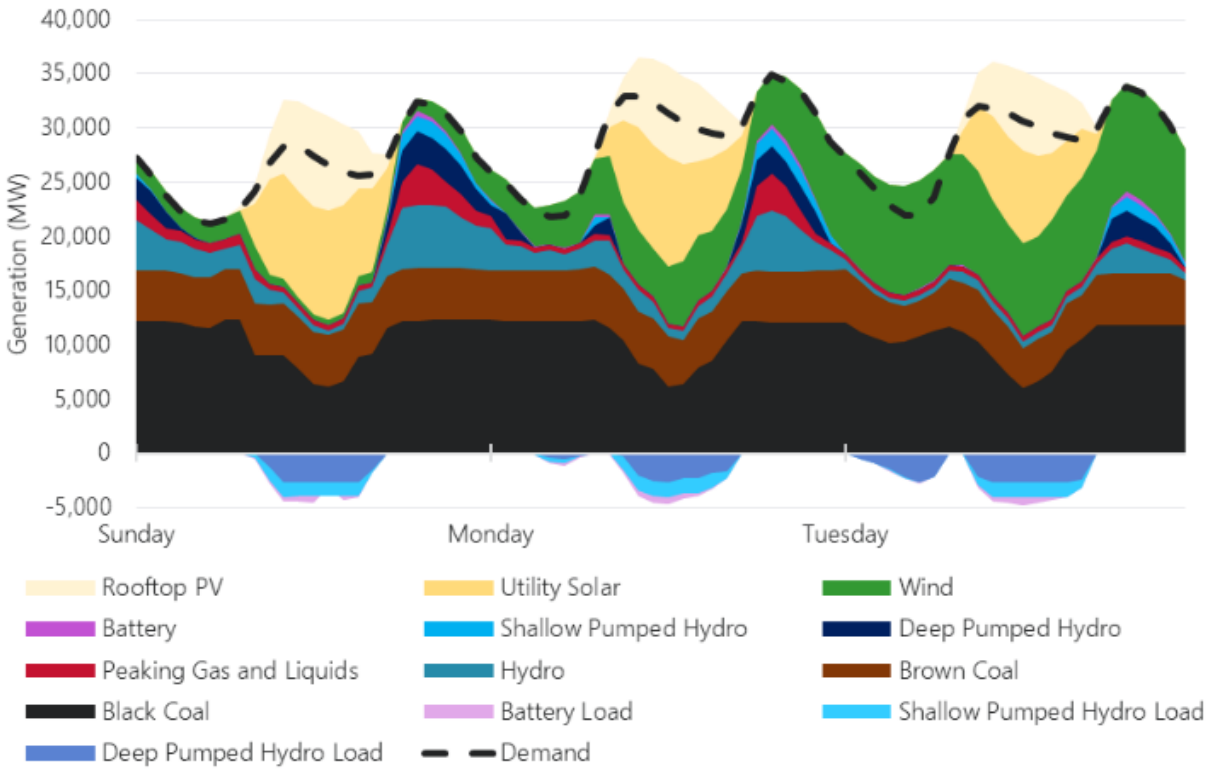
Solar batteries can help integrate rooftop solar into local electricity distribution networks. A battery charging around midday helps to alleviate high voltages in the local network. Discharging in the evening reduces evening demand, which may defer or avoid the need to augment local infrastructure. Batteries are not the only way to achieve these benefits, for example running hot water systems can similarly alleviate high voltages. Renew is currently undertaking a project on this issue – a report is due in early 2020.

7.3. The electricity grid

Grid-connected solar batteries play a role in the transition of our electricity grids from fossil fuels to renewable energy. In the longer term their most important benefit is to smooth out rooftop solar generation from midday into the evening, reducing the need for centralised generators to quickly increase output in the evening. If uptake of these batteries is slow then this benefit will be reduced.

The Australian Energy Market Operator (AEMO) predicts that over the next decade, batteries will only play a minor role compared to hydroelectricity (both traditional and pumped hydro) and gas peaking plants. This indicates that slow uptake of household solar batteries won't be a major problem for the grid. For example, on the following chart[35] battery discharge is represented by the very thin pink line below the thick green one. The chart is drawn from AEMO's neutral scenario, and the "battery" category includes both household batteries and large grid-connected batteries such as the Hornsdale Power Reserve ("Tesla Big Battery") in South Australia. It's possible that batteries may play a greater role in their "step change" scenario to be published in AEMO's 2019-20 Integrated System Plan.

Figure 2 Typical winter NEM generation profile in 2030, with portfolio of storages



Appendix 1: Standards committee

AS 5139 was prepared by Committee EL-042—Renewable Energy Power Supply Systems and Equipment. Its members represented the following organisations:

Australasian Fire and Emergency Service Authorities Council
Australian Energy Council
Australian Energy Market Operator
Australian Industry Group
Australian PV Institute
Australian Solar Council
Clean Energy Council
Clean Energy Regulator
Construction, Environment and Workplace Protection, ACT Government
Consumer Electronics Suppliers Association
CSIRO
Department of Economic Development, Jobs, Transport and Resources (VIC)
Electrical Compliance Testing Association Electrical Regulatory Authorities Council
Electrical Safety Organisation (New Zealand)
Electricity Engineers Association (New Zealand)
ElectroComms and Energy Utilities Industries Skills Council
Energy Networks Australia
Engineers Australia
Independent Expert (EL-054)
Institute of Electrical and Electronics Engineers
Institute of Electrical Inspectors
Joint Accreditation System of Australia and New Zealand
Master Electricians Australia
National Electrical and Communications Association
New Zealand Electrical Institute NSW Fair Trading
Office of the Technical Regulator (SA)
Research Institute for Sustainable Energy
Solar Energy Industries Association
Standards New Zealand
Sustainable Electricity Association New Zealand
Sustainable Energy Association
The University of New South Wales
Wellington Electrical Association
Worksafe New Zealand

References

[1] Electricity coming directly from a solar panel or battery is always DC rather than AC.
[2] AS 3000 2007, section 1.5.7
[3] E.g. Victorian Electrical Safety Regulations 2010, part 1.7.
http://www.legislation.vic.gov.au/domino/Web_Notes/LDMS/LTObject_Store/LTObjSt7.nsf/07c00f1b6c5c4afbca25776700219570/e605c6373e136016ca257b25001dbce7/$FILE/10-21sr002bookmarked.pdf
[4] https://assets.cleanenergycouncil.org.au/documents/accreditation/battery-installation-guidelines-2017.pdf, https://www.smartenergy.org.au/resources/australian-battery-guide
[5] The standard's full title is "Electrical installations – safety of battery systems for use with power conversion equipment".
[6] https://infostore.saiglobal.com/en-au/
[7] https://shop.standards.govt.nz/default.htm
[8] This includes the Battery Management System which lithium batteries need to manage individual cells within safe voltage, temperature etc.
[9] https://assets.cleanenergycouncil.org.au/documents/products/ESD-List-191031.pdf
[10] http://www.batterysafetyguide.com.au/
[11] Bathrooms, laundries, pantries, hallways etc are not habitable rooms. https://www.abis.com.au/habitable-room-and-legal-ceiling-heights
[12] As defined in AS 1530.1.
[13] AS 5139, section 6.3.4.10
[14] AS 5139, section 6.3.4.2.1
[15] AS 5139, section 6.3.2.4. This applies if the calculated arc flash is greater than 4.0 cal/cm2.
[16] AS 4509.1: 2009, appendix A, section 7.3.
[17] AS 4086.2 1997, section 5.3
[18] Units of measure: calorie per square centimetre, cal/cm2.
[19] AS5139, section 3.2.4.2.1
[20] AS5139, table 3.3
[21] AFIE = 4.267 from table F.2. Then PPE level = 2 from table 3.3.
[22] https://safetyspecialists.com.au/product/arcsafe-t9-coverall-low-energy-arc-flash-switching-kit/
[23] Known as "inter-string protection". See AS 5139, figure 6.15.
[24] AS5139, table 3.2
[25] AS 5139 table 3.2, note 2. "If a battery system is either DVC-B or DVC-C, it will be treated as an LV installation as defined in AS/NAZ 3000." Low Voltage (LV) includes 240V AC household wiring, and requires an electrician.
[26] At the time of writing, DVC was not yet written into other standards such as AS3000 and AS5033. However we expect these standards will follow suit when they're next revised.
[27] AS 5139, 6.3.1.1 "The cabling and installation requirements of the battery system shall be treated as DVC-C if a non-separated PCE other than an inverter is installed (e.g. solar charge controller) and the non-battery side of the PC is greater than DVC-A."
[28] Such as a charge controller using Pulse Width Modulation (PWM) rather than MPPT. A downside is that these devices harvest much less solar energy when the battery is depleted and/or solar conditions are poor.
[29] https://www.npr.org/sections/thetwo-way/2016/07/06/484988211/half-a-million-hoverboards-recalled-over-risk-of-fire-explosions
[30] https://www.theguardian.com/technology/2019/jul/31/lyft-ebike-fires-san-francisco
[31] https://www.abc.net.au/news/2018-10-21/man-dies-in-mobility-scooter-fire-in-geraldton/10401782
[32] https://sonnen.com.au/faq/
[33] http://www.tradehq.co.nz/what-electrical-work-are-you-legally-allowed-to-diy-in-new-zealand/
[34] AS 5033 clause 3.4.1 states that a charge controller or inverter connected to a PV array operating at "Low Voltage" (ie above ELV) must earth fault detection and alarm functions. On the other hand an exemption is provided if there's no product to do this available on the market. For more info please see this video by Guy Stewart. https://www.youtube.com/watch?v=gl0mBaX1mYU
[35] Page 8, "Building power systemresilience with pumped hydro energy storage", July 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2019/ISP-Insights---Building-power-system-resilience-with-pumped-hydro-energy-storage.pdf