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Blunt Instrument: Uncompensated Solar Cut-Off Isn't the Only Solution to the Minimum Demand 'Problem'

A Concerning Precedent for Control of Household Solar

Introduction

So much in the National Electricity Market (NEM) is complex because it involves engineering, economics and consideration of consumers' best interests. In the case of cutting off rooftop solar exports, each of these dimensions are complicated and contested.

In this briefing note, we attempt to unpack necessity from opportunity to show why the rooftop solar cut-off regulation imposed from 28 September last year on South Australian homes and businesses and used on 14 March this year sets a concerning precedent.[1],[2] The first part of the briefing note focuses on the technical rationale—the engineering definition of the problem. Then we delve into the economics and policy processes surrounding the advent of rooftop solar cut-off.

The solar cut-off regulation applies to all new household rooftop solar connections. It requires them to have a connection in the smart meter to enable a consumer-appointed agent to switch off the solar entirely when directed to do so by South Australian Power Networks (SA Power Networks) on direction from the Australian Energy Market Operator (AEMO). During the cut-off period the household consumes and pays for electricity from the grid.

The solar cut-off regulation prevents households from using electricity from their own solar panels.

This curtailment capability was used for the first time on a high solar generation, low demand afternoon when the SA-Vic interconnector was partially out of service, undergoing scheduled maintenance.

[1] SA Department of Energy and Mining. Remote Disconnect and Reconnection of electricity generating plants.
[2] AEMO. Solar PV curtailment initiative by SA Government Supports the NEM. 18 March 2021.

Part 1: Why the Engineering of Rooftop Solar Cut-Offs is Contested

It's important to look first and in-depth at the engineering mindset that poorly defines distributed PV as a 'problem'. The AEMO May 2020 report on Minimum Demand in South Australia (SA)[3], defines two system security issues (our emphasis):

1. Rooftop solar disconnection on disturbance: the disconnection of rooftop PV which could be up to 400 megawatts (MW) *and if* South Australia is operating as an island *and if* there is a 'severe fault in or close to the Adelaide metropolitan area, causing a large synchronous unit to trip' *and if* this is during a period of high distributed PV generation and moderate-to-low load (i.e. probably a spring or autumn day) then, this *may limit* the ability of AEMO to operate the system securely (also examined by AEMO under non-islanded conditions with the understanding that would be a less risky scenario).

2. Minimum load required to operate under islanded conditions: *If* SA is islanded, AEMO needs sufficient demand to play with because it is trying to match the minimum output of the synchronous units to provide required levels of system strength, inertia, frequency control and voltage management.

The May 2020 report stated that 'AEMO estimates that under some conditions, the threshold level of operational demand required will be around 550MW in late 2020 (with two synchronous condensers installed), reducing to around 450MW from late 2021 (with four synchronous condensers installed)' (p.4).

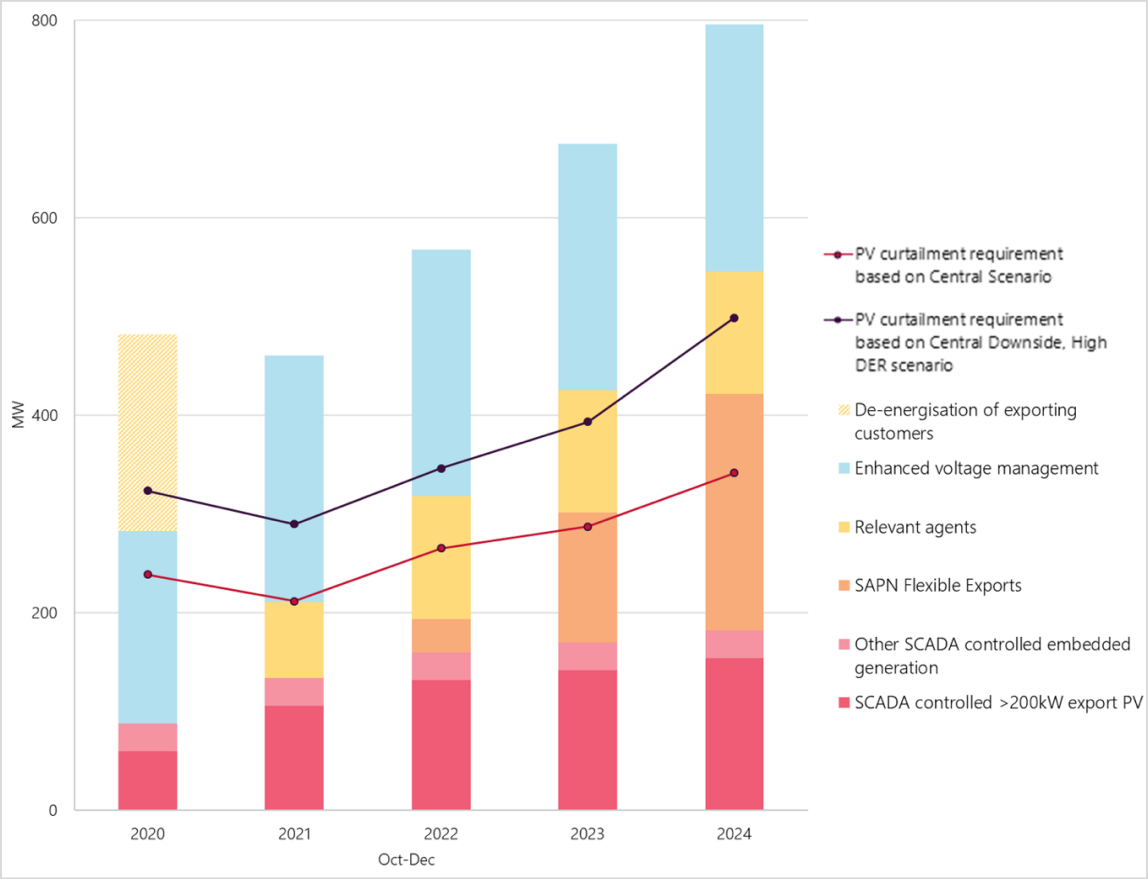
AEMO's media release and media commentary around the 14 March event reveal a 400MW threshold has been set for secure system operation in South Australia. That may well be prudent, but as far as we are aware, there has been no opportunity for external or independent parties to review the technical measures by which AEMO is defining minimum demand as an engineering emergency.

We see several concerns associated with the propositions put by AEMO and the process of defining the problem and 'solution' of solar cut-off:

The first is that **AEMO is determining technical requirements for the operation of the system with no oversight**. In contrast, the independent Reliability Panel is required to publish standards governing how the power system operates including the system restart standard, access and generator technical performance standards and the frequency operating standard (FOS). In the case of minimum demand, AEMO is prescribing the technical requirements and the solution to a problem of its definition.

[3] AEMO. Minimum operational demand thresholds in South Australia (SA). May 2020- referenced throughout this article by page number for exact quotes.

Figure 1: Emergency PV Curtailment Capacity Required in South Australia With Estimated Response From Identified Approaches (90% POE Minimum Demand)



Source: AEMO.

Both system security issues are defined as needing to be urgently addressed *if* SA is islanded.[4] These are therefore not NEM-wide issues, but temporary issues with SA being at the end of our long, skinny grid and as soon as a second interconnector is constructed (i.e. by 2024), the risk of these issues should be negligible.

If we accept AEMO's advice that there is a system security issue, then it is temporary and therefore temporary low-cost solutions should be prioritised—rather than permanent regulations imposed on new household PV installations.

AEMO's May 2020 report states for disconnected PV impacts: 'If EnergyConnect proceeds as proposed in 2023, this risk should be largely eliminated beyond that date' (p.34).

[4] 'Since market start in 1998, South Australia has separated from the rest of the NEM 16 times, although six have occurred in the past four years.' p. 34

The approach to transitional problems is critical and it could have flow-on effects, as we now see other jurisdictions proposing to take the same blunt response—both Queensland and Victoria are considering similar approaches on AEMO's advice.[5]

The likelihood and magnitude of the PV disconnection risk when islanded has not been calculated. PV disconnection is considered part of the same credible contingency[6] as large-scale generation disconnection and on the basis of analysis AEMO posits 'it might be appropriate to plan for high risk faults in relevant locations in South Australia at a rate of roughly once per year or less'.[7] However, the likelihood of the combination of operating conditions required for rooftop solar to cause AEMO to possibly no longer be able to operate SA securely in an islanded state 'are anticipated to occur rarely' (p. 34). In other words, the actual 'severe contingency' risk has not been assessed. Further, the magnitude of the resulting impacts should AEMO not be able to operate SA securely in an islanded state were not included in AEMO's report. Therefore, since both the likelihood and consequence of such an occurrence have not been defined, the risk is unknown.

Both Queensland and Victoria are now considering similar approaches on AEMO's advice.

In good news, it would appear this risk is now mitigated by the inclusion of voltage disturbance ride-through in inverter standard AS4777.2—which goes to the importance of forward thinking on distributed energy resources (DER) technical standards, and which we'll return to at the end of this briefing note.

The likelihood and magnitude of the minimum demand risk has not been calculated. AEMO admitted it was 'not yet able to provide detailed advice on the minimum operational demand threshold that will be sufficient for the power system to ride through a non-credible loss of the Heywood interconnector. This requires extensive modelling, which could not be completed in time for this report.' In other words, AEMO had not been able to do the quantitative analysis to define 'extreme abnormal conditions' (p.14). This is not a term defined in the National Electricity Law or Rules (NEL or NER), it was a new term used by AEMO but never defined in its May 2020 report. A 400MW threshold has been set for minimum demand in SA.

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[5] ABC News. Electricity provider authorised to switch off rooftop solar in SA in emergencies. 27 August 2020.

[6] AEMC. Credible contingency events are events that AEMO considers to:
- be reasonably possible to occur
- have the potential for a significant impact on the power system.

[7] AEMO. Minimum operational demand thresholds in South Australia. May 2020. p. 35

AEMO stated demand recovery reserves for 'minimum demand' are 'likely to be used very rarely'.[8]

The conclusion that must be drawn is that we have two risks which are likely to arise rarely or very rarely, and consumers and industry have little clarity about the likelihood of those risks or the consequences. This is especially notable when compared to the well-defined lack of reserve (LOR) notices used for the Reliability & Emergency Reserve Trader (RERT) scheme and the presence of guidelines published by the Reliability Panel to guide AEMO's implementation of the RERT.[9]

If there is not a strong quantitative understanding of the risk, the budget available to address the risk cannot be calculated. A cost-benefit analysis of possible solutions is therefore impossible. Nor has fair compensation been offered to solar producers (to be discussed further in part two of this briefing note).

The definition of the problem has been placed in question by the 'solution' in practice. AEMO's definition is 'Emergency Solar PV shedding capabilities – to require as a condition of connection that all new distributed solar PV, of any capacity, could be disconnected as a last resort, in rare circumstances if severe abnormal operational conditions arise, to protect the overall power system.'[10] Yet, when the cutoff regulation was first used on 14 March, it was during a known and predictable event, 'a planned outage of the circuits feeding the Heywood interconnector'.[11] This would seem to suggest that rather than being a last resort, AEMO are now regarding rooftop solar cutoff as a standard control measure.

Solar cut-offs open the door to further interference with consumer-owned assets.

Further, on 14 March the disconnection of household PV by regulation contributed just 10MW (an estimated 2,000-2,500 households). More than four times this, 40MW of rooftop solar PV (say 8,000-10,000 households) was cut off through SA Power Networks (SAPN) increasing voltage above the 253V threshold at seven substations. Note that this is sledgehammer measure, but given its obvious

[8] On its website AEMO defines 'Emergency Solar PV shedding capabilities – to require as a condition of connection that all new distributed solar PV, of any capacity, could be disconnected as a last resort, in rare circumstances if severe abnormal operational conditions arise, to protect the overall power system.'
[9] Reliability Panel. Reliability and Emergency Reserve Trader Guidelines, final guidelines. 21 August 2020.
[10] AEMO. Energy explained: Minimum operational demand. 25 August 2020.
[11] PV Magazine. South Australia rooftop solar switched off in search for stability. 18 March 2021.

effectiveness it also poses the question of why the SA complex cut-off regulation is needed.

In addition, 17MW of mid-scale solar PV was cut off via supervisory control and data acquisition (SCADA) systems and SAPN's ability to curtail these systems is part of their connection agreements.[12]

We have a total of 67MW of generation disconnected yet AEMO stated it would be too expensive for batteries to be used to soak up the amount of generation that needed to be curtailed. As we'll discuss in part 2, comparative costs for different options to address the 'problem' were not calculated as would normally be standard practice in policy or regulatory development.

The solar cut-offs through regulation and substation voltage rise open the door to further interference with consumer-owned assets. If fact, since we started writing this briefing note, there are media reports that South Australia is trying to fast-track appliance cut-offs through the implementation of a demand response standard AS4755. This would cover swimming pool pump controllers, home chargers for electric vehicles (EVs), electric storage hot water and air conditioners. If you know where to look, a presentation on this proposal is on the SA Department of Energy and Mining website.[13] However, while the slides state submissions are due on 9 April, there are no further details of the proposal on the Department's website and national bodies such as the Smart Energy Council have not been notified of any proposed regulatory changes.

Even more concerningly, energy ministers appeared to have agreed to the AS4755 in principle despite a Commonwealth Office of Best Practice Regulation critique.[14]

If AEMO or the network businesses want access to those DER assets for any purpose, and that will include electric vehicles, batteries and any DER resource on the other side of the meter, then they need to show the alternative options are more expensive, pay for these services—and, above all, seek permission. While the AEMO control room needs to have the flexibility to operate the system in line with its responsibilities, it needs comparable levels of guidance and oversight to those that exist for the reliability standard and the RERT.

There is a smart solution available very soon at the distribution-level (as AEMO acknowledges): dynamic operating envelopes (DOEs), otherwise known as dynamic connection agreements, should be able to address these issues constraining solar within the bounds of the distribution network and if needed to enhance system security. SA Power Networks have said these will only be able to be in place in 2023 and AEMO has recommended the rollout be accelerated as much as possible. The Distributed Energy Integration Program (DEIP) DOE work stream is

[12] AEMO. Solar PV curtailment initiative by SA Government supports the NEM. 18 March 2021.
[13] SA Department of Energy and Mining. A Demand Response Requirements for Swimming Pool Pump Controllers, Home Chargers for Electric Vehicles, Electric Storage Water Heaters and Air Conditioners. Consultation Sessions. 17 March 2021.
[14] Office of Best Practice Regulation. Smart Demand Response Capabilities for Selected Appliances. 26 November 2019.

working to develop an agreed national approach,[15] including to consumer engagement, after which dynamic operating envelopes should be compulsory in areas with high DER penetration—and then universally. Dynamic operating envelopes would be a more efficient means to limit rooftop solar export when and as needed, compared to a blunt turn off instrument.

Fortunately, also while writing this briefing note, SA Power Networks announced they are ready to begin trials of DOEs—termed 'flexible exports'—by the middle of this year in both South Australia and Victoria.16 Following this trial, SA Power 'hope to make Flexible Exports available as a standard service offering for customers'.[17]

Future thinking for a high-DER, digital and zero-inertia system needs to start yesterday.

While these specific issues about the household solar cutoff concern us, the overarching engineering approach of AEMO is a larger concern. It seems to us to be reflective of blunt **control-based thinking rather than future high-DER thinking** which assumes digitisation, flexibility, power electronics, AI and multiple management tools with a customer focus. We recognise that AEMO must exercise its primary responsibility, as politicians crudely say, 'to keep the lights on'. That will require judgement, flexibility and agility as the transition to a smart DER grid continues. We argue that in doing so AEMO be forward looking and open about exigent need versus long-term solutions—temporary fixes should not be allowed to morph into the permanent way.

In the 2020 Electricity Statement of Opportunities (ESOO), AEMO states 'Minimum demand is approaching thresholds where challenges will be encountered in managing voltage, system strength, and inertia'.

AEMO needs to be thinking about and planning for a zero-inertia system. The characterisation of these as 'problems' reflects an old fashioned synchronous generation focus and doesn't look to a smarter, more dynamic future of a majority renewable system.[18] Dr Tim Finnigan's recent report for IEEFA offers insights into where we are heading.[19]

The good news in Dr Finnigan's report is we can transition from the current energy system which is the equivalent of a lumbering diesel semi-trailer to a clean, manoeuvrable electric-motorbike renewable energy system. Essentially the future can be zero-emission and zero-inertia. With grid-forming inverters, smart power

[15] ARENA, DEIP. Dynamic Operating Envelopes Workstream
[16] SA Power Networks. Trial aims to help support more solar. 2 October 2020.
[17] SA Power Networks. Smart option to enable new solar customers to export up to 10kW from their solar panels. 14 April 2021.
[18] When South Australia is operating as an island, there is a need for sufficient demand to match the minimum output of the synchronous generating units needed to provide required levels of system strength, inertia, frequency control and voltage management. (AEMO 2020 | Minimum operational demand thresholds in South Australia p.4)
[19] IEEFA. Australia's opportunity to plan ahead for a secure zero-emissions grid. March 2021.

electronics and smart power system controls we can create 'a new grid paradigm, whereby millions of generators and loads are orchestrated flexibly and automatically'. In other words, minimum demand is no more of a problem than peak demand if you have the smart systems developed to address it.

We haven't had the chance to test the potential for smarter solutions in the engineering analysis and implementation of this solar cut-off regulation. There was no time for sunlight to penetrate AEMO's black box declarations of a minimum demand emergency before regulation was imposed on households which have and are making private investments in solar assets in record numbers.

However, it's not too late for AEMO to resource discussions about how to speed up the adoption of DOEs and lead the conversation about the transition to more dynamic, high-DER, zero-inertia system operation. We would welcome the opportunity to be involved in open and transparent discussions about this transition where meeting the long-term needs of consumers is placed front and centre.

Part 2: Why the Economics of Rooftop Solar Cut-Offs is Contested

In the first part of this briefing note we focused on the engineering definition of the system security problems and the 'solution' of control of household solar. The second and third parts delve into the economics and policy processes surrounding the advent of rooftop solar cut-off.

We saw in part 1 that we have two system security risks which AEMO defines as 'rare' or 'very rare', where the likelihood and the consequences have not been quantified. Without a sense of the magnitude of the economic consequences should the risk fail to be addressed, the budget available to address the risk cannot be calculated. We have a sense some lights may go out, but how many of the lights, in how much of South Australia, for how long and how often?

We don't know the possible benefit of avoiding the possible risk. Unfortunately we also don't know the cost of the solution that's been put in place either.

When AEMO first proposed the solar cut-off in the May 2020 report, it suggested utilising and improving standard smart meter remote de-energisation capabilities would be the way to implement the solar cut-off. This was described simply as 'low cost'.

The SA Government's subsequent three-page paper 'Consultation on the Proposed Remote Disconnection and Reconnection Requirements for Distributed Solar Generating Plants in South Australia'[20] contains not a single figure on the cost of the proposed regulation on individual households installing solar with cut-off requirements met. AEMO's verbal estimate of the cost was AU$30 to $50 for the majority of customers going from single to two elements (of the order of 80% of customers) and up to AU$130 for most of the rest, but this has not been put in writing or independently verified.[21]

No economic analysis means we don't know the overall cost to consumers of solar cut-off—or the cost of any alternatives.

Quality policy making would calculate the total cost of the new regulation including:

- the additional installation costs,

[20] Government of South Australia, Department for Energy and Mining. Remote disconnect and reconnection of electricity generating plants.
[21] We can find no written record of these costs but are aware they were used in inline briefings with stakeholders.

- the administration costs of implementation of the regulation (including the creation of a whole new category of 'agents' who have the authority to disconnect and reconnect solar systems), and

- the (in this case, unmentioned) costs of compensation to solar owners for times of solar cut-off.

Quality policy making would also have developed several options for addressing the problem which could have been tested against one another to determine that which was lowest cost and/or had the greatest benefits.

It is reported that the combined loss of export income and the cost of grid supply for just over an hour during the event on 14 March was of the order of AU$1/household which is of course trivial.[22] However, that means the combined cost for solar households was of the order of AU$12,500 for the hour—not a trivial amount, especially if it happens more than once and for longer time periods.

Large generators are compensated for assisting system security, including through Reliability and Emergency Reserve Trader (RERT), why not small generators? Why is AEMO putting all the costs for managing the system in known circumstances of interconnector maintenance on distributed PV with no compensation?

The combined cost for solar households of the hour-long cut-off on 14 March was roughly AU$12,500.

Regardless of the exact magnitude, the costs of other system security measures such as RERT is borne by all consumers. Should only solar households wear the costs of the transition to a majority renewable supply?[23]

In sum, we don't know the costs of the solar cut-off regulation and, as discussed in part one, we don't know the nature of the risk and so can't quantify the benefits. Therefore, the most basic form of economic analysis—a cost-benefit analysis of the solar cut-off regulation is impossible. The SA Department of Energy and Mining stated: 'Customer impacts were assessed as part of the decision-making process, with the benefits associated with these proposals considered to be greater than the costs.'[24]

[22] Pers comm.
[23] Indeed AEMO writes that 'generation shedding capability should be considered analogous to load shedding capability – it is a last resort mechanism used to maintain system security in exceptional circumstances'. If that is the case, then there should be a RERT-equivalent (Reliability and Emergency Reserve Trader) mechanism that pays for generation shedding.
[24] Department for Energy and Mining response to feedback from consultation on regulatory changes for smarter homes.

Part 3: Why the Process of Rooftop Solar Cut-Offs is Contested

The AEMO May 2020 paper proposed that:

> *'Trials should be conducted to verify real-time efficacy and coordination with the AEMO control room. Further investigation is required to determine the pathways for enabling this in real-time, and how this should be coordinated with NSPs. The most suitable regulatory frameworks for supporting rollout of this capability also need to be determined.'*

Such trials were never conducted.

One alternative trial that could have been conducted was voluntary disconnection which AEMO rejected for 'reliability reasons'. However, Monash research suggests that with appropriate communications capabilities the demand response by consumers could be significant, as well as low-cost.[25] Ideally a range of trials of different solutions should have been conducted. Lowering minimum demand was a foreseeable challenge for the system operator, even if it has happened faster than it expected.

Instead, the SA Government's 'Consultation on the Proposed Remote Disconnection and Reconnection Requirements for Distributed Solar Generating Plants in South Australia' paper was published at the end of June with submissions due less than two weeks later, on 10 July 2020.

The SA Government's 'Smarter Homes' regulations, where all customers installing or upgrading solar systems in South Australia are required to appoint a 'relevant agent' who will be responsible for disconnecting and reconnecting the system during State electricity security emergencies (not defined) were then gazetted on 24 September 2020.

This precedent could be particularly dangerous for electric vehicles (EVs).

These changes were outside NEM rule-making and set a poor precedent for consultative, transparent and open policy-making. Regulations as significant as these need to be made through a process at least equivalent in transparency and consultation to the Australian Energy Market Commission's (AEMC's) rule making, if not by the AEMC to avoid costly state-by-state rule-making. For all the challenges of AEMC rule-making, that process allows for stakeholders' views to be considered and arguments as to what is in the long-term interests of consumers to be aired. Good governance of DER technical standards and regulations is vital to the future of the

[25] Strengers Y, Nicholls L, Glover A, Arcari P, Martin R. 2019. Engaging households towards the Future Grid: an engagement strategy for the energy sector, Emerging Technologies Research Lab (Monash University) and Centre for Urban Research (RMIT University), Melbourne, Australia.

NEM and consumers' long-term interests.

These cursory processes in response to questionable definitions of transitional challenges must not be allowed to set a precedent in terms of control of private, consumer-owned resources. No water utility controls any household or business rainwater tanks as far as we are aware. This precedent could be particularly dangerous for electric vehicles (EVs).

Many of these policy and regulatory discussions fail to acknowledge that consumers have invested thousands of their own dollars in generation assets (and increasingly in storage—both batteries and increasingly EVs). As at the end of 2020 this was more than AU$4 billion of consumer investment in the infrastructure of the NEM. These private assets are co-located with load and therefore the most cost-effective form of supply (no network charges, no network losses, no retail costs for rooftop PV/batteries/EVs). Managed well, this collective consumer investment will dramatically reduce costs for all consumers in the NEM. The Energy Networks Australia (ENA) Electricity Network Transformation Roadmap[26] modelled that a renewables-only NEM could save AU$16 billion in infrastructure costs by 2050, and reduce average household bills by AU$414 every year, a reduction of around 30% on 2017 charges.

We would request that, as a minimum, changes not be made to the operation of consumer-owned assets without consumers' comprehensive participation in the process. A social licence to control consumers DER is needed. Energy Consumers Australia have commissioned excellent research from CutlerMerz[27] on what constitutes a social licence and why it's needed. That research concluded that mandated programs seeking to mitigate system security/safety risks, with little direct benefit to the consumer with DER, require the greatest level of cost/effort to achieve a social licence.

It's not enough for AEMO to claim 'emergency' circumstances in the case of minimum demand. The belly of the duck was always going to fall with growing rooftop solar. The onus on AEMO and the other energy market institutions is to plan for the future. One way to tackle any technical measures needed to manage minimum demand would be to include them in DER technical standards, set through robust consultation.

Regulators haven't sought or gained a social licence to make changes to privately-owned electricity assets.

To this end, there's a long-overdue need to include DER technical standards in the National Electricity Rules. In September 2020, the Energy Security Board (ESB) lodged a rule change request to establish enduring governance arrangements for DER technical standards across the NEM. The proposed changes include creating DER technical standards in the NER or subordinate instrument, providing for

[26] Energy Networks Australia. Electricity Network Transformation Roadmap. April 2017.
[27] CutlerMerz for Energy Consumers Australia. Social Licence for Control of DER. December 2020.

compliance enforcement of those standards, and establishing the AEMC as the decision-maker for creating the DER technical standards (preferably informed by an industry and consumer expert committee similar to the Reliability Panel). While the AEMC has been busy addressing the non-urgent issue of who pays for the small changes to Distribution Network Service Provider (DNSP) systems and operations to better integrate DER, the AEMC has not had the resources to open the ESB rule change.

More generally, we support the ECA recommendations that for a social licence for mandatory control, there needs to be:

- 'Provision of compensation for any private costs
- Consideration of exemptions for certain sub-sets of consumers who may have high private costs
- Reconsidering the need for a mandatory program to achieve objectives (e.g., whether a voluntary program open to all consumers is more cost-effective than a mandatory program for a sub-set of DER consumers).'[28]

We recommend energy market institutions and state governments develop a future-oriented mindset which urgently prioritises DER integration, respects consumers as owners of electricity system assets and views a zero-inertia electricity system as inevitable.

Just because you can do something doesn't mean you should. We propose the lessons of this hopefully temporary experiment in crude curtailment of solar exports are:

- Engineering analysis needs the opportunity to be tested in the sunlight of public consultation—especially so smarter solutions can be workshopped.
- If analysis shows that the most cost-effective or beneficial solution is for DER owners to provide system services, they should be compensated for doing so—just as others are for RERT or in the FCAS markets. Create a price signal and let electricity retailers sell this as an opt-in service.
- Good public policy requires an open, transparent, consultative process, including with cost-benefit analysis or equivalent rigour, where consumers' best interests are able to be debated.
- All energy market institutions and government agencies need to be looking to and planning for the future, which will be high-DER (on the supply and demand sides) and zero-inertia. Time and resources spent solving yesterday's problems or imposing permanent regulations for temporary challenges is a disservice to all electricity system users.

[28] Ibid. pg iii.

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