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How rapid implementation of flexible exports could maximise rooftop solar

- *Flexible exports – enabled by smart software operated by distribution networks – could nearly double household solar exports from new systems, and reduce electricity costs for all energy consumers.*
- *Flexible exports have been fully implemented in South Australia, but are not being rolled out consistently or quickly across the country, causing additional costs for inverter and gateway manufacturers, and unnecessarily increasing the cost to solar consumers.*
- *We estimate that the delays to implementing flexible exports cost households installing new solar systems and those with existing 8-15kW solar systems a combined A$35 million in 2023. This cost will accumulate to A$211 million over the next three years, and will grow further if the implementation of flexible exports is delayed beyond 2026.*
- *A rapid rule change is needed to ensure consumers benefit from fast, consistent implementation of flexible exports across the National Electricity Market (NEM).*

The first households to install rooftop solar (RTS) in the 2000s commonly installed 1.5 kilowatt (kW) systems because of the relatively high cost. These systems were allowed to export to the grid, usually under a 5kW static export limit set by the distribution network service providers (DNSPs, the local poles and wires companies). While those limits made sense then, they are unsuitable today with the average rooftop solar system nearing 10kW. Because DNSPs traditionally have had very little visibility of the energy flows in their networks and less experience with two-way energy flows, these static limits were set at a very conservative level.

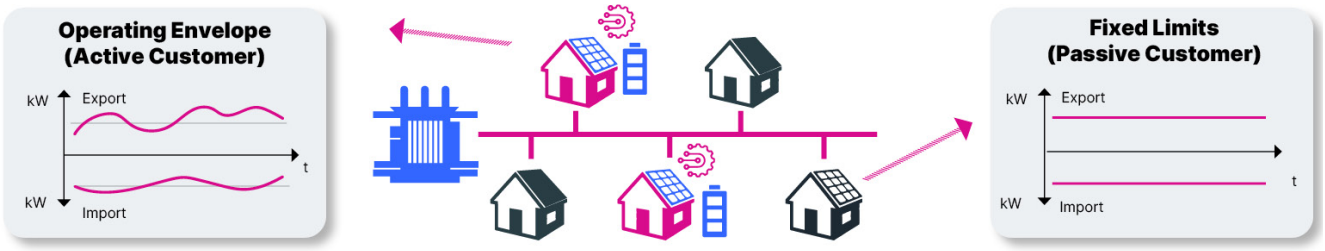
Flexible exports are a valuable innovation by SA Power Networks

Fortunately, the DNSP for South Australia, SA Power Networks, recognised the inefficiency of a static export limit. In 2017, it started developing software to forecast the hosting capacity of the distribution network 24 hours in advance, on a five-minute basis. The hosting capacity is the size and nature of export flows the local poles and wires can support without breaching technical limits, primarily voltage and thermal limits.

Based on the available hosting capacity, SA Power Networks software sends a dynamic operating envelope (DOE) of up to 10kW to each solar inverter that has a connection agreement for "flexible exports", 24 hours in advance, on a five-minute basis. In this way, solar exports can rise and fall with the capacity of the local network.

Exports from solar or batteries or other distributed energy resources (DER) will only be curtailed when and where it is necessary to maintain network security, and avoid congestion on the distribution network. All electricity system users benefit from the additional exports since the increased energy supply can reduce electricity prices for everyone. This sometimes even causes wholesale prices to be negative in the middle of the day while the distribution network operator ensures its networks operate within their technical limits.

Figure 1: Dynamic operating envelopes (DOEs) compared with fixed limits



Source: Melbourne Energy Institute

SA Power Networks modelling shows flexible exports will likely be set below the doubled 10kW limit only 2% of the time or approximately 50 daylight hours per year. This is extraordinary, especially given about half of households already have rooftop solar installed in the SA Power Networks area, and at times rooftop solar supplies more than the state's total electricity demand.

The innovative software means solar households in SA could double their solar exports, and potential earnings from those exports, 98% of the time. The average Australian household RTS system being installed is close to 10kW, and less than one fifth of homes are including a battery with their solar installation. This is due to falling system costs and as households prepare to charge future electric vehicles (EVs) and electrify their homes. Flexible exports could significantly increase the return on investment for many existing and all future rooftop solar owners.

Implementation of flexible exports in SA was achieved for A$32 million – less than 1% of SA Power Network's A$3.9 billion revenue from FY2020-25, so this measure is relatively low cost. (Noting this doesn't include the costs for original equipment manufacturers (OEMs) or aggregators to comply with the DOEs.) SA Power Networks notified the solar industry about its plans for flexible exports in April 2021, with trials commencing in September 2021 and full implementation achieved in 2024.

Significant value potential for households and the electricity system

There have been several trials of flexible exports by other DNSPs, which are detailed below. Increasing solar exports through advanced DOEs could unlock A$5.08 billion in benefits for all consumers (net present value) to 2042, according to Deloitte Access Economics' Cost Benefit Analysis for Project EDGE. This unlocked DER capacity is used to partially displace large generators in wholesale supply (most of the benefit), to provide local network support and contingency frequency control ancillary services (FCAS) to stabilise the grid.

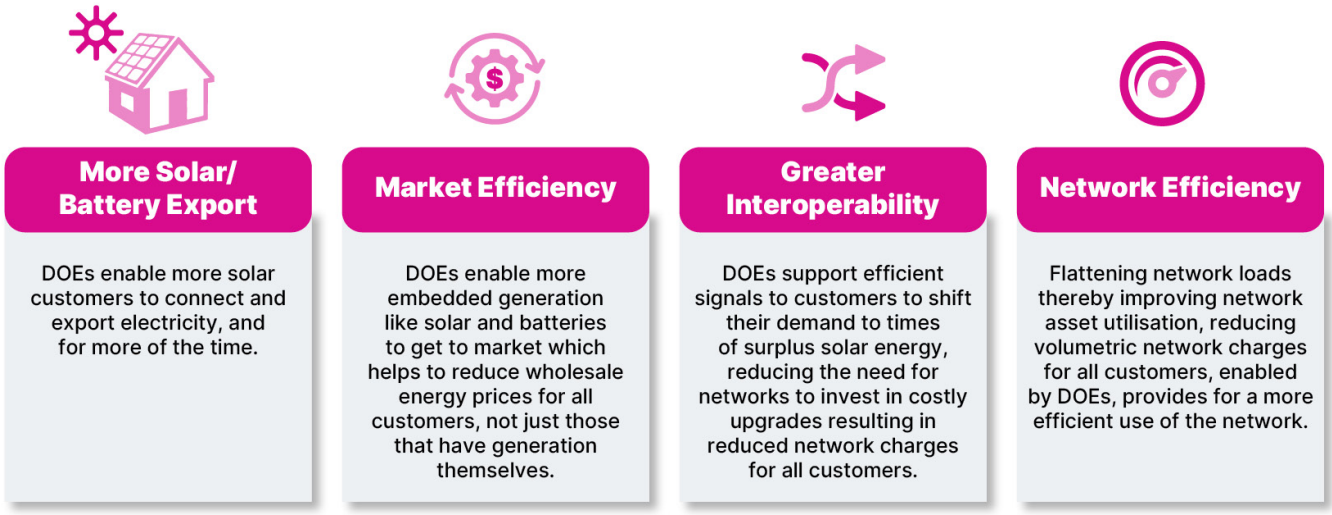
Solar Analytics (SolA) has estimated the value of additional solar exports, had flexible exports been in place nationally from 1 July 2023 and had existing solar owners with systems over 7kW been able to retrofit their solar system to support flexible exports. For one-third of solar systems, the cost of the upgrade would have been free (via an online inverter software upgrade) and $400 for the remainder to fit a consumption meter to their systems.

Using data from SolA's 35,000 customers and extrapolating this to the 3.3 million solar owners nationwide on 1 July 2023, using Clean Energy Regulator (CER) data, we found:

- From Sunwiz and CER data, it would make financial sense for the estimated 298,000 systems sized 8-15kW with consumption meters to switch to flexible exports.
- From SolA data, an export-limited solar home lost 766 kilowatt hours (kWh) of energy on average in 2022.
- For those 298,000 households that equates to 228 gigawatt hours (GWh) or A$7 million a year in extra export earnings (assuming a tariff of 4c/kWh).
- If we add the 300,000 solar systems installed in FY2023-24 and assume they install 10kW systems with access to flexible exports (with 24% additional self-consumption and reduced purchases of retail electricity), that gives 230GWh or A$24 million in additional export income.
- **Total additional earnings for solar households with flexible exports over the year to 1 July 2024 would have been A$35 million – and this amount will accumulate to A$211 million over three years.**
- These figures are only based on 4c tariff for solar export and an avoided 30c retail tariff. Where households are exposed to wholesale prices or participate in virtual power plants (VPPs), they may be able to earn additional revenue by exporting at times of higher prices.

The 458GWh of freed-up rooftop solar generation equates to about 3% of total utility solar generation in 2023. In addition to the savings for the solar-owning households, the extra solar electricity on the grid would help reduce wholesale prices for everyone.

Figure 2: Potential benefits of Dynamic Operating Envelopes

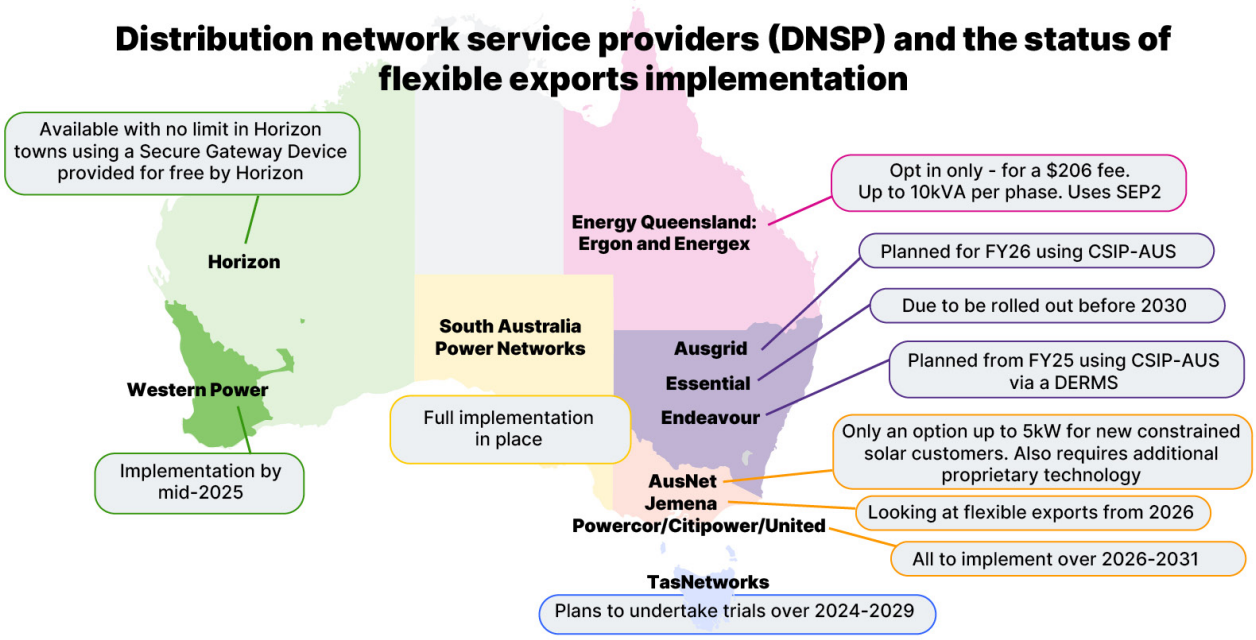


Sources: Distributed Energy Integration Program, Outcomes Report, March 2022

The state of implementation of flexible exports

This analysis of DOE implementation across Australia highlights the lack of uniform national regulation. Each distribution network implementing DOEs has set its own inverter profiles (CSIP-AUS or SEP2.0), which has affected the technology, communication and cost of DOEs being implemented.

Figure 3: Australia's DSNPs and status of flexible exports



Source: DNSP websites and revenue proposals

Victoria

Solar Victoria's annual notice to market in May 2023 stated that from 1 March 2024 all new inverters installed in Victoria must be capable of remotely and dynamically adjusting their solar export limits. The notice requires installed systems to implement the Australian common smart inverter profile (CSIP-AUS) and the IEEE 2030.5 standard (on which CSIP-AUS is partially based), which are developing as the standard open communication protocols from DNSPs to inverters and other DER. Victoria's requirements for flexible exports also made possible the use of CSIP-AUS for the Australian Energy Market Operator (AEMO)'s solar cutoffs for system security (the "emergency backstop").

AusNet has a Flexible Export connection offer, but only up to 5kW per phase for solar customers in constrained parts of the network. It says it is an "alternative solar connection offer for AusNet customers who would otherwise be limited to no more than 1.5kW fixed export per phase due to their local network conditions". It also requires Flexible Export customers to install a SwitchDin Droplet device to communicate with their solar system, at an additional cost to consumers. This is curious given it is a specified commercial product not required by other DNSPs, and locks the DNSP into a specific technological solution. In addition, only three brands of solar inverters (Fronius, GroWatt and SMA) tested as part of the Flexible Exports for Solar PV Trial are allowed, whereas other products work with a much wider range of solar inverters. AusNet states, "In coming years, enhanced solar connection offers from AusNet may be extended to CSIP-AUS compliant inverters."

Eastern Victoria DNSP Jemena states it is "looking at flexible exports for solar PV from 2026, then imports from 2028 for 'opt in' EV charging. To mitigate both minimum and peak demands".

Since 1 March 2024, CitiPower, Powercor and United Energy Services have run a flexible exports trial for 100 residential and commercial and industrial (C&I) customers as part of a broader set of capabilities, including hot water load control trial and a low-voltage DER management system (LV DERMS) with Australian Renewable Energy Agency (ARENA) funding. Powercor, United and Citipower's draft proposals for 2026-2031 state they will implement flexible exports for residential customers over this period, but do not specify when.

Queensland

Energy Queensland (EQ, via Energex and Ergon Energy) has set up DOEs as "dynamic connections" with a different specification to SA Power Networks, based on a 10 kilovolt-amps (kVA) per phase limit rather than 10kW. Queensland households can opt in to a dynamic connection for an additional fee of $206 for systems up to 30kVA.

EQ's requirements include that "inverters shall be capable of sending and receiving information via SEP2 using CSIP directly or via a third party" not aligned with the CSIP-AUS communication protocol. In addition, under the implementation of DOEs, EQ has the ability to take control of the import rates for charging of batteries and EVs, viewed as overreach by the industry and, indeed, consumers.

New South Wales

Of Essential's customers, 37% have no export limit, 1% have a zero export limit and 62% are export limited (usually to 3kW in rural areas and 5kW in urban areas). Essential's 2024-29 revenue proposal states it will implement flexible connections, but not when.

Endeavour states it is "developing a detailed DOE implementation plan and trial project with the aim to have a flexible exports offer by FY25". It plans "to implement a DER Management System (DERMS), customer connection portals and associated installer processes", which will communicate via standardised protocols such as IEEE2030.5/CSIP-AUS and use "the DOE mechanism for passing through AEMO's minimum demand curtailment directives (as applicable)".

Ausgrid states in its proposal for 2024-29 that it will invest A$8.1 million to enable dynamic pricing, DOEs and the requisite support systems. Ausgrid is also trialling dynamic network pricing, which includes DOEs, through Project Edith.

ACT

A 5kVA per phase export limit applies to all residential solar systems in the ACT, and EvoEnergy states in its regulatory proposal for 2024-29 it will implement DOEs, but not when.

EvoEnergy completed a trial of "shaped operating envelopes" (SOEs) for 1,000 customers through Project Converge in January 2024. SOEs take DOEs to the next level by integrating aggregation services, factoring in "what aggregators know about DER use in real time capacity allocation processes". The Project Converge Final Technical Report states, "SOEs produce superior overall system benefits when compared to DOE approaches in offline simulations. However, these benefits only become significant once DER penetration levels become high. This suggests that DOEs may be sufficient in the short term."

Tasmania

TasNetworks has allocated funding to consumer energy resource enablement, including DOE trials in 2024-2029.

Western Australia

In June 2024, WA completed Project Symphony, which trialled DOEs for 90 days. By mid-2025, Western Power says it will "finalise communications protocols, data, and technology requirements to predict and publish dynamic operating envelopes (DOE), in accordance with the [distribution network's] co-ordination requirements".

Horizon has had DOEs up and running under its Smart Connect Solar scheme for new or upgraded solar systems since late 2023. It states, "once a town is Smart Connect Solar enabled, hosting capacity limits won't apply". Smart Connect Solar requires a Secure Gateway Device (SGD) that connects a solar inverter to Horizon's energy management system. Horizon supplies and maintains the SGD free of charge. Any costs to install and connect the SGD are at the installer's discretion. Interestingly, Horizon's system can reduce the total amount of solar electricity a solar energy system generates, not just the exported amount. Horizon states capacity allocation "is the same across the town so it's fair and equitable".

There is a major question about whether DNSPs (or AEMO) have any business reaching behind the meter to effectively require consumers to buy power from the grid instead of consuming their own solar energy. Another question is whether DNSPs have any business limiting the amount of electricity that can be imported for batteries or EV charging, as EQ has done. This is not something, as far as the author is aware, the rule-making body, the Australian Energy Markets Commission (AEMC), has examined. DNSPs have long had the ability to switch hot water systems on and off remotely overnight through ripple control, but this was on a separate circuit and tariff. The question of which entities, if any, have the rights to control a household's rooftop solar system has not been subject to regulatory consultation.

This question has a practical dimension, because to reduce export to zero rather than turn off a solar system outright, an additional consumption meter must be installed. This is needed so the "controller" knows how much to curtail the solar output to reduce the export to zero, and no more. Consumption meters are increasingly common with solar installations, and are compulsory for battery installations. Given the cost implications of consumption meters, the issue of behind-the-meter (BTM) control should be the focus of a public policy discussion.

Where is the Australian Energy Regulator in all of this?

The National Consumer Energy Resources (CER) Roadmap released in mid-2024 states that, "Fast track implementation of flexible exports component of dynamic operating envelopes (DOEs) by network operators to enable increased CER flexibility, third party participation and maximise benefits to the system and customers" will be completed in 2025. When contacted, the federal Department of Climate Change, Energy, the Environment and Water (DCCEEW) said the Australian Energy Regulator (AER)'s Export Limits Guidance Note would need to be considered when progressing this work by the CER Working Group.

The history of the AER's involvement in flexible exports includes the following:

- In FY2018-19, the AER assessed and eventually approved SA Power Network's expenditure to develop, trial and implement flexible exports.

- In October 2022, the AER released a flexible export limits issues paper for consultation.
- On 31 July 2023, the AER released its response to the flexible export limits issues paper consultation, which included a priority action to initiate "a rule change proposal to provide the AER with the appropriate head of powers to develop and publish a binding Export Limit Guideline governing methodologies for export capacity allocation and provision of information to consumers".
- On 17 November 2023, the AER published the draft export limit interim guidance note for consultation.
- On 23 October 2024, almost a year later, the AER published the final guidance note (see below).
- The priority action to initiate a rule change proposal, almost 15 months earlier, has not been completed. Instead, the AER states in its Export Limits Guidance Note – Explanatory Statement that, "Over the next 12 months, the AER intends to monitor DNSP adherence to the guidance note to determine whether it has been effective in addressing identified problems and promoting the intended policy outcomes. … This approach will allow the AER to observe a broad cross section of DNSP behaviour to determine whether the guidance note has been effective, or whether there are elements that need further refinement or strengthening through a rule change request to the AEMC to ensure intended policy outcomes are delivered." (Note: emphasis added.)

The AER's decision seems to prioritise the views of DNSPs over the benefits of national consistency and energy ministers' agreement to expedite the implementation of flexible exports. This is disappointing, especially considering the AER's acknowledgment that, "Flexible export limits play an important role in realising the full potential of CER."

Seven years since SA Power Networks began work on flexible exports, most consumers in the NEM don't have access to this software and distribution network innovation that could substantially increase earnings from their DER. Flexible exports are only the default in SA. There is no compulsion for DNSPs to implement DOEs or do so in a consistent manner or in a manner that protects consumers.

What guidance has the AER provided?

The AER's Export Limits Guidance Note covers the following topics:

- Capacity allocation principles and methodology
- Consumer participation
- Customer education and awareness
- Consultation requirements
- Governance arrangements
- Performance reporting and monitoring
- Dispute resolution

However, there are no specific requirements on any of these topics. For example, on the "communication protocol", it simply states: "DNSPs should consult with industry stakeholders on the communications protocol that is used to communicate the dynamic limit. DNSPs should

have regard to the CER Roadmap reforms, which include a workstream to develop an initial set of technical standards for CER interoperability and flexibility." Likewise, on "notifications", "DNSPs should engage with industry on how consumers will receive information about when their flexible export limit is reverted to static export limits or will not be able to export, or has been identified as non-compliant with export limit or technical requirements."

The AER doesn't appear to appreciate that variations in specification of DOEs and their implementation by DNSPs will increase costs for original equipment manufacturers (OEMs), principally of solar inverters. This is not only in terms of development cost, but also the update costs for equipment as variations are made. Increased costs associated with this lack of standardisation will lead to increased equipment costs for consumers, including increased installation costs as inverters must be configured differently in each DNSP area.

Impacts on manufacturers and consumers

Although the benefits for consumers in being able to export more energy have been established, the cost of the current implementation of flexible exports must be considered. DOEs have been rolled out with the "emergency backstop" mechanism (aka solar cutoffs) required by AEMO.

Backstop mechanisms are mandatory in SA, WA, Victoria and Queensland. The implementation across four jurisdictions by 11 different DNSPs has been delivered via six different mechanisms. DOE implementation has been tagged onto the backstop rollout as the same communication protocol (CSIP-AUS or SEP2.0) is used. The networks have passed on the cost of developing these mechanisms to consumers.

For equipment manufacturers, the integration process for the backstop mechanism and DOEs must be developed per network only after full Clean Energy Council (CEC) product and SA Power Networks CSIP-AUS testing, certification and additional CEC listing have been completed. Manufacturers must undertake integration and witness testing per utility per inverter group; the process for each network takes about two months. This means it will take over 18 months for any new inverter to be introduced in Australia, to fully comply with backstops or DOE requirements in the jurisdictions offering these functions. This contradicts and affects the innovation cycle of most manufacturers given the fast-paced development of the industry.

It has been suggested that the implementation headache is simply a transitional issue, and that once up and running, there will be no additional cost or burden for manufacturers. This will not be the case. CSIP-AUS will continue to develop, and network requirements will continue to change. There is a proposal for CSIP-AUS v1.3 which will require retesting and new implementation across all networks. There will also be additional requirements for the implementation of public key infrastructure (PKI) and Cyber Security Standards, which means that unless there is a nationally consistent approach to communication and integration, meeting all requirements for all DNSPs will be a huge undertaking by industry.

The ongoing cost for service, support and maintenance is to be primarily worn by manufacturers, including data storage and archiving. Installer training and compliance checking are also primarily expected to be managed and supported by manufacturers.

What does this mean for the consumer? It will push up the cost of doing business in Australia for manufacturers, which ultimately will make Australia less appealing with higher product and installation costs than any other global region unless a nationally co-ordinated approach to dynamic connection communication can be implemented.

Consistent requirements for flexible exports will benefit consumers

There are some basic requirements that could be put in place to minimise the costs of compliance by inverter manufacturers with flexible exports across different DNSP areas. It is in the interests of consumers that these be put in place as soon as possible given approximately 300,000 household solar systems are being installed annually and the financial benefits calculated above.

While the details of each network will vary, the principles and parameters to apply when determining DOE limits are the same. Therefore, IEEFA recommends that the minimum set of requirements include:

Standardisation needed	Specifics
Communication protocol from the DNSP to the inverter	CSIP-AUS provides a standard open communication protocol already required for new solar inverters installed in SA and Victoria, as well as specified by EQ in its Dynamic Connections. While CSIP-AUS continues to evolve, it should be considered as the standard communications protocol between a DNSP and an inverter/DER.
Testing and certifying equipment	There should be a national approach towards testing and certifying equipment to ensure it is receiving export limits as intended.
Data communication standards	The frequency and volume of data provided by DNSPs to inverters and other DER needs to be standardised. For example, how frequently the export limit signal is sent and whether the data can be used by any software controlling the inverter for forecasting.
Flexible exports communication	Export limits should be sent via consistent authorisation and authentication messages – they should not look different depending on the utility server.
Visibility of DOEs to VPP operators/ aggregators	If DNSPs are communicating DOEs, it seems sensible that DOEs take precedence over any other remote command sent by another party for a different reason. Therefore, inverter manufacturers need to ensure they understand the precedence of commands, and implement accordingly, and VPP operators/ aggregators need to have free visibility of the DOE.
Behind-the-meter (BTM) access	For the consumers' benefit, the DNSP should not be able to reach in behind the meter, and any DER (e.g. batteries, EVs) should be able to be charged from on-site solar.

BTM interoperability standards have developed by the DER Integration Application Programming Interfaces (API) Technical Working Group led by the Australian National University, and have been handed off to Standards Australia to expand into a new standard AS 5438. Once complete, these BTM interoperability standards should also be included in the above requirements to ensure that DOE instructions can be communicated consistently behind the meter.

Basic consistency in flexible exports should be required

An important question is who is leading policy and regulation to support the integration of consumer-owned DER into the NEM? As this analysis has shown, the valuable and world-leading innovation by SA Power Networks is being rolled out by other DNSPs at a timing over which consumers or regulators have no control, and in a way that may not be consistent. The costs of inconsistency for inverter manufacturers are likely to be significant, and passed onto consumers in the form of higher prices and less competition.

On 25 July 2024, the AEMC made a draft determination on the Integrating price-responsive resources into the NEM rule change. If the rule change is finalised in accordance with the draft, it will allow DER to bid into the spot market, set prices, receive dispatch instructions and earn revenue in markets that require scheduling (e.g. regulation FACS).

As part of this draft rule, the AEMC proposes to introduce an incentive to drive market participation of aggregated DER. However, the AER appears unconcerned if slow, inconsistent implementation of flexible export software limits aggregated DER participation in markets.

As I've written elsewhere, a rule change should look at options to manage minimum system load (including the "emergency backstop" mechanism) and the fast implementation of flexible exports. Both issues affect the management of customers' rooftop solar systems, and should be addressed jointly to ensure the best technical and social outcome.

To improve outcomes for consumers, **IEEFA recommends** the Minister for Climate Change and Energy lodge a rule change with the AEMC to require DNSPs to fast-track the implementation of flexible exports, and to explore options to manage minimum system load (including AEMO's "emergency backstop" mechanism).

- As part of this rule change, standardised requirements should be considered for – at least – the following in a subsidiary instrument under the rules:
  - Communication protocol from the DNSP to the inverter
  - Testing and certifying equipment
  - Data communication standards
  - DOE communication
- Standardised provision of information to consumers could also be considered in the course of this rule change.

Outside the scope of this briefing note, but nevertheless important, work is also needed to develop a pathway to a national best-practice methodology or approach for estimating hosting capacity. The CER Roadmap Taskforce could examine the most open, transparent and consultative way in which this could be done.

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