Best case scenario

Local energy and climate change resilience

Discussion paper
September 2019

Mark Byrne
TEC Energy Market Advocate

Contents

Summary	3
1. Introduction	4
2. Context	5
3. The role of local energy in climate change adaptation	7
4. Towards a resilience metric	10
5. Valuing DER in climate change adaptation	13
6. Pros and cons	14
7. Equity implications	14
8. Lessons from the survey	15
9. Other findings and recommendations	15
10. Conclusions	16
Appendix 1: Survey results	17
Appendix 2: DER equity principles	24
Appendix 3: AEMC resilience review	26
Endnotes	27

This project was funded by Energy Consumers Australia (www.energyconsumersaustralia.com.au) as part of its grants process for consumer advocacy projects and research projects for the benefit of consumers of electricity and natural gas. The views expressed in this document do not necessarily reflect the views of Energy Consumers Australia.

Summary

In the face of accelerating climate change impacts – in particular the frequency and intensity of severe weather events – local energy (or distributed energy resources, DER) can play a significant role in increasing individual household, local community and systemwide resilience. This paper represents an early attempt to recognise this potential role. It is the principal output of an ongoing TEC project, and combines a summary of research (part 1) and the results of a DER user survey (part 2).

Part 1: Local energy can increase system resilience in several ways. Energy efficient buildings ensure that energy needs are reduced. Small scale generation, supported by local storage and microgrids can help maintain supply if centralised generation is temporarily unavailable. EVs with vehicle to home or grid capability can provide extra flexibility because of their portability. Demand response can reduce stress on the grid—eg during heatwaves, when demand can exceed supply and place stress on network infrastructure. And where more local energy results in less reliance on poles and wires solutions, this can reduce the risk of blackouts and damage from severe weather events such as bushfires, which are often caused by downed live lines.

However, this potential role is not currently well integrated into the energy market regulatory regime. We find that there are several gaps:

1. The *concept* of resilience and how it differs from reliability is not well understood.
2. There is no recognition of the *value* to the system of household and local system resilience—for example, for networks to factor into their future investment plans—or the relative cost of increasing resilience via local versus centralised supply.
3. There is no accepted *metric* for measuring household and local system resilience.

An appropriate metric (or metrics) would recognise as key variables a generation dimension (layers of redundancy or backup supply) and a network dimension (levels of connection), with flexibility being a potential third dimension . While this would be useful in assessing or predicting personal or private resilience, it is also important to develop a methodology to assess the public benefits of local energy supply, storage and distribution—for example, in assessing the costs and benefits of investment to enable higher penetrations of DER, and in determining and applying the value of customer reliability (VCR).

Part 2: The other part of this study was a survey to measure how engaged consumers are around the issue of severe weather and energy system resilience. A self-selective survey of 141 Renew members and a shorter survey of 1,201 Solar Citizens supporters found a high degree of awareness of this issue and the range of potential private and public actions that could be undertaken to increase local energy system resilience. These include a greater emphasis on the energy efficiency and thermal performance of dwellings, solar access rights, prioritising supply to critical infrastructure such as hospitals and schools, support for community microgrids and batteries, and more undergrounding of power lines.

In contrast, most respondents did not support individual solutions such as going offgrid, and showed a high level of concern for supporting people who can't install their own energy equipment to manage the impact of extreme weather on their supply.

Feedback is welcome. Please contact the author, Mark Byrne, TEC's Energy market advocate, at markb@tec.org.au. Thanks to Dean Lombard and Damien Moyse from Renew and Mark Silberg of Rocky Mountain Institute for their valuable input.

A 6 point plan for a more resilient local energy system

1. Ensure ***housing*** stock is energy efficient (for likely future as well as current conditions).
2. Increase access to rooftop or community ***solar energy*** which can operate in island mode.
3. Invest in ***home or community batteries*** for backup supply.
4. Invest in grid-connected but islandable ***microgrids***.
5. In high bushfire risk areas, invest in ***stand-alone power systems*** or microgrids, whichever is cheaper.
6. To improve flexibility, incentivise ***electric vehicles*** (EVs) with vehicle to home or grid capability.

"In the face of today's climate challenge, both despair and complacency are equally unwarranted."

Amory Lovins, founder of Rocky Mountain Institute

"'We Have Fire Everywhere'… How did it end? It hasn't. It won't."

Jon Mooallem, *New York Times*[1]

1. Introduction

Australia is widely regarded as one of the countries most vulnerable to climate change in the developed world.[2] Climate change is already impacting the energy system in Australia as elsewhere. Until now, the attention of energy market bodies, researchers and advocates has focused mainly on the ability of grid scale infrastructure—large power stations, transmission and distribution lines, interconnectors and substations—to withstand or respond to severe weather events.[3] As we saw with the "black system" event in South Australia in September 2016, even when overall systemwide reliability is high, centralised electricity grids can be vulnerable to widespread blackouts caused by localised severe weather events, causing serious economic losses and societal disruption.

By contrast, this study—another collaboration between the Total Environment Centre and Renew,[4] and the first of its kind we are aware of—explores how local energy or DER (see box below) can assist in climate change adaptation (rather than mitigation). It is a first pass or scoping study including a self-selective survey rather than a full scale cost benefit analysis or feasibility study. The focus on adaptation in no way reflects our commitment to climate change mitigation—that is, decarbonising the energy system. Rather, it reflects the reality that even if mitigation is successful, the climate is already changing and a degree of adaptation will still be required.

The project objectives are:

1. To understand how a high DER system can contribute to overall energy system resilience in the context of accelerating climate change impacts (perhaps at lower cost than the old centralised system and one-way supply chain).
2. To provide advice to DER owners and third parties as to the pros and cons of various responses—eg, going offgrid or setting up microgrids or embedded networks—and the readiness of DER technology (especially inverters and batteries) to function in islanded/offgrid mode.
3. To address the potential equity implications for non-DER owners of some DER owners going offgrid.

We consider that DER can play important roles in increasing energy system resilience in the face of more frequent and severe weather events—floods, bushfires, droughts, severe wind events (gales, tornados and cyclones) and heatwaves—particularly by complementing centralised generation, storage and transmission. Local networks can be islanded, and energy trading continued, where there is sufficient local generation and storage and networks have been designed for localised operation.

However, before conducting this study we suspected that the response of many DER owners to the threat of severe weather and grid blackouts may have been to design their systems to operate offgrid. We wanted to test this suspicion, and perhaps to challenge it on resilience and financial grounds, but also to see if DER owners focused on climate change adaptation had lessons for others.

We were also concerned that the responses of some DER owners to the threat of climate change may lead to the evolution of a two tier energy system (akin to private versus public hospitals) whereby those who can afford it insulate themselves from some of the impacts of climate change, while others remain dependent on an increasingly fragile and/or expensive grid. We wanted to explore how non-DER as well as DER owners could work together to increase energy system resilience.

As part of the project, we separately surveyed members of Renew and supporters of Solar Citizens to ascertain whether they shared our concern about this issue, what they had done about it, and what they were planning to do. This final paper incorporates the results of the surveys and recommendations for further action.

Finally, a word about the title. Planning for severe weather events often takes the form of a worst case scenario such as low probability but high impact events. We wanted to focus instead on the positive role that local energy can play in increasing energy resilience in the face of an increasingly chaotic climate system.

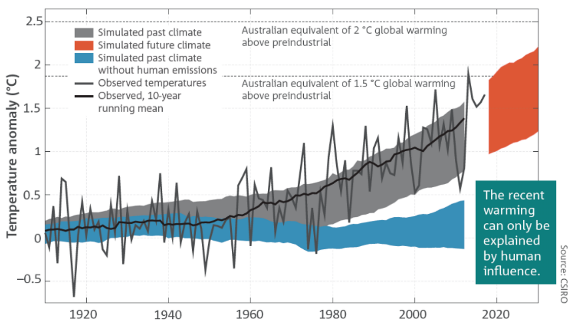
What is local energy?

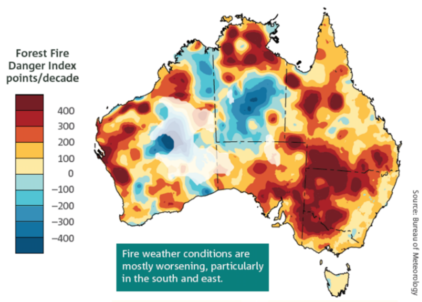
Local energy or DER here refers to anything that customers connected to the distribution network* can do to at least partly manage their supply and demand. This includes:

- Self-generation including rooftop solar energy.
- Energy storage including home and community batteries.
- Electric vehicles (EVs) and other e-mobility products.
- Home energy management systems.
- Peer-to-peer (P2P) energy trading.
- Virtual power plants (VPPs).
- Community energy projects.
- Energy conservation.
- Energy efficiency product and services.
- Demand management and demand response products and services.

** Local energy or DER could also include activities (eg tariff reform) by distribution network operators, but they are not included in the current study.*

2. Context





Source:State of the Climate 2018: Bureau of Meteorology and CSIRO

Evidence is mounting of serious and accelerating climate change impacts in Australia.[5] The electricity system is amongst the critical infrastructure affected by climate change:

> Higher temperatures and longer, more intense heat waves skew electricity use: lower in winter, but with higher, more sustained peaks in summer, to meet consumer demand for cooling. Higher temperatures also reduce the effectiveness of cooling systems and transmission lines, decreasing the efficiency of electricity generation at the very time it is most needed. This combination drives up electricity costs and stresses the system, increasing the likelihood of blackouts…
>
> More frequent or persistent droughts reduce the availability of water for electricity production. While new thermal plants may use dry rather than wet cooling, this option is less efficient and may produce more greenhouse gas emissions. All forms of extreme weather events can knock out generators or networks, and may also delay restoration of supply.[6]

The impacts are already being experienced in Australia's energy system, with heatwaves, severe storms and bushfires in particular being blamed for blackouts, damage to electricity infrastructure and related loss of life and economic losses.

Black Saturday bushfire survivors secure $500 million in Australia's largest class action payout

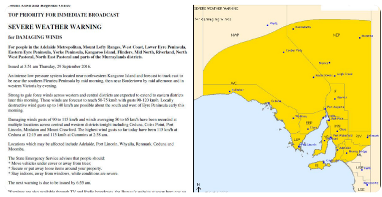
Sydney storms: 55,000 city and central coast properties left without power

Endeavour Energy and Ausgrid say more than 750 electrical hazards need to be repaired before supply can be restored

SA SES @SA_SES

Follow

Latest @BOM_SA warning, issued at 03:51am, 29th Sept. Severe weather warning for damaging winds bit.ly/2deb5uo



As we approach peak summer, Australians now add city-wide blackouts to the list of things to worry about during the season, after sunburn, bushfires and drought.

Sources: media headlines, 2018-19

In the absence of serious national and global success in reducing greenhouse gas emissions commensurate with the IPCC goal of limiting warming to no more than 1.5 degrees C,[7] these impacts will only increase over time. The most likely impacts on the energy supply system are summarised in the table below.

Climate change impacts on the electricity system[8]

	Driver	Risk scenario	Impacts	Probability
5	Severe winds	Arcing from downed lines causes bushfires	Blackouts; property damage; loss of life	Very high
1	Heatwaves	Increase in peak demand Decrease in efficiency of infrastructure	Higher infrastructure costs & consumer bills	High
2	Heatwaves	Thermal overload of substation transformers	Blackouts	High
3	Storms	Lightning strikes on trees causing bushfires	Blackouts; property damage; loss of life	High
4	Severe winds	Transmission lines or towers destroyed	Blackouts	High
5	Severe winds	Trees fall on distribution lines	Blackouts	High
7	Severe winds and heatwaves	Trees fall on distribution lines causing bushfires	Blackouts; property damage; loss of life	High
9	Drought	Lack of water to run turbines at hydro plants or to cool turbines at coal plants	Temporary loss of output reducing grid capacity	Medium-high
6	Extreme rainfall	Flash flooding causing damage to infrastructure	Blackouts	Medium
8	Flooding	Damage to infrastructure	Blackouts	Medium
10	Warming oceans	Increasing numbers of jellyfish clogging water intakes of power plants	Temporary loss of output reducing grid capacity	Low
11	Rising sea levels + storm surges	Inundation of infrastructure	Short term: blackouts Longer term: need to relocate infrastructure	Low

9

What is a catastrophic power outage?

- Events beyond modern experience that exhaust or exceed mutual aid capabilities
- Likely to be no-notice or limited-notice events that could be complicated by a cyber-physical attack
- Long duration, lasting several weeks to months due to physical infrastructure damage
- Affects a broad geographic area, covering multiple states or regions and affecting tens of millions of people
- Causes severe cascading impacts that force critical sectors—drinking water and wastewater systems, communications, transportation, healthcare, and financial services—to operate in a degraded state

Source: NIAC, 12

3. The role of local energy in climate change adaptation

While most discussion around DER and climate change has focused on their potential for mitigation by reducing greenhouse emissions, they may also have an important role play in adapting to the impacts of accelerating climate change, in at least two ways:

- By increasing consumer autonomy and control (or "private resilience").
- By increasing system resilience.

Autonomy and control

The main way that Australians are increasing their autonomy and control in relation to their energy supply is by investing firstly in rooftop solar (over two million systems to date), and now also in home batteries, in rapidly increasing numbers, driven in large part by government rebates.

Surveys show that having more control over bills is the second or third most common reason for buying a home battery (after the belief that they will reduce power bills, and before or after environmental motivations).[10] Some Australians see their energy supply as one facet of life in which they can express their desire for autonomy from governments and corporations which they may not trust to act in their individual or the broader public interest.

A second strategy is to invest in a solar and battery system which can operate in island mode if there is a blackout on the grid. There do not appear to be any reliable statistics on the numbers or percentage of home battery systems can operate in islanded or backup mode, and it is likely that many owners are making this purchase on the assumption that the system will operate offgrid when in fact most do not.[11]

Thirdly, people also talk about going offgrid, usually with the help of a backup petrol or diesel generator, although there is little evidence of significant numbers of households going offgrid at this point.[12] That is, it is a desire rather than a practical option. In practice, most offgrid households are in isolated locations and are offgrid not by preference but because there is no grid connection available, or the cost of a grid connection is higher than the cost of a stand-alone power system.

But going offgrid does not necessarily lead to the best environmental outcomes, for several reasons:

- Investing in (additional) rooftop solar energy capacity generally reduces energy sector emissions more than a similar investment in home solar batteries (unless the latter are used to store excess solar energy that is below minimum demand and may otherwise need to be curtailed, and the energy is then consumed in the evening instead of fossil fuelled generation).
- Surplus generation from offgrid solar systems is wasted rather than exported to the grid and displacing non-renewable generation used by others. (Alternatively, home batteries can be sized to meet maximum demand, but in this case most of the capacity would be wasted most of the time.)
- Whether lead-acid, lithium-ion or other technologies, chemical batteries take energy and resources to manufacture, have limited lifespans, and contain materials that may be toxic to dispose of.
- The cheapest and simplest way to increase autonomy and control, and to produce a net environmental benefit, is usually to invest in energy efficient homes, retrofits and appliances.

If an increasing number of households go offgrid, there are also implications for other consumers—especially those unable to increase their energy self-sufficiency, perhaps because they have low household income or wealth, rent their homes, or they live in apartments. The cost of running and maintaining electricity networks is largely determined by the size of the network, not by the number of customers connected or the amount of electricity they use. This cost is shared by all the connected customers, who pay the network provider via their retail electricity bills. If a significant number of customers leave the network, similar costs need to be shared by those that remain, leading to higher costs for all of them.

Some, but not all, of the same arguments are made in relation to people who install solar but do not go offgrid. They are helping to reduce their own, and the system's, energy emissions. And in bulk, rooftop solar reduces and pushes out peak demand to later in the day, helping to reduce wholesale market prices. But while solar customers draw much less electricity from the network than those without solar—and thus pay lower network charges, which are based on usage—on average their peak demand is still similar. Because peak demand is a significant driver of new network investment, solar customers actually pay a smaller share of this cost. This increases the cost burden for non-solar customers. Fortunately, there is a range of remedies to this potential problem, including network tariff reform.

In short, there are systemwide as well as individual advantages to increasing energy self-sufficiency, but also some potential downsides in the case of going completely offgrid. Perhaps counterintuitively, a better self-sufficiency outcome may be achieved by remaining grid connected. This will be clearer when we also consider how DER contribute to energy resilience.

The rapid growth of local energy is creating other options for increasing control or autonomy, including community energy projects, microgrids and virtual power plants (VPPs). These options all give less autonomy than individual offgrid systems, but can be designed to increase local system resilience while creating other benefits including—in the case of community energy projects—greater community cohesion and local employment.

The view from FERC

In the US, the federal regulator FERC initiated a a new proceeding (Docket No. AD18-7-000) in January 2018, ordering regional transmission organisations (RTOs) and independent system operators (ISOs) to provide information about the resilience of the bulk supply system. In doing so, it explicitly rejected the Trump administration's attempt to prop up ageing coal and nuclear plants, and instead identified as risks "the threat of cyber or physical attacks and natural disasters, such as the extreme weather events that are occurring more frequently as a result of climate change."

The FERC docket is also notable for Commissioner Glick noting in general terms the contribution of DER to system resilience:

> …it is important to consider the advantages that newer technologies, such as distributed energy resources, energy storage, and micro-grids, may offer in addressing resilience challenges to the bulk power system.

Resilience

In recent years there has been an increasing emphasis on the need to ensure that the energy system is resilient to climate change impacts—especially severe weather events. But what do we mean by resilience? Here's how Energy Networks Australia defines it:

> Climate resilience is the ability of a system to absorb climate-related disturbances while retaining the same basic structure and ways of functioning. With respect to network assets this refers to the ability of assets to absorb climate related impacts but still retain adequate, reliable and safe functioning.[13]

Similarly, in the US, in 2018 the federal regulator FERC defined resilience as "The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[14] For instance, the grid of Puerto Rico is being rebuilt after the devastation of Hurricane Maria in 2017 with a new emphasis on microgrids and minigrids, because the government recognises that they offer greater resilience than a system dependent on either a single transmission backbone or a fully distributed system.[15]

With the release in 2015 of its *Climate Risk and Resilience Industry Guidance Manual*, ENA pioneered a holistic approach to this issue in Australia. Rather than attempting to specify and quantify projected climate change impacts, the manual adopts a strategic decision tree or matrix approach "to assist businesses in the identification, quantification and projection of potential asset impacts as a result of a climate change."

Nevertheless, it does identify some increasing risks, including more frequent and severe cyclones and bushfires.

But the objective of the manual is "to assist our energy network businesses and external stakeholders alike to assess the risks of a changing climate and develop adaptation plans that addresses the 'high' risks that were identified." That is, it is, quite reasonably, focused on network businesses. The question for us, on the other hand, is, "How might DER contribute to system resilience?"; or more specifically, "What are the options for consumers to use DER to improve their own, and the community's collective, energy system resilience in the face of accelerating climate change impacts?"

Fundamental to this different perspective is the recognition that, on the one hand, the less an energy supply relies on long lines and multiple poles, the less exposed it is likely to be to severe weather events. On the other hand, a supply which is self-contained or freestanding is still vulnerable to localised severe weather events such as floods and tornadoes, but those risks exist regardless of whether the system is a SAPS, a microgrid or a traditional network. *The sweet spot would appear to be a system which can operate in standalone mode while also been connected to a local grid which can be islanded from the centralised supply system when necessary.*[16]

Potential roles for DER in climate change adaptation

	ACTION	PERCEIVED CLIMATE CHANGE ADAPTATION BENEFIT*	POTENTIAL RISKS** & DOWNSIDES
1	**Reduce energy consumption**	Reduce reliance on grid electricity Increase economic independence	Some vulnerable people reduce comfort &/or safety to save energy & money
2	**Improve home energy efficiency**	Reduce reliance on grid electricity Increase economic independence	Some higher upfront costs
3	**Shift loads to match rooftop solar output**	Reduce reliance on grid electricity Increase economic independence	Some users have low ability to load-shift
4	**Install energy management hardware and/or software**	Reduce reliance on grid electricity Increase economic independence	Cybersecurity
5	**Install rooftop solar and sell excess for FiT**	Reduce reliance on grid electricity Increase economic independence	High bidirectional flows can cause overvoltage &/or thermal capacity issues
6	**Install islandable rooftop solar**	Generate electricity during grid blackouts on sunny days	More expensive upfront than grid connected system Only works when sun shining
7	**Install grid-connected home solar battery**	Reduce reliance on grid electricity	Less resilient than islandable battery
8	**Install islandable home solar battery**	Generate electricity during grid blackouts	More expensive than grid connected system
9	**Install stand-alone (offgrid) power system (solar + battery, with or without genset)**	Eliminate reliance on grid electricity Generally higher reliability in fringe of grid Reduced bushfire risk	High upfront cost Reduced resilience in the context of some localised severe weather impacts (compared to grid connection)
11	**Buy EV with vehicle to home or grid capability**	Generate electricity during grid blackouts	Limited current availability of these models Faster depletion of battery capacity Complex tech interfaces required
12	**Do P2P trading**	Share local energy—potentially with non-DER owners	Complex tech for trading platforms Cybersecurity
13	**Support community solar project**	Share local energy—potentially with non-DER owners Economies of scale compared to individual systems	Network charges reduce financial viability
14	**Build islandable microgrid**	Generate electricity during grid blackouts Economies of scale compared to individual systems	Greater ownership and management complexity Greater exposure to localized disruptions (distribution lines)

15	**Build community batteries at local substations**	Share local energy—potentially with non-DER owners Economies of scale compared to individual systems Access to multiple value streams (solar storage, arbitraging, FCAS, etc)	Multiple value streams create regulatory complexities High upfront cost
16	**Underground power lines**	Higher reliability Lower bushfire risk	Prohibitively expensive in rural areas

* Aside from a greater sense of control + autonomy (common to all of the above)

** Aside from the risk of stranded transmission assets in the long term (common to most of the above)

What is a microgrid?

Put simply, a microgrid or minigrid is a small network of facilities, buildings or properties a local source of supply/ generation, storage, switching, and controls. There are several types:

1. Stand-alone or disconnected from the main grid.
2. Attached to the main grid but able to function independently (ie, in island mode).
3. Permanently attached to the main grid via a single connection (aka embedded networks)
4. Permanently attached to the main grid via multiple connections (aka meshed networks).

In this paper, the term microgrid is used generically to refer to any or all of the above options. The fundamental principle is that, with the exception of type 1 above, microgrids containing local generation and storage have the potential to provide at least one additional source of supply and connection when the main grid is down.

Rocky Mountain Institute has been a global leader developing and advocating for role of microgrids in increasing energy system resilience. In their work in Caribbean island nations, microgrids not only often reduce costs for customers (when compared to imported diesel-powered power systems) but also support adaptation to climate impacts (e.g. hurricanes). Here is how they explain the role of microgrids:

> Microgrids can be connected to the larger electricity grid; however, in the event of a widespread outage, microgrids will disconnect from the main grid and continue to operate independently to maintain electricity supply to the homes and businesses that are connected to the microgrid's electricity network. The same incentives leading to an increased uptake of connected microgrids—improved reliability, greater sustainability, and lower costs—are also driving the transformation of isolated microgrids, such as island grids.

4. Towards a resilience metric

The nearest proxy we have for system resilience at present is reliability,[17] as measured by the number and total length of outages annually. However, reliability is a systemwide measure of the frequency and duration of interruptions to supply from all causes, and does not in itself help to identify the factors that contribute towards resilience.

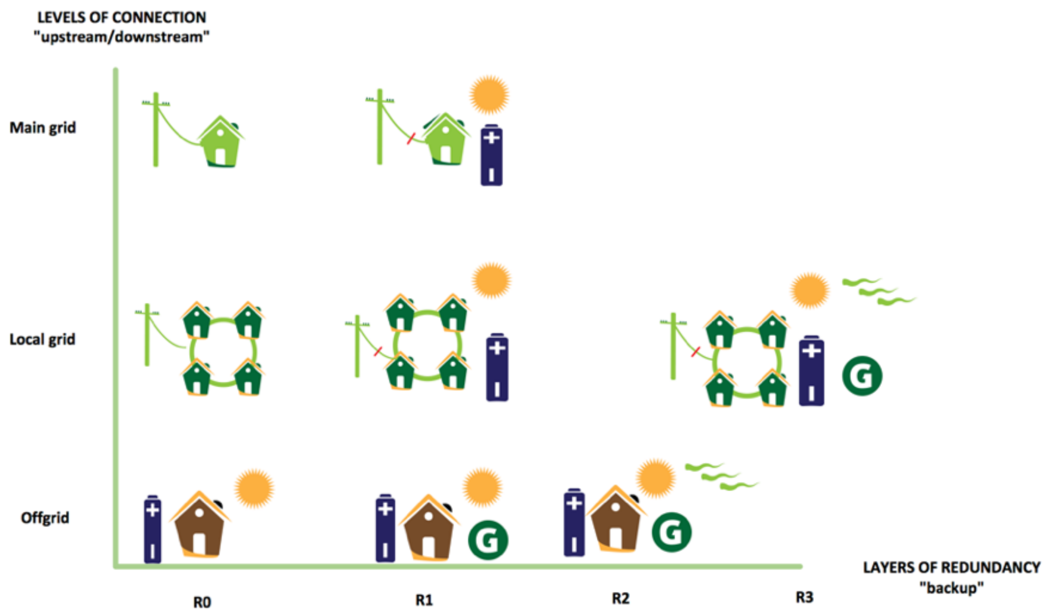
We have identified four key characteristics of a resilient energy system:

1. **Toughness**: Infrastructure that has been engineered to withstand extreme weather (eg, by undergrounding powerlines).
2. **Flexibility**: The ability to adapt to changing conditions (ie, grid management/behavior and technology), including
   - Detecting and self-repairing faults.
   - Installing some portable assets—batteries, gensets.
   - Prioritising critical loads during emergencies.
   - Speedy recovery after breakdowns.
3. **Generation redundancy**: So if one source of supply goes down, another is available.[18]
4. **Network redundancy**: That is, access to a network that is meshed to provide continuity of supply when one line goes down; or is equipped with smart routing and controls so network failures can be isolated and don't lead to cascading failures.

The figure below shows one attempt to illustrate how the last two of these four factors might influence system resilience. Unlike reliability metrics, it is focused on individual customers rather than the system as a whole. The x axis focuses on generation and storage, and represents degrees or levels of redundancy. The y-axis is focused on networks, and represents the levels of connection.

Our working hypothesis is that for more resilience, it is better to have multiple sources of supply, and to be connected at more than one level of the system.

A two-part visualisation of local energy resilience



Notes
On the y axis, main grid, local grid and offgrid represent three different types of connection (or disconnection), so this axis is not intended to be a progressive scale. G stands for genset. A line though the wire between the grid and in the house indicates an islandable supply. 4 houses joining in a circle indicates a microgrid, which may have access to a community batteries, solar or gensets.

The highest level of resilience would be facilitated by the middle row of the right hand column, where a DER owner is on an islandable microgrid and has both upstream and downstream connections (so they can still have power if 2 levels of connection go down); and the combination of wind, solar, battery and a genset means they still have power if one or more sources of generation or storage is unavailable.

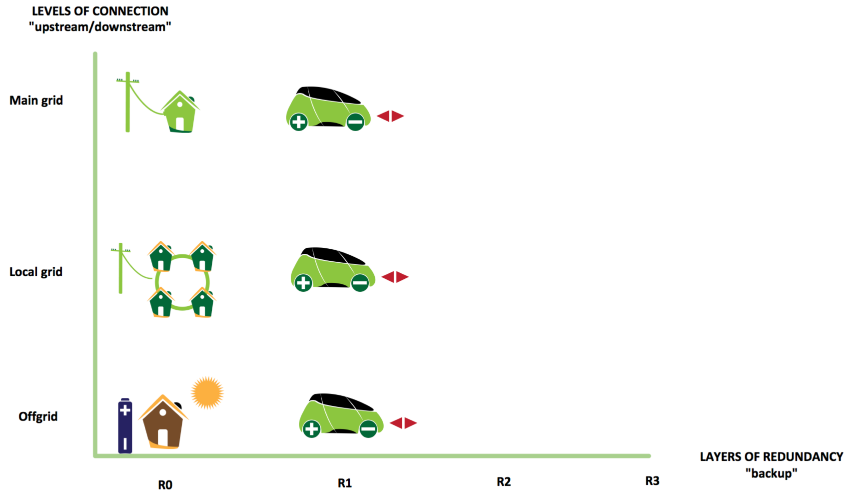
However, this is also amongst the most expensive solutions, and if an approach like this is further developed, it would need to balance resilience with cost. In the meantime, the sweet spot would appear to be in the middle of the chart, where there is access to at least one level of both backup generation and grid connection without incurring extreme expense.

The other issue that requires more thought is how to value community scale versus individual household solutions, given that the former are usually more cost-effective well also improving access to resilient DER products and services to more households and businesses.

Flexibility

Let's look at how another factor contributing to resilience, flexibility, might fit into this schema. There is one emerging technology that will leapfrog all these levels and stages. If you have an electric vehicle (EV) that can feed power back into the home or grid (V2H or V2G capability), then (putting aside the technical and regulatory issues for now) you not only have a backup supply source; you can potentially provide power to households that are offgrid and on a microgrid as well on the main grid—not only your own house but your neighbours, too. With a fleet of EVs, you potentially have a midscale mobile battery that could be deployed at short notice to wherever it is needed until agreed the grid recovers. That makes a full three levels of connection, and an extra layer of redundancy. It is not surprising that V2G technology emerged first in Japan, as a response to the Fukushima nuclear power crisis. It was all about increasing resilience.[19]

A third factor: flexibility

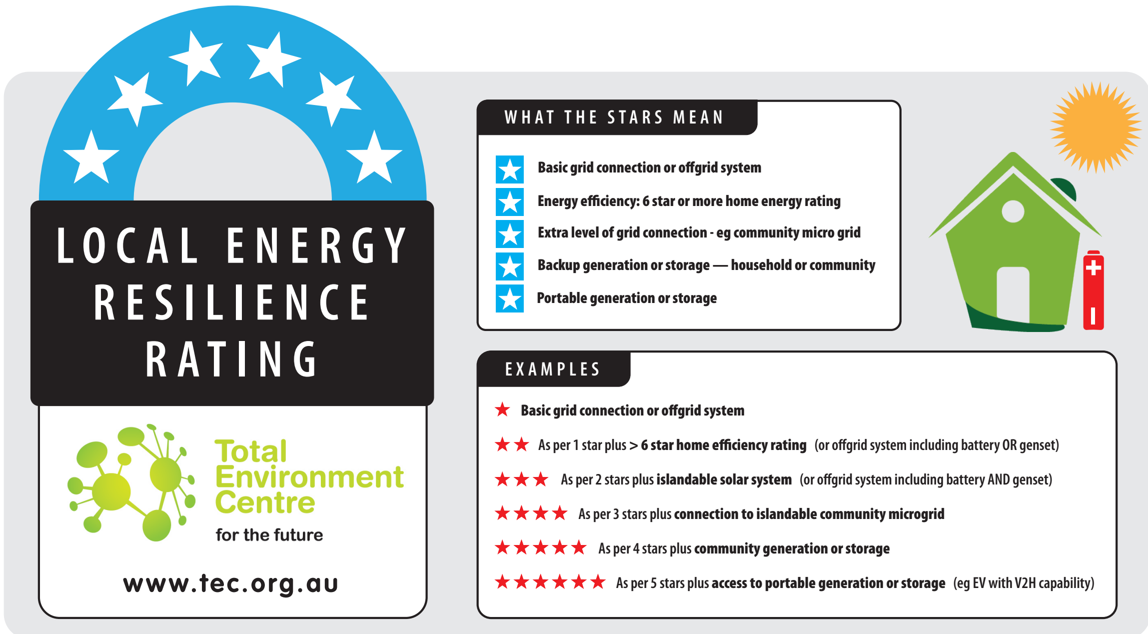


Note

The red arrows in front of the car indicate V2H/G capability.

What difference would it make, having a metric like this in our toolkit? Even in its relatively crude current form, a resilience metric like this will tell consumers that they would be better off staying connected to the grid but having a system that can continue to operate if either the main grid or their own system goes down (or, in future years, get an EV with V2H/G capability), instead of either maintaining a standard grid connection at one end of the spectrum, or going totally offgrid at the other extreme. Future iterations could be useful in, say, making choices about where to live or what capital investments are likely to reap the greatest rewards in respect of increasing household or community resilience.

Below is one user-friendly way of representing a resilience metric which reflects the above graphs in a simplified format, based on existing appliance energy rating labels.



5. Valuing DER in climate change adaptation

The best proxy for the value that individual consumers place on increasing resilience in the face of climate change impacts is probably the amount of money they are willing to pay for *backup supply*. The second parameter, *levels of connection*, could be valued by applying the concept of the value of customer reliability (VCR) to the level of individual consumers rather than on a region-wide basis. At this stage we are not aware of any straightforward way of valuing the third parameter identified above—ie, *flexibility*.

There may also be collective public or systemwide benefits from climate-resilient local energy. For instance, a microgrid which is able to island itself and continue to operate when there is a threat to grid supply not only increases the resilience of microgrid consumers; it also reduces the burden on the main grid, because a lower load means less risk of blackouts caused by thermal overloads and less power is required to restart it. It also reduces the cost burden on other consumers of new or replacement capital expenditure, because the grid can effectively be constructed and maintained for lower peak demand. (This is aside from the value streams of standard DER, such as wholesale price arbitraging and frequency and voltage control.)

While these resilience related services are not currently valued, this is likely to change in the near future, as energy sector stakeholders recognise the need for dynamic pricing of DER products and services to fairly allocate the costs and benefits.[20]

Although it presents its own complications, another perspective on value might be suggested by the experience of networks (such as PG&E in California and Ausnet in Victoria) which have been successfully prosecuted when their poles and lines, downed by high winds or lightning strikes associated with questionable vegetation management, have then caused catastrophic bushfires.[21] However, not only such damages but also the savings from going local to avoid this outcome are difficult to predict.

Elsewhere, this issue was the subject of an April 2019 report by the US National Association of Regulatory Utility Commissioners. It discussed "four different specific methods that have been used to analyze the resilience value of DER: contingent valuation, the defensive behavior method, the damage cost method, and input-output modeling."[22] The report observed that

> Although it is clear that DERs offer resilience benefits, it is unclear how to determine the value of those benefits. Identifying appropriate methodologies to calculate the value of resilience will be an important step toward ensuring that resilient DERs are considered alongside alternatives and integrated into future energy infrastructure and investment planning efforts.[23]

The view from RMI

Rocky Mountain Institute is one of the world's leading energy transformation thinktanks. With a mission to transform global energy use to create a clean, prosperous insecure low carbon future, in recent years it has been increasingly focusing on energy system resilience—for instance, in developing microgrids in Puerto Rico after the devastation of Hurricane Maria in 2017, and by advocating for building energy efficiency improvements.

Another RMI project focused on building community scale energy resilience close to RMI's Boulder, Colorado headquarters after nearby bushfires in 2018. According to an RMI blog post, "the local electric cooperative… has partnered with RMI to explore solutions for increasing energy resilience in the communities it serves."

An April, 2019 stakeholder workshop come up with a number of ideas for increasing local energy system resilience including:

- Community microgrids
- Bulk supply resilience
- Mobile generation fleet/refuge centre backup supply
- Critical services energy assessment
- Gas pump resilience
- Adding battery storage or a microgrid to a planned solar farm
- Improving building energy efficiency

6. Pros and cons

The shift to a high DER system has advantages other than greater climate resilience, including benefiting from more efficient utilisation of the distribution network (because it is being used for two-way flows), lower line losses, and fostering community awareness and cooperation.

But without proper management, the shift to more local energy also brings with it a range of risks and vulnerabilities, including:

- The inherent variability of renewables without storage, which can create risks to system security (see Appendix 3).
- Technical challenges related to high bidirectional flows (especially in relation to over-voltage and thermal constraints).
- The susceptibility of local as well as centralised energy infrastructure to severe weather impacts (especially, in Australia, bushfires).
- The generally higher cost of supplying isolated or fringe of grid customers.
- The generally higher capital cost per kWh of output of small scale energy systems.
- The potentially unfair distribution of economic costs and benefits (see below).
- Existing networks are providers of last resort and customer protections are well documented and known, whereas these systems have more risks regarding customer safety and protections.

A highly climate resilient local energy system is also likely to have a higher upfront cost than a non-resilient one, for several reasons:

- The local grid would be need to be meshed or reinforced to provide an extra layer of connection (ie, redundancy).
- Customers would need to have backup sources of generation and storage.
- Household batteries do not currently pay for themselves within the warranty period under most circumstances.
- There is currently little live monitoring of local low voltage networks (ie, voltage, frequency and other fault detection).
- Most households do not yet have advanced energy monitoring and management software.

However, while this is yet to be quantified, the higher upfront cost is likely to be more than offset by the financial and other advantages resulting from higher reliability and lower replacement costs.

Second, there are emerging opportunities to overcome some of the costs and other challenges, including aggregating capital procurements (eg for VPPs) and substituting individual household batteries with community scale batteries located at network substations, where they can potentially also provide network benefits such as peak demand management and voltage control.

7. Equity implications

There is a risk that more affluent households will simply buy themselves a higher level of climate resilience —for instance, by going completely offgrid—leaving low income and other vulnerable households dependent on the old centralised energy system and therefore simultaneously at the mercy of severe weather events and left to foot the bill to restore power after catastrophic blackouts and strengthen the network to better withstand such events.

The foundational principles that policy makers, regulators and other stakeholders should adopt to create a climate resilient local energy system that is also fair are twofold (in order of priority):

1. Energy is an essential service which should be provided in a safe, affordable and environmentally sustainable manner independent of a consumer's financial or other status.
2. The costs of shifting to a more climate resilient local energy system should be shared fairly by its users, in proportion to costs they impose on it and the value they derive from it, and with consideration of their capacity to pay and to invest to improve their own resilience.

(A fuller list of DER equity principles is contained in Appendix 2.)

Applying these principles, a climate resilient energy system that is also equitable would encourage DER owners to stay connected to the main grid, while also sharing their energy locally via microgrids, VPPs, P2P trading and community energy projects such as solar gardens and community scale batteries.[24]

8. Lessons from the survey

We undertook two surveys to ascertain whether others shared our concern about this issue, what they had done about it, and what they were planning to do. The first contained 10 questions and was sent to members of Renew and the Facebook group My Efficient Electric Home. The second contained three of the same questions and was sent to Solar Citizens supporters. (See Appendix 1 for the questions.)[25]

The main findings are as follows:

1. Respondents recognised that household and local systems can play an important role in increasing overall energy system resilience in the face of accelerating climate change impacts. This supports TEC and Renew's preliminary view.
2. Conversely (but happily), the survey results did not support our initial suspicion that respondents would favour offgrid solutions to increase resilience.
3. However, the survey also highlighted some issues we had not considered in depth in relation to increasing household and local community resilience, including:
   - Alternatives to not only fossil fuels but also electricity per se.
   - The advantages of more local energy include greater transport system resilience, by lowering fuel import and storage needs.
   - The importance of urban planning and building energy efficiency in increasing energy resilience by reducing energy needs.
4. The key message from the survey for individual households is that their own resilience is best safeguarded and reinforced through a combination of behind the meter resources, local connections like microgrids, and maintaining a connection to the main grid.
5. In relation to public policy and regulation, the survey showed that more attention needs to be paid to a variety of issues including:
   - The need for a thorough and independent assessment of the vulnerability or resilience of different parts of the energy system—especially cost benefit analyses of local versus centralised supply and stand-alone versus islandable microgrids.
   - The extent to which energy system automation and sophisticated communications increase resilience — or, by contrast, increase vulnerability (eg via the risk of cyberattacks).
   - The role of public buildings as emergency shelters (reinforcing the role of local energy systems).
   - Whether the standards for DER are stringent enough to prevent damage during severe weather events (without being prohibitively expensive).
6. The survey also reinforced the need for greater energy literacy in a high local energy environment, especially around the benefits of community rather than individual or centralised solutions.

9. Other findings and recommendations

7. The ***keywords*** for a resilient high DER energy system appear to be diversity, flexibility and backup (rather than, say, autonomy and self sufficiency).
8. In regard to energy ***equity***, a climate resilient energy system that is also equitable would encourage DER owners to stay connected to the main grid, while also sharing their energy locally via microgrids, VPPs, P2P trading and community energy projects such as solar gardens and community scale batteries.
9. There are ***benefits to distribution networks*** as well as DER users of increasing reliance on local energy, including
   - Reduced risks from power lines being damaged during storms and bushfires.
   - Reduced expenditure on vegetation management.

- Reduced expenditure on upstream (transmission, sub transmission and HV) infrastructure, especially end of life asset replacement, whereupon a DER-heavy system should allow lower capacity upstream assets to be introduced.

10. Networks and regulators should be encouraged to recognise these benefits through the ***regulatory regime***. This relates especially to the question of how to introduce a metric to measure the resilience of individual users and local communities, which warrants more detailed consideration.
11. Like community energy groups and projects, a focus on the local energy system has potential ***co-benefits*** beyond increased climate change resilience, including greater community cooperation and cohesion.

10. **Conclusion**

The concept of resilience has only recently been applied to energy systems, and this may be the first attempt in Australia to apply it to local energy or DER in particular. As such, it raises more issues which warrant further investigation rather than provides definitive answers. While our contact with DER owners has convinced us of their interest in this issue and their goodwill in contributing to solutions, the onus should now be on policymakers to pursue policy and regulatory reforms that will help us to build climate-resilient local energy systems that can operate in the broader public interest and complement measures to improve resilience in the centralised energy system while preparing us for a future of increasing climatic instability.

Appendix 1: Survey results and analysis

Renew (long version)

There were 141 responses from members of Renew and the Facebook group My Efficient Electric Home. Please note that TEC and Renew do not necessarily agree with all the responses listed below.

Multiple choice questions

Q1. How concerned are you about the likelihood of more frequent, intense and prolonged severe weather events?

Nearly two-thirds (65%) said they are concerned 'a great deal', while only 5% said they were not, or only a little, concerned.

Q2. How much thought have you given to how your energy supply might be impacted by severe weather events?

Half (52%) said they had given it a great deal or a lot of thought, while only 13% had considered it a little or not at all.

Q3. How important is household energy self-sufficiency in adapting to the current and likely impacts of severe weather?

Over two-thirds (69%) said this was extremely or very important, while only 3% said it was not important.

Q4. What have you already done that increases your household energy self-sufficiency?

The most common responses were improving home installation/thermal performance and buying more energy efficient appliances (both 84%). Over three-quarters (77%) had also installed rooftop solar. This highlights the variance between survey respondents and the broader population, of which a little over 20% have installed rooftop solar.[26]

Q5. If you have recently installed rooftop solar or a battery, did you specify that it should be able to operate when the grid is down or if you go offgrid (i.e. in islanded mode)?

Nearly one-third (31%) had specified offgrid/islandable capability.

Q6. What else are you considering doing that increases your household energy self-sufficiency?

Half (49%) said buying an electric car. Other common responses were installing a battery (40%), buying more energy efficient appliances, improving home insulation/thermal performance (30%), installing rooftop solar (23%) and joining a virtual power plant (20%).

Q7. If you could afford to spend whatever was necessary, what would be your preferred approach to achieve a reliable energy supply in the face of increasing extreme weather events?

Nearly two in five (38%) said they want to stay connected to the main grid. A quarter (27%) want to be part of a grid-connected microgrid. One in five (18%) want to go offgrid.

Q8. If your answer to the previous question included fully disconnecting from the electricity grid, what is your main reason for wanting to disconnect?

A desire for energy independence (26%) and lack of trust in governments or the energy industry (22%) were the most popular answers.

Q9. How do you think governments or the community should support people who can't install energy equipment to manage the impact of extreme weather on their energy supply?

Nearly two-thirds chose one or more of four choices:

- Incentives for landlords to install solar, batteries, etc.
- Subsidies for low income owner-occupiers to install solar, batteries, etc.
- Regulatory reforms to make it easier and cheaper to share local energy.
- Subsidies or special programs support the establishment of microgrids to share local energy.

No-one thought that it's not a problem that needs to be solved.

Open-ended questions ("other—please specify")

Q4. What have you already done that increases your household energy self-sufficiency?

Common themes

- Load shifting to match solar output
- Moved away from gas
- Audited energy consumption
- Backup from generators, camping gear
- Replaced electric hot water system with heat pump unit
- Installed solar hot water system

Notable answers

- Specified white roof
- Built DIY Powerwall (battery)
- Use of personal heating devices (eg battery heated jackets)
- Grow own food
- Installed outdoor blinds and grown plants to shade windows (renter)
- Bought electric bicycle
- None of the options are available to renters
- Joined solar-friendly electricity retailer

Q6. What else are you considering doing that increases your household energy self-sufficiency?

Common themes

- Build PassivHaus
- Get off gas
- Install hydronic heating

Notable answers

- Biofuel generator
- Solar oven

Q7. If you could afford to spend whatever was necessary, what would be your preferred approach to achieve a reliable energy supply in the face of increasing extreme weather events?

Notable answers

- Microgrids connected to the grid are useful but far more agile and efficient coordination at Federal level would go a long way.
- Develop ways of meeting household needs that do not rely on home energy supply, as many weather events that disrupt access to the grid are also likely to disrupt any home-based energy resource or make it unsafe to use.
- Use our EV as an emergency electricity source (V2H)
- I'm not that concerned. Losing power won't be the end of our world! I have lived through a hurricane. Stock up on ice!

Q8. If your answer to the previous question included fully disconnecting from the electricity grid, what is your main reason for wanting to disconnect?

Notable answers

Rural infrastructure is still poor

Manage unpredictable risks like cyber terrorism taking grid down

Energy produced and used locally is more efficient

This [going offgrid?] would be a sad waste of an asset.

Q9. How do you think governments or the community should support people who can't install energy equipment to manage the impact of extreme weather on their energy supply?

Common themes

- Improve energy-efficiency of rental housing/mandate minimum standards
- Loans rather than subsidies; solar should pay for itself
- Take action to reduce emissions to minimise extreme weather events related to climate change.

Notable answers

- Ethical investment fund to provide low interest loans
- Rooftop solar is a very individual action that discriminates those who can't afford it or access the benefits
- Make the grid as robust as is reasonable.
- Raise standards or use market mechanisms so that industry drives the change over rather than setting up reliance on the public purse.

Q10.What else should we be thinking about in relation to the role of local energy in increasing energy system resilience?

Common themes

- Underground rural power lines in bushfire-prone areas
- More emphasis on energy efficient housing stock
- Remove constraints on solar exports
- Encourage load shifting to make better use of solar

Notable answers

- Local community buildings and shelters/refuges should be able to operate in times of crisis
- Prioritise vulnerable populations and businesses
- More pumped hydro and energy storage
- More emphasis on bioenergy, geothermal
- Get the media involved
- Solar powered EV charging stations
- Reduce reliance on long distance electricity transmission lines.
- Small, local (suburban) nuclear energy power stations.
- Discourage use of gas
- More education about the advantages of solar
- Residential wind turbines
- Tidal and wave energy
- Need to address transport energy consumption
- Increase grid resilience so it can cope with large intermittent inputs from wind, solar etc.
- Home pumped hydro power and home hydrogen power.
- Feed in tariffs more representative of true value
- Upgrade transmission network and connect EVs to a smart grid
- Promote solar hot water
- Supporting communities to establish local power generation - grid-connected but local
- Subsidise microgrid installation
- Low interest loans to help more people make the energy transition

- Use public buildings such as libraries and carparks as solar panel sites
- Better and cheaper batteries
- Don't preference local over central provision as a matter of ideology
- Public owned utilities with operational social principles to avoid gaming the system
- Encourage people with solar, batteries and EVs to provide services to the grid to help to stop blackouts
- Address structural vulnerability
- Direct public investment to where resilience matters most - where grid is under-capacity or in areas most vulnerable to disruption
- Address rural land use conflicts
- Local manufacturing and food production to minimise transport energy
- Community scale batteries in substations

Analysis

Respondents showed a high degree of interest or concern in relation to climate change in general and the resilience of their energy supply in particular. This was to be expected in view of the groups selected for surveying.(Q1,2)

Respondents showed a high degree of interest or concern about the present or potential role of their own homes in increasing energy resilience. (Q3,4,5)

It is notable that half of respondents thought that buying an electric car would increase their energy self-sufficiency. (Q6) This could be either because they planned to power their EV from rooftop solar, or because they were thinking of some EVs' V2H capability.

The preference of respondents for staying connected to the main grid or being part of a grid-connected microgrid, rather than wanting to go offgrid was unexpected but reflects a high degree of energy literacy. (Q7,8) That is, while aware of the resilience issue, unlike survivalists they did not generally assume that the best response would be to completely self-sufficient.

On the other hand, those who were interested in fully disconnecting from the main grid spoke about the poor standard of electricity infrastructure in rural areas, unpredictable risks like cyber terrorism taking the main grid down, and the higher efficiency of energy produced and used locally (presumably because of lower line losses and the reduced need for upstream poles and wires).

Respondents were highly supportive of a variety of efforts to support households which were not DER owners themselves. (Q9)

Some respondents noted solutions to increase local energy resilience that we had not canvassed, including

- Passive solar home design
- Moving away from fossil fuels for stationary energy and transport
- Having alternatives to electricity for home energy supply (eg biofuel generators, solar ovens, residential wind turbines, shallow geothermal for hydronic heating, home pumped hydro and hydrogen energy)
- Relying on camping equipment in blackouts
- Using personal heating devices to reduce consumption
- Solar powered EV charging stations

There was also interest expressed in improving consumer energy literacy through media and educational campaigns.

Some responses focused on policy and regulatory reforms, including

- Lifting export limits on rooftop solar energy and ensuring that feed in tariffs are more representative of its true value
- Undergrounding rural power lines in bushfire-prone areas
- Encouraging load shifting to make better use of solar (presumably through tariff reform)

- Increase grid resilience so it can cope with large intermittent inputs from wind, solar etc.
- Subsidising microgrid installation
- Ensuring that local community buildings and shelters/refuges can operate in times of crisis
- Encouraging people with solar, batteries and EVs to provide services to the grid to help to stop blackouts
- Directing public investment to where resilience matters most—eg, in areas most vulnerable to disruption

Solar Citizens (short version)

There were 1,202 responses to the shorter version of the survey subsequently sent out by Solar Citizens to its supporters.

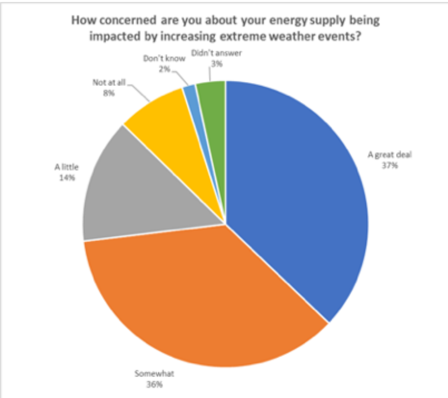
The three questions were as follows:

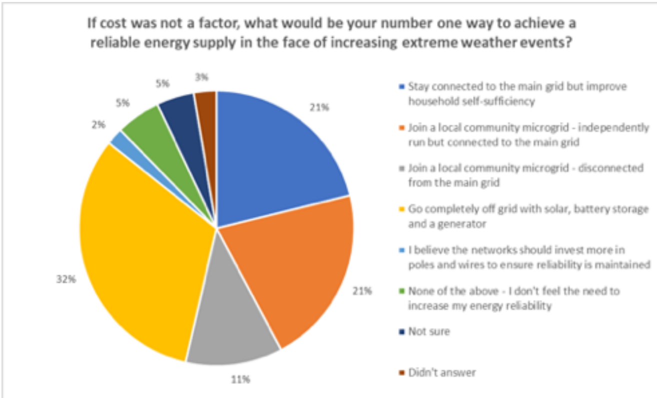
How concerned are you about your energy supply being impacted by increasing extreme weather events?

If cost was not a factor, what would be your number one way to achieve a reliable energy supply in the face of increasing extreme weather events?

Do you have other concerns or comments about the role of local energy in increasing energy reliability?

Responses to question 1 were similar to the Renew version. In relation to question 2, however, nearly twice as many Solar Citizens supporters were interested in going completely off grid. There are a number of potential explanations for this difference, but most would be speculative. What we do know about the Solar Citizens respondents specifically is that they skewed significantly toward the elderly (75% over 60) and males (two-thirds).





Below is a selection of Solar Citizens respondents' answers to the third question—some typical, others unusual. Most of the suggestions in the corresponding question in the Renew survey also came up in the Solar Citizens survey. One exception was that two respondents in the latter mentioned the need for solar access rights to prevent rooftop PV systems being overshadowed by neighbours or trees.

"The whole distribution network should become more resilient to faults, and increasing decentralised storage can help when parts of the network become temporarily disconnected. It still makes sense to remain connected as it means that power can be moved from where there's a surplus to where it's needed. Moving off-grid completely, on an individual household or even microgrid basis, would likely cause excessive use of backup generators as demands can be high based on a geographic region. Power distribution should become smarter, able to deal with power flows in all directions to support a resilient network of renewable generation, storage and consuming participants."

"I grew up with no elec. So to me I can live humble. If I lose power. My 90yr old Mum till she died recently washed sheets and towels by hand preferring not to start up her (collectors item) wringer washing machine wasting water for just one person…

Pple today are too dependent on their mod cons. I feel sorry for them. Everyone as a rite of passage should join Boy Scouts as kids and hi schools take classes on camp outs to teach them survivalist skills. I brought up my children camping a lot as a single mum with four children it was quite a task when I look back on it in the 80s and 90s we went camping a lot and to lots of festivals the children knew how to survive I don't mean camping with all the mod cons like they do these days in caravan parks I mean in the wild my 10 year old boy could dig a hole and have Hessian walls around poles for the toilet so we were quite comfortable and knew have to deal with our s*** which a lot of campers in the rough are totally disrespectful and leave mess around that attracts flies and then the Flies land on the food when my son was a teenager and went with a group camping he was the only one who knew how to build a fire they are hopeless hopeless City kids City kids some of them have never been bush have never been camping what are we doing bringing up kids on concrete and go home and just watch TV and play games that is not preparing human beings to survive without electricity you can have electricity from a battery I lived in Tasmania with 4 children with a battery for power I lived in a cow bales with no walls until I was washed out by the flood down the hill from a heavy rain storm. You don't need all those things in the kitchen appliances that suck power you don't need them I used to cook a roast in Queensland on a methylated spirits burner that you can buy at a camping disposal shop for a dollar 25 in 1975 it folds up the legs fold up and the little tiny hot with the holes in it where the flames come out is so small you can fit it in your handbag you can boil water on it for cup of tea you can cook toast on it with a toast rack thing that people don't even know what it is these days and I cooked roasts in a tray with oil I didn't have a fridge and 30 degree heat if the nut butter melted it didn't matter we used it melted and you only bought milk that you needed for one day and meat for the evening meal. We don't need hair dryers you don't need vacuum cleaners most of the planet use a straw broom to sweep out their mud huts and concrete floors like in villages in Egypt where I have been where the women have to carry water and they buy the food for the evening meal there's no leftovers there's no fridge. I think one of the best things to happen would be for the electricity to break down and people would have to learn to improvise to survive... hospitals hopefully can have enough fuel to run generators maybe we can design generators that run on cooking oil if it hasn't already been done because if I do need an operation I definitely would be thankful for the generator to keep all the systems happening at the hospital. I am sad that no one from solar citizens was seen interviewed as a spokesperson for election issues as get up got lots of bad press which was sad but you are in my opinion as I explain to people that you are a lobby."

"Australia needs policy changes to encourage provision of distributed renewable generation and enable local microgrids to deliver reliable supply, rather than building more powerlines. As well the asset values of existing overbuilt transmission & distribution powerlines need to be written down to reduce the high profits to monopoly network companies and reduce the network electricity cost component for consumers."

"I believe social licence to operate brings ethical/moral obligation to ensure energy supply is as equitable as possible - and that Big Energy has dropped their responsibility Big Time."

"Lack of laws guaranteeing access to sunlight. I have solar panels and my neighbour put a DA to heighten their house which puts my solar panels on my roof in the shade after 1pm"

"Reducing the large scale grids to smaller microgrids would add to the safety and reliability of electricity supply in the event of major grid failure causing many to loose power against only a few loosing power in a microgrid. It would also be easier and quicker to fix a breakdown with less adverse impacts."

"Would like to be totally independent so that I can disconnect from the grid when I want to but be able to feed into the grid to help others when needed."

"The refusal of energy authorities to accept as much solar energy as any household can generate is so selfish. Also short sighted. Households should be abe to generate as much as they can afford and the infrastructure needs to be upgraded to welcome the input.'

"Can the network cope with the extra solar generated power being fed back into the grid?"

"Already in some country areas, one cannot feed excess back into the grid because the network can't cope."

"study your history and you will see global worming is a mith"

"There should be a change in regulations allowing for large scale, incentivised demand management. People should be able to access their Smart meters and utilise these to control non-critical loads. WA is trialing a scheme where battery banks with inverters are connected at strategic locations, people can store excess output from their solar systems and recover this after hours (all for a fee). This system also facilitates being able to support the local network at times of heavy loading, curtailing the need to augment the network."

“we need energy efficiency rather than use more energy; that way people would not need to be so desperate about the amount of energy. some local energy solutions could be deleterious for the environment in other ways eg vegetation removal to make way for panels or towers or micro-hydro”

Appendix 2: Draft DER equity principles

This document is the work of the DER sub-group of the National Consumer Roundtable on Energy, and does not necessarily reflect the views of all the organisations represented on the Roundtable. It should also be regarded as a work in progress.

Context and objective

The NEM is moving towards a high DER energy system, driven by a combination of government incentives, consumer preferences and environmental imperatives. While acknowledging the inevitability of this transition, this group considers it is imperative that it happens in an equitable manner–ie that it

1. is inclusive of people and groups who may not be able to directly invest in, and derive financial benefits from, DER: renters, apartment residents and low income households; and
2. minimises material equity imbalances, wealth transfers or cross subsidies between DER owners and others, to ensure that the latter are not effectively paying for benefits they cannot access.

That is, our overarching objective is to support the shift to a high DER energy system that also increases (or ensures?) energy equity.

Principles

To help consumer advocates and others engage effectively in designing, and respond appropriately to the equity implications of, DER initiatives (ie, rebates/incentives and regulatory reforms), we suggest that the following principles should apply. They are not necessarily in order of priority, although the first three are probably the most important. Numbers one and two may be in tension, requiring a nuanced public policy response.

1. **Public good:** Government spending on DER initiatives should be targeted to achieve social and environmental as well as economic benefits for the whole system and broader public, social and economic policy outcomes rather than for the benefit of individual households and businesses.
2. **Fairness/equity**: Public spending on DER should be targeted to maximise not only the economic and environmental benefits but also to reduce inequity between consumer cohorts. This principle implies that:
    1. Low income and other vulnerable households should be the primary recipients of government spending on DER. Means testing and/or targeted approaches should be in place where appropriate.
    2. Subsidies for DER should not be recouped through bills, where low-income households pay disproportionately more of their income on electricity, and ideally come instead from government budgets.
    3. Where a historically regressive cross subsidy cannot easily be rectified by shifting costs to government budgets, complementary measures (e.g. energy efficiency programs) should be introduced to help people affected
3. **Causer pays and benefits**: Wherever feasible, those whose actions create costs to the system should pay those costs. Conversely, those who pay the costs should also be rewarded for the benefits they bring to the system.

---

4. **Transparency**: Wherever possible, the user and system-wide costs and benefits of DER initiatives should be made clear, so that policy makers and consumers can respond appropriately.
5. **Materiality**: When assessing the costs and any cross subsidies related to DER initiatives there is a need to determine whether these are material (ie, substantial), taking into account transactional costs, convenience/simplicity, and the extent to which costs are offset by corresponding benefits.

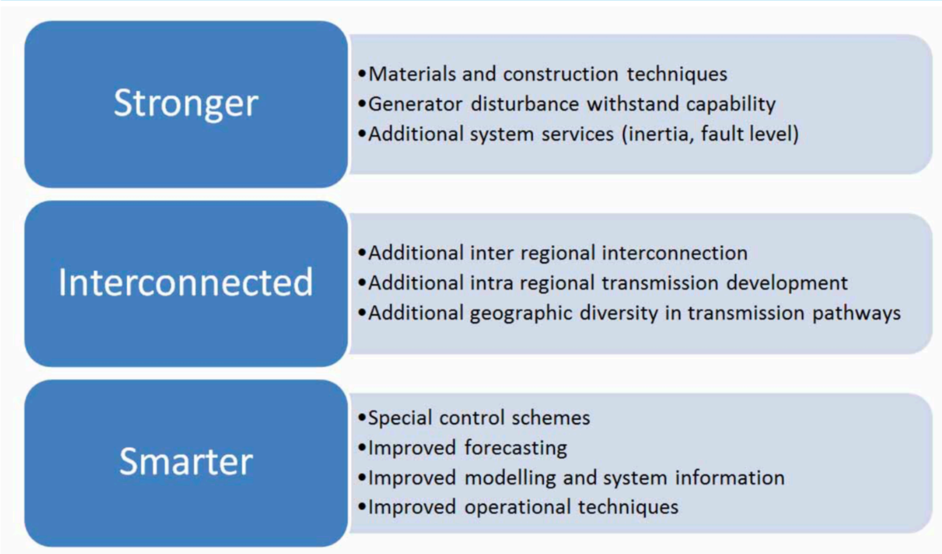
6. **Simplicity**: Where there is a choice of responses to unwind an inequitable cross-subsidy or mitigate an adverse impact of DER, , and the differences between them are otherwise minor, the cheapest and simplest measure should be chosen wherever possible.
7. **Complementary measures**: Sometimes the best way to ameliorate the regressive impact of a cross-subsidy, poorly targeted policy, or cost-reflective pricing design is not to unwind it but to introduce other measures that will help the people affected (e.g. via energy efficiency programs or taxation reforms).
8. **Messaging**: Given the escalating climate emergency, we should attempt to find solutions which increase the uptake of renewable energy—e.g. by making solar energy available to more low income and rental households—rather than sending a price or policy signal that renewable energy or DER owners are a problem.

Appendix 3: AEMC resilience review

The concept of energy system resilience formally entered the public domain in Australia shortly before the release of this paper with the AEMC's *Mechanisms to enhance resilience in the power system—Review of South Australia Black System Event, Discussion paper*.

In response to the increasing probability of High Impact, Low Probability (HILP) events, the paper proposes a number of regulatory reforms which are conceptualised in the figure below;

Figure 2.2: Options for enhancing power system resilience



The AEMC's approach represents a significant step forward in advancing understanding of, and responding to, challenges to energy system resilience related to severe weather events and cyberattacks. However, its only recognition of the role of DER in relation to resilience is to view them as a problem:

> AEMO has identified that high DER penetration, in particular small rooftop PV, may have increasing implications for the secure operation of the system. These include:
>
> - evidence that significant proportions of DER can disconnect or cease operating during power system disturbances (up to 40%), which in the future could translate into the sudden loss of hundreds of megawatts in regions like Queensland, Victoria [and] New South Wales.
> - under much smaller, localised distribution network voltage and frequency events, between 8-20% of monitored DER was observed to reduced generation to zero over unpredictable periods.
> - observed behaviour of DER under disturbed system security conditions indicate small percentage of rooftop PV fails to comply with existing standards, posing risks to system security predictability.[27]

These are real issues, but at a high level, if high penetrations of DER can create system security issues for the main grid, then the more DER can be localised via microgrids during HILP events, the less severe will be the wider impacts. Resolving the system security issues identified above will also benefit local DER users if they are separated from the main grid.

Conversely, we would encourage the AEMC to also consider the benefits of DER in managing and increasing system resilience by potentially increasing supply and connection options and flexibility, as explained in this paper (which will be formally submitted to the AEMC as part of the above process). However, unfortunately the Commission's assessment framework does not appear to allow recognition of the costs and benefits of localised versus centralised supply.

Endnotes

[1] From Jon Mooallem, "We have fire everywhere": *New York Times*, 31 July 2019: https://www.nytimes.com/interactive/2019/07/31/magazine/paradise-camp-fire-california.html.

[2] See, eg, Cole Latimer, Australia one of the countries most exposed to climate change, bank warns, https://www.smh.com.au/environment/climate-change/australia-one-of-the-countries-most-exposed-to-climate-change-bank-warns-20180322-p4z5n8.html, 22 March 2018.

[3] See The Climate Institute, Coming Ready or Not: Managing climate risks to Australia's infrastructure, 2012; Energy Networks Australia, Climate Risk and Resilience - Industry Guidance Manual, 2015.

[4] See also TEC and Renew, Cross about subsidies: The equity implications of rooftop solar in Australia, discussion paper, 2018.

[5] See eg https://theconversation.com/state-of-the-climate-2018-bureau-of-meteorology-and-csiro-109001.

[6] The Climate Institute, Coming Ready or Not: Managing climate risks to Australia's infrastructure, 2012, 35.

[7] See IPCC, Special Report on Global Warming of 1.5°C, 2018.

[8] Original table by TEC. Note that this table is concerned exclusively with electricity system impacts and does not consider second order impacts on human health and well-being or ecosystem impacts, as important as these are.

[9] The President's National Infrastructure Advisory Council, Surviving a Catastrophic Power Outage, 2018,12.

[10] https://www.abc.net.au/news/2017-09-22/solar-batteries-the-future-poll-finds/8967652

[11] This is based on anecdotal evidence and warrants further investigation .

[12] There are no reliable statistics are available on the number of offgrid systems in Australia.

[13] ENA, 2015, 263.

[14] See FERC docket no AD18-7-000: https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf. Note that climate is one of many threats to the system; in the FERC definition you could also include physical or cyber terrorism, war, etc.

[15] Resilience also features in the Hawaiian Public Utilities Commission's 2019 performance-based regulation decision as a recommended regulatory outcome and related metric, at the decision does not detail what is meant by resilience: see https://puc.hawaii.gov/wp-content/uploads/2019/05/DO-36326.05-23-2019.pdf.

[16] Noting the counterargument that if you have grid-connected microgrids that are controlled/responsive to signals from the macrogrid, that creates multiple entry points for hackers.

[17] "A reliable power system has enough generation, demand response and network capacity to supply customers with the energy that they demand with a very high degree of confidence. This requires:

- well-functioning electricity spot and contract markets providing clear price signals, along with forecasts and notices from the system operator, AEMO, backed up by policy certainty from governments. This gives market participants incentives and information to supply generation and demand response when and where it is needed.
- a reliable transmission and distribution network (the poles and wires)
- the system being in a secure operating state, that is, able to withstand shocks to its technical equilibrium": https://www.aemc.gov.au/energy-systemelectricityelectricity-system/reliability.

[18] Noting that generation failures account for only around 1% of all grid disruptions.

[19] EVs are also useful in contributing to transport energy system resilience, by reducing reliance on the long distance transportation of fuels which are vulnerable to political and security risks.

[20] See eg https://www.aemc.gov.au/market-reviews-advice/electricity-network-economic-regulatory-framework-review-2019.

[21] See eg https://www.energynetworks.com.au/news/energy-insider/power-lines-and-bushfires-pge-story

[22] Converge Strategies for the National Association of Regulatory Utility Commissioners, The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices, 4.

23 Converge Strategies for the National Association of Regulatory Utility Commissioners, The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices, 4.

[24] TEC is currently undertaking an ECA-funded study into the business case for community scale batteries under various ownership scenarios.

[25] No demographic data was collected for the Renew survey, but for the Solar Citizens survey, 75% of respondents were aged 60 or above and 65% were male.

[26] As of December 2018 (https://www.cleanenergycouncil.org.au/news/number-of-australian-homes-with-rooftop-solar-tops-2-million-and-counting)

[27] AEMC, Mechanisms to enhance resilience in the power system - Review of South Australia Black System Event, Discussion paper, 15 August 2019, 58-59.