Challenges and opportunities

for delivering grid-tied microgrids for energy resilience

Professional perspectives on governance and business models

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Executive summary

While interviewing householders around Australia, we often hear people wonder why microgrids are not commonplace. It seems intuitive that with so much solar in our suburbs or small towns, we could develop mostly self-sufficient local energy systems that would avoid expensive and unsightly transmission infrastructure, provide local jobs and decarbonise our electricity system.

This report focuses on energy and disaster professionals' views on why grid-tied microgrids are not a common feature of our energy system. We explore a broad question, what are the key opportunities and challenges for microgrids in Australia? This report is one of numerous outputs from the Southcoast Microgrid (μ-grid) Reliability Feasibility (SμRF) project.

The report finds that, contrary to what might appear at first sight, grid-tied microgrids are not a panacea for any of the potential problems they seem to solve, whether that is resilience, decarbonisation or greater community control over the energy transition.

Our interviews reveal that none of the many values, benefits or expectations the public have of microgrids, that we covered in our previous report[1] are readily accessible or straightforward in the current energy governance framework. The implication of this analysis is that other technologies or policy responses will be more appropriate options to improve the energy resilience of most regional communities. The report finds that we are simply not yet ready from a governance, social or regulation perspective for grid-tied microgrids, or indeed smart local energy systems in general. In the current context, grid-tied microgrid projects risk disappointing the public, potentially creating negative public perceptions of microgrids, and renewable projects generally.

The exception could be that in remote parts of the grid, grid-tied microgrids have the potential to provide reliability and resilience benefits. Many participants agreed we need trials to explore in concrete terms what benefits this technology could provide in this remote areas, particularly in terms of resilience.

In the energy industry, feasibility is often understood in techno-economic terms. Issues such as social acceptance, governance (broadly understood) and sustainability are usually excluded from traditional feasibility studies. In our project, we understand feasibility in its broadest sense. To us, feasibility involves understanding the social and technical conditions that would enable microgrids to deliver benefits to people and planet.

Our report starts with a deep dive into key concepts and terms that will be important to whether or not microgrids can deliver the kinds of benefits that people expect.

We then analyse interviews with 19 professionals working in three Australian states as well as fieldwork data with 60 householders and business owners living full or part-time in the Eurobodalla shire, on the New South Wales south coast, a region that was devastated and without power for a long period in the 2019/20 bushfires.

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Many of the component parts – especially batteries – remain expensive. It is very difficult under the current governance framework to work out and gain sufficient revenue for a reliable business model.

There are also questions of risk and accountability that are complicated for many different organisations – particularly community groups – to navigate and resolve. Finally, some participants point to an absence of a regulatory framework to enable microgrids. Embedded in questions of a workable business model remain tricky questions of social equity related to the way that the energy system – and network – is currently governed.

Participants identified quite a few benefits to microgrids. Interestingly, reducing energy bills for people locally and decabonisation were not seen as primary benefits that microgrids could provide in the current energy system. Instead, benefits such as reliability, avoided transmission, community building and resilience to extreme events were identified. However, participants also raised issues and caveats with these benefits.

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Overall, interviews reveal that there is still uncertainty over:

- the benefits that microgrids can provide concretely – how and in what contexts, and
- the difficulty in translating different benefits into revenue streams, with some benefits such as 'community cohesion' being absent within the current energy governance regime.

Our interviews revealed that there seems to be no agreement on ownership across stakeholder groups. Networks are seen as inefficient and (by some) as untrustworthy. Retailers are not motivated enough since microgrids are not commercially profitable, nor are they trusted by the community. Experts don't see community as owners or competent operators. And the local government participants did not see themselves as owner/operators. Even if having enough revenue to pay for and maintain the microgrid, it appears as if a lack of a trustworthy capable microgrid owner/operators may be the biggest hurdle to overcome for feasibility of microgrids in regional Australia.

The biggest policy challenge with grid-tied microgrids relates to social equity and sustainability more broadly. The interview analysis above reveals limitations in the market governance regime's capacity to find the most efficient and fair solution to a resilience gap because of the complexity of the energy system, the skills and capacity gaps organisationally as well as the heterogenous nature of the Australian community.

The current situation of leaving it to individual communities to advocate for microgrids means there is no clarity around whether investing in what is currently still expensive infrastructure will genuinely improve system and community resilience. Simple questions that remain unresolved include:

- **PRICING**. How can we develop business models that do not undermine the equity principles behind postage stamp pricing for network connections?
- **ACCESS**. Which location in the grid gets to access the potential benefits of a microgrid and is the process to decide this fair and follows due process?
- **EQUITY**. Microgrids by their very (technical) design are likely to exclude some members of the community who aren't in the 'right bit of the grid', even though they are part of the broader community. How is this question of equity to be managed? How do nearby residents not connected to the microgrid relate to it?
- **FAIRNESS**. What is the governance arrangement during a disaster-related outage for the microgrid participants to manage energy use fairly?

At its heart, improving resilience is about creating the kind of future that we collectively desire. As such, there will always be some level of conflict because people have different understandings of the problem and expectations of the future.

Rather than assume that we can sweep these disagreements under the carpet through an optimal technical solution, it is important to include energy users in policy reform, including whether and how microgrids could support a resilient energy future.

The report has revealed deeply held assumptions about governance that shape appetite and openness to reform for resilience. For example, there is genuine concern for some participants inside market bodies about changing any rules that might challenge the principle of competition that underpins the mechanism for accountability in the national electricity rules. As such, any alternatives to the current system – including microgrids – will be viewed through this lens.

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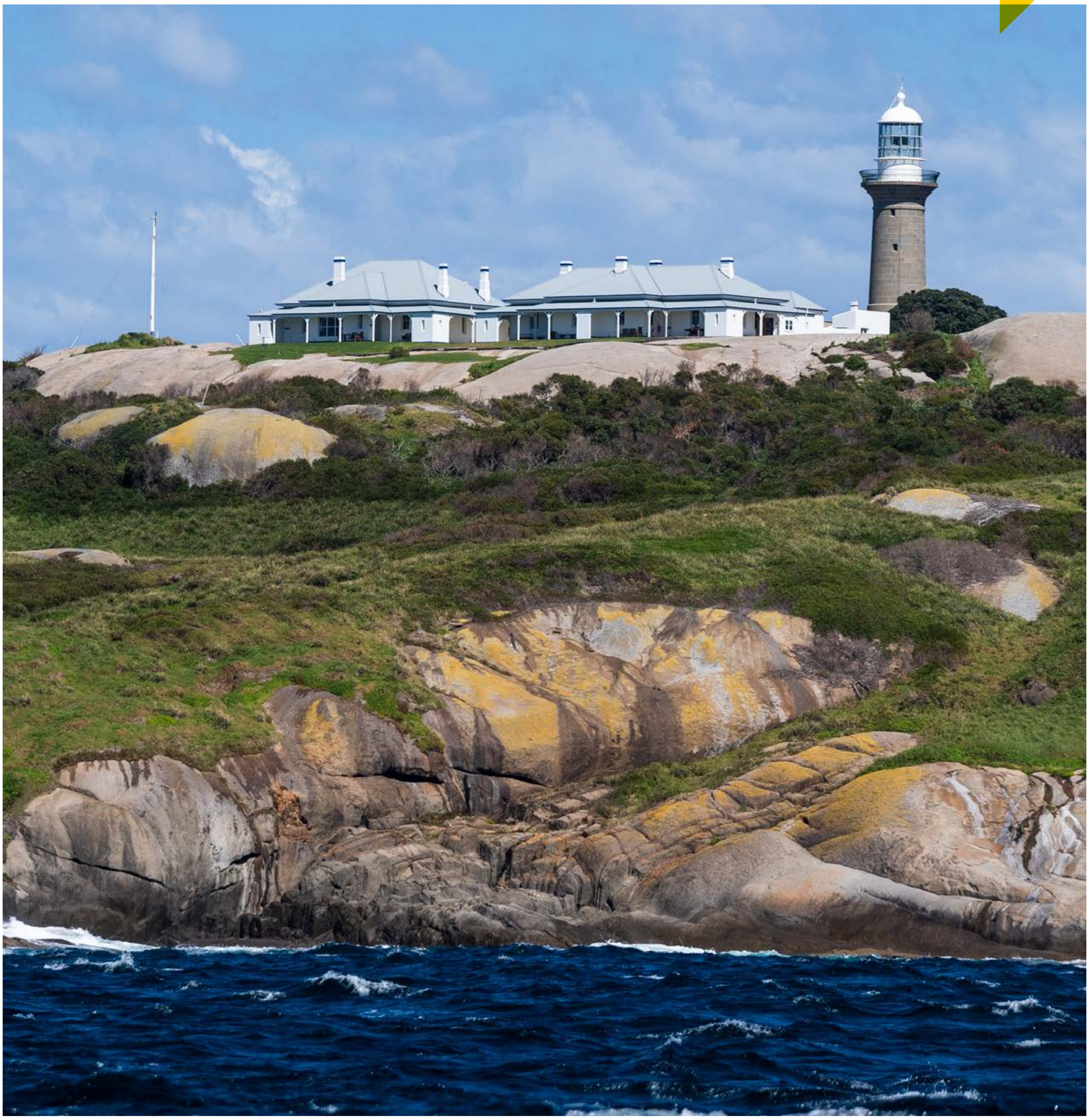
Importantly, we know that this is a different perspective from many members of the public and this difference should be explored and addressed before, or as part of, any regulatory reform.

For energy resilience, a key takeaway from this report is that there are likely to be lower cost, more equitable solutions to improve energy resilience that are also more immune to the effects of bad weather than grid-tied microgrids. What will improve resilience will be specific to each community. But there are examples of cheaper, more equitable and physically more robust alternatives such as emergency community hubs (with the facility to easily 'plug in' a diesel generator).

As our previous report[1] suggests, supplying energy to vital telecommunications infrastructure (for phone coverage and EFTPOS) is also key, as is supplying power for petrol stations, water pumps, and refrigeration (in shops and chemists). Supplying back up to key services across a whole region will improve regional energy resilience more so that providing electricity to whole communities in only some parts of a council area. Finally, there are technical modifications to existing rooftop solar on homes or community facilities that would enable people to use solar power even when the network is down.



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Introduction

While interviewing householders around Australia, we often hear people wonder why microgrids are not commonplace. It seems intuitive that with so much solar in our suburbs or small towns, we could develop mostly self-sufficient local energy systems that would avoid expensive and unsightly transmission infrastructure, provide local jobs and decarbonise our electricity system.

This report focuses on energy and disaster professionals' views on why grid-tied microgrids are not a common feature of our energy system. We explore a broad question, what are the key opportunities and challenges for microgrids in Australia? This report is one of numerous outputs from the Southcoast Microgrid (µ-grid) Reliability Feasibility (SµRF) project. The SµRF project focuses on islandable microgrids as a potential means of boosting the resilience of electricity infrastructure to extreme weather events (e.g., bushfires). The project is a transdisciplinary[i] and community-based research project that explores ways to bolster the energy resilience of the Eurobodalla shire on the NSW south coast, with broader lessons learnt for regional Australia.

While there is a dominant policy narrative in energy that individual market actors make infrastructure decisions based on price signals, the situation is usually much more complicated than that.[2] Understanding the perspectives of professionals inside the policy and infrastructure development worlds is important because they are on the frontline of decisions. More than a simple cost benefit curve, our analysis can support decision-makers and the general public to understand the range of issues at stake if we began investing in grid-tied microgrids in the near future.

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[i] 'Transdisciplinary' refers to research that responds to and seeks to address a 'real-world' problem or question by integrating knowledge from different disciplines and from the broader context (e.g., community, government or industry knowledge).

People make technology decisions through a complex range of factors that usually include price and product availability, but also cover a range of non-cost factors. Other relevant dimensions include, public support, how that technology captures our imaginations, fit with existing infrastructure, aesthetics, familiarity can play a role in the sort of energy systems we see unfolding.

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For example, how different incumbents use their power to resist change often provides the biggest clues about whether and what new technologies become commonplace.[3] This is why researchers have previously focused a lot on understanding contestation and conflict as a key dimension to social acceptance and market formation. Conflict about new technologies is not just about land use, industrial relations (jobs created), but can also be more fundamental. Tensions can also be over what energy is for, and about who should have ultimate decision-making power over our energy infrastructure. For example, Laura Nader, an anthropologist who studied energy in the US for over 40 years argued:

During the 19th century, a political war was waged over whether electricity should be a public service or a commodity to be exploited by corporations. As the balance tipped towards the latter, business became guided by profit rather than efficiency...[4]

What professionals – either experts inside the system, or advocates working alongside the energy transition – believe about emerging technologies is important. Professional practices and norms and organisational cultures in engineering contexts usually makes infrastructure safe and reliable. But they can also sometimes lead to blind spots and poor decision-making in the context of new technologies and systems.[5] While this study is not a deep-dive ethnography into how professionals in the electricity system makes decisions about infrastructure design and planning, similar research has guided the questions we have explored in this report.

In energy, Canay Ozden-Schilling, explained how electricity markets were created in the US.[6] She unpacked how the quirky nature and physics of electricity met different economic theories and how experts brought together their different expertise into electricity market design. What we can learn from this is how different experts can work together to apply their reasonings to a problem definition and then then to the kinds of solutions they negotiate, and it also teaches us that some types of reasoning and experience can be excluded from policy design. The lived experience and future visions of everyday users of electricity were missing in US market designs – and the same can be said for Australian market designs.

In Australia, the effects of this exclusion have been documented by researchers who show us the clear gap between industry futures of the electricity grid, and those of electricity users.[7,8,9]

Previous research with energy professionals has shown us that it is important to uncover the *reasoning* behind a view of any technology. This includes *assumptions* and taken-for-granted explanations about what energy is for and how it should best be organised (by whom, through what mechanism). As social scientists, we cannot ask questions about professional judgements in isolation. We need to understand people's answers through their eyes; how do these reasonings fit into their broader context, their professional biography; their organisational mandates; and the particular problems they are working on.

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With all this in mind, we followed Mazmanian's[10] definition of a 'technological frame', to explore with different professionals the question: 'What is the nature, role and potential application of microgrids in what kind of context?' This has provided insights into how a possible future microgrid could be used and experienced if built in the next few years. This can help us to see blindspots we might be missing, and some potential conflict we could avoid by understanding all perspectives and concerns.

Why microgrids?

The electricity system is changing, as is the climate. Within these changes the expectations that people have of the energy system are evolving. We are more aware of future risks – like bushfires – and are seeking both to mitigate (through more renewables) and adapt to, the effects of climate change. Microgrids may be one part of this change.

In essence, microgrids are small electricity grids. They may be physically isolated or they may be connected to other grids with switches that allow them to disconnect from (and connect to) these other grids. Importantly, the critical characteristic of microgrids is that they can operate independently (when disconnected from other grids). In this project our focus is on these 'grid-tied microgrids' that are connected to the national grid for the vast majority of the time.

People come to microgrids as a perceived solution for various reasons. One key factor is that Australia already has a lot of rooftop solar. If that solar could be stored and coordinated locally, they could make a microgrid. In particular for this project, microgrids seem intuitively well placed to provide power when parts of the grid are damaged (e.g. by flooding or a bushfire).

While emerging technologies such as microgrids appear to be an intuitive way to improve resilience, there still remains many questions to explore to understand whether not only they are feasible, but also whether they can deliver on many of their promised benefits, and if so, how?

Many community energy groups in Australia and elsewhere have projected onto microgrids idealised futures of autonomy, control and empowerment and decarbonisation. But a closer look at the governance and business model dimensions in this report reveal many intractable challenges that raise questions of equity and sustainability in smart local energy systems. They also show some intractable tensions embedded in these technologies, for example between an ideal of autonomy which is in tension with the need for any project to participate in the national electricity market, and the broader system generally (ie the distribution system).

Guide to this report

So far we have outlined why our report focuses on energy and disaster professionals' perspectives. In the following chapters we take your through:

Exploring microgrid governance, business models and energy resilience
Key concepts and terms that will be important for you in interpret the report and to understand the questions we explore.

Methods
We outlined the methods we used to explore microgrid feasibility from the point of view of governance, business models and resilience.

Microgrid feasibility and energy resilience
Covers the results of our work and what we think this means for microgrid feasibility.

Energy resilience
Outline what our analysis suggests; that there are key questions and issues that need policy attention if we are to meet public expectations of success.

By the end of the report, you will have learnt about the diversity of views on what microgrids can do, and what is slowing down their development. You will see that there is no overarching agreement on the key benefits, nor is there a clear sense of a workable business model under current conditions or a clear regulatory setting. The report will also reveal significant gaps between what energy professionals think microgrids can do, and what householders and small businesses expect from microgrids and energy transitions generally.

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Exploring microgrid governance, business models and energy resilience

In this report, the two key ideas we used to dig deeper into microgrid feasibility are 'governance' and 'business models'. We know from previous studies that these two themes have emerged as key challenges to whether microgrids are likely to have a positive impact on energy users.[11]

Often the technical challenges can be fairly easily worked through, but the rules that govern the technology design, installation and operation as well as how to make it 'stack up', tend to be harder questions to resolve.

We'll use the concepts 'governance' and 'business models' as a springboard to explore, 'what would make microgrids feasible in Australia today?' and 'Can microgrids improve the resilience of our energy system?' In the energy industry, feasibility is often understood in techno-economic terms. Issues such as social acceptance, governance (broadly understood) and sustainability are usually excluded from traditional feasibility studies. In our project, we understand feasibility in its broadest sense. To us, feasibility involves understanding the social conditions that would enable microgrids to deliver benefits to people and planet.

> **...feasibility involves understanding the social conditions that would enable microgrids to deliver benefits to people and planet.**

Microgrids as a *commons* governance challenge

Governance is about the rules that shape people's activities. It is about the laws, rules, decisions and practices that constrain, prescribe and enable goods and services. It is also about who has authority to make decisions and how new rules are made and old ones changed.[12,13]

For microgrids to work well, we need rules to make sure energy balances out, and the microgrid's business model makes sense and delivers energy to users. In energy governance, some of the rules are formal, written down and backed by a legal process and system. Others are informal and often quite unconscious; about 'the way things are done'.

In Australia, there is an extensive set of rules for building and operating electricity infrastructure and guide the flow of electrons on the grid. Some of these rules are made and enforced by various market bodies. And yet others, for infrastructure development and safety, may sit with State and Federal law-making. For energy infrastructure, governance must cover many concerns and goals from the highly local (e.g. 'this infrastructure is an eyesore!') to the global (e.g. supply chains of materials and life cycle impacts of materials and disposal).

For any new technology, then, we can ask:

Do existing rules make it difficult for this new technology and how easy it might be for new developments to happen under the current rules, in keeping with social expectations about technology impacts?

Because electricity travels via a shared piece of infrastructure, formally called the transmission and distribution grid (but often referred to simply as 'the grid'), it is useful to draw on 'commons governance'. This is not the rules framework that we use in Australia, but it can help us ask useful questions about governance relevant to microgrids.

Commons governance unpacks how we can best manage resources that are, or could be, held and used in common.[14–18] In economic terms, common resources are those which are available to all (or non-excludable) and which are susceptible to being depleted.[19] While the grid cannot be 'depleted' per se, it is a finite resource because it has limits on how much power can be transported (stipulated by voltage and thermal limits). For example, if too many people export their solar on the grid at one time the grid will be imbalanced and there will be faults and blackouts.

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Common resources are different from public resources, which are available to all and administered by government organisations. Bollier and Helfrich make the point that it is usually not the common resource itself that is non-excludable and depletable; it is people who are being excluded and it is how the resource is managed that makes it vulnerable to being depleted, and so they prefer to view commons as living social systems.[19]

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The problem posed by common pool resources governance is that individuals might draw on the resource for their own purposes, but all would be better off if most or all of them took a different action.[18, 20] That is why managing how different batteries and rooftop solar work on the grid can be seen as a collective action problem requiring cooperation. We know for example that neighbourhood batteries are a more efficient way to stabilise the grid compared to many household batteries working together.

As an economist studying this problem over many years, Eleanor Ostrom, noticed that most people are constrained when they are making decisions by incomplete information, limited cognitive processing capabilities, and the influence of culture and norms.[20] Contrary to myths about resources inevitably getting depleted through individualistic actions, Ostrom showed that people can and do self-organise to successfully govern common resources. She and her team identified eight conditions that increase the likelihood of sustained success.[20] We added our own suggestion of how this might work in the microgrid context in Appendix 1.

While commons governance raises many potential questions about microgrid governance, the key ones for the purposes of our interviews were:

What is the current capacity and future potential for communities to self-organise and make their own rules about microgrid design and the current system's ability to accommodate and support to communities to do so?

Also, and importantly, because a grid-tied microgrid is inevitably part of a broader system, it is important that the rules and the design of the microgrid do not have negative impacts on the broader system. So, we also need to explore:

Where is a microgrid appropriate for system functioning and where does it create new risks and burdens onto the broader system? And

Microgrids by their very (technical) design are likely to exclude some members of the community who aren't in the 'right bit of the grid', even though they are part of the broader community. How is this question of equity to be managed?

Governing microgrids

The values and goals underpinning energy governance can shift. For example, we have come to expect that electricity will be available most of the time across most of Australia. Yet, many householders remember a time where frequent short outages were commonplace. Interestingly, our recent fieldwork has revealed an appetite among some householders for occasional outages, as a trade-off for other perceived benefits (such as reduced bills and/or a high percentage of renewable power).[21] So, even a seemingly basic goal that we have come to accept as 'normal', can be seen in a fresh light as other concerns become front of mind. For a microgrid, goals could include:

- reducing grid costs
- reducing electricity bills for householders and businesses
- maintaining constant power supply
- enabling greater thermal comfort
- minimising carbon emissions
- providing a feeling of control over the energy system, and
- even contributing to technology uptake and transitions elsewhere.[22]

What makes it even more complicated is that goals will differ depending on the stakeholder in question. Our previous research has revealed that householders, distribution networks and retailers have very different concerns and priorities, especially in regards to new technologies and how the transition should be managed.[23]

For microgrids, there will always be highly local concerns – for microgrids are inherently localised infrastructures – such as where the infrastructure will be located and how it affects electricity access. But microgrids are also part of a broader system with different stakeholders and concerns.

Grid-tied microgrids are thought about as a small part of—or nested within—a larger energy system. This is the case both in terms of governance and physical infrastructure. The microgrid is subject to levels of governance that sit above it which cumulatively affect the actions that can be taken and the outcomes achieved (Figure 1).

A study published in 2024 asked experts worldwide how smartgrids could function.[24] They found four distinct views on how microgrids would be managed institutionally and through what technologies:

1. **CENTRAL OPERATOR** Some experts thought that information technology controlled by a central operator could manage microgrids, yet others thought that control should be local (but still technology led).
2. **REAL-TIME RATES FOR DISTRIBUTED GENERATION AND STORAGE**. This paradigm also maintains a connection with current grid managers. It advocates for the implementation of real-time rates to facilitate the development of distributed generation and storage within microgrids. These microgrids are envisaged to be owned and operated by prosumers. By combining storage capacity with internal generation it enables the reliable and efficient integration of variable renewable sources with variable demand loads. Additionally, this paradigm places emphasis on the significance of ICT and the deployment of remote automated digital meters, commonly referred to as 'smart meters'. Similar to paradigm I, a minority of experts expressed a contradictory view compared to others. This minority lacked confidence in the idea that the introduction of ICT would actively engage end-users and transform the centralised grid into a network of interconnected microgrids. Instead, they advocated for legal transformations that promote co-production of resources and consumer control over storage and EV-loads.

3. **LOCAL MARKETS** A third paradigm believed that microgrids would be governed primarily as local markets, independent from any central authority. In this arrangement, migrogrids would have their own internal control systems that adjusts to fluctuating loads and supplies, as well as to external price signals. The internal energy management system would allow for more flexible and localised management of renewable energy matched more closely to consumption.
4. **HYBRID** A fourth paradigm saw microgrids as being part of a hybrid polycentric grid of interconnected distributed systems of microgrids.

The author concludes:

> **Identified contradictions in the [different] paradigms strongly highlight the acknowledged or unacknowledged significance of control over the new infrastructures at the microgrid level.**

The study's findings support the examination of questions we need to ask in Australia such as, how would microgrids be controlled:

- By whom and how?
- And how are end users part of this arrangement?

Future business models will change drastically depending on the answers to these questions. Till now, these all remain unanswered questions in the Australian energy policy landscape.

So, an important question for us to explore is:

Are the constitutional rules' objectives and processes (i.e. the National Energy Rules) in line with the goals and desires of actors operating within the collective-choice and operational levels of potential microgrid design (i.e. the people on the ground)?

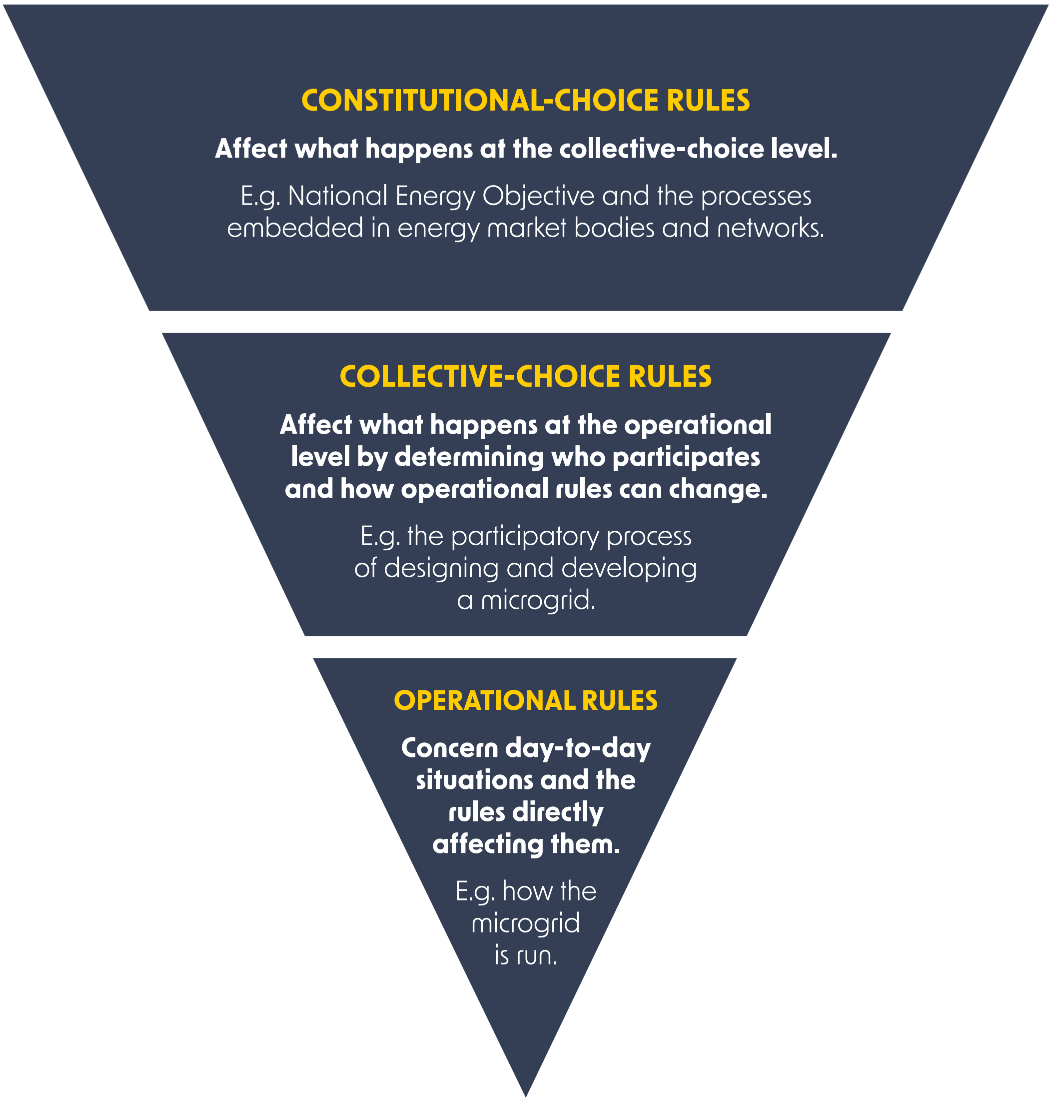

Figure 1 Nested levels of governance for a grid-tied microgrid, adapted from Ostrom.[19]

Business models

Business models are key because they describe how and to whom microgrids provide value. How do we understand business models for a grid-tied microgrid? There are a few different ways. One approach is to break them down into several parts:

1. **ARCHETYPES**
   What is the overall approach? (e.g. DNSP-owned microgrid, or a community microgrid?)
2. **ALIGNMENT**
   How do the different parts of the business connect?
3. **ELEMENTS**
   What are the key necessary parts of the business? (e.g. a business canvas)
4. **LOGICS**
   The consequence chain of different activities
5. **ACTIVITIES**
   How all the above looks like in practice.

In energy, it is common to focus on 'archetypes' and 'elements'. And this may be helpful for people zooming in on what would best suit their circumstance. For example, a business model canvas (the 'elements' of a business model) consists of building blocks that show the logic of how an organisation intends to create value and for whom.[25] One limitation of zooming in the business model archetypes (e.g. 'DNSP owned') and their associated business canvas is that it's possible to miss the broader governance context and how different technologies, regulatory contexts etc. make different business models possible.

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Given the diversity of technologies and organisations/sectors involved, defining what a business model is in the context of microgrids is not straight-forward.[26] For example, consider how different contexts – remote, community, utility distribution, campus, military, commercial/ industrial, direct current – will each have their own business model.[26] Interestingly, the way business models for microgrids are often framed is with reference to ownership structures[27] (Table 2).

If we unpack what a business model is, as we have done above, we know that identifying the owner of some or all of the microgrid assets/technologies does not comprise a model as such, but suggests the perspective to be taken when identifying a business model; the elements of a BM or logics of value creation.

Table 2 Examples of ownership typologies identified in international literature.

Ownership structure/models	Operational dimension
An individual or collection of individuals own all the infrastructure	This could be directly operated by the owner or controlled remotely by a private or public energy company[11]
Utility owned	Utility operated with some parts of operation sub-contracted to a third party[28]
Hybrid ownership[28]	Hybrid operation or operated by a single party
Retailer (public or private) owned	Retailer operated
Community or council[29]	Operated by the collective or by a third party
Microgrid operator[29]	
Network service provider	Operated entirely or in part
Distribution System Operator or Aggregator[ii]	Operated entirely or in part
Energy Service Company owning generation assets[30]	Operated entirely or in part
Energy Service Company offering design and operation as a service[30]	Operated entirely

As Table 2 shows, there is enormous variation in terms of ownership and operation for microgrids. What we have learnt from microgrid implementation in other studies is that ownership rights by themselves are not enough to ensure effective operation. One case study of the White Gum Valley project in Perth, WA, explored how peer to peer energy trading could work with a shared solar PV and battery storage systems in three apartment buildings.

...there is enormous variation in terms of ownership and operation for microgrids... ownership rights by themselves are not enough to ensure effective operation.

Researchers found that although residents were the owners of the generation and storage assets, they were unaware of their rights.[31] The software trading platform organisation involved did not communicate their property rights and responsibilities to the residents, resulting in residents initially being unable to act on their rights (e.g., changing strata company or internal electricity pricing).

Because ownership is only one dimension of business models and understanding who benefits, we focus instead on activities. Activity systems consist of three design elements:

1. **CONTENT**
   Set of activities
2. **STRUCTURE**
   Sequencing or links between activities, and
3. **GOVERNANCE**
   Who performs activities.[32]

ii A Distribution System Operator, sometimes also referred to as an 'aggregator' is an emerging entity type, which can have different ownerships structures, which manages generation and storage in real time to keep the grid stable. It includes services such as monitoring grid conditions, scheduling dispatch of energy at certain times, and selling energy or grid stability into the wholesale market.

Bolton and Hannon[33] have said 'the activity system perspective is a particularly useful framework for understanding how a business model is constituted through interactions between market actors'.

The kinds of values and services we might imagine a microgrid providing, and the activities to deliver this, include:

- Power under normal circumstances
- Power during a prolonged outage (resilience)
- Power during a short outage (reliability)
- Providing grid stability when the broader network is suffering issues
- Providing communities with a greater sense of 'control' over the energy transition
- Reducing power bills
- Decarbonising the electricity system

There are many different stakeholders interested in these different values.

Similarly interested in system change, Hellström et al[34] applied the activity system perspective to study collaboration between firms in the energy industry. They observed that the increased interdependency between firms that resulted from collaboration led to an increase in overall value creation. Yet in Australia, our disaggregated rules model actively prohibits collaboration, let alone interdependency. The system has been designed so that all parts of the system compete with each other, even though in real operational terms the interdependency exists.

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So, a microgrid business model may only be successful if other capacities and business functionalities exist to support it. All of this, prompts the question:

What activities, regulatory environment, social context, governance and broader business capabilities would need to be present for a microgrid business model to be successful?

Cross cutting themes: complexity, digitalisation and fairness

Cutting across the governance and business model approaches are three additional themes worth drawing out because of their importance to governance and business models – complexity, digitalisation, and fairness.

Complexity

Because microgrids and energy systems are technically detailed, and deal with risky live power, there is always a need for experts (e.g., utilities, software companies) to be involved in their design and operation.[28]

Microgrids are also a new suite of technologies, with, as we'll see, no clear bounded definition. Together with the range of services that microgrids could deliver, across scales, and domains (local planning and sustainability policy) outlined above, this makes putting together a business model and governing microgrids an inherently complicated task, with many actor types with different ideas about what microgrids can and should do. Basic questions such as:

- what is the role of solar owners and non-solar owners in decisions making about the microgrid operation, and
- how do people work together to make decisions have yet to be defined.

Hall and Roelich[35] introduced the notion of 'complex value', defined as 'the production of financial, developmental, social and environmental benefits which accrue to different parties, across multiple spaces and times, and through several systems'. The authors highlighted that business models involving complex value feature a high degree of uncertainty and risk.

One challenge in energy is that some values can be difficult to capture, i.e., cannot easily be monetised by the organisation operating the business model, a challenge that we have already noted for neighbourhood batteries.[22] And yet, because energy is an essential service, there is a need for simplicity, both for ease of regulatory oversight, but also for energy users to participate.

What makes microgrids complicated and could this be a barrier to feasibility?

Digitalisation

Another important dimension to understand for microgrids is digitalisation – the use of Information and Communications Technology (ICT) in managing the flows of energy on the grid – often referred to as 'smart local energy systems'. Many are attracted to the idea that digital technologies could enable new types of ways of sharing energy.

People could develop local energy markets where they share energy with one another and keep money local. But so far, research on smart grids have given us reason to be cautious. Firstly, many of the assumptions built into these trials of engaged prosumers who are motivated to change their behaviour and participate have proven to be exaggerated.[36] The requirement on people to be heavily engaged can be unrealistic for most householders and the expectations of literacy are impractical. (Here we are simply referring to standard reading level literacy, which is not uniform across the Australian population.)

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Second, some of the basic infrastructure to enable smart grids – for example smart meters – have been found to be unpopular with some parts of the public.[37] Heather Lovell who has researched smart grid experiments in Australia found: *...the promise of smart grids has not for the most part been delivered... new digital technologies have not 'behaved' in the way originally planned. Growing evidence points to smart grid technologies [e.g. smart meters] undermining the promise of smart grids.*[38]

Third, case studies of local energy market experiments have so far shown some surprising results. Local electricity exchange experiments in Europe for example that they end up consolidating the power of incumbent actors (e.g network business and retailers) as well as provoking a lot of local contestation and disagreement in the community.[39] This runs counter to the idea that local trading would provide a radically new empowered relationship to the energy system for communities.

A useful question to ask might be:

Is there potential for ICT to enable microgrid designs that genuinely improve people's experiences of energy? Who owns and controls the ICT?

Fairness and justice

As with any new technology, perceived fairness and questions of justice are paramount. Decades of research into new infrastructure and technology have found that if projects don't feel and look fair, there will be significant public opposition.[40] As explored in our previous report, many Australian householders already perceive the current energy system as being unfair.[21] So microgrid feasibility will also need to consider whether the design, build and operation of a microgrid is considered fair by local residents and other interested groups.

Decades of research into new infrastructure and technology have found that if projects don't feel and look fair, there will be significant public opposition.[40]

A core problem of fairness in microgrids is that the microgrid's existence relies on a connection to the main grid. The main grid is paid for by all electricity users in the catchment of that grid. Costs are smeared so even though it costs a lot more to service remote areas, regional customers pay the same as those connected to a central part of the grid.

If a microgrid is going to be built in one part of the network, to be seen as fair, it would need to be the most cost-effective part of the network to do so. At the moment, under the current rules where the 'market' decides, so long as an investor pays and it complies with safety rules, microgrid developments could go into parts of the network that do not necessarily reduce costs for everyone, i.e. the network does not 'need' this investment.

This may not matter so much if it was a 'trickle down' technology that everyone may eventually access, but because of grid constraints, it is not possible for every community to have a microgrid with large amounts of power generation in the distribution network. For example, in the Eurobodalla region in the NSW south coast, our engineering report found that not every village across the shire could accommodate a solar farm to support a microgrid. So an important question for us to meet the 'fairness' criteria of social acceptance:

Which location gets to access the potential benefits of a microgrid and is the process to decide this fair and follows due process?

There are other fairness and justice questions, such as how the microgrid operations data is used and made public, how are landowners compensated for infrastructure, how are communities consulted etc. Many of these questions are not explored in this report as we are not exploring a concrete proposal but more generally the capacity of the governance system to make microgrids feasible.

So we might ask instead:

What is the potential for fairness and justice problems to emerge for affected community members under the current energy governance arrangements?

Microgrids, smartgrids and resilience

A key part of what we have been interested in in the SμRF project is whether microgrids could improve the community's resilience in the face of bushfire or flood related interruptions to power supply. It seems intuitive that decentralised grids that operate independently but are still connected to a grid most of the time could be more resilient in the face of bad weather. But are microgrids and resilience a natural fit? Our literature analysis found that resilience must be considered as both social – involving people and institutions – and technical, involving the material infrastructures that provide services.

Our literature analysis found that resilience must be considered as both social – involving people and institutions – and technical, involving the material infrastructures that provide services.

Furthermore, there is agreement among resilience experts that a compartmentalised approach to improving resilience – for example, by only focusing on energy, one community, or on an individual technical system – is insufficient. In addition to specific systems, the bigger picture of the NEM and its social and technical infrastructures must be included.

The increasing complexity of our electricity system means that there is greater risk of cascading, non-linear and/or unforeseen consequences, such as the recent storm in February 2024 in Victoria which left 500,000 without power at the peak of the outage. There were six transmission towers lost, one coal power station shutdown, and no telecommunications, nor trains running for a period.

Electricity systems are subject to multiple hazards, including severe weather and cyberattacks, some of which are unavoidable. The types of risks are constantly evolving, and the asset values at stake have substantially increased. Ageing grid infrastructure is also a key driver. In addition, infrastructures such as those providing essential services are becoming more interdependent, complex and critical, and are sometimes more dependent on higher power quality.

With this in mind, it is unlikely that microgrids on their own will resolve energy resilience concerns for communities. But it is still important to seek to understand what role microgrids could play from a social and technical perspective.

Also important to understand the relationship between microgrids and resilience is that in Australia, there is no agreed industry approach for 'valuing reliable supply of electricity following a long duration localised outage' nor for 'assigning probabilities to the frequency of occurrence of natural hazard events'.

There is currently no regulatory requirement for network companies to invest in resilience measures. The current framework does not incentivise improvements in resilience such as measuring Networks' ability to recover quickly from major event days.[41]

There is currently no regulatory requirement for network companies to invest in resilience measures. The current framework does not incentivise improvements in resilience such as measuring Networks' ability to recover quickly from major event days.

As such, business models for microgrids at the moment cannot rely on any financial return from improving resilience. We also do not yet know whether microgrids will actually improve a community's' resilience in a bushfire, storm flooding event as we have very little experience of this. See SuRF report *Bringing community into designing resilient regional energy futures: Perspectives from the NSW South Coast* for more community perspectives on issues with energy resilience.

Despite this broader complexity, we still seek to explore in this report:

What role could microgrids play in improving the resilience of our energy system?

Image: Eurobodalla Coast Tourism ©

Methods

We've taken time to lay out what we mean by governance and business models and to lightly touch on existing research findings on these topics. When deciding how to design a research project, it is useful to start from what we already know, and what the gaps in our understanding are.

It's also helpful to think about the best ways we can answer these questions (i.e. what methods would be useful). Based on the literature review above, we decided to conduct semi-structured interviews with professionals who work in and around energy and resilience policy and planning as a way to better understand the feasibility of microgrids in Australia.

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As a refresh, here are the research questions we outlined that were in our mind as we explored grid-tied microgrids with our research participants:

Do existing rules make it difficult for this new technology; how easy it might be for **new developments** to happen under the current rules?

Who is included about **decisions for managing a microgrid** and how would those rules be made?

What is the current capacity and future potential for **communities to self-organise and make their own rules** about microgrid design and the current system's ability to accommodate and support to these communities to do so?

Where is a microgrid appropriate for system functioning and where does it create **new risks and burdens** onto the broader system?

Are the constitutional rules' objectives and processes (i.e. the National Energy Rules) in line with the **goals and desires of actors** operating within the collective-choice and operational levels of potential microgrid design (i.e. the people on the ground)?

What activities, regulatory environment, social context, governance and broader business capabilities would need to be present for a **microgrid business model to be successful?**

What makes microgrids complicated and could this be a barrier to feasibility?

Is there potential for ICT technology to enable microgrid designs that genuinely **improve people's experiences of energy?**

Which community gets to access the potential benefits of a microgrid and is the process to decide this fair and follows due process?

What is the potential for fairness and justice problems to emerge for affected community members under the current energy governance arrangements?

What role could microgrids play in **improving the resilience** of our energy system?

While these are our research questions, they are not the interview questions themselves. These were simpler and designed to draw out the themes we were interested in.

Professionals and advocates

Table 3 Sector breakdown of interviews with 19 professionals

Sector	Professionals interviewed
Local government	Four
State government	Two
Distribution businesses	Two
National Electricity Market Bodies	Four
Energy retailer	One
Experts (either in consulting or university)	Four
Advocacy organisation	Two

The majority of these professionals worked in the field of energy in New South Wales, Western Australia and Victoria. Two of the participants had specific professional focus on disaster preparedness and management. Another five participants worked more generally in the sustainability space.

Despite our efforts to sample for diversity, 13 of the 19 participants were male reflecting a gender imbalance found more broadly across the energy sector. We selected participants for sectoral diversity and focused on people with experience and interest in local smart energy systems.

Despite our efforts to sample for diversity, 13 of the 19 participants were male reflecting a gender imbalance found more broadly across the energy sector. We selected participants for sectoral diversity and focused on people with experience and interest in local smart energy systems.

We conducted the interviews between November 2022 and August 2023, after receiving approval from the Australian National University human ethics process. We recorded all interviews and we analysed the transcripts as a team. We coded the interviews deductively but with an eye to the sorts of issues and questions raised in *Exploring microgrid governance, business models and energy resilience.*

Community interviews and workshops

As part of the broader SμRF project, we also conducted interviews and focus groups with householders and small business in the Eurobodalla region. The results will of this work will only be touched on lightly here in to contextualise the interview results with professionals. A deeper analysis of what householders expect and think about microgrids and resilience can be found in the following two reports:

1. *Community perspectives on microgrids and resilience in the Eurobodalla*[21]
2. *Bringing community into designing resilient regional energy futures: Perspectives from the NSW South Coast*[42]

When we speak of householder perspectives in this report, we are drawing on the data from fieldwork with 60 householders and small business owners living either fulltime or part time in the Eurobodalla region.

When we speak of householder perspectives in this report, we are drawing on the data from fieldwork with 60 householders and small business owners living either fulltime or part time in the Eurobodalla region.

Limitations

While our fieldwork data has yielded important findings and provided us with a good sense of the key issues and tensions, it has necessary limitations. It does not represent a full picture of all energy professionals local, state and national in Australia. Our geographic focus is limited to New South Wales, Western Australia and Victoria. Additionally, we limited the local professional participant sample to the Eurobodalla region. Other States and council areas will have very different experiences and interests in renewable technology. There were also particular groups (e.g. retailers) and engineering companies that are not well represented in our interview sample. We suggest our analysis be used as a springboard to further explore these questions in other places to see if they yield different results and analyses. There are also other methods that could be used to explore the research questions in more detail, such as a more detailed review of regulatory settings and experiences (requiring document review) and surveys to explore how widespread some of these findings are.

We suggest our analysis be used as a springboard to further explore these questions in other places to see if they yield different results and analyses.

Image: istock by Getty Images Baracapix

Microgrid feasibility and energy resilience

Why aren't microgrids more common?

According to our research participants, there are many reasons we don't see microgrids being deployed at scale in our energy system, which we now detail in turn.

Unfamiliar and technically complicated

One of the simplest reasons microgrids are not more common is that they are a new technology combination and many parts of a microgrid – for example the control system used to balance supply and demand and a battery – are new to many organisations. Inertia and path dependency are common characteristics of large organisations that manage significant technical risk, such as Networks. Building familiar infrastructure is often the default option because it is a known quantity:

> **And I know that following the 2019–2020 fires, some of the New South Wales networks ... rather than build back poles and wires, [they] built back standalone power systems. And they managed a couple...And I got the sense that that was a cultural thing within the business, that they went to their reg[ulatory] team and the reg[ulatory] team kind of threw up their hands and said, "But we know how to put back poles and wires! That's what we know. Please can we do that?" And so I guess because it was novel to do [the microgrid] – so they struggled to get that to work.**
>
> **Jacqui, energy consultant**

Moreover, engineers pointed out that it is not always technically possible, or simple to island a piece of the network. The infrastructure and geography needs to be appropriate. For example, it is no good if it's underwater, or if it will be destroyed by fire, if people aren't connected to the same part of the grid, or if the environmental impact of the infrastructure itself would be too great. Others raised cultural heritage considerations in their locality.

Batteries and microgrid parts are still expensive

Most interviewees agreed that lithium batteries are still expensive and unlikely to come down in price any time soon. Yet others suggested we should be exploring other battery technologies e.g. flow batteries, especially if it can be located far enough from residential areas. One interviewee told us the problem with cost, relative to alternative options, is unlikely to be resolved anytime soon:

> **But probably the one that stands out to me the most as being the biggest challenge that I actually don't see an answer to yet even in a future state in 10 years' time is how do microgrids or islandable microgrids provide a lower cost of energy for that particular community. That concept sounds awesome, it sounds like a really key driver. How you do that practically and keep within a regulated industry to me is a really big step that I can't quite comprehend yet.**
>
> **Walter, Network**

Business models are complicated in the current governance framework

All participants who had experience in energy agreed that the business model question remains a significant challenge. Put most simply 'who pays and who benefits is a big challenge.' Part of this is a well-known challenge associated with the disaggregation of network operation and the retail market, often referred to as 'ring-fencing'.

The financial return that a solar farm or battery can provide come from a two main sources:

1. trading in the electricity markets (arbitrage and Frequency, Control Ancillary Services markets) and
2. providing value to the network either through deferring particular upgrades, or providing stability to the grid.

But these two potential revenue streams are now 'disaggregated', meaning no one entity can access both, making it difficult to reap a sufficient return. Disaggregation was a governance decision that happened progressively in the east coast, ostensibly to reduce the negative impact of a monopoly (the networks) and to encourage competition. But it was not rolled out in Western Australia, providing a neat counter example.

A significant theme emerged that in many cases it would make sense for Network operators to invest in microgrids, because in long, stringy parts of the network, it can provide a more cost-effective solution than traditional poles and wires. However, networks owning batteries are subject to a lot of restrictions. Under the rules, they are not allowed to own generation assets and trade in the energy market.

At the same time, third parties such as a retailer or a community group have found it difficult to put up a business case as they don't have a good understanding of where the network constraints are.

Interviewees' stress that 'in theory', networks could pay a third party to support them with their network issue, but experience suggests that networks are not typically open to having third parties solve network problems. Put simply, there is a tension between the current regulatory impetus for creating an even commercial playing field (i.e. encouraging competition) and embracing new technologies that provide multiple values like microgrids.

Put simply, there is a tension between the current regulatory impetus for creating an even commercial playing field (i.e. encouraging competition) and embracing new technologies that provide multiple values like microgrids.

Moreover, at the heart of business model concerns and challenges is the question of fairness and equity. This is a concern in particular for regulators. At the moment, the cost of running the network is socialised – a fact not well communicated to the public, and therefore not generally a part of people's every day energy system literacy (see our other reports).[21,43] The purported localisation benefits of microgrids depend on certain changes being made to this existing order.

One reason that locally generated energy might be cheaper is because it does not have to travel very far, which should lead to lower network costs.

For customers to pay lower costs, however, networks must be allowed to break with uniform pricing, thereby exposing other customers, particularly those in remote parts of the grid, to higher costs. Grid-tied microgrids are imagined to be connected the main grid most of the time, meaning if they have locational pricing arraignments, microgrid users would no longer be sharing the collective cost of the network. As regulators stress, the idea that locally generated energy should be cheaper is one with very real and potentially regressive social consequences.

Regulators in our sample generally believed the current model of regional pricing should stay in place, so that any savings arising from microgrids are shared among all customers in the region (not passed on only to those in that location). One expert participant suggested a workaround to this problem: that network costs could be shifted onto government so that they are no longer 'user' pays. But the same participant also believed this would be politically unpalatable.

As will be noted below, most energy experts did not see decarbonisation as a key potential benefit and revenue source. The small-scale reduction in carbon emissions that microgrids could provide are now being 'wiped out' by large scale renewable developments and energy efficiency. This view had evolved for one expert in our sample, revealing an important theme: in a fast-changing environment where generation is built by an unpredictable market context, microgrid business models are vulnerable to external or industry change. It becomes difficult to predict and plan for potential revenue streams to generate a business canvas. This creates a serious impediment, for small organisation who cannot absorb the financial risk of market dynamism.

This view had evolved for one expert in our sample, revealing an important theme: in a fast-changing environment where generation is built by an unpredictable market context, microgrid business models are vulnerable to external or industry change.

Risks and accountability

Another important theme that emerged was the question of risk and accountability. Local councils and regulators were concerned about non-experts managing microgrid projects. They were concerned that electricity infrastructure is inherently risky and dangerous, and yet also essential so it becomes important to have a professionally trained and large enough organisation to manage the financial and technical risks of owning and managing a microgrid project. Practical questions such as 'who takes over in the event of financial failure, and who bears the cost of that failure?' emerged in interviews:

> **...if you're providing an essential service, the bar is very high in terms of if you get it wrong, then people's life support doesn't work, people's freezers thaw out, people miss their telehealth appointments.**
>
> **Naturally, the performance expectation is going to be very high. So, in that context, who is appropriate to take on that risk is a question that we need to answer.**

Martin, small retailer

Council's experience with infrastructure projects in instructive as well on this front.

> **...who's maintaining it and what happens when this battery fails, who's paying for it? Because that's when the problem started. So we get the money up front and we say all the time, we can get money for capital upgrade to the cows come home. It's harder to get money for renewal and *you can never get money for maintenance.***

Rob from emergency management

The theme of accountability will be covered in more detail below but it's worth noting that maintenance quality and integrity has been a significant issue with longstanding standalone microgrids in regional Australia and is worth bearing in mind as a likely blindspot for policy.[44]

Absence of a regulatory framework

Finally, some participants pointed out that there is also simply no regulatory or policy framework for grid-tied microgrids, as there exists for standalone power systems. Issues of settlement, consumer protections, liability and general risk management are yet to be discussed and worked through by relevant stakeholders. And yet other participants believe there is no impediment to developing grid-tied microgrids in the current framework.

It appears as if there are contradictions within key stakeholders on even such a basic question as to whether the regulatory settings are ready or not for grid-tied microgrids.

What benefits can microgrids provide?

There was a wide range of views on the key benefits to microgrids. But also some key themes. All experts believed it was important to consider microgrids, and it was timely to investigate their benefits and challenges.

Importantly, no energy experts believed that decarbonisation was a primary benefit from microgrids. One expert reflected that at one time in the past, microgrids could have been seen as beneficial for decarbonisation:

> **I think it was at one time, but governments have now set objectives to decarbonise the central system very quickly, so that the fundamental – one of the fundamental policy objectives which have been – which will and have been driving the evolution of the electricity sector (i.e. to decarbonise) I don't think is necessarily enhanced through microgrids. I think they're going to be much of a muchness going forward, at least as the central system now is going to move to cleaner sources very quickly.**

Barry, energy researcher

Due to their expense, and the difficulty for small generators to make profit in the national electricity market, making energy bills cheaper for microgrid local householder participants was also not seen as currently feasible. At this time, the only clear potential for reducing household bills identified was seen around avoiding network costs – a saving that would be passed down to everyone paying bills into the network and region (for reference, network and transmission costs represent roughly half of an average electricity bill in the Eurobodalla).

The key potential benefits identified by participants fit into four clusters:

1. **RELIABILITY** An interim technology to allow communities and networks to get comfortable with disconnecting from the grid in edge of grid locations
2. **SUSTAINABILITY** Reducing reliance on large-scale renewables and transmission infrastructure, which improves the efficiency of the grid (avoiding transport wastage)
3. **RESILIENCE** Back-up power supply in areas of high environmental risk from bushfires or flood
4. **BUILDING SOCIAL CAPITAL** Providing an opportunity for communities to come together and re-connect with one another and their connection to the environment (via energy supply).

Importantly, interviews also revealed that none of these four types of benefits were straightforward or easy to realise under the contemporary governance framework. Participants also shared that context is key to understanding whether benefits will be realised in practice. Let's go through them one by one.

Importantly, interviews also revealed that none of these four types of benefits were straightforward or easy to realise under the contemporary governance framework.

Reliability at edge of grid

Energy regulators were quite clear that grid-tied microgrids could be a transition to a standalone microgrids in remote parts of the grid that were very expensive to service. But the regulators themselves, together with other energy experts said that in this interim period, it becomes a very expensive solution as all consumers are paying both for the line into that community, and for the microgrid solution.

In effect, there is a doubling up on the costs of supplying energy to that community. There is appetite to explore this as a solution, but as mentioned above, an awareness that this represents a new way of doing things for networks, with a steep learning curve for both networks themselves and the communities to operate within a standalone system:

"

So, I think there's this sort of transitional element to a microgrid that in my mind warrants the most focus...but the step between where we are now and that fully operational microgrid solution is really tough to get to.

"

Rohan, energy regulator

As our research has found, and something picked up by energy professionals, the conversations with local communities about suitability of microgrids for their specific locale can be difficult because of a lack of exposure to system literacy of the general public. As one regulator put it:

"

...clarifying those expectations with the local residents is important. They may think that because we are only using 50% of our local grid in the Eurobodalla Shire, then we only need to pay 50% of the cost or our part of the cost, but that's not how the electricity system works. The cost of running the network is socialised.

"

Bob, energy regulator

Given the high costs of microgrids, from a public benefit perspective, prioritising trialling grid-tied microgrids in parts of the grid that are already experiencing reliability issues and high costs to service makes the most sense. Importantly however, under a governance regime in the East coast that is market-based and grants-based, any community with the resources to invest in a proposal can currently explore and invest in a microgrid, without necessarily having the system literacy to understand where best to invest for fairer social outcomes. If this fairness aspect is not addressed, experiences with other technologies hints that conflict and contestation may negatively affect microgrids' social acceptance moving forward.

Given the high costs of microgrids, from a public benefit perspective, prioritising trialling grid-tied microgrids in parts of the grid that are already experiencing reliability issues and high costs to service makes the most sense.

Sustainability

Many professionals have an intuitive sense that decentralisation provides benefits around reducing wastage associated with bringing electrons from far away. Tied into this is not just concerns about wastage, but also around accountability and social acceptance.

> **[the market bodies] are miles from the action. They need to coordinate between different parts of the NEM (National Electricity Market) which have got very different perspectives and needs. That's the last thing we need. We need local – locally focussed government, fleet a foot, accountable locally. So yeah, I think the state governments – and this is happening. It's happening anyway. It's not yet featured in the microgrid thing but I'm sure it will.**

Barry, energy expert

Various experts talked about a mix of large-scale and local energy systems being a good basis for the future energy system but, no participant had any clear sense of how that mix would be decided and a comprehensive list of various considerations that would need to be considered for a planning framework.

It appears from an engineering perspective that the only way microgrids could displace transmission is if a significant part of our regional networks were to be turned into microgrids in the immediate future – which brings its own environmental impacts (in terms of local infrastructure but also the embodied costs of green technology and digital infrastructures for control systems). It would also be a very costly proposition in the immediate term.

Participants mentioned the existing sunk cost of an already large network that requires a certain return on investment. How to align this with replacement of generation remains a serious question. In this context, without a clear policy framework, the potential sustainability benefit of grid-tied microgrids are difficult to gauge and warrants further research.

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Resilience

The potential for grid-tied microgrids to improve resilience appears for many experts to be a key potential benefit, but one that raised just as many questions.

Some experts argued that microgrids can add extra redundancy in infrastructure, but their presence may not automatically improve resilience. It depends on the context and event. For example, it is possible that the impacts of fire, smoke and flooding damage, will impact the microgrid infrastructure itself. In this vein, a couple of participants were concerned that the public's interest and focus on microgrids and renewables was setting an unrealistic expectation around the real limitations of making any one entire piece of infrastructure entirely immune from disaster events.

Instead, there was a strong theme that resilience was complex, and multi-faceted, involving individuals, communities, council and many other government agencies both in terms of disaster preparedness and response.

Instead, there was a strong theme that resilience was complex, and multi-faceted, involving individuals, communities, council and many other government agencies both in terms of disaster preparedness and response.

Where to invest limited resources into improving resilience becomes a key question for governments and networks as well as councils and householders. A key concern for regulator participants in our research was investment in expensive microgrid infrastructure, where alternatives may be cheaper. Participants saw the benefit of microgrids for providing backup power for a short period for one small community, but were unclear of how that could improve the resilience of a whole affected region.

There was a concern from regulators that microgrids could be an overly expensive solution for resilience – where other entities could service and/or other solutions may be cheaper. For many energy professionals, there was a lack of familiarity with the concept of resilience and, in particular whether microgrids could deliver the benefit in a cost-effective way.

Householders and communities' experiences and strategies for preparedness were important in how they experienced a long duration outage. In the Eurobodalla for example, many people had never experienced a bushfire before:

“

...we were impacted by some pretty major power outages during the bushfires and there's all the unanticipated consequences of that. People just were not ready for – we're used to maximum 12-hour blackouts and this challenged so many of the things about what we think we can rely on.

”

A shire councillor

In terms of local resilience in a council areas, an emergency management officer did not see microgrids and resilience being coupled together naturally. Instead, he believed it may make more sense to have back-up power for critical sites that impact the community if they don't have power across the council area. This would include locations such as nursing homes, emergency shelters, petrol stations and supermarkets.

...may make more sense to have back-up power for critical sites that impact the community if they don't have power across the council area.

The community development aspect of microgrids was raised by several participants as a potential benefit of microgrids. At the same time, many participants also raised the concern that communities do not always have the capacity to self-organise and make decisions together. The capacities and skills to do so may need to be developed if this benefit were to be realised:

“

...but we've got gaps in lots of parts of our community in that and we need training, we need help to grow that, especially get people to come together and make decisions well together.

I think we've got to regain and reclaim a lot of those skills and knowledge to be able to do that well. We're a community that's had a lot of recovery projects and now resilience projects coming into the community. All these questions about what would it take to be a prepared community and a resilient community. And I just keep on coming up against, 'Well, we need to build the capacity in our community to hold meaningful conversations well, to facilitate them well and to help people be able to think well and work together to come to good decisions'. I don't think we've got that.

”

A shire councillor

Interviewees believed a potential benefit of microgrids was bringing people together in new ways but were not clear exactly what that would look like. Ownership and crowdfunding raised fairness issues within the community that many participants were concerned about. And yet, the same participants had seen international examples of where community ownership and driving a project led to a community gaining new skills and new connections.

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Translating potential benefits into price signals and value streams is hard

Overall, interviews reveal that there remains uncertainty over:

1. the benefits that microgrids can provide concretely – how and in what contexts, and
2. the difficulty in translating different benefits into revenue streams, with some benefits such as 'community cohesion' being completely absent within the current energy governance regime.

Uncertainty over the definition of grid-tied microgrids

New technologies often have a lot of flexibility when they first emerge. There is uncertainty about what the technology affords. As this quote reveals even for people inside the energy technology space, there is still some uncertainty around what a microgrid is – its component parts and its functionalities:

> **There's a lot of companies, I think, obscuring things around this. Basically saying, "We're building microgrids." What is a microgrid?**
>
> - **Is it DER [distributed energy resources e.g. home batteries] talking to each other?**
> - **Is it about market participation?**
> - **Is it islandability?**
>
> **What exactly is it? At least in terms of the kinds of definitions that ARENA seems to accept in regional Australia, microgrids pilot program, they seem to be talking about all the way from the standalone power system, to islandable microgrids, to some sort of embedded microgrid, which is effectively DER talking to each other.**

Martin, small retailer

A lack of certainty is not necessarily a bad thing for new technologies. Instead, it represents an opportunity to explore what functionalities people expect, what they can concretely deliver, and the gaps in between. At the same time, confusion about what a grid-tied microgrid is specifically, can also make it hard to have a conversation about benefits and risks, as there is no clear public understanding of what the conversation is about in substantive terms.

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Who should own and manage microgrids?

As mentioned above, ownership is only one aspect of a business model, but remains an important dimension. The regulatory requirements to build electricity infrastructure, and the risks associated make it easier for incumbents to participate. At the same time, there exists a trust deficit in energy companies, making ownership one of – perhaps in many cases – the most important dimension of social acceptance for microgrids.[45,46] It may be that the question of ownership proves to be the most important dimension of feasibility, if and when costs come down.

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Energy experts had different views on ownership; views that usually aligned with assumptions around how energy should be governed. For regulators, for example, any group community or commercial – so long as they are complying with the rules can participate in the national electricity market. This aligns with the idea of encouraging competition. The one exception of this view is for networks, which regulators have a natural suspicion about because of their status as a monopoly.

On the other hand, if networks were to make the case for a microgrid to provide reliability, then this is a territory that is more familiar and comfortable for regulators.

However, a prevailing assumption and goal inside energy policy is 'efficiency' (a term that can be interpreted to mean different things, see e.g.[47]). This means, most energy experts are also concerned about who and how it would work to use some parts of the microgrid (e.g. a battery), to trade in the wholesale markets (something that networks are not allowed to do):

> **So if you have a DNSP-owned and operated microgrid, the DNSP is going to have to own generation, for which it may or may not need... Well, it will need a waiver. And then how it owns, particularly, even if it's storage. So how that waiver operates, and what bits can the DNSP do versus another third party, say, for the energy piece?**

Jackie, Energy expert

Community ownership will be covered in more detail below. Most experts believed it would be difficult for a community group to finance and take on the risk of a microgrid. One professional did suggest that ownership and operation could be separated and while the community could own the microgrid, they could outsource to a third party to operate. This still raises questions about the capacities required of a community group to understand and interpret the expertise provided by a third party ensuring they are operating in line with community interests.

For reasons of social licence and of accountability, many interviewees assumed that local councils would be ideal owners and maintainers of the microgrid, especially in the context of a long electricity outage – in order to communicate with and be an intermediary between the technology and the local community:

> **...They'll [microgrids] be ceded to the local authority. They'll become part of the electricity division of a local authority. And we'll go back to how electricity was distributed and sold in Australia, just about everywhere in Australia really up until the 1980s where there was some level of central production, often a fair bit of local production but the local authority did the distribution and the billing. And that's where I think microgrids are likely to end up.**

Barry, energy researcher

However, the local government participants in this study did not see themselves as playing this role at all. They did not consider that they had the resources or the expertise to manage a microgrid, in large part because of the complexity and technical nature of the current energy system.

There was very little discussion about private companies owning and managing microgrids – although a small number of participants believed it may happen. It is most likely participants did not see retailers as obvious owners because the infrastructure is currently expensive, and unprofitable.

The transaction costs required to engage with the community and build social acceptance was raised as an important cost for organisations with few intimate local communities' ties such as networks and large energy companies.

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When we consider our interview and workshop participant data with householders from this project, we can see there may be a natural tension in expectation between householders and experts. Overwhelmingly, householders gravitated towards community ownership – a finding that mirrors our previous research with neighbourhood batteries.[43]

In our fieldwork, as householders began to understand the complexity of what's involved in building and running a microgrid (i.e. requiring interaction with the energy market), people responded in different ways. Some become interested in a network ownership option (though with considerably less enthusiasm), and yet others, decided that perhaps no action may be preferable. In other words, if a microgrid could not be owned by the community, then perhaps it was better not to have a microgrid at all. In our data, only one householder saw a private company as a possible option.

Our interviews revealed that there seems to be no agreement on ownership across stakeholder groups. Networks are seen as inefficient and (by some) as untrustworthy. Retailers are not motivated enough, nor are they trusted by the community. Experts don't see community as owners or competent operators. And the local government participants did not see themselves as owner/operators.

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Even before coming to enough revenue to pay for and maintain the microgrid, it appears as if ownership may be the biggest hurdle to overcome for feasibility of microgrids in regional Australia.

What professional skills and capacities are needed to design, build and operate microgrids?

An important question for feasibility is whether the current institutions and organisations hold the skills and capacities to design and deliver new technologies. We did not explore this from a vocational trades and skills perspective – although this is a critical angle that requires thorough investigation – at a region-by-region scale.

For many regional areas, the energy transition is seen as an opportunity to improve energy resilience and local energy sovereignty, to eliminate large powerlines from their region and hence some bushfire risk, and to take action to reduce greenhouse gas emissions. However, experience suggests that simply engineering a grid-tied microgrid will not bring about these kinds of desired futures.

The technology of microgrids are the outcomes of political, economic and social activities, as are all public infrastructures. Energy infrastructure that we witness in transition involves the many institutions that regulate, build, maintain, use and profit from it, community participation and governance, local political economies, and much more.

What we know for energy transition research is that all these organisations and rules frameworks would require reorganisation and new ways of doing if microgrids were to deliver positive social and economic co-benefits. These changes will require new skills and capabilities across many parts of the sector to create the conditions for a transition to local energy systems to occur, to establish new infrastructures, and to operate and care for those infrastructures and the people who rely on them.

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Community engagement

One of the biggest aspects requiring capacity building raised was governance and deliberation with communities. Under the current energy policy framework, there are no policy requirements on local energy projects to fulfil and report on concrete social and environmental benefits. For example, a battery or solar farm could be run or optimised for profit, cost savings, carbon emissions, or self-sufficiency.[2] (These are not always complementary).

Arguably, such decisions should not be left to 'the market' to decide, but rather clear policy guidance provided as to which of the values is most important for public benefit. However, for an microgrid project to be socially accepted, it would need to engage with the affected community to decide what the business model should prioritise and the form, type and location of the infrastructure. We can expect some contestation around this as householders and business owners would have different views on this question.

In addition, planning and preparation would be required for operation under special circumstances, such as during bushfires when the connection to the main grid may be lost. During these times, governance must be equipped to successfully manage a finite, common pool of energy in a complex, unfolding situation that could involve knowledgeable permanent residents alongside other people, such as less knowledgeable residents or transient tourists.

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Design, operation and accountability

As we described earlier, microgrids are designed to optimise for specific outcomes, such as maximising the use of locally produced energy or maintaining a certain duration of back-up power. The possibility of multiple optimisation goals is just one among many sociotechnical factors that make technologies like microgrids inherently complex. In energy, many businesses and experts have suggested that digitalisation is proposed as a solution.

However, digitalisation in practice can hide complexity, leading to even less clarity, missed communications and a decline in public trust. In other words, putting an algorithm in charge of decision-making can create new complexity that must then be managed through continual social interventions such as adjustment, information-sharing and evaluation. The range of necessary skills to deliver a successful microgrid grows accordingly.

Many interviewees were clear that 'demand management' (i.e. people changing their energy consumption) would be an important feature of a grid-tied microgrid working well. To add complexity, a grid-tied microgrid works in multiple modes. Most of the time it would be expected to work in grid-tied mode which is when the lowest level of community participation in demand management is required.

However, in islanded mode, users of the microgrid might need to reduce electricity use to maintain a finite supply for as long as needed. But if the power has not been interrupted – because there is a microgrid – how will they know it is time to practice a different mode of consumption? Furthermore, there may be an additional mode when the community is preparing for an approaching disruption. During this time, microgrid users might need to conserve energy. Automation could offer a solution, but microgrid designers still need to appreciate the additional social capabilities and processes required, and operators will need to make it work.

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What is the community's role in microgrids?

Groups must have the skills to negotiate community interests that may be conflicting and must work transparently such that larger scales of governance are able to monitor for potential problems such as local corruption, non-contributors, negative discrimination and strategic behaviour.[13]

As we talked about in *Exploring microgrid governance, business models and energy resilience*, community groups engaged in common resources like a microgrid need to interact with the technology and potentially change their behaviour e.g. in an outage context. As mentioned already, one of our interviewees made the point that training in these 'commoning' skills would be required before – in the case of the Eurobodalla – South Coast communities would be capable of governance. Another argued that practicing face-to-face discussion between community members was an essential and irreplaceable part of cultivating trust and accountability.

Experts believed that community groups taking on responsibilities in delivering essential services like electricity need to be sustainable. They must avoid placing too much reliance on individuals, as volunteers are prone to burnout, a situation, research elsewhere has found becomes more difficult during times of economic decline.[48] Groups must have the skills to negotiate community interests that may be conflicting and must work transparently such that larger scales of governance are able to monitor for potential problems such as local corruption, non-contributors, negative discrimination and strategic behaviour.[14]

Professionals largely agreed that community should be involved in decision-making and design, but differed in the degree to which they see this involvement being productive.

Unsurprisingly, the institutional actors who regulate and operate the energy system envisaged the least active role for people, seeing them through an economic lens as 'consumers' who participate via a retail offering. Others recognised the need for community engagement in energy system planning, but preferred that it occur under a 'residual realist' framework whereby the engagement format is fixed, designed to be scalable, and occurs after the technical challenges have been solved.[49] These participants framed community engagement as pragmatic processes within the constraints of conventional engineering project delivery.

All participants – including people with experience in local community organising – agreed there are limits to community ownership and governance because of limited capacity to manage the complexity, legal liability, and safety of energy infrastructure. However, some recognised that community groups might be in a position to take on extra risks and tolerate failure, in contrast to other actors such as local governments who generally have to apply more pragmatism and risk-aversion to investments and decisions.

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In contrast, what did householders understand community participation in microgrids to involve? We've already discussed ownership. Otherwise, householders believed that engagement was complex and difficult. They spoke at length about how difficult it was to get people to turn up to information events in their community (e.g. about bushfire preparedness), and said it was likely, that in the end a small group of people would drive any potential project. They said in this context, it would be challenging to see representativeness in this small group and emphasised that broad engagement and representation would still be important (and challenging).

Householders were certainly willing to adjust their energy use in times of an outage and had some ideas about how this would work in practice. However, without a specific model of microgrid, it is difficult to speak in detail about how householders might like to participate. Research in smart energy trials has revealed a lot of challenges with models that require significant digital and reading literacy, and assume a motivated, time rich 'prosumer'.[50–55]

Householders were certainly willing to adjust their energy use in times of an outage and had some ideas about how this would work in practice. However, without a specific model of microgrid, it is difficult to speak in detail about how householders might like to participate.

We've learned that complicated business models that require ongoing monitoring and active participation are unlikely to be feasible for the majority of householders.

Image: Nuno Marques on Unsplash

Energy resilience

Can grid-tied microgrids improve energy resilience?

We have briefly spoken about the challenges for grid-tied microgrids to improve overarching energy resilience.

Resilience in the context of energy systems usually refers to the ability of the system to recover from high impact, low probability events such as extreme weather, encompassing the immediate and long-term aftermath and focusing on not only engineering operations but on the lived experiences of people affected.[56]

A resilient response could mean a return to stable conditions, either to the previous conception of 'normal' or adaptation to something new.[57] Resilient energy systems should therefore have the capacity to adapt to long-term change. Because energy systems can both contribute to climate change and be subject to its impacts, long term adaptive capacity includes mitigation of climate change.

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How does a renewables microgrid fit into the above concept of a resilient energy system? It would mean that microgrids would need to fulfil multiple criteria – they would need to:

1. Be the fastest and fairest option for providing back-up power into a community that has lost power; but at the same time also,
2. Be the most efficient means of decarbonising our electricity supply.

It was not immediately clear from interviews that grid-tied microgrids fulfilled both these criteria, in all contexts.

So what, then are the alternatives to building new microgrids for improve the energy resilience of regional areas?

To understand what a resilient energy system could look like, we can learn from the experiences of the disaster preparedness community. Over time, we've learnt that resilience as a pursuit of 'stability' can tend to favour the status quo of existing advantage, injustice or unsustainability.[58] A framing of resilience, blind to inequality of capacities between householders, which puts the responsibility only on individuals to become more resilient can be unhelpful.

Disaster events tend to exacerbate existing household or demographic inequalities and insecurities as they intersect with sociodemographic factors that correlate with the affordability of, or interest in, energy technologies such as age, education, remoteness and reliance on social housing.[59]

As some of our participants emphasised, disasters exacerbate any issues in the underlying social fabric and investment in improving social fabric are more often more important and effective than technical solutions. At the same time, other interviewees stress that householders still have a responsibility for resilience, for example, by preparing a bushfire plan, and knowing where local evacuations centres are located etc.

As some of our participants emphasised, disasters exacerbate any issues in the underlying social fabric and investment in improving social fabric are more often more important and effective than technical solutions.

To improve resilience, it is important to understand that context matters. Energy vulnerabilities can relate to network, geographical and environmental variables such as remoteness, line voltage, accessibility and cost of energy, frequency of outages and extreme weather events.[60] Social and behavioural factors such as energy practices and access to energy technologies can also shape the vulnerability of low-income households.[59] In some areas, including the NSW South Coast, transient groups such as tourists bring different energy practices and needs and can be a source of local community resentment, seen as consumers of finite resources who do not contribute.

Some people we interviewed working in energy policy and regulation viewed energy system resilience as similar to day-to-day reliability in energy supply, only at a greater scale with longer outages affecting more people.

From this point of view, improvements to energy resilience were assessed against the cost of providing them in order to find the most economically efficient outcome. Other participants emphasised the goal of 'bouncing back' after a major disruption and adapting to changing conditions, which requires systemic and long-term change. Some noted that community expectations of energy resilience were much higher, and encompassed more issues, than what is the currently-accepted responsibility of regulators and network operators.

And yet others understood resilience differently and believed at the system level that the governance framework itself was producing vulnerability:

> **…so a lot of the challenges that we're seeing with resilience at the moment happen because our whole energy system, the structure, has been designed for a market model that no longer exists and won't exist going forward. So a lot of the regulatory changes over the years have become very piecemeal. They're very reactive rather than trying to be on the front foot.**
>
> **And as a result, I think that over time our whole system has become significantly less resilient coupled with the additional challenges of climate change and other market shocks that we've seen, whether it be the war in Ukraine or the global financial crisis or where it's COVID.**
>
> **There have been a number of other market shocks and all those factors have compounded to get to a point where – while on paper, our grid probably looks almost more resilient than ever. We certainly spent a lot of money on it. I don't feel confident that we have resilient grid.**

Lorrae, energy researcher

Many participants believed that improving resilience requires all hands on deck but it looks different at different scales and for different parts of the problem. Only networks and councils can work together to identify and find a solution to provide back-up for the telecommunications tower (yet they currently struggle to raise funds to do so).

But only householders can build social relationships and have the knowledge about who in their street doesn't have a car and needs a helping hand. Our participants emphasised the importance of local context and experimentation in developing resilience, as well as a need for a national resilience authority with a long view and better national/state-level coordination of agencies.

But only householders can build social relationships and have the knowledge about who in their street doesn't have a car and needs a helping hand. Our participants emphasised the importance of local context and experimentation in developing resilience, as well as a need for a national resilience authority with a long view and better national/state-level coordination of agencies.

The following quote from Western Australia, provides a hint as to the importance of local actors and resources, particularly in remote regional areas:

> **Well, I think, I guess the advantage of councils, especially in our more regional areas of the network, is they have a lot of local resources available to them as the council entity and a community group. So, I guess, as you...take away that long transmission level connection and everything being centralised more back to major centres to now having technology deployed more locally, what does that look like as far as first line service level type reviews in maintenance and if there's still fuel required, so fuel top-ups and things like that. Then that kind of thinking opens up to what's that local role to play versus a crew and a depot that still might be a couple of hundred or a hundred kilometres away, could still complement that local resource.**

Network professional, Western Australia

Similarly, multiple levels of governance were seen as important that can combine the small-scale benefits of local knowledge, with the larger-scale benefits of investment and abilities to address potential poor or corrupt governance.[14]

For networks, research has shown that governance for resilience within an organisation needs to occur at multiple scales, at the:

- **OPERATIONAL LEVEL**, focusing on ensuring the day-to-day ability to absorb disturbances
- **TACTICAL LEVEL**, focusing on continuous improvement, adaptive risk management and opportunistic adaptive capacity; and
- **STRATEGIC LEVEL**, working with other system players to ensure that the energy system is being transformed towards long-term sustainability in the context of inevitable change and disruption.

Practically, the clearest finding was that investing in social infrastructure would likely be the biggest way to improve energy resilience for regional communities. Otherwise, improving existing network infrastructure, especially critical infrastructure was seen as important. Remote parts of the grid – which would not include the Eurobodalla – would be an exception to this. Remote parts of the grid were seen as good candidates for stand-alone microgrids with the potential to improve resilience (if the infrastructure is not destroyed in an extreme weather event).

Practically, the clearest finding was that investing in social infrastructure would likely be the biggest way to improve energy resilience for regional communities.

Most participants did not believe that fossil fuel generators were ideal from a resilience perspective. While they are the cheapest form of back up now, they require fuel on hand and the skills to use them, and have a high emissions profile.

Another alternative is households become self-sufficient with their own household battery. This option is currently the most socially regressive, as it means that only asset owners can access resilience and that they do not contribute to paying for an essential service (unless funding for networks is raised by a different means). Using EVs as a 'vehicle to home' option may be less socially regressive because at least EV owners are contributing to network fees through charging up the car, though further analysis would be helpful.

At the same time, grid-tied microgrids were not seen as improving energy resilience resilience for a few reasons. Firstly, because the disaster event can still destroy that infrastructure (e.g. an out of control fire can burn a solar farm), and secondly, because it may not be the most efficient way to decarbonise our electricity system where there exists a grid connection already.

At the same time, grid-tied microgrids were not seen as improving energy resilience resilience...because the disaster event can still destroy that infrastructure (e.g. an out of control fire can burn a solar farm), and secondly, because it may not be the most efficient way to decarbonise our electricity system where there exists a grid connection already.

Image: Eurobodalla Coast Tourism ©

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Where to next? Can we develop a microgrid that meets public expectations?

Our report has shown some significant tensions and challenges with microgrid feasibility. No aspect – from who should own them, to whether they'll genuinely improve resilience – held a straightforward or clear answer.

Other experts have already investigated the regulations needed to change to enable microgrids to be developed within the current energy governance framework.[61] Stepping back, our interviews seem to reveal something key to feasibility that requires consideration before we explore trials and developing new regulations. We need a clear governance framework to ensure that we are building microgrids in line with the values of a sustainable and resilient energy system.

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Without this it is difficult to gauge:

- In what locations would a grid-tied microgrid improve energy resilience
- What other capacities and activities are required to improve community energy resilience
- What decision-making framework determines why a microgrid is suitable (versus other options)
- Who is going to engage the community to interact with the microgrid design and operation and how is this funded?

If we zoom out to fully understand householder interest and excitement in technologies like neighbourhood batteries and microgrids we can more fully begin to grapple with the nature of the energy governance challenge before us.

In Australia, the decentralisation of energy has been led by individual householders and some community groups who are frustrated with the slow pace of the energy transition.[45] And yet, the motivations, interests and capacities of most market participant energy companies (for whom the current system is designed) versus householders, local government and small businesses are vastly different. How those two scales of system operation interact in terms of governance, organisational and financial flows is an open question that remains unresolved. And yet, they need to be legible to one another in order to lead to a cohesive future energy system.

Policy clarity and public interest

The biggest policy challenge with grid-tied microgrids relates to social equity and sustainability more broadly. The interview analysis above reveals limitations in the market governance regime's capacity to find the most efficient and fair solution to a resilience gap currently because of the complexity of the energy system, the skills and capacity gaps organisationally as well as the heterogenous nature of the Australian community. The current situation of leaving it to individual communities to advocate for microgrids means there is no clarity around whether investing in what is currently still expensive infrastructure will genuinely improve system and community resilience.

The current situation of leaving it to individual communities to advocate for microgrids means there is no clarity around whether investing in what is currently still expensive infrastructure will genuinely improve system and community resilience.

Earlier on in the SμRF project, we developed a matrix that considered a range of factors that would need to be considered in deciding where a microgrid could improve energy resilience. Factors included the number of elderly people living in that community, and the existing network typology.[62] We argued that the choice of suitable sites for microgrids is not only a techno-economic process, but that we need to consider social vulnerability and capacity as well.

We argued that the choice of suitable sites for microgrids is not only a techno-economic process, but that we need to consider social vulnerability and capacity as well.

Alongside the usual techno-economic considerations, the site selection process itself must be responsive to the local socio-political context and concerns (e.g. multiple values, needs and expectations of energy infrastructure or perceived fairness of technology deployment).

But the policy context has yet to reflect evidence that the public's perceived fairness is critical to the social acceptance of new technologies.[40] In this sense, it has become clear that microgrids are a microcosm of broader policy challenges in the energy transition. There remain important social and political considerations that need to be reflected in a governance regime that is fit for purpose with contemporary public values.

There remain important social and political considerations that need to be reflected in a governance regime that is fit for purpose with contemporary public values.

This regime needs to resolve questions such as, what are the public policy goals of the energy transition? What mechanisms will be used when solutions require consideration of trade-offs and complexities? The complexity of the issues outlined by our interviewees demonstrates that grappling with these questions through relying on a cost benefit analysis alone will likely slow down the transition to a renewables and socially acceptable energy system.

Our previous research has shown the consumer protection gaps in technologies like rooftop solar where householders with very little energy expertise must contend with complex technologies of variable quality in a context of industry self-regulation.[63] The microgrid development context will likely face similar challenges. Currently, there is very little monitoring or scrutiny of these types of infrastructure once they have been built:

“

...We're out of the loop at that point and they [The Network] deliver that microgrid and we would let them go about that. So, we don't handhold after the decision is done if that makes sense.

”

Regulator

While policymakers were highly attuned to questions of consumer protection when it came to questions of safety, reliability and retail competitiveness, there was also blindspots when it came to question of whether a potential grid-tied microgrid developer would consult the community, respond to concerns and maintain the quality of the infrastructure over time. As case studies of the Bushlight Program caution, the resources required to engage the community, design and build complicated energy systems of high quality are extremely high.[64]

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Trials

Participants raised many ideas for different dimensions of microgrids that are unknown and would benefit from real-world trials. But as our analysis has already revealed, trials should only be considered in remote parts of the grid that are experiencing significant reliability challenges. Trials should focus on second-order learning whereby expectations and models are altered based on what is learnt along the way. This means that rather than a 'road map' (where the destination is predetermined), microgrid trials and research should take the form of a story with multiple strands.

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Areas for development include:

Social

What can microgrids do and how does operationalising them affect things like consumer trust, community resilience, community/economic development; equity and fairness; microgrids in the broader context/structure of the energy transition.

Technical

Islanding, operationalising remote control, maintaining power quality, in different sections of the network with different topologies and different types of loads/end use.

Economic

Trialling different services, including voltage and thermal capacity, market services, and value stacking; as well as viability.

Legal and regulatory

Legal frameworks for experimentation and sharing responsibilities; allowed role/s of networks and third parties, testing/clarifying regulatory pathways.

Creating resilient energy futures

At its heart, improving resilience is about creating the kind of future that we collectively desire. As such, there will always be some level of conflict because people have different understandings of the problem and expectations of the future. Rather than assume that we can sweep these disagreements under the carpet through an optimal technical solution, it is important to include energy users in policy reform, including whether and how microgrids could support a resilient energy future.

In areas as diverse as municipal budgeting, to water management and infrastructure planning, we know that involving people in decision-making leads to better, more appropriate solutions, as well as smooth project implementation as people are more likely to trust that their concerns have been addressed.

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Public involvement in resilience planning and energy system change is even more important since they need to understand the options and uses of energy during extreme events. The public are more likely to understand these options if they have been involved in the planning.

For energy resilience, a key takeaway from this report is that there are likely to be lower cost, more equitable solutions to improve energy resilience, that are also more immune to the effects of bad weather (e.g. smoke impacts) than grid-tied microgrids.

What will improve resilience will be specific to each community. But there examples of cheaper, more equitable and physically more robust alternatives such as emergency community hubs (with the facility to easily 'plug in' a diesel generator). As our previous report[1] suggested, supplying energy to vital telecommunications infrastructure (that enables phone coverage and EFTPOS) is also key, as is supplying power for petrol stations, water pumps, and refrigeration (in shops and chemists) across a whole region may improve energy resilience more so that providing electricity to whole communities in only some parts of a council area.

Finally, there are technical modifications to existing rooftop solar on homes or community facilities that would cheaply enable people to use solar power even when the network is down.

The analysis above has revealed important and deeply held assumptions about governance that shape appetite and openness to reform for both resilience and providing a coherent policy framework for grid-tied microgrids. For example, there is genuine concern for some participants inside market bodies about changing any rules that might challenge the principle of competition that underpins the mechanism for accountability in the national electricity rules.

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As such, any alternatives to the current system – including microgrids – will be viewed through this lens. Importantly, we also know that this is a different perspective from many members of the public and this difference should be addressed and explored before any regulatory reform.

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Appendix

Applying commons governance principles for microgrids:

1. The boundaries of the resource and the actors that can access it are clearly defined
   - We know who participants in the microgrid are and it is clear to participants themselves.
2. Rules for appropriating and provisioning the resources are tailored to the local context
   - The microgrid design might fit local context, for example smaller infrastructure in a space constrained location, or providing backup in a location that experiences frequent blackouts.
3. People affected by the rules can participate in modifying the rules
   - Microgrid participants understand and participate in changing the rules and terms of participation.
4. Develop a system, carried out by community members, for monitoring members' behaviour
   - Monitoring of whether the rules are being followed is simple and acceptable to microgrid participants.
5. Graduated sanctions are imposed on rule violators
   - Microgrid participants experience graduated sanctions
6. Low cost, local conflict resolution mechanisms are easily accessible to users and officials
   - Microgrid participants have access to a low-cost means for dispute resolution
7. The rights of users to organise are recognised and not challenged by authorities
   - Microgrid participants can make some of their own rules and this is respected by the governing bodies.
8. Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system.
   - The microgrid is part of a bigger system and it is important to think about what responsibility is appropriate to microgrid users, and yet other responsibilities is more appropriate for the network level and, above that the energy system as a whole.