CHAPTER 2

Networks

What Is a Network, and What Types of Network Do We Find in Smart Grids?

A network, put simply, is a group formed from parts that are connected together (Cambridge Dictionary, 2020) or a collection of points joined together in pairs by lines (Newman, 2018, p. 1). Networks describe relationships between things—how things and people are linked together. There are many different types of network, from networks of humans (social networks) to ecosystems of plants and animals, and networks within and between organisations. Many different types of network have been observed across the Earth's ecosystems, infrastructures, and societies, from food system supply chains, to 5G communication networks, to social networks. In relation to energy sector innovation, most networks comprise a mix of social and technical elements: sociotechnical networks are about people-technology interactions (see Chap. 1 for a summary of academic theories in this area). We see evidence of people-technology interactions in the three smart grid examples discussed in this chapter.

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There is overlap between the terms system and network, and they are often used interchangeably. For instance, Thomas Hughes, a historian of technology, defines a system in a very similar way to the network definition above as "constituted of related parts or components" (Hughes, 1983, p. 5), but for Hughes, the network is the physical or material structure that links the components. In science and technology studies, the term system is used more often than network to describe large complex infrastructures such as electricity. An alternate view is to see networks as a simplification of systems, as the physicist Newman explains:

> A network is a simplified representation that reduces a system to an abstract structure or topology, capturing only the basics of connection patterns and little else… a lot of information is usually lost in the process of reducing a full system to a network representation. (Newman, 2018, p. 7)

It is therefore important to remember that in order to study networks, things and people that are judged to be less critical to the operation of the network (and/or to the interest of the person studying the network) are excluded from the conceptualised network. This curation means that the boundaries of any conceptualised network are imposed or idealised; in practice, they tend to be much more blurred and fluid.

Characteristics of Networks and Their Relevance to Smart Grids

The key characteristics of networks are their components and the relationships between them. In other words, networks are about multiple components and the relations between these components, which, in turn, define how the network is arranged and how it functions. There are many ways that networks can be analysed, such as calculating how centralised the network is, looking at subgroups within a network, or identifying powerful nodes. Many of these techniques are quantitative and use mathematical theories. Here I concentrate on the qualitative study of networks. The main reason networks are studied is because the pattern of interactions within a network can affect network behaviour or outcome. In other words, understanding network interactions helps us to understand network function.

Networks are relevant to smart grids because, first and foremost, smart grids are about the digitalisation of (in most parts of the world) an already existing significant infrastructure network: the electricity grid. At its heart, the large-scale electricity grid system is about connectivity: providing electricity to multiple consumers from large-scale electricity generators. Traditionally it has been a supply network, although, in recent decades, there has been a shift towards a more complex grid to also manage generation from consumers (prosumers) because of decentralised electricity generation. Smart grids involve modernising existing infrastructure through the integration and overlay of new digital technologies and capabilities. This allows the traditional (physical) grid infrastructure to be operated more effectively because there is real-time data on factors such as generation, consumption, voltage, and condition of the electricity lines.

In the above description, the electricity network is described mainly as a physical network of technologies: power lines, sensors, substations. There are many examples of definitions of the electricity network that follow this kind of description, for instance, the following from industry association Energy Networks Australia:

> Electricity Network means transmission and/or distribution systems consisting of electrical apparatus which are used to convey or control the conveyance of electricity between generators' points of connection and customers' points of connection. (ENA, 2008, p. 3)

This definition is very technical, focusing on the material infrastructure and objects that comprise the electricity network. In reality, there are many fundamentally social aspects of an electricity network—from the rules and standards that define the technical specification of the network, to the decision-making of end consumers. Where the smart grid gets interesting, and considerably more complicated, is when we consider the human actors within smart grid networks. As mentioned in the introduction to this book, often people are quite absent from smart grid definitions, as in this definition from the US National Institute of Standards and Technology:

> [smart grids involve] the addition and integration of many varieties of digital computing and communication technologies and services with the power-delivery infrastructure. (NIST, 2014, p. 33)

Humans are, of course, relevant to smart grids in a number of ways, whether as individuals or as part of households, organisations or community groups. If we start to see smart grids as mixed social and technical (sociotechnical) networks, this is a bit more complicated, but it better reflects the actual on-the-ground workings of smart grids. It is when smart grids are conceptualised as just a technical network that we can run into problems, as a manager of an energy NGO described to me in relation to the implementation of a smart metering programme:

> A lot of the leadership of the project had been handed over [by the government] to consultants. And it really felt to me like there was a lack of understanding in government, that **it was not just an industry issue but that it was a public policy, social policy and political issue** that needed leadership that reflected all of that. And I think they got there in the end but it was painful to get there. (Interview, November 2016)

Different Ways of Thinking About Networks

In the biological sciences, the main focus of network analysis is plants, animals, and ecosystems. In computer science, attention in recent years has concentrated heavily on machine learning networks. In the social sciences, policy networks are an area of interest—groups of actors from inside and outside of government that together influence what is on the policy agenda and how well policies are implemented. Social network analysis is another key area of social science research that uses quantitative data on who knows who to create intricate maps showing social relations. Social scientists studying technology are interested in networks made up of people and technologies: sociotechnical networks. They aim to take a neutral view about which type of actor in the network is doing work, technology, or person. In other words, there is an openness to non-human things—devices, infrastructure, technology, computers—doing equivalent work to humans. Sociotechnical networks are a key type of network analysed in this book because of their strong relevance to energy innovation. Table 2.1, below, provides a summary of the types of networks that social scientists are interested in, and how different disciplines conceptualise and explain the diverse functions of these networks.

Table 2.1 Types of networks studied by social scientists

Type of network	*Field / discipline*	*Common terms and descriptors*	*Core characteristics*	*Definitions*
Policy network	Political science	Networks, coalitions, policy network analysis, policy communities	• Comprised of people, organisations, values, beliefs and resources • Structures (institutions) that define, generate and implement policies • Operate as a form of collaborative governance, including both formal and informal, public and private interactions • Develop over time and tend to be longstanding, but are also constantly evolving • Change typically happens in response to changes outside of the policy network (exogenous changes)	"Policy networks are sets of formal institutional and informal linkages between governmental and other actors structured around shared if endlessly negotiated beliefs and interests in public policymaking and implementation. These actors are interdependent and policy emerges from the interactions between them." (Rhodes, 2006, p. 424) "[Policy] Networks… result from repeated behaviour and, consequently, they relieve decision makers of taking difficult decisions; they help routinize behaviour. They simplify the policy process by limiting actions, problems and solutions." (Marsh & Smith, 2000, p. 6) "Operating in a more or less institutionalized setting, [policy network] actors are engaged in horizontal, relatively nonhierarchical discussions and negotiations to define policy alternatives, or formulate policies, or implement them." (Coleman, 2001, p. 11608)

(*continued*)

Table 2.1 (continued)

Type of network	*Field / discipline*	*Common terms and descriptors*	*Core characteristics*	*Definitions*
Sociotechnical network	Science and technology studies, innovation studies	Actor-networks, sociotechnical systems, large technical systems, technological networks	• Comprised of social and technical things, which become coherent actors (i.e., capable of doing a task or performing a service) if they are closely interconnected • Technologies and other material things provide stability to the network, especially if they are durable (e.g., power stations) • Characterised as unstable in actor-network theory but stable within sociotechnical system theories	"Sectors like energy supply, water supply, or transportation can be conceptualized as socio-technical systems. Such systems consist of (networks of) actors (individuals, firms, and other organizations, collective actors) and institutions (societal and technical norms, regulations, standards of good practice), as well as material artifacts and knowledge… The systems concept highlights the fact that a broad variety of elements are tightly interrelated and dependent on each other… This has crucial implications for the dynamics the systems exhibit, and especially for system transformation." (Markard et al., 2012, p. 956) "networks are comprised of diverse materials, woven together in order to ensure the durablity of the consolidated relations…such relations count for little unless they are held together by durable and resilient materials." (Murdoch, 1998, p. 360) "networks are not **in** the actors, but are produced **by** them." (Callon, 1991, p. 155)

Economic / business networks	Economic geography, business studies	Global Production Networks, network models	• Comprised of corporations and their products • Strong international focus • Networks of production and consumption • Business networks are specifically about the relationship of one business with others (their network), differing from other network theories, which are about "the relations between all elements of the set" (Kilkenny & Fuller-Love, 2014, p. 303); that is, they include technologies or other types of organisation. • Economic networks operate at multiple scales and levels of analysis (Knoke, 2014) • Emphasis on quantitative analysis (e.g., quantitative network models are used to assess network structures and function (see Jackson, 2010))	Global Production Networks are "the complex firm networks and territorial institutions involved in globalized economic activity, and how these are structured both organizationally and geographically." (Coe & Yeung, 2019, p. 777) "Economic networks operate at multiple levels of analysis, including individuals (consumers, employees), groups (households, work teams), organisations (firms, interest groups), and populations (industries, markets), as well as across these levels." (Knoke, 2014, p. 3)
Social networks	Sociology, economic sociology, organisation studies	Social network analysis, social networks	• Comprised of humans • Emphasis on detailed *social network analysis* using computer software and quantitative techniques • The technique has been used to study a range of different social networks, from religious groups to friendship patterns	"A social network is a set of socially relevant nodes connected by one or more relations. Nodes, or network members, are the units that are connected by the relations whose patterns we study. These units are most commonly persons or organisations." (Marin & Wellman, 2011, p. 11)

One way to think about characterising different types of network is by what links the components of the network. For instance, in international smart grid networks, it is expertise, work and organisations that link members (see Case Study 2.1). In community smart grid networks, it is typically location and a sense of place that links the members (see Case Study 2.2 of Bruny Island). In other spheres of life, it might be values or beliefs that are the link binding the members of a network together. For example, the political scientist Sabatier's ideas about *advocacy coalitions* focus on networks of people working across a range of organisations (public and private) who are united to push for policy change based on their values (Sabatier & Jenkins Smith, 1993).

Network resilience depends on the strength of these linkages. A theory within science and technology studies called actor-network theory (see Chap. 1; also Table 2.1) is relevant to the discussion because of its focus on early-stage innovations. Actor-network theory is one of the people-technology interaction theories that study both the social and the technical elements of networks. A key observation is how fragile sociotechnical networks are: they are very prone to breaking down. One of the founders of actor-network theory, Michael Callon, demonstrates in his case of scallop conservation in France how when the scallop larvae failed to thrive in new specially designed collector units, and they were harvested too early by the fishermen, the network failed (Callon, 1986). From Callon's classic case to examples in agriculture (Higgins & Kitto, 2004), housing (Lovell & Smith, 2010) and medicine (Singleton & Michael, 1993), actor-network theory scholars have examined issues of network fragility, breakdown and failure.

According to Callon and others, a critical stage in the development of new networks is that of *translation*—a process by which previously disparate things and people are brought together into a coherent network (an actor-network) that can act in a unified way. Callon and other science and technology studies scholars have noted the amount of work involved in translation, as well as the ongoing effort required to maintain network stability (Callon, 1986; Murdoch, 1997). These ideas about the tendency of sociotechnical networks to disintegrate have also been applied to utility infrastructures (Graham & Marvin, 2001; Sovacool et al., 2018). This is highly relevant in thinking about smart grids and other types of energy innovation, where lots of hidden behind the scenes work goes into keeping things like electricity networks running smoothly. As Graham and Marvin in their book *Splintering Urbanism* remind us, infrastructure networks are "precarious achievements" (2001, p. 182).

Case Study 2.1 International Smart Grid Policy Networks

Italy decides to implement new digital electricity meters in all households, thirty two million in total, a programme that commences in 1999 and requires new meters to be specially built, as none yet exist. The State of Victoria in Australia decides in early 2006 to upgrade its planned new electricity metering programme to an advanced metering programme so that meters can communicate with each other (DPI, 2007). In a suburb of Austin, Texas, a comprehensive smart grid pilot is implemented in 2008 (The Pecan Street Project, 2010). How are these diverse decisions and programmes connected? The answer: through international smart grid policy networks. No smart grid pilot or initiative is done in isolation. People in government, corporations, and other types of organisation working in the field of smart grids do not make decisions alone, but rather with reference to what has gone before, and in other places.

Several international governance organisations facilitate this very type of information exchange. There is the International Smart Grids Action Network through which governments share smart grid ideas, policies and programmes (ISGAN, 2015). There is also an equivalent corporate international group—the Global Smart Grid Forum (recently renamed as the Global Smart Energy Federation) (GSEF, 2020). Mission Innovation is another international organisation that has a dedicated smart grid programme based on sharing learning between countries and specific sites of smart grid innovation (Mission Innovation, 2021). There are also international standards organisations such as the International Organisation of Legal Metrology and the International Electrotechnical Commission that work closely to set new standards to underpin smart grids and to facilitate seamless smart grid operation from country to country.

Through these international policy networks, smart grid activities worldwide are connected, reviewed and learnt from. To more fully understand the social aspects of smart grids and their effects, it is essential to recognise that these international networks exist and are active in sharing both the good and the bad of smart grid practices. These global networks bring both advantages and disadvantages (more about this later).

A branch of social science called policy mobilities seeks to better understand this type of international policy network (Peck & Theodore, 2010). Policy mobility scholars are interested in how policy ideas and programmes have joined the globalisation bandwagon. The idea is that with globalisation, policies are becoming increasingly mobile—travelling around the world and being implemented in different places, based on what one country or city has been doing over in Asia or Europe. The international policy networks mentioned above are pivotal in facilitating this global diffusion of smart grid policies from country to country, city to city. We can see many examples of this. For instance, the graph below (Fig. 2.1) shows how Australian smart grid projects have been referenced internationally from a sample of over one hundred international policy and industry reports.

We can also drill down to look at specific smart grid projects and how other countries have cited them. Data on two large Australian smart grid projects—Smart Grid Smart City and the Victorian Advanced Metering Infrastructure (AMI) Program—is shown in the graph below (Fig. 2.2). Interestingly, there was a peak in referencing these projects in 2011 to 2012 at the beginning of the implementation of Smart Grid Smart City and partway through the implementation of the Victorian AMI Program. This peak in interest was much higher than when the findings and data were released at the end of the projects (2014 and 2013, respectively).

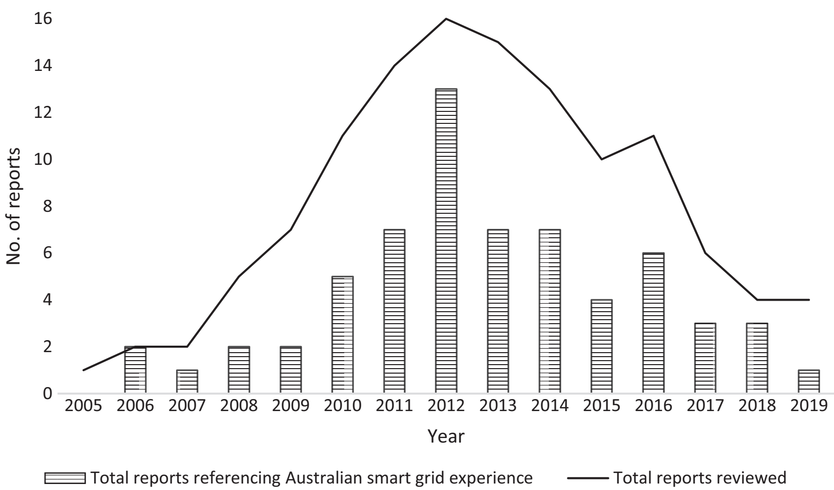

Fig. 2.1 Number of international policy documents referencing the Australian smart grid experience over time. (From analysis provided by Dr Cynthia Nixon, University of Tasmania)

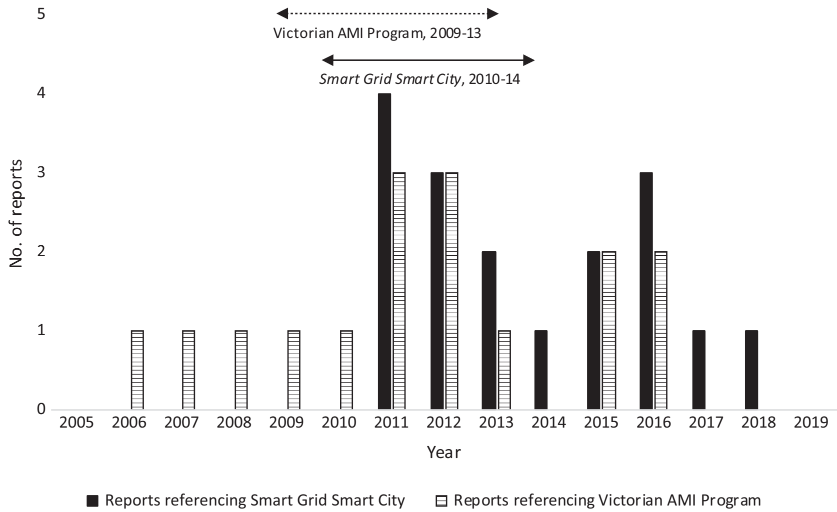

Fig. 2.2 References to the Smart Grid Smart City Project and the Victorian Advanced Metering Infrastructure (AMI) Program in international documents over time. (From analysis provided by Dr Cynthia Nixon, University of Tasmania)

In turn, Australia has drawn heavily on other countries to learn about smart grids. For example, the main policy document produced at the outset of the Australian Smart Grid Smart City project explains how:

> Smart Grid, Smart City can also take lessons from other domestic and international smart grid related initiatives, such as Solar Cities in Australia; Smart Grid City in Boulder, Colorado, US; other US smart grid demonstration projects; and the PRIME project in Europe. (DEWHA, 2009, p. 12)

However, there is also some caution about the applicability of lessons from overseas, as the International Electrotechnical Commission smart grid standardization roadmap notes:

> The power distribution system in the USA, Canada and many other countries of the world (Brazil, Mexico, Australia, South Africa, Korea etc.) is significantly different to the distribution system in Europe. (IEC, 2017, p. 54)

This caution is demonstrated too in a comment made to me by an innovation manager of an Australian utility, at the time heavily involved in a large smart grid demonstration project:

> So I guess one of the things the AER [Australian Energy Regulator] always try to do is compare us as networks because 'a pole's a pole's a pole' but we do have quite different geographical constraints across the [Australian] States. In the latest determination they've been comparing us to Canada as well which obviously is extremely different. (Interview, April 2015)

From this brief review, it is clear that international policy networks can encourage or hinder innovation, depending on how programmes and ideas from elsewhere are interpreted.

Case Study 2.2 A Local Community Network: Bruny Island, Australia

Bruny Island sits just off the south-east coast of another Australian island, Tasmania. It has a modest population of around 800 people, which surges significantly in the summer due to an influx of tourists and second home (shack) owners. Bruny Island is connected to the primary electricity grid in Tasmania through two undersea cables. While Bruny Island is mostly a story about a community (social) network, the undersea cables are a key component of this network. The cables are old and cannot supply quite enough electricity to Bruny Island to meet peak demand. For several years, TasNetworks, the local utility, has had to run diesel generators at times of peak demand to compensate.

In 2015 a group of universities, along with TasNetworks, the local utility, and an Australian energy start-up company, Reposit Power, were awarded funding for an alternative solution to meet peak demand, rather than using the diesel generators. This was a smart grid solution, with household battery storage installed in around thirty households on Bruny Island, along with rooftop solar. Electricity was automatically drawn from these batteries at times when the electricity network required it. I was part of this project team, leading the social research component of the project, along with four other social researchers.[1] The rest of the team were engineers, economists, and information and communication technology experts.

At the start of this three-year smart grid project, the physical, material features of Bruny Island and its electricity system were the main focus of

[1] Including Dr Phillipa Watson, Dr Andrew Harwood, and PhD student Veryan Hann (all of University of Tasmania) as well as Dr Hedda Ransan-Cooper, Australia National University.

discussion within the project team: the undersea cable, the technical interface between the household batteries and the grid, the operation of the diesel generator and so on. But by the end of the project, it was just as likely that social issues were a point of discussion in our regular project meetings: whether it was the latest findings from our social research, or the high volume of rumour mill driven inquiries TasNetworks was receiving from households. During the project, it became apparent that there was a tight-knit community on Bruny Island and a community whose preferences around energy storage were quite different from those previously observed in urban areas. This presented a challenge within the project team because Reposit Power had developed their product largely within a metropolitan area in Canberra, Australia. Most of their experience was with urban and urban-fringe households.

Bruny Island was distinctive in that many of the households in the smart grid trial had concerns about being left without power during energy outages. Outages are frequent on Bruny Island because it is an edge-of-grid location, where the electricity network is more expensive and difficult to maintain. Plus, Bruny Island has many highly forested areas with power lines prone to being damaged by tree falls, as you can see in the photograph below of one of the island's roads (Fig. 2.3). During the trial, there was one outage of three days that affected many trial households. Because of this context of frequent, sustained electricity grid outages, trial households were understandably interested in the role their battery could play in providing back-up power to their household. Back-up power was a key issue raised by Bruny Islanders right from the start of the project. Perhaps none of this sounds especially surprising, but it was surprising to Reposit Power. Reposit Power does not offer back-up power to households as part of its product. Instead, its product is focused on providing a service to utilities based on the certainty of being able to draw power from household batteries when utilities require it.

An illustration of the value that the Bruny Island trial households placed on back-up power was that most paid several hundred dollars extra to have their batteries provide this type of emergency power. This cost is not insignificant given that the median income of households on Bruny Island is A$34,000 a year, well below the Australian national average (A$45,000) (ABS, 2015).

The case of Bruny Island gives us insights into the role that community can play in influencing the implementation of smart grid technologies. This was a close-knit community and one with particular vulnerabilities to

Fig. 2.3 Long rural road on Bruny Island, Australia, showing trees near power lines. (Source: Dr Phillipa Watson, University of Tasmania)

electricity network outages. The community, therefore, had a particular expectation of what household level battery storage meant for them. In other words, the context on Bruny Island strongly affected the smart grid trial—both positively and negatively (Watson et al., 2019). Similar findings about the importance of context have been identified by Laura Watts in her energy social research on the Orkney Islands, Scotland. As she writes poetically of Orkney electricity and its relationship to the communities on Orkney:

> The Orkney electron… has both electrical and political power… it is constituted by islander people and their engagement, who make it brighten and flow. (Watts, 2018, p. 72)

On Bruny Island, the local community raised issues that were not expected by the research team. These issues were helpful for project learning and may indicate what will occur during the implementation of other island smart grids, or those in similar remote and rural locations. But what we also see in the case of the Bruny Island smart grid is the interplay between the social and technical. It is this complex sociotechnical network of issues and things, from household anxieties about outages to technical product specifications, that is important to recognise and attend to in order to better understand processes of energy innovation.

Case Study 2.3 A Fragile Network: The State of Victoria's Digital Metering Program, Australia

The State of Victoria's mandatory digital (or advanced) metering programme is a good example of a smart grid network breaking down. Victoria was Australia's first state to privatise its electricity sector in the late 1990s. Victoria was keen to proceed with digital metering so that its newly privatised market could function better: digital meters facilitate greater choice of consumer tariffs and easier household switching of electricity company provider. So, in 2004 state government approval was given in Victoria to proceed with an interval metering programme. Interval meters were an early-stage digital meter that collect consumption data in a digital form but do not transmit or communicate the data remotely. As the technology choice in meters rapidly improved in the mid-2000s, the Victorian metering programme was upgraded to advanced meters in 2006. Advanced meters have communications embedded and so can transmit data remotely, without having to be manually read. The Victorian Advanced Metering Infrastructure (AMI) programme ran from 2009 to 2013 and resulted in 2.3 million digital meters being installed in 93% of homes and small businesses in Victoria.

However, not everything went smoothly with the implementation of digital meters in Victoria: the network unravelled. This was partly because of changes to components of the AMI programme network but also to do with the changing context in which the network was operating. A key component that changed was the AMI network's star performer: the digital meter. The late 2000s and early 2010s were a period of rapid innovation for digital meters internationally. The State of Victoria was testing these new technologies at scale, which inevitably led to some teething problems. As Adrian Clark, Head of Smart Metering Australia at Landis Gyr, an international metering company, explained, "the Victorian problems emanated from decisions taken almost 10 years ago, and since that time the [metering] technology has leapfrogged" (cited in MacDonald-Smith, 2015).

Technical teething problems with the meters were resolved, but the issues delayed implementation and pushed up costs; costs which were passed down to households and small businesses. Rising costs became a source of tension with the AMI programme. There were also technical issues with the communication systems that the new digital meters relied on to provide remote reading of electricity consumption and other services. Again, this was a rapidly developing area of technology over the four to five year period of the AMI programme, so lots of things were being learned and refinements made during the programme implementation, rather than at a pilot or prototype stage. The instabilities in the core technical components of the AMI network created further instabilities across the network. This is in keeping with actor-network theory, which highlights the ability of technologies to either disrupt or stabilise networks.

There were also changes in the wider context in which the AMI programme network was situated. Most notably, in 2010, at a crucial stage in the life of the AMI programme (as implementation was just getting underway), there was a change of government in the State of Victoria, from Labor to a Liberal-National government. The new government had campaigned in the election on the AMI programme, raising the possibility that it would stop it. This was because problems were already starting to emerge with the programme. There was growing public discussion about some of these, particularly the high metering implementation charge to households, many of whom had not yet had a meter installed. However, the new government did decide, somewhat reluctantly, to proceed, albeit with notable changes to the programme, including introducing optional flexible pricing, establishing a Ministerial Advisory Council, and subsidising in-home energy displays (see Victorian State Government, 2015). The new State Energy Minister explained the decision as follows:

> analysis shows that if you were looking at it from a blank sheet of paper you probably wouldn't go down this [AMI program] path. There are actually more detriments to consumers, or costs to consumers as the result of the project as a whole, compared to the benefits. But we're not starting with a blank sheet of paper. We're starting with the mess we've inherited from the Labor government. (Victorian Energy Minister Michael O'Brien, 2011)

As we know from how international smart grid policy networks operate (see Case Study 2.1), new information was also continuously flowing in from other countries about different ways of implementing meters. In particular, the case of New Zealand's metering programme came to be important because this was a voluntary implementation programme; that is, households did not have to get a new digital meter. In New Zealand the programme was opt-in or market-led, and so was quite different to

Victoria's mandatory implementation approach. New Zealand was frequently cited as a counterbalance to the negative case of Victoria, as an Australian state government manager explained at the time:

> New Zealand is largely seen as a positive example and Victoria as a negative one. (Interview, April 2015)

The State of Victoria's AMI programme network was fragile because so many things kept changing—the components of the network were unstable—including its core technology: the digital meter.

Learning from Smart Grid Networks

Smart grids demonstrate how energy sector networks are a mix of the social and the technical, that is, sociotechnical networks. Like all energy systems, the successful function of smart grids is achieved not only in efficient technical operation but through the whole network of things and people working together in harmony. The smart grid case studies presented in this chapter highlight the diversity of networks of different technologies, materials, people and organisations that drive energy innovation. In the table below, I summarise the key learnings from these smart grid network case studies and suggest how they might guide future practice.

Key learning	*Recommendation for energy practitioners*
Smart grids are sometimes conceived of as technical networks, whereas in reality, they are sociotechnical (part social, part technical).	When energy innovations such as smart grids are conceptualised as just a technical network, we can run into problems: from the outset, energy sector innovations should ideally be thought about as much as a social program as a technical one.
Decisions about energy innovations are not made in isolation—there are international policy networks that continuously circulate new ideas and information, and these information flows can have both positive and negative effects.	Participating in international policy networks is beneficial, but knowledge shared within these networks can often be quite edited (i.e., the most positive narrative of what happened). Connecting directly with the people about projects to also find out what went wrong is likely to provide more detail than is found in the version presented in international policy network discussions.
There are many different types of network relevant to smart grids and energy innovation: policy, social, sociotechnical, and business.	The existence of multiple networks means that implementing new technologies is most likely not going to be straightforward. Steps to mitigate technology risk such as piloting the technology or building in review periods are important, as is managing expectations.

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