Nodes

WHAT IS A NODE, AND WHAT TYPES OF NODE DO WE FIND IN SMART GRIDS?

Nodes are parts of networks where elements of the network intersect. They are at junction points of flows—a point of intersection or an *obligatory passage point* (Callon, 1986). The most basic definition of a node is a point where one thing joins another (Collins Dictionary, 2021) or a point in a network or diagram at which lines or pathways intersect or branch (Google Definitions, 2021). Within smart grids, nodes can be organisations, people, or technologies. Nodes are anchor points and typically act as brokers at critical intersections within smart grids. Nodes are therefore best seen as social or technical, or a mix of both, sociotechnical. Either way, nodes are important in smart grids in terms of providing stability, order, and co-ordination.

Nodes can be many different things. In the social sciences, nodes are usually individuals or organisations. In the physical sciences, nodes are typically material things, such as sensors or inverters, and in the biological sciences, they are junctions within plant structures or circulatory systems. The characteristics of nodes are closely related to the network they are part of: some networks have many nodes, and some only have a few. The position of the node on a network affects the agency the node has, and the network outcomes (Borgatti et al., 2009). Nodes are sites worthy of attention because many things happen when flows intersect at nodes. Nodes

can operate well, in which case they are usually not noticed very much, or they can become sites of blockage and malfunction. If nodes malfunction, they tend to attract a lot of attention; think of a traffic light that breaks down, causing a traffic jam.

DIFFERENT WAYS OF THINKING ABOUT NODES

There are many different terms used to describe nodes across different research areas including broker (e.g., knowledge brokers or policy brokers), boundary object, and junction (e.g., innovation junction). Node is the default term used in biology and the physical sciences. Scientists in areas such as botany and computer science use the term node to describe the intersection of parts of plants (plant nodes) and junctions in machine learning models. A branch of geography—economic geography—uses the term node to describe large cities, such as London and New York, which are viewed as important global sites of innovation and trade (Sassen, 2002). Node is also the primary term used within the social sciences in social network analysis. Social network analysis is a methodology and approach to analyse patterns within social networks; a node is an individual or organisation within the network. The bigger the node, the more social linkages that person has (Borgatti et al., 2009).

Elsewhere in the social sciences, nodes are more commonly referred to using other terms, including brokers, entrepreneurs, boundary objects and junctions. Brokers are individuals who have particular skills in connecting people and exchanging ideas and information. Knowledge broker is a popular concept used across several social science disciplines, including business and management studies and sociology. A knowledge broker is defined by the sociologist of innovation Morgan Meyer as “people or organizations that move knowledge around and create connections between researchers and their various audiences.” (Meyer, 2010, p. 118). Policy broker (sometimes referred to as policy entrepreneur) is a term used in the political sciences to describe individuals adept at connecting different policy networks. The political scientist John Kingdon (2003, p. 122) first coined the term *policy entrepreneur* to describe people who are “[willing] to invest their resources—time, energy, reputation, and sometimes money—in the hope of a future return”, with the *return* in this instance being policy change. A number of authors have subsequently drawn on Kingdon’s work to explore how individuals generate new ideas and catalyse

change within government, acting as important nodes in the policy system (see e.g., Bartlett & Dibben, 2002; Etzkowitz & Gulbrandsen, 1999).

The term boundary object was first introduced by science and technology studies scholars Star and Griesemer (1989) to explain how a natural history museum functions as a node. The museum enables different social groups involved in the museum's work—scientists, field ecologists, university administrators, farmers and animal trappers—to work together effectively to collect, classify and analyse specimens. In this context, boundary objects were things like classification systems, specimens, field notes, or maps of particular territories (1989, p. 408), which all had some potential to be differently understood by the different social groups that worked for the museum. Although this example is obviously far removed from the energy sector, it can usefully be applied in terms of considering the distinct types of expertise operating relatively discretely within the energy sector—from economists to planners to power engineers—each with slightly different understandings of, and perspectives about, what energy sector innovation is.

The boundary object concept is used in this chapter to describe the changing role of electricity meters in the home (see Case Study 3.1). A boundary object is defined as a node positioned between different social groups or types of organisation, such as householders, government, and utilities. A boundary object has a lot of flexibility in how it is understood, allowing useful work to be done even in situations where there is conflict or misunderstandings between different social groups. A focus on boundary objects is highly relevant to smart grids and energy innovation more generally, where there are many entities (typically technologies or organisations) that play the role of mediating between different social groups.

Innovation junctions are bounded spaces in which multiple technologies are being used. The core idea is that grouping multiple technologies in one particular place—the junction or node—leads to innovation. De Wit et al. use the office as an example of an innovation junction. In their historical analysis of changing office technologies in the Netherlands from 1880 to 1980, they define the innovation junction as:

a space in which different sets of heterogeneous technologies are mobilized in support of social and economic activities and in which, as a result of their co-location, interactions and exchanges among these technologies occur. These interactions and exchanges lead to location-specific innovation patterns. (de Wit et al., 2002, p. 50)

In the following case studies, I consider three different types of smart grid nodes: an electricity meter, an organisation, and an island.

CASE STUDY 3.1 THE DIGITAL ELECTRICITY METER AS A NODE: HOUSEHOLD TRANSITIONS IN THE UK

Over the last decade or more there have been programs world-wide to replace traditional mechanical spinning disc meters with new digital meters (see also Case Study 2.3). Governments and energy sector organisations have framed the digital meter as an important new node in future energy systems. They see digital meters as critical to the transition to a secure, low carbon energy system at an affordable cost and in allowing for greater engagement and interaction with householders (GSGF, 2012; ISGAN, 2014). As the UK government agency with responsibility for the uptake of smart meters describes:

The smart meter roll-out programme constitutes the largest transformation of a core area of nationwide infrastructure undertaken in a generation. It is a programme that aims to reach every household across the whole of Great Britain. (Smart Energy GB, 2013, p. 8)

With the transition to digital, the energy meter has expanded from the simple function of measuring energy demand to a host of features, mostly aimed at the householder, such as providing detailed feedback on energy consumption from digital devices and facilitating new types of energy tariff. Through multiple programs to replace meters in people's homes, utilities and governments have made meters a focal point of action and discussion for energy innovation. The meter is an important node that sits at a vital point in the electricity network, between utilities and consumers (households, businesses), and helps to shape relationships between them.

The idea of a boundary object (briefly introduced above) helps us to understand the ways in which a meter acts as a node. As we saw with the example of how workers in a natural history museum relate differently to the objects in the collections, so the digital meter is understood differently by the social groups of government, utilities, and consumers (Lovell et al., 2017). In comparison, traditional mechanical energy meters are a long-standing, relatively stabilised technology. The flexibility of how the digital meter can be interpreted has had both positive and negative effects. These effects are demonstrated well in the example below, the UK digital

metering program, and a more detailed case study of an intensive community energy project involving meters.

In the UK, digital metering has been managed through a voluntary program, with overall targets set, but with the idea of encouraging households to obtain digital meters rather than making it compulsory. The UK government program commenced in 2016, and the aim is to have fifty three million new meters in place by the now extended deadline of 2024. The deadline was initially set at 2020 but was delayed in late 2019, largely in response to the COVID-19 pandemic (see Ambrose, 2019). Progress to date has been slower than expected but is still continuing reasonably well, with just under twenty four million smart meters in place across the UK as of the end of 2020 (UK BIES, 2020).

Part of the explanation for the relatively high digital metering uptake by UK households is how the UK government took the time and effort to better understand the social world of householders in the initial design of the program (Lovell et al., 2017). For example, a compulsory feature of the UK program is a digital home interface (DECC, 2012), which allows households to easily access and interpret digital metering data so that they can receive good quality real-time feedback on their consumption. Making the digital home interface compulsory was a decision that came out of prior research with households, seeking to understand how households value digital meters from their own perspective. The case of the UK smart metering program shows how the incorporation of household perspectives into the program design has facilitated the implementation of new digital meters—mediating between government, utilities and households—and reducing the amount of conflict between these different social worlds.

I was involved in a research project looking at changes to metering in Wyndford (Hawkey & Webb, 2014; Hawkey et al., 2016), a community in the west of the city of Glasgow, Scotland, that has high unemployment and high levels of socio-economic deprivation (Scottish Government Statistics, 2011). A new district heating system was implemented in Wyndford in 2012, providing space heating and hot water for approximately 2000 homes. The upgrade was organised by the local housing association (Cube Housing Association) and the utility (SSE), with part funding from a Community Energy Saving Programme award from British Gas. As part of the district heating, new digital meters were installed in every home.

The meters were very different to what Wyndford householders had previously. At the same time as the metering change, the tariffs in Wyndford

changed from pay as you go (i.e., a card-based top-up system, so households only had power if they were in credit) to a new tariff with a standing charge and usage charge that was averaged out over the year. The intention of the new tariff was to reduce bill shock during the winter months when heating requirements are, of course, much higher. But many households found the changes in tariffs very difficult to manage on a tight household budget. This was exacerbated by the new digital meter, which showed the daily charge plus levelized (annual average) consumption over a year and not actual consumption data. The organisations involved in the new district heating thought that households would not be interested in any more detailed data than this, and had located a second meter showing this data out of reach in an inaccessible place. A group of households complained about the new metering set up and associated tariffs. Changes were subsequently made, including providing access to the second consumption data meter and dropping the daily standing charge for some households.

This brief look at digital meters highlights how they act as a node at a critical boundary between the household and other organisations, including utilities and government. Meters control, standardise, and frame the identities of, and relationships between, the social worlds of government, utilities, and householders. Energy meters are currently in the midst of a contested and uneasy transition period, with old framings and ways of doing shifting into new ones. This reframing of the meter, and the relationships it shapes and mediates, are issues that the boundary object concept helps us to understand. By focusing on the meter itself as a node, changing social practices and relations are usefully brought to the fore.

CASE STUDY 3.2 THE AUSTRALIAN ENERGY MARKET OPERATOR AS AN ENERGY INNOVATION NODE

The Australian Energy Market Operator (AEMO) plays a crucial role in overseeing the market function of electricity and gas markets and hence acts as an important node in energy innovation. Over the past few years, it has developed a twenty-year plan for Australia's energy sector, called the Integrated System Plan (ISP). The ISP has become key to how energy innovation and transition are framed and discussed in Australia. AEMO describes the electricity sector (NEM: National Electricity Market) as a fast-changing complex system:

The NEM is an intricate system of systems, which includes regulatory, market, policy and commercial components. At its centre is the power system, which is an inherently complex machine of continental scale. This system is now experiencing the biggest and fastest transformational change in the world since its inception over 100 years ago. (AEMO, 2020, p. 10)

Such a complex system of systems requires organisational nodes to enable good governance. Through the ISP, AEMO has become an important node or broker in facilitating dialogue and decision-making about Australia's energy futures on a long-term, twenty-year horizon. AEMO has acted as a node of innovation in Australia, co-ordinating multiple stakeholders' inputs and carefully analysing system changes and risks. AEMO is similar to organisations internationally, such as the National Grid Electricity System Operator in the UK and the California Independent System Operator in the US (see National Grid ESO, 2020).

The Australian Commonwealth, state and territory governments established AEMO in 2009 to manage the National Electricity Market (NEM). The NEM operates in most states in Australia but not the Northern Territories. In 2015, AEMO's remit was extended to include the State of Western Australia (which has its own separate electricity network, not connected to the NEM). AEMO also now looks after gas markets. AEMO is an independent body jointly owned by governments (60%) and market participants (40%). AEMO has three main areas of responsibility: maintaining secure electricity and gas systems, managing gas and electricity markets, and leading the design of Australia's future energy system. It is this third function that is of most interest in relation to energy innovation. The shift to long term planning in Australia is in response to the increasing pace of change in its electricity system. A manager at AEMO explained back in 2015 the problems they were facing in this regard:

one could almost say that at some point in the future you may need to put sell-by dates on the advice [we produce at AEMO]. The National smart meter specification was good to a point, but then it became outdated and then you have to move on and it's ... the market is moving so what we've just spoken about may be largely irrelevant in another five years. (Interview, Manager, AEMO, April 2015)

In 2018, AEMO published its first Integrated System Plan (ISP). The ISP initiative came out of the 2017 Independent Review into the future

security of the NEM by Australia's Chief Scientist Alan Finkel (the Finkel Review), which recommended greater use of strategic planning within Australia's energy system (Finkel, 2017). The ISP has a 20-year planning horizon, is updated every two years, and it is based on detailed engineering and economic modelling of Australia's electricity network. The ISP recognises the significant changes underway in Australia, with a flattening in electricity demand from the grid and a significant shift in consumer preferences and behaviours (AEMO, 2018, p. 3). The 2020 ISP is described *as* "an actionable roadmap... to optimise consumer benefits through a transition period of great complexity and uncertainty" (AEMO, 2020, p. 9). The core proposal from AEMO is for an increase in the transmission infrastructure, identifying the "crucial role of transmission" (AEMO, 2018, p. 6) in the transition:

The transmission grid itself requires targeted augmentation to support the change in generation mix. ... strategically placed interconnectors and REZs [Renewable Energy Zones], coupled with energy storage, will be the most cost-effective way to add capacity and balance variable resources across the whole NEM. Without adequate investment in transmission infrastructure, new VRE [renewable energy] will be struggling to connect. (AEMO, 2020, p. 13)

In other words, the ISP positions the centralised grid as continuing to be important even in the face of increased distributed generation. The ISP, therefore, advocates an increased level of investment in the electricity grid transmission lines.

Since publication of the first ISP, AEMO has grown in status to become a critical node in discussions about the future of the energy sector in Australia. In late 2020, the Australian Energy Regulator published guidelines aimed at translating the ISP into action, effective from the 2022 version of the ISP onwards (AER, 2020). In other words, the ISP will now become a regulated requirement under the National Electricity Rules in Australia. In this way, the ISP has bolstered the role of AEMO as an influential node in planning and informing Australia about its possible energy futures, albeit one particular version of the future (see Case Study 5.3).

CASE STUDY 3.3 ISLANDS AS ENERGY INNOVATION NODES: KING ISLAND, AUSTRALIA

Urban areas are often portrayed as a natural centre of energy innovation due to the concentration of finance, people, and resources, plus multiple utility infrastructures. However, social science research shows us that rural communities are also important in innovation and learning about new energy futures (Lovell et al., 2018; Naumann & Rudolph, 2020). This is perhaps particularly true for islands because island communities are edge-of-grid: energy services are typically expensive to maintain here, so there are technical reasons why island communities tend to be at the forefront of energy innovation. Island communities also often have closer social networks and cultural ties because of their isolation; this may facilitate learning. These factors can help to explain how islands may become energy innovation nodes.

King Island is positioned north-west of the island State of Tasmania (see Fig. 3.1). The island has a small population of approximately 1500 people and a strong focus on rural industries of farming and fishing, as well as tourism. King Island's electricity grid does not have an undersea connection to Tasmania or the State of Victoria on the mainland: it is an isolated grid. Electricity is provided by a mix of renewable energy (solar, wind) and diesel generators. Diesel is imported to King Island by boat, and the whole island is powered by a 6-megawatt diesel power station.

From 2010 to 2013, the utilities on King Island undertook a range of smart grid energy innovations and upgrades, funded by the Australian Renewable Energy Agency (ARENA). The smart grid project was called KIREIP (King Island Renewable Energy Integration Project). It comprised a number of technologies and initiatives, including new solar and wind generation, a battery, flywheel, dynamic resistor and a customer demand response system (Hydro Tasmania, n.d.). The objective of KIREIP was to reduce diesel use on King Island and thereby enable the island to be more self-sufficient in energy resources. KIREIP successfully enabled a 65% reduction in diesel consumption on King Island through an entirely automated system.

KIREIP has been a notable success in terms of its replication in other places, and in this way, King Island has acted as a key node for energy innovation. The smart grid technology trialled on King Island has since been implemented (albeit in a slightly modified form) on Flinders Island

Fig. 3.1 Map of Tasmania, Australia, showing the location of King Island and Flinders Island. (Source: Original image from iStock, modified by the author)

in Tasmania, Rottneest Island in Western Australia and in Coober Pedy, a remote town in South Australia (ARENA, 2020). Hydro Tasmania has done this implementation work in conjunction with its commercial subsidiary Entura (see Entura, 2020b). After KIREIP, Entura packaged the smart grid technologies used on King Island and developed a modularized product housed within shipping containers. This Hybrid Energy Hub was implemented on Flinders Island (ARENA, 2017), a nearby island off the north-east coast of Tasmania, as the aerial photograph below shows (Fig. 3.2).

Fig. 3.2 Aerial view of the smart grid system batteries on Flinders Island, Australia. (Source: ARENA, see <https://arena.gov.au/blog/flinders-island/>)

The Hybrid Energy Hub was marketed on the basis of its successful implementation and performance in a rural context, on islands. In other words, the rural islandness of King Island has been important in establishing credibility for the technologies trialed on King Island and for the learning and innovation processes more generally. In a press release from ARENA announcing the start of the project on Flinders Island in 2015, the links between the two projects are highlighted:

The Flinders Island project will build on the success of a similar project Hydro Tasmania developed on King Island... which is delivering 100 per cent renewable energy to the island. (ARENA, 2015)

And in local media coverage, the utility manager highlights the benefits of the new system on Flinders, based on the experience on King Island:

The technology [being implemented on Flinders Island] was developed on nearby King Island, which was the first remote system capable of supplying the power needs of an entire community solely through wind and solar

energy... based on the King Island results, Flinders Island's power supply [will] become significantly more reliable. (Shine, 2017)

Entura voices similar sentiments in describing the system they implemented in a remote community in South Australia:

The Coober Pedy hybrid renewables project builds on the King Island Renewable Energy Integration Project (KIREIP), which led the world when it first achieved 100% renewable operation using variable wind energy in 2012. (Entura, 2020a)

So, King Island acted as a node—a location where new sociotechnical energy innovations have been tested out and have then been replicated elsewhere. However, there have been some modifications to the King Island smart grid product as it has moved from place to place. For example, the customer load smart grid system, implemented as part of KIREIP, was not replicated on Flinders Island because it was found not to be frequently used on King Island and was expensive to implement. Also, some changes were made to how the technologies were packaged, as the Hydro Tasmania hybrid energy solutions manager explained:

Hydro Tasmania took a different approach on Flinders Island in the way the system was deployed. We have modularised the enablers and we have used the platform of shipping containers. It is an approach we can deploy to other parts of the world. The Flinders Island Hub is becoming a showcase of the technology. (Shine, 2017)

So there has not been a straightforward replication of King Island smart grid technologies to different island contexts. Still, there has been significant knowledge exchange and dissemination from the King Island node.

LEARNING FROM SMART GRID NODES

Nodes in smart grids play an important role in providing stability (keeping things the same), as well as innovating. As seen in the case studies presented in this chapter, nodes can be technologies (the digital electricity meter), places (islands), or organisations and individuals (an energy market organisation). In the table below, I summarise the key learnings from these smart grid node case studies and suggest how they might guide future practice.

<i>Key learning</i>	<i>Recommendation for energy practitioners</i>
Nodes typically have what is termed interpretative flexibility, that is, they are understood differently by different actors, and this is generally seen to be a strength; the flexibility allows them to function.	A good example of this flexibility is different understandings of electricity meters. For government and industry practitioners, meters are primarily technical nodes at the intersection of the household and utilities. However, for households, meters raise social issues about trust and equity. Appreciating these different perspectives about a node helps to plan policies and interventions and to better anticipate any problems that might arise.
Attempts are often made to replicate successful nodes elsewhere, in different contexts, but this does not always work because the things and people they are co-ordinating are subtly different.	Studies of energy innovation on islands suggest that energy innovations are usually modified along the way. Further, diversity in types of energy systems might be the new normal in the future, as communities wish to have solutions tailored to their local context, and decentralised technologies increasingly allow for this. Ideally, energy innovations are tailored to the local context in which you are working.
When nodes are positioned at the intersection of different networks (e.g., policy networks), they are particularly active and influential.	Seek to identify nodes at the intersection of different networks and notice whether they are growing in importance or waning.

REFERENCES

- AEMO. (2018). *2018 Integrated System Plan for the National Electricity Market*. Australian Energy Market Operator (AEMO). Retrieved June 16, 2020, from https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2018/integrated-system-plan-2018_final.pdf
- AEMO. (2020). *2020 Integrated System Plan for the National Electricity Market*. Australian Energy Market Operator (AEMO). Retrieved January 19, 2021, from <https://www.aemo.com.au/-/media/files/major-publications/isp/2020/final-2020-integrated-system-plan.pdf>
- AER. (2020). *Guidelines to make the Integrated System Plan actionable*. Australian Energy Regulator (AER). Retrieved March 12, 2021, from <https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/guidelines-to-make-the-integrated-system-plan-actionable>
- Ambrose, J. (2019, September 17). Smart energy meter rollout deadline pushed back to 2024. *The Guardian*. <https://www.theguardian.com/environment/2019/sep/16/smart-energy-meter-rollout-uk-deadline-pushed-back-2024>

- ARENA. (2015). *Flinders Island next off-grid community to go renewable*. Retrieved December 11, 2020, from <https://arena.gov.au/news/flinders-island-next-off-grid-community-to-go-renewable/>
- ARENA. (2017). *Flicking the switch: (Hybrid) energy comes to Flinders Island*. Retrieved February 10, 2020, from <https://arena.gov.au/blog/flinders-island/>
- ARENA. (2020). *King Island renewable energy integration project*. Retrieved February 10, 2020, from <https://arena.gov.au/projects/king-island-renewable-energy-integration-project/>
- Bartlett, D., & Dibben, P. (2002). Public sector innovation and entrepreneurship: Case studies from local government. *Local Government Studies*, 28(4), 107–121.
- Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network analysis in the social sciences. *Science*, 323(5916), 892–895.
- Callon, M. (1986). Some elements in a sociology of translation: Domestication of the scallops and fishermen of St. Briec Bay. In J. Law (Ed.), *Power, action, belief* (pp. 196–233). Routledge and Kegan Paul.
- Collins Dictionary. (2021). *Node – definition*. Retrieved January 4, 2021, from <https://www.collinsdictionary.com/dictionary/english/node>
- de Wit, O., van de Ende, J., Schot, J. W., & van Oost, E. (2002). Innovation junctions: Office technologies in the Netherlands, 1880–1980. *Technology and Culture*, 43(1), 50–72.
- DECC. (2012). *Smart metering implementation programme: Programme update April 2012*. Department of Energy and Climate Change. Retrieved June 13, 2019, from https://webarchive.nationalarchives.gov.uk/+/http://www.decc.gov.uk/en/content/cms/consultations/cons_smip/cons_smip.aspx#data
- Entura. (2020a). *Coober Pedy hybrid renewables project*. Retrieved February 21, 2020, from <https://www.entura.com.au/projects/8165/>
- Entura. (2020b). *Entura – Our projects*. Retrieved December 10, 2010, from <https://www.entura.com.au/projects/>
- Etzkowitz, H., & Gulbrandsen, M. (1999). Public entrepreneur: The trajectory of United States science, technology and industrial policy. *Science and Public Policy*, 26(1), 53–62.
- Finkel, A. (2017). *Independent review into the future security of the National Electricity Market: Blueprint for the future*. Commonwealth of Australia.
- Google Definitions. (2021). *Definition – Node*. Retrieved January 4, 2021, from https://www.google.com/search?xsrf=ALeKk02ubtMk9RjQFCHJUq0jXQi hfw2Uxw%3A1615424873881&ei=aW1JYLS0NaCZ4-EPyrOYqA0&q=google+dictionary&oq=google+dictionary&gs_lcp=Cgdnd3Mt d2l6EAMyCAgAELEDEIMBMggIABCxAXCDATICCAyAggAMgIIADICCAyAggAMgIIADICCAyAggAOgQIIxAnOgsIABCxAXCDARCRAjoFCAAQkQI6CggAELEDEIMBEEM6BAGAEEM6CggAEIcCELEDEBQ6DQgAEIcCELEDEIMBEBQ6BAGAEAM6BQguELEDogoIABCxAXCDARAKOgcIABCHAhAUOgQIABAKUP9jWot-

- YMCEAWgDcAJ4AIAB4AGIAb0dkgEGMC4xOC4zmAEAoAEBqgEH
Z3dzLXdpesABAQ&scient=gws-wiz&ved=0ahUKEwj0jJ
POhqfvAhWgzDgGHcoZBtUQ4dUDCA0&uact=5#dobs=node
- GSGF. (2012). *Global Smart Grid Federation 2012 report*. Global Smart Grid Federation (GSGF). Retrieved September 13, 2019, from https://www.smart-grid.gov/files/Global_Smart_Grid_Federation_Report.pdf
- Hawkey, D., & Webb, J. (2014). *Wyndford estate district heating: Draft case study for Scottish Futures Trust's district heating delivery structures guidance*. University of Edinburgh. Retrieved March 12, 2021, from <https://heatandthecity.org.uk/resources/page/2/?pid=65#resources>
- Hawkey, D., Webb, J., Lovell, H., McCrone, D., Tingey, M., & Winskel, M. (2016). *Sustainable urban energy policy*. Routledge.
- Hydro Tasmania. (n.d.). *King Island renewable energy integration project (KIREIP)*. Retrieved July 13, 2019, from https://www.hydro.com.au/docs/default-source/clean-energy/hybrid-energy-solutions/king_island.pdf?sfvrsn=f3ad4828_2
- ISGAN. (2014). *AMI case book version 2.0: Spotlight on advanced metering infrastructure*. International Smart Grid Action Network (ISGAN).
- Kingdon, J. W. (2003). *Agendas, alternatives and public policies* (2nd ed.). Harper Collins College Publishers.
- Lovell, H., Pullinger, M., & Webb, J. (2017). How do meters mediate? Energy meters, boundary objects and household transitions in Australia and the United Kingdom. *Energy Research & Social Science*, 34, 252–259.
- Lovell, H., Hann, V., & Watson, P. (2018). Rural laboratories and experiment at the fringes: A case study of a smart grid on Bruny Island, Australia. *Energy Research and Social Science*, 36, 146–155.
- Meyer, M. (2010). The rise of the knowledge broker. *Science Communication*, 32(1), 118–127.
- National Grid ESO. (2020). *World's leading power system operators launch global consortium*. Retrieved December 13, 2020, from <https://www.national-gradeso.com/news/worlds-leading-power-system-operators-launch-global-consortium>
- Naumann, M., & Rudolph, D. (2020). Conceptualizing rural energy transitions: Energizing rural studies, ruralizing energy research. *Journal of Rural Studies*, 73, 97–104.
- Sassen, S. (2002). *Global networks, linked cities*. Psychology Press.
- Scottish Government Statistics. (2011). *Wyndford-01*. Retrieved March 13, 2021, from <https://statistics.gov.scot/atlas/resource?uri=http%3A%2F%2Fstatistics.gov.scot%2Fid%2Fstatistical-geography%2FS01010358>
- Shine, R. (2017). *Flinders Island going for green with renewable energy hub, farewells dirty diesel*. Retrieved February 21, 2020, from <https://www.abc.net.au/news/2017-11-05/flinders-island-farewells-dirty-diesel-with-renewable-energy-hub/9117108>

- Smart Energy GB. (2013). *Smart meter central delivery body: Engagement plan for smart meter roll-out*. Retrieved April 12, 2020, from <https://www.smart-energygb.org>
- Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, translations and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science*, 19(3), 387–420.
- UK BIES. (2020). *Smart meter statistics in Great Britain: Quarterly report to end December 2020*. UK Department of Business, Energy and Industrial Strategy (BEIS). Retrieved January 16, 2021, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/968356/Q4_2020_Smart_Meters_Statistics_Reportv2.pdf

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.