



Network operators and the transition to decentralised electricity: An Australian socio-technical case study



Genevieve Simpson

School of Earth and Environment, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009, Australia

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ABSTRACT

A socio-technical transitions theory approach is used to consider the extent to which network operators in Western Australia are perceived as facilitating, or blocking, a transition towards a distributed generation-based network. A total of 48 semi-structured, in-depth interviews with community, industry and government representatives were performed in 2015. This research finds that network operators are perceived as ‘pushing back’ on distributed generation by increasing the complexity, cost and unreliability of connection applications, by restricting further connection of distributed generation to the network, and by requiring consumers to invest in technology for grid protection. Interview respondents suggest network operators do this because: distributed generation creates technical issues at the distribution-scale of the network; distributed generation can reduce financial revenue for the network operator; as a response to a lack of strategic direction on how network operators should respond to distributed generation; and due to a ‘risk averse’ engineering culture that rejects the unknown. Government intervention may be required to direct network operators to address technical implications of increased distributed generation and redevelop tariff models to allow fair cost recovery of network assets. However, government intervention may lead to adverse outcomes, including in relation to the cost-recovery of state-owned assets.

1. Introduction

This research considers the role of network operators in assisting with a transition towards a distributed and renewable generation system. The introduction starts by defining the electricity industry as a socio-technical system and the important role that network operators will play in electricity sector transitions. The introduction subsequently identifies key policies driving change in the Western Australian electricity sector, before posing objectives for the research.

1.1. Socio-technical transitions and energy supply

The twenty-first century is characterised by environmental issues such as anthropogenic climate change, pollution and deforestation, which are largely a function of humanity's increasing levels of economic growth and associated increasing levels of consumption (Arrow et al., 1995). To reduce the negative externalities of humanity's consumption there is a need to transition towards cleaner processes of production that change the way humanity consumes products and energy. While environmental issues associated with modes of production may be the result of technologies, these technologies are embedded in financial,

social and geographical frameworks that are often difficult to shift (Antonelli, 1997). Based on this, the socio-technical transitions framework has been theorised as a way to consider technological evolutions, with the suggestion that ‘infrastructure’ is not a physical utility in its own right, but instead is a combination of the technical and social organisational characteristics that make it ‘active’ (Guy, 2006; Wolsink, 2012). Patterns of behaviour within these organisational characteristics are in reality the institutions that define the ‘rules of the game’ of production and consumption (North, 1990), with these rules charting a status quo path of functioning. The incumbent actors within the socio-technical framework therefore reinforce the existing path, leading to ‘lock in’ of particular technologies or institutional practices (Foxon and Pearson, 2008). There are numerous theories on the ways in which innovations can be accepted into these socio-technical systems, including the ‘multi-level model’ theorised by Rip and Kemp (1998).

Rip and Kemp (1998) identified three hierarchical levels interacting with an innovation's adoption. The lowest tier is the micro-level technological niche, where a ‘window’ exists for a new technology to be trialled and accepted, including through learning processes, price or performance improvements and support from elites (Geels and Schot, 2007). The middle tier is the meso-level socio-technical regime, the

Abbreviations: AMI, Advanced Metering Infrastructure; GTE, Government Trading Enterprise
E-mail addresses: Genevieve.Simpson@research.uwa.edu.au, glmsimpson@gmail.com.

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incumbent system into which the technology will be inserted. This regime level is constituted by not only the existing actors but the institutional ‘rules’ governing how actors interact (Rip and Kemp, 1998). It is at this level that a new technology receives regime-wide confirmation and experiences ‘lock in’, with institutional rules transitioning to support this new technology, often at the expense of other emergent technologies that could fill a similar niche (Wolsink, 2014). Finally, there is the macro-level landscape scale that provides over-arching direction or pressure for regime change or continuation. Landscape-scale factors change slowly (over periods of decades) and include society-wide influences, such as socio-political systems and environmental stresses (Geels and Schot, 2007). Each successively higher tier in the hierarchy is more resistant to change and is likely to impose pressures for change on the tier below it (Foxon and Pearson, 2008), however co-evolution occurs across all levels. In particular, technologies in the niche layer require ‘linking up’ with the incumbent regime (Elzen et al., 2004; Rip and Kemp, 1998).

The energy sector is an example of a regime that is currently undergoing a transition. Landscape-scale pressures from government and society to promote a more sustainable energy supply system are producing changes to electricity sector management, including an increasing focus on renewable energy and energy efficiency (Solomon and Krishna, 2011). These changes are experienced at a number of points in the regime, with renewable energy replacing incumbent fossil fuel generation and demand-side management increasing efficient use of networks. The socio-technical transition model has been used to describe many of these changes, in particular Wolsink (2012) focuses on the potential adoption of a decentralised electricity system ‘smart grid’ that will make use of distributed generation, batteries and Advanced Metering Infrastructure (AMI) to allow electricity consumers, retailers or network operators to dispatch electricity at different times. Using these technologies a decentralised electricity system can reduce the need for additional generation capacity to meet peak loads, increase energy efficiency by reducing line losses, and can facilitate the adoption of small-scale renewable energy generation (Zangiabadi et al., 2011). Various innovations (both hardware technologies and regulatory amendments) could accumulate to form an independent regime, however, efficiency of the system will be maximised if the existing electricity regime, including electricity retailers, rules, regulations, and network systems, is accessed. Such a transition could either ‘lock in’ a system with industry control over pricing and network usage, with coincident increases in monitoring of individual electricity consumption/generation, or could promote a ‘democratisation’ of the system that would have end-users as key actors in the electricity regime (Wolsink, 2012). The adoption of distributed renewable generation, in particular small-scale solar photovoltaic systems, is often seen as the first step in transitioning towards a decentralised energy system.

1.2. The Western Australian electricity sector and distributed generation

The electricity regime in the state of Western Australia is influenced by two landscape-scale strategies promoted by successive governments: energy market reform to promote increased competition between private firms and an associated reduction in electricity tariffs; and increasing support for renewable energy generation to assist in meeting national carbon emissions abatement targets. As part of the first landscape pressure the former State Government-controlled electricity utility was divided into three corporate entities in the form of Government Trading Enterprises (GTEs). The Western Australian Electricity Corporations Act 2005 (Government of Western Australia, 2016c) stipulates that the GTEs are to function under an independent Board and are to make decisions based on maximising commercial efficiency, in the interests of shareholders (the Western Australian public). The Minister for Energy can, however, direct the GTEs to perform functions and has oversight of GTE budgets. The three GTEs include Synergy, the metropolitan retailer-generator, Western Power, the metropolitan

network operator, and Horizon Power, the regional electricity producer, which provides network, generation and retailer services. Synergy was established to promote competition with private generators and retailers, while Western Power is a monopoly with tariffs and work program budgets approved by the Economic Regulation Authority (Government of Western Australia, 2014). There is considerable cross-subsidisation between the metropolitan energy utilities and Horizon Power, with the Western Australian electricity sector expected to be subsidised by the State Government at a cost of approximately AU\$430 million in 2016–17 (Government of Western Australia, 2016a).

The second landscape-scale strategy to transform the electricity regime is focused on increasing the proportion of electricity sourced from renewable energy generation. There have been numerous state and federal policies to promote renewable energy generation in Western Australia. The most prominent of these is the federal Renewable Energy Target, which includes a renewable energy certificate market with financial benefits for large-scale and small-scale systems (Climate Change Authority, 2012). The Western Australian State Government has also made reimbursements (Collier, 2009) and premium net feed-in tariffs (Collier, 2010) available to promote residential solar energy. Additionally, the GTEs have trialled renewable energy generation and its interaction with the network (Western Power, 2012).

Initially, financial incentives for the increased adoption of distributed generation contributed to modest uptake of small-scale solar systems and negligible uptake of micro-hydro and wind turbines. However, a reduction in solar system prices associated with market competition, a glut of systems and generous financial subsidies, alongside increasing electricity tariffs, good solar resources and peer-to-peer interactions promoting solar resulted in a dramatic increase in the installation of distributed small-scale solar systems in 2011 (Simpson and Clifton, 2015). This has resulted in Australia having some of the highest penetration of residential solar generation in the world, with Australia-wide penetration levels of 16.5% (Bruce and MacGill, 2016), and as high as 31% in the Australian state of Queensland (Australian PV Institute (APVI), 2016). This is already higher than the Western Australian network operator-initiated trials on the impact of ‘high penetration’ solar on the network, at 30% in 2011 (Western Power, 2012).

Despite this support for distributed generation (in the form of small-scale solar) at the niche (household) level and also at the landscape level (the latter involving political support for environmental reasons) the ‘success’ of distributed generation in Western Australia, as measured in near-universal adoption, is not guaranteed. While there are niche-level limitations, in particular existing buildings that are incompatible with distributed generation installation, limitations are also placed on distributed generation in the form of resistance to change from the incumbent regime. The chief actors in this regime are the market operators, regulators, energy retailers, generators and the network operators. Distributed generation will influence forecasting of markets (McConnell et al., 2013), add another layer of energy supply for regulators to consider (Wood and Carter, 2014), act as a competitor to generators (Stock, 2014), and will change the financial dynamics for retailers by influencing wholesale cost prices (Simshauser, 2016). Network operators may be the most influential incumbent regime actors in the adoption of distributed generation and transition towards decentralised electricity systems. This is because it is the network operators that will be the technological interface ‘linking up’ distributed generation and the incumbent regime. Network operators act as ‘gate keepers’ to the network for all generation types and facilitate the transfer of power from the site of generation to areas of consumption, thereby contributing financial benefits for solar ‘prosumers’ (producer-consumers) but with direct implications for the network operators’ infrastructure and cost recovery models (Simshauser, 2016).

Government incentive policies promote the adoption of niche-level distributed generation technology, specifically small-scale solar photovoltaic systems. Financial incentives promote market growth, allow for ‘learning by doing’ (Van Benthem et al., 2008) and move the technology

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