



A conversation about energy futures for remote Australian communities

Tira Foran, David Fleming, Bruno Spandonide

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About the author

Based in Canberra, Tira Foran and David Fleming are Research Scientists with CSIRO Land and Water Flagship. Tira's research interests are in interdisciplinary approaches to addressing sustainability challenges. David's research interests are in spatial and econometric approaches to economic growth and development.

Based in Alice Springs, Bruno Spandonide is a Research Officer working on the Transport Futures project as part of the Climate Change Adaptation, Energy Futures and Carbon Economies in Remote Australia project with the CRC-REP. Bruno's research interests are in transport geography and strategic regional planning.

For additional information please contact

Ninti One Limited

Communications Manager

PO Box 154, Kent Town

SA 5071

Australia

Telephone +61 8 8959 6000 Fax +61 8 8959 6048

www.nintione.com.au

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Tira Foran

David Fleming

Bruno Spandonide



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CRC
AUSTRALIA



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Shortened forms

BAU	business as usual
CCS	carbon capture and storage
GHG	greenhouse gas
NEM	National Electricity Market
PJ	petajoule
PV	photovoltaic
RE	renewable energy
SLA	statistical local area
TWh	terawatt-hour

Executive summary

Remote Australia – an area that covers 85% of the continent but houses just 2.3% of its adult population (ABS 2014) – is considered distant from many markets and centres of power. Remote Australia’s social distance puts a premium on local knowledge and technical and social innovations to address problems that mainstream approaches may fail to resolve. In the ‘Exploring energy futures for remote Australian communities’ project, we were interested in the future of social and organisational innovations that make consumption of energy by households and industry more sustainable – regardless of what the future holds.

The paper documents the creation of a conceptual framework that could be used to support ongoing conversations around energy futures. To engage the reader in those conversations, we raise a series of questions for readers to reflect on. The questions address a range of topics: visions of more liveable and resilient futures, policy approaches and instruments; governance dependencies; energy-related social practices; and the value of techniques and methods used to think about the future.

This paper focuses on scenarios (sets of plausible storylines for how the future may unfold) and visions (outcomes that people value), and the relation between them. We find that existing Australian energy scenarios offer useful technology content but have notable limitations from the perspective of participatory policy development. Existing scenarios do not elaborate on questions of social agency (how and through whom change and innovation occur), nor on liveability (what is it like to live in alternate energy futures?). Demonstrating that a more holistic analysis is possible, we develop three energy-related scenarios that deal with housing and innovation, in a manner more accessible to generalists.

1. Introduction

This paper focuses on substantive, unresolved issues that motivated the ‘Exploring energy futures for remote Australian communities’ project. Throughout the paper, shaded/filled boxes pose a series of questions for readers to reflect on. A companion document (Foran et al. 2014) summarises two workshops in Alice Springs (May 2014) during which many of the questions posed here were initially explored.

In this project, we were interested in the future of social and organisational innovations: innovations that make consumption of energy by households and industry more sustainable regardless of what the future holds. Our purpose was as follows:

Taking into account future uncertainties, we want to develop a collaborative understanding of how alternative energy-related practices and regimes of provisioning may impact on the future liveability of selected communities in remote Australia, focusing on housing, enterprises and mobility.

Each underlined phrase contains concepts that have influenced our thinking, so we unpack them further below. Section 2 of this paper summarises the project’s participatory method. Section 3 introduces innovation, providing examples of innovative practices relevant to remote Australia. Section 4 summarises some existing visions for remote Australia that involve social and technical innovation around energy systems (including those of the Arid Lands Environment Centre and Zero Carbon Australia). Section 5 introduces scenario thinking, a method to generate alternative storylines of social and technical futures. We review existing Australian energy scenarios, including the Future Grid Forum scenarios by CSIRO (2013). We briefly comment on the prospects of some of the visions, introduced in Section 4, in several contrasting energy futures. We then create a set of three new scenarios that contrast alternative technical *and* social futures for housing and thermal comfort, for Alice Springs in the year 2050. Section 6 concludes by emphasising the urgency and importance of the research agenda, which revolves around identifying, through participatory methods, policies and innovations that are ‘no regrets’ strategies, either to avoid undesired futures, or to craft desired development pathways.

Importance of uncertain futures. The future of remote Australia depends on how a number of different uncertain driving forces will play out over time. As we show below, these forces have economic, social and biophysical dimensions. They can be visualised as acting at different levels, for example, projected 4°C global warming by 2100, more volatile and possibly slower global and national economic growth, higher global energy prices, uncertain international and Australian commitments towards pricing carbon and uncertain state-level commitments towards regulating building codes.

To explain this visually, Figure 1 shows existing pipelines and electricity grids, which are centralised in the more populated areas of the country. However, depending on levels of policy support for solar energy, some observers can visualise a future landscape where electricity generation becomes much less centralised, and hydrogen-based transport fuels reduce dependence on diesel fuel. In short, renewable energy techniques and storage technologies could alter today’s energy landscape (Pittock 2011).

Consequently, planners, policy advisors and residents interested in, or responsible for, long-term planning in remote Australia face the challenge of understanding a range of possible futures for their communities, including those futures with adverse implications. For example, in Northern Australia, climate change is projected to include intensifying tropical storms, affecting the provision of energy to households with anticipated extended periods of grid disconnection in regions such as the remote Kimberley.¹

¹ Race D [Principal Research Leader, Climate Change and Energy Futures project, CRC-REP] 2014, pers. comm., March 28

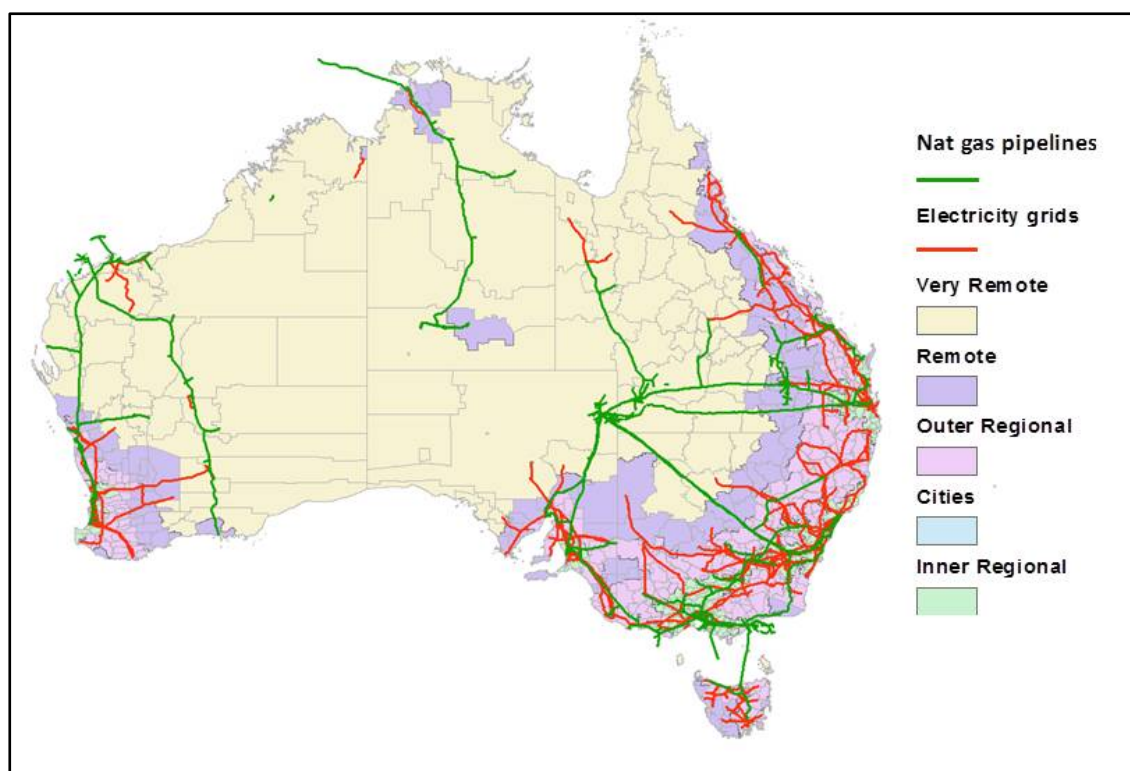


Figure 1: Australia's energy infrastructure and regions

Source: Authors

Collaborative understanding. By collaborative understanding we mean understanding that emerges from a participatory, knowledge-seeking process informed by theories of collaborative governance (Ansell & Gash 2008, Emerson et al. 2012). Collaborative governance refers to consensus-based modes of public policy formation, which aim to craft new policies or make policy recommendations. Such approaches contrast to bureaucratic or managerial modes of policy. The approach is initiated by leadership and driven by the recognition of actors that a particular issue is uncertain, important and has interdependencies. Examples of interdependencies in the context of our project include between social welfare policy, housing policy, health policy, employment/enterprise development policy and energy policy. Other examples might include the need for public acceptance and cooperation for the siting and maintenance of particular energy technologies.

Emerson et al. (2012) propose that collaborative governance processes work by generating a virtuous cycle of three processes, each of which is itself sustained by micro-social processes (interactions between individuals or small groups): (1) 'principled engagement' refers to micro-social processes that lead to understanding other actors' interests. These processes include reasoned argument and deliberation aimed at defining problems and finding agreements together. Over time, principled engagement enables (2) 'shared motivation'. This term refers to the outcome of processes that build trust, mutual recognition of interdependence, shared ownership and internal legitimacy. Achieving shared motivation or commitment, in turn, increases (3) the capacity for 'joint action'. Joint action refers to mobilisation of resources and knowledge and the changed institutional arrangements that lead to outputs and outcomes that cannot be

accomplished in isolation (e.g. changes to energy usage that rely on changing practices in housing or mobility).²

The science and craft of collaborative governance is relatively new, which means that future projects could make contributions to both. For instance, Emerson et al. (2012) emphasise the creation of a shared theory of action (i.e. a shared understanding of a pathway to impact, also known as ‘theory of change’).

We proposed to (i) facilitate dialogue around *uncertainty*, one of the drivers of collaborative governance (e.g. by hosting a discussion about future energy prices and energy-related policies). We also (ii) facilitated awareness of *interdependency* (e.g. the linkages between housing and energy), another driver of collaborative governance.³ Furthermore, the research team provided particular kinds of (iii) *technical support* (dialogue facilitation, modelling, impact pathway workshops) that may contribute to mobilising *joint action*.

Given the long-term nature of collaborative dynamics, could a short-term research project informed by collaborative governance theory help policy actors generate a shared theory of action?

Energy-related practices in remote Australia. The project sought to improve understanding about the history and future prospects of meaningful, inspiring and innovative practices. By ‘practices’ we mean a combination of common understandings (e.g. what is a need? what is a luxury?), material infrastructures (e.g. timber, brick veneer, sealed roads, central grid-supplied electricity) and practical knowledge (e.g. the knowledge that an architect has about what designs will or will not be commercially viable) (Strengers & Maller 2011). Through this lens, a particular system of energy provisioning (see below) can be seen as an assemblage of social practices.

Stafford Smith and Cribb (2009, Chapter 7, pp. 97–110) distinguish different types of remote settlements, for instance service towns, mining towns, tourism-dependent communities, pastoral stations and Aboriginal communities. We would expect these different types of settlements and communities to differ with respect to how they frame the challenge of energy-related liveability. The project proposed to take a contrasting case study approach, focusing on Alice Springs, a service centre whose recent identity has included support for solar photovoltaic (PV) technologies, and smaller remote Aboriginal settlements in central Australia that are less advantaged. It also sought to understand different types of potentially innovative or adaptive energy-related practices and their history and dynamics (how they emerged and have been sustained, or not, over time).

Importance of regimes of provision. Most work on energy futures focuses on how specific energy technologies (such as solar PV) evolve. Our approach to energy futures included, but also extended beyond, the question of which energy technologies are considered best for remote Australia. From a sociological perspective, the way in which energy, housing, transport and social welfare are governed, produced, distributed and consumed can be studied as distinct systems of provision (Reusswig 2009, Shove 2010, Van Vliet et al. 2005). The extended understanding thus aimed to include how the provisioning of energy-related services (such as cooling, heating, cooking and mobility) is influenced by widely held beliefs, specific planning and technical practices and dynamic social and economic forces (Figure 2 below).

² In this context Ansell and Gash (2008) refer to meaningful intermediate outcomes such as joint fact finding or other ‘small wins’.

³ Increased awareness of interdependency and uncertainty is seen as driving collaboration.

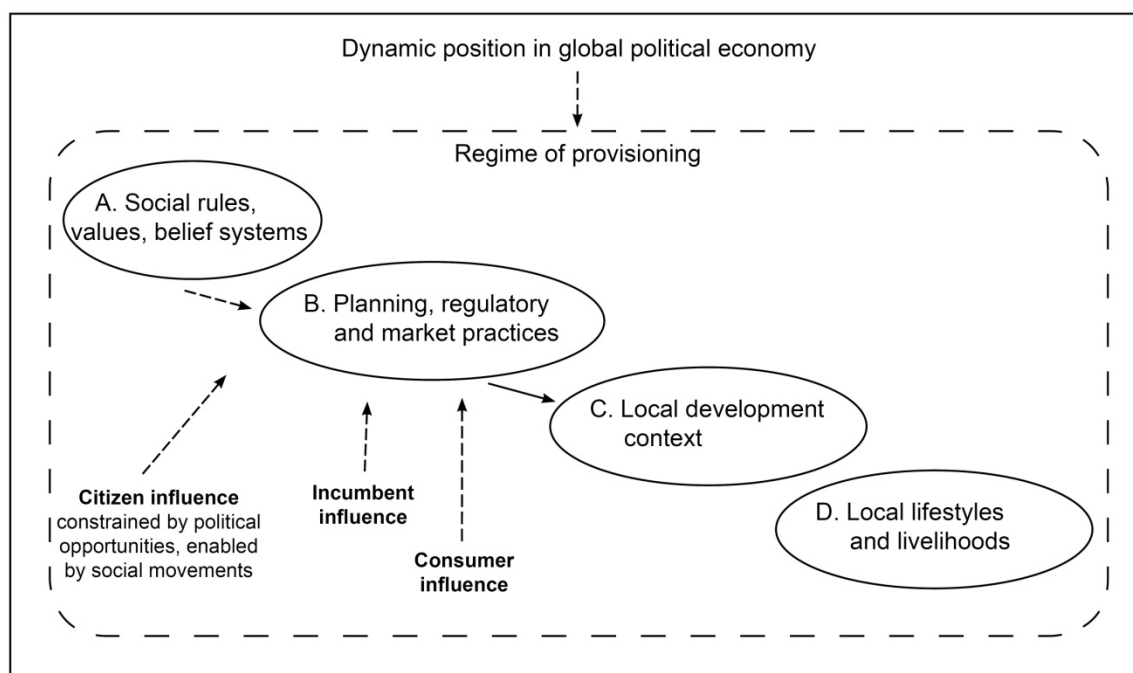


Figure 2: Regime of provision

Source: Authors

Regimes of provisioning can be understood as having three dimensions:

1. a multi-level system of mental conceptions and practices – as well as interest-based contestation between incumbents and challengers around particular conceptions and practices
2. a level and pattern of energy or resource flows (e.g. how much electricity is consumed per capita)
3. the material infrastructure that supports those flows and associated system beliefs.

We regarded the first dimension as most important. Regimes of provision thus have considerable history and structure that reflect particular alignments of ideas and interests. Often the structure is one of path-dependence, as the following examples illustrate.

First, sector-specific planning and regulation is influenced by a number of widely held values and norms (Figure 2, A). For example, individual privacy and convenience are highly valued, influencing the popularity of automobile transport and low-density settlements dominated by single homes (Filion 2010). Another dominant belief system is a model of economic development that emphasises consumption as a driver of public and private investment, employment and other desired outcomes. In this model, the market value of conventional (fossil) fuels does not capture all of their environmental damages, leading to a situation where conventional energy technologies have accumulated, over time, economies of scale and – in the absence of specific interventions such as taxes and subsidies (Figure 2, B) – can be offered at lowered prices than renewable energy.⁴

⁴ However, should they choose to invest in proven renewable energy technologies, such as wind, major conventional energy firms have capital and know-how that may confer a competitive advantage (Hess 2013).

Also in the above belief system, conventional utility business models (i.e. institutions) make revenues a direct function either of energy sales or of investment in power plants, poles and wires (Figure 2, B). Significant investment in energy efficient technologies or spatially distributed energy generation (e.g. grid-connected rooftop PV systems, hybrid solar-diesel systems for remote communities) *conflicts* with conventional business models by reducing the energy sales of distribution and transmission companies and the sales of large generators (CSIRO 2013, pp. 59–60; Northern Territory Government 2012, p. 6) (Figure 2, B). Even when renewable energy is economically competitive, willingness to invest in it (e.g. solar-diesel hybrid generators for mine sites) may be limited because of engineering conventions about power reliability and risk aversion (Northern Territory Government 2012) (Figure 2, B).

Institutionalised rules and conventions therefore shape the extent to which challengers, as well as dominant actors, can introduce alternative perspectives on environmental and social issues into long-term planning around energy infrastructure or housing designs. The choices that can be made in such spaces (e.g. policy settings, business models) greatly influence the design of specific energy generation technologies, building designs and appliances (Figure 2, C) from which end users can choose (Figure 2, D).

In short, at various levels of the system, different actors are constrained by higher level structures (i.e. institutions or ‘rules’). They can act strategically in attempts to change aspects of the system. Challengers (e.g. consumer movements advocating for local government support of renewable energy) lobby against dominant actors (e.g. investor-owned utilities) to influence policy outcomes (e.g. rules permitting community choice aggregation⁵) (Hess 2013) (Figure 2, B). A variety of new institutional designs that support distributed solar energy have emerged, both for-profit and non-profit. However, well-resourced commercial actors (new entrants to the electricity industry, such as Google and venture capital-backed firms) have dominated non-profit models, such as those in which local communities retain ownership of solar panels (Hess 2013).

In this perspective, particular policy outcomes depend on the competition between various kinds of ideas (belief systems, arguments) as well as underlying material interests and the ability to mobilise resources. The importance of material interests (e.g. the ownership of capital-intensive assets by dominant organisations) means that innovative ideas tend to be selectively appropriated and modified before they get incorporated into the prevailing regime of provision (Hess 2013, Smith & Seyfang 2013).⁶

2. Design

The proposed project design used a participatory methodology summarised in Figure 3. Workshops were intended for a range of participants with experience of different components – social, policy-related, market-related and technical – in an energy-related system of provisioning. Two rounds of multi-stakeholder workshops were proposed, with the first round having taken place in May 2014. The proposed design took participants on an inquiry that began by asking (1) What innovative, energy-related practices

⁵ Aggregation of large numbers of customers in a geographic region into a contract with an energy services provider based on a negotiated price and energy mix (Hess 2013).

⁶ One conceptual framework used to explain change and continuity in large technical systems is the multi-level perspective (MLP), which uses the concept of social-technical niches, regimes and landscapes. Earlier work on this perspective has been criticised for managerial, depoliticised treatment of change, in part a function of the MLP’s system-oriented, long-duration time scale. More recent contributors who use the MLP or related approaches (such as ‘strategic niche management’) recognise the importance of political contention (Hess 2013). However, for specific concepts related to political interaction between challengers and incumbents in a system of provisioning, we need to look beyond the MLP to political sociology (McAdam et al. 2001), specifically to social movement studies and field theory (Fligstein & McAdam 2011, Hess 2013, Smith & Seyfang 2013).

currently exist in remote Australia? What practices deserve to be better understood (in terms of their organisational, business or other social aspects)? (2) What practices do participants attach high value to?

We would then help participants explore how future uncertainties might make some practices more viable than others. A comparison of how various energy-related practices perform in different Australian futures could then lead to visions (e.g. for particular sets of practices and supportive environments) as well as recommendations to policy actors at different levels of government (as well as to the private sector). The project attempted to generate consensus-based recommendations.

We organised separate first-round workshops to explore (a) housing and (b) transport and mobility as two important systems of provisioning for remote Australia. We were also interested in the possibility of convening separate meetings to discuss energy issues for specific types of remote settlements, such as (c) Aboriginal and Torres Strait Islander communities, (d) pastoral settlements and (e) mining operations.

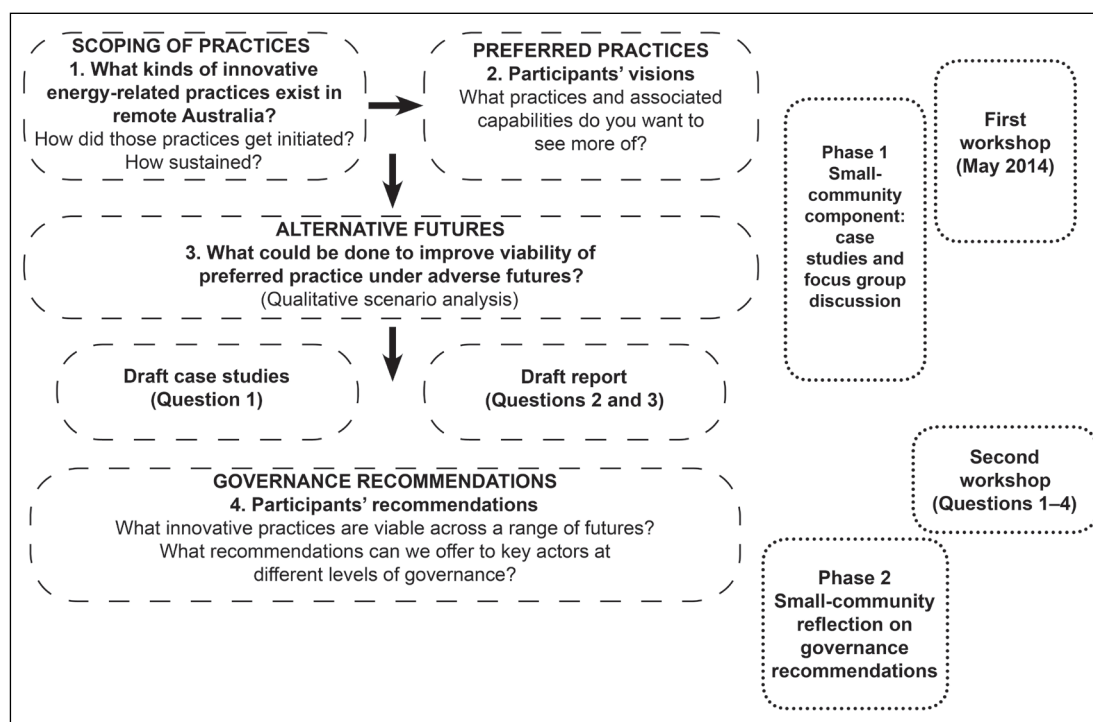


Figure 3: Outline of research questions and project design

Source: Authors

3. Innovative practices

Innovation often gets confused with invention. An invention refers to the discovery or creation of something new to the world, for example, a new technical or scientific idea or concept. Innovation, by contrast, focuses on discovery or learning that is new to a particular group of people. World Bank (2012) defines innovation in agricultural development as:

[T]he process by which individuals or organizations *master and implement the design and production of goods and services* that are new to them, irrespective of whether they are new to their competitors, their country, or the world.

(World Bank 2012, p. 15) (emphasis added)

Innovation matters for a host of reasons. In globally connected market economies, it is thought to be a source of industrial competitiveness, economic growth and employment. However, as we have already noted, remote Australia is distant from many markets, centres of power, and possibly from dominant rules and practices. This puts a premium on local technical and social innovations to address problems that mainstream approaches may fail to resolve (Stafford Smith & Cribb 2009). Some of these local innovations might be considered ‘grassroots’ innovations, as we describe below.

3.1 Innovations relevant to remote Australia

Table 1 shows a number of innovative, energy-related practices that either occur in, or are potentially relevant to, remote Australia. The practices are sourced from a literature review as well as from preliminary interviews conducted in October 2013. The table focuses on practices close to the end user, as opposed to supply-side generation practices. While innovation also occurs around the development of fossil energy (e.g. developing regulatory and policy regimes for coal seam gas production), our focus on how end users can innovate to improve their energy security using commercially viable technologies means that we downplay the importance of emerging or capital-intensive technologies.

In addition to the practices listed in Table 1, what other energy-related practices deserve consideration by the participants in this project?

Table 1: Innovative, energy-related practices relevant to remote Australia

Proponent	Type of practice / Details	References
	Energy technology and systems	
Federal Government	Low income energy efficiency program (LIEEP)	Interview I (10/10/13)
Northern Territory Government	Increased residential building energy efficiency performance requirements (May 2010: shift from 3.5-star to 5-star equivalent rating for new homes and extensions; apartments/flats move from no requirement to 3.5-star equivalent)	NT Government (2010)
Tangentyere Council	Energy efficiency retrofits to 61 houses in 12 Alice Springs Town Camps. Results: Indoor temperatures up to 7°C below shaded air temperature with relatively minor passive modifications: roof insulation, insulated shade walls, pergola extensions, window coverings, sealed cornice and wall junctions	Tangentyere Design (2013) Tangentyere Council (2011) Interview G (10/10/13)
Bushlight	Remote area power supply system featuring reliable and durable solar PV. Approximately 90 systems installed. Design includes one essential electric circuit (fridge, one light, one fan) designed to run continuously on renewable energy (RE) Community and household planning and costing service, methodology around what users want to do with electrical power	Stafford Smith & Cribb (2009, p. 114) Interview I (10/10/13)
Alice Springs Town Council	Alice Solar Cities Program helped to increase the number of residential rooftop solar PV systems from 2 to 444 between 2008 and 2012, at a cost of around \$9000 per household (after subsidies and credits). Main determinants of early adopters of PV (277 households) were house style and level of education	Havas et al. (2012)
New South Wales	Time-varying pricing ('dynamic peak pricing'): 10–40 times increase in price of electricity relative to off-peak rate for up to four hours duration. Result: peak load reductions of approximately 30%	Newsham and Bowker (2010) Strengers (2010)

Proponent	Type of practice / Details	References
	Energy technology and systems	
Horizon Power (Utility owned by WA Government)	Location-specific solar feed-in tariffs (exceed state tariff of 8c/kWh) reflect cost of delivering energy to remote locations; people in more remote areas (where it is more expensive to supply electricity) receive up to 50c/kWh for their solar feed-in	Energy Matters (2012)
	Building design and collective practices	
Remote community arts centres	Cooling centres – use of community arts centre as cooling hubs	Interview C (7/10/13)
	Precinct or town planning practices	
Earthship World Community, New Mexico, USA	A residential community, on 600 acres, of 120 planned homes constructed from rammed earth and recycled materials. Promoted as 'world's first sub-division approved without utilities'.	Seyfang (2009) www.earthship.com
	End-user social practices	
	Staying cool by sitting outside buildings in shade Spray systems on shade cloth shelters	Horne et al. (2013) Santamouris & Kolokotsa (2013)
	Water management	
Alice Springs Town Council	Managed aquifer recharge scheme uses treated sewage water for irrigation; up to 600 ML/y stored in aquifer	Stafford Smith & Cribb (2009, p. 117)
	Transport	
Central Australia	The Centre Bush Bus: a subsidised trunk service for passengers, (refrigerated) freight, and mail. The bus services over 35 remote communities in Central Australia, and more than 1 million kilometres are travelled annually: improved reliability, safety and cost-effectiveness.	http://centrebushbus.com.au/
World/Australia	Community Transport Organisation: Several examples of vehicle pooling/community transport, based on the principle of operating under-used vehicles and matching vehicle sizes to local needs. Carpooling is a common practice in numerous very remote communities at an informal level.	http://www.cto.org.au/
Adelaide City Council	Tindo Bus (a result of the Adelaide Solar City program) combines a zero emissions vehicle with the largest grid-connected solar PV system in the state to provide the first example in the world of a carbon neutral electric bus recharged by 100% solar PV electricity.	http://www.adelaidecitycouncil.com/environment/energy/tindo-solar-bus/
World/Australia	Several electric vehicles are available in Australia (Nissan Leaf, Mitsubishi I-MIEV), with several new models to be commercialised soon. Significant improvements of ranges and battery performance can be expected. Up to 75% of all vehicles could be autonomous by 2040 (Institute of Electrical and Electronics Engineers).	http://emarketing.pwc.com/reaction/images/AutofactsAnalystNoteUS(Feb2013)FINAL.pdf http://www.ieee.org/about/news/2012/5september_2_2012.html

Source: Authors

3.2 Analysing innovation

In *The new economics of sustainable consumption: seeds of change*, Gill Seyfang (2009) distinguishes two broad types of innovation: grassroots-based and market-based. The two differ according to driving ideas, contexts, dominant organisational form and resource base (Table 2).

The pervasiveness of markets means that market-based images dominate thinking around innovation. However, the logic of a market economy does not need to govern the provisioning of all goods and services. One strand of critical thinking argues that sustainable systems of production and consumption require much more investment attention in the ‘social economy’. This is a sphere that sits uneasily beside, and is dominated by, the wider market economy. In the social economy, profit is not primarily appropriated by private actors but ‘reinvested into the grassroots’. The driving force is ‘social need’ (Seyfang 2009, Chapter 4, pp. 63–82).

Governments or non-government organisations invest in the social economy when they fund work that delivers regional, national or global public goods (i.e. outputs and outcomes that cannot be appropriated by individual actors). Examples from remote and regional Australia include programs that invest in Aboriginal and Torres Strait Islander ecological knowledge and apply it to maintain biodiversity, manage fire and maintain cultural heritage (Altman & Kerins 2012). Altman’s concept of a ‘hybrid’ economy incorporates state support for the customary economy in remote Australia. The hybrid local economy is conceptualised as ‘interlinked and interdependent customary, state and market sectors’, where customary activity also enables participation in market activities such as production of art and craft (Altman 2010).

Table 2: Two types of innovation

	Market-based innovations	Grassroots innovations
Context	Market economy	Social economy
Driving force	Profit: Entrepreneurial rent (above-market economic returns obtained from possession of an innovation)	Various interpretations of social need
Niche	May be protected from market forces by taxes and subsidies	The niche embodies alternative values
Organisational form	Firms	Very diverse (informal groups, networks, associations)
Resource base	Commercial income	Diverse (grants, voluntary inputs, mutual exchanges, commercial income)

Source: Adapted from Seyfang (2009).

Note: Niches are sites of interaction around a particular set of practices that is by definition not mainstream practice.

What Seyfang (2009) refers to as ‘grassroots innovation’ around sustainable housing and food systems also takes place in the social economy. Production and exchange of goods and services takes place according to non-market values. In concrete terms, this involves voluntary exchanges of labour, knowledge and services, often centred on a particular community of place, in whose economic and social wellbeing residents choose to invest.

Seyfang’s description provides an idealised vision⁷ for how systems of provisioning should operate, a vision that attaches high importance to social inclusiveness and economic accessibility of technical solutions. Other analysts, however, draw attention to the complex relations that exist between grassroots innovations and the market economy. For example, we noted at the end of Section 1 that due to concentrated ownership of capital-intensive assets in market economies, innovative ideas tend to get transformed and modified before they get incorporated into prevailing systems of provision (Hess 2013, Smith 2007, Smith & Seyfang 2013).

⁷ Section 4 discusses the importance of visions.

3.2.1 Evaluating innovation through the lens of sustainable consumption

Seyfang (2009) suggests that innovation can be evaluated using indicators that capture five dimensions of sustainable consumption. In Table 3 we list these five indicators, describe them and provide examples where these can be applied in remote Australia.

Table 3: Indicators of sustainable consumption

Indicator	Descriptions	Examples
1. Localisation	Contributing to more self-reliant local economies Increasing local economic linkages Reducing length of supply chain	Self-provisioning / local provisioning of food, housing, energy
2. Reducing ecological and social footprint	Shifting consumption to reduce negative impacts on others Reducing energy and resource use	Adopting lower-carbon lifestyles, voluntary simplicity
3. Community building	Nurturing inclusive and cohesive communities Effective support networks	desertSMART COOLmob http://desertsmartcoolmob.org/ Social networks around green building, permaculture
4. Collective action	Collaboration leading to greater empowerment of people in systems of production and consumption	Local organisations and initiatives that offer spaces or platforms for learning, collaboration, and engagement with government and other actors in policy processes Carpooling systems that use governmental and non-governmental organisation fleets
5. Building new systems of provision	Developing new sets of beliefs, values and technical rules that are more sustainable (e.g. more localised, lower footprint, pro-community)	Gaining institutional acceptance of alternative housing, alternative food distribution, local currency systems

Source: Adapted from Seyfang 2009

Anticipating a variety of plausible changes to industries and markets, what goods might make sense to be able to produce locally?

3.2.2 Dynamics of innovation

Hekkert et al. (2007) propose that crucial activities in a technology-specific innovation system can be analysed. They propose seven such crucial ‘functions’, which can be assessed as positive or negative for the development of a particular technology. Interactions between these activities can lead to positive feedback (virtuous circles) for the activity of interest, or dampen it. Their analysis focuses on entrepreneurial activity. They see entrepreneurs as essential for a productive innovation system: ‘The role of the entrepreneur is to turn the potential of new knowledge, networks, and markets into concrete actions to generate ... new business activities’ (Hekkert et al. 2007, p. 421).

Entrepreneurs engage in two kinds of activities with risky or uncertain outcomes. First, through experimentation, they develop technologies and practices, leading to knowledge creation and diffusion through relevant networks, which influences expectations about the prospects of that technology, which in turn influences degree of entrepreneurial activity (Figure 4, left hand loop). Second, entrepreneurs also engage in various kinds of advocacy, potentially influencing policies that favour that specific technology. Such policies (e.g. feed-in tariffs) shape specific markets, which in turn influence the decisions of other actors (e.g. suppliers, home owners) to allocate resources that favour the entrepreneurial activity (Figure 4, right hand loop).

What organisations and networks are important for innovation in remote Australia?

The framework proposed by Hekkert et al. (2007) highlights the importance of two kinds of activities: participation in policy formulation and engagement with specific practices or technologies. Looking critically at the right hand loop of this framework, we see that it does not explain the dynamics of policy formulation. This is, of course, influenced by activities of other actors and by changing political contexts.⁸ Likewise, market formation is not just by entrepreneurs, but by dominant actors in a supply chain, and their position with respect to innovative practice needs to be understood.

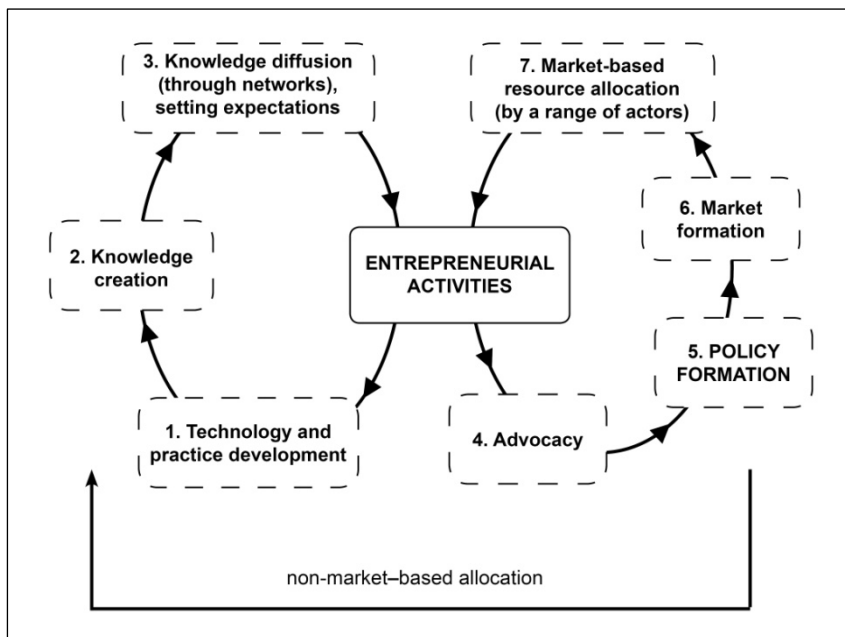


Figure 4: One perspective on entrepreneurial dynamics

Source: Adapted from Hekkert et al. (2007)

The framework makes explicit reference to market-based innovation, particularly around new technologies. On first inspection, the framework does not appear particularly well suited to innovations in the social economy or in governance. However, by defining the ‘entrepreneur’ as any innovative actor (e.g. Bushlight and Tangentyere Design in Table 1), it could perhaps encompass grassroots innovation.

How useful is the above framework for understanding the dynamics of innovation?

⁸ Hekkert et al. (2007) refer the reader to Sabatier’s ‘Advocacy Coalition Framework’, which is a conceptual framework developed to explain policy changes over a decade or more (Sabatier 2007).

4. Visions of the future

By ‘vision’ we mean imagined future outcomes that people attach importance to. People value some of these outcomes (objectives, aspirations, goals) positively and wish to see them realised. A useful vision can also include outcomes that people explicitly wish to avoid. This section provides examples of energy-related visions relevant for remote Australia (Table 4). Note that the grassroots innovations in Section 3 are also highly visionary.

Table 4: Examples of energy-related visions

Proponent	Vision
Zero Carbon Australia 2020 Stationary Energy Plan (Wright & Hearps 2011)	<ul style="list-style-type: none"> • An ambitious plan to transform the Australian energy sector into a 100% renewable energy (RE) system in ten years (2011–2020) for a cost of approximately \$370 billion • Costs (including return on assets) could be covered by a tariff increase of 6.5c/kWh by 2020 • 60% of electricity to be generated from concentrating solar power (with molten salt storage), 40% from wind and 2% from hydropower and crop-waste biomass during extended periods of concurrent low solar and wind availability • A new national grid to be formed by connecting three existing large grids: National Electricity Market, South West Interconnected System and North West Interconnected System • Northern Territory grids also transform to 100% RE, but remain isolated
desertSMART COOLmob (McClellan & McHenry 2014)	<ul style="list-style-type: none"> • 100% of electricity in Alice Springs is generated from clean, renewable resources • Distributed generation (high percentage of users generate their own electricity from community-based or individual systems) • All residents in Alice Springs can afford electricity for basic needs, including vulnerable people and those on low incomes
Australian PV Association (Lovegrove et al. 2012)	<ul style="list-style-type: none"> • By 2020, Alice Springs and Central Australia have developed into a world-leading solar energy centre: high levels of solar energy deployment, test and demonstration facilities, high levels of community support and engagement, best-practice financial and market mechanisms for solar, energy efficiency and demand-side management.
NT Government, (Green Energy Taskforce 2011) Australian Government (Commonwealth of Australia 2014)	<ul style="list-style-type: none"> • 20% of electricity demand to be met by renewable and low emission sources by 2020 • A similar target has been established at the national level (41,000 GWh by 2020, plus small-scale solar generation) – to be achieved through the Renewable Energy Target (RET) scheme, which obliges wholesalers and some generators to purchase renewable energy certificates from approved providers (e.g. large and small-scale renewable power systems)
Pittock (2011, n.d.)	<ul style="list-style-type: none"> • Remote Australia is self-sufficient in RE • Large-scale renewable-powered electricity exported to national grid • Use of solar energy to produce ammonia as a transport fuel • Remote communities and regional towns benefit from construction, maintenance and other associated economic development
Various (De Graaf & Batker 2011, Schor 2010, Seyfang 2009)	<ul style="list-style-type: none"> • Liveability is maintained and enhanced through social innovations that are provided by voluntary social networks • Production of housing, food, energy is more distributed • People may work fewer hours in the formal market economy and instead invest more time in building human and social capital needed for climate-adapted housing and food provisioning. • Schor (2010) refers to this as ‘plenitude’. Seyfang (2009) terms it ‘New Economics’.
Innovative and energy efficient housing provision (this paper)	<ul style="list-style-type: none"> • By 2050, houses are designed and built using passive cooling and heating principles and achieve a minimum energy efficiency rating of 10 stars. Two new residential estates in Alice Springs developed that do not require centrally supplied power (see Section 5.3 below)

Source: Authors, based on literature cited.

As Figure 5 below emphasises, Australia’s existing systems of energy provision are fossil-fuel dominated. In 2006–07 hydropower, wind and solar energy supplied only 8% of electricity consumed nationally.⁹ Thus, whether for Alice Springs or for Australia, visions where the renewable energy share of electricity supply increases to 20%, or beyond, imply major transformations. Alice Springs for example has three gas-fired power stations that provide 100 MW of capacity, compared to a peak demand of 51 MW in 2012–13. A significant proportion of this existing capacity would be left unused if renewable power were to substitute.

Considering the future of energy-related liveability in remote Australia, and the above examples of visions (Table 4), what additional dimensions or alternative visions do participants have? By what social and technical pathways are such visions achieved? Does the attainment of a vision in a particular place require social changes at a higher level?

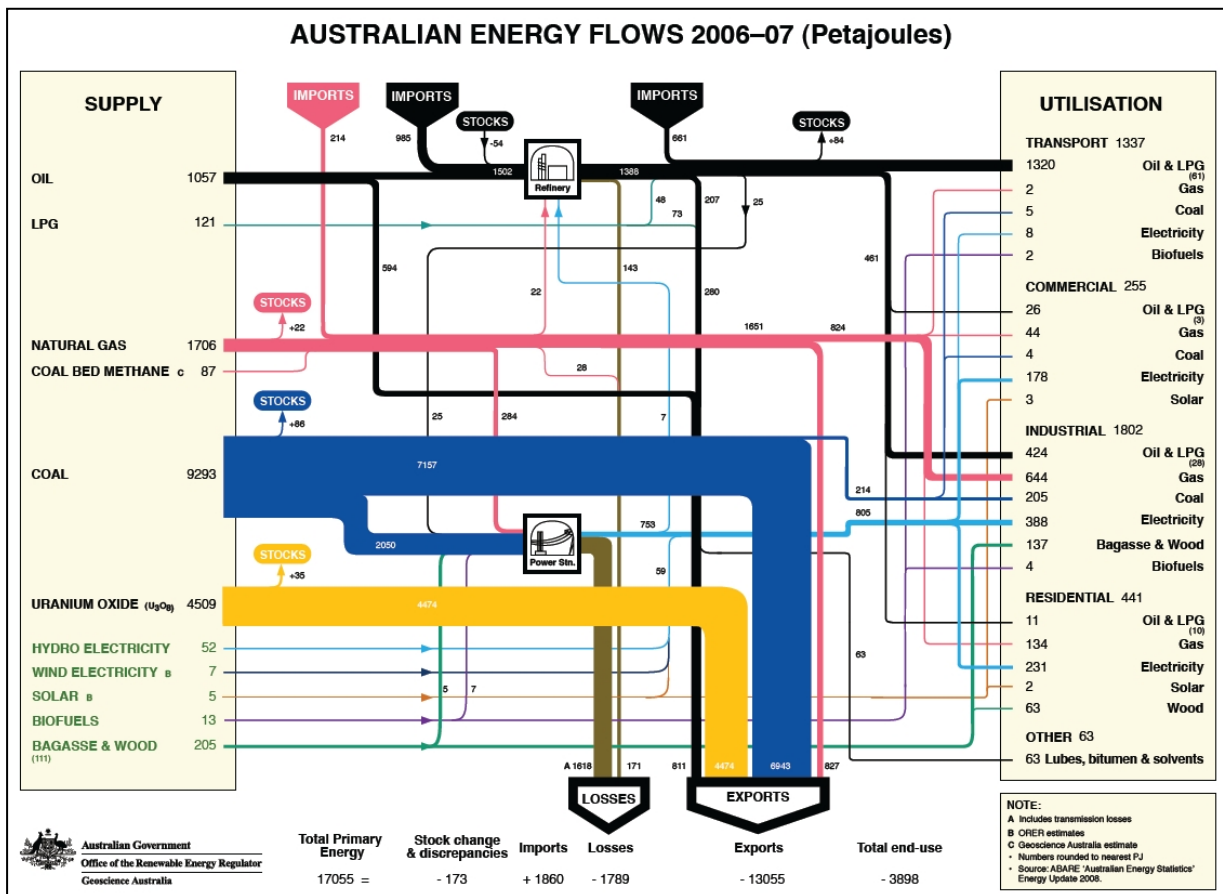


Figure 5: Australian energy flows 2006–07

Source: Geoscience Australia (2008)

After reviewing a number of existing visions, and perhaps generating fresh visions in a participatory manner, the next step in the project was to explore what happens to such visions in alternative energy-related future worlds.

⁹ 62 petajoules (PJ), based on Figure 4. Total national electricity consumption was 805 PJ, of which 29% (231 PJ) was in residences.

5. Alternative energy-related futures

The visions summarised in Table 4 tend to consist of one scenario preferred and promoted by a particular organisation, sometimes in contrast to a ‘business as usual’ (BAU) scenario (e.g. Wright & Hearps 2011). However, the presence of multiple kinds of uncertainty – social, technical, economic, environmental and political – means that it makes sense to analyse particular visions more rigorously, by comparing them to a number of alternative plausible futures (not just to BAU). Section 5.4 presents such a comparison. This section begins by introducing readers to Australian energy scenarios and the basic methodology used to construct their storylines.

How useful are the approaches presented in this section for generating scenarios relevant to remote Australia?

5.1 Driving forces considered in Australian energy scenarios

The future, though uncertain, can be visualised. Scenario-based approaches commonly visualise the future as a set of imagined outcomes (values, levels) that a number of critical ‘driving forces’ could plausibly take. Driving forces are issues or factors that have an influence on the system and that are usually out of the short-term control of policymakers. What counts as a driving force depends on the level of analysis. For example, to a national policymaker, global oil prices are typically a driving force, while import and export taxes are not. To a local policymaker, both of these factors may qualify as driving forces, whereas policies set locally are not (Foran et al. 2013).

A critical driving force is a powerful biophysical or social process with ability to influence the system of interest. It could be a *trend* (high influence, low uncertainty), as well as a known but *uncertain* force whose future value or dynamics cannot be predicted (e.g. high or low, fast or slow rate of change). It could also be a real process that is presently poorly understood (e.g. because thus far it seldom emerged or has not fully emerged).

Table 5 summarises driving forces of critical importance in two recent, independently commissioned, Australian energy scenario studies (McLennan Magasanik Associates & Strategis Partners 2009, CSIRO 2013). The table shows how both studies consider social attitudes, carbon policy and energy technology costs as drivers of critical importance.

Many of the driving forces in Table 5 are interrelated. For example, the degree to which end users engage more or less actively in electricity provisioning depends on the affordability of key technologies (e.g. smart meters, solar PV panels), institutional and policy support (e.g. to charge consumers the prices that reflect the cost of providing peak power), as well as users’ perceptions about how a technical or institutional change might impact on them or other users (CSIRO 2013, pp. 9, 31–32).

Table 5: Critical driving forces in two Australian scenario studies

Type of driving force	MMA & Strategis Partners (2009)	'Change and Choice' – the Future Grid Forum (CSIRO 2013)
Social	Consumer attitudes: influence receptivity to a range of demand-side options, including new electricity contracts, onsite generation and associated behavioural change	
	Public attitudes: influences support for low carbon energy technologies	(Not explicitly treated as a critical driving force)
Policy and regulation framework	Global and domestic carbon policy	Domestic policy support for greenhouse gas (GHG) reduction
Techno-economic	Cost of energy technologies influences amount of renewable energy in generation mix Influences demand for onsite vs. centralised generation	
	Focus on viability of centralised low carbon technology: carbon capture and storage (CCS) and geothermal	Focus on cost of electricity storage for onsite generation
Economic	Overall rate of Australian economic growth	Not considered a critical driving force
	Fossil fuel prices	
	Focus on oil, gas, and coal	Focus on natural gas prices

Source: Authors, based on references cited.

Overall, however, the two scenario studies are relatively focused on the energy sector: they focus on uncertainties associated with specific energy technologies, user interactions with technology and associated policies. The scenarios are issue-based, not geography based.

Both studies proceed from their critical uncertainties to construct a more elaborate scenario framework, as we review below.

5.2 Scenarios report to Australian Energy Market Operator (MMA & Strategis Partners 2009)

Figure 6 from MMA & Strategis (2009) shows a number of influences on the energy sector in Australia, focusing on stationary energy. Their specific scenario framework consisted of six factors: (1) global economic growth, (2) Australia's population growth, (3) global carbon policy, (4) centralised supply-side response, (5) decentralised supply-side response and (6) demand-side response (MMA & Strategis 2009, Table 1, p. 4).

Both centralised and decentralised supply-side responses were chosen by MMA & Strategis (2009) as influential. 'Centralised supply-side response' refers to the prevailing technology system, which is dominated by large-scale, capital-intensive electricity generation and long-distance transmission (as opposed to distributed generation). It is affected by the relative cost of centralised vs. decentralised technologies as well as by climate policy, energy-related design practices and end-user attitudes.

Both types of response can be supplied by renewable as well as non-renewable energy; for example, natural gas-fired cogeneration is decentralised, while large-scale geothermal, hydropower and wind are centralised. Financial viability of centralised vs. decentralised systems will depend on energy policy choices that affect investment costs. Such policy choices include how the costs of grid connection are distributed, as well as possible feed-in tariffs.

Based on different imagined outcomes for the six factors listed above, MMA & Strategis (2009) created five different scenarios for the Australian stationary energy sector. Table 6 summarises key dimensions of these scenarios.

Table 6: Key dimensions of MMA & Strategis (2009) energy scenarios

Driver	Scenario 1 (Fast rate of change)	Scenario 2 (An uncertain world)	Scenario 3 (A decentralised world)	Scenario 4 (Oil shock and adaptation)	Scenario 5 (Slow rate of change)
Common trends	Above average temperatures, more frequent, prolonged droughts Renewable Energy Targets for electricity sector				
1. Economic growth	High	High	Medium	Low	Low (mixed)
2. Population growth	High	High	Medium	Medium	Low
3. Global carbon policy	Strong (≤ 450 ppm)	Weak (≤ 550 ppm)	Strong (≤ 450 ppm)	Moderate (≤ 500 ppm)	Weak (≤ 550 ppm)
4. Centralised supply-side response	Strong	Strong	Weak	Moderate (renewable)	Moderate
5. Decentralised supply-side response	Strong	Weak	Strong	Weak	Weak
6. Demand-side response	Strong	Weak	Strong	Weak	Weak
User attitudes	Progressive Support high resource and energy efficiency	Consumerist, conservative	Very progressive	Progressive	Conservative
Oil and gas prices	High	Moderate oil, low gas	Moderate	Very high	Moderate oil, low gas

Source: Authors, adopted from MMA & Strategis (2009).

Note: 'ppm' refers to parts per million of CO₂ equivalent atmospheric concentration (assumed target in year 2050).

Based on MMA & Strategis (2009), we can summarise the storylines derived from the above scenario framework as follows:

- **Scenario 1 (Fast rate of change):** The Australian energy sector transforms rapidly to meet strong global emissions reductions targets. Strong investment in demonstration projects has lowered the cost of both renewable and fossil-based technologies (i.e. carbon capture and storage [CCS]). Geothermal, solar thermal and wind operate on a large scale, as do coal-fired CCS plants. Consumer response to demand-side technologies (e.g. smart meters, tariffs based on time and season of use) are very positive, and large improvements in energy efficiency result, in part because of high density housing designs (which in turn support cogeneration technologies).
- **Scenario 2 (An uncertain world):** Despite strong economic growth, uncertainty in carbon policy results in lower and uneven government support for technology research and development. Solar thermal technology is supported, but support for other new technologies is weak, resulting only in incremental changes in technology. Social attitudes are conservative and consumerist.
- **Scenario 3 (A decentralised world):** This scenario is very similar to Scenario 1, except that the cost of geothermal and CCS technologies has not fallen, despite government support. In order to meet strong emissions reductions commitments, decentralised and renewable solutions become even

stronger in importance than in Scenario 1. Rooftop solar PV and solar water heaters are commonly installed, as are demand-side management technologies such as time-based tariffs, switches that shut off appliances during periods of peak usage and appliances that are programmed to run during off-peak periods.

- **Scenario 4 (Oil shock and adaptation):** This scenario features very high domestic prices for oil and gas, resulting from constraints on the development of global hydrocarbon reserves and sluggish economic growth. In common with Scenario 3, CCS technology is not viable, leading to increased reliance on centrally supplied geothermal and wind technology. However, in contrast to Scenarios 1 and 3, despite progressive attitudes, the weak economy makes rooftop solar PV and many demand-side technologies (including solar water heaters) relatively unaffordable. Users face high bills and cut back on power consumption unassisted by sophisticated technologies.
- **Scenario 5 (Slow rate of change):** This scenario is essentially the inverse of Scenario 1: in the absence of a strong global carbon policy and facing low economic growth (including the decline of energy-intensive manufacturing), the energy sector transforms only slowly.

Assumptions. The scenario framework expresses two important structuring assumptions not stated explicitly by MMA & Strategis (2009). First, the extent of decentralised (as well as demand-side) responses depends on two conditions: (i) economic growth must be at least medium strength, and (ii) user attitudes to new technology and higher density housing must be progressive.¹⁰ Second, the commercial viability of CCS is treated as highly uncertain. If CCS is assumed to be non-viable, then the scenario logic assumes that development of centrally supplied renewable power will compensate, unless the decentralised response is also strong.

Other notable aspects of the MMA & Strategis (2009) study are its treatment of economic growth and carbon policy as separate driving forces. Although weak economic growth is intuitively linked to unwillingness to price carbon, decoupling the two factors allows for scenarios in which high global oil and gas prices drive consumers to proactively increase their efficiency, despite weak economic growth (MMA & Strategis 2009, Scenario 4, pp. 13–14).

5.3 CSIRO Change and Choice – Future Grid Forum scenarios

The Future Grid Forum scenarios (CSIRO 2013) explored a set of driving forces summarised in Figure 6. CSIRO explores two specific types of futures of particular interest to remote Australia, in both of which levels of distributed (onsite) generation are high: a grid-connected scenario (‘Rise of the Prosumer’, Scenario 2) and a future that features significant levels of disconnection after 2035 (‘Leaving the Grid’, Scenario 3).

¹⁰ MMA & Strategis (2009) also assume that the price of natural gas will influence the extent of decentralised generation.

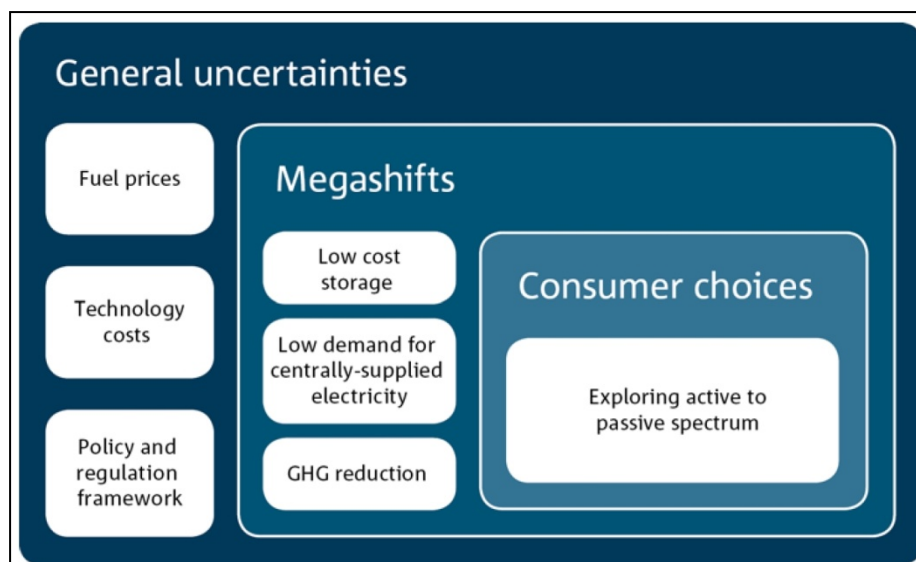


Figure 6: Scenario framework, Future Grid Forum

Source: CSIRO (2013)

Table 7 summarises how CSIRO (2013) translated the general uncertainties and ‘megashifts’ in the above scenario framework into variables that could be explored using electricity system models.

Table 7: CSIRO (2013) energy scenarios: variables and defined outcomes

Variable	Scenario 1 (Set and Forget)	Scenario 2 (Rise of the Prosumer)	Scenario 3 (Leaving the Grid)	Scenario 4 (Renewables Thrive)
Common trends	Economic growth: not explicitly stated* Carbon price: \$23 in 2012–13, rising to approximately \$145 by 2050 (CSIRO 2013, Figure 10, p. 27) Population: not explicitly stated* Natural gas price: approximately \$6/GJ in 2012, rising to approximately \$12/GJ by 2030 (CSIRO & Roam Consulting 2013, Figure 11, p. 31)			
Centralised generation [§]	High	Low	Low	Low
Distributed generation [§]	Low (~18 %) [†]	High (~46%) (grid connected)	High (~32%) (disconnected) [‡]	Moderate (~26%)
Demand-side response	High	High	Low (Loss of demand)	High
Consumer engagement	Low	Very High	High	Moderate
Fuel prices (natural gas)	Medium	Low	Low	Medium

Source: Authors, based on references cited.

Notes:

* CSIRO (2013) carbon price is based on Treasury modelling, which assumes population of 36.6 million by 2050 and 1.4% increase in real per capita GDP (Commonwealth of Australia 2011)

[†] Refers to distributed generation as share of total generation (CSIRO 2013, Figure 16, p. 34)

[‡] Assumes all existing and new onsite generation users disconnect from the grid after 2020

[§] Based on cost projections shown in CSIRO (2013, pp. 28–29).

In contrast to Scenario 1, Scenarios 2–4 assume that greater cost reductions for renewable energy and cogeneration technologies will occur by 2050.

Some key findings of the CSIRO (2013) scenario study are as follows. The projected share of onsite (distributed) generation rises from approximately 8% in 2012 to 48% by 2050, depending on the scenario (CSIRO 2013, Figure 16, p. 34). Scenarios where distributed generation is moderate or high (i.e. Scenarios 2–4) reduce the system load factor¹¹, indicating less efficient usage of the distribution network (CSIRO 2013, Figure 18, p. 39). These scenarios, however, assume a policy choice to maintain and expand existing centralised distribution networks.

Assuming investments in network expansion will continue, the unit cost (c/kWh) of distributed electricity increases, notwithstanding high levels of consumer engagement in demand management programs. The study identifies a positive feedback loop that leads to higher distribution system unit costs:

High electricity prices encourage uptake of energy efficiency measures and on-site generation, which leads to lower consumption ... lower consumption increases the per unit cost of distribution that would be passed through to all users under current volume-based tariffs and encourages the further adoption of energy efficiency and on-site generation.

(CSIRO 2013, p. 40)

All scenarios assume decreases in GHG emissions and increase in unit cost of grid-supplied electricity. Increased unit costs are required under the assumption that current distribution networks are maintained. In addition to approved investment in distribution networks, cost increases result from increased generation costs (partly as a result of carbon policy). They also result from equipment and other costs associated with distributed generation (whether grid-connected or off-grid).

Three out of the four scenarios (Scenarios 1, 2, and 3) reduce year 2050 electricity sector emissions by $\geq 55\%$, at an average wholesale cost per unit of less than \$140/MWh. Scenario 3 appears to be more cost effective in terms of emissions reduction. Scenario 4 achieves much greater (approximately 90%) reductions but at higher average wholesale cost per unit. All of the above scenarios assume a positive carbon price (Table 7). Assuming a zero carbon price results – not surprisingly – in modest emissions reductions and does not circumvent increases in wholesale prices (Figure 7).

The CSIRO (2013) study emphasised, however, the importance of looking beyond unit costs to also consider impacts from other perspectives, including impacts on different classes of consumers and the cumulative system cost. The least-cost scenario from the latter perspective is Scenario 1 (Set and Forget), followed by Scenario 4 (Renewables Thrive), Scenario 2 (Rise of the Prosumer) and Scenario 3 (Leaving the Grid). Scenario 3 has the highest cumulative cost because of its off-grid cost component, which includes advanced metering and control equipment (CSIRO 2013, Figure 23, p. 44).

¹¹ The load factor is the ratio of total energy consumed in a given year to the total energy that would have been consumed had demand remained at peak levels throughout the year.

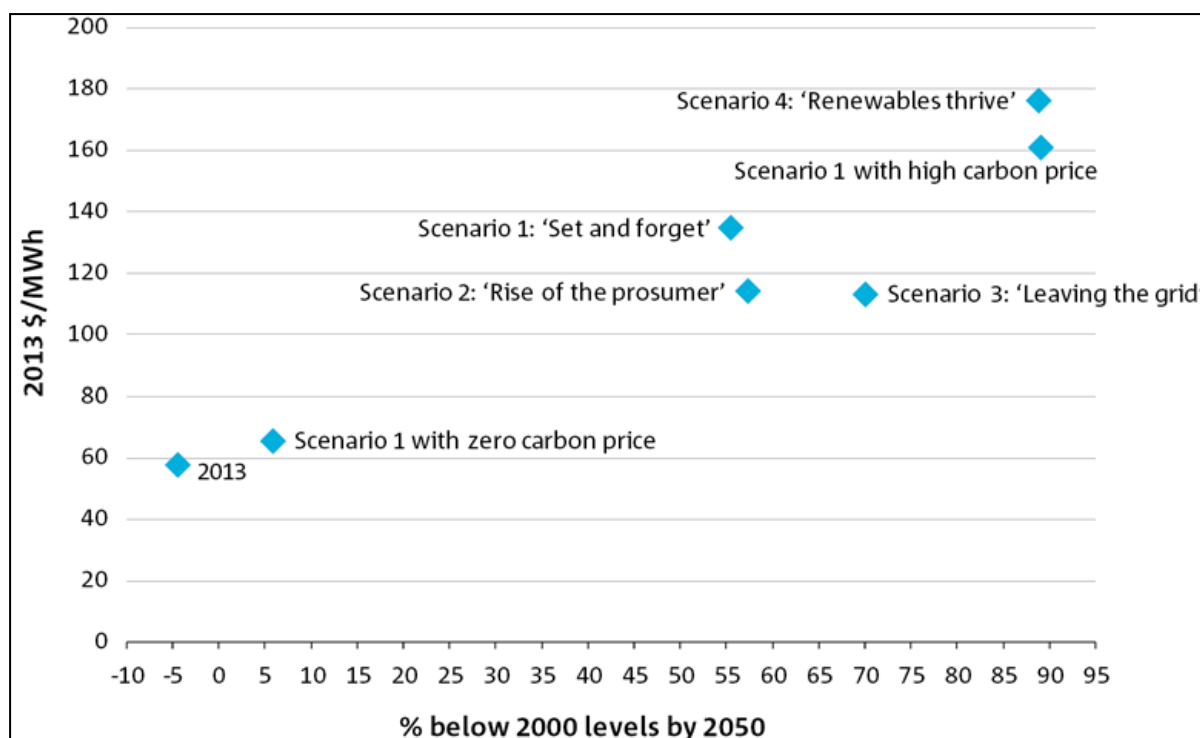


Figure 7: Projected wholesale electricity unit costs by CSIRO (2013) scenario against year 2000 GHG levels

Source: CSIRO (2013, Figure 21, p. 43)

Note: Costs are averaged

From the perspective of an average residential consumer (consuming 6000 kWh/yr in 2013), the least-cost strategy in 2030 is to increase energy efficiency (or reduce consumption). If that is not possible, then the average consumer does slightly better by investing in some level of solar panels for onsite generation. Based on modelled projections, the study states that:

By 2050 ... it is financially preferable for all residential customers to have some type of on-site generation rather than grid-supply only ... over time, circumstances will tend to push customers towards adoption of on-site generation and potentially into disconnection, with the plausibility of this latter step highly depending on costs of storage systems relative to any changes in the cost of network connection.

(CSIRO 2013, p. 46)

The study uses Treasury's assumptions that average real wages will rise by 37% by 2050. The share of an average electricity bill in an average wage is projected to be 2.3–2.9% by 2050, across scenarios. This appears comparable to the current 2.5% share. However, the study noted that negative impacts of climate change on wages growth was not considered by Treasury, leading to an overestimate of real wages growth (CSIRO 2013, p. 46).

The CSIRO study notes that the most vulnerable consumers are single parents, non-home owning pensioners and people in unemployment programs such as Newstart. An average electricity bill currently

comprises 14% of a Newstart recipient's income and 9% of a pension. For pensioners, the projected future income share of electricity ranges between 8% and 10% across scenarios (CSIRO 2013, p. 46).¹²

5.3.1 Implications for energy providers

All four electricity system futures imply some type of transformation for energy providers. Table 3 of the Future Grid Forum report shows plausible changes to energy providers classified into segments such as retailer, distribution, transmission, generation and transmission system operators, energy service companies, metering services, generators, storage technology providers and electric vehicle providers (CSIRO 2013, p. 60).

Scenario 3 (Leaving the Grid) contains the largest amount of change for supply chain actors. However, even modest changes to Australia's future energy landscape under Scenario 1 (Set and Forget), result in substantial or vast changes to coal- and gas-fired generators, with gas-fired expanding in place of coal.

How relevant are the Future Grid Forum scenarios and projections for consumers and providers in remote Australia?

Where are the greatest opportunities to improve energy efficiency?

Can current off-grid households in remote Australia provide insights for future energy development across the country?

The Future Grid Forum reports provide much interesting discussion and scenario analysis, but are also not straightforward to interpret.¹³ The Forum did not explore uncertainty in economic growth, and uncertainty in carbon and natural gas prices is explored as a quantitative sensitivity run against Scenario 1. With respect to economic growth, organisers of the Forum noted that 'the biggest news in the electricity sector of the last five years is that electricity demand and economic growth have de-linked ... no one in the electricity sector believes economic growth is a major driver any more' (Graham P [Research Engineer, CSIRO Energy Flagship] 2014, pers. comm., April 3). In 2013–14, on the National Electricity Market (NEM)¹⁴, total electricity consumed was 194 terawatt-hours (TWh), a decline of approximately 8% from levels in 2008–09 (AER [Australian Energy Regulator] 2014a). By contrast, during the same period, total electricity generation in the Northern Territory and WA *increased* by 4.4% (Bureau of Resources and Energy Economics [BREE] 2014). Countering the argument that economic growth has de-coupled from electricity demand growth, Northern Territory's Power and Water Corporation (2014, p. 25) finds a very high historical correlation between gross state product and electricity demand.

Other commentators point to the importance of peak electricity demand. Planned supply-side expansion to meet peak demand under a centralised grid system drives up costs. Peak demand in the NEM declined 6% between 2008–09 and 2013–14 (AER 2014b). One energy regulator attributed the slowdown in growth of peak demand to a lack of extreme hot days in the recent time series as opposed to a permanent de-linking (Grattan Institute 2012).

¹² In three out of four scenarios, the share of electricity bill as a percentage of customer income declines or is unchanged (Scenarios 1, 3, 4). However, the absolute electricity bill increases in all scenarios (CSIRO 2013, Figure 24, p. 45).

¹³ Translating between qualitative storylines and models requires many specific quantitative choices to be made.

¹⁴ A wholesale spot market that serves South Australian and the eastern Australian states and territories (but does not include onsite generation or generation in Western Australia or the Northern Territory).

5.4 Visions compared to alternative futures

Table 8 provides a preliminary and general assessment of the degree to which some of the visions introduced above (Section 4) can be achieved under alternative national future conditions. The analysis is preliminary because the scenarios created by MMA & Strategis (2009) left most social and economic details unelaborated, including the future of grassroots innovation. Also, the prospects for grassroots innovation will differ between different types of communities and sub-regions.

Table 8: Likelihood of achieving a particular vision in different national futures

Vision	Scenario 1 (Fast rate of change)	Scenario 2 (An uncertain world)	Scenario 3 (A decentralised world)	Scenario 4 (Oil shock and adaptation)	Scenario 5 (Slow rate of change)
ALEC (100% of electricity in Alice Springs generated from clean, renewable resources)	Likely	Highly unlikely	Likely	Unlikely	Highly unlikely
Zero Carbon Australia (100% RE by 2020)	Possible	Highly unlikely	Likely	Unlikely	Highly unlikely
Business as Usual	Unlikely	Possible	Unlikely	Unlikely	Possible
New economics (grassroots innovation maintains liveability)	Possible, with significant challenges				

Source: Authors

5.5 A scenario framework for housing futures in remote Australia

The scenario studies reviewed above did not consider energy efficiency standards as an uncertain adaptation policy relevant to remote Australia. In this section, we use a similar scenario methodology to generate alternative scenarios that explore innovation around housing design, focusing on residential thermal comfort in Alice Springs. We then briefly compare these local-level housing scenarios to the national energy scenario by MMA & Strategis (2009). To the best of our knowledge this kind of analysis has not been done before.

5.5.1 Background

According to survey data by BRANZ Ltd (2007), Alice Springs had approximately 14,000 dwellings in 2002. The typical dwelling then had a floor area of 135 m², is timber-framed, air-conditioned, and either timber- or brick-clad. Just under half (42%) of dwellings had some ceiling insulation; just over a third had wall insulation.

The annual heating and cooling requirements per square metre depend on a number of factors, including climate zone; assumed thermal comfort standards, which are translated into heating and cooling thermostat settings; building orientation; and building design variables, such as the materials used in the building fabric (roof, floors, external walls, thermal insulation), window glazing, building sealing, use of natural ventilation and other ('passive') heating and cooling strategies, and appliances that affect thermal performance (such as lights and exhaust fans) (Northern Territory Government 2010, Wang et al. 2010).

Building energy efficiency in Australia is typically communicated as a particular value on a scale from 0 to 10 stars on the Nationwide House Energy Rating Scheme (NatHERS). A value of 10 stars indicates that

the building requires very little additional energy to heat or cool it, whereas a value of 0 stars indicates that the building shell does ‘practically nothing’ to reduce the discomfort of hot or cold weather (NatHERS 2010a).

Figure 8 shows how star values correspond to a range of climate-specific MJ/m²/per year values. The existing housing stock in Australia has average rating of 2 stars (Wang et al. 2010). For each climate zone, the Building Code of Australia specifies in detail what building solutions comply with a particular energy efficiency standard. Builders can either follow the ‘deemed to satisfy’ provisions, or provide alternative evidence of performance.

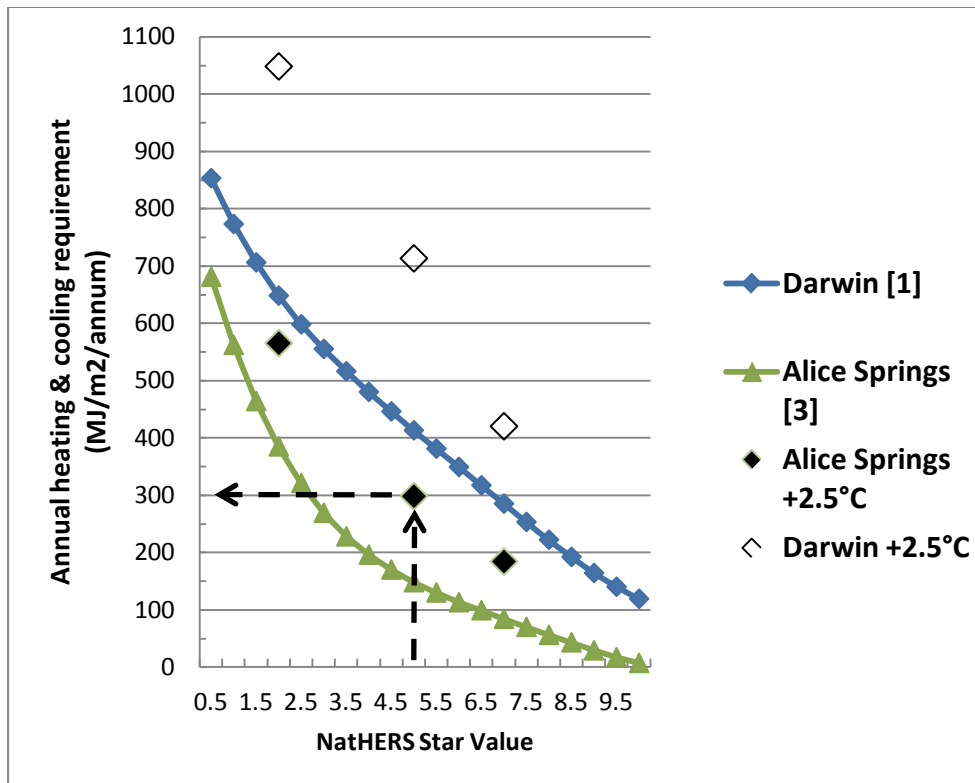


Figure 8: Annual heating and cooling requirements corresponding to Australian house energy ratings by city and climate zone

Source: Authors, based on NatHERS (2010b) and Wang et al. (2010) for +2.5°C.

Note: Arrows show how increased cooling requirements under average temperature increase of 2.5°C will downgrade the energy efficiency of a house that currently achieves a 5-star rating. Number in brackets refers to NatHERS climate zone.

As modelled by Wang et al. (2010) a 2-star house in Alice Springs consumes a total 373 MJ/m²/yr, of which more than 70% goes towards cooling. (These results assume a cooling thermostat setting of 26.5°C). In 2010, the NT Government increased the standard for new homes to 5 stars. A 5-star house in Alice Springs consumes 143 MJ/m²/yr, of which 82% is for cooling (Figure 9; Wang et al. 2010, Table 5, p. 1672).

However, in 2050, with average temperatures expected to increase by 2–2.5°C, depending on assumed global emissions scenario, the 5-star house will require an *additional* approximately 150 MJ/m²/yr of useful energy to cool and heat it to the same standard (Figure 8, dashed arrow; Wang et al. 2010, Figure

11, p. 1675.¹⁵ Table 9 shows the estimated total cost of providing this energy, per square metre, assuming this energy is provided by an efficient 7-star (appliance rating) reverse cycle air-conditioner. The value in bold (\$6.70/m²/yr) incorporates effects of increased energy requirement *and* increased tariffs.

Table 9: Annual cost of cooling and heating energy per square metre, 5-star house, Alice Springs, 2013 vs. 2050

			Assumed tariff (c/kWh) (2013 dollars)		
Useful energy required		Appliance Energy Efficiency Ratio (EER)	Electricity required (kWh/m ² /yr)	27.13 (year 2013)	49*† (year 2050)
Year	MJ/m ² /yr			Electricity bill (\$/m ² /yr)	
2013	143	5.95 [†]	7.0	1.81	3.27
2050	293	5.95	13.7	3.71	6.70

Source: Authors.

Notes:

* Based on cooling EER of Daikin model FTXZ25N (E3 Equipment Energy Efficiency 2013)

† Based on CSIRO, 48–50 c/kWh in 2050 (2013, Figure 22, p. 44).

Additional modelling could be done to explore technologies such as evaporative cooling or solar thermal-assisted cooling. For Darwin, the anticipated impacts of climate change are even more severe: a 5-star house in Darwin performs at 1.5-star level or worse by 2050. An apartment built at 3.5-star level is expected to perform at approximately 0.5-star level by 2050. In order to perform at 5-star level in 2050, a house built today would need to achieve approximately an 8-star rating.

Once long-term, life-cycle costs and benefits are taken into account, the existing housing regime appears inadequate. For example, analysis for a cool temperate climate such as Melbourne shows that investing in high efficiency (8 star) homes yields net positive present values (a measure of benefit to cost) compared to a 5-star baseline (Morrissey and Horne 2011, Morrissey et al. 2013). This finding holds across a range of future energy prices and discount rates. We would expect that investing in 8-star homes in central Australia would provide similar net benefits. Moreover, the analysis by Morrissey et al. (2013) did not include increased cooling loads resulting from a warming climate. Once climate change is taken into account, net present values would increase beyond those reported by Morrissey et al. (2013).

Between now and 2050, will the standards specified in building codes tighten to maintain energy expenditures at today’s levels despite a warmer climate?

Will householders consume approximately twice the energy to maintain a 26.5°C standard, or will they adapt their comfort standards and practices – spending more time in shaded outdoors areas or community cooling centres?

What about the larger socio-economic context? Is the regional economy growing moderately or only minimally? What happens to affordability of electricity, gas, petrol and water?

¹⁵ The IPCC ‘A1B’ scenario results in a average 2°C increase in Alice Springs; the ‘A1F1’ scenario in an average 2.5°C increase. In the warmer climate of 2050, the 5-star house in Alice Springs actually performs no better than a 3.5 star house in today’s climate (Figure 8; Wang et al. 2010, Table 7, p. 1679).

5.5.2 Scenario framework

In order to explore how the above socio-technical uncertainties play out in alternative future worlds, we create a simple scenario framework, drawing on the driving forces shown in Figure 6. We develop brief storylines consistent with it. The framework consists of underlying trends (higher energy prices and warmer climate) and three drivers whose future values are uncertain: economic growth, policy commitment and grassroots innovation.

In this framework, ‘policy commitment’ refers to the level of support for climate-adapted housing design as expressed in various rules (legislation, regulations, standards) as well as financial incentives associated with such policies. ‘Grassroots innovation’ refers to solutions organised not through commercial markets or government, but through bottom-up community-based initiatives. As defined above, grassroots innovation requires particular social values, which may include localisation (increased self-reliance), community building, and environmental sustainability (e.g. through reduced carbon and water consumption).

5.5.3 Storylines

In 2050, houses built in 2000 are 50 years old, reaching the end of their physical lifetime. How they get renovated or rebuilt varies by scenario. A total of eight scenarios are possible (Figure 9). In this framework, values such as ‘high’, ‘low’ and ‘moderate’ describe conditions in Alice Springs in the year 2050.

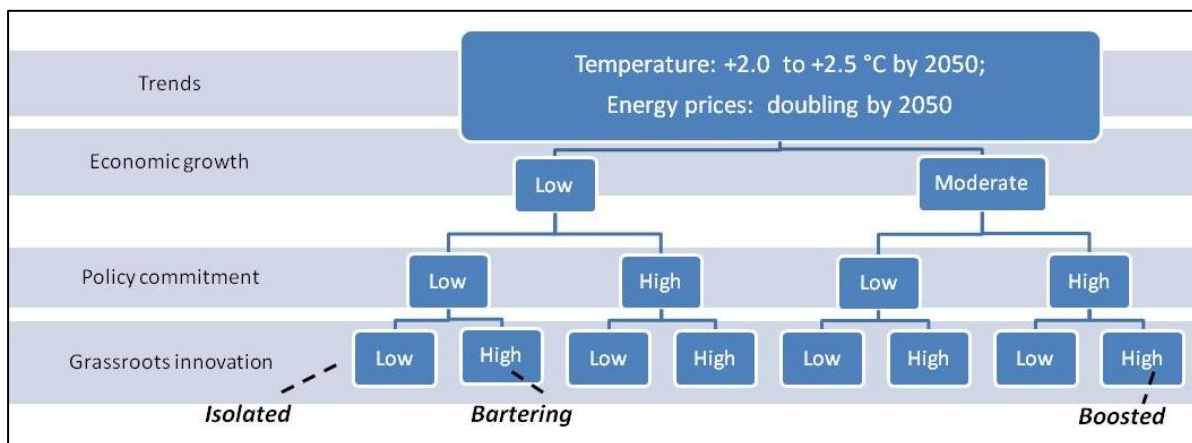


Figure 9: A scenario framework for housing design futures

Source: Authors.

Notes: energy price increases based on CSIRO (2013).¹⁶

To visualise three possible scenarios:

(1) Isolated represents a future world in which economic growth is slow, grassroots innovation is low and policy commitment to climate-adapted housing is also low. In this future world, imagine that ‘low’ policy commitment means that all new or renovated houses in 2050 must attain an energy efficiency rating that is equivalent to 7 stars in 2010 terms (84 MJ/m²/yr; NatHERS 2010b). In today’s climate, such a rating might be achieved by installing R2.0 insulation to external wall cavities, R4.0 insulation to the ceiling, R1.5

¹⁶ In 2012, the average household regulated tariff was approximately 25 c/kWh (2013 AUD). In the CSIRO (2013) scenarios, this increases to approximately 30 c/kWh in 2030 and 48–50 c/kWh in 2050 (CSIRO 2013, Figure 22, p. 44); the precise increase depends on assumptions about self-generation. In some scenarios, the assumed 37% in real wages is not enough to offset increases in electricity bills (CSIRO 2013, p. 46).

insulation to the floor edges and weather strips or seals to windows (Wang et al. 2010, Table 4, p. 1671). However, in the 2.5°C warmer climate of 2050, such houses require an *additional* approximately 100 MJ/m²/yr for annual heating and cooling (Wang et al. 2010, Figure 11, p. 1675), making their total consumption (182 MJ/m²/yr) equivalent to the performance of a 4–4.5 star house today (Figure 8).

Low grassroots innovation means that few people have the knowledge and networks to access alternative housing designs that may be more affordable and comfortable. Energy costs have increased as a proportion of their household expenses. The slow economy means little competition in the local home building industry. Builders continue to provide houses that are relatively expensive, often poorly constructed, and that require air conditioning. Lack of support for expanded community cooling facilities puts pressure on existing libraries, swimming pools, shopping centres and similar. Social conflicts and tensions are managed with a reactive law-and-order approach, and the town's public image is poor.

(2) Bartering, by contrast, presents a scenario in which people have come together out of frustration with the conventional economy and the housing industry to develop their own low-tech solutions and associated social innovations. In 2050, several hundred houses are built with rammed earth and used tires, and other alternative designs and materials exist. People pool their labour to get houses built.

Some of the residences built follow a co-housing model, which features common kitchen and laundry facilities, as well as garden space. The houses built are not always compliant with building codes and Council regulations, but the poor economy means that the will to enforce such regulations varies according to the government in office. Lack of policy commitment, however, means that private and public housing tenants continue to suffer thermal stress. The interiors of conventional homes are frequently uninhabitable for low-income tenants, putting a premium on shaded outdoors spaces. Social tensions are similar to the **Isolated** scenario.

(3) Boosted is a 2050 world with a stronger economy, clear policy commitment and grassroots innovation. New houses must meet or exceed an energy efficiency rating that is equivalent to 10 stars (in today's terms). The NT Government supports a sophisticated home energy audit service and offers a generous rebate scheme for energy efficiency renovations based on audit recommendations. It offers zero interest loans that are repaid through consumer power bills or employee direct debit arrangements. High grassroots innovation and policy support for such innovation means that two new residential estates have even been developed with no centrally supplied power utilities (compare to Earthship, Table 1 above). Houses in these estates are designed to use passive heating and cooling principles and generate all of their power requirements using solar PV panels. Notwithstanding the above social and technical changes, however, everyday life presents many challenges for people unable to access the services provided by housing innovation networks.

5.5.4 Relation to national-level energy scenarios

Building codes and climate adaptation policy were not explicitly considered by MMA & Strategis (2009). In three of their five scenarios, however, the outlook appears favourable for climate-adapted building design (Scenarios 1, 3, 4). Users face strong incentives to reduce their energy bills as a result of global and domestic emissions targets. In addition, in those three scenarios user attitudes are assumed to be progressive: social attitudes favour investment in distributed generation systems and active engagement in lower carbon emissions.

In the remaining two scenarios by MMA & Strategis (2009), the outlook for climate-adapted building design and grassroots innovation is less favourable. In Scenario 2, despite high economic growth, both social attitudes and the policy stance towards investment in new technologies (such as geothermal) are

imagined to be conservative. Consumerism offsets improvements in energy efficiency. In Scenario 5, economic growth is low, energy prices are not high, and consumers worry more about job security than investing in distributed technologies or demand management.

5.6 Framework to explore potential changes in local economies and household budgets across remote Australia

This section discusses how existing data, including trends of particular indicators across space, could be used to provide quantitative support to the energy-related scenarios that have been introduced above. Different methods exist to model the economic dynamics of regions or nations: input–output tables and general or partial equilibrium models are common ways to model economic activity. However, because this project considers energy futures for remote Australia, it is possible to move from standard regional economic modelling approaches to a practical framework that could be used in the group meetings and workshops. This section elaborates on a modelling exercise proposed (see Appendix A for additional details).

Fuel is the primary type of energy expenditure; for people with access to a private motorised vehicle it represents more than a third of their transport costs (Spandonide 2014). Fuel costs represent 3–7% of individuals' annual income in remote Australia and up to 10% in very remote communities. Increasing fuel prices would further limit the use and potentially reduce the safety¹⁷ of private motorised vehicles in a context of increased transport demands and isolate community members from employment opportunities and socio-cultural activities.

In current conditions, very few alternatives exist. In Central Australia public transport systems consist of a few local urban buses and the Centre Bush Bus, and there is a small amount of non-motorised transport systems (walking, cycling) in large remote communities such as Alice Springs. A potential increase in petrol prices could be addressed by promoting the use of more fuel efficient and appropriate vehicles, providing more appropriate infrastructure, developing existing public transport systems, designing new forms of community transport and optimising transport systems within integrated regional and urban planning (Booz & Company 2011, Litman 2012).

5.6.1 Household component

As noted by ABS (2013a), fossil fuel consumption encompasses the largest part of all energy consumption and expenditures made by Australian households. Given this fact, the variation of petrol prices across the country is a key indicator to understand what budget allocation households across remote areas make for vehicle fuel consumption, compared to non-remote households. Using a household expenditure allocation model framework, we propose to use petrol prices over time to establish how different energy scenarios (to be translated into fuel prices) can affect household budgets (welfare in terms of disposable income) across remote areas of the country, compared to households in non-remote areas.

Household consumption of electricity and gas will also be included (dwelling energy costs). Although diesel generators are the main source of electricity in the case of very small communities, most electricity in remote Australian towns is fuelled by natural gas (BREE 2013). Given the current market conditions, it has been projected that natural gas costs will rise significantly in the coming decades. In addition, only 2% of all off-grid electricity supplied in Australia comes from renewable sources, compared to around 10% for electricity supplied in the national energy market (BREE 2013). These are further important facts to

¹⁷ As a result of increased passenger loading per vehicle.

consider when addressing energy futures for remote households and will be linked in the dwelling energy component of the household expenditure allocation model (see Appendix A, Figure A 1).

The model considers an initial baseline to be estimated from real data and will assume at least two different future trajectories of households' income growth across space (cf. Figure A 1). From this baseline and assumed income trajectories, the model can provide data for comparing remote to non-remote households in terms of budget shares for energy (fuel for vehicles and dwelling energy), for each of the different energy futures to be analysed in the project. Other components of the model could be estimated and projected differently, to check robustness of results.

What would happen to the viability of particular settlements if fossil fuel prices double?

What happens to the budget of remote households, compared with city households, if, under current conditions, fossil fuel prices double?

What would happen to electricity bills – and their weight on household's budgets – if the natural gas price keeps rising?

5.6.2 Industry component

Industry in remote Australia is an important consumer of fuel and electricity. Agriculture and livestock are heavily dependent on fuel prices given that they involve large movements of inputs and outputs. Thus petrol prices strongly influence the profitability of businesses in these industries (Queensland Department of Transport and Main Roads 2013). It is possible to construct employment indicators across regions to describe how important are the different industries in remote areas of the country, compared to non-remote areas. It is also possible to elaborate an energy dependency index for the different industries with presence in remote Australia in order to contribute to the discussion of the potential effects of energy futures in local economies.

Particular attention could be placed on the mining industry given its relevance for the energy futures discussion: the industry consumes around 70% of all electricity used in remote areas (BREE 2013).

To what extent are future energy prices important for the productivity, profitability and employability of the mining, agriculture and livestock industries in remote Australia?

Is the mining industry promoting innovative practices for generation and consumption of energy in remote areas?

Electricity and transportation systems influence productivity and the attractiveness of primary industries to employees. The transportation of goods is heavily reliant on transport technologies and fuel costs, while efficient and safe transportation corridors help retain and attract appropriate staff. Enhanced multi-modal transport systems and platforms could increase the productivity of primary industries by optimising the use of existing transport systems (PricewaterhouseCoopers 2013, Rodrigue & Slack 2013).

6. Conclusion

This paper focused on scenarios (sets of plausible storylines for how the future may unfold) and visions (outcomes that people value), and the relation between them. The energy-related futures studies reviewed from Australia provide valuable content, but – from the perspective of participatory policy development – also have limitations. They do not cover the Northern Territory or any other remote energy-provisioning system. They do not elaborate on the questions of how and through whom change and innovation occurs (which are questions of social and political agency). The technically focused futures analyses are likewise silent on questions of liveability (what is it like to live in alternate energy futures?) which require exploration of values, meanings and experiences (cf. Foran et al. 2013) and specific attention to how remote areas function.

We introduced the project's purpose and associated research questions, which revolve around the possibilities for more innovative practices at various points in energy-related systems of provisioning. We introduced the concepts and methods we propose to address those questions.

To demonstrate that a more holistic analysis is possible, we briefly elaborated three energy-related scenarios that deal with housing and innovation, in a manner more accessible to generalists.

If the future is uncertain, a strong economy, progressive social attitudes and policy support cannot be guaranteed. What particular policies and innovations should be promoted as no-regrets strategies, regardless of what the future holds? What policies and innovative practices may create new synergies or desired development dynamics?

These questions lie at the heart of the project. They deserve to be answered through participatory research. In May 2014, we organised two workshops in Alice Springs, during which those questions were initially discussed and debated (Foran et al. 2014).

Appendix A: Household expenditure allocation model for workshop interaction

The household expenditure allocation model considers seven main components as described in Figure A 1. Among the components, energy is subdivided into fuel for vehicles and dwelling energy. The idea of this modelling exercise is to estimate how different energy scenarios, translated into different energy prices, could affect households in remote areas compared to households in cities or big regional towns.

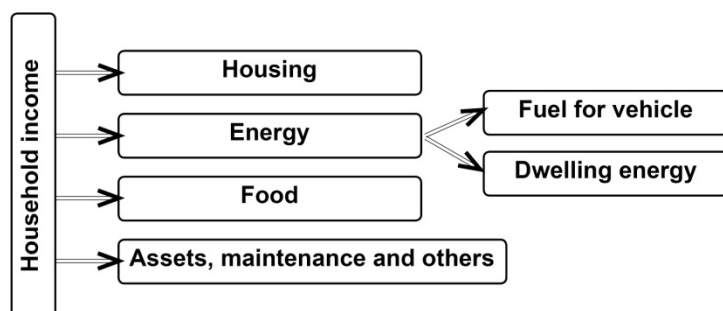


Figure A 1: Components of household expenditure allocation model

The first step to formulate the expenditure allocation model is to estimate the expenditure share on energy from available income based on real data. Table A 1 shows household income across regions and the approximate expenditure of households on housing costs and energy. The table reports the average value for Statistical Local Areas (SLAs) across five different remoteness categories defined by the Australian Bureau of Statistics. The location of these remoteness categories can be seen in Figure 1.

The average share of energy expenditure in 2011 for the total budget of households across the country went from approximately 6.6% in cities to around 10% in outer regional, remote and very remote areas. It is important to mention here that these values are preliminary. A more detailed decomposition can be made by estimating household energy expenditure (fuel and dwelling energy expenditure) across remoteness categories and towns such as Alice Springs from the micro data of the Household Energy Consumption Survey (ABS 2013a).

From the estimated baseline (respective energy expenditure shares across households), we can construct energy scenarios, informed by the kind of scenario framework we developed in Section 5.5. We can translate alternative storylines into energy prices to see how different average households across the country are likely to be affected in their budgets.

The energy scenarios can be analysed considering three different trajectories for household incomes: income growth across remote households will either be lower, higher or similar than income growth in households of city areas. The model can also consider potential changes in housing costs (reference values are also provided in Table A 1), food, water and other expenditures.

In regards to the industry part of the analysis, we can provide a detailed description of industry presence across space. In particular, we can provide information in terms of employment numbers for different industries across space and an index of energy dependency of the different industries in order to contribute to the discussion of how different energy scenarios could affect industry activity, and consequently employment, across remote areas.

Table A 1: Selected household income and expenditure indicators by SLAs across five remoteness categories of the ABS and Alice Springs

	Cities (n=581)	Inner Regional (n=260)	Outer Regional (n=306)	Remote (n=96)	Very Remote (VR) (n=107)	Alice Springs (n=5)	Difference: Cities – VR
Household median income	1518.21	1107.06	1048.65	1083.67	1138.83	1524.80	379.38
Housing costs: median mortgage payments (dollars per month)	2009.28	1505.22	1341.10	1057.93	875.27	1928.40	1134.01
Housing costs: median rent	338.01	233.18	196.00	118.50	84.49	273.00	253.52
2011 Average petrol price (cents per litre) [*]	140.66	142.43	144.47	144.37	152.72	161.58	-12.07
2001 Average petrol price (cents per litre) [*]	86.87	91.58	93.15	98.83	98.52	107.01	-11.65
2011 Approximate expenditure on petrol [†]	59.85	60.61	71.27	71.22	75.34	79.71	-15.49
2001 Approximate expenditure on petrol [†]	36.97	38.97	45.96	48.76	48.61	52.79	-11.64
2012 dwelling energy expenditure [‡]	39.00	39.00	38.33	38.33	38.33	37.00	0.67
Percentage of household income spent on energy	6.51	9.00	10.45	10.11	9.98	7.65	-3.47

Source: Authors, based on data from ABS (2013a), ABS (2013b) and AAA (2013).

Notes: All values are weekly Australian nominal dollars, unless otherwise stated. Household income and housing costs correspond to average of SLA (statistical local area) data. Parentheses in first row show the number of SLAs over the respective sample.

^{*} Prices are year averages of monthly average prices provided by AAA (2013). The City category considers values of the average prices in the five largest cities in Australia. Inner regional considers the price in Canberra. Outer regional values are the average prices in Port Pirie (SA), Albany (WA), Cairns (Qld) and Burnie (Tas). Remote values are the average prices in Port Lincoln (SA) and Katherine (NT). Very Remote values are the average prices in Kalgoorlie (WA), Ceduna (SA), Carnarvon (WA), Tennant Creek (NT), Charters Towers (Qld) and Longreach (Qld). Prices in Alice Springs correspond to the actual data.

[†] Expenditure estimates considering an average use of 43 litres of petrol per week in the average household in the City and Inner Regional categories and 48.7 litres per week in the average household of the remainder categories. Litres of petrol are own estimations obtained from data provided in ABS (2013a).

[‡] Values obtained from dwelling energy expenditure in households across climate zones described in ABS (2013a). City and Inner Regional prices correspond to the average of zones 2, 5, 6 and 7. Outer Regional, Remote and Very Remote are averages of household energy costs in zones 1, 3 and 4. Alice Springs value is the average expenditure in zone 3.

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PARTNERS IN THE CRC FOR REMOTE ECONOMIC PARTICIPATION

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