Article

ELRR

The Economic and
Labour Relations Review
2017, Vol. 28(1) 57–76

DOI: 10.1177/1035304617694826
journals.sagepub.com/home/elrr
SAGE

A national strategy for a low-carbon economy: The contribution of regional development planning

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Abstract

Planning for a low-carbon future in Australia will need to address simultaneously three aspects of sustainable development: centralisation/regional development, mobility and communication. After reviewing existing roadmaps for low-carbon growth by 2050, the article identifies the importance for Australia of an integrated and mutually reinforcing set of measures, based on a bold approach to urban and regional planning. Taking account of national geography, the approach is based on the decentralisation of energy production, use and storage, and on new uses of communication, transport and the location of food, water and mineral resources. Revitalised regional centres could be connected, through new energy and transport solutions, by a national transport arc and electrified highways. The use of infrastructure funding to support low-carbon regional development would avoid the 'tragedy of the commons', transcending incremental, cumulative approaches based on compensation and incentives for household, business and sectoral abatement efforts. It would generate long-term environmentally sustainable development.

JEL Codes: Q16, Q2, Q35, Q42, Q54, R1

Keywords

Carbon emission reduction, carbon neutrality, clean energy production and storage, climate change, global warming, greenhouse gas reduction, infrastructure funding, low-carbon growth, regional development, water resources

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Introduction

This article is a distillation of ideas on the nexus between carbon-based energy demand and environmental sustainability in Australia, written in the context of our commitment to shared targets for mid- and long-term reduction in greenhouse gas emission levels. It takes a step back from existing sector- and timeline-based roadmaps to climate change mitigation and adaptation, by focusing on the terrain through which roads to change must pass. It re-imagines the geography of Australia's economic activity, based on the most sustainable use, storage and development of land, energy, water and mineral resources, and on the integration of this activity into the redesign both of urban and regional centres, and of the transport and communication links among them.

We have now reached the point where we must review our behaviour and the way we conduct our relationships with one another. Australians have entered an agreement with our world to reduce the level of CO_2 production which, at present levels, threatens the sustainability of life as we know it. We are bound to review our behaviour, since Australia's ratification of the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC) (2016a) came into effect on 9 December 2016.

To date, Australia has committed to a 2020 target of reducing emissions by 5% below 2000 levels, and a 2030 target of a 26%–28% reduction below 2005 levels (Australian Government, Department of the Environment and Energy, 2017a). By 2020, each party to the Paris Agreement is expected to produce a roadmap of actions to be undertaken by 2050 in order to achieve significant carbon footprint reductions (UNFCCC, 2016b).

A wide spectrum of Australian scientists, governments at all levels, think tanks and community activists has been involved in research, innovation and policy-making to contribute to a roadmap to greenhouse emissions reduction.[1] The present article 'zooms out' to a re-imagining of the geography within which expert- and community-based sectoral approaches can be applied in a national planning and development approach. For example, how can emerging battery storage technology support the electrification of rail and road infrastructure that would link regional centres supporting optimal land, mineral and water use? How can the outcomes of ongoing specialist technical and policy work be applied and coordinated in a long-term land and resource planning approach in order to avert the 'tragedy of the commons' – the adverse impact of sectoral interests on national and global resource sustainability?

The next section outlines the context of approaches to sustainable development following the Paris Agreement. Section 'Scenario planning and roadmaps' briefly reviews literature on criteria for an adequate roadmap, and overviews some roadmaps to 2050 already developed by other nations. It argues that a national plan must consist of more than the simple aggregation of sectional and sectoral abatement strategies. Section 'Statement of the problem' outlines the terrain which an effective Australian roadmap will need to traverse, articulating the essential features of a coordinated and integrated approach to sustainable regionally based national development. Section 'Proposed elements of an integrated Australian plan' then maps elements of a land and environment planning approach that could underpin the details of an Australian deep decarbonisation plan, indicating how this comprehensive approach could amplify the benefits of achievable and mutually reinforcing strategies on energy, building, transport, land and mineral

https://doi.org/10.1177/1035304617694826 Published online by Cambridge University Press

resource use (including water), and travel/communication. The article concludes that a re-imagining of the geographical terrain as a whole, as well as of the sectoral components of the roadmap within it, may save Australians from ourselves and help sustain our planet.

Context

The Paris Agreement came into force on 4 November 2016, and Australia ratified it in time for full participation in the November 2016 Marrakech implementation conference of parties (COP22). This conference set common mid-term decarbonisation goals, as well as encouraging parties to lodge long-term strategies, supported by a 2050 Pathway Platform for governments, cities, states and companies to help all countries develop mitigation and adaptation strategies. The Marrakech meeting noted that Canada, the US and Australia were already behind in meeting their 2020 targets (UNFCCC, 2016b).

The Australian government has launched a review of climate change policies in 2017 (Australian Government, Department of the Environment and Energy, 2017b). The terms of reference of this review include the opportunities and challenges of reducing emissions on a sector-by-sector basis; the impact of policies on jobs, investment, trade competitiveness, households and regional Australia; the integration of climate change and energy policy, including the relationship between state-based and national approaches,; and potential long-term emissions reduction goals post 2030. It will be important for the review to build a political and policy consensus around a roadmap and action plan. Hopefully, it will draw together initiatives by industry state and territory governments (e.g. Australian Capital Territory (ACT) Government Environment, Planning and Sustainable Development Directorate – Environment, 2016; Government of South Australia, Department of State Development, 2017), and the significant work on deep decarbonisation and green infrastructure already undertaken at municipal, community sector and research centre/think tank level (see, for example, Beyond Zero Emissions (BZE), 2016; Climate Works Australia et al., 2014). The Paris Agreement goals have the support of business (Business Council of Australia (BCA), 2016; West and Brereton, 2013) and unions (Australian Council of Trade Unions (ACTU), 2015).

Scenario planning and roadmaps

National-level long-term scenario planning for transition to a low-carbon future is now well-established (Torrie et al., 2013). Deep decarbonisation projects within the UN Sustainable Development Solutions Network have established that significant emissions reductions are technologically and economically feasible. Within this network, Climate Works Australia et al. (2014) applied a multi-regional forecasting model to the electricity, building, transport, industry and agriculture/forestry sectors, and modelled the economic impacts of one illustrative transition pathway to indicate that while 'strong' action is needed, economic growth can be uncoupled from CO_2 emission increases (p. 16).

By January 2017, five major emitters (the US, Mexico, Canada, France and Germany) and one climate change vulnerable nation, Benin, had submitted strategies or work plans for low-carbon growth by 2050 (UNFCCC, 2016b). Although national support for the US Mid-Century plan is in doubt following the 2016 presidential election outcome, it

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sets out multiple pathways to a reduction of −80% in greenhouse gas emissions by 2050, and provides cost pathway scenarios to demonstrate that the narrower the base of decarbonisation, the more costly it will be (White House, 2016). The Mexican Mid-Century Climate Change Strategy sets a 2050 emission reduction goal of −50% on 2005 levels. It defines 10-, 20- and 40-year milestones, and ways of addressing 'critical cross-cutting issues' across five action areas including energy production and consumption, sustainable cities, pollutant reductions and sustainable agriculture (Ministry of Environment and Natural Resources (SEMARNAT) and National Institute of Ecology and Climate Change (INECC), 2016). Canada's Mid-Century plan commits to a 2050 greenhouse gas emission reduction goal of −80% on 2005 and is based on decentralised regionally and sectorally based mitigation action (Canada, Environment and Climate Change Canada, 2016). The French plan commits to 75% reduction from 1990 levels by 2050. It outlines detailed and sector-differentiated milestones and targets in the areas of transport, building, agriculture/forestry, industry, energy and waste (France, Ministry of Ecology, Sustainable Development and Energy, 2016). Germany's Climate Action Plan has a long-term target of emission reductions of −80% to 95% on 1990 levels. It is derived from a process of consultation with community groups, local governments and Länder, and sets an interim target for 2030 (Germany, Federal Ministry for the Environment, Natural Conservation, Building and Nuclear Safety, 2016).

While these national roadmaps are based on different levels of policy centralisation, they all rely on aggregating existing regional and sectoral initiatives. This detailed approach is important, but it is also important to consider a more integrated and thoroughgoing reframing of national policy. McGrail (2015) provides a review of sectional roadmaps developed in Australia. These have been produced variously by peak industry bodies, academic and non-profit research groups, and private consultancies. McGrail expresses concern that divergent pathway proposals, reflecting competing value-judgements and agendas – particularly for the built environment – may compete for resources. He argues the need for greater attention to attitudinal and behavioural change, in line with research on geographies of urban transition, and calls for greater coordination and collaboration in setting priorities. The following analysis seeks to start a conversation that may, in the end, foster such a fundamental re-thinking of Australian resource planning.

Statement of the problem

For Australians to get our own house in order is no simple task, if only because within our own 'house', there are significant differences between 'household members' in their production of CO_2 and in the way the costs or burdens of its production are borne. We nonetheless must attempt to construct an appropriate plan to reduce the production of CO_2 and produce a calculus of its burden.

For a century, Australians have tried to meet our demand for a reliable supply of energy to develop our cities and pursue a rich variety of activities in them. From some perspectives, we have been successful in doing so. We are now, however, confronted by the paradox that our 'success' comes at an unacceptable cost. We have relied on the consumption of coal, oil (petroleum) and gas to secure a reliable supply of 'clean' energy to transform the materials needed to construct our cities and to enable us to 'create' the conditions under which we wanted to live.

Planning for a low-carbon future will need to address simultaneously both the challenges to and the opportunities for sustainability within three aspects of 'development':

Centralisation: A feature of the mode of production of energy we have employed is that the energy conversion and supply system has been highly centralised. The economies of scale of the 'production' and distribution of energy have led also to a concentration of political and economic power, making the suppliers of high carbon-based energy important actors in public decision-making.

Mobility: We have relied heavily on petroleum products to develop and sustain reliable supplies of food and secure our health and well-being and to enable us to 'move about' and travel between the settlements in which we live and to engage with others.

Communication: Over the last few decades, we have reshaped the information/communication systems of the nation. One benefit of the development of fast and relatively inexpensive communication is that regional producers and service providers have better information about the demands of the urban populations in cities and regional centres and, indeed, of international markets, and so can frame their responses to those demands in a more timely fashion.

Proposed elements of an integrated Australian plan

An appropriate Australian Plan for a more energy-efficient and fairer Australia would

1. Significantly reduce production of CO_2 to reduce our impact on the global climate system;
2. Increase our energy security;
3. Reduce the cost of electrical power
   a. for domestic purposes,
   b. for regional development of value adding primary production;
4. Increase industry development of modern high-efficiency building materials;
5. Increase efficiency in the development of renewable energy production;
6. Increase the economic security of regional centres;
7. Improve the efficiency of the national freight and passenger transport systems;
8. Provide greater protection for areas of high primary production value;
9. Provide greater protection of environmentally sensitive areas;
10. Lead to greater regionalisation of education and research, which in turn would bolster regional development and security;
11. Lead to better management of waste water flows to reduce their negative impact on the environment.

Decentralised energy resource pooling: Averting the tragedy of the commons

The net effect of our behaviour is that through the consumption of carbon-based energy sources, we have imposed large stresses on the eco-systems we are part of, in which we live and on which we depend. Despite this dependence on these eco-systems, our

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behaviour may yet lead to their collapse, unless we rapidly adopt policies and practices to ameliorate the consequences of our behaviour, or change it. Australia is already in a vulnerable state in that it currently operates with low levels of fossil fuel reserves. It has approximately 3 weeks' 'buffer supply' of petrol and diesel on which to run most of the land-based transport and other fossil fuel dependent activities (less if electricity generating capacity is included). Such short-term supply leaves the nation highly vulnerable – not only in its economy but also its ability to defend itself (Australian Government, 2016; Hale & Twomey Limited, 2012).

There is a high level of variation among different sections of the population in their consumption of 'natural resources', but it is possible to reshape the nature of our demand for energy by pursuing 'renewable' energy sources that have a less damaging impact on the eco-system. In doing so, we need to acknowledge the income- and even wealth-contingent nature of the variation among citizens in their consumption of energy, and develop strategies to ensure that there is a fair sharing of energy resources and the associated burden on the eco-system of which we are all a part.

As we may be confronting a tragedy of the commons of unprecedented scale, many believe that we are obliged to do our utmost to adopt strategies that will reduce the consumption of carbon-based energy that directly increases environmental stress: not to do so will mean an inevitably catastrophic outcome. One opportunity that offers hope lies in the possibility of substituting renewable energy sources which have significantly lower carbon signatures, in the production of materials and transport of people and goods in and between settlements. Fortuitously, individual and household take-up of these technologies also reduces limitations that would otherwise be placed on their activities. One of the most promising strategies is the direct conversion of solar energy to electrical energy.

Figure 1 reveals the speed with which Australian households and some commercial undertakings have 'taken up' investment in solar energy. Over a relatively short period, we have experienced a dramatic increase in the number of households installing solar energy supply systems to meet some of their demand for domestic energy consumption. Some have done so out of concern for the sustainability of the environment, others to reduce their household energy bills. We have also seen local authorities and an appreciable number of commercial undertakings investing in renewable energy systems for similar reasons. The production and installation of new domestic systems is also leading to innovation, with significant increases in the efficiency of energy capture and conversion. The focus on renewable energy has also led to research into ways in which comfort levels for dwellings may be efficiently attained and maintained.

One limitation to wide 'take-up' of solar energy conversion systems has previously been their ability to provide an assured supply of energy throughout the day. The continuing development of the reliability and favourability of battery storage now opens further opportunities for 'domestic', commercial and industrial exploitation of renewable energy (Stock et al., 2015).

In regions with appropriate topography and soil profiles, including some with relatively low natural rainfall, we are able to develop energy storage systems by using cheap solar power to pump water to higher storage ponds that can 'recover' much of the energy expended in the pumping cycle by releasing the stored water to flow through turbines to

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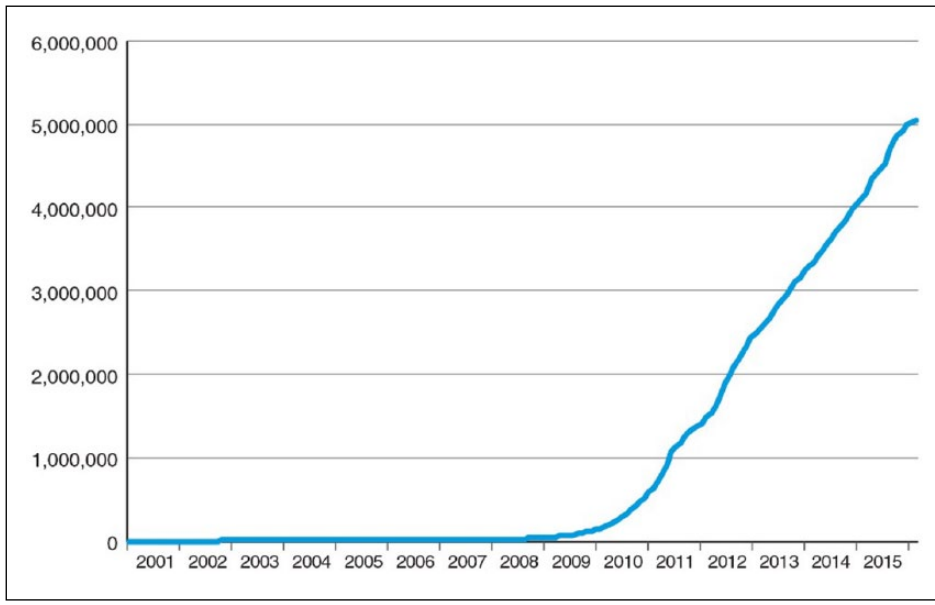

Figure 1. Australian photovoltaic installations since April 2001: total capacity (kW).
Source: Australian Photovoltaic Institute (APVI) (2016a).

provide energy during darker periods to lower level pondage (Forcey and McConnell, 2014).

The incremental 'accidental' decentralisation of solar energy conversion to electrical energy, together with improving technology in energy storage, now offers opportunities for the development of a 'mixed' energy system that is at once more robust, more economically efficient and based on the pooling of resources.

One feature of the emerging system is that it is able to accommodate differing modes and scales of energy production and storage. That is, the adoption of solar energy conversion employing different technologies has meant that the earlier systems of renewable energy collection and storage may continue to produce and store energy in an economically efficient manner. The efficiency of wind turbines (on both vertical and horizontal axes) to generate electrical energy has increased dramatically and they may be a significant source of renewable energy that may be 'stored' (Parkinson, 2013). This enables a system with a significant degree of decentralisation and mixed mode of production to flourish, and allow households and businesses to obtain the economic benefits from their investment.

The flexibility of the emerging regional power centres would enable those who participate in their creation, by 'connecting' their individual domestic solar and/or wind conversion systems, to form the power centres to participate (and benefit) in a manner that is consonant with their own demands and financial abilities and capacities. It may be seen as a 'new' way of developing a collaborative or communal response to the demand for a more environmentally sensitive source of energy. One important benefit would be

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that it would generate increased communal understanding of the imperative need to reduce the pressures on climate change.

Another feature of the present 'social landscape' of the development of solar power is that its benefits are available to individuals, households and businesses who can 'afford' the investment in the necessary UV light panels and/or wind turbines that are not so obviously available to low-income households or tenants, or even to small businesses.

One benefit of the development of community-owned low-carbon footprint regional power centres is that associated with them would be a stronger focus on local community power enabling them to share the benefits of lower cost energy production with their customers – residential and commercial.

Another benefit of the new 'dispersed' form of energy production is that it provides a degree of resilience and security in supply not available in other, more traditional, organisational forms of electrical energy supply which usually depend on large 'central' sources (it must be noted, however, that historically the connection of other 'central' energy suppliers to one another has afforded a high degree of security). The recent challenges to the reliability of the network supplying power to South Australia due to weather extremes and associated high winds were not due to the sources of power but to the failure of the network itself that relied on a single highly elevated power line. The development of more regionally dispersed energy sources connected by lower level, less exposed connections would significantly reduce the risk to networked supplies of extreme weather events.

Thus, new developments in battery technology extend the reliability and resilience of such supplies. The 'dispersed' form of energy production opens possibilities to pursue other changes to the organisation and operation of the nation's cities and towns. It also creates new ways of developing and operating the information and communication infrastructure that is needed to support the social and economic ambitions of society.

Renewable power plants

Renewable power generation plants (wind and solar and possibly hydro or tidal) could be sited in or close to regional centres on the National Transport Arc (Figure 2). This Arc connects the state capitals and intervening regional centres from Townsville, Brisbane, Sydney, Canberra, Melbourne, Adelaide to Perth. Such siting would also provide incentives for the location, in those centres, of new industries manufacturing the modern high performance materials that are needed to build the new generation of high efficiency, low-cost housing. Such housing is needed to redress the current slide into low levels of home ownership.

The development of such local power plants would require a new approach to the management of pooled energy production sources. It would also lead to greater regional economic independence and therefore of regional influence in national public life. The precise form that the 'ownership' of community power plants would take would reflect the level of ownership of the power source. Such ownership might involve new arrangements to ensure that the present attractions of renewable energy ownership were retained. That is, it would be important to retain the strong element of 'self-preservation' and of communal engagement offered by development of the present systems.

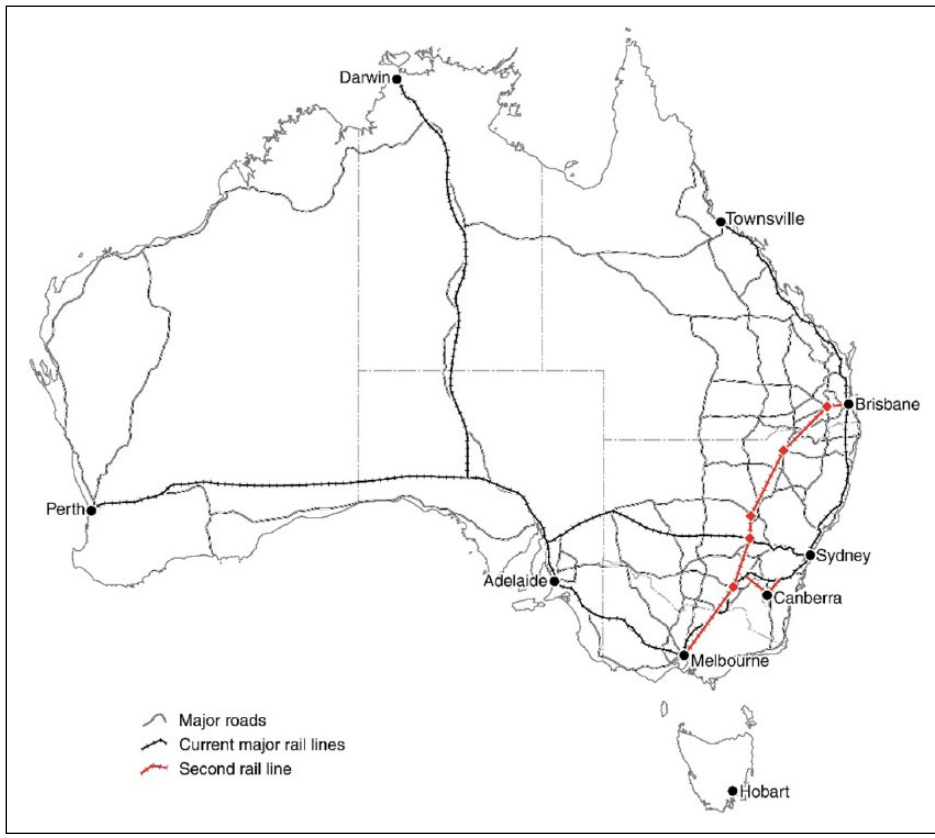

Figure 2. National Transport Arc. (See colour figure online at http://journals.sagepub.com/home/elr).
Source: National Transport Commission (2016).

National transport system

At the time of Federation in 1901, non-Indigenous members of the former Australian colonies had no plan for the development of a national transport system. Existing rail systems reflected the jealousies and narrow visions of the various colonies, with the state rail systems operating on different gauges. It is also important to note that up to that time, the great bulk of interstate transport of goods and people was by sea. One condition set for the siting of the new national capital was that it would be directly connected to Melbourne and Sydney – a condition which has been observed in the breach and increasingly becomes a source of inefficiency and unnecessary environmental stress.

The most ambitious and important initiatives in developing some of the basic elements of a national rail system have now been taken. We now enjoy a standard gauge rail connection between the major centres on our National Transport Arc and have improved the geometry of the main line between Sydney and Melbourne, enabling faster freight and passenger services between them.

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It would be feasible to take the next steps in the development of the national infrastructure by further upgrading the National Transport Arc connecting the state capitals and intervening regional centres from Townsville, Brisbane, Sydney, Goulburn to Canberra to Yass, Melbourne, Adelaide to Perth, with the major cities and regional centres able to handle faster train services for passengers and freight. While it seems clear from a number of studies of the possible development of super high-speed rail that it would be premature to try to introduce *very* high-speed rail services on the National Transport Arc in the short term, the strategic development of the rail network to enable better, faster passenger and freight services between major centres would be feasible and economically desirable.[2]

Upgrading the 'main line' connections between Melbourne–Canberra–Sydney could, within a short period, recast the national transport system. A commitment to the development of national infrastructure development of the Australian Transport Arc would have a number of significant benefits, including encouraging and supporting regional development. That is, commitment, as part of a Commonwealth/State national infrastructure development plan, to the staged development and upgrade of the National Transport Arc would be of undoubted benefit to the productive regional centres. Upgrading the second high-quality north-south rail service in that Arc by connecting regional centres in the more fertile regions west of the Great Divide would also be beneficial.

Additional improvement would be realised as a consequence of improved rail services. For example, we could expect that increasing the speed of direct rail services between the cities and regional centres would lead to fewer people driving or even flying between them, thus also reducing environmental stress. Introducing new technology in freight management would also greatly reduce road and air freight – especially for high value or perishable goods. A further benefit is that passenger rail services would be provided from city centre to city centre.

It may not be essential to adopt immediately the latest very high-speed trains – although that could become a medium term ambition – because many of the benefits sought could be realised by improving the permanent way on the main lines and operating the rail system at speeds appreciably faster than those presently achieved. That is, although we are facing a period of financial stringency, it would be feasible to 'stage construct' and operate an improved National Transport Arc. Although it is important to make no small plans – if only because they have no capacity to capture the public imagination – it is more likely that the community would share in and support the development of a plan of larger imagination, if they could see and experience progress in the development of a modern transport system.

Holding out a promise to develop a high-speed rail network would likely be more strongly supported if individuals and communities could see and experience a revivification of regional economies that was made feasible by development of regional renewable energy power plants. Here, we would need to explore faster rail transport options without necessarily committing to very fast trains to all links in the transport arc.

Encouraging or facilitating the development of regional renewable energy power plants would also facilitate the staged development of an electrified rail transport system on the National Transport Arc.

Electrification of highways

Electric powered buses, trucks and cars are now available and will become increasingly common – we already have buses that can run 500+ km between 'charges' and cars that easily manage 250+ km between charges. Advances in battery storage technology are rapidly changing the 'practical' adoption of electrical powered road vehicles and will increase their 'range'.

The improvement in the transport systems would also be reflected in regional development plans. Improvement of the national passenger and freight rail system would also elevate the importance and development opportunities of the regional centres. The national transport corridors would thus also become baseline electricity supplies. One opportunity this would present would be to strategically locate alternative energy power plants so that they provide energy to the settlements and regional centres on the line of National Transport Arc.

This would not only facilitate the use of such energy to power the rail lines but make it easier strategically to locate 'battery recharge centres' on the major highways to take advantage of, and provide incentives for, households to take up electric powered vehicles, and would provide the facilities for buses and trucks to be also conveniently 'recharged'.

Ecological sustainability

Central to the development of Australia's infrastructure is the determination to proceed in a way that is sustainable – meaning nothing must be done to prejudice the ecological sustainability of the planet.

The regions in Australia that are fertile and from which we derive much of our primary production are limited in extent (Figure 3). Australia has substantial reserves of gas, coal and oil which for the most part overlap, or coincide, with the smaller areas of fertile land from which our food supplies, and indeed a considerable portion of our export income, is derived.

A high premium should be placed on securing the integrity of the areas of high agricultural value. That is, every effort should be made to ensure that primary production in the fertile regions is protected from injury to their water table. The fertile areas should be protected from mining and fracking activities that are detrimental to the pursuit of primary production. Similar efforts would be needed to ensure that those areas where primary production might be compromised by noise and dust problems are similarly protected.

It would be preferable to leave the oil, gas and coal in the ground (Figure 4) to ensure the sustainability of our society, but it is also acknowledged that some exploitation of those resources may be necessary outside the areas of prime agricultural land during a 'conversion' phase of the world economy.

The sustainability of society could be achieved by making a national effort to develop a network of renewable energy 'power stations'. We could not only encourage the take-up of 'distributed' or 'domestic' solar panel sources of renewable energy but also develop local or regional centres that may include a variety of energy sources (domestic solar panels + wind turbines (on vertical or horizontal axes) or, where appropriate, hydro or tidal power capture). It will be obvious from Figure 5 that we, as individuals (households

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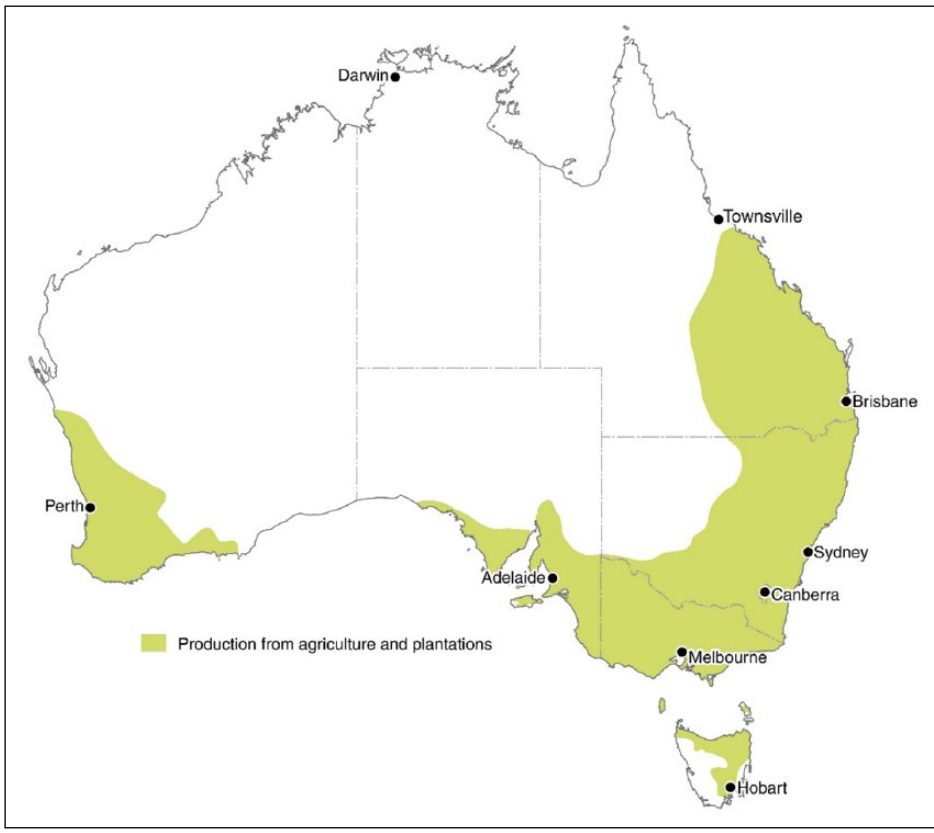

Figure 3. Fertile regions of Australia.
Source: Australian Bureau of Agriculture and Resource Economics (ABARE) (2005–2006).

and businesses), already have made significant investment in the development of solar power plants, which makes it easier for other communities to make similar investment in, and development of, a national solar power network. Encouraging the further development of renewable energy power plants by locating them appropriately on the National Transport Arc would significantly increase the resilience and integrity of the national energy system.

Regional economy

Infrastructure development is central to the development of an environmentally sensible, efficient, thriving economy. The development of a national renewable energy system designed around the National Transport Arc would encourage local value adding processes to local agricultural production. This would in turn strengthen the nation's regional economic base. One feature of this is that it would enable a stronger engagement by regional communities in their development and operation.

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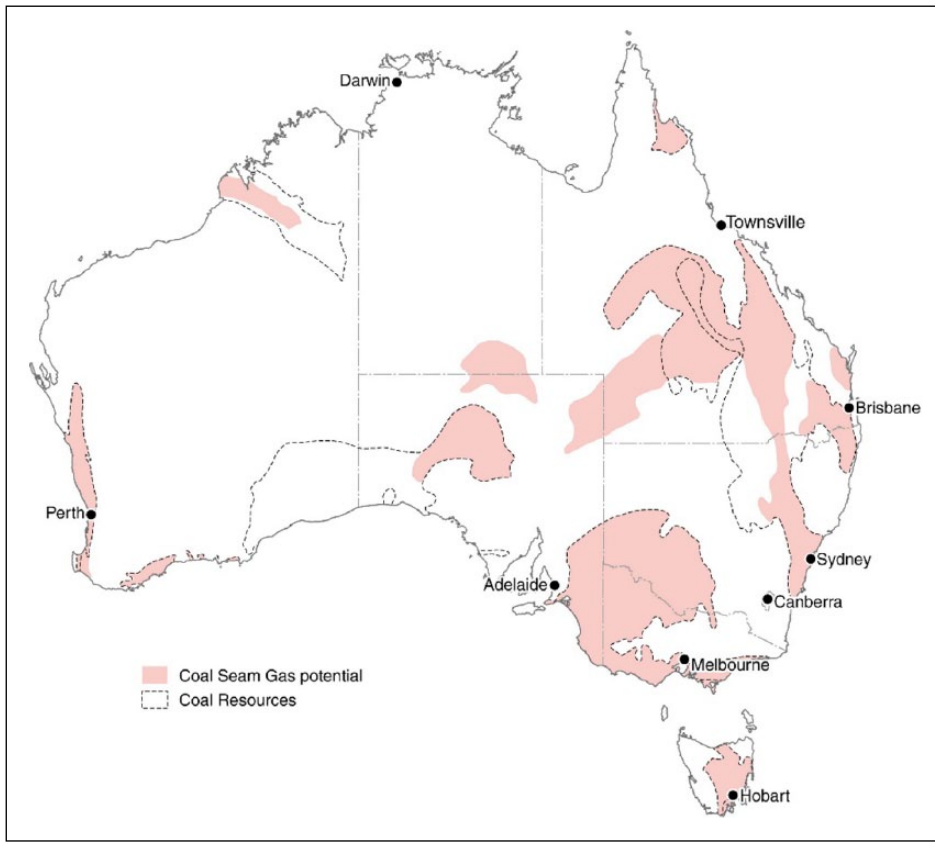

Figure 4. Mineral resources of Australia.
Sources: Australian Government, Department of Resources, Energy and Tourism/Geoscience Australia/Bureau of Resources and Energy Economics (2012); Australian Government/Geoscience Australia (n.d.).

Developing the National Transport Arc in the manner outlined would significantly reduce national vulnerability. It would also mean that the development strategy would stimulate the investment networks needed to develop the national infrastructure. During and following World War II, a shared understanding between the Commonwealth and States was developed to articulate a set of programmes to address major challenge to our infrastructure – road, rail, health services and housing. The crucial thing then was that we built a cooperation between the Commonwealth and States in pursuit of that national compact. Our task today is no less challenging, but we now have a more urgent need to build our nation in a way that meets our ambition to build a more sustainable, fairer nation.

To give focus to this development strategy would include, where appropriate, identification of local projects which may be seen as taking communities across the nation together on that journey. Where the States have relevant competence or operational responsibilities, it will be necessary for them to work on the articulation of the

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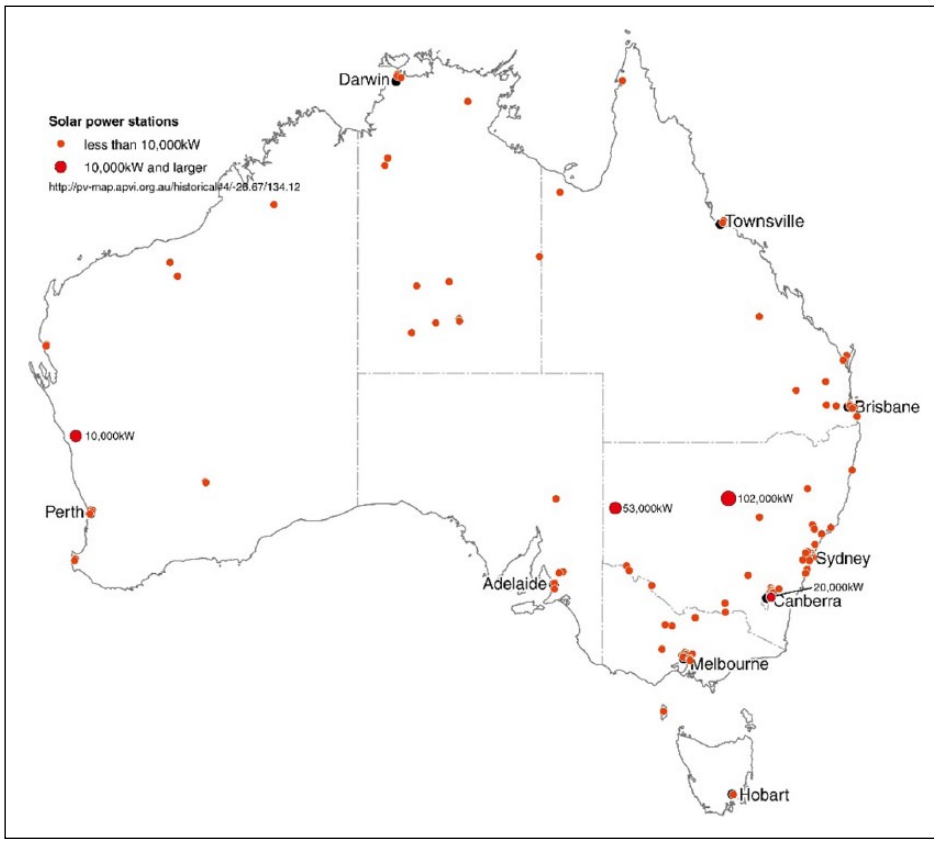

Figure 5. Existing renewable energy power plants.
Source: APVI (2016b).

development strategy and in the delivery of the appropriate infrastructure. Proceeding sequentially in the manner suggested will provide opportunities for private investment. Private and community investment in regionally located electricity power generation is only one of the more obvious areas in which the private sector might become engaged. Private sector engagement in the actual construction envisaged in development of the National Transport Arc would be essential.

Australia already has world class research capacities in this field that wants only a public determination to secure the development of battery technology, for domestic energy storage and for the manufacture of motor vehicles that depend on their ability to rapidly recharge, and also to increase their range. The twin objectives of developing electrification of rail passenger and freight transport, and 'electrification' of road transport, would be sustained by the development of regional power generation. Achieving these goals would be reinforced through the appropriate degree of engagement by regional tertiary education and research institutions in the development of power generation and energy storage.

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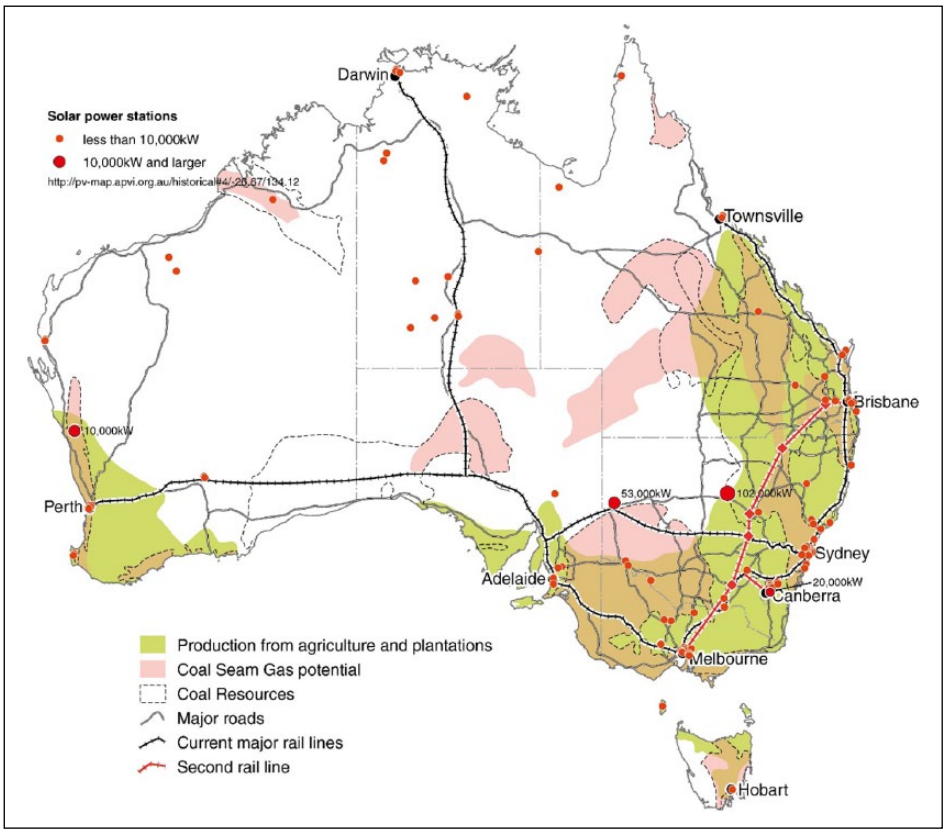

Figure 6. National low-carbon economy. (See colour figure online at http://journals.sagepub.com/home/elr).
Source: Figures 1–5.

A major component of the successful pursuit of the two objectives lies in the development of regional information and communication technologies that would facilitate the regionalisation of value adding to the processing of primary products closer to their point of production to become a source of strength for regional Australia.

Rather than conclude that Australia cannot compete in the production of basic materials of construction and fabrication, we would reshape our production of steel, aluminium and cement to take advantage of the variable availability of low-cost energy from the renewable energy power stations. The profile of demand for energy for domestic purposes and the daily rhythms of the cities and regional centres means that we expect regularly to generate more renewable energy which could be available at low cost for the production of materials for construction or manufacture of products. We would also be able to use battery storage to enable us to change the profile of that manufacturing.

The main source of steel would likely be a continued reliance on using good quality coking coal with the higher grade iron ore. Other materials (glass, cement and aluminium) used in modern construction could also be produced with lower levels of coal or gas

https://doi.org/10.1177/1035304617694826 Published online by Cambridge University Press

fired energy production (Figure 6). One early candidate for consideration in the use of low-cost energy in manufacturing would be the adoption and improvement of electric arc smelting techniques in the manufacture of steel from recycled steel waste.

Management of energy and water resources

For a complex set of reasons, the notion that increasing urban density will be environmentally beneficial has gained currency – that is, the idea that it will lead to less environmental stress due to a reduction in energy and water consumption.

The facts are that higher density offices and dwellings are built using materials with high levels of embodied energy. They need assisted transport within them and higher levels of security. Their servicing leads to high levels of consumption of water (resulting from the tragedy of the commons). These combined effects of their operation indicate that the comfortable belief of higher density leading to lower environmental stresses is unfounded.

Another area which has been neglected, to our cost, is water. We have not been prudent in our stewardship of our water resources. In our cities, we have exploited all easily available water resources but now are approaching some limits to their growth. Rainfall has become less predictable, which consequently means we must exercise more caution. Unfortunately, we have not made a major attempt to minimise or treat urban or regional waste water flows. As a consequence, we discharge increasing volumes of waste water, leading to increasing levels of acidification of 'in shore' ocean waters – including those inshore of the Great Barrier reef which is now experiencing low coral growth.

The growth of our cities and their increasing per capita domestic consumption of water now pose problems. Domestically, the greater part of our water consumption is not for sustenance of life nor is it for godliness but is a debt to pleasure. That is, our consumption of water in the shower, clothes washer and dish washer is more than our basic needs but is a measure of the pleasures we take in showering, in having an easy way of 'cleaning' our clothes and in our preparation and cooking of food.

We have become more conscious of the water consumption in our gardens and have changed many gardening practices, but we need to do more to develop ways of maintaining our level of cleanliness and comfort while reducing water consumption. This requires us to develop ways of reducing and managing our 'waste water' flows. It will also require us to pay more attention to the dangers to public health of the use of nanoparticles that may not be removed from present waste streams but may become a serious threat to public health and to the environment. This may require the development of Commonwealth-wide regulations to prevent the use of such particles.

We may use some of the renewable energy production to 'process' waste water flows from inland centres to bring them to a standard where the recovered water may be used in other industrial projects (including primary production), or to create greater security in the supply and to the preservation of biodiversity in our regions. Some renewable energy may also be employed to reduce the pollution load of water discharged to nearshore coast regions.

In all this, we must ensure that the security of water supplies to our major cities and towns is not compromised by mining of resources such as coal or attempts to recover oil or gas by fracking in our near-city water catchment areas. The threat to the security of

Sydney's water supply by mining in its near catchment reserves is eloquent confirmation of the need for urgent action.

Developing a sensible response to the challenges of growth is not confined to exploring ways of capturing solar energy. We continue to face the challenges posed by population growth, especially in our large cities, all of which have grown beyond their capacity to provide their own food. Taking advantage of the opportunities that low-cost energy production offers to facilitate regional industrial development does, however, offer an avenue to reduce the pressures under which they now operate.

A high level of private investment in solar energy conversion should be encouraged. We could, however, magnify the effect of this environment-related and economically sensible energy initiative by encouraging regional centres to support and facilitate the development of renewable energy power plants as pooled resources that should be managed by, for and on behalf of the community.

The Commonwealth already has *Infrastructure Australia*, now shaped to be a major development bank that could be charged with the responsibility to encourage the construction of community-owned regional renewable energy power stations to deliver power to the developing transport networks, and also to support the development of enterprises to add value to primary production in the regions. In performing such a task, *Infrastructure Australia* would be seen as a 'change agent', especially in providing or facilitating access to technical and financial advice needed to establish the appropriate model of renewable energy power plant for each region.

The Commonwealth could enhance such an initiative by increasing research funding in the conversion of solar energy and in the development of new battery technology. It could also encourage and support regional centres in the development of new production processes, not only for value adding of primary production but also for new modes of production of basic materials like steel, cement and aluminium to take advantage of supplies of low-cost energy. The Commonwealth could also support improvement in regional communications to improve the understanding and operation of markets.

Conclusion

This article has argued that a thoroughgoing response to climate change is required in Australia. Such a response must involve a radical re-imagining of systems for our land, water and mineral use, and of transport and communication systems. An effective deep decarbonisation strategy cannot be based simply on an aggregation of diverse sectional approaches. Rather, setting aside pre-judgements, a national conversation is required, leading to action that is informed as well as resolute in order to save us and our planet from ourselves.

As indicated by a number of studies cited above, climate action is not a zero-sum game in which environmental sustainability is bought at the expense of economic development. Rather, economic growth and CO_2 abatement can go hand in hand. The costs may be not so much financial as the expenditure of effort and imagination required to change attitudes and habits, particularly in relation to regional patterns of economic activity. Indeed, the new international awareness of the urgent need to respond to the challenges of climate change offers an opportunity to develop a new plan for the

https://doi.org/10.1177/1035304617694826 Published online by Cambridge University Press

development of Australia's economy – one that listens to all communities, including our First Nations. Such a plan would foster the further development of the great natural resources of the nation by including the protection and enhancement of its highly fertile regions. This would be a plan to protect, develop and enhance the most important elements of the national heritage.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

Notes

1. For example, Beyond Zero Emissions (BZE) has produced publications with specific proposals for carbon capture and storage, stationary energy, carbon-neutral housing and buildings, low-emission agriculture and forestry, electric vehicles and high-speed rail (BZE and Cagney, 2016; Consolidated Land and Rail Australia (CLARA), 2016; International Energy Agency, 2016; Melbourne Energy Institute et al., 2014).
2. For another rail proposal, see CLARA (2016). For discussions of very fast rail feasibility, see Melbourne Energy Institute et al. (2014).

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