Markets, regulation, policies and institutions for transition in the electricity sector

Insights from the Australian-German Energy Transition Hub

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About the Australian-German Energy Transition Hub

The Australian-German Energy Transition Hub is a bilateral initiative for applied research on energy transition opportunities. The Hub is supported by the Australian Department of Foreign Affairs and Trade and the German Federal Ministry for Education and Research.

The Hub brings together leading research organisations that are central to energy transition in each country. The Hub is providing an innovative and effective architecture for collaboration. Virtual conferencing and regular collaborations through video conferencing are enabling close working relationships and knowledge exchange. It is fostering closer links between researchers, industry, and government entities.

The bilateral relationship between Australia and Germany is strengthened through Hub research, dialogue, and stakeholder engagement that helps to identify and harness the opportunities for both countries in the transitionto a net-zero emissions world economy. It has highlighted the complementary opportunities created by Germany's *Energiewende* experience and Australia's substantial energy and mineral resources. This is clearly evident two years into the Energy Transition Hub. Faster identification of policy lessons and investment and trade opportunities, and a deeper exchange of useful research methods and findings, are being enabled through this initiative.

The Hub is co-led by the University of Melbourne and the Australian National University in Australia. In Germany, the Hub is co-led by the Potsdam Institute for Climate Impact Research, the Mercator Research Institute for Global Commons and Climate Change, and the University of Münster. In addition to these five core partners, the Hub now has eight research partners: five in Australia and three in Germany.

This document presents some of the principal findings of research supported through the Hub. A more comprehensive collection of research, web tools and engagement undertaken is available at the Energy Transition Hub website energy-transition-hub.org

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INTRODUCTION

Energy transition is happening globally and in Australia and Germany. It is occurring in response to rapidly changing technology costs and as countries move to implement policies in line with the Paris Agreement goals. This transition poses policy and technological challenges. If managed well, it can also deliver great economic opportunities in both Australia and Germany.

Insights about the implications of the global energy transition for Australia and Germany that have become evident from the Energy Transition Hub's work include:

1. Rapid deployment of renewables in Australia is an essential part of a cost-efficient transition to a net-zero emissions economy. There is the potential to create an export industry based on Australia's renewable energy resources (as much as, or even more than, doubling Australia's domestic electricity demand).
2. Substantial and complementary export opportunities emerge for Germany and Australia as a result of the move to energy networks powered by renewables, electrification of other sectors of the economy, the transition to zero emissions synthetic fuels and growing demand for zero-emissions metals and energy intensive goods.
    - Australia, with its plentiful wind and solar energy resource, available land, and stable regulatory and institutional environment, is well positioned to become a leading exporter of renewable energy and renewable-based energy-intensive goods.
    - Germany, as a leading manufacturer and engineering innovator of energy transition technologies, can benefit from an increasingly global deployment of technologies for renewable energy transformation, conversion and the electrification of energy end-uses.
3. Large-scale carbon dioxide removal (CDR) is another essential component of any transition that limits warming to 1.5°C, or even to 2°C, unless the pace of mitigation to 2030 increases significantly. CDR is needed to complement the transformation in other sectors: it is not an alternative to rapid deployment of low-emissions technologies across the economy. CDR could create opportunities for Australia as a source of nature-based CDR solutions, bioenergy with carbon capture and storage (BECCS) or direct air capture with CCS (DACCS), and for Germany as a provider of carbon capture and utilisation (CCU) technologies.
4. Regulation, market design and policy have important roles to play. A cost-effective, timely energy transition that unlocks the potential for new industries, supports affected regions, and protects ecosystems is not guaranteed – it is an outcome achievable in both Germany and Australia with effective policy

Recent work on these issues is summarised in a series of papers. This report addresses some of the questions that arise in relation to the fourth point. Specifically, it covers insights on reform in the Australian and German electricity sectors.

Transition in the electricity sector

The transition of energy systems can bring large economic benefits. However, the adjustment can also place pressure on communities and businesses. Effective settings for regulations, markets and policy are needed to support the transition. In many instances, reform is needed to adapt to changed circumstances and new objectives. Getting regulation, market frameworks and policy settings right underpins the process towards electricity supply with low- and ultimately zero-carbon emissions while maintaining reliability of supply and limiting energy costs. Zero-emissions electricity supply is at the heart of a shift to a clean energy system.

Technological improvement is driving change in the electricity sector and is set to make low-emissions electricity supply at affordable costs possible. Technological advances include falling costs of renewable energy production; advances in energy storage and transmission; and new opportunities for decentralised energy supply and flexible energy demand, including through new digital technologies. An important research focus of the Energy Transition Hub is to contribute to understanding the regulatory, institutional, market and policy frameworks needed. Ideally these frameworks would be designed to support investment and innovation in a zero-carbon economy; retain competitiveness and energy affordability; and facilitate adjustment that harnesses economic opportunities and makes energy transitions socially acceptable.

Germany and Australia share many of the basic challenges. And they differ - sometimes greatly - in a number of aspects, among them the wealth in renewable and fossil energy resources, economic and social context, institutional frameworks and policy approaches taken by governments, and the nature of the opportunities that arise from transition. Comparison of insights and experiences in the two countries can help inform decision-makers, business and communities.

This brief gives an introduction to ongoing activities undertaken by the Energy Transition Hub on electricity sector issues. These can be broadly categorised in three areas:

- Institutional and policy frameworks to meet energy sector and national economy objectives;
- Regulatory frameworks and mechanisms for electricity markets, networks and distribution, including effective integration of distributed resources; and
- Options for governments to facilitate structural change and manage the social risks of energy transition within communities

Electricity supply in Australia and Germany

Australia and Germany share fundamental characteristics of electricity supply and their respective transitions share common challenges and opportunities. The similarities include, as with many nations, a historically strong reliance on coal including lignite for electricity generation; a rapid increase in renewable energy generation in recent years; the need for additional grid infrastructure to facilitate anticipated higher shares of renewable energy generation in the future; higher electricity prices for some types of consumers compared to earlier years; and resultant concerns about affordability and competitiveness (Figures 1-4).

The dissimilarities include:

- Different physical features – e.g. Australia has no practical limitations in expansion of renewable energy generation but lacks the international interconnection of the electricity system that Germany enjoys;
- Differences in policy objectives and the policy instruments currently in place – e.g. in Germany electricity generation is subject to a carbon price under the EU Emissions Trading Scheme, the German government plans to phase out both nuclear and coal power, and mechanisms for the support of renewable energy differ;
- Different regulatory and market frameworks and traditions – e.g. while both countries have an energy-only wholesale market, Australia has regionally differentiated pricing and may further disaggregate pricing.

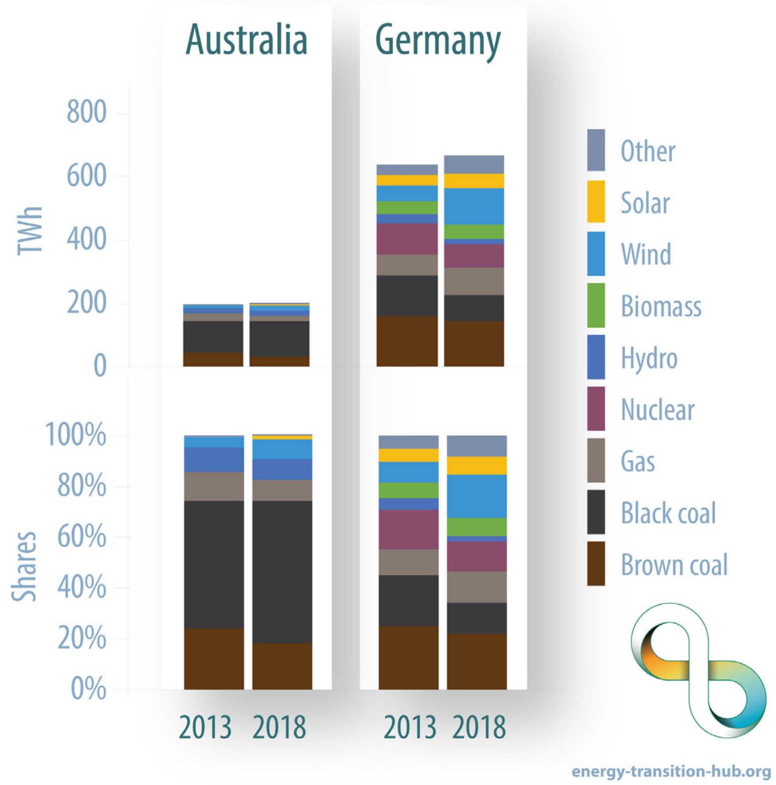
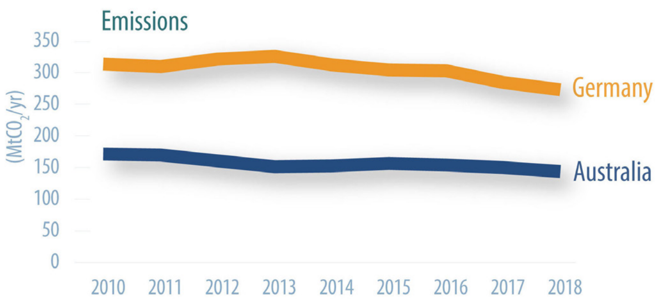


Figure 1: *Electricity supply mix*

Note: Data for Australia in table and figure refer to electricity generation in the National Electricity Market (which excludes Western Australia and the Northern Territory) plus estimated rooftop PV generation.

Data sources: BMWI Energiedaten Gesamtausgabe; AEMO data; Australian Energy Council mix (Data can be found in the table on page 11)



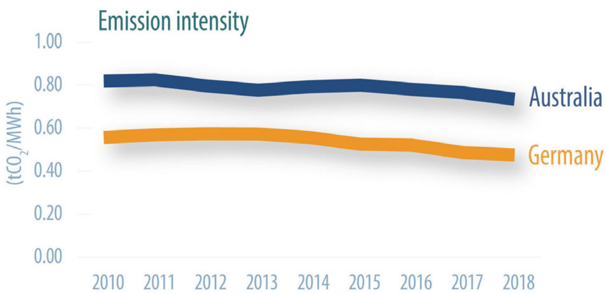


Figure 2: *Emissions and emissions-intensity of electricity generation in Australia and Germany, 2010 to 2018*

Note: Data for Australia refer to electricity generation in the National Electricity Market (which excludes Western Australia and the Northern Territory) plus estimated rooftop PV generation.

Data sources: BMWI Energiedaten Gesamtausgabe; AEMO data; Australian Energy Council mix

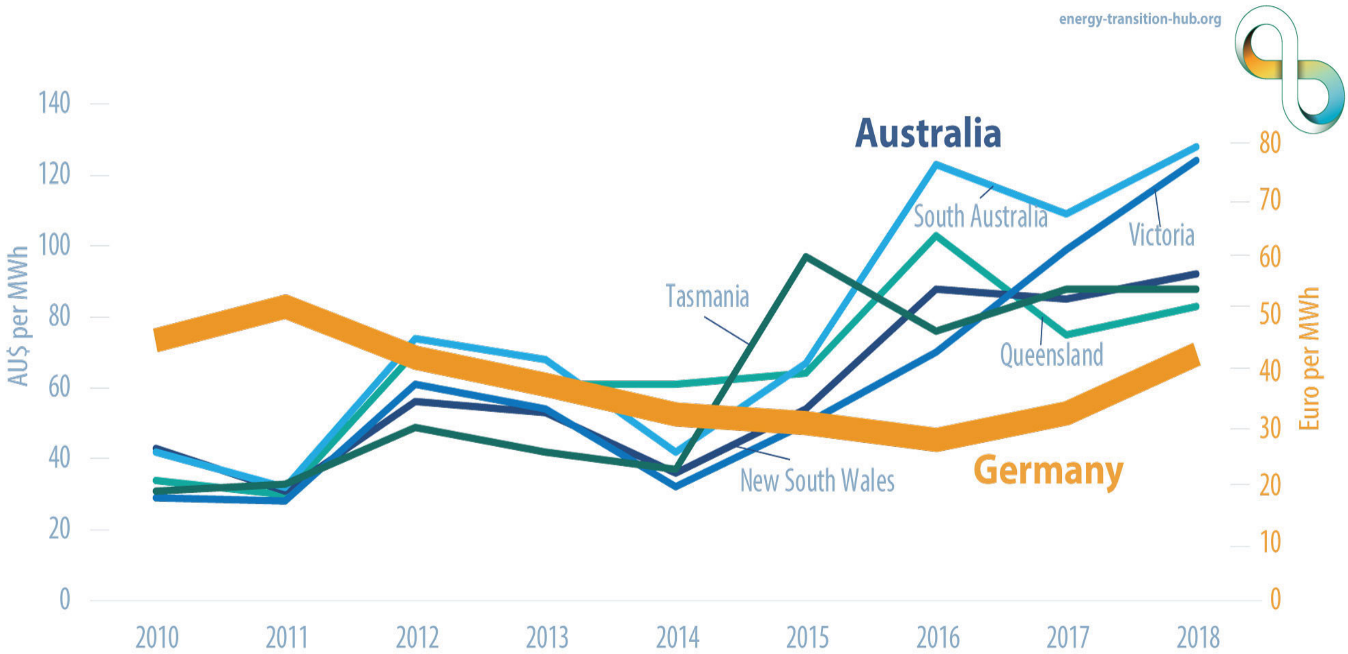


Figure 3: *Wholesale electricity prices in Germany and by NEM region, 2010-2018*
Sources: Australian Energy Regulator, Fraunhofer ISE.

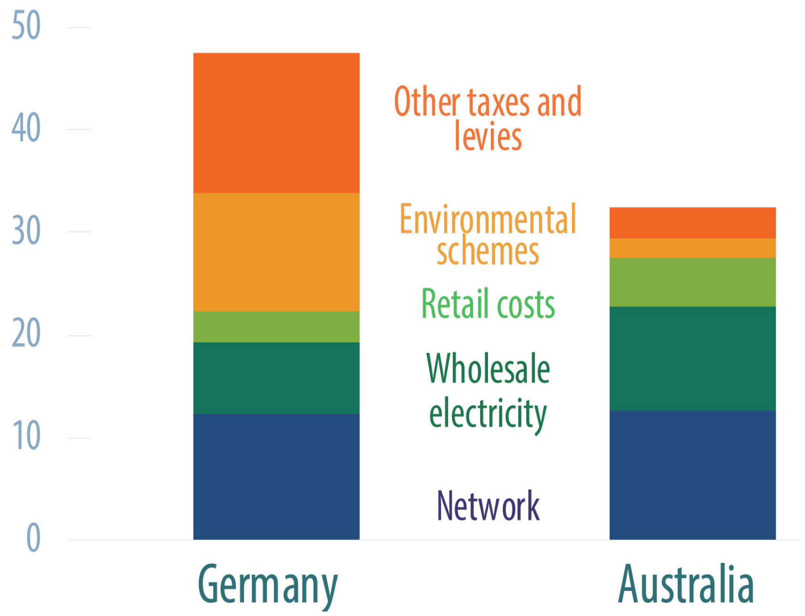


Figure 4: *Composition of retail electricity prices in Australia and Germany 2018 (AU cents per kWh at 0.62 EU/AUD)*
Sources: ACCC and BDEW.

Support for zero-emissions technologies

Innovation in, and deployment of, low-carbon technologies will be at the core of any successful energy transition.

A focus of Hub research is understanding how to design low-carbon innovation and diffusion policies in both the electricity sector and the broader economy. These need to be cost-effective, consistent across sectors and achieve distributional fairness.

At the core of these considerations is the design of effective combinations of energy pricing, regulatory instruments, and research and development incentives.

There is an active debate in Germany about reform of policy settings including carbon pricing for the sectors not covered by the EU emissions trading scheme. Hub researchers are contributing to this debate by providing advice and assessments to government (e.g. Edenhofer et al. 2019, Löschel et al. 2019, Bach et al. 2019), and in drawing lessons from the other country's experience (eg Jotzo and Löschel 2019).

Support policies for renewable energy deployment have been in place for many years in Germany.

These have helped reduce costs of renewable energy and built capacity in these new industries but have accumulated large ongoing liabilities to pay households and business premium rates under feed-in tariff arrangements that paid comparatively high rates for early contracts. These policies have triggered massive technology development and deployment and may pave the way for carbon pricing as a future dominant policy approach in Germany (Pahle et al. 2018). Recent Hub research has investigated the effects of price-based support policies on investments into cleaner technologies and business models (Ohlendorf et al. 2019), and how to overcome barriers to new price-based policies (Leipprand et al. 2019).

Australia has had the highest rates of PV deployment per person of any country.

Australia has a Federal renewable energy certificate trading system that is winding down as the 2020 target is fulfilled. State-based renewable energy targets and various subnational support schemes for renewable energy deployment also exist. Hub research indicates that Australia's Federal Small-scale Renewable Energy Scheme has been highly effective in stimulating the adoption of rooftop solar photovoltaics (Best et al. 2019). Investment in wind and solar PV was very rapid during 2018 and 2019 (Clean Energy Regulator 2019), and Australia has had the highest rates of solar PV deployment per person of any country at 250 W per person per year (Blakers et al. 2019).

Renewable energy is now generally the cheapest form of new-build electricity generation in Australia.

The levelised cost for energy from new wind farms and solar parks is well below current wholesale market prices (BNEF 2019). The focus for policy and regulation is therefore shifting to reliability of supply, which includes ensuring that transmission infrastructure for new renewable generators is provided in a timely and cost-effective way, and that grid-scale energy storage facilities are available (Blakers et al. 2019).

Australian experiences with government funded support for zero-emissions innovation suggest that such models can operate successfully and cost-effectively.

The Australian Renewable Energy Agency provides grants for applied research and development on advanced renewable energy technologies. The Clean Energy Finance Corporation is a 'green bank' that co-funds first-of-a-kind commercial projects in renewable energy, energy efficiency and other emissions-savings technologies, leveraging private investments while making a return for government. Both have been successful in fostering targeted innovation and early deployment of advanced low-emissions technology, in collaboration with industry. This experience shows that infusing technology policies with market elements can be an effective approach.

Regulation and price signals for tomorrow's grid

Any successful energy transition policy framework will need to manage the challenges of an electricity network with high shares of renewable energy and decentralised generation.

Future demands on grids are likely to differ from today's. A larger, more complex infrastructure will be needed to accommodate:

(i) A higher share of renewable power;

(ii) Increased electricity production and consumption to allow sector coupling/electrification in other sectors; and

(iii) Production of new electricity-based energy, such as green hydrogen.

This is not just a question of technology. Appropriate regulatory frameworks are required to allow large amounts of cost-effective investment and production.

The grid of the future, and the trajectory toward it, look very different for Germany and Australia.

In Germany, the evolution of market design and regulation is driven by the need to expand and integrate renewable energy sources into the grid, and most recently by the need to decarbonise other sectors through electrification. A focus of research and analysis has been on large-scale renewable integration by improved market, dispatch and grid operations. For future large-scale renewable integration, large-scale energy storage and sector coupling are discussed (Zerrahn et al. 2018). Large investments by the German government in research capability for energy transition, including for electricity, have enabled the development of advanced modelling tools that allow technology and policy ideas to be tested for their whole-of-system impacts. Many of these tools are available to Hub partners and can be adapted to the Australian context.

In Australia, market design and regulation have primarily been driven by the objectives of (i) enabling consumer participation to improve overall system operation and management; (ii) increasing competition in the grid flexibility market; and (iii) containing costs in the distribution, transmission and generation of electricity. More recently, an investment boom in wind and solar power (Clean Energy Regulator 2019) has raised the central question of how to ensure timely and cost-effective grid integration of larger shares of variable renewable energy.

Specifically, regulatory reforms are under consideration to move to more geographically disaggregated (nodal) electricity pricing (AEMC 2019), and to ensure that decisions about investment in new transmission lines are made in line with system requirements for renewables integration and consideration of cost-effectiveness in this context. Australia's governing institutions for the National Electricity Market (NEM) are currently engaged in a reform process with a broad remit to decide and design changes to the electricity market to apply from 2025 (Energy Security Board 2019). The Hub is engaged in this process including through membership on the technical working group to the reform process.

Australia's experiences, both positive and negative, in integrating high proportions of distributed renewable energy resources into a grid without significant excess generation capacity will be of interest to regulators elsewhere, including in Germany. Several research initiatives under the Hub are providing specific analytical capabilities and applicable insights.

Prosumage modelling

Hub researchers are conducting a series of model-based analyses of prosumage, investigating system effects in Australia and Germany, examining sector coupling interactions and analysing impacts of regulatory choices.

For example, an open-source model was developed to analyse the relationship between tariff design and household investments into rooftop PV and batteries in Germany (Günther et al. 2019). The research has explored how decisions around residential solar-battery systems are linked to both feed-in tariff rates and retail tariff design. Increasing the fixed component of a retail tariff can reduce the incentive to invest in storage systems because self-generation becomes less economically attractive.

Further, real-time pricing could incentivise households to better align their self-consumption patterns with the wholesale market. A regulated feed-in cap on peak energy fed into the grid could relieve distribution grids without causing large financial disadvantages for prosumage households. The research also suggests that there is a trade-off between residential PV capacity expansion and system cost contribution by residential prosumagers. Under volumetric retail tariffs, larger rooftop PV systems mean that remaining grid costs are increasingly borne by other consumers.

Smart meters

A comparison of three smart meter rollouts—two in Australia and one in Germany—explored how the rollouts took place, the aims of the programs, different designs for data access, and security measures. In Australia, the state of Victoria was an early adopter of mandatory smart meter rollouts by global measures and has now installed smart meters in all households and small businesses.

The distribution of benefits from smart metering depends heavily on the interplay of infrastructure, regulatory arrangements and industry structure (Kallies et al. 2019). Smart meters can help to reduce electricity prices and to provide critical information and infrastructure as societies venture into new energy services, such as electric vehicles. However, the comparison of German and Australian experiences found that consumer empowerment and protection will be crucial elements of successful smart meter deployment.

Locational investment signals

The placement of new generation determines network expansion requirements, costs, and grid congestion. Both Australia and Germany experience grid congestion (Bundesnetzagentur 2018; AEMC 2019). Locational investment signals can ease the strain on transmission and distribution lines. These signals emerge from the electricity market, especially in relation to the design of the system. In Germany, the renewable support scheme (known as the 'Referenzertragsmodell') features de facto locational signals, but only for wind energy. In Australia, the NEM is geographically organised into five pricing zones, which provides a (albeit coarse) locational signal, and marginal loss factors aim to reflect average transmission losses for different locations. As described above, a model of more geographically disaggregated pricing is under consideration.

The Hub has undertaken a review of policies that create locational investment signals for the placement of new electricity generation for 12 liberalised power markets, including Australia and Germany (forthcoming publication). A rich variety of locational signals exists worldwide which can be grouped into five categories: locational electricity markets, deep grid connection charges, grid usage charges, capacity mechanisms, and renewable energy support schemes. The review examined the resulting price and revenue differences as well as the pros and cons of the respective instruments. It found that no single best solution exists, with suitable models being specific to physical characteristics, regulatory context, and policy objectives.

Time-based retail pricing

Numerical analyses show that real-time retail pricing can become increasingly beneficial beyond a certain share of variable renewable energy in the market (Gambardella et al. forthcoming). This may become particularly important when a large part of carbon-free electricity is supplied variably and is used for heating, cooling and transportation purposes. Hub research quantifies the potential efficiency gains from introducing real-time retail pricing in such a system (Gambardella forthcoming).

There are two key research findings. First, allocative efficiency gains from introducing real-time pricing increase considerably with increases in electricity demand. This relationship results from the large-scale electrification of the heating and transportation sector. Second, allocative efficiency increasingly depends on how closely load follows wind and solar generation. The more demand profiles co-vary with renewable output, the higher are potential gains from implementing real-time pricing, since variable renewable resources can be used more efficiently. Hence, in systems with relatively high degrees of electrification, efficiency will largely depend on the characteristics of heating, cooling and transportation demand patterns.

Regional transitions

Transitions in the energy sector often have an important regional dimension, and the resulting economic and social challenges find recognition in policy processes. Emerging experience and evidence from past transitions can help governments and societies to ease the adjustments.

Many coal-fired power plants in Australia and Germany are expected to close in coming decades, and will not be replaced with the same type of plant in the same locations. In Germany, the Commission on Growth, Structural Change and Employment (Coal Commission) has recommended closure of all coal-fired power stations by 2038 or 2035, and government appears likely to implement this as part of the overall energy transition strategy (Kommission Wachstum, Strukturwandel und Beschäftigung 2019). In Australia, the low supply cost from renewable generation means that new coal plants will not be commercially viable, and existing coal plants are coming under increasing pressure in the electricity market, shortening their economic lifetimes and potentially leading to sudden or unpredictable exit.

Coal power plants, and associated mining operations, are generally located in regional areas. Their closure can have regional economic and social effects, unless well managed. In Germany, Hub research in support of the Coal Commission has examined potential welfare consequences of various policy measures (Haywood et al. 2019). The research concludes that priority responses to support strong regional and sectoral transitions include analysing scenarios for the pace of closure of coal-fired generation; understanding how to create a just transition for vulnerable workers and communities; and strengthening economic and employment outcomes.

The process of transition away from coal will benefit from greater predictability and systematic preparation (Jotzo et al. 2018). This is important due to the large scale of individual plants relative to the size of regional economies, coupled with evident policy and societal concern about coal communities. In Germany, approaches to creating indicative timetables of coal plant exit are now being discussed, including the possibility of market mechanisms to help determine an efficient order of plant exit (Aurora 2019), drawing on concepts developed in Australia (Jotzo and Mazouz 2015).

In Australia, Hub research has shown that the closure of a dozen coal-fired power plants over the last seven years has been associated with a small but statistically significant and persistent increase in regional unemployment (Burke et al 2019). This finding illustrates why closure of large industrial installations and the loss of significant numbers of relatively well-paid jobs is a concern for structural adjustment policy. The responses to the sudden closure in 2017 of the Hazelwood brown coal (lignite) power station in Australia's Latrobe Valley (Wiseman et al. 2017) shows that Australian governments are willing to support regional areas and affected local communities. Innovative institutional approaches such as the Latrobe Valley Authority have been established to support the transition.

In Germany, it is expected that there will be large structural adjustment programs to support regional communities, in particular in the lignite areas where power plants and mines will close. The Coal Commission proposed large-scale financial assistance to the electricity industry and energy users, implying taxpayer funded transfers to the electricity sector overall.

Both countries will gather further experience with regional structural adjustment in the energy transition, as well as institutions and government support for the social and economic change in coal regions. Systematic assessment and comparison of the effectiveness of different approaches will be beneficial in bilateral exchange in the future, and the Hub partner institutions will be able to conduct relevant research.

National energy transition assessment

Successful transition of energy systems requires ongoing monitoring and evaluation of progress relative to stated objectives, including assessments of the efficacy of regulatory and policy frameworks in the interplay with business investment decisions. German Hub partners are leading protagonists in national monitoring and evaluation of Germany's energy transition, chairing an independent expert commission established by the federal government that reports annually (Löschel et al. 2019).

Indicator-based monitoring and evaluation of energy transition processes provides policymakers with the best tools and information and helps to identify transferable leading practices. Such energy transition assessment can help to better understand the status and prospects of the energy transition within a country and in international comparison, including through publicly accessible and harmonised quantitative indicators. Developing a transparent framework as a robust method facilitates comparative understanding of national efforts, as well as an assessment of efficiency potentials and an identification of internationally transferable leading practices.

Periodic, systematic assessment of aspects of change in Australia's energy system can help the policy community, business and broader society understand a range of issues in Australia's energy transition. The Hub is well placed to inform a future process of energy system assessment in Australia.

Such an energy transition assessment process compiles a large number of available indicators for the national energy system in a publicly accessible online platform and is in part built on the Hub's OpenNEM platform. In addition to physical indicators, it creates and consistently computes economic and social indicators that are of importance to policymakers and industry. The assessment will also report innovative new indicators such as a measure for "real unit energy costs", an indicator of energy affordability for industry, and when used in international comparison, a measure of changes in energy-based competitiveness. Preliminary analysis for Australia shows that the manufacturing and transport sectors exhibit the highest levels but also the largest decreases over time in real unit energy costs (Jotzo, Löschel and Zunker forthcoming). The energy transition assessment further provides a range of quantitative indicators of household energy costs and affordability.

Table (p5): *Electricity supply mix*

	Australia (NEM)			Germany		
	GWh, 2018	Share, 2018	Change over 2013	GWh, 2018	Share, 2018	Change over 2013
Brown coal	36	18%	-24%	146	22%	-9%
Black coal	110	56%	12%	83	12%	-35%
Gas	16	8%	-28%	83	12%	23%
Nuclear	0	0%	0%	76	11%	-22%
Hydro	17	8%	-10%	17	3%	-41%
Biomass	0.2	0%	-24%	46	7%	14%
Wind	14	7%	79%	113	17%	114%
Solar	3.1	2%	457%	46	7%	49%
Other	0.1	0%	36%	55	8%	67%
Total	197	100%	0%	666	100%	4%

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