Job Impacts of a Decarbonised Australian Economy

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Abstract

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) posits that developed countries will need to make significant cuts in greenhouse gas emissions to limit the chances of dangerous climate change. Numerous studies in the Australian context have examined a broad range of emission reduction targets and their impact on different sectors of the economy. The majority of these studies show that one of the biggest transformations is expected to occur in the energy sector. In regard to electricity generation, a carbon price makes renewable generation more competitive relative to coal, leading to a transition away from conventional coal-fired generation towards renewable technology. The transition has flow-on effects to other sectors of the economy such as mining. This paper uses input-output analysis to estimate direct and indirect impacts on employment for Australia from a transition towards a decarbonised economy. The results show that the magnitude of change is highly dependent on the uptake of alternative low emission technologies and the emissions reduction trajectory that is pursued in Australia and the rest of the world.

1. Introduction

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) posits that developed countries will need to make significant cuts in greenhouse gas emissions to limit the chances of dangerous climate change. Fisher *et al.* (2007: 173) suggest upper end targets could reasonably aim for emissions "to peak before 2015 and be around 50 percent of current levels by 2050" (Fisher *et al.*, 2007: 173) (see also Gupta *et al.*, 2007). There is evidence that greenhouse gas emissions from human activities have accelerated in recent years (Garnaut, 2011; IEA, 2011) implying that emission reduction targets at the upper end of the ranges outlined above may be required to limit the chances of dangerous climate change. This has significant implications for Australia given its emissions intensive economy (see World Bank, 2009; ABARES, 2011).

Australia's high ranking in emissions per capita reflects its relatively high proportion of fossil fuels in energy consumed, high usage of relatively less efficient private transport and relatively high production of non-ferrous metals per capita (most of which is exported). Stationary energy is the single largest source accounting for around 53 per cent of the total 542 megatonnes (Mt) CO_2-e, with electricity generation accounting for the majority at 194 Mt CO_2-e (DCCEE, 2011).

The high share of emissions from the stationary energy sector is mainly due to coal-fired electricity generation. Black and brown coal-fired plants accounted for 77.3 percent of electricity generation in 2009-10 (ESAA, 2011). The dominance of coal is the result of a number of factors. First, coal-fired plants are a mature technology that feature relatively low capital costs per kilowatt (kW) of electricity generated. Second, the proximity of coal basins to major demand centres (for example, capital cities) together with improvements in mining processes has ensured a low-cost fuel supply. Third, 'negative externalities' (for example, greenhouse gas emissions) have not been priced into the cost of electricity charged to end-users.

The dominance of coal masks Australia's rich diversity of renewable energy resources (wind, solar, geothermal, hydro, wave, tidal, bioenergy). Except for hydro and wind energy which currently account for most renewable generation, these resources are largely undeveloped and could contribute significantly to Australia's future energy supply (Geoscience Australia and ABARE, 2010).

The juxtaposition of high emissions per capita and the need for significant reduction in greenhouse gas emissions implies a transition to a decarbonised economy.

This paper estimates the direct and indirect employment impacts of a transition to a decarbonised economy with a focus on the electricity generation and mining sectors. The Energy Sector Model (ESM) is used to estimate the change in technology mix in the electricity generation sector under two renewable uptake scenarios. Direct employment multipliers derived from literature review are then used to calculate net employment impacts in the electricity generation sector from the transition away from non-renewable primary energy sources. Input-output analysis is employed to estimate the indirect employment impacts on other industry sectors.

Two scenarios are modelled which sees the electricity sector decarbonises by 2050 (Scenario I) and 2035 (Scenario II) with a linear increase from 20 per cent renewable share in 2020 under existing policy settings to 100 per cent share by 2050 and 2035, respectively.

Table 1 summarises the employment effects involved in each Scenario. It shows the sector-specific (Direct) employment generated and the indirect employment created as a consequence of the sectoral input-output linkages. There are two impacts modelled: (a) the growth in overall electricity consumption (and production) which leads to employment growth; and (b) the changing mix towards renewable which are more labour-intensive.

Table 1 Summary electricity employment effects, Scenarios I and II, 2010-2050

	2010	2020	2030	2035	2045	2050
Scenario I						
Direct Non-Renewable	24,006	21,781	13,425	17,995	10,431	0
Direct Renewable	6,378	27,514	63,672	73,345	116,356	144,423
Total Indirect	29,200	47,373	74,090	87,779	121,842	138,791
Total Employment	59,584	96,669	151,187	179,119	248,628	283,214
Scenario 2						
Direct Non-Renewable	24,006	21,931	9,857	0	0	0
Direct Renewable	6,378	27,798	73,891	114,393	133,723	144,085
Total Indirect	29,200	47,790	80,482	109,932	128,507	138,466
Total Employment	59,584	97,519	164,231	224,325	262,230	282,551

Source: see text for explanation.

While it is clear that there will not be devastating employment effects involved in the decarbonising of the electricity sector there will still be winners and losers. Workers of all skills in the non-renewable sector and the communities they live in will be disadvantaged by the policy-induced structural change.

We outline a policy framework which we argue will provide for a ‘Just Transition’ to a low-carbon economy which will reduce the costs of the structural change for individuals and communities and maximise the benefits of the transition.

The paper is structured as follows. Section 2 discusses the methodology involved in developing the renewable employment estimates and outlines the input-output model assumptions. Section 3 presents the results of the analysis. Section 4 presents the policy implications of the results and develops a framework to guide a just transition. Concluding remarks follow.

2. Methodology

2.1 Scenario definition

The position that developed countries may need to reduce emissions at a greater rate in the medium-term is a departure from the straight-line reduction path that is typically modelled in emission reduction scenarios. In the Australian context, examples include (Allen Consulting Group, 2006; Australian Climate Group, 2004; Saddler *et al.,* 2007; Graham *et al.*, 2008a; Turton *et al.*, 2002). Studies examining more aggressive emission reduction targets to zero emissions are a more recent development in the literature and include global studies (Jacobson and Delucchi, 2011, Delucchi and Jacobson, 2011, WWF, 2011, Jacobson and Delucchi, 2009), the U.S. (Fthenakis *et al.*, 2009, Alliance for Climate Protection, 2009), U.K. (CAT, 2010), Europe (EREC, 2010), Europe and North Africa (PWC, 2010), and Australia (Beyond Zero Emissions, 2010).

In constructing appropriate scenarios for this paper, consideration was given to the availability of low emission electricity generation technologies at reasonable cost, the age profile of the existing electricity generation fleet in Australia and the potential disruption of a transition to a decarbonised electricity sector on other sectors of the economy. Based on this evaluation, two scenarios were chosen:

1. The electricity sector decarbonises by 2050, assuming a linear increase from 20 per cent renewable share in 2020 under existing policy settings to 100 per cent share by 2050
2. The electricity sector decarbonises by 2035, assuming a linear increase from 20 per cent renewable share in 2020 under existing policy settings to 100 per cent share by 2035.

2.2 Energy Sector Model

To model the future uptake of renewable electricity generation technologies under each scenario this paper used a partial equilibrium modelling framework called the Energy Sector Model (ESM). It was originally co-developed in 2006 by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). Since that time ESM has been significantly modified and expanded by the CSIRO.

ESM is a partial equilibrium (bottom-up) model of the electricity and transport sectors. It has a detailed representation of the electricity generation sector with substantial coverage of centralised generation (CG) and distributed generation (DG) technologies. The transport module considers the cost of alternative fuels and vehicles as well as detailed fuel and vehicle technical performance characterisation such as fuel efficiencies and emission factors by transport mode, vehicle type, engine type and age. Competition for resources between the two sectors and relative costs of abatement are resolved simultaneously within the model. In this paper only the electricity sector module of ESM was utilised.

ESM has been applied to the analysis of numerous energy futures scenarios for Australia including: alternative greenhouse gas emission targets (for example, CSIRO, 2008; Graham *et al.*, 2008b; Reedman and Graham, 2009), alternative carbon price regimes (for example, CSIRO and ABARE, 2006; Commonwealth of Australia, 2008); potential for distributed generation (CSIRO, 2009); prospects for sustainable liquid fuels (CSIRO, 2011, Graham *et al.*, 2011) and peak oil scenarios (Graham and Reedman, 2010).The main features of the electricity sector module of ESM are:

- Coverage of all Australian states and the Northern Territory (Australian Capital Territory is modelled as part of New South Wales);
- Twenty-one centralised generation (CG) electricity plant types: black coal pulverised fuel; black coal integrated gasification combined cycle (IGCC); black coal with CO_2 capture and sequestration (CCS) - the CO_2 capture rate for CCS technologies in the model is 90 percent; brown coal pulverised fuel; brown coal IGCC; brown coal with CCS; natural gas combined cycle (CCGT); open-cycle natural gas peaking plant (OCGT); natural gas with CCS; nuclear; biomass; hydro; onshore wind; offshore wind; solar thermal; solar thermal-gas hybrid; solar thermal with storage; large scale photovoltaic (PV); hot fractured rocks (geothermal); wave; and ocean current (tidal);
- Seventeen distributed generation (DG) electricity plant types: internal combustion diesel; internal combustion gas; gas turbine; gas micro turbine; gas combined heat and power (CHP, also known as co-gen); gas micro turbine CHP; gas micro turbine with combined cooling, heat and power (CCHP, also known as tri-gen); gas reciprocating engine CCHP; gas reciprocating engine CHP; rooftop PV; biomass CHP; biomass steam; biogas reciprocating engine; wind; natural gas fuel cell CHP and hydrogen fuel cell;
- Trade in electricity between National Electricity Market regions;
- Assignment of a vintage in annual increments for all centralised electricity generation plant, based on when they were first purchased or installed;

- Four electricity end use sectors: industrial; commercial & services; rural and residential; and
- Representation of time in annual frequency (2006, 2007, …, 2050).

All technologies are assessed on the basis of their relative costs subject to constraints such as the turnover of capital stock, existing or new policies such as subsidies and taxes. The model represents real world investment decisions by simultaneously taking into account:

- The requirement to earn a reasonable return on investment, represented as a discount rate, over the life of a plant;
- That the actions of one investor or user affects the financial viability of all other investors or users simultaneously and dynamically;
- That consumers react to price signals (price elastic demand);
- That the consumption of energy resources by one user affects the price and availability of that resource for other users, and the overall cost of energy services; and
- Energy and transport market policies and regulations.

The model evaluates uptake on the basis of cost competitiveness but at the same time takes into account the key constraints on the operation of the electricity market (for example demand-supply balance, need for peaking plant), current policy settings (for example Renewable Energy Target), existing stock of plant in each state, and lead times in the availability of new plant. It does not into account issues such as community acceptance of technologies. However, this could be incorporated by imposing various scenario assumptions which constrain the solution to given limits.

In this paper, each scenario was implemented by imposing a constraint in ESM to force an increasing share of renewable electricity generation as prescribed in the scenario definition above.

2.3 Direct employment multipliers

Direct employment includes those jobs created in the design, manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration (Wei *et al.*, 2010). Direct employment multipliers for different electricity generation technologies are presented in numerous studies and there is considerable variation in the estimates revealed (for example, ACIL, 2000; EPRI, 2001; Greenpeace, 2001; REPP, 2001, 2006, 2006; CALPIRG, 2002; REN21, 2005; WGA, 2005; CEC, 2006; McKinsey, 2006; Bezdek, 2007; CofFEE, 2008; EWEA, 2008; Access Economics, 2009; Friedmann, 2009; Climate Institute, 2011; EPIA 2006; NREL, 2006). This paper follows the approach used in (Kammen *et al.*, 2004) and (Wei *et al.*, 2010) to normalise the data from each study.

This approach considers two job function groupings: (1) construction, installation, and manufacturing (CIM); and (2) operations, maintenance, and fuel processing. Items in the first group are typically reported in “job-years per MW installed” or equivalently, “job-years per peak (or nameplate) MW” while the second group is reported in jobs per peak MW over the lifetime of the plant. To combine one-time employment (for example installation) with ongoing employment an average over the life of the project is calculated.

By converting the CIM job-years per peak MW to *average* jobs per megawatt over the lifetime of the plant, the two can be combined. Jobs per peak megawatt (MWp) is normalised to total jobs per average megawatt (MWa) by dividing jobs per peak megawatt by the capacity factor, where the capacity factor is the fraction of a year that the facility is in operation (obtained from ESM). This follows since lower capacity technologies will have to build more plants than higher capacity technologies to deliver the same output.

This averaging technique has the advantage of providing a simple metric for comparing employment for different technologies. Annual employment for a given technology is calculated based on only two parameters: annual output energy (in GWh) and the employment multiplier (in job-years per GWh). This simplicity enables a straightforward implementation of a jobs model without having to track the exact details of combining one-time employment activities with ongoing employment on a year to year basis, and the approach converges to the correct number of cumulative job-years after several years. The disadvantage is that it underestimates total employment for a technology that is growing rapidly (for example renewable energy technologies), while it overestimates employment for a technology that is reducing capacity.

Table 2 shows the direct employment multipliers used in this paper. Given the variation in estimates from the literature an average for each technology in ESM was calculated similar to the approach of (Wei *et al.*, 2010).

Table 2 Direct employment multipliers (Total person years per GWh)

Type of energy	Multiplier
Brown coal	0.12
Brown coal CCS	0.18
Black coal	0.10
Black coal CCS	0.18
Gas CCGT	0.06
Gas OCGT	0.16
Gas CCS	0.18
Biomass	0.16
Wind	0.20
Hydro	0.08
Solar Thermal	0.27
Large PV	0.31
Geothermal	0.19
Wave	0.10
Tidal	0.06
Gas Co/Tri Gen	0.13
Rooftop PV	1.15
Biogas	0.79
Diesel	0.13

2.4 Input-Output analysis

The employment multipliers discussed in the previous section refer to direct employment as a result of electricity generation. However, employment effects spread wider than just direct employment. Upstream and downstream suppliers will benefit from electricity generation activity which will create further employment (indirect employment). Moreover, the incomes generated in the electricity generation sector will lead to expenditures, which create further employment elsewhere in the economy (induced employment). Consequently, to appreciate the full employment impacts of changing the share of renewables in total electricity generation, direct, indirect and induced employment effects need to be accounted for.

To estimate all three employment sources, we employ the standard analytical technique of Input-Output (IO) analysis. IO analysis reveals the employment interrelations between different industries based on interdependencies in the production process. For example, assume Sector A uses outputs from Sector B as an input. An IO analysis allows us to estimate the impact of a production decrease in sector A on sector B's output, which – using average sectoral productivity – can be translated into full time equivalent employment. We use the most recent IO tables for Australia for 2006-2007 (ABS, 2010). We use (ABS, 2011b, ABS, 2011a), to (1) update the 2006-2007 model to 2011; and (2) allow a state level decomposition. We therefore assume that the IO multipliers are fairly robust over time and space.

We can use the IO model to estimate total direct, indirect and induced employment in 2011 which is generated by the electricity generation sector. Subsequently, we use the 2011 electricity generation industry mix (in terms of its resource use) and the direct employment multipliers from Section 2.3 to establish direct employment effects. The difference between both measures must represent the indirect multiplier employment effects of electricity generation (that is, indirect employment plus induced employment). We find that the indirect employment multiplier effect is 0.96. That is, for every full-time (FTE) job generated in the electricity generation industry another 0.96 jobs are created elsewhere in the economy. Consequently, whilst about 30,000 full-time jobs existed in 2011 in the electricity generation sector, another 30,000 jobs were created indirectly because of the activity in the electricity generation sector, implying the sector 'provides' 60,000 full time jobs to the Australian economy.

In Table 3 we present slightly different figures. Here we concentrate on the employment effects of the non-renewable industry. Since this is the part of the electricity generation that will be phased out according to the scenarios described in Section 2.1, Table 3 gives the total number of jobs involved in this phasing out. For Australia, this amounts to just over 50,000 jobs (or 0.51 per cent of total employment), which is 83 per cent of total employment generated by the sector. This is indicative of the current reliance on non-renewables. However, we also note stark differences between states. Whilst the phasing-out of the non-renewable electricity generation industry affects nearly 1 per cent of total employment in the Queensland economy, the same exercise would leave the Tasmanian economy nearly intact.

Table 3 FTE jobs involved in non-renewable electricity generation industry, 2011

	Australia	NSW+ACT	VIC	QLD	SA	WA	TAS	NT
Agriculture, Forestry and Fishing	321	90	69	116	18	26	1	2
Mining	2,832	792	608	1,025	158	226	7	16
Manufacturing	5,020	1,404	1,078	1,816	280	401	13	28
Electricity, Gas, Water and Waste Services	23,100	6,460	4,958	8,359	1,286	1,847	60	129
Construction	5,611	1,569	1,204	2,030	312	449	15	31
Wholesale Trade	1,390	389	298	503	77	111	4	8
Retail Trade	952	266	204	344	53	76	2	5
Accommodation and Food Services	719	201	154	260	40	57	2	4
Transport Postal and Warehousing	3,126	874	671	1,131	174	250	8	17
Information, Media and Telecommunication	694	194	149	251	39	55	2	4
Financial and Insurance Services	1,393	389	299	504	78	111	4	8
Rental, Hiring and Real Estate Services	263	73	56	95	15	21	1	1
Professional, Scientific and Technical Services	3,040	850	652	1,100	169	243	8	17
Administrative and Support Services	1,010	283	217	366	56	81	3	6
Public Administration and Safety	369	209	160	0	0	0	0	0
Education and Training	146	41	31	53	8	12	0	1
Health Care and Social Assistance	12	3	3	4	1	1	0	0
Arts and Recreation Services	121	34	26	44	7	10	0	1
Other Services	1,611	450	346	583	90	129	4	9
Total	51,730	14,519	11,144	18,652	2,871	4,121	135	288
As percentage of total FTE employment	0.51	0.45	0.46	0.93	0.42	0.39	0.07	0.26

3. Results

This section briefly discusses the optimal technology mix under the two scenarios prior to discussion of employment effects.

3.1 Technology mix

Scenario I posits that the electricity sector decarbonises by 2050, assuming a linear increase from 20 per cent renewable share in 2020 under existing policy settings to 100 per cent share by 2050. Figure 1 shows the optimal national electricity generation technology mix from ESM.

Figure 1 shows that over the near-term there is an expansion in renewable generation mainly in onshore wind, biomass, geothermal and rooftop PV to meet the existing Renewable Energy Target by 2020 and an increase in gas-fired generation to 2035. Existing brown (black) coal-fired generation is phased-out around 2025 (2035) with some deployment of coal CCS technologies during that period. To achieve zero emissions by 2050, significant deployment of large scale PV and solar thermal plants are required.

Scenario II posits that the electricity sector decarbonises by 2035, assuming a linear increase from 20 per cent renewable share in 2020 under existing policy settings to 100 per cent share by 2035. Figure 2 shows the optimal national electricity generation technology mix from ESM.

Figure 2 shows a similar deployment profile to 2020. Existing brown (black) coal-fired generation is phased-out around 2025 (2035) but given the 100 per cent renewable constraint from 2035 no deployment of CCS technologies occurs. The main difference is greater deployment of large scale solar thermal plants with storage, and to a lesser extent PV and wave.

3.2 Employment effects of the two scenarios

Having explained the renewable transition for both scenarios, we can look at the employment consequences of both scenarios throughout the transition period. We note there are two factors contributing to employment change during the transition period. First, changes in the energy mix used to produce electricity may lead to changes in employment through differences in direct employment multipliers as outlined in Section 2.3. Secondly, the overall consumption (and hence production) of electricity is projected to increase overtime, which will also affect employment levels.

Since the latter effect will happen regardless of a transition towards renewables, we will discuss both employment effects separately, before wrapping up total employment effects of the renewables transition.

Figure 3 graphically presents the summary results in Table 1. Employment profiles are shown for each scenario by non-renewable and renewable jobs from the 2010 baseline until 2050. Under both scenarios, renewable energy employment overtakes non-renewable employment by 2019.

By the end of the forecasted adjustment period, total employment arising from the transition rises to around 283 thousand workers (split between 144 thousand directly employment and 138 thousand indirect jobs). Clearly the transition to renewable is more rapid under Scenario II.

Figure 1 Optimal national technology mix for Scenario I

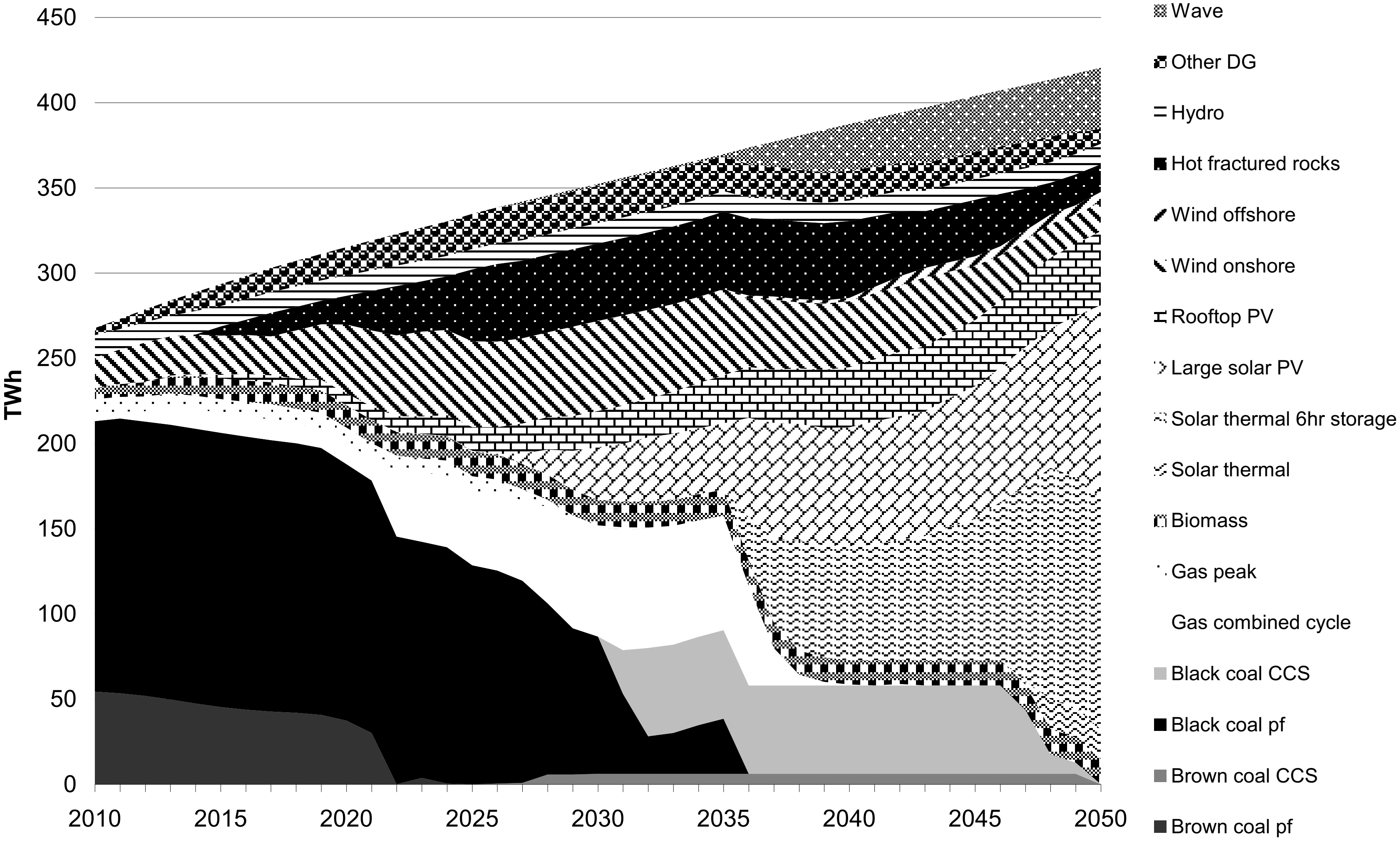


Figure 2 Optimal national technology mix for Scenario II

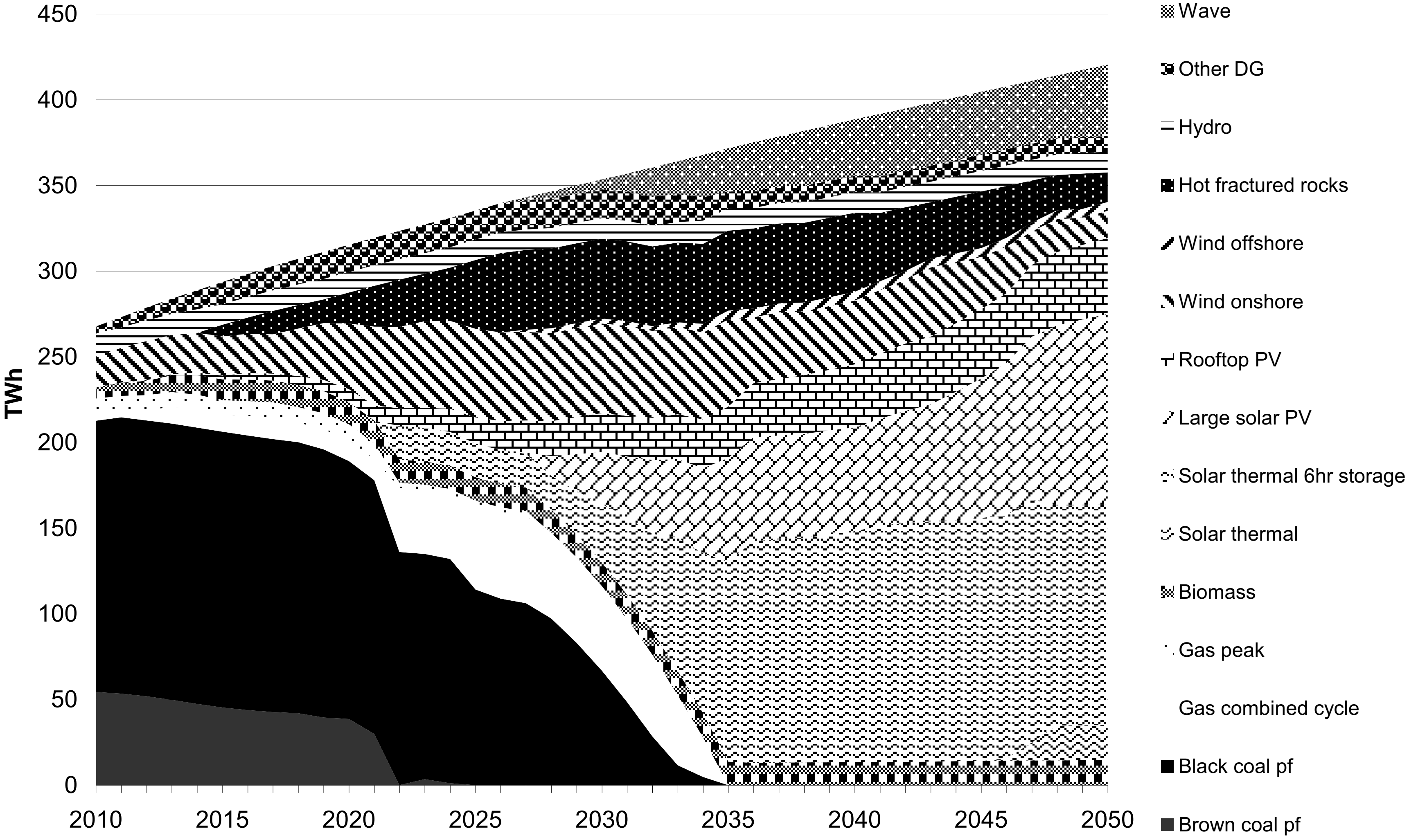
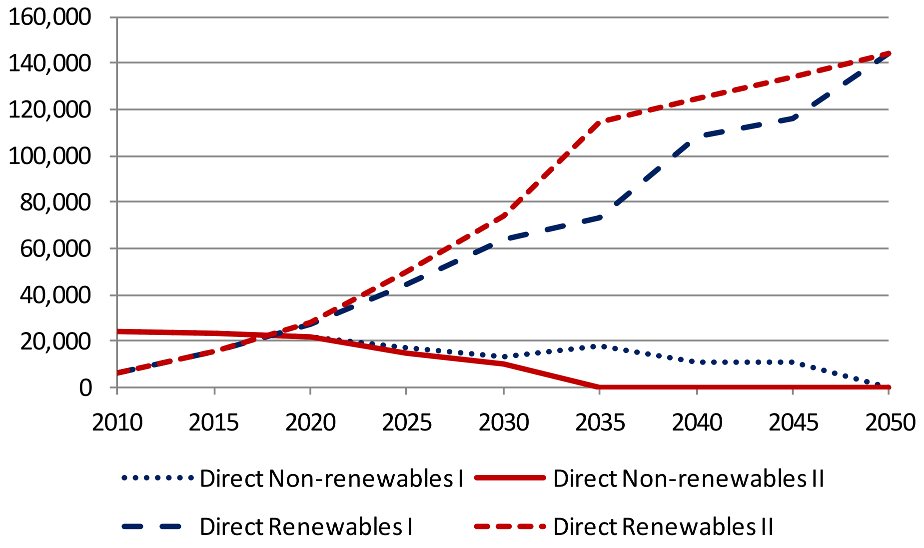


Figure 3 Direct employment effects for Scenarios I and II, 2010-2015



Source: see Table 1.

Table 4 provides a different perspective of the direct job implications by expressing employment effects per GWh of produced electricity as a consequence of the transition towards non-renewables for Australia and its states under each Scenario. The growth of direct employment per GWh of produced electricity is expressed in index number form where 2010=100 and as full-time equivalents. The data thus shows the contribution of changes in the energy mix to employment growth. Since renewables are generally more labour intensive than non-renewables, it should not come as a surprise that we see a sharp increase in employment overtime. For Australia, the analysis predicts a tripling of employment per GWh of produced electricity between 2010 and 2050 under Scenario I. The smallest employment gain per GWh is projected for Tasmania which is the case because it already has a significant renewable industry, implying its renewables transition is only moderate. The Northern Territory will see – in relative terms – the largest employment gain per GWh, because at present it relies heavily on gas-fired generation, which has the lowest labour intensity of all resources used in electricity generation.

There is very little difference between the two scenarios in this regard. Under Scenario II, the road towards a 100 per cent renewable electricity generation sector is bumpier and shorter than under Scenario I. The bumps arise under Scenario II because existing non-renewable plants are shut down abruptly once they are written off and replaced immediately by non-renewables, which leads to employment shocks. Since most non-renewable plants are written off by 2035, the transition is obviously shorter under Scenario II.

The variations in employment growth reflect the projected regional variations in energy production increases up until 2050. The modelling assumes an increase of energy production for Australia of about 60 per cent from 2010 levels although this increase is not uniform across the states. For example, Queensland is predicted to double its production from 2010 levels, exploiting its comparative advantage in renewable resources. Victoria is predicted to experience the lowest increase in electricity production.

Table 4 Direct FTE jobs per GWh for Scenarios I and II, Index 2010=100, 2010 – 2050

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Scenario I									
Australia	100	116	138	161	193	218	270	277	303
NSW+ACT	100	130	150	155	170	198	278	292	327
Victoria	100	112	131	147	157	167	199	203	232
Queensland	100	102	116	143	208	235	293	297	316
South Australia	100	131	157	206	239	279	334	374	408
Western Australia	100	115	151	211	259	294	308	312	333
Tasmania	100	102	112	141	136	182	226	217	225
Northern Territory	100	223	388	431	471	492	519	521	560
Scenario II									
Australia	100	117	139	169	208	271	282	291	302
NSW+ACT	100	130	148	162	202	286	298	311	316
Victoria	100	112	132	143	149	196	201	212	235
Queensland	100	102	121	162	231	316	312	316	318
South Australia	100	130	156	197	246	294	346	356	392
Western Australia	100	117	151	236	274	296	307	317	335
Tasmania	100	102	107	132	129	166	224	224	231
Northern Territory	100	230	388	463	493	556	557	558	565

Source: Authors' calculations.

Table 5 Direct and indirect FTE jobs for Scenarios I and II, Index 2010=100, 2010 – 2050

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Scenario I									
Australia	100	127	162	201	254	301	390	417	475
NSW+ACT	100	138	183	183	204	258	353	382	457
Victoria	100	114	138	171	199	205	251	268	316
Queensland	100	122	146	200	310	373	518	556	607
South Australia	100	161	185	261	331	406	522	519	624
Western Australia	100	129	182	276	357	426	467	495	548
Tasmania	100	101	114	160	154	225	328	353	363
Northern Territory	100	239	436	505	572	617	672	697	776
Scenario II									
Australia	100	128	163	212	275	376	409	440	474
NSW+ACT	100	139	171	193	245	402	405	434	455
Victoria	100	116	150	161	174	248	254	277	319
Queensland	100	120	153	230	362	446	519	561	594
South Australia	100	160	186	265	359	486	580	608	672
Western Australia	100	130	181	309	378	429	466	504	551
Tasmania	100	101	109	142	144	232	323	325	345
Northern Territory	100	246	436	542	601	707	731	752	783

Source: Authors' calculations.

Table 5 shows the regional variations in total employment growth (direct and indirect) under the two scenarios. By the end of the transition, the modelling predicts that there would be nearly five times as many jobs attributable to the electricity generation sector Australia-wide than at present. The Northern Territory will see an eightfold increase in employment, while Tasmania and Victoria will see a 3 to 3.5 times increase in their employment as a result of the transition to renewables.

However, in this analysis we assume that the indirect employment multiplier remains constant at 0.96. Given the considerable change in the structure of the electricity generation industry, that multiplier is unlikely to remain constant. Unfortunately there is no reliable data available on what that multiplier would look like in a world of pure renewable electricity generation.

4. Policy implications – the need for a Just Transition framework

Overall, the analysis shows that there will be significant gains in employment in the electricity industry under either scenario modelled. This comes about because there is likely to be a growing consumption (and production) of electricity over time (population growth etc) and because renewable energy production is more labour intensive (so the change in mix of energy production creates employment growth).

So while the future employment prospects involved in both scenarios are excellent there will still be winners and losers both at the personal and community level. To manage the structural adjustment that will be involved an appropriate policy framework must be developed and implemented.

CofFEE (2008) developed a detailed framework for managing ‘Just Transition’ to a lower carbon-dependent economy that protects local communities and environments during the period of massive structural change. It was argued that any major change in industry mix requires governments at all levels to play a critical role in fostering such a just transition. Several key principles emerge in this context that should form part of the policy intervention.

In general, CofFEE (2008) indicated that the policy mix must attempt to address several basic issues, which include ensuring that:

- There is on-going technological progress via research and development to reduce the economic cost disadvantage associated with renewable energy. A major federal government funding boost for research and development in renewable energy and energy efficiency would boost its international reputation in these technologies and facilitate local industry development. Support for innovation and partnerships for new local industries, research and development and an infrastructure investment is required.
- Barriers which prevent investment in and take-up of renewable energy are reduced. Scale disadvantages can be overcome, in part, by adopting an export strategy. Provision of first class public infrastructure including transport systems, port capacity and communication systems is crucial in this regard.
- Where regional dislocation might occur, State and Federal governments should work together to ensure that new infrastructure that can support renewable energy production and distribution which would attract industry clusters and skilled labour is provided. Cheap loans and subsidies for new industries and employers would provide further incentives for the redistribution of resources away from carbon to renewable. There should be relocation assistance for displaced workers and special targeted support for older, disabled and less educated workers. In all cases, there should be extended periods of income maintenance and adequate redundancy entitlements and retraining allowances

provided. The governments should provide compensation and equipment buy-outs for contractors unduly disadvantaged by the transitions. Adequate notice of workplace change and closures and consultation and full engagement of relevant unions is required.

- Human capital development keeps pace with the investment in renewable energy capital to reduce the chance of skilled labour bottlenecks inhibiting innovation and implementation. Targeted initiatives in the area of renewable energy skills are desirable and would require improved Government/industry collaboration. The State TAFE system is ideally placed to offer new training courses in renewable energy, with linkages into schools and potential employers. A significant boost in funding is needed to support quality teaching, to attract students and engage employers. A just transition requires investment in training programs and apprenticeships to create a highly trained 'green' workforce.
- An appropriate social safety net should be put in place to smooth the labour market transitions from fossil fuel based industries to renewable energy industries. Training and alternative employment tailored to local and individual needs and opportunities should be prioritised. We recommend the introduction of a Job Guarantee is essential to ensure that everyone who wants to work and is currently unable to find employment is provided with productive work by the public sector at the minimum wage. This buffer stock of jobs would work on community development and environmental restoration projects (as an example) and guarantee income stability as the transition ensues. Further, social infrastructure in the form of community development and adequate housing and recreation is required.

5. Conclusion

This paper has estimated the direct and indirect employment impacts of a transition to a decarbonised economy with a focus on the electricity generation and mining sectors. The Energy Sector Model (ESM) is used to estimate the change in technology mix in the electricity generation sector under two renewable uptake scenarios. Direct employment multipliers derived from literature review are then used to calculate net employment impacts in the electricity generation sector from the transition away from non-renewable primary energy sources. Input-output analysis is employed to estimate the indirect employment impacts on other industry sectors.

Two scenarios are modelled which sees the electricity sector decarbonises by 2050 (Scenario I) and 2035 (Scenario II) with a linear increase from 20 per cent renewable share in 2020 under existing policy settings to 100 per cent share by 2050 and 2035, respectively.

The paper finds that under each scenario significant employment gains will be achieved by the electricity generation sector which will also stimulate indirect employment gains via the input-output structure.

The employment gains occur because there is likely to be growing consumption (and production) of electricity over time (population growth etc) and because renewable energy production is more labour intensive (so the change in mix of energy production creates employment growth).

But this transition is unlikely to be smooth and there will be winners and losers both at the personal and community level. To manage the structural adjustment that will be involved an appropriate policy framework will need to be developed and implemented.

Following CofFEE (2008), the paper outlined the basics of policy framework to manage this adjustment process which is based on the principle of a 'Just Transition' which seeks to protect local communities and environments during the period of massive structural change. It was argued that any major change in industry mix requires governments at all levels to play a critical role in fostering such a just transition. Several key principles emerge in this context that should form part of the policy intervention.

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