

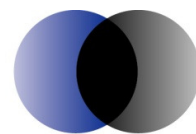
Confidential

Employment in the Renewable Generation Sector

Job opportunities in the
geothermal, solar, ocean and
wind power sectors

Prepared for the Australian Geothermal Energy
Association (AGEA)

June 2009



ACIL Tasman

Economics Policy Strategy

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1 Introduction

Background

The Australian Geothermal Energy Association (AGEA) engaged ACIL Tasman to carry out a study of direct and indirect employment in the renewable energy generation sector.

ACIL Tasman sought information on direct and indirect employment numbers from Australian renewable energy firms utilising (or planning to utilise) the following categories of power generation (a full list of firms and organisations who were asked to provide information is at Appendix A):

1. Geothermal energy plant
2. Solar energy (including solar thermal and photovoltaic plants)
3. Wind power plants
4. Ocean energy systems (including wave, currents and tidal energy)

The position of these firms on the innovation chain varies considerably. The wind energy firms are certainly the most mature group within the renewable energy sector. Many wind farms have been built and more are planned. Consequently the availability of employment data is relatively good.

Solar energy is probably the next most advanced. It is important to note that this report only considers the employment associated with larger plants built to supply electricity for distribution to end users via the electricity grid.¹ Examples include the Solar Systems plants in central Australia as well as the planned plant it is building with the support of funding under the LETDF scheme. We also consider also the potential employment associated with plants such as the one built by Ausra to provide a “solar boost” to the steam used to generate power at the coal fired plant at Liddell.

Ocean energy systems are at the point of deployment at the pilot or demonstration level. A number of different approaches to electricity generation using ocean energy have been developed.

In the case of geothermal energy, the most advanced firms are probably at a similar level of readiness to deploy their generation technology as the ocean energy firms. They have identified their energy resource and are at the point of

¹ In the case of solar energy there is of course already considerable use of solar energy for providing hot water as well as a large number of domestic roof top photovoltaic (PV) installations. In some jurisdictions, the emergence of favourable feed in tariffs for surplus electricity exported to the grid, coupled with installation subsidies, has seen rapid growth in the number of PV installations.

being ready to build their first pilot plant(s). Other geothermal energy firms are still only at the exploration stage.

Employment information sought

For each of the firms listed in Appendix A we sought their advice on the number of people likely to be directly employed by the firm during:

- the planning phase
- the construction phase; and
- the operation and maintenance phase.

In order to develop indices of employment per MW of installed capacity we also sought information on how many MW of installed capacity these employment numbers related to.

We also sought details on the nature of the employment involved. For example, what number of jobs are skilled versus unskilled, how many jobs in management versus operations, etc.?

The above questions provided data on direct employment opportunities. We also sought firms' estimates of indirect employment associated with their project(s). For example, employment by firms that provide materials or services (such as legal services, financial services, utilities, etc). Again, we sought their best estimates of the man days per year involved and how many MW of generation capacity the employment numbers related to.

Another area of employment that we explored was the research sector. We asked firms about their links to particular research groups. To the extent that any such links were identified we sought further information on their level of demand for services from the research sector and for their best estimate of the number of man days involved each year.

Finally, we asked firms to provide any other information that they might have that could assist ACIL Tasman in preparing this report.

The information was collected by emailing firms a list of questions. The contact details for the firms were either provided by AGEA or were from our own databases. If no response was received within two working days a follow up telephone call was made to the contact person.

Other Australian and overseas data

We also carried out a desk top search for Australian and overseas data on employment in the renewable energy generation sector. Our objective was to both ascertain the degree of concordance between our survey results and other

studies, and to obtain additional employment data to fill in any gaps in the information collected from the survey.

Data availability

Many of the firms surveyed for this study have not yet actually built a renewable energy generation plant. Therefore, the employment data collected is in many cases based on estimates by those renewable energy firms. Consequently, while these estimates are certainly well informed, the employment opportunities should be regarded as indicative.

Not all firms were able to respond to our request for information. Reasons for this included the relatively short time available to carry out the study and the nascent nature of some of the firms in the sector.

2 Australian employment data

The following sections summarise the employment information received from Australian renewable energy firms.

2.1 Wind

Table 1 **Employment in the wind sector – power generators**

	Employment Numbers
Generation Capacity	140 MW
Direct Jobs	
Component manufacture	120
Wind farm development	5
Construction/installation	170
Operation and maintenance	3
Total direct jobs	180
Direct jobs /MW	1.3
Direct O&M jobs/MW	0.02
Indirect Jobs	
Component manufacture	120
Wind farm development	35
Operation and maintenance	7
Consultants	20
Shipping/transportation	20
Total indirect jobs	202
Indirect jobs/MW	1.44

Data source: Roaring 40s

According to the data in Table 1 there are 3 people employed in the operation and maintenance of a 140 MW wind farm, or approximately 1 person for every 50 MW of capacity.

The University of Newcastle was the only research institution that provided employment information regarding the wind sector. The university employs four wind technology researchers. For three of these staff members, 50% of their research is associated with wind firms; and 100% for the other staff member.

2.2 Geothermal

Employment in the geothermal industry is estimated to reach around 380 people by the end of 2009.² This includes employment by geothermal firms, the research sector, and supporting industries. This figure does not include indirect employment.

Four geothermal firms provided information on estimated employment in association with potential generation projects (see Table 2).

Table 2 **Estimated employment in the geothermal sector**

Generation Capacity	Employment numbers				
	100 MW (a)	10.7 MW (b)	48 MW (b)	500MW (c)	260 MW (d)
Direct jobs					
Planning and exploration	18	10	29		141
Construction	50	30	87		182
Operation and maintenance	20	2	9		23
Total direct jobs	88	42	125	850	346
Direct jobs/MW	0.88	3.9	2.6	1.7	1.3
Direct O&M jobs/MW	0.20	0.19	0.19	n.a.	0.09
Estimated indirect jobs	114	55	162	1105	450
Estimated total jobs/MW	2	9	6	4	3

Note: Indirect jobs estimate based on multiplier of 1.3 indirect jobs for each direct job (see Table 10).

Data sources: (a) Torrens Energy, (b) Green Earth Energy, (c) Geodynamics (as advised by PIRSA), (d) Petrathern (employment numbers are based on maximum number employed in any one year)

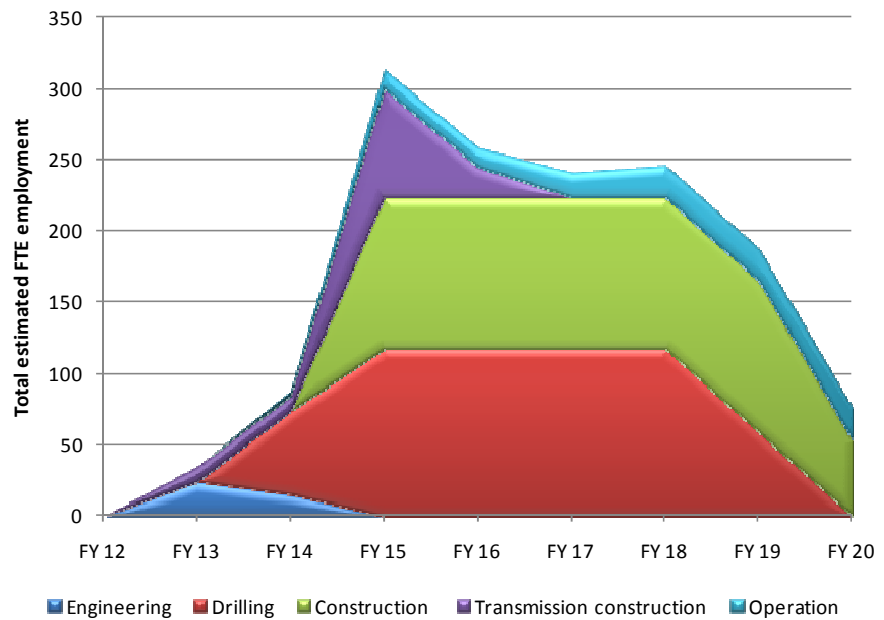
Table 2 illustrates that the total employment opportunity increases with generation capacity. However, economies of scale mean that employment per MW of capacity declines as total capacity increases.

ACIL Tasman also spoke to KUTh Energy. They estimated that at their highest point of activity, 10 people will be directly employed by the firm – with 2 jobs in management/corporate administration, 4 in operations and 4 skilled/technical workers. Indirect employment associated with the firm's projects at present is approximately three FTE staff, however this number will grow in future.

Figure 1 shows the pattern of estimated employment over time for Petrathern's proposed 260MW geothermal power plant. Total cumulative employment associated with the proposed 260MW plant is 1445 man years between 2013 and 2020.

² Personal communication with PIRSA, June 2009.

Figure 1 Estimated employment for a 260MW geothermal plant



Data source: Petratherm personal communication

Industry - research community links

Torrens Energy has research links with the University of Adelaide, University of Western Australia, University of Queensland, Melbourne University and Monash University. Green Earth Energy is currently investigating the potential for a research link with an unspecified university. They anticipate that the employment associated with the partnership would be three people with half being provided by each partner.

KUTh Energy has research links with the University of Tasmania.

Table 3 Employment in the geothermal sector – researchers

	Research staff	Percentage of research that is linked to geothermal firms' activity
University of New South Wales	3 postdoctoral fellows, 6 PhD, 1 administration	60%
University of Adelaide	20	30%
Melbourne University	5	
Monash University	1 staff member, 1 student	25%
University of Queensland	4 staff currently, 8 by the end of 2009.	100%

Note: ACIL Tasman did not receive responses from all research departments

ACIL Tasman also received information from a geothermal consultancy firm that employs 11 geoscientists - nine full-time, one at four days-a-week, and one

at three days-a-week. The company outsources machining, electronics, and software development work, averaging 3-4 man days a month, and hires a bookkeeper for 2 days per month.

2.2.1 An example of indirect employment

In the case of geothermal energy (and for some solar thermal installations) the temperatures being exploited are relatively low, generally in the range of 100 to 300 degrees Celsius. The Organic Rankin Cycle engine is a technology that is well suited for converting this lower temperature heat energy into electricity. Box 1 illustrates the potential impact on employment for one firm that is seeking to position itself to supply the Australian geothermal and solar thermal sectors.

Box 1 Organic Rankin Cycle (ORC) engine manufacturing

Air International Thermal Systems (AITS) is an Australian based company with over 40 years of specialist expertise in developing and manufacturing air-conditioning and engine cooling systems to the global automotive market.

AITS is seeking to expand its business into manufacturing Organic Rankin Cycle generators to meet the needs of renewable and waste heat power generation. AITS is primarily targeting 'medium grade heat' applications that are suitable for power generation such as - Thermal Solar, Geothermal, Bio-energy, Waste Heat sources with temperatures in the range 100 - 300° C.

AITS is offering an opportunity for an initial group of its customers to work closely with the firm as part of its staged growth plans. By working in close collaboration with a group of customers AITS aims to ensure that their ORC system package is fully optimised for their customers' specific applications.

AITS currently has a small team developing this new opportunity which has the potential to expand significantly by the end of the year if the opportunity is realised. The demand from geothermal and solar thermal generators will determine the rate that employment numbers can grow but is anticipated as significant if the company's expectations are fully realised.

In addition, AITS' suppliers (who provide components such as heat exchangers, generators, pumps, assembly units) are likely to grow at similar rates. Their employment will expand at similar rates in the short term if demand for ORC systems from geothermal and solar thermal generators begins to emerge

By way of comparison, some of AITS' overseas competitors in the ORC market currently employ between 100 and 400 persons and their suppliers employ a similar number.

Source: Personal communication, Air International - Thermal Systems, June 2009

2.3 Solar

One solar thermal firm provided data on employment (see Table 4).

Table 4 **Estimated employment in the solar thermal sector**

	Ausra
Generation Capacity	140 MW
Direct jobs	
Construction and manufacturing	900
Permanent/operation and maintenance	40
Total direct jobs	940
Direct jobs/MW	6.7
Direct O&M jobs /MW	0.28

Data source: Ausra

Ausra estimates that a 140MW stand alone solar thermal plant would create approximately 900 construction and manufacturing jobs, and 40 permanent jobs. This translates to 6.7 jobs per MW. Ausra have advised that they have strong research links with Australian research institutions and organizations including the Australian Solar Institute. They are seeking to become an active participant in the Australian Government's Solar Flagships Program.

2.4 Ocean

Two firms provided estimates of potential employment in the ocean energy sector. The results are shown in Table 5.

Table 5 **Estimated employment in the ocean energy sector**

	Carnegie	Oceanlinx
Generation Capacity	50 MW	250 kW
Direct Jobs		
Manufacturing, Construction and Commissioning	100	20
Operation and Maintenance (O&M)	7	3
Total direct jobs	107	23
Direct jobs/MW	2.14	92
Direct O&M jobs /MW	0.14	12

Data source: Oceanlinx and Power to Change: Australia's Wave Energy Future, Carnegie Corporation and WWF Australia, June 2009.

Carnegie estimate that by 2020 its anticipated 1500 MW of generation capacity will create around 3,210 direct and indirect jobs. The high number of employees /MW of capacity reported by Oceanlinx may possibly be due to a

Employment in the Renewable Generation Sector

combination of factors, including the still emerging nature of the technology and the lack of any significant economies of scale when building a relatively small plant.

Currently Carnegie has a significant research and development effort, and employs around 20 engineers, scientists and commercial staff. Carnegie also has research links with a number of Australian institutions and organizations including the CSIRO, Curtin University of Technology and Murdoch University³.

Table 6 University sector employment in the ocean energy sector

	Research staff	Proportion of research that is linked to power generating firms
University of Western Australia	1	10%
University of Queensland	2	No significant links, other than a small amount of consulting

Note: ACIL Tasman did not receive information from all research departments.

³ Note that no researcher employment data for these universities are included in Table 6.

3 Overseas employment data

ACIL Tasman has conducted a search for international information on employment opportunities associated with renewable energy generation. There are a number of reports that consider the employment associated with energy generation, including from renewables. A recent report by Access Economics pulled together some of the data.⁴ Results for renewables are shown in Table 7.

Table 7 **Estimated employment for new entrant generators**

Renewable technology	Construction (FTE/MW)	Operation (FTE/MW)
Wind	2.9	0.12
Geothermal	4.2	0.22
Solar thermal	4.9	0.15
Solar PV	10.2	n.a.
Ocean wave	5.6	n.a.
Ocean tidal	5	n.a.

Note: Employment numbers have been rounded to one decimal point.

Data source: MIT and EPRI as reported by Access Economics

The following sections discuss some of the additional employment information for various renewable technologies that we were able to identify.

3.1 Wind

Table 8 provides a good overview of employment within the European wind industry. The data in this table is solely for direct employment.

Table 8 **Wind power employment in Europe**

Country	Direct employment - 2007	Net Generating Capacity (MW) - 2006	Gross electricity generation (GWh) - 2007	Employees /GWh	Employees /MW
Austria	700	966	2,019	0.35	0.72
Belgium	2,000	212	520	3.85	9.43
Denmark	23,500	3,135	7,171	3.28	7.50
France	7,000	1,388	4,050	1.73	5.04
Germany	38,000	20,622	39,500	0.96	1.84
Greece	1,800	749	1,847	0.97	2.40

⁴ Access Economics report for the Clean Energy Council, *The net employment impacts of climate change policies*, June 2009.

Employment in the Renewable Generation Sector

Ireland	1,500	746	1,875	0.80	2.01
Italy	2,500	1,902	4,144	0.60	1.31
Netherlands	2,000	1,558	3,437	0.58	1.28
Spain	20,500	11,736	26,969	0.76	1.75
Sweden	2,000	516	1,430	1.40	3.88
United Kingdom	4,000	1,955	6,160	0.65	2.05

Data source: Employment data from: European Wind Energy Association, 2008. *Wind at work. Wind energy and job creation in the EU.* Net generating capacity and gross electricity generation from: IEA, 2008. IEA Statistics. Renewables Information, 2008.

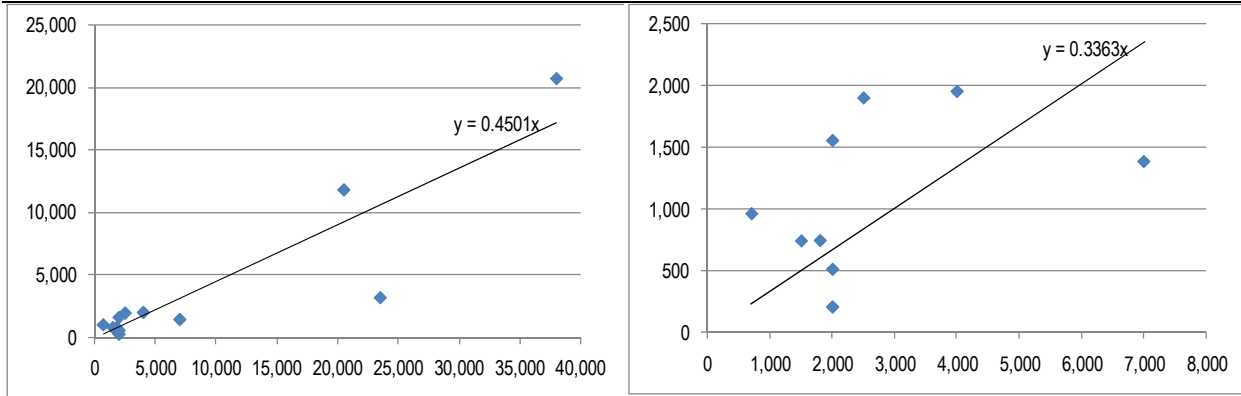
There is considerable variation in the employment data for wind shown in Table 7. Some of the variation may be due to economies of scale factors. However, it is possible that the way in which the data was collected and presented may also be behind some of the variation. We note that the report *Green Jobs and the Clean Energy Economy* suggested there were 2.6 jobs per MW of installed wind capacity.⁵ This figure is in line with that in Table 1.

An indicative illustration of the relationship between MW and employment is presented in Figure 2. The straight lines show the best fit linear relationship between the net generating capacity (MW) and employment. The left hand panel of the figure includes all countries from Table 8. The coefficient of 0.45 suggests a need for some two employees per additional MW of capacity.

The right hand panel of the figure excludes the data for Denmark, Germany and Spain, the three countries with the highest installed capacity. For this smaller sample of countries the coefficient is 0.33, suggesting that roughly three employees are taken on for each additional MW of capacity. Intuitively, the drop in employees per MW of incremental capacity as cumulative capacity increases makes sense since you would expect wind power firms to benefit from economies of scale and learning by doing.

⁵ Copenhagen Climate Council, Thought Leadership Series #4, May 2009

Figure 2 **Linear trend to the MW – Employment relationship - Europe**



Note: Linear trend with constant term equal to zero.

Source: ACIL Tasman

Table 9 lists both direct and indirect employment numbers for three countries based on data in a UNEP report. The figures in italics are derived based on the information for direct employment shown in Table 8.

Table 9 **Direct and indirect employment in the wind power sector**

	Total Employment	Direct Employment	Indirect Employment	Net Generating Capacity (MW) - 2006	Gross electricity generation (GWh) - 2006
Germany – 2006 (a)	82,100	38,000 (c)	<i>44,100 (d)</i>	20,622	30,710
Spain – 2007 (b)		20,500		11,736	26,969
United States – 2006	36,800	16,000	20,800	11,329	26,676

Note: a. Data includes direct and indirect jobs. b. Direct jobs only. c. taken from Table 8. d. derived figure

Data source: Employment data from: UNEP, 2008. Green Jobs: *Towards decent work in a sustainable, low-carbon world*. Net generating capacity and gross electricity generation from: IEA, 2008. IEA Statistics. Renewables Information, 2008.

The data in Table 9 suggest that for countries with large well established wind power sectors there is slightly more than one person indirectly employed for each person directly employed.

3.2 Geothermal

Geothermal Energy provides approximately 0.4% of the world's global power generation. At present, the largest markets are in the USA, Philippines, Mexico,

Indonesia, Italy and Iceland.⁶ Most of these markets are tapping near surface heat sources. Australia is seeking to use Enhanced Geothermal Systems to draw on sources of heat located at greater depths.

Installed geothermal capacity in Italy is about 810MW. With 420 MW of installed capacity, Iceland is a world leader in the use of geothermal energy. For example, geothermal energy supplies 89% of domestic heating demand. Iceland's geothermal resources are estimated to be sufficient for a generation capacity of 4000 MW. Turkey has an estimated capacity of electricity generation from geothermal sources of between 200 and 300 MW.

Geothermal electricity capacity in Europe is projected to be 1500 to 2000 MW in 2010. That figure is expected to increase to 4000 to 6000 MW by 2020.⁷

Table 10 lists the employment associated with the geothermal energy sector in the US. The data suggest that there are approximately 4 direct employees per MW of capacity and that for every person directly employed there are 1.3 persons indirectly employed. This is largely in accord with the data in Table 7.

Table 10 **Employment in the US geothermal energy sector**

	Total Employment	Direct Employment	Indirect Employment	Net Generating Capacity (MW) - 2006	Gross electricity generation (GWh) - 2006
United States – 2006	21,000	9,000	12,000	2,274	16,581

Data source: Employment data from: UNEP, 2008. Green Jobs: Towards decent work in a sustainable, low-carbon world. Net generating capacity and gross electricity generation from: IEA, 2008. IEA Statistics. Renewables Information, 2008.

3.3 Solar

It is more difficult to draw a link between employment and electricity generation capacity in the solar energy industry, particularly for photovoltaic power. There are well established solar industries in Germany and Spain that employ over 50,000 people in photovoltaic and 24,000 in thermal.

The data on PV generating capacity tell quite different stories. Possible reasons for this include that much of the industry in Spain's production is destined for exports rather than domestic use. It may also be due to how the use of PV modules for household generation is accounted for.

⁶ (European Geothermal Energy Council, 2008)

⁷ (European Geothermal Energy Council, 2008)

Employment in the Renewable Generation Sector

The PV employment numbers for Germany (9.5 employees/MW) are in line with those in Table 7.

Table 11 **Employment in solar photovoltaic**

	Total Employment	Direct Employment	Indirect Employment	Net Generating Capacity (MW) - 2006	Gross electricity generation (GWh) - 2006
Germany – 2006 a	26,900			2,831	2,220
Spain – 2007 b.		26,449		175	486
United States – 2006	15,700	6,800	8,900	697	15

Note: a. Data includes direct and indirect jobs. b. Direct jobs only

Data source: Employment data from: UNEP, 2008. Green Jobs: Towards decent work in a sustainable, low-carbon world. Net generating capacity and gross electricity generation from: IEA, 2008. IEA Statistics. Renewables information, 2008.

There are similar issues with the solar thermal employment numbers shown in Table 12. The data suggests that direct employment amounts to around 2.1 employees/MW and indirect employment is 2.8 employees/MW.

Table 12 **Employment in solar thermal**

	Total Employment	Direct Employment	Indirect Employment	Net Generating Capacity (MW) - 2006	Gross electricity generation (GWh) - 2006
Germany – 2006 (a)	13,300			-	-
Spain – 2007 (b)		9,142		-	-
United States – 2006	1,900	800	1,100	388	550

Note: a. Data includes direct and indirect jobs. b. Direct jobs only

Data source: Employment data from: UNEP, 2008. Green Jobs: Towards decent work in a sustainable, low-carbon world. Net generating capacity and gross electricity generation from: IEA, 2008. IEA Statistics. Renewables information, 2008.

California carried out a study of the economic impact of deploying concentrating solar thermal power technologies.⁸ The study compared the economic impact of solar thermal plants with natural gas power plants. It examined large-scale deployment scenarios where solar thermal plants were built between 2008 and 2020. It found that building between 2,000 and 4,000 MW of solar thermal capacity would create between 1,500 and 3,000 jobs. The implied employment per MW is less than half that calculated above.

⁸ L. Stoddard, J. Abiecunas, and R. O'Connell, *Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California*, Black and Veatch, April 2006

The study found that a solar thermal plant requires a workforce that is approximately two-thirds larger than a comparably sized combined cycle gas plant. It concluded that:

“ investment in CSP⁹ power plants delivers greater return to California in both economic activity and employment than corresponding investment in natural gas equipment.”

3.4 Ocean

With the exception of the figures quoted in Table 7, we were unable to identify any international reports that provided information on employment associated with ocean energy.

A June 2008 press report referred to the proposed construction of a 4 MW wave power plant off the coast of Scotland that was expected to employ about 50 people during the 18 month construction phase.¹⁰

⁹ Concentrating Solar Power

¹⁰ <http://news.scotsman.com/scotland/Turbine-marks-advance--for.4342160.jp>

4 Findings

Table 13 summarises the estimated direct employment opportunities for renewable energy technologies based on the various international sources of information discussed above as well as the results of a number of Australian reports and our own survey of Australian renewable energy firms’ construction plans and employment estimates.

Table 13 **Employment for various energy technologies (jobs/MW)**

	Wind	Geothermal	Solar PV	Solar thermal	Ocean
Direct employment (construction)	1.3 to 2.9	1 to 4	9.5 to 10.2	2.1 to 6.7	2 to 6
Direct employment (O&M)	0.02 to 0.12	0.10 to 0.22		0.15 to 0.28	0.14
Indirect employment multiplier	1.1	1.3	1.3	1.4	

Note: Figures are rounded to one decimal point.

Data source: ACIL Tasman

Direct employment opportunities associated with the construction of renewable energy plants vary considerably, both between different technologies and across the same technology. In general however, the newer (or “emerging”) technologies have higher upper bounds to their employment estimates.¹¹ The same is generally true of the employment opportunities associated with the operation and maintenance of renewable energy plants.

The data we have identified all points towards the number of indirect employees for all renewable energy plants being greater than the number of direct employees. Again the “emerging” technologies appear to have higher levels of indirect employment. This is not surprising since the emerging technologies are more likely to need stronger formal and informal links with other groups as they seek to bring their technology to market.

Our discussions with renewable energy firms have established that their links are particularly strong with research institutions. In addition, key firms that are hoping to become suppliers to emerging renewable energies are also actively seeking to build longer term relationships with the latter.

Finally, we would note that the discussion in this report has focussed on annual employment. The total number of man years of employment that are

¹¹ By “emerging” renewable energy technologies we are referring to the less mature technologies such as geothermal and ocean and to a lesser degree solar thermal and PV.

provided by the construction of a renewable energy plant will be determined by the number of years that it takes to build. Table 14 shows ACIL Tasman’s estimates of construction times for various renewable energy plants.

Table 14 Indicative information on renewable energy technologies

Generation technology	Capacity factor (%)	Construction lead time (years)	Other factors
Wind farms	20-40	1.5-2	<ul style="list-style-type: none"> • Mature technology • Intermittent generation • Poor correlation with heat waves
Geothermal	around 90	2-3	<ul style="list-style-type: none"> • Emerging technology • Australia at forefront of EGS^b technology • Potential baseload
Solar thermal	20-30	1.5 – 2.5	<ul style="list-style-type: none"> • Relatively mature technology • Daylight hours only (without storage) • Good correlation with heat waves
Solar PV	15-30	5-6 ^a	<ul style="list-style-type: none"> • Relatively mature technology • Daylight hours only (without storage) • Good correlation with heat waves
Ocean energy	depends on location	2-4	<ul style="list-style-type: none"> • Emerging technology • No commercial plant operational in Australia • Some technology variants can also provide desalinated water

Notes (a) Time is for Solar Systems 154MW plant and includes a period of time for technology optimisation (b) Enhanced Geothermal Systems

Data source: ACIL Tasman estimates

Based on the data in Table 13 and Table 14 the construction of a 100MW power plant of the different renewable energy technologies would have upper bounds on total cumulative employment over the construction of the plant as shown in Table 15.

Table 15 Estimated upper bounds for cumulative employment for the construction of a 100MW renewable energy plant

	Wind	Geothermal	Solar PV	Solar thermal	Ocean
Direct employment on construction /MW	2.9	4	10.2	6.7	6
Capacity (MW)	100	100	100	100	100
Annual employment	290	400	1020	670	600
Construction time (years)	2	3	6	2.5	4
Cumulative employment (man years)	580	1200	6120	1675	2400
Indirect employment multiplier	1.1	1.3	1.3	1.4	1 (a)
Total cumulative employment	1218	2760	14076	4020	4800

(a) ACIL Tasman would judge this multiplier to be a conservative estimate.

Note: The data in this table are upper bounds

Data source: ACIL Tasman estimates

The cumulative employment figures in Table 15 should be regarded as indicative upper bounds at best. The data does however suggest that the cumulative employment opportunities associated with power plants using emerging renewable energy technologies may be greater than those associated with more mature technologies.

Over time the construction times for emerging renewable energy technologies are likely to decline as firms “learn by doing”. This will of course reduce the cumulative employment associated with building power plants using these technologies.

A Renewable energy firms contacted

Table 16 List of contacted firms and organizations

Wind	Solar	Geothermal	Ocean	Universities
Acciona Energy	ANZSES	Hot Rock Ltd	Carnegie Corporation	University of Western Australia
AGL	ISES	Geodynamics Ltd	Oceanlinx	University of New South Wales
Roaring 40s	Solar Systems	Greenearth Energy Ltd		University of Adelaide
Sulzon Energy Australia	Ausra	Green Rock Energy Ltd		Melbourne University
TrustPower Ltd	IT Power Australia	KUTh Energy		Monash University
Vestas - Australian Wind Technology		Origin Energy		University of Queensland
		Panax Ltd		Australian National University
		Petratherm Ltd		University of Wollongong
		Torrens Energy Ltd		University of Newcastle
		Clean Energy Aus P/L		University of Western Sydney
		Granite Power Ltd		
		New World Energy Solutions		
		Hot Dry Rocks P/L		

We stress that not all the firms listed in Table 16 were able to respond within the short time frame allowed for this study.