Energy Efficiency and Conservation Authority

Research Project: How many jobs can be created by biomass for energy?

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EXECUTIVE SUMMARY

Renewable energy promotion has become a particular area of focus as policy mechanisms are developed to induce replacements for conventional fossil fuel energy sources – a major source of greenhouse gas emissions.

As part of the policy development process, it is important to assess the full range of possible implications of any policy changes. Recognising this fact, the Energy Efficiency and Conservation Authority (EECA) commissioned PA Consulting Group (PA) to investigate the implications for employment in New Zealand of direct heat biomass energy production.

1. Aim

The stated research objective was to determine "for every PJ/y of additional demand generated by biomass for energy in New Zealand how many jobs (FTEs) are created."

In order to achieve this EECA have requested a model be developed that assesses the employment contribution biomass can make to New Zealand. While this model will focus on biomass, EECA have expressed a desire for it to be flexible enough to be used with other renewable energy technologies in the future.

2. Project Outline

To achieve this aim a three phase approach was undertaken consisting of:

- A literature review,
- Development of a New Zealand specific model, and
- Application of the model to a New Zealand biomass project to create estimates of biomass job creation.

3. Literature review

The study begins with a review of the literature pertaining to the impact on employment of biomass renewable energy technology. The aim of the literature review was to develop:

- An understanding of the different methodologies used to estimate the impact of renewable energy projects on employment,
- An understanding of the applicability of these methodologies to New Zealand and an appropriate methodology to develop a New Zealand specific model, and
- A range of employment estimates to benchmark the model against.

The employment implications of biomass developments have been studied almost as much as the impacts on greenhouse gas emissions. As such information relevant to the study aims was relatively easy to come by. The key conclusions taken from the literature review were:

- Information gathered directly from a plant is the best way to estimate direct jobs.

- An input-output model is a commonly accepted and used method to determine the wider economic benefits of a project, such as indirect and induced jobs. The contribution of these jobs to total employment is significant and worth investigating.
- Region specific input-output tables allow for estimates specific to the region of interest.
- A range of estimates exist in the literature with differences explained by methodology, project type, region and treatment of the many methodological considerations identified.

4. Model development

Building upon the understanding developed in the literature review and discussion with EECA, PA developed an Input-Output model of the New Zealand economy that can be used to generate employment estimates. In brief the model:

- Takes a range of possible inputs that relate to bio energy projects such as project life, construction costs, fuel requirements, heat energy produced,
- Uses input output analysis, based upon New Zealand input-output tables, to assess the indirect and induced employment effects, and
- Reports estimates for total job creation per unit of biomass energy.

5. Model application and results

The final phase of the study involved applying the model to a New Zealand biomass project to generate employment estimates.

After reviewing information provided by EECA on New Zealand biomass projects, the waste energy solutions project in Nelson was selected as the representative case. This project takes biomass waste materials and converts them into wood pellets suitable for use in biomass direct heat plants.

The results are presented in terms of both primary and final energy. Here primary energy represents the energy content of the wood chips produced and thus is the best measure for assessing the demand created by direct heat (or other uses) for the biomass energy. However, the conversion process of the potential energy in the wood chips to heat is not perfectly efficient and thus the value of heat (considered final energy) is lower. We thus report the result in terms of final energy as well which provides a metric of the employment impact per unit of heat actually delivered (excluding costs and employment associated with conversion of wood chips to heat).

As a final point it should be noted that the employment impact of renewable energy is only one factor to be considered in policy making. This is particularly relevant when using the employment per unit of energy figures presented here. While a high level of employment per unit of energy may seem intuitively a positive result, if we simply think of the case of a less efficient plant (or a plant creating the same output but more expensive to build or maintain) we would generate higher employment impact numbers even though this less efficient plant is obviously less desirable.

The results are presented in Table 1:

Table 1 Estimates of biomass employment creation

	Lifetime Employment		Per unit energy produced in lifetime			
			Primary Energy		Final Energy	
	Total	Annual average	Job year / PJ lifetime	Job year / lifetime GWh	Job year / PJ lifetime	Job year / lifetime GWh
Total	**171.57**	**4.29**	**117.45**	**0.42**	**138.18**	**0.50**
- Direct	80.09	2.00	54.83	0.20	64.50	0.23
- Indirect	21.41	0.54	14.66	0.05	17.25	0.06
- Induced	70.07	1.75	47.96	0.17	56.43	0.20
Phase						
Construction Phase	8.97	0.22	6.14	0.02	7.23	0.03
Operating and Maintenance	162.60	4.07	111.31	0.40	130.95	0.47
Sector of employment						
At project	60.00	1.50	41.07	0.15	48.32	0.17
Agriculture, Horticulture and Fisheries	5.29	0.13	3.62	0.01	4.26	0.02
Forestry	0.37	0.01	0.26	0.00	0.30	0.00
Mining inc Oil and gas	0.30	0.01	0.20	0.00	0.24	0.00
Food manufacturing	3.56	0.09	2.44	0.01	2.87	0.01
Textile Manufacturing	10.73	0.27	7.34	0.03	8.64	0.03
Wood products manufacturing	0.98	0.02	0.67	0.00	0.79	0.00
Paper product manufacturing	2.18	0.05	1.49	0.01	1.76	0.01
Petroleum and chemical manufacturing	1.36	0.03	0.93	0.00	1.10	0.00
Metal and mineral manufacturing	2.55	0.06	1.74	0.01	2.05	0.01
Transportation Manufacturing	0.48	0.01	0.33	0.00	0.39	0.00
Machinery, equipment and other manufa	8.73	0.22	5.98	0.02	7.03	0.03
Electricity water and gas supply	1.28	0.03	0.88	0.00	1.03	0.00
Construction	5.67	0.14	3.88	0.01	4.56	0.02
Wholesale Trade	12.49	0.31	8.55	0.03	10.06	0.04
Retail Trade	18.99	0.47	13.00	0.05	15.30	0.06
Transport	4.40	0.11	3.01	0.01	3.54	0.01
Service - Insurance, financial, legal, busi	19.11	0.48	13.08	0.05	15.39	0.06
Government & Community Services	13.09	0.33	8.96	0.03	10.54	0.04
Total	**171.57**	**4.29**	**117.45**	**0.42**	**138.18**	**0.50**

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1. INTRODUCTION

1.1 BACKGROUND

Growing concern over climate change is driving public interest in the environmental impact of energy consumption. Renewable energy promotion has become a particular area of focus as policy mechanisms are developed to induce replacements for conventional fossil fuel energy sources – a major source of greenhouse gas emissions.

As part of this process, it is important to assess the full range of possible implications of any policy changes. This is particularly true in the current economic climate where economic and employment implications of policy assume even greater importance.

Recognising this fact, the Energy Efficiency and Conservation Authority (EECA) is interested in assessing the impact of renewable energy sources on the New Zealand economy, specifically the impact on employment.

To understand this impact EECA commissioned PA Consulting Group (PA) to undertake a research project of the implications for employment in New Zealand of direct heat biomass energy production.

1.2 AIM

The stated research objective was to determine "for every PJ/y of additional demand generated by biomass for energy in New Zealand how many jobs (FTEs) are created."

In order to achieve this objective, EECA have requested a model to be developed that assesses the contribution biomass can make to New Zealand employment levels. While the focus in the first instance will be on biomass, EECA have expressed a desire for the model to be flexible enough to be used with respect to other renewable energy technologies in the future.

1.3 PROJECT OUTLINE

To achieve the stated aim a three phase approach was undertaken consisting of:

- A literature review,
- Development of a New Zealand specific model, and
- Application of the model to create estimates of biomass job creation in New Zealand.

1.3.1 Literature review

The study begins with a review of the literature pertaining to the impact of biomass renewable technology on employment. The aim of the literature review was to determine:

- An understanding of the different methodologies used to estimate the impact of renewable energy projects on employment,
- An understanding of the applicability of these methodologies to New Zealand and an appropriate methodology to develop a New Zealand specific model, and
- A range of employment estimates against which to benchmark the model results.

1.3.2 Development of New Zealand specific model

Building upon the understanding developed in the literature review and discussion with EECA, PA developed an Input-Output model of the New Zealand economy that can be used to generate employment estimates.

The model development is discussed in Chapter 3 with a full user guide included in APPENDIX A:. In brief the model:

- Takes a range of possible inputs that relate to bio energy direct heat projects such as project life, construction costs, fuel requirements, heat energy produced,
- Uses input output analysis, based upon New Zealand input-output tables, to assess the indirect and induced employment effects, and
- Reports estimates for total job creation per unit of biomass energy.

1.3.3 Estimation of job creation from biomass in New Zealand

The model is then applied to a representative project, in this case the Waste Energy Solutions wood pellet plant in Nelson, to create job creation estimates for New Zealand.

These estimates are presented, compared with the literature, and discussed in Chapter 4.

2. LITERATURE REVIEW

The assignment began with a review of the literature pertaining to the impact of biomass renewable technology development on employment. The information gathered has been used to inform the development of the model and ultimately the results specific to New Zealand biomass.

2.1 AIM

The aim of the literature review was to develop:

- An understanding of the different methodologies used to estimate the impact of renewable energy projects on employment,
- An understanding of the applicability of these methodologies to New Zealand and an appropriate methodology to develop a New Zealand specific model, and
- A range of employment estimates against which the model results could be benchmarked.

2.2 FINDINGS

The employment implications of biomass developments are a reasonably well studied area. As such, information relevant to the study aims was relatively easy to come by. The literature also pointed to a number of difficulties in the development of employment estimates pertinent to the creation of New Zealand specific estimates. Findings from the literature review are discussed in more detail below.

2.2.1 Methodologies

Wei, Patadia and Kammen (2010) find that there are two common methods for assessing the employment effects of renewable energy projects: Input-Output top down models and analytical bottom up models. Our review of the literature suggests that general equilibrium and Keynesian multiplier techniques are also used. Further, while not a means of directly creating estimates, literature reviews are common in some reports as a means of creating a nationally scalable estimate. Each of these approaches is discussed below.

a. TOP-DOWN: INPUT-OUTPUT APPROACH

Input-Output models provide the most complete picture of the economy as a whole. They capture not only the direct employment created by the project but also the wider macro-economic effects of indirect and induced employment. Here, direct employment refers to jobs created at the project, such as operating and maintenance jobs; indirect jobs are those that are created in supplying sectors (and sectors supplying the suppliers); and induced jobs are those created by the employees spending the wages gained from extra employment.

Input output models, however, tend to be complex and opaque and suffer from the use of a number of simplifying assumptions. In particular, the level of aggregation applied will leave the model either complex (with little aggregation) or opaque (with a greater level of aggregation). Without direct and detailed information on the industry of interest a conflict between simplicity and realism is to be expected (Krajnc and Dormac (2007)).

Swenson (2006) offers a strong critique of the input-output approach used in the assessment of renewable projects. Concentrating on bio fuel production in Iowa, Swenson argues the large range of estimates available suggests great uncertainty; he points out a number of issues with these studies.[1] Specifically, Swenson points out input-output tables are based on outcome ratios that describe the magnitude of inter-industrial linkages and multiplier analysis is based on the assumption that as output increases inputs must increase according to these ratios. Of course, in practice the ratios are based on the current average production, and marginal changes may produce little or no difference to the demand for inputs; this is particularly true for industries with high economies of scale. Christopherson and Siversten (2009) warn of this being a particular issue with utility jobs such as natural gas, water and electricity.

Swenson does not, however, reject the basic idea of input output analysis as a means to generate the wider economic impacts of renewable projects. Instead Swenson adjusts the indirect effects in certain sectors based upon common sense and some degree of surveying, concluding with more conservative multiplier estimates.

b. BOTTOM UP: SURVEY OF BIOMASS PROJECTS

The bottom up approach focuses on the calculation of direct employment effects (Kammen, Kapadia & Fripp (2004)). This is usually done by examining existing projects such as in Hakkila (2004) or Thornley et al (2007).

The advantages of such an approach according to Saez, Leal and Linares (1996) are that it provides for transparency, consistency and comprehensiveness.

The obvious disadvantage to such an approach is that it ignores the indirect and induced employment effects which are significant contributors to employment in many studies (Wei et al). It can also be particularly site and technology specific (Saez, Leal and Linares)

c. GENERAL EQUILIBRIUM MODELLING

General equilibrium modelling can be thought of as an extension to the input-output approach (Ten Raa 2009). General equilibrium modelling estimates the wider macro-economic indirect and induced effects with a more sophisticated representation of the changes in production and behaviour of firms and households (improving the issue with cause and effect discussed previously).

General equilibrium models are, however, necessarily an order of magnitude more complex and opaque. In practice general equilibrium modelling is used when the negative impact on output and employment of higher energy prices, resulting from increased renewable usage, is of interest.

d. KEYNESIAN MULTIPLIER

Krajnc and Dormac (2007) use a Keynesian multiplier approach to the assessment of employment and spending increases resulting from increased biomass utilisation in Slovenia and Croatia. The multipliers are used in an attempt to capture indirect and induced effects similar to the input output analysis at a detailed regional level. The

[1] A relatively large range of possible estimates was also a feature of PA's literature review (as discussed in 2.2.3).

advantage of this approach is that it can be undertaken without the requirement of regional input-output tables.

However, this approach represents an oversimplification of the indirect and induced multiplier dynamics. Ten Raa explores the relationship between Keynesian multiplier and input output analysis, showing that input-output multipliers represent a micro-economic foundation to the macro-economic Keynesian multiplier.

Closer examination of the results produced by Kranjc and Dormac also show that they vary widely by region, due to differences in the large proportion of expenditure by business and households on products created outside of the regions and thus results are unlikely to be comparable to national level results.

e. LITERATURE REVIEW

A significant number of studies rely on literature reviews of other studies.[2] In the literature covered, a number of advantages from this approach were evident.

- A few studies such as Wei et al and Kammen et al undertake some of the work of converting competing studies into comparable estimates.
- Wei et al in particular uses a combination of studies in such a way as to produce results for biomass electrical plants based on information that only covers feedstock fuel job creation estimates.
- In some studies such as SEC (2005) information from separate studies based on different plant are combined to create average values specifically designed to be scaled to a higher level, presumably based on expert judgement.

2.2.2 Considerations

The literature survey also highlighted several considerations which must be addressed when undertaking employment estimation. These include:

a. QUALITATIVE ELEMENTS

Del Rion and Burguillo (2008) stress the importance of the qualitative elements of jobs creation:

- In the simplest terms this can take the form of the continuity of jobs, with short term impacts generally associated with construction less valuable than long term sustainable employment.
- The impact on specific sectors of the population can also be of interest. The impact on women, young people and long term unemployed can be of important to policy makers.

Sastresa et al (2010) suggests adjusting job estimates by a quality factor and presents a method for doing so.

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[2] A few source references could not be sourced, or sourced in English.

b. SECTORAL IMPACTS

Further to the above point about the qualitative components of jobs, the different sectoral impacts can be of interest. Del Rio and Burguillo also discuss the desirability of job creation in some sectors over others; this can be motivated by a desire to boost certain sectors, or simply a desire to promote high skill jobs. Kammem et al. also stress that the move from conventional to renewable energy is likely to see significant change in the sectors of employment which is likely to be of interest to the policy maker.

This area has been specifically highlighted by EECA as an area of interest and will need to be addressed in the model developed.

c. SUPPLY OF LABOUR

Tourolias et al. (2009) discuss issues with respect to the impact of the supply of labour in the context of conventional generation. They start with the assertion that in a perfectly competitive market the price of a good, such as labour, is equal to its opportunity cost. If this is true the wages of a newly employed person would be equal to the opportunity foregone (possibly in the form of a job already held or leisure time) creating no social benefit.

This theory is unlikely to hold in practice with forced unemployment observed in the real world. However Tourolias et al. suggest adjusting employment impacts for:

- The probability that any newly employed person came from the unemployed.
- The value of their leisure time given up if so, or their previous income if not.
- The value of health related consequences of the new employment versus the persons previous situation (unemployed or employed separately).

An important point here relates to the induced multipliers developed in input output analysis. The induced multipliers are based on the presumption that all the extra employment (both direct and indirect) generates wages that are then spent in the economy, if however, this additional employment represents people giving up other jobs with wages (or the unemployment benefit) the induced multiplier will not be as high.

d. THE COUNTERFACTUAL AND DISPLACED JOBS

As the previous two points suggest there are important issues to consider around the counterfactual. In particular with the creation of a biomass energy plant, it is important to think about the impact on conventional energy, and specifically whether any jobs will be lost from that sector. This issue will need to be addressed in a way that is specific to the exact type of project considered and the New Zealand context.

e. UNITS – CAPACITY VS ENERGY

Another consideration identified by Wei et al. is the use of peak capacity or energy[3] as the denominator in reporting employment impacts. This is particularly problematic when

[3] Wei et al actually refers to average megawatts, which, by converting peak capacity with a capacity factor, is an equivalent unit to energy.

comparing different technologies as some will generate more employment per peak megawatt than per unit of actual energy.

f. BOUNDARY ISSUES AND IMPORTS

Finally there are issues around the boundaries of interest for the study. Many studies (Weisbord (1996), Moreno and Lopez (2006), Sastresa et al. (2010) among others) focus on the impact on a local area and attempt to exclude the impact outside of that area. For the purpose of this report New Zealand is the area of interest, meaning only the impact on employment outside New Zealand will be excluded. This will need to be addressed when considering wider economic effects such as direct and induced jobs as some of the supply (or spending of wages) will be on imports which do not stimulate within region employment.

g. DEFINITIONS OF INITIAL, DIRECT, INDIRECT AND INDUCED EFFECTS

Definitions differ around the use of the terms initial, direct, indirect and induced. Miller and Blair (2009) classify these effects as follows:

- The initial effect: The extra demand for a good,
- The direct effect: The increase in production of supplying sectors to create the good,
- The indirect effect: All increases in further supplying sectors; and
- The induced effect: Effects associated with the increase in consumer spending from initial direct and indirect increases in consumer spending.[4]

However, more common in the literature is the inclusion of all jobs directly associated with the project, including project management, construction, operating and maintenance in the direct effect (Wei et al, Kammen et al., Tourkloias et al. among others), while increases in supplying sectors is considered the indirect effect.

2.2.3 Estimates

Table 1 summarises the estimates found in the literature.

As noted in several literature review studies (Wei et al, Kammen et al.) comparison between results is problematic for a number of reasons. Firstly, units differ greatly amongst studies, both in terms of jobs (hours, FTE, job-years, jobs per year, or unspecified jobs) and energy or production units (GWh, MW, 1000m3 of wood chips, tons of biomass production). Further, it is often hard to determine whether the number of jobs reported is per unit of energy per year or per unit of energy created over the life of the plant. Given these limitations conversion to a common unit has been undertaken where possible and is reported in Table 1.

Even after the simple consideration of units is taken into account the type of jobs included in the estimates often differs; obviously, the number of direct jobs is going to be significantly less than the total (including indirect and induced jobs) created by any project and thus it is difficult to know how to compare results for total job creation against simply direct job creation.

[4] Refer APPENDIX A: for discussion of different types of multipliers

Finally, and perhaps most importantly, some studies are based on specific plant whiles others adopt a more aggregate look at a country or region. This leads to different treatments of the specifics of plant details and further complicates comparison (e.g. one study may look at a specific biomass technology such as co-firing mill waste in coal plants, where other studies look at the contribution of biomass as a whole including all technologies and fuels).

2.3 CONCLUSIONS

There are several conclusions that can be taken from the literature review pertinent to the study going forward:

- Information gathered directly from a plant is by far the best way to estimate direct jobs.
- An input-output model is a commonly accepted and used method to determine the wider economic benefits of a project, such as indirect and induced jobs. The contribution of these jobs to total employment is significant and worth investigating.
- Region specific input output tables allow for estimates specific to the region of interest.
- There are a number of considerations to account for when developing a model or estimate of employment generated by renewable energy.
- A range of estimates exist in the literature with differences partially explained by methodology, project type, region and treatment of the many methodological considerations identified.

Table 2 Estimates of biomass employment gathered from literature

Study	Year	Location	Fuel	Technology	Jobs	Method	Estimate Range		Unit	Estimate lifetime jobs/ lifetime GWh	
Electricity production and combined heat and power (CHP)											
Scottish Executive	2005	Scotland	Wood fuel	CHP 2MW - 10MW and merchant power	Direct, Indirect, Induced	Literature Survey	26.1		Jobs years to 2020 per MW capacity in 2020		
SEC	2005	European Union	biomass co-firing (50%) biomass CHP installations (50%).	Bio-electric	Direct	Literature Survey	900		FTE per TWH - year 2010	0.9	
Kammen et al.	2004	USA	Biomass	Electric	Direct	Literature Survey	0.09	0.33	person years / GWh	0.09	0.33
Saez et al	1996	Spain		Bio - electric	Direct, Indirect	Bottom up and Input - Output	100	120	jobs per year / 20MW plant	0.67	0.81
Scottish Executive	2005	Scotland	Wood fuel	Co-firing	Direct, Indirect, Induced	Literature Survey	22.6		Jobs years to 2020 per MW capacity in 2020		
Barkenbus et al.	2006	TVA - US	Largely wood, but agricultural and mill residue (2% and 14%)	Co-firing	Direct, Indirect, Induced	Input - Output	0.71		Investment jobs per Gwh	0.71	
Barkenbus et al.	2006	TVA - US	Largely wood, but agricultural and mill residue (2% and 14%)	Co-firing	Direct, Indirect, Induced	Input - Output	0.85		Operating jobs per Gwh	0.85	
Perez-Verdin et al.	2008	Mississippi - USA	Wood biomass	bio electric	Direct, Indirect, Induced	Input - Output	4,328		MMBtu / person	0.80	
TREN	2000	European Union	Biomass	Biomass anaerobic	Direct, Indirect, Induced	Input - Output	0.19		FTE / Gwh	0.19	

Study	Year	Location	Fuel	Technology	Jobs	Method	Estimate Range		Unit	Estimate lifetime jobs/ lifetime GWh
TREN	2000	European Union	Biomass	biomass combustion	Direct, Indirect, Induced	Input - Output	0.08		FTE / Gwh	0.08
TREN	2000	European Union	Biomass	biomass gasification	Direct, Indirect, Induced	Input - Output	0.09		FTE / Gwh	0.09
Groscurth et al.	2000	Sweden	Forest residue and Sawmill waste	CHP	Direct, Indirect	Input - Output	0.45		h / MWh	0.23
Groscurth et al.	2000	Portugal	Forest residue and Sawmill waste	Industrial CHP	Direct	Bottom up	0.1		h / MWh	0.05
Groscurth et al.	2000	Portugal	Short rotation coppice	Industrial CHP	Direct	Bottom up	0.7		h / MWh	0.36
Moreno and Lopez	2006	Austrias Spain	Biomass	Electric	Direct, Indirect, Induced	Collaboration of sources	4.14		jobs / MW	0.56
Krajnc and Dormac	2007	Savinjska - Slovenia	Biomass	Just energy (excl. fuel)	Direct, Indirect, Induced	Keynesian Multiplier	14		jobs per 87 GJ of energy	
Krajnc and Dormac	2007	Karlovac - Croatia	Biomass	Just energy (excl. fuel)	Direct, Indirect, Induced	Keynesian Multiplier	8		jobs per 32 GJ of energy	
Wei et al	2010	USA	Biomass	Bio - electric	Direct	Literature Survey - In effect	0.19		Job years / GWh	0.19
Wei et al	2010	USA	Average of different fuels	Bio - electric	Direct	Literature Survey - In effect	0.22		Job years / GWh	0.22
Grebner et al.	2009		Biomass		Indirect, Induced	literature survey	1.45	5.2	Employment multipliers	
Thornley et al.	2008	USA	Biomass	Bio - electric	Direct, Indirect, Induced	Analytic model	1.27		man years/GWhe	1.27

Study	Year	Location	Fuel	Technology	Jobs	Method	Estimate Range		Unit	Estimate lifetime jobs/ lifetime GWh
Morris	1999	USA	Biomass	bio electric	Direct, Indirect	Not stated - assume survey	4.9		FTE per MW	0.66
Direct Heat										
Scottish Executive	2005	Scotland	Wood fuel	Domestic Boilers	Direct, Indirect, Induced	Literature Survey	18.2		Jobs years to 2020 per MW capacity in 2020	
Scottish Executive	2005	Scotland	Wood fuel	Industrial and commercial heating	Direct, Indirect, Induced	Literature Survey	16.9		Jobs years to 2020 per MW capacity in 2020	
SEC	2005	European Union	Boilers or small CHP (50%), large CHP, district and industrial heating (50%)	Bio-heat	Direct	Literature Survey	245		FTE per TWH - year 2010	0.25
Moreno and Lopez	2006	Austrias Spain	Biomass	Thermal	Direct	Collaboration of sources	0.13		jobs / tep	
Biomass fuel collection or production										
TEKES	2004	Finland	Small tree chips - mechanised cutting	Forest Chip Production	Direct and Indirect	Survey of existing operations	0.6		work years per 1000m3 of chip production	0.78
TEKES	2004	Finland	Small tree chips - manual cutting	Forest Chip Production	Direct and Indirect	Survey of existing operations	1.2		work years per 1000m3 of chip production	1.56
TEKES	2004	Finland	Stemwood chips - self employed forest owners	Forest Chip Production	Direct and Indirect	Survey of existing operations	2		work years per 1000m3 of chip production	2.60
TEKES	2004	Finland	Logging residual chips	Forest Chip Production	Direct and Indirect	Survey of existing operations	0.3		work years per 1000m3 of chip production	0.39
TEKES	2004	Finland	Stump chips	Forest Chip Production	Direct and	Survey of existing	0.35		work years per 1000m3 of chip	0.45

Study	Year	Location	Fuel	Technology	Jobs	Method	Estimate Range		Unit	Estimate lifetime jobs/ lifetime GWh	
					Indirect	operations			production		
Fraser Alexander Institute	2006	Scotland		Demand for wood fuel	Direct, Indirect, Induced	Input - Output	3.785		Total jobs for every one job in wood fuel demand		
Perez-Verdin et al.	2008	Mississippi - USA	Wood biomass	recovering residuals	Direct, Indirect, Induced	Input - Output	1712				
Krajnc and Dormac	2007	Savinjska - Slovenia	Biomass	Fuel production	Direct, Indirect, Induced	Keynesian Multiplier	11800		m3 of wood biomass per job	0.11	
Krajnc and Dormac	2007	Karlovac - Croatia	Biomass	Fuel production	Direct, Indirect, Induced	Keynesian Multiplier	5100		m3 of wood biomass per job	0.25	
REPP	2001	US	Switch grass	Biomass crop to station	Direct	Analytic model	0.31	0.558	h/MWh over ten years	0.16	0.29
REPP	2001	US	Poplar	Biomass crop to station	Direct	Analytic model	0.33	0.528	h/MWh over ten years	0.17	0.28
REPP	2001	US	Willow	Biomass crop to station	Direct	Analytic model	0.231	0.339	h/MWh over ten years	0.12	0.18
REPP	2001	US	Silver cultural Wood	Waste Biomass to station	Direct	Analytic model	0.287	0.449	h/MWh over ten years	0.15	0.23
REPP	2001	US	Mill residue	Waste Biomass to station	Direct	Analytic model	0.067	0.183	h/MWh over ten years	0.03	0.10
REPP	2001	US	Urban wood waste	Waste Biomass to station	Direct	Analytic model	0.087	0.34	h/MWh over ten years	0.05	0.18

2.4 REFERENCES

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3. INPUT-OUTPUT MODEL

3.1 MODEL DESIGN

Discussion with EECA on the results of the literature review led to the conclusion that information provided by a specific project, supplemented with a New Zealand specific input-output model, would be the most appropriate methodology to generate employment estimates. The advantages of such an approach are as follows:

- As shown in the literature review, a range of estimates exist with estimates differing substantially between geographic areas, making an approach specific to New Zealand desirable.
- The best estimates of jobs directly created from a project come from bottom up surveys of projects. Thus information provided directly from a New Zealand project would be the best approach to estimation of this impact.
- Input-output analysis allows for the estimation of the often considerable indirect and induced employment effects associated with renewable energy. The availability of Make and Use tables make the development of a New Zealand specific model possible.
- Such a model could in the future easily be applied to other projects including other renewables, an aim stated by EECA.

This section gives a brief introduction to the input output model developed, a complete user guide and detailed development documentation are included in APPENDIX A:.

3.2 MODEL INPUTS AND USE

The model inputs can be classified into three main groups:

- Technical output data: This is technical information about the plant used to determine its energy output.
- Employment directly associated with the project (and salaries): As discussed employment directly associated with the plant is best taken from an actual (or survey of several) project(s). This employment is broken down between temporary (i.e. initial project management and organisation, and ongoing operation and maintenance).
- Expenditure: Expenditure at each stage of the project (initial and ongoing) is required. This expenditure also needs to be broken down by commodity to be applied to the input output multipliers.

The model is flexible in the sense that it can be applied to any type of project so long as the above inputs are available.

3.3 MODEL MECHANICS

As discussed, the model is based upon input-output analysis. Input output analysis uses transaction information for a given year, in this case 2003, between industries to estimate how if final demand is increased, supplying sectors must increase their output (and sectors that supply these sectors increase their output and so on). In such a way the change in total output can be calculated from a change in final demand.

In this way the change in total output is calculated based on the expenditure information entered in the inputs section. The impact this will have on employment is then calculated by using the ratio of employees to total output in each sector.

In order to include the induced effect of the increased wages on employment, households are added as an extra sector in a method called closing the model.

It should be noted there are various assumptions associated with input output analysis that one must be comfortable with in order to interpret the results.

- Firstly an increase in demand for an industry's output will result in a proportionate increase in all its inputs. Thus no economies of scale exist for any industry and production mix is invariant to output quantity.
  - Further to this point any increase in total output of an industry proportionally increases employment in that industry.
  - This also applies to households which consumes goods in the same proportion as they did in the reference year with any increase in income.
- As we are only interested in the effect on New Zealand employment, imports as part of the production mix must be corrected for. (As it is assumed they do not contribute to New Zealand employment, transport, distribution, wholesale and retail are considered their own products/industries.)
- Each sector produces a single homogenous product with no substitution around the input or production of products (see APPENDIX A: for detailed discussion of the treatment of secondary products).
  - This includes households which supply a homogenous "labour" good[5] compensated by wages.
- A level of aggregation has been selected that strikes a balance between simplicity and the level of detail required, while being specifically targeted to the needs of this project and in line with the level seen in the literature survey. This point is important in light of the previous one that industries produce a homogenous good.
- It is also assumed that all employment created is not at the expense of existing employment, that is, there is no crowding out. This assumption is defensible on the basis that jobs created from biomass projects tend to be in rural, higher unemployment areas. However, while this may hold at the margin, if there were to be a large shift towards renewable energy this assumption may need to be reviewed.

3.4 MODEL RESULTS

The model reports the resulting increase in employment calculated from the data provided and the input-output analysis. The results are:

- Reported in jobs per energy output (with several different units).
- Broken down by direct, indirect and induced effects
- Broken down by industry as requested.

[5] Labour in this sense is denoted in dollar terms and not hours or effort which results are converted to in the end.

4. *MODEL APPLICATION AND EMPLOYMENT ESTIMATES*

Having established an appropriate model specific to the New Zealand economy, the next step is to apply this model to a representative biomass project. This will allow us to generate values which can be used to estimate the impact of renewable energy on biomass in New Zealand.

4.1 PROJECT SELECTION

The task then is to select a project from which to base the results of the study. The desirable criteria for such a project include:

- *Complete information available:* Complete information would be available on energy output, employment and expenditure
- *Scalability*: The project should be considered representative; such that results can be generalised to New Zealand as a whole.
- *Identification of counterfactual*: The state of the world, particularly as regards employment, if the project had not gone ahead should be able to be estimated.

After reviewing information provided by EECA on New Zealand biomass projects, the waste energy solutions project in Nelson was selected[6]. This project takes biomass waste materials and converts them into wood pellets suitable for use in biomass direct heat applications.

This project has the following advantages as a reference case:

- EECA is primarily interested in the effect of direct heat biomass on employment. However, the main result of installation of a direct heat biomass system is to replace a coal system. In practice this means little extra ongoing maintenance, operating expense or employment (with some small extra installation work) and instead means biomass is consumed instead of coal[7]. Thus it makes sense to target the analysis at the creation of the biomass fuel, in this case pellets, as this represents the main change to the status quo.
- Further to the above point, the displacement of coal provides an easily identifiable and addressable counterfactual. With the increase in biomass production, less coal is consumed. For the purpose of this report we assume that the reduction in coal does not impact national employment from coal production. This assumption can be thought of as either the reduction in consumption of imported coal, or equivalently any excess domestically produced coal is sold onto the export market. In either of these cases national coal production, and thus employment, is unchanged.
- The project has also provided a reasonable amount of information regarding the costs and direct employment associated with the project – the fundamental drivers of the models results.

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[6] All information on this project is sourced from Marchant (2009) Wood Pellet Plant Monitoring Report, produced for the Energy Efficiency and Conservation Authority (EECA).

[7] The biomass heat for schools scheme is a good example of this result.

- Discussion with EECA leads us to believe that the results for this project are representative of those that could be seen elsewhere in New Zealand and this represented a reasonable test case.

The estimates produced by examining the Waste Energy Solutions project will represent the increase of employment expected in New Zealand from the increase in demand for biomass (as opposed to heat energy generated from biomass, which is one step further down the supply chain). This result is in line with the desired aim of the study and should allow for easy application to possible future biomass projects.

However, the following must also be kept in mind when generalising results from this project.

- While the information provided by the project is reasonable, a few areas are crucially missing or underrepresented, including:
  - The expected operating life of the project is unknown and thus estimated from the literature.
  - Information on employees directly involved in the project construction phase, such as project management, is not reported.
  - Ongoing operating and maintenance costs are unknown with only limited estimates available.

  This missing information biases downwards the estimates reported here.
- While the project is considered representative in the whole this may not be true of the employment impact of gathering biomass residue. In the selected project biomass was already collected as part of the normal operation of the company, thus creating an easily accessible supply for the wood pellet plant. However, where this is not the case there would be employment associated with the collection of biomass. As seen in the literature survey this employment can be substantial, thus again this biases the results towards a lower estimate.
- Finally the majority of the results seen in the literature review refer to biomass electrical plant, which is a different proposition. This makes direct comparison of the results of this study to that seen internationally more problematic.

4.2 EMPLOYMENT ESTIMATES OF BIOMASS TECHNOLOGY IN NEW ZEALAND

Combining the selected test project with the input output model developed allows us to develop the estimates shown in Table 3 for biomass energy in New Zealand.

The results are presented in terms of both primary and final energy. Here primary energy represents the energy content of the wood chips produced and thus is the best measure for assessing the demand created by direct heat (or other uses) for the biomass energy. However, the conversion process of the potential energy in the wood chips to heat is not perfectly efficient and thus the value of heat (considered final energy) is lower. We thus report the result in terms of final energy as well which provides a metric of the employment impact per unit of heat actually delivered (excluding costs and employment associated with conversion of wood chips to heat).

Table 3 Employment estimates of biomass production at wood pellet plant

	Lifetime Employment		Per unit energy produced in lifetime			
			Primary Energy		Final Energy	
	Total	Annual average	Job year / PJ lifetime	Job year / lifetime GWh	Job year / PJ lifetime	Job year / lifetime GWh
Total	**171.57**	**4.29**	**117.45**	**0.42**	**138.18**	**0.50**
- Direct	80.09	2.00	54.83	0.20	64.50	0.23
- Indirect	21.41	0.54	14.66	0.05	17.25	0.06
- Induced	70.07	1.75	47.96	0.17	56.43	0.20
Phase						
Construction Phase	8.97	0.22	6.14	0.02	7.23	0.03
Operating and Maintenance	162.60	4.07	111.31	0.40	130.95	0.47
Sector of employment						
At project	60.00	1.50	41.07	0.15	48.32	0.17
Agriculture, Horticulture and Fisheries	5.29	0.13	3.62	0.01	4.26	0.02
Forestry	0.37	0.01	0.26	0.00	0.30	0.00
Mining inc Oil and gas	0.30	0.01	0.20	0.00	0.24	0.00
Food manufacturing	3.56	0.09	2.44	0.01	2.87	0.01
Textile Manufacturing	10.73	0.27	7.34	0.03	8.64	0.03
Wood products manufacturing	0.98	0.02	0.67	0.00	0.79	0.00
Paper product manufacturing	2.18	0.05	1.49	0.01	1.76	0.01
Petroleum and chemical manufacturing	1.36	0.03	0.93	0.00	1.10	0.00
Metal and mineral manufacturing	2.55	0.06	1.74	0.01	2.05	0.01
Transportation Manufacturing	0.48	0.01	0.33	0.00	0.39	0.00
Machinery, equipment and other manufa	8.73	0.22	5.98	0.02	7.03	0.03
Electricity water and gas supply	1.28	0.03	0.88	0.00	1.03	0.00
Construction	5.67	0.14	3.88	0.01	4.56	0.02
Wholesale Trade	12.49	0.31	8.55	0.03	10.06	0.04
Retail Trade	18.99	0.47	13.00	0.05	15.30	0.06
Transport	4.40	0.11	3.01	0.01	3.54	0.01
Service - Insurance, financial, legal, busi	19.11	0.48	13.08	0.05	15.39	0.06
Government & Community Services	13.09	0.33	8.96	0.03	10.54	0.04
Total	**171.57**	**4.29**	**117.45**	**0.42**	**138.18**	**0.50**

There are several points to take note of in regards to the results:

- Induced jobs make a very significant contribution; this is a result of the fact that the highest expenditure through the life is on salaries which count as inducing jobs (on top of the employment induced through increased output). Further, the areas of households expenditure are relatively labour intensive, creating a greater induced employment multiplier than an induced output multiplier. Intuitively this can be thought of as direct (and indirect) expenditure being on industries where labour is a relatively small input, such as machinery manufacturing, where induced expenditure from households is in areas such as government and community services where labour is a substantial input.
- For this same reason, indirect jobs make a relatively low contribution; the direct expenditure on non-labour items have relatively low labour intensity.
- The vast majority of jobs created throughout the lifetime of the project are in operating and maintenance (and the indirect and induced effect of these jobs).
- Due to the high proportion of induced jobs, a high proportion of employment created is in areas where household spending is high. These areas also tend to be relatively labour intensive.

Comparison to the results gathered in the literature review is difficult as many are focused on the conversion of biomass to electricity and report aggregated results. The project we have chosen, however, does not include the costs of building, maintaining or operating the biomass electrical, combined heat and power or direct heat plant.

Comparison to the results that report only the collection element of biomass electricity is again problematic. As discussed earlier this is not included in the chosen project as collection of biomass residue was already undertaken as part of the companies operation and information is not available on the employment involved.

These issues aside the results considered most comparable are collected for comparison in Table 4.

Table 4 Comparable estimates found in literature

Study	Note on comparability	Technology	Employment Estimate		Estimate in job years / GWh
Tekes (2004)	Estimate of direct and indirect employment associated with forest chip production. Converted to GWh using average forest chip energy content included in report.	Small tree chips - mechanised cutting	0.6	Man years / 1000 m3 of chip production	0.78
		Small tree chips - manual cutting	1.2		1.56
		Stemwood chips - self employed forest owners	2		2.6
		Logging residual chips	0.3		0.39
		Stump chips	0.35		0.45
Barkenbus et al. (2006)	Employment associated with production of biomass fuels. Includes direct, indirect and Induced.	Biomass production	3667	Total	0.38 (Final energy)
Grebner et al. (2009)	Multipliers associated with different aspects of biomass production	Recovery of residuals (high estimate)	2.92	Employment Multipliers	
		Recovery of residuals (low estimate)	2.15		
		Procurement of small diameter trees	1.45		

Table 4 demonstrates that the estimates developed in this report are roughly in line with the most directly comparable results found in the literature. The final value is very close to the value of Barkenbus et al. and the multiplier created by the model is in line with the values seen in Grebner et al. The value is also very close to the value for logging residuals derived by TEKES which appears to be a very comparable process. However, the TEKES result does not include induced jobs, a significant contributor to employment generated by the model, meaning the model estimates may be on the low side[8].

As a final point it should be noted that the employment impact of renewable energy is only one factor to be considered in policy making. This is particularly relevant when using the employment per unit of energy figures presented here. While a high level of employment per unit of energy may seem intuitively a positive result, if we simply think of the case of a less efficient plant (or a plant creating the same output but more expensive to build or maintain) we would generate higher employment impact numbers even though this less efficient plant is obviously less desirable.

4.3 SUGGESTIONS FOR EXPANSION OF STUDY

There are several areas in which value could be added through further investigation:

- Most importantly the operating and maintenance expenditure of the plant should be further investigated. The values provided likely under report actual expenses; this biases the employment results lower particularly in regard to the direct and indirect job creation.
- The expenditure to convert the biomass woodchips into heat, i.e. the construction operating and maintenance employment of direct heat systems, should be calculated to improve the accuracy of the results per unit of final energy.
- It may be useful to evaluate the employment associated with the collection of biomass materials to make the result more applicable to areas where there is not a ready supply of pre-collected biomass. It may be possible to create a proxy for this result by adding expenditure to the forestry industry; this would rest on the assumption that biomass is produced in a similar way to other primary forestry products.
- Finally policy makers may be interested in researching further the qualitative elements of jobs created here, in terms of skill and impacts on groups of interest.

[8] Possible explanations for slightly low estimates are discussed in section 4.1.

APPENDIX A: INPUT OUTPUT MODEL

This appendix contains a user guide for the input-output model in addition to detailed development documentation.

A.1 USER GUIDE

The model created is contained entirely in a single Microsoft excel workbook spread across a number of sheets. In order to operate the model the user must change the parameters in the inputs sheet which will produce new estimates in the outputs sheet. A more detailed examination of each sheet is included below, with notes on changes that may be required in the future to apply the model to different applications.

A.1.1 The inputs sheet

The inputs sheet is where the majority of the user input is required. In this sheet the user must input employment, cost and technical information relating to the desired project.

Technical information required includes:

- The output of the plant in terms of biomass and energy content of biomass,
- The conversion efficiency of biomass into end use energy, such as heat energy (only required if results in terms of final energy are of interest), and
- Plant operating life expectancy

Construction phase information required includes:

- The number of full time employs associated with the projects construction such as project management, this is outside of employees associated with project expenditure (e.g. construction workers are paid for by construction expenditure),
- The average salary paid to direct employees, and
- The expenditure at the construction phase, broken down by commodity category.

Operating and maintenance phase information required includes:

- The number of full time employees associated with the projects operating and maintenance such as plant operators, this is outside of employees associated with project expenditure (e.g. mechanics hired from outside the project are covered in project expenditure),
- The average annual salary paid to direct employees, and
- The annual expenditure associated with plant operation and maintenance, broken down by commodity category.

A.1.2 The outputs sheet

The outputs sheet then reports the employment generated by the project through its direct, indirect and induced effects. The employment benefits are denominated in total and per unit of final and primary energy as well as being split by phase (construction or operation) and by industry.

A.1.3 The calculations sheet

The calculations sheet does the majority of the work of the model. This sheet does not require any user input. It simply applies the values in the inputs sheet to the multipliers and a few transformation assumptions that are clearly recorded.

A.1.4 The Input Output Model Sheet

Contains the information derived from the use and make tables to create the input-output multipliers.

A.2 CREATION OF INPUT OUTPUT TABLE

The input-output tables were created using the 2003 make and use tables published by Statistics New Zealand. The make and use tables record how supplies of different kinds of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate and or final uses, including exports.

A.2.1 Aggregation

The make and use tables provided by Statistics New Zealand cover 62 products and 86 industries; this level of detail is not required for the purpose of the analysis in this report and needlessly complicates inputs to the model as well as making it difficult to work with in Microsoft Excel. A greater level of aggregation is typical in the literature with commodities and industries commonly grouped into around 20 categories.

As such, the industries and products have been aggregated into 18 products and categories. The aggregation is roughly in line with that of Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006, with extra definition left in the forestry and wood product areas to allow for more detailed treatment of the biomass products that are used by the biomass plant. The aggregation to a symmetric 18 products and 18 industries is not strictly necessary although it simplifies the interpretation of the results.

Details of product and industry aggregation is included in APPENDIX B:.

A.2.2 Controlling for imports

The make tables report the domestic production of goods by each industry. The use tables report the consumption of goods by each industry, but do not differentiate between the use of imported goods and those produced domestically. As we are interested in the impact on domestic firms we must then adjust the use tables to contain only the use of domestically produced goods and services.

The procedure for doing this is that considered most common by Miller and Blair (2009). In this procedure the proportion of imports that make up demand is considered constant across final demand and the demand of intermediate production for each good. Thus the consumption of goods by industry is reduced by this same proportion, unique to each product, regardless of the industry consuming goods.

A.2.3 Construction of Input-output technical co-efficients

The simplistic structure on which input-output analysis is based presumes that each industry only produces one good, and is therefore the only industry to produce that good.

In the real world of course industries produce a range of goods as bi-products; these are called secondary goods.

The treatment of secondary goods can be undertaken in either of two ways "commodity technology" or "industry technology". In the industry technology model, industry input structures are the important source of data and the commodity input structure is a weighted average of these. In effect each industry has an explicit input and output structure. The alternative assumption called "commodity technology" assumes that each product has a defined input structure, regardless of what industry produces it.

Miller and Blair (2009) contains a lengthy discussion of the pros and cons of each approach and a survey of different opinion and evaluations. They, however, reach no strong conclusion on which is the appropriate assumption.

For the purpose of the input output model used in this report we use the Industry technology approach. This approach has several advantages. In particular, from a theoretical standpoint it is difficult to believe that secondary commodities are created with the same combination of products as are used in the primary sector (i.e. produced in separate facilities with similar structure to that of the primary industry). It is more reasonable to think of them as bi-products of the production of that sectors primary commodity, thus produced with the same inputs as the primary product of that industry.

The industry technology also means that the total requirements matrix, and thus later the multipliers, does not contain negative values. Negative values are intuitively implausible; an increase in final demand should not reduce production, and is thus undesirable.

A.2.4 Closing the model with respect to households

The model created thus far consists of inter-industry and final demand and can be used to create direct and indirect multipliers. As discussed with EECA the use of induced multipliers is also desirable. In order to create induced multipliers, which contain the response of households to increased income, we must close the model with respect to households.

Closing the model with respect to households is similar to including households as another industry, which consumes commodities (a proportion of final demand) and produces labour which is used by industries in production. A simplification required by this assumption is that the price of labour is constant no matter what industry is consuming it. Further, it is also assumed that increases in household income will be spent in the same proportion as current household demand. While neither of these assumptions is desirable both are necessary and not completely out of line with real world behaviour.

Data on household consumption is included in the use table provided by Statistics New Zealand, as a subcomponent of final demand, as is compensation of employees as a subcomponent of value added. This information is used to create the household column and row in the input-output tables.

This information is incomplete, however, in that it does not include demand for labour by households or final demand (including government and exports). Further, household expenditure is greater than total income from labour, reflecting the missing demand for labour and the fact that households have non-labour sources of income.

As such to create a household sector a few assumptions must be made. In the case of this model the assumption has been made that the unreported missing final demand for household labour is enough to allow them to achieve the reported level of expenditure. This assumption is likely to result in slightly higher multipliers, particularly on induced effects.

A.3 CREATION OF MULTIPLIERS

The output multipliers are a simple extension of the input-output technical co-efficients, called a Leontief Inverse. The input-output multiplier shows how an extra one dollar of final demand for any one product, will result in extra output in all the domestic industries. However, the input output tables are denominated in 2003 dollars and thus costs estimates must first be converted to 2003 equivalent prices, this is done using CPI information provided from Statistics New Zealand.

A.3.1 Employment multipliers

The multipliers developed above are still dominated in dollars and thus we need to make an assumption about how this relates to employment. To do this we take the employment data by industry from Statistics New Zealand and calculate the employment / dollar of total domestic output. This is then used to transform the output multipliers to employment multipliers, based on the simple assumption that a 10% increase in output of a sector will result in a 10% increase in employment.

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APPENDIX B: AGGREGATION OF PRODUCTS AND INDUSTRIES

B.1 PRODUCTS

Product	Aggregated Category
Accommodation, restaurant & bar services	Service - Insurance, financial, legal, business
Advertising & marketing services	Service - Insurance, financial, legal, business
Agriculture services	Agriculture, Horticulture and Fisheries
Architectural & engineering services	Service - Insurance, financial, legal, business
Basic metals	Metal and mineral manufacturing
Beverages & tobacco	Food manufacturing
Cattle	Agriculture, Horticulture and Fisheries
Central government admin & defence	Government & Community Services
Clothing & footwear	Textile Manufacturing
Communication services	Service - Insurance, financial, legal, business
Computer services	Service - Insurance, financial, legal, business
Construction	Construction
Culture & recreational services	Government & Community Services
Education	Government & Community Services
Electricity	Electricity water and gas supply
Electronic equipment & appliances	Machinery, equipment and other manufacturing
Equipment hire services	Service - Insurance, financial, legal, business
Finance services	Service - Insurance, financial, legal, business
Fishing & fish products	Agriculture, Horticulture and Fisheries
Forestry & logging	Forestry
Furniture	Machinery, equipment and other manufacturing
Grain & other crops	Agriculture, Horticulture and Fisheries
Health & community services	Government & Community Services
Horticulture & fruit	Agriculture, Horticulture and Fisheries
Industrial chemicals	Petroleum and chemical manufacturing
Industrial machinery	Machinery, equipment and other manufacturing
Insurance services	Service - Insurance, financial, legal, business
Legal & accounting services	Service - Insurance, financial, legal, business
Local government admin	Government & Community Services
Management consultancy services	Service - Insurance, financial, legal, business
Meat & dairy products	Food manufacturing
Mining & quarrying	Mining inc Oil and gas
Motor vehicles & other transport equipment	Transportation Manufacturing
Non metallic mineral products	Metal and mineral manufacturing
Oil & gas	Mining inc Oil and gas
Other business services	Service - Insurance, financial, legal, business
Other food	Food manufacturing
Other livestock & animal products	Agriculture, Horticulture and Fisheries
Other manufactures	Machinery, equipment and other manufacturing
Other transport services	Transport
Owner-occupied dwellings	Service - Insurance, financial, legal, business
Paper products	Paper product manufacturing
Personal & other community services	Government & Community Services
Petroleum products	Petroleum and chemical manufacturing
Photographic & scientific equipment	Machinery, equipment and other manufacturing
Printing, publishing & recorded media	Paper product manufacturing
Real estate services	Service - Insurance, financial, legal, business
Repair services to machinery & equipment	Service - Insurance, financial, legal, business
Retail margin	Retail Trade
Road transport services	Transport
Rubber, plastic & other chemical products	Petroleum and chemical manufacturing
Services incidental to mfg	Metal and mineral manufacturing
Services to finance & insurance	Service - Insurance, financial, legal, business
Sheep	Agriculture, Horticulture and Fisheries
Structural, sheet & fabricated metal products	Metal and mineral manufacturing
Textiles	Textile Manufacturing
Travel debits	Transport
Water supply	Electricity water and gas supply
Wholesale margin	Wholesale Trade
Wholesale trade	Wholesale Trade
Wood products	Wood products manufacturing
Wool	Agriculture, Horticulture and Fisheries

B.2 INDUSTRIES

Industry	Aggregated Category
Accommodation	Service - Insurance, financial, legal, business
Basic metal manufacturing	Metal and mineral manufacturing
Beverage, malt & tobacco manufacturing	Food manufacturing
Builders supplies wholesaling	Wholesale Trade
Central Govt admin & defence	Government & Community Services
Clothing and footwear manufacturing	Textile Manufacturing
Communication services	Service - Insurance, financial, legal, business
Community care services	Government & Community Services
Computer services	Service - Insurance, financial, legal, business
Construction trade services	Construction
Dairy & cattle farming	Agriculture, Horticulture and Fisheries
Department stores	Retail Trade
Electricity water and gas supply	Electricity water and gas supply
Electronic equipment appliances manufacturing	Machinery, equipment and other manufacturing
Fertilizer, petroleum & other industrial chemical manufacturing	Petroleum and chemical manufacturing
Finance	Service - Insurance, financial, legal, business
Financial charges	Service - Insurance, financial, legal, business
Fishing	Agriculture, Horticulture and Fisheries
Food, drink and tobacco wholesaling	Wholesale Trade
Forestry and forestry services	Forestry
Furniture manufacturing	Machinery, equipment and other manufacturing
General Insurance	Service - Insurance, financial, legal, business
Health and dental services	Government & Community Services
Horticulture & fruit growing	Agriculture, Horticulture and Fisheries
Hospitals & nursing homes	Government & Community Services
Industrial machinery manufacturing	Machinery, equipment and other manufacturing
Investors in other property	Service - Insurance, financial, legal, business
Legal and accounting services	Service - Insurance, financial, legal, business
Libraries museum and the arts	Government & Community Services
Life and health Insurance	Service - Insurance, financial, legal, business
Livestock & cropping farming	Agriculture, Horticulture and Fisheries
Local Govt admin	Government & Community Services
Logging	Forestry
Machinery and equipment wholesaling	Wholesale Trade
Meat & dairy manufacturing	Food manufacturing
Mining & quarrying	Mining inc Oil and gas
Motion picture, radio and TV services	Government & Community Services
Motor vehicle wholesaling	Wholesale Trade
Motor vehicle and part manufacturing	Transportation Manufacturing
Motor vehicle retailing and servicing'	Retail Trade
Non-building construction	Construction
Non-metallic mineral product manufacturing	Metal and mineral manufacturing
Non-residential building construction	Construction
Oil and gas exploration and extraction	Mining inc Oil and gas
Other business services	Service - Insurance, financial, legal, business
Other chemical product manufacturing	Petroleum and chemical manufacturing
Other education	Government & Community Services
Other farming	Agriculture, Horticulture and Fisheries
Other food manufacturing	Food manufacturing
Other manufacturing nec	Machinery, equipment and other manufacturing
Other personal and household goods wholesaling'	Retail Trade
Ownership of owner-occupied dwellings	Service - Insurance, financial, legal, business
Paper and paper board containers manufacturing	Paper product manufacturing
Personal and household goods wholesaling	Wholesale Trade
Personal and private household services & household employed staff	Government & Community Services
Petroleum metal and chemical wholesaling	Wholesale Trade
Photographic and scientific equipment manufacturing	Machinery, equipment and other manufacturing
Plastic product manufacturing	Petroleum and chemical manufacturing
Post school education	Government & Community Services
Prefabricated building manufacturing	Machinery, equipment and other manufacturing
Pre-school, primary & secondary education	Government & Community Services
Printing, publishing & recorded media	Paper product manufacturing
Pulp paper and paper board manufacturing	Paper product manufacturing
Real estate	Service - Insurance, financial, legal, business
Religious organisations and interest groups	Government & Community Services

Residential construction	Construction
Restaurant and bars	Retail Trade
Road and rail transport	Transport
Rubber product manufacturing	Petroleum and chemical manufacturing
Scientific research & technical services	Service - Insurance, financial, legal, business
Services to agriculture and hunting & trapping	Agriculture, Horticulture and Fisheries
Services to finance & insurance	Service - Insurance, financial, legal, business
Services to transport	Transport
Sewerage, drainage & waste disposal services	Government & Community Services
Ship, boat and other transport equipment manufacturing	Transportation Manufacturing
Specialized food and liquor retailing	Retail Trade
Sports and recreation	Government & Community Services
Structural, sheet & fabricated metal product manufacturing	Metal and mineral manufacturing
Superannuation fund operation	Service - Insurance, financial, legal, business
Supermarkets, grocery stores and furniture, houseware appliances and recreational goods wholesaling	Wholesale Trade
Textiles product manufacturing	Textile Manufacturing
Unprocessed primary products wholesaling	Wholesale Trade
Vehicle and Equipment hire	Service - Insurance, financial, legal, business
Veterinary services	Government & Community Services
Water and air transport	Transport
Wood product manufacturing	Wood products manufacturing