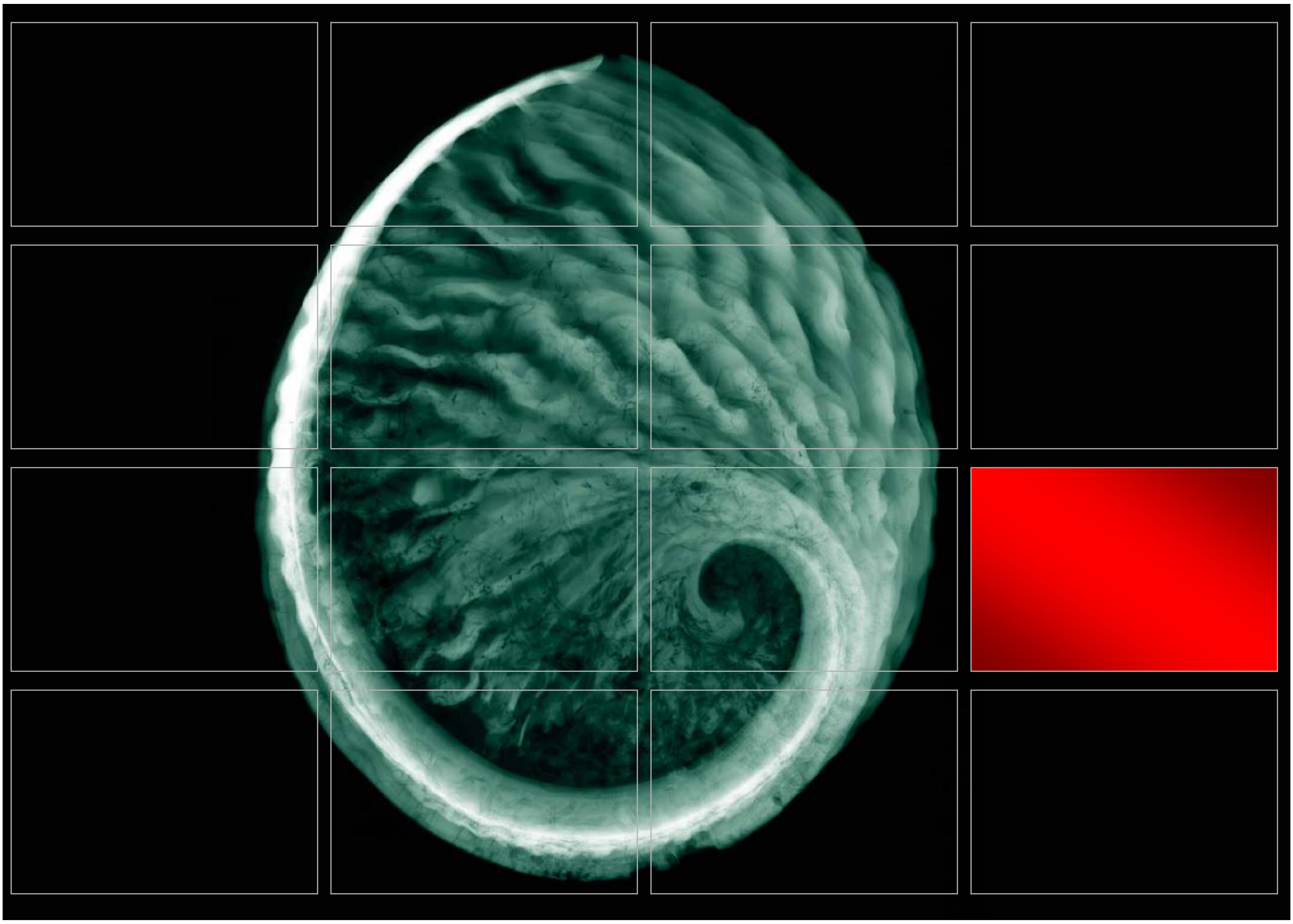

Quantification of the Benefits of Resource Efficiency to the New Zealand Economy

Final

Ministry for the Environment

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FINAL REPORT

Ministry for the Environment

Quantification of the Benefits of Resource Efficiency to the New Zealand Economy

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For and on behalf of
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ABBREVIATIONS

AERU	Lincoln University Agribusiness and Economics Research Unit
AgriLINK	AgriLINK New Zealand Limited
ANZSIC	Australia and New Zealand Standard Industrial Classification
C&D	Construction and Demolition
CCC	Christchurch City Council
CoP	Code of Practice
Dairy NZ	Dairy New Zealand
DCD	Dicyandiamide (a nitrification inhibitor)
DEFRA	United Kingdom Department for Environment Food and Rural Affairs
DM	Dry Matter
EA	Environment Agency of England and Wales
EAW	Environment Agency of Wales
EIAM	Economic Impact Assessment Model
EREP	Australian Environment and Resource Efficiency Plans Programme
ERM	ERM New Zealand Limited
gCO_2e	Grams of Carbon Dioxide Equivalent
GHG	Greenhouse Gas
GWP	Global Warming Potential
ha	Hectares
kWh	Kilowatt-hours
kg	Kilograms
ONS	United Kingdom Office of National Statistics
l	Litres
lbs	Pounds
MAF	New Zealand Ministry of Agriculture and Forestry
MfE	New Zealand Ministry for the Environment
Mm^3	Millions of cubic metres
mm	Millimetres
MS	Milksolids
MWh	Megawatt-hours
N	Nitrogen
NZ$	New Zealand Dollars
P	Phosphorus
SFF	MAF Sustainable Farming Fund
SIC	Standard Industry Classification
SWNZ	Sustainable Winegrowing New Zealand
t	Tonnes
TRC	Taranaki Regional Council
UK	United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WAG	Welsh Assembly Government

GLOSSARY

Data Aggregation	The combining of two or more kinds of an economic entity into a single category. As an example, data on waste generation is typically aggregated across industries at the Transfer Station level making it difficult to identify which industries produced which types of waste. The lowest level of disaggregation is single-business level data, typically from case study type analysis. In general the highest level of aggregation within an economy is at the national level, such as measures of Gross Domestic Product per capita which combine all output values across all industries into a single measure.
Global Warming Potential	Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by convention equal to 1). A GWP is calculated over a specific time interval and this time interval must be stated whenever a GWP is quoted or else the value is meaningless.
Input-Output model	Input-Output tables are used to model inter-industry relationships and show how changes to one industry can have flow on effects into other industries and across an entire economy. They show for each sector/industry the value of inputs by each industry type.
Standard Industrial Classification	Classification system used to group businesses primarily by the output they produce. The Australian and New Zealand Standard Industrial Classification (ANZSIC) was produced by the Australian Bureau of Statistics and the New Zealand Department of Statistics for use in the collection and publication of statistics in order to make it easier to compare industry statistics between the two countries and with the rest of the world.
Total Economic Impact	Total economic impact is the increase in total output for each efficiency-realising sector as a NZ$ figure. It is the sum of the direct, indirect and induced impacts of the modelled efficiency measures. The direct impact arises from the initial reallocation of saved expenditure to consumption of goods and services in other sectors. The indirect impact arises from increased spending by businesses as they purchase additional inputs so as to increase production to meet direct impact demand. This indirect impact can be envisaged as an expanding ripple effect. The induced impact is the result of increased household income being spent and leading to a further ripple effect of increased employment, output and income.

E EXECUTIVE SUMMARY

E.1 INTRODUCTION

The Ministry for the Environment's (**MfE**) aim is to achieve high environmental standards for New Zealand while sustaining and enhancing social and economic development. One of the ways this can be achieved is through the effective management of New Zealand's natural resources – to foster improved productivity while reducing the negative environmental impacts of the production and consumption of goods and services. This can be summed up in the concept of *resource efficiency*.

The purpose of MfE's resource efficiency policy work is to build a robust evidence base on resource use, efficiency, and the potential for efficiency improvements.

This Report presents a study into the potential benefits of implementing resource efficiency measures within a number of key sectors to the New Zealand economy and environment. The study centred on the development and application of a methodology for quantifying the benefits of resource efficiency to the New Zealand economy. MfE engaged independent consultants ERM New Zealand Limited, together with Lincoln University's Agribusiness and Economics Research Unit (**AERU**) and AgriLINK New Zealand Limited (**AgriLINK**) (together, '*the Project Partners*') to undertake this study.

E.2 STUDY METHODOLOGY

The study methodology centred on three key phases:

Phase One: *Methodology Development*

This phase comprised two central activities:

1. A comprehensive review of literature relating to frameworks through which the benefits of resource efficiency can be quantified; and
2. The development of a calculation methodology based on the outputs of the literature review, but tailored to the specifics of the New Zealand context and sectoral data availability constraints.

Phase Two: *Focal Sector Data Collection and Benefits Quantification*

In Phase Two, the benefits quantification methodology was applied to a number of sectors identified by MfE. Data used to undertake the benefits quantification was collated through a baseline review of existing datasets and supplemented through a combination of interviews, survey and case study analysis of various New Zealand businesses within the focal sectors.

Focal Efficiency Measures

In developing the scope for the project, MfE specified four resource efficiency measures that should form the focus of the study:

- Water use;
- Material use;
- Waste production; and
- Greenhouse Gas (**GHG**) emissions.

Focal Sectors

Within the proposed project scope, MfE identified a list of five key sectors within the New Zealand economy for consideration within the study. To maintain consistency with government statistics, these key sectors were defined in alignment with the Australian and New Zealand Standard Industrial Classification (**ANZSIC**) 2006[i]. During the project initiation phase and through an initial baseline data review, it was recognised that further focussing of these sectors would be required given the scope of the project, data limitations within a number of these sectors, as well as potential overlap with various ongoing studies on resource efficiency being undertaken by other government departments.

As such, MfE in collaboration with the Project Partners narrowed this initial list down to three focal sectors and two ANZSIC sub-categorisations within each sector. These sectors and sub-sectors were:

- Agriculture (ANZSIC Level 2 Subdivision A01):
  - Fruit and Tree Nut Growing (A013); and
  - Dairy Cattle Farming (A016).
- Food and Beverage Manufacturing (ANZSIC Level 2 Subdivisions C11 and C12 respectively):
  - Bakery Products Manufacturing (C117); and
  - Wine [and Other Alcoholic Beverage] Manufacturing (C121400).

[i] Statistics New Zealand (2010) *Industrial Classification*. Available from: www.stats.govt.nz/methods_and_services/surveys-and-methods/classifications-and-standards/classification-related-stats-standards/industrial-classification.aspx

- Construction (ANZSIC Level 1 Division E):
  - Residential Building Construction (B301); and
  - Non-Residential Building Construction (B302).

<u>Phase 3: *Project Review*</u>

The final phase focused on evaluation of the data collection and methodological process used throughout the course of the project. Limitations in both areas were identified and potential opportunities for improvement were explored. Recommendations for the future development of the methodology and its wider application were also developed.

E.3 *STUDY SECTOR RESULTS*

In addition to developing the benefits quantification methodology, the study also sought to demonstrate the effectiveness of the model and identify potential areas for improvement through the application of the methodology to a number of specific efficiency measures and industry sectors.

E.3.1 *Dairy Cattle Farming*

Through the data gathering and review process, several opportunities for resource efficiency in each of the four resource efficiency measures studied were identified for the Dairy Cattle Farming sector. These opportunities are summarised in *Table 1*.

From the data gathered, two key opportunities for efficiency gains were identified and modelled using the Economic Impact Assessment Model (**EIAM**) developed by the AERU. First was a 4% reduction in nitrogen fertiliser replicated over 20% of the industry (through the use of the nitrification inhibitor, dicyandiamide). The second efficiency gain modelled was a 20% reduction in electricity use replicated across 20% of the industry.

These efficiency gains, when distributed across and consumed by other sectors of the economy, achieved a total economic impact[ii] of **NZ$2.6 million per annum**.

E.3.2 *Fruit and Tree Nut Growing*

Through a comprehensive data gathering and review process, several opportunities for resource efficiency in the four measures were identified for the Fruit and Tree Nut Growing sector. These opportunities are summarised in *Table 1*.

[ii] See Glossary for definition of Total Economic Impact

From the data gathered, two key opportunities for efficiency gains were identified and modelled using the EIAM. First was a 20% reduction in electricity, replicated across 20% of industry (primarily from improved irrigation management). Also modelled was a 25% reduction in diesel consumption across the entire industry.

These efficiency gains, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$3.9 million per annum**.

E.3.3 Bakery Products Manufacturing

Through the data gathering and review process, several opportunities for resource efficiency in each of the four resource efficiency measures studied were identified for the Bakery Products Manufacturing sector. These opportunities are summarised in *Table 1*.

From the data gathered, three key opportunities for efficiency gains were identified and modelled using the EIAM. First was an average reduction in electricity consumption of 15% across the entire industry. Second was an average 38% reduction of water consumption from production and wash-down waters across the entire industry. Third was an average 15% reduction of total waste disposed at landfills across the entire industry.

These efficiency gains, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$9.3 million per annum**.

E.3.4 Wine Manufacturing

Through the data gathering and review process, several opportunities for resource efficiency in each of the four resource efficiency measures studied were identified for the Wine Manufacturing Sector. These opportunities are summarised in *Table 1*.

From the data gathered, three key opportunities for efficiency gains were identified and modelled using the EIAM. First was a 25% reduction in electricity use replicated across 20% of the industry. The second efficiency gain modelled was a 5% reduction in natural gas consumption across 20% of the industry. A third efficiency gain modelled was a 52% reduction in glass packaging across 20% of the industry.

These efficiency gains, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$6.2 million per annum**.

E.3.5 Building Construction

Through the baseline data review it was identified that whilst aspects such as the types of material used within the building construction do vary between the residential and non-residential sub-sectors, the major differences within the context of this study centred on project size and hence economies of scale and feasibility when implementing resource efficiency measures. Therefore the sector analysis was undertaken using the broader 'building construction' category, with a focus placed on the range of replication rate modelled in order to mirror the difference in ease of uptake within the sub-sectors.

Through the data gathering and review process, several opportunities for resource efficiency in each of the four resource efficiency measures studied were identified for the construction sector. These opportunities are summarised in *Table 1*.

From the data gathered, one key opportunity for efficiency gains was identified and modelled using the EIAM. This was a 58% increase in total mixed waste diverted from landfill for the whole of both industries, and was an aggregate average across commercial and residential building demolition and construction.

These efficiency gains, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$24.3 million per annum**.

Table 1: Summary Efficiency Areas and Options

Resource Efficiency Measure	Efficiency Areas and Options				
	Dairy Cattle Farming	**Fruit and Tree Nut Growing**	**Bakery Products Manufacturing**	**Wine Manufacturing**	**Construction (Residential and Non-Residential)**
Water Use	Irrigation - Water management plans - Improved soil moisture monitoring - Improved distribution uniformity	Irrigation water - Improved soil moisture monitoring - Improved distribution uniformity across orchards	Wash down waters - New equipment, e.g. low-volume, high-pressure hose system - New practices, e.g. reuse water from high quality streams/dry cleaning/ equipment soakage Production waters - Recycling systems for non-product production waters, e.g. for mixer pumps	Process water - Replacement of single pass cooling with cooling tower - Checks for leaks - Use of low-quality water for cooling - Re-circulate low-quality process waters Wash waters - High pressure nozzles with auto-shutoff - Use of brooms/mops - Use of low quality water/ stormwater - Minimise flushing of lines	Site wash down waters - New equipment, e.g. low-volume, high-pressure hose - New practices, e.g. reuse wastewaters/stormwaters
Material Use	Fertiliser and feed - Related to GHG (nitrous oxides) emissions reduction	Fertiliser use - Limited opportunities - Consolidation of variability across orchards	Ingredient use - Linked to waste production and GHG emissions options	Limited opportunities - Related to waste minimisation	Raw material use - Linked to waste production options - Design phase considerations - Material substitution

Resource Efficiency Measure	Efficiency Areas and Options				
	Dairy Cattle Farming	**Fruit and Tree Nut Growing**	**Bakery Products Manufacturing**	**Wine Manufacturing**	**Construction (Residential and Non-Residential)**
Waste Production	<u>General farm wastes</u> - Improvement of collection systems - Better integration with waste management service providers, e.g. scrap metal dealers, mobile service units for vehicle waste oils - Education/awareness building	*Limited opportunities e.g. potential for biofuel*	<u>Ingredient wastage</u> - Consolidation of manufacturing streams - Modification/ optimisation of food processing equipment <u>Organic waste disposal</u> - Diversion from landfill, e.g. to animal feed/anaerobic digestion plant <u>Non-food waste</u> - Bulk purchasing of input materials - Reusable output packaging/ transportation crates etc.	<u>Solid waste</u> - Use as compost or soil amendments - Use as stock feed - By-product production <u>Wastewaters</u> - Reuse as irrigation water or low quality process water	<u>Construction</u> - Effective inventory management/near real-time supply ordering - Site waste management plan - Waste segregation - Use of precast and prefabricated products - Return of excess materials <u>Demolition</u> - Deconstruction versus demolition
GHG Emissions	<u>General</u> - Energy efficiencies - Lift in productivity <u>Nitrous oxide</u> - Restricted grazing - Efficient use of nitrogen fertiliser - Nitrification inhibitors - Use of dairy farm effluent - Low nitrogen feed supplements <u>Methane</u> - Antibiotic modification of rumen microflora	<u>Fuel Use</u> - Sheep grazing of orchards (limited) - Improved management/ planning of mowing and/or spray passes	<u>Transport logistics</u> - Delivery and ingredient sourcing planning <u>Site energy reduction</u> - Energy efficiency initiatives - Ovens and air compression improvements - Heat exchange on steam boilers	<u>Refrigerant loss</u> - Change of refrigerant - Modification of system <u>Glass bottle manufacture</u> - Use of light weight glass - Use of alternatives, e.g. PET	<u>Plant use and vehicle movements</u> - Improved fleet management - Improved logistical planning - Material sourcing/waste disposal location <u>Material use</u> - Waste minimisation - Material substitution

E.4 LIMITATIONS

A number of limitations were identified, associated with both the data gathered through the study, as well as the model into which this data was inputted in order to generate the industry-wide resource efficiency savings.

E.4.1 *Data Limitations*

Initial analysis of the data gathered for the Dairy Cattle Farming and the Fruit and Tree Nut Growing sectors identified a potential limitation of the project associated with the nature of the data gathered and its integration with the benefits quantification methodology employed in the study. Specifically, the scale of the calculated resource savings, was small and potentially not significant when considered with the limitations of the study. There are several possible explanations for these results:

- <u>The potential resource savings are accurate and reflective of the nature of the primary sectors being studied.</u> For primary sectors such as Dairy Cattle Farming and Fruit and Tree Nut Growing, many resource efficiency practices are already embedded within the industry (albeit perhaps not explicitly referred to as 'resource efficiency' practices). Additionally, the usage of raw material resources within these industries is minimal compared to other sectors;
- <u>More data is required to effectively model resource savings within the sectors being studied</u>; and/or
- <u>The most available data does not reflect the key resource efficiency opportunities for each sector.</u> For each sector studied, the resource efficiency quantification has been shaped by data availability at the resource efficiency measure levels as well as the sector level. As such, data was not available for all resource efficiency measures in each of the sectors studied, which may provide more extensive efficiency benefits.

E.4.2 *Model Limitations*

The sectors selected for attention in this report were defined in alignment with Level 3 or Level 4 ANZSIC 2006 codes. The EIAM sectors however were constructed using selected combinations of ANZSIC 1993 Level 2 industries. This means that the total economic impacts are likely to be over-estimated within the current EIAM as savings reductions are applied at a level which includes more ANZSIC Level 3 industries than those considered in the study. To accommodate an analysis using the EIAM modelling framework at ANZSIC 2006 Level 3 would necessitate disaggregation of the current model sectors requiring resources beyond the capacity of the current project.

A further limitation of the EIAM was the lack of monetary values for water as inputs to the *Horticulture and Fruit Growing* and *Dairy and Cattle Farming* sectors of the EIAM. The agricultural sector represents a major water user, but only a small proportion of the overall water used is provided through public supply and almost none is charged volumetrically. In the absence of a price charged for water, a value was derived from apportioning on farm electricity use, as the volume of water use is predominantly tied to the cost of operating irrigation pump equipment.

E.5 CONCLUSIONS AND RECOMMENDATIONS

This study identified a range of potential resource efficiency opportunities within six focal industry sectors. Extrapolation of the most promising of these efficiency options across each sector through the EIAM resulted in estimated potential efficiency savings ranging from **NZ$2.6 million per annum** (Dairy Cattle Farming) through to **NZ$24.3 million per annum** (Residential and Non-residential Building Construction).

There were, however, a number of limitations within these estimated values, associated with the availability of data on resource efficiency methods within each focal sector and also within the EIAM itself.

Additional modelling using the EIAM also identified that those areas within each key sector which may provide the greatest opportunity for resource efficiency were not necessarily those resource efficiency measures specified by MfE as focal points for this study. For example, the largest input to the B*everage, Malt and Tobacco* sector comes from *structural, sheet and fabricated metal product manufacturing* at 10.6% of the value of total inputs (although this input is likely to be associated with plant and infrastructure involved in the wine making process, which was not incorporated within the study).

Therefore, whilst the study provided a framework and calculation methodology through which the benefits of resource efficiency to the New Zealand economy can be calculated, it is recommended that further work be undertaken centred on:

- Additional data gathering to obtain further real case study information on efficiency measures and savings opportunities in order to provide greater rigour around the EIAM outputs. In other similar studies reviewed through this project, it is clear that government programmes that seek to encourage resource efficiency (such as the UK's Envirowise programme) can also help to further build the business case for continued resource efficiency through the real case study data that is generated through the programme;

- Disaggregation of the EIAM sectors in order to reduce over-estimation of the savings and provide more accurate quantification of the benefits of the efficiency measures within each sector. Alternatively, the sectors studied could be selected in order to better reflect the EIAM sectors;
- Targeting of the efficiency measures studied within each sector in light of the additional modelling undertaken using the EIAM to identify those areas within each key sector which may provide greatest opportunity for resource efficiency; and
- Further analysis of the effect of efficiency measure replication rate within each sector in order to provide MfE with guidance on the level to which effort could or should be best used to increase the replication of efficiency measure within each sector to gain maximum financial benefit.

1. *BACKGROUND*

1.1 *CONTEXT*

The Ministry for the Environment's (**MfE**) aim is to achieve high environmental standards for New Zealand while sustaining and enhancing social and economic development. One the ways this can be achieved is through the effective management of New Zealand's natural resources – to foster improved productivity while reducing the negative environmental impacts of the production and consumption of goods and services. This can be summed up in the concept of *resource efficiency*.

The purpose of the MfE's resource efficiency policy work is to build a robust evidence base on both the current resource use of key sectors and the potential benefits of resource efficiency to the New Zealand economy and environment.

Characterising the current resource use of key sectors was the focus of MfE's *Resource Efficiency in New Zealand* project, completed in July 2010. The *Resource Efficiency in New Zealand* project, described in detail elsewhere, sought to collate environmental and economic indicators for a selection of New Zealand industry sectors and, using this data, determine the resource efficiency of these sectors.

Following on from the *Resource Efficiency in New Zealand* project, MfE engaged independent consultants ERM New Zealand Limited (**ERM**), together with Lincoln University's Agribusiness and Economics Research Unit (**AERU**) and AgriLINK New Zealand Limited (**AgriLINK**) (together, '*the Project Partners*') to further add to this evidence base by developing and testing a methodology for quantifying the benefits of resource efficiency to the New Zealand economy. It is this project that forms the focus of this report.

1.2 *PROJECT AIM AND OBJECTIVES*

The overall aim of the project detailed in this report was to enable MfE to quantify the potential resource savings and associated financial benefits of resource efficiency within the New Zealand economy.

To do this, the following objectives specific to the project were formulated in collaboration with MfE:

1. To develop a robust calculation methodology to quantify the benefits of applying cost-effective resource efficiency measures within the New Zealand economy at a sectoral level;
2. To apply the framework calculation methodology to a number of specific sectors and resource efficiency measures identified by MfE, in order to demonstrate the applicability and functionality of the framework; and

3. To review the calculation methodology and the outputs of the sector calculations in order to identify improvements to the methodology and facilitate the application of these across other industrial sectors.

By applying the calculation methodology to a select number of sectors, the project also sought to provide MfE with an understanding of:

- What activities businesses in the focal sectors could undertake to improve their resource efficiency; and
- Which of the focal sectors have the greatest potential for resource efficiency savings and hence reduced impact on the environment through adopting resource efficient practices.

1.3 *PROJECT APPROACH*

1.3.1 *Project Phasing*

To reflect the three project objectives identified in *Section 1.2*, the project was undertaken in three distinct phases.

Phase One: *Methodology Development*

This phase comprised two central activities:

1. A comprehensive review of literature relating to frameworks through which the benefits of resource efficiency can be quantified; and
2. The development of a calculation methodology based on the outputs of the literature review, but tailored to the specifics of the New Zealand context and sectoral data availability constraints.

The literature review presented as *Annex A* identified that to estimate the value of resource savings from resource efficiencies for businesses, three main data sources are required:

- The base level of current resource usage;
- The amount of savings that could be achieved; and
- The values associated with the saved resources.

It was, however, also ascertained that the availability of such data will vary across sectors, resources and efficiency activities. These disparities in data dictate that a range of methods and approaches is required to estimate savings across multiple resource types and key sectors.

The general approach of matching the valuation method to the available data type was therefore a core characteristic of the benefits quantification methodology developed for the study (see *Annex B*). This approach followed the process employed in the most applicable of the literature resources studied; the United Kingdom (**UK**) Department for Environment Food and Rural Affairs (**DEFRA**)'s *Quantification of the Business Benefits of Resource Efficiency* study[1]. The three approaches employed were:

- Where there were only single one-off case studies, the method employed to aggregate up to sector level centred on an estimation of how many other sector participants could be expected to achieve the same resource savings as the case study organisation;
- Where multiple case studies were available within industries, the quantity of resource savings as a percentage of pre-intervention resource quantities was modelled and used to estimate mean savings rates for the sector; and
- For industry sectors where highly aggregated data was available, the approach taken was to apply savings rates based on previous sector level analysis of savings potential to the aggregate data sets. However, this approach assumes that all businesses will adopt the particular resource savings activities, which may not have been the case.

To analyse the flow-on impacts of resource savings across the New Zealand economy the *Economic Impact Assessment Model* (**EIAM**) developed by the AERU was employed. The EIAM is based on an input-output model of the New Zealand economy. It shows the inter-industry relations of the New Zealand economy, the inputs into a sector and how these are interrelated by value, illustrating how dependent each industry is on all others in the economy, both as customer of their outputs and as supplier of their inputs. Using the EIAM, resource savings were treated within a framework that assumed that resource savings achieved by a particular sector are distributed across and consumed by other sectors of the economy.

Phase Two: *Focal Sector Data Collection and Benefits Quantification*

In Phase Two of the project, the benefits quantification methodology was applied to a number of sectors identified by MfE. Data used to undertake the benefits quantification was collated through a baseline review of existing datasets and supplemented through a combination of interviews, survey and case study analysis of various New Zealand businesses within the focal sectors.

Focal Efficiency Measures

In developing the scope for the project, MfE specified four resource efficiency measures that should form the focus of the study. These resource efficiency measures reflect the key opportunity areas identified in previous studies, such as the DEFRA *Quantification of the Business Benefits of Resource Efficiency* study[1], but took into consideration potential overlaps with existing schemes established within New Zealand, such as the Energy Efficiency and Conservation Authority. The four resource efficiency measures incorporated within the study were:

- Water use;
- Material use;
- Waste production; and
- Greenhouse Gas (**GHG**) emissions.

Focal Sectors

Within the proposed project scope, MfE identified a list of five key sectors within the New Zealand economy for consideration within the study. To maintain consistency with government statistics, these key sectors were defined in alignment with the Australian and New Zealand Standard Industrial Classification (**ANZSIC**) 2006[2]. The five key sectors initially identified by MfE were:

- Agriculture (ANZSIC Level 2 Subdivision A01);
- Food and Beverage Manufacturing (ANZSIC Level 2 Subdivisions C11 and C12 respectively);
- New Zealand-based Manufacturing (excluding food and beverage, ANZSIC Level 2 Subdivisions C13 to C25);
- Construction (ANZSIC Level 1 Division E); and
- Tourism (various ANZSIC classifications, such as Level 1 Divisions H (Accommodation and Food Services) and Division R (Arts and Recreation Services)).

During the project initiation phase and through an initial baseline data review, it was recognised that further focussing of these sectors would be required given the scope of the project, data limitations within a number of these sectors, as well as potential overlap with various ongoing studies on resource efficiency being undertaken by other government departments.

As such, MfE in collaboration with the Project Partners narrowed this initial list down to three focal sectors and two ANZSIC sub-categorisations within each sector. These sectors and sub-sectors were:

- Agriculture (ANZSIC Level 2 Subdivision A01):
  - Fruit and Tree Nut Growing (A013); and

- Dairy Cattle Farming (A016).

- Food and Beverage Manufacturing (ANZSIC Level 2 Subdivisions C11 and C12 respectively):
  - Bakery Product Manufacturing (C117); and
  - Wine [and Other Alcoholic Beverage] Manufacturing (C121400).
- Construction (ANZSIC Level 1 Division E):
  - Residential Building Construction (B301); and
  - Non-Residential Building Construction (B302).

Further details on the focal efficiency measure and focal sector selection are provided as *Annex C*.

Phase 3: *Project Review*

The final phase focused on evaluation of the data collection and methodological process used through the course of the project. Limitations in both areas were identified and potential opportunities for improvement were explored. Recommendations for the future development of the methodology and its wider application were also developed.

1.3.2 Industrial Steering Group

One of MfE's central requirements for the project was for it to be sufficiently grounded by industrial practicalities. This requirement stemmed from the realisation that the data outputs should present realistically achievable resource and financial savings and that any future policy measures developed as a result of the study would need to be supported by industrial stakeholders in order to be effectively implemented.

In order to provide this industrial grounding, the Project Partners supplemented their own industrial experience with the advice and support of a number of key industrial stakeholders within the focal sectors. These stakeholders formed the basis of an informal 'industrial project steering group' that provided sector data for integration into the benefits quantification model along with industry-specific advice and guidance to the Project Partners.

1.4 REPORT SCOPE AND STRUCTURE

The purpose of this report is to present a summary of the process through which the resource efficiency benefits quantification methodology was developed and implemented, and to highlight key decision points and decision rationale to support future development and refinement. As such, the report comprises of the following sections:

Sections 2 to 6 document the resource efficiency opportunities for each sector in turn as identified through the data review. Summaries for the outputs of the benefits quantification modelling process for each sector are also presented within these Sections. *Section 7* then presents the gaps and limitations identified through the project whilst *Section 8* provides a number of recommendations resulting from the project.

2. *DAIRY CATTLE FARMING*

Dairy products continued to be New Zealand's largest export earner in the 2009 calendar year, accounting for 20.5% of total merchandise exports and valued at 8.1 billion New Zealand dollars (**NZ$**)[3]. In 2008/09, dairy farms produced 16.0 billion litres (**l**) of milk containing 1.39 billion kilograms (**kg**) of milksolids (**MS**). Total MS processed increased 5.9% from 2006/07 (a widespread drought in 2007/08 limits the viability of comparison with the previous year)[4]. Between 2006/07 and 2008/09 the total effective area has increased by 7.5% to 1.52 million hectares (**ha**) and total cows increased by 8.6% to 4.25 million ha.

2.1 *KEY DATA SOURCES*

A range of data sources were identified through the baseline data review and supplemental data collection phases of the project as relevant to both of the agricultural sectors (Dairy Cattle Farming and Fruit and Tree Nut Growing) studied through the project. These data sources included:

- The Ministry of Agriculture and Forestry's (**MAF**) *GHG Footprinting Strategy*[5], a programme that centred on the establishment of GHG footprints and reduction strategies for New Zealand's primary sectors;
- The *New Zealand GHG Inventory*[6], an inventory of New Zealand's GHG emissions and removals. The inventory records and reports the yearly emissions and removals of GHG from six sectors: energy; industrial processes; solvents; agriculture; land use, land-use change and forestry; and waste. This inventory is required under the United Nations Framework Convention on Climate Change (**UNFCCC**) and the Kyoto Protocol. The inventory is also a key element in MfE's reporting on the state of the environment; and
- The Taranaki Regional Council (**TRC**)'s *Investigation into Taranaki's Rural Waste Survey* (MAF Sustainable Farming Fund (**SFF**) Grant No. L03/025)[7]. The report centres on a survey of waste management practices within the Taranaki rural community. Dairy farms comprised 84% of the survey population, providing a useful overview of waste management practices and efficiency opportunities for this study.

A number of specific studies relevant to resource efficiencies within the Dairy Cattle Farming sector, often focused on the farm level, have also been identified. These are detailed in the Baseline Review Database highlighted within *Annex D*, and include:

- The annual *NZ Dairy Statistics*[8] published by the Livestock Improvement Corporation (www.lic.co.nz) and Dairy New Zealand (**Dairy NZ**, www.dexcel.co.nz), summarising New Zealand dairy production;

- Material use information determined through several life cycle assessment projects. These assessments include resource use inventories as well as the farm GHG emissions, two of the most recent reports being those undertaken by Barber in 2010[9] and Lundie et al. in 2009[10];
- The 2006 edition of Aqualinc's *Snapshot of Water Allocation in New Zealand* report[11] prepared for MfE, which provides a comprehensive water use stock take[i]; and
- Several irrigation efficiency reports and contacts on the MAF SFF website (www.maf.govt.nz/sff).

2.2 RESOURCE EFFICIENCY OPPORTUNITY

Table 2.1: Dairy Farming Efficiency Opportunities

Resource Efficiency Measure	Efficiency Area	Efficiency Option
Water Use	Irrigation	- Water management plans - Improved soil moisture monitoring - Improved distribution uniformity
Material Use	Fertiliser	- Related to GHG (nitrous oxide) emissions reduction
	Feed	
Waste Production	General farm wastes	- Improve collection systems - Better integration with waste management service providers, e.g. scrap metal dealers, mobile service units for vehicle waste oils - Education/awareness building
GHG Emissions	General	- Energy efficiencies - Lifting productivity
	Nitrous oxide	- Restricting grazing - Efficient use of nitrogen fertiliser - Nitrification inhibitors - Use of dairy farm effluent - Low nitrogen feed supplements
	Methane	- Antibiotic modification of rumen microflora

[i] Note that the Aqualinc report has been updated since the 2006 version documented within this report, however the updated Aqualinc report had not yet been released at time of publishing this report.

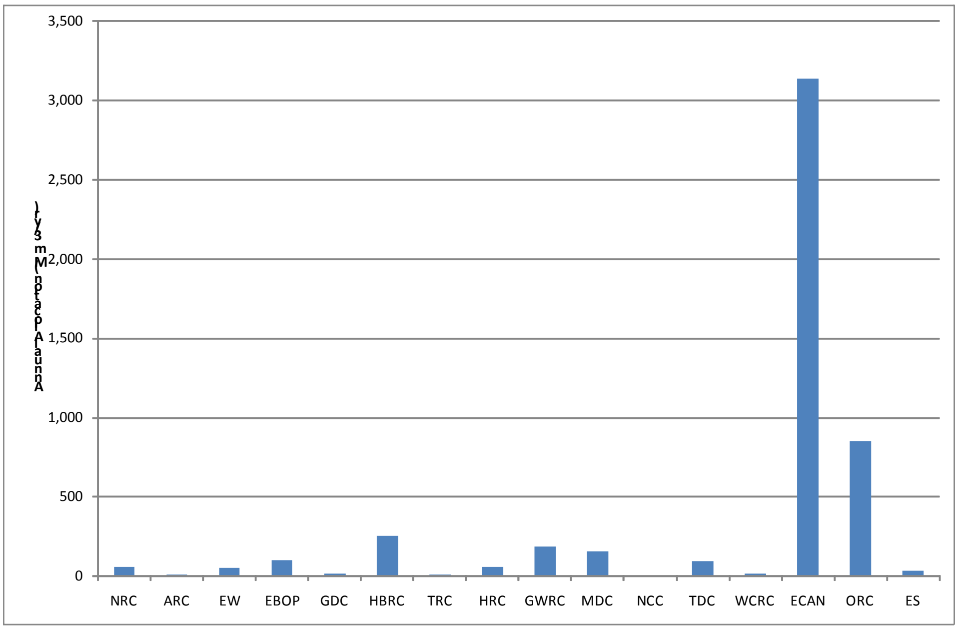
2.2.1 *Water Use*

Farm dairy water uses includes stock drinking, cleaning and milk cooling, and for approximately 20% of dairy farms, pasture irrigation. The largest quantity used is for irrigation. The 2006 version of Aqualinc's *Snapshot of Water Allocation in New Zealand* report[11] determined that of the almost 20,000 consented water takes in New Zealand, 78% are for irrigation which accounted for 77% of the allocated flow. In 2006 the total consented irrigation area was 972,650 ha. This is an increase of 55% over that reported in the 1999 survey[12]. Pasture was 301,500 ha (31%), although the category of "other" representing 20% of the irrigated area is also likely to include a large share of pasture. The arable industry accounts for the largest irrigated area at 408,510 ha (42%).

By area almost three quarters of pastoral irrigation occurs in Canterbury, with a further 13% in Otago. While not all pastoral irrigation is on dairy farms, for the purposes of analysis in this report it has been assumed that all pastoral irrigation occurs on dairy farms.

The Aqualinc report further identified that the total annual allocation of water in New Zealand is 9,816 million cubic metres (**Mm^3**), of which 51% or 5,044 Mm^3/year is for irrigation. *Figure 2.1* shows that of all consented irrigation takes (pastoral, arable, and horticulture) Canterbury accounts for 62% and Otago 17%.

Figure 2.1: Annual Consented Irrigation Allocation by Council (North to South)



Source: *Snapshot of Water Allocation in New Zealand* (2006)[11]

A study by Davoren and Scott[13] determined that in Canterbury, irrigation demand on intensive pastures was exceeded by between 670 to 815 millimetres (**mm**) per season in 20% of the years studied. The range was based on different soil water holding capacities. Using a total seasonal demand of 750 mm and assuming farmers typically use 80% of their allocation, seasonal water use can be estimated at 600 mm. This is almost 25% higher than the average consented water take in Canterbury of 485 mm (based on figures presented in the 2006 Aqualinc study) which is 35% less than the modelled consented take.

The *Primary Sector Water Partnership*[14], which comprises key stakeholder groups within the New Zealand farming sector such as Dairy NZ, Fonterra, Irrigation New Zealand and Federated Farmers of New Zealand has an aim that by 2016, 80% of extracted water used by the partners will be under a self management approach to meet benchmarks of industry "good practice" for water use.

If these management techniques can achieve water use savings of 20%, for example through improved irrigation management, then based on total pastoral irrigation in New Zealand of 1,800 Mm^3 and a 20% replication rate[ii], annual water savings of 72 Mm^3 are possible, or the ability to irrigate a further 12,000 ha.

2.2.2 *Material Use*

The key materials consumed on a dairy farm, excluding pasture, are energy, fertiliser and supplementary feed. Efficiency opportunities within these material inputs will also have the potential to reduce GHG emissions and are therefore discussed in *Section 2.2.4* below.

The carbon footprinting report commissioned by MAF/Fonterra and prepared by Lundie et. al. in 2009[10], determined that the weighted average New Zealand dairy farm was 123 ha and used 109 kg of Nitrogen (**N**)/ha, 45 kg of Phosphorus (**P**)/ha and 970 kg of supplementary dry matter (**DM**) in the form of pasture and maize silage.

Based on these weighted averages *Table 2.2* extrapolates total material consumption on New Zealand dairy farms. The most significant input is nitrogen fertiliser, which, based on this analysis, accounted for 48% of New Zealand's total nitrogen use in 2005.

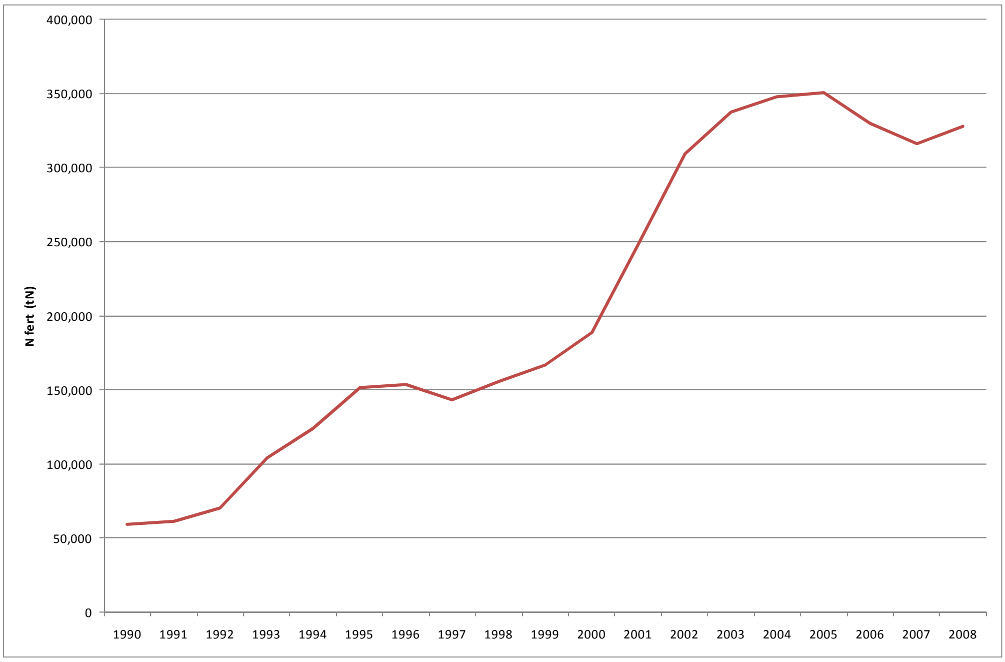
[ii] A 20% replication rate has been used within this study in line with the Defra study. This seemed reasonable taking into consideration that early adoption of new technologies may result in a 2-5% replication rate, whilst best management practices after sufficient time may incur a 80%+ replication rate.

Table 2.2: Projected Dairy Farm Material Use

Input	Tonnes
Nitrogen fertiliser (tonnes of Nitrogen)	165,600
Phosphorous fertiliser (tonnes of Phosphorus)	68,400
Maize silage (tonnes of DM)	647,100
Pasture silage (tonnes of DM)	826,400

There has been a five-fold increase in the amount of synthetic fertiliser nitrogen applied to soils since 1990. *Figure 2.2* charts the rise in New Zealand's use of synthetic nitrogen fertiliser[iii]. These figures differ from those reported in the UNFCCC's 'common reporting format' tables[15] as the values reported in the common format reporting tables are adjusted to account for the amount that volatises as ammonia (**NH_3**) and oxides of nitrogen (**NO_x**).

Figure 2.2: Synthetic Nitrogen Fertiliser Use in New Zealand



As with the issue of water use highlighted above, the *Primary Sector Water Partnership* has an aim that by 2013, 80% of nutrients applied to land nationally are managed through quality assured nutrient budgets and nutrient management plans, and that by 2016, 1.7 million ha of intensively farmed land will have implemented nutrient management plans.

Dairy farmers have already exceeded these targets with 97% of farmers using a nutrient budget (Fonterra, no date)[16]. An outcome of using nutrient budgets is often reduced fertiliser costs by ensuring the most effective time to apply just the right amount of fertiliser.

[iii] Data derived from the *New Zealand GHG Inventory*

2.2.3 *Waste Production*

TRC's *Investigation into Taranaki's Rural Waste Survey*[7] highlights that farmers generally employ more than one waste disposal method, and that burning and burying of waste on farms is the most common waste disposal method (undertaken by 40-60% of farmers). Skips were used by 16% of the surveyed farms and 23% used wheelie bins, whilst only 4% of farmers disposed of waste directly to a landfill. A varying proportion of farm waste is recyclable, although the reuse rates of materials such as plastic containers, timber, sheeting, tyres, clothes and oil was high. Items such as vehicle batteries and dead livestock had high farmer participation rates in recycling/reprocessing activities. The TRC report attributes this to the availability of systems in place for these materials, and the presence of some residual economic value.

The TRC report highlights that the most significant quantity of waste produced was total household waste of 8,750 tonnes (**t**) or 350 kg/person, almost 70% of which was disposed of on-farm. It was estimated that households generated 2,010 t of recyclable waste (23% of total household waste).

The largest quantity of on-farm waste is plastic silage wrap, pit covers and plastic containers. In 2004 when the Taranaki Rural Waste Survey occurred, most was burnt (56% of agricultural chemicals containers and 71% of plastic wrap). The rest were buried or sent to landfills. The common practices of burning or dumping on farm were the only options in 2004, while it is now considered to be bad practice, although it is still the most widespread behaviour. In March 2009 the *Agrecovery Rural Recycling Programme* (www.agrecovery.co.nz) introduced the collection of silage wrap, and another nationwide scheme *Plasback* (www.plasback.co.nz) also collects and processes the plastic wrap. In 2006 the Taranaki District Council estimated that less than 1% was recycled and by 2009 this had increased to 5%. It is expected that this will continue to increase given the options and costs of collecting plastic have improved since 2009.

The report also identifies that the waste management practices carried out by farmers were dependent on a range of factors, including:

- the geographical location of the farm and its relative proximity to off-farm disposal options;
- age and attitude of farmer;
- farming and farm management type;
- farm size;
- waste material to be disposed; and
- time available to dispose of waste.

Cost was identified as the main driver for burning and burial. A study in the Hawke's Bay and Canterbury regions in 2003 (*Sustainable Management of Waste Agrichemicals and Waste On-Farm Plastic*, MfE Project 4183) showed that burning followed by drop off to landfill were the most cost effective options for waste disposal. Although these are the cheapest disposal methods, when hidden costs such as labour and machinery fuel costs are taken into account they are not as inexpensive as they may first appear. On-farm burning cost between NZ$100 – NZ$115/t, burial NZ$180 – NZ$200/t and dropping off at a landfill between NZ$150 – NZ$175/t. Drop off for recycling was NZ$175/t in the Hawkes Bay and NZ$265/t in Canterbury, possibly reflecting fewer sites and further travel distances. It is certainly a reasonably large disincentive to recycle.

Aluminium cans (50% recycled) and glass (22% recycled) was found to be the most recycled materials, with the rest buried or sent to a landfill. Approximately 90% of all cardboard, 86% of all paper, and 86% of plastic containers generated in households on farms are not recycled. Poor access to recycling facilities was stated as the reason for not recycling these materials. It was often considerably easier to put everything into the wheelie bin or skip when these were used.

The TRC report identifies a number of opportunities to improve current waste disposal practices in the Taranaki region, focusing on the diversion of wastes away from practices such as burning and burying. These opportunities generally focused on three main areas:

- Improved collection systems, including for example nationwide farm plastic and agrichemical container system collection schemes;
- Better integration/collaboration with waste management service providers, such as scrap metal dealers, mobile service units for removal of vehicle waste oils; and
- Improved education/awareness of farmers and community groups.

However, the report notes that future disposal options may be influenced by disposal restrictions, such as National Environmental Standards for air quality affecting the burning of waste.

Table 2.3 shows the quantity of the main dairy waste streams in 2004 and New Zealand projections based on Taranaki representing 11.2% of the New Zealand dairy industry. An article in the Taranaki Daily News[17] published in May 2010 highlights the TRC estimates that 760 t of wrap are used in the region annually. This is a 50% increase on the 2004 survey findings. Consequently the figures in *Table 2.3* are likely to now be conservative.

Table 2.3: Taranaki Dairy and Projected New Zealand Dairy Rural Waste.

	Taranaki Region	NZ (projected)	units
Plastic wrap	500	4,460	t
Plastic pit cover	35	310	t
Plastic containers (20 – 200 L)	27,100	242,000	containers
Mastitis tubes	1.3 million	11.6 million	tubes

2.2.4 *GHG Emissions*

As part of the MAF GHG Footprinting Strategy, MAF and Fonterra jointly funded a carbon footprinting project using a life cycle methodology to measure GHG emissions in Dairy Cattle Farming from initial grass cultivation to a 1 t product delivered to the customer. The headline result, 940 grams of carbon dioxide equivalent (**gCO_2e**) per litre of milk to the farm gate (10.9 $kgCO_2e/kgMS$), has been released along with the methodology report[10]. The analysis showed that from cows to customers 85% of GHG emissions occur on farm, of which 59% are methane (**CH_4**) from the microbes in the rumen. Processing and manufacturing accounts for 10% and distribution 5% of emissions.

Previous studies, often focused on the farm, have also been conducted and made publically available. These are detailed in the Baseline Review Database highlighted within *Annex D* and include studies by Barber in 2010[9], Barber and Pellow in 2008[18], Basset-Mens et al. in 2005[19] and 2007[20], and Saunders and Barber in 2008[21].

In 2010, Barber conducted a literature review and modelled potential GHG reduction strategies through OVERSEER® (www.overseer.org.nz), a pastoral model developed by AgResearch. Within the study, nitrous oxide emissions, which typically account for 25 to 40% of dairy farm GHG emissions, were found to mostly arise from animal excreta deposited during grazing (75%), with the remainder from nitrogen fertiliser either during manufacture or once applied to the soil. Nitrous oxide (**N_2O**) reduction strategies included restricting grazing, efficient use of nitrogen fertiliser (quantity and timing), nitrification inhibitors, utilisation of dairy farm effluent, and low nitrogen feed supplements.

The *Primary Sector Water Partnership* has an aim that by 2013, 80% of nutrients applied to land nationally are managed through quality assured nutrient budgets and nutrient management plans which will include such mechanisms[14]. Furthermore, by 2016, the goal of the *Primary Sector Water Partnership* is that 1.7 million ha of intensively farmed land will have implemented nutrient management plans. The initiative is supported within the Dairy sector through the involvement of Fonterra.

There are several methane mitigation strategies currently being studied in New Zealand; however results are inconclusive and require proof of function before they can be used as a methane reduction strategy on New Zealand dairy farms[9]. The most promising CH_4 mitigation strategy is the use of *monensin* an antibiotic that can modify the rumen microflora. A study for the *Pastoral Greenhouse Gas Research Consortium*[22] identified that a 33% reduction in methane from the *monensin*-treated sheep could be achieved compared with the control group. They are also used extensively in US beef and Dairy Cattle Farming to improve growth rates.

Dung beetles (*Coleoptera: Scarabaeidae*) have the potential to reduce GHG emissions and lower the carbon footprint of milk through increased production. An SFF project, *The Biological of Pastoral dung in New Zealand* (SFF Grant No. 09/079[23]), is currently investigating and applying to the New Zealand Environmental Risk Management Authority (www.erma.govt.nz) for the importation, mass rearing and release of dung beetles into New Zealand.

Energy efficiency opportunities will also lower GHG emissions although they are generally less than 2% of the farm's GHG emissions profile and even on an irrigated farm are likely to be less than 5%. Apart from lifting productivity, improved energy efficiency, particularly within the milking shed and irrigation system, is currently one of the few practical measures that farmers can take to reduce their GHG emissions.

As highlighted above, data from the New Zealand GHG Inventory includes GHG emissions from agricultural soils and livestock emissions. *Table 2.4* shows the different sources of GHG emissions based on the study conducted by Barber in 2010[9], projecting these farm emissions to New Zealand total emissions and the *New Zealand GHG Inventory*[6].

Table 2.4: Dairy GHG Emissions

	GHG Emissions (tCO_2e)	Percent
Energy[1]	22,677	0%
Fertiliser and purchased feed[1]	1,271,517	7%
Methane[2]	11,208,740	65%
Nitrous oxide[2]	4,705,916	27%
Nitrous Oxide – excreta & effluent direct[2]	2,969,518	17%
Nitrous Oxide – excreta & effluent indirect[2]	825,295	5%
Nitrous Oxide – N fert direct & indirect[2]	911,102	5%
Total	**17,208,849**	

Notes: [1] From the 2010 Barber study
[2] Adapted from the *New Zealand GHG Inventory*

As highlighted above, the 2010 Barber study[9] used the OVERSEER model (with adjusted Global Warming Potential (**GWP**) values for CH_4 and N_2O of 25 and 298 respectively) to demonstrate the effect of different GHG mitigation strategies on a "typical New Zealand dairy farm". Three scenarios were modelled:

- *Scenario 1:* Increase animal efficiency by reducing animal numbers but maintaining production;
- *Scenario 2:* Using a nitrification inhibitor while maintaining nitrogen fertiliser use (2.2% increase in production); and
- *Scenario 3* Using a nitrification inhibitor while decreasing nitrogen fertiliser use (maintaining production).

It should be noted that the version of OVERSEER used in the study (v5.4.1) is based on the New Zealand GHG Inventory prior to it adopting changes in the emission factors when using the nitrification inhibitor *dicyandiamide* (**DCD**). Scenarios 2 and 3, which involve the use of DCD, do not therefore show the same level of reduction as described by Clough et al.[24] in 2008. Nitrification inhibitors (DCD) are used on 3.5% of New Zealand dairy farms.

Table 2.5: Dairy GHG Reduction Opportunities

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 1 & 2**	**Scenario 1 & 3**
% saving in CH_4 and N_2O	5.2%	5.5%	6.4%	10.5%	11.3%
Savings (tCO_2e)	832,024	869,065	1,011,826	1,674,390	1,792,514
20% replication rate					
Savings (tCO_2e)	166,405	173,813	202,365	334,878	358,503
Value[1] (NZ$)	4,160,122	4,345,325	5,059,131	8,371,952	8,962,570

Notes: [1] based on $25/$tCO_2e$

2.3 ECONOMIC IMPACT ASSESSMENT MODELLING

2.3.1 *Efficiency Gains*

Two areas of efficiency gains were modelled for the ANZSIC (2006) A016 Dairy Cattle Farming sector corresponding to EIAM Sector 3: *Dairy and Cattle Farming*. First was a 4% reduction in nitrogen fertiliser replicated over 20% of the industry (through the use of DCD). The second efficiency gain modelled was a 20% reduction in electricity use replicated across 20% of the industry. This reduction fed into the model through the *electricity generation* sector of the model.

Resource efficiency gains achieved within the Dairy and Cattle Farming sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact[iv] of **NZ$2.6 million per annum**.

2.3.2 *Target Efficiency Areas*

The dairy and cattle farming sector has a large percentage of input from the *fertiliser and other industrial chemical manufacturing* (9.67%) which is significantly larger than any other resource measures considered, indicating a possible area of focus for savings.

To extend this scoping approach, *Table 2.6* presents values of each of the key sectors top five inputs.

Table 2.6: Dairy Cattle Farming Top Five Inputs (2006)

Input	Input Value (NZ$ million)	% of Sector Inputs
3. Dairy and Cattle Farming *(ANZSIC 2006 A016 Dairy Cattle Farming)*		
Wholesale and retail trade	$426.522	19.8
Livestock and cropping farming	$249.784	11.1
Fertiliser and other industrial chemical man	$217.289	10.1
Services to agriculture, hunting and trapping	$163.047	7.1
Horticulture and fruit growing	$130.731	5.8

Looking at *Table 2.6* tells us that inputs from goods sectors dominate the top five valued inputs into the Dairy and Cattle Farming sector. Inputs from *wholesale and retail trade* are the highest valued input and are about 71% greater than the value of the next highest valued input sector, *livestock and cropping farming*. Inputs from the *fertiliser and other industrial chemical manufacturing* are also considerably important to this sector.

2.3.3 *Replication Rate Sensitivity Analysis*

In order to provide some context on the effect that the rate of efficiency measure replication can have on the overall scale of benefits accrued, a sensitivity analysis was undertaken using the EIAM. For the Dairy Cattle Farming sector, a 10% replication rate and a 50% replication rate for the reduction in nitrogen use and electricity use was modelled. The results are presented in *Table 2.7* alongside the original estimate of a 20% replication rate.

[iv] See Glossary for definition of Total Economic Impact

Table 2.7: Dairy Cattle Farming Replication Rate Sensitivity Analysis

Inputs	10%	Original (20%)	50%
Total Increase in Output (NZ$ Million per annum)	1.16	2.62	5.81
Relative Increase from 10% Replication Rate	-	2.3	5.0
Relative Increase from 20% Replication Rate	-	-	2.2

The sensitivity modelling highlights that for the dairy farming sector, doubling the replication rate from 10% to 20% more than doubles the potential financial savings. However, in moving from a 20% to a 50% replication rate the extent to which financial savings are accrued slows. Whilst further analysis would provide a more comprehensive picture, the initial results suggest that the financial benefits of increasing replication rate decreases as the replication rate increases.

3. *FRUIT AND TREE NUT GROWING*

3.1 *KEY DATA SOURCES*

As a result of the GHG footprint studies undertaken through MAF's GHG Footprinting Strategy (see *Section 2.1* above) comprehensive resource use inventories for the kiwifruit and pipfruit sectors have been established[25]. These two industries cover approximately 36% of New Zealand's fruit growing area. Grapes represent 54% of the area, however their GHG study did not conduct the same level of detail in terms of resource use surveys.

The *Nitrogen Management for Environmental Accountability* project (SFF Grant No. 05/004)[26] has also recently completed the development of a nutrient management programme for the horticultural and arable industries based on OVERSEER. The projects aim was to address the issue of responsible nitrogen use, providing useful background to the potential efficiencies associated with resource use within the Fruit and Tree Nut Growing sector.

3.2 *RESOURCE EFFICIENCY OPPORTUNITY*

The key grower-provided resource inputs for fruit and nut production are energy, fertiliser, agrichemicals and irrigation water. The potential resource savings opportunities within these areas are highlighted in *Table 3.1* below and further discussed in the subsequent sections.

Table 3.1: Fruit and Tree Nut Growing Efficiency Opportunities

Resource Efficiency Measure	Efficiency Area	Efficiency Option
Water Use	Irrigation Water	- Improved soil moisture monitoring - Improved distribution uniformity across the orchard
Material Use	Fertiliser Use	- Limited opportunities - Consolidation of variability across orchards
Waste Production	Limited opportunities	- *Potential for biofuel*
GHG Emissions	Fuel Use	- Sheep grazing of orchards (limited)
		- Improved management/ planning of mowing and/or spray passes

3.2.1 Water Use

The inputs related to water use for the Fruit and Tree Nut Growing sector arise from plant irrigation. Irrigation case studies on kiwifruit conducted by Barber in 2006[27] found significant opportunities for improved irrigation efficiency, consequently improving both electricity and water use efficiency. Improvements in irrigation efficiency can often be achieved through soil moisture monitoring and better distribution uniformity across the orchard. Improving irrigation uniformity reduces the mean application depth applied to ensure an area is fully irrigated. Distribution can be affected by pressure variation and sprinkler/ dripper condition.

<u>Kiwifruit</u>

In 2006 the distribution uniformity on the two case study orchards was 0.78 (fair) and 0.58 (poor)[v]. In 2010, a follow-up audit after improvements had been made to the poorly performing orchard scored a result of 0.90 (excellent). Theoretically this should result in water and electricity use savings of 50%. There are a large number of other factors that contribute to irrigation efficiency, however taking into account differences in effective rainfall between seasons there has been on average a 21% reduction in water use between the new and old irrigation system.

<u>Pipfruit</u>

All but one of the 51 conventional pipfruit orchards surveyed during the MAF Pipfruit GHG Footprinting project (Hume, et. al., 2009)[28] used some form of irrigation. In the most recent Agricultural Census undertaken in 2007 by Statistics New Zealand[29], the total irrigable area for the pipfruit industry was 10,013 ha, although there is some inconsistency with the data on total production area of 9,250 ha obtained within the same census. It was therefore assumed that 90% of the total production area was irrigated, this being 8,350 ha.

No figures were found on the quantity of irrigation applied annually. Therefore it was based on the methodology described by Morgan[30] for the Hawkes Bay. In Napier peak pipfruit irrigation demand in 4 out of 5 years, is 25 mm/week and 370 mm/season. Assuming that growers on average apply 80% of this peak requirement the irrigation rate is 300 mm/season.

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[v] Distribution uniformity describes how evenly water is applied across a field. It is approximated by combining results of sprinkler and pressure tests. Because uniformities are always less than perfect (<1.0) the distribution uniformity is less than any single test result. Guidelines for the ratings are based on Clemmens and ASAE 405.1: *Design and installation of microirrigation systems* as follows:

Result	Perfect	Excellent	Good	Fair	Poor
Distribution Uniformity$_{field}$	1.00	0.95-0.90	0.89-0.85	0.84-0.75	0.74-less
ASAE 405.1		>0.90	0.90-0.80	0.80-0.70	0.70-0.60

Grapes

MAF's *Economic Value of Irrigation in New Zealand* report[31] estimated the irrigated area in grapes to be 11,200 ha, which is 38% of the total grape area in 2007. This is more conservative than the 27,222 ha (92%) from the 2007 Agricultural Census and Sustainable Wine New Zealand's estimate of 90% of grapes being irrigated excluding Auckland and Gisborne (83% overall). 11,200 ha was used as a conservative estimate of the irrigated area, on the basis that the higher estimates are likely to include those areas that had irrigation during establishment, but do not irrigate mature plants,. No information was found on water or electricity use, so in the absence of any data the same approach as taken for pipfruit was used to determine water and electricity use. The crop factor for grapes is 0.75 compared to 0.85 for pipfruit, which using the Morgan methodology results in a seasonal irrigation demand of 300 mm/season, 80% of which (assumed typical use) is 240 mm/season.

Summary

The water and electricity use along with their associated reduction resulting from improved irrigation distribution uniformity, together with the GHG reductions are summarised in *Table 3.2*. For the industry the water and electricity savings were estimated at 20% and the replication rate was also estimated to be 20%[vi].

Table 3.2: Fruit Water and Electricity Reduction Opportunities

	units	Pipfruit	Kiwifruit	Grapes	Total	
Total Production Area	ha	9,280	13,290	33,420	55,990	
Irrigation Area	ha	8,350	3,320	11,200	22,870	
Irrigation Rate	mm	300	135	240	-	
Estimated efficiencies at 20% resource savings and 20% replication rate						**Value (NZ$)**
Water	m^3	1,002,000	179,415	1,075,000	648,660	
Electricity	kWh	310,690	248,520	333,310	995,790	139,600
GHG[1]	tCO_2e	67	53	72	192	4,800[2]

Note: GHG emissions reductions are based on electricity savings and an average emissions rate of 0.215 $kgCO_2e/kWh$
Electricity price are estimated at \$0.15/kWh and carbon pricing at \$25/tCO_2e

[vi] As with the dairy farming sector, a 20% replication rate has been used within this study in line with the Defra study. This seemed reasonable taking into consideration that early adoption of new technologies may result in a 2-5% replication rate, whilst best management practices after sufficient time may incur a 80%+ replication rate.

3.2.2 *Material Use*

Fertiliser Use

None of the GHG Horticulture sector reduction reports prepared for the MAF GHG footprint studies identified opportunities for reducing fertiliser inputs. In fact, the pipfruit report stated that the amount of nitrogen applied to the orchards was below the amount of nitrogen exported in the fruit. Thus, the amount of nitrogen applied to the soil via fertiliser could be considered optimum and could not be further reduced.

Although average fertiliser inputs could be considered optimum, the large variability across different operations offers the possibility for efficiencies in fertiliser use. For example kiwifruit nitrogen inputs averaged 129 kgN/ha but varied between 50 and 220 kgN/ha. Likewise pipfruit averaged 20 kgN/ha and varied between 0 and 120 kgN/ha.

Based on a surveyed average nutrient application rate per hectare, it is possible to estimate the fertiliser inputs into the fruit sector as well as the overall costs to the industry (see *Table 3.3*). The nitrogen fertiliser inputs used in the fruit sector can then be placed into context through comparison with the 328,157 tonnes of nitrogen used in New Zealand during 2008, as documented in the *New Zealand GHG Inventory*. To put it into context, extrapolation of the nitrogen data for the fruit sector based on a bottom up analysis, shows that they account for less than 1% of New Zealand's total nitrogen use.

Table 3.3: Fruit Fertiliser Use

2009	Apple	Avocado	Kiwifruit	Wine Grape	Black-currant	Cherry	Total (ha)		
Production Area (ha)									
North Is.	6060	4100	12650	9060	-	20	31890		
South Is.	3230	10	640	24360	1270	580	30090		
Total	9280	4120	13290	33420	1270	600	61980		
% of Total	15%	7%	21%	54%	2%	1%			
Material Inputs (kg/ha)							**Total (kg)**	**Costs (NZ$/kg)**	**Cost (NZ$)**
N	20	-	129	18	48	-	2,546,000	3.39	$8,628,000
P	2	-	27	4	1	-	499,000	2.48	$1,239,000
K	19	-	215	18	55	-	3,685,000	2.48	$9,141,000
S	26	-	90	-	25	-	1,470,000	2.48	$3,647,000
Mg	0	-	48	-	0	-	642,000	-	-
Lime – soil	172	-	423	833	0	-	35,068,000	0.043	$1,508,000
Lime – tracks	210	-	0	-	-	-	1,949,000	0.043	$84,000
									$24,280,000

3.2.3 *Waste Production*

As with material use, there have been limited opportunities identified to reduce waste production within the Fruit and Tree Nut sector. This parallels with the Dairy Cattle Farming sector and can be attributed to the strong drivers for waste reuse (both organic and inorganic) in the agricultural sector. This is more broadly discussed in the TRC Investigation into Taranaki's Rural Waste Survey outlined in *Section 2.1* above.

3.2.4 *GHG Emissions*

The main sources of GHG emissions in the Fruit and Tree Nut sector is nitrogen fertiliser, both manufacturing and once applied in the field, and energy comprising diesel, petrol, oil and electricity use, and includes fuel purchased by the orchardist and that used by contractors. GHG emission reduction opportunities have been identified in various MAF co-funded carbon footprinting reports; however the opportunities are reasonably limited.

Kiwifruit

Four short to medium term orchard-based GHG emission reduction opportunities identified through the MAF and Zespri GHG footprinting study, reduced orchard GHG emissions by just over 20%; although almost half of which was a modelled increase in productivity. One of the next most significant opportunities was substituting mowing for sheep grazing. However, the suggestion of a 50% reduction seems unlikely given that sheep could only graze when the vines are dormant and grass growth is minimal anyway. Most tractor operations are power takeoff based so consequently there are limited reduction opportunities through better setup. Nevertheless, the large variation between orchards suggests that different management practices, such as the number of mowing and spray passes, could yield lower fuel use on some orchards.

Mithraratne et al.[32] showed average fuel use from 32 surveyed green kiwifruit orchards was 460 l/ha. However, there is an enormous range of between 57 and 1,008 l/ha (unpublished data). While variable record keeping may account for some of the variation, nevertheless opportunities clearly exist for reducing fuel use. Fuel use on a modelled orchard was 350 l/ha.

Electricity use on green kiwifruit irrigated orchards average 2,020 kilowatt-hours (**kWh**) per hectare (compared to 3,050 kWh/ha on gold kiwifruit irrigated orchards), while un-irrigated orchards averaged 150 kWh/ha.

As highlighted previously, few reduction opportunities were identified in the study by Deurer et al. and were linked with on-orchard transportation. It is however estimated that on average orchards may be able to reduce their diesel fuel use from 460 l/ha to 350 l/ha, an approximately 25% reduction.

Pipfruit

Based on the survey conducted for the MAF and Pipfruit New Zealand GHG Footprinting project[28], electricity use for irrigation is 930 kWh/ha, ranging between 90 – 2,830 kWh/ha (unpublished data). Similar 20% savings could be anticipated as estimated for kiwifruit (*Section 6.2.1, Water Use*).

3.3 ECONOMIC IMPACT ASSESSMENT MODELLING

3.3.1 *Efficiency Gains*

Two areas of efficiency gains were modelled for the ANZSIC (2006) A013 Fruit and Tree Nut Growing key sector corresponding to EIAM Sector 1: *Horticulture and Fruit Growing*. First was a 20% reduction in electricity, replicated across 20% of industry (primarily from improved irrigation management). Also modelled was a 25% reduction in diesel consumption across the entire industry. This reduction fed into the model through the 'petroleum refining, product manufacturing' sector of the model.

When distributed across and consumed by other sectors of the economy, these resource efficiency gains achieve a total economic impact of **NZ$3.9 million per annum**.

3.3.2 *Target Efficiency Areas*

For the *Horticulture and Fruit Growing* sector, inputs from *rubber, plastic and other chemical product manufacturing* (4.2%), *paper and paper product manufacturing* (3.95%), and *fertiliser and other industrial chemical manufacturing* (4.53%) represent the resources sectors that could be prioritised for saving potential.

To extend this scoping approach, *Table 3.4* presents values of each of the key sectors top five inputs.

Table 3.4: Fruit and Tree Nut Growing Top Five Inputs (2006)

Input	Input Value (NZ$ million)	% of Sector Inputs
1. Horticulture and Fruit Growing *(ANZSIC 2006 A013 Fruit and Tree Nut Growing)*		
Services to agriculture, hunting and trapping	203.988	15.6
Wholesale and retail trade	151.110	11.5
Finance and insurance	143.150	11.1
Other business services	107.990	8.2
Fertiliser and other industrial chemical manufacturing	59.448	4.5

Service sector inputs are of primary importance to the *Horticulture and Fruit Growing* sector, comprising three of the top five expenditures. Inputs from *wholesale and retail trade* are the second highest value. While inputs from *fertiliser and other industrial chemical manufacturing* are considerably lower than other top five inputs, at about half the value of the next highest value input, *other business services*.

3.3.3 *Replication Rate Sensitivity Analysis*

In order to provide some context on the effect that the rate of efficiency measure replication can have on the overall scale of benefits accrued, a sensitivity analysis was undertaken using the EIAM. For the Fruit and Tree Nut Growing sector, a 10% replication rate and a 50% replication rate was modelled for the reduction in electricity and reduction in diesel consumption across the entire industry. The results are presented in *Table 3.5* alongside the original estimate of a 20% replication rate.

Table 3.5: Fruit and Tree Nut Growing Replication Rate Sensitivity Analysis

Inputs	**10%**	**Original (20%)**	**50%**
Total Increase in Output (NZ$ Million per annum)	0.84	3.89	4.19
Relative Increase from 10% Replication Rate	-	4.6	5.0
Relative Increase from 20% Replication Rate	-	-	1.1

The sensitivity modelling highlights that for the Fruit and Tree Nut Growing sector, doubling the replication rate from 10% to 20% more than doubles the potential financial savings. However, in moving from a 20% to a 50% replication rate the extent to which financial savings are accrued slows significantly. Whilst further analysis would provide a more comprehensive picture, the initial results suggest that the financial benefits of increasing the replication rate decrease as the replication rate increases. The initial results even suggest that a potential plateau point could be reached within the sector where increasing the replication rate generates negligible savings.

4. BAKERY PRODUCTS MANUFACTURING

Under the ANZSIC classification, Bakery Products Manufacturing includes bread, cake, pastry, and biscuit manufacturing, including canned or frozen bakery products. Specifically excluded from the classification are units that are mainly engaged in selling products baked on the same premises directly to the general public, which are included within the Bread and Cake Retailing sector classification.

4.1 KEY DATA SOURCES

There are few documented New Zealand studies of resource efficiency initiatives implemented within the Bakery Products Manufacturing sector. Some data was however obtained from the project steering group on emerging efficiency initiatives and resource savings opportunities in a number of New Zealand commercial baking facilities. This data was supplemented by several UK and Australian studies associated with the Envirowise and Environment and Resource Efficiency Plans (**EREP**) programmes respectively that were identified through the baseline data review (see *Table 4.1* below).

Table 4.1: Bakery Case Study Efficiency Gains

Case Study	Country	Target Efficiency Measures	Efficiencies Achieved			
			Water Use	Material Use	Waste Production	GHG Emissions
Ginsters	UK	- Take advantage of cost savings - Environmental benefits	- 50% reduction in water used for cleaning	- 30% reduction in cardboard waste per tonne of product	- 47% reduction in food waste per tonne product - 27% reduction in waste to landfill per tonne of product	Not presented in case study
Goodman Fielder	AUS	- Comply with EREP program - Understand energy and water reuse - Become more sustainable	- Water reduction from 10L per to 2.5L per mix on vacuum mixer pumps	Not presented in case study	- Diverting 5000t waste bread from landfill to reuse	Not presented in case study
General Mills	US	- Demonstrate and measure pollution prevention benefits by integrating environmental considerations into design practice	Not presented in case study	- 40% reduction in ingredient wastes	- 40% reduction in ingredient wastes - 97% of ingredient and material waste recycled	Not presented in case study
Speedi-bake	UK	- Optimise energy use - Utilise low energy technology	Not presented in case study	Not presented in case study	Not presented in case study	- Reductions in energy costs
Avana Bakeries	UK	- Reduce water use and effluent	Not presented in case study	Not presented in case study	- Improved solid waste segregation - Improved recycling and compaction of wastes	Not presented in case study
Country Bake Bakery	AUS	- Reduce volumes and pollutant loading of wastewater generated at the site	Not presented in case study	- Reduction of pancoat oil use by 90%	Not presented in case study	Not presented in case study

4.2 RESOURCE EFFICIENCY OPPORTUNITY

The data review identified a number of efficiency opportunities as highlighted in *Table 4.2* and discussed in the following sections.

Table 4.2: Bakery Products Manufacturing Efficiency Opportunities

Resource Efficiency Measure	Efficiency Area	Efficiency Option
Water Use	Wash down waters	- New equipment, e.g. low-volume, high-pressure hose system - New practices, e.g. reuse water from high quality streams/dry cleaning/ equipment soakage
	Production waters	- Recycling systems for non-product production waters, e.g. for mixer pumps
Material Use	Ingredient use	- Linked to waste production and GHG emissions options
Waste Production	Ingredient wastage	- Consolidation of manufacturing streams
		- Modification/optimisation of food processing equipment
	Organic waste disposal	- Diversion from landfill, e.g. to animal feed/anaerobic digestion plant
	Non-food waste	- Bulk purchasing of input materials - Reusable output packaging/ transportation crates etc.
GHG Emissions	Transport logistics	- Delivery and ingredient sourcing planning
	Site energy reduction	- Energy efficiency initiatives - Ovens and air compression improvements - Heat exchange on steam boilers

4.2.1 *Water Use*

Water usage on bakery manufacturing sites includes process waters and waters used to wash-down and clean facilities. The data review identified potential efficiency options associated with changes in practices, new equipment and water stream diversion.

For example, the Envirowise Ginsters case study[33] identified the use of low-volume/high-pressure hose nozzle systems with trigger control for cleaning in the bakery and production areas contributed to a 50% saving in total water consumption. The Curtin University Centre of Excellence in Cleaner Production (www.cleanerproduction.curtin.edu.au) study on cleaner production methods at a Tip Top Bakeries site in Western Australia[34] and the United Nations Environment Programme (**UNEP**) Working Group for Cleaner Production study at Country Bake, Queensland[35], both indicated better housekeeping, such as avoiding leaving taps and hoses running and ensuring leaks are repaired as well as dry rather than wet cleaning, as key measures for water use reduction.

Diversion of wastewaters from high quality water streams (such as from production waters) for use as 'feed-waters' for lower quality processes, such as cleaning, or recycling non-food process waters, were also identified as a potential water reduction opportunity in a number of studies. Whilst this can generate significant savings, it can also involve significant capital cost in order to re-engineer existing processes. For example, the EREP Goodman Fielder case study[36] highlighted that installation of a water recycling system on their mixer vacuum pumps reduced water use from 10 litres per mix to 2½ litres per mix.

Some process changes are also identified within the UNEP Country Bake study that can reduce contaminant loading of wastewaters, such as the replacement of oil with water as a non-stick agent in dough-tipping machines and the replacement of the oil-spray system to reduce overspray of baking tins. Changes in the oil used to spray baking tins from pancoat oil to an emulsified oil also changed wastewater contaminant loading, as well as reducing spoiling of bread products by grease build-up on conveyor belts.

The case studies reviewed (see for example *Table 4.1* above) identified the potential for these measures to produce 25% reduction in production water use and 50% reduction in washdown water use.

4.2.2 *Material Use*

Material inputs to the Bakery Products Manufacturing sector centre predominantly on product ingredients, and as such opportunities for the reduction of resource usage can be limited. Such opportunities can also be closely linked with efficiencies in waste production and GHG emissions. Reduced food waste for example decreases the volume of ingredients required for production, whilst alternative sourcing of ingredients using environmental parameters such as local sourcing can help to reduce GHG emissions. These opportunities will therefore be discussed in *Sections 4.2.3* and *4.2.4* respectively.

4.2.3 *Waste Reduction*

Food Waste Diversion

Food waste diversion is a key waste minimisation opportunity for the bakery products industry, with a range of alterative reuse routes. Animal feed and lower quality products (e.g. breadcrumbs for waste bread products) are two common alternatives to landfilling, whilst composting and energy generation through supply to anaerobic digesters are also potential routes for diversion.

In a number of studies (e.g. the Curtin University Tip Top Bakeries study and the Australian EREP Goodman Fielder case study) returned products were also considered for waste diversion (see *Table 4.1* above).

Production Consolidation

Another key waste reduction/material use optimisation opportunity highlighted within the Envirowise Ginsters case study and also identified in New Zealand-specific information provided by the project steering group centres on the consolidation of different bakery product streams. Within the Envirowise study, it was highlighted that Ginsters had twenty-two different pastry specifications, meaning that different bakery product lines could not be reworked into one another, leading to the generation of significant food wastage. To counter this wastage, Ginsters standardised their pastry recipe in consultation with their customers to allow mixing of product lines.

Similarly, a waste minimisation opportunity identified by the project steering group focuses on the consolidation of bakery products within a number of different manufacturing facilities. Instead of manufacturing all products within all facilities, products could be grouped with all similar component products being manufactured in the same facility, thus allowing excess base ingredients to be utilised in other production streams. Such initiatives can also be combined with consideration of the geographical location of ingredient sources to enhance GHG emissions reductions, as will be discussed in *Section 4.2.4*.

Processing Equipment Modification/Optimisation

A further food waste minimisation opportunity identified within the Envirowise Ginsters case study was the modification of processing equipment to reduce wastage. Within the study, two initiatives were undertaken. Firstly, it was identified that a slight modification of the pastry cutting equipment would allow an extra row of product to be made, thus not only reducing pastry wastage, but also increasing productivity. A more capital intensive initiative was the replacement of Ginsters' meat mincers to equipment that was more efficient at removing gristle, which halved the original 4% meat loss.

Similarly, the UNEP Country Bake study identified that during the dough tipping process, significant dough was lost during the transfer. Improvement of the inclined plate positioned between the mixers and the metal bin guides eliminated this wastage.

Process optimisation using information technology is the subject of two case studies, one from the University of Waikato[37], which utilises data mining techniques to cross reference production process data with product quality data and the second from Microsoft®[38] relating to the use of business intelligence to improve communications with customer delivery efficiencies. In both cases, the focus centres more on the quality and customer service benefits of implementing such technologies, however there are clearly potential resource efficiency savings through reduction of wastage, although these are not quantified within the case studies. These initiatives are also unlikely to be low cost options, requiring some investment in information technology systems.

Non-Food Waste

Some opportunities to reduce non-food waste were identified during the data review, such as bulk ordering of ingredients to reduce packaging waste, alternative product delivery mechanisms (e.g. moving from delivery of products to customers in cardboard boxes to re-usable plastic trays). Supply chain engagement to develop return schemes for re-usable/recyclable materials (e.g. ingredient delivery buckets/cardboard) was also identified in a number of studies.

Equipment modifications such as improved packaging robotics to reduce damage were also identified as more high-cost initiatives.

Table 4.3: Summary Waste Production Efficiency Opportunity

Waste Production		
Total Waste Diversion from Landfill	**Food/ Ingredient Waste Reduction**	**Non-Food Waste**
10%-30%	40-97% reduction	30% reduction cardboard

4.2.4 *GHG Emissions*

Transport Logistics

Whilst data on the scope of GHG emissions reductions that could be accrued through improved management of transport logistics has not been identified within the data review, it is a potential area of opportunity given the need to transport ingredients to manufacturing sites and manufactured products to customers. Options include improved sourcing of ingredients (using locally grown ingredients); improved fleet management (through driver education and vehicle maintenance); as well as enhanced logistical support (for example efficient route planning). Changes to fleet through for example the use of low carbon vehicles is also an option, but could require significant capital investment to realise efficiency benefits.

Energy Reduction

Data focussed on GHG emissions reduction opportunities within the bakery manufacturing products area has predominantly centred on energy efficiencies at manufacturing sites. Energy intensive processes such as oven baking and air compression are often the main focus of attention, with improved insulation and maintenance being commonly identified mitigation options, as well as the installation of heat exchange on steam boilers. Whilst these improvements are likely to require reasonably high cost investment, some lower cost improvements can also be identified, such as ensuring the minimisation of energy usage during machinery/facility down-time.

Efficiency studies gathered through the process of the data review identified these improvements could result in savings in the order of 10-30%.

4.3 *ECONOMIC IMPACT ASSESSMENT MODELLING*

4.3.1 *Efficiency Gains*

Several areas of efficiency gains were modelled for the ANZSIC (2006) C117 Bakery Product Manufacture focal sector corresponding to EIAM Sector 13: *Other Food Manufacturing*. First was an average reduction in electricity consumption of 15% across the entire industry. This reduction fed into the model through the *electricity generation* sector of the model. Second was an average 38% reduction of water consumption from production and wash-down waters across the entire industry. This reduction fed into the model through the *water supply* sector of the model. Third was an average 15% reduction of total waste disposed at landfill across the entire industry. This reduction fed into the model through the *sewage, drainage and waste disposal services* sector of the model.

Resource efficiency gains achieved within the *Other Food Manufacturing* sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$9.3 million per annum**.

4.3.2 *Target Efficiency Areas*

For the *Other Food Manufacturing* sector, major material inputs come from *rubber, plastic and other chemical product manufacturing* (4.54%), with significant input also coming from *road freight transport* (5.33%).

To extend this scoping approach, *Table 4.4* presents values of each of the key sectors top five inputs.

Table 4.4: Bakery Products Manufacturing Top Five Inputs (2006)

Input	**Input Value (NZ$ million)**	**% of Sector Inputs**
13. Other Food Manufacturing *(ANZSIC 2006 C117 Bakery Product Manufacturing)*		
Other food manufacturing	$1,117.859	28.1
Fishing	$517.171	13.1
Wholesale and retail trade	$501.742	12.5
Other business services	$252.743	6.1
Road freight transport	$213.507	5.3

The *Other Food Manufacturing* sector covers food production excluding meat and dairy. This sector's highest value inputs come from within the sector, with inputs from *fishing* encompassing less than half this value. Distribution of food products means that inputs from the *road freight transport* are of significant value.

4.3.3 *Replication Rate Sensitivity Analysis*

In order to provide some context on the effect that the rate of efficiency measure replication can have on the overall scale of benefits accrued, a sensitivity analysis was undertaken using the EIAM. For the Bakery Products Manufacturing sector, a 10% replication and a 50% replication rate for the reduction in electricity consumption, reduction of water consumption and reduction of total waste disposed at landfill across the entire industry were modelled. The results are presented in *Table 4.5* alongside the original estimate of a 100% replication rate.

Table 4.5: Bakery Products Manufacturing Replication Rate Sensitivity Analysis

Inputs	**10%**	**50%**	**Original (100%)**
Total Increase in Output	0.92	4.62	9.25

Inputs	10%	50%	Original (100%)
(NZ$ Million per annum)			
Relative Increase from 10% Replication Rate	-	5.0	10.0
Relative Increase from 20% Replication Rate	-	-	2.0

The sensitivity modelling highlights that unlike the previous two sectors, the effect of increasing replication rate on efficiency savings within the Bakery Products Manufacturing sector exhibits a linear trend. Thus by doubling the replication rate, there is a doubling in potential financial benefits even towards a 100% replication rate.

5. *WINE MANUFACTURING*

5.1 *KEY DATA SOURCES*

5.1.1 *Sustainable Winegrowing New Zealand*

Production in New Zealand wineries has increased from 60 million litres per year in 2000 to 205 million litres in 2009[39]. Alongside this growth the industry has put in place the Sustainable Winegrowing New Zealand (**SWNZ**) programme (www.nzwine.com/swnz/index.html). The programme is an accreditation scheme that monitors and sets targets for enhanced environmental management in vineyards and wineries and has a key goal of providing a "best practice" model of environmental practices in the industry.

There are 1,244 vineyards (comprising 1,128 growers) and 135 wineries out of 643 involved in the programme. The number of participating vineyards increased by 82% between 2008 and 2009 and winery participation rate similarly increasing by 75%. One of SWNZ's current initiatives is the development of a database and associated management tools which will enable them to identify key production issues that will enhance the long-term sustainability of the wine-grape industry.

SWNZ projects that have been completed, or that are currently in progress, and have specific relevance to resource efficiency within the Wine Manufacturing sector include: winery energy benchmarking including application of the BEST-Winery tool (http://best-winery.lbl.gov/); carbon footprinting of the whole supply chain using full life cycle principles; and the development of the *Code of Practice* (**CoP**) *for Winery Waste Management*[40]. The winery energy benchmarking and efficiency measures study was part of the joint SWNZ and SFF project *Strategy for Improving Energy Use in the Wine Industry* (SFF Grant No. 06/096[41]). An extension of the project is expected to include collection of data on water consumption.

Alongside these projects each SWNZ member is audited against key performance indicators such as: soil and nutrient management; water management; plant protection; energy; and conservation. Currently this is a "tick box" approach to a series of questions, however in the future more resource use data is likely to be collected. It is only a recommendation, but respondents can currently enter their water and energy use.

5.1.2 *Other Data Sources*

New Zealand Wine (**NZ Wine**, www.nzwine.com) produces an annual report, which includes sector statistics on grape and wine production. NZ Wine also has a comprehensive CoP for winery waste management and was involved in a MAF funded project focused on developing a wine industry-specific GHG Product Accounting Guidelines[42]. The resultant GHG Product Accounting Guidelines includes a worked example with an inventory of material inputs along with the GHG emissions. Further information on these data sources is provided in the Baseline Review Database highlighted within *Annex D*.

5.2 *RESOURCE EFFICIENCY OPPORTUNITY*

The data review identified a number of efficiency opportunities as highlighted in *Table 5.1* and discussed in the following sections.

Table 5.1: Wine Manufacturing Efficiency Opportunities

Resource Efficiency Measure	Efficiency Area	Efficiency Option
Water Use	Process water	- Replacement of single pass cooling with cooling tower - Check for leaks - Use of low-quality water for cooling - Re-circulate low-quality process waters
	Wash waters	- High pressure nozzles with auto-shutoff - Use of brooms/mops - Use of low quality water/ stormwater - Minimise flushing of lines
Material Use	(Limited opportunities)	- Related to waste minimisation
Waste Production	Solid waste	- Use as compost or soil amendments - Use as stock feed - By-product production
	Wastewaters	- Reuse as irrigation water or low quality process water
GHG	Refrigerant loss	- Change of refrigerant - Modification of system
	Glass bottle manufacture	- Use of light weight glass - Use of alternatives, e.g. PET

5.2.1 *Water Use*

Water use in the Wine Manufacturing sector is predominately associated with cleaning (hot and cold) and refrigeration (heat exchangers, cooling towers). New Zealand winery water use figures could not be found, although the BEST-Winery tool uses a US industry average of 6 litres of water per litre of wine produced. This would equate to New Zealand wineries using approximately 1,230,000 m^3 of water per year. Waste water disposal (see below) comprises approximately 70% of this, which seems to be a reasonable fit.

Electricity used for pumping water is approximately 0.012 kWh/l wine produced (BEST-Winery modelled figure) equating to 2,400 megawatt-hours (**MWh**) or around 3% of a winery's energy use.

The BEST-Winery programme lists a number of potential water saving measures including:

- Implementing a water management programme;
- Repairing leaks;
- High pressure nozzles with auto-shutoff devices;
- Replacing single pass cooling system with cooling tower; and
- Alternative sources of make-up water in cooling towers.

The water savings associated with these efficiency options are presented in *Table 5.2*.

Table 5.2: Summary of Winery Resource Use Savings

BEST-Winery Efficiency Option	Water Savings
implementing a water management programme	5%
repairing leaks	2%
high pressure nozzles with auto-shutoff devices	20%
replacing single pass cooling system with cooling tower	90% cooling water saving or 10% total water use
alternative sources of make-up water in cooling towers	11%

The short-term reduction options (those with immediate to less than 2 year payback period) could typically achieve savings of around 35%. Longer term reduction options such as replacing the single pass cooling system could add a further 9% water saving.

The SWNZ *CoP for Winery Waste Management*[40] also identifies a number of potential options for minimising water use and wastewater production in winery operations, as presented in *Table 5.3*.

Table 5.3: Overview of Cleaner Production Techniques for Minimising Wastewater in Winery Operations (after SWNZ)

Process Control	Process Modification
Use brooms or squeeze-mops to clean floors rather than wash down	Phase out wet discharge filters in favour of dry discharge filters
	Use nozzles which turn off when the grip is released
	Separate stormwater
Reduce frequency of washing	Use low volume, high efficiency cleaning systems
Use no more water than needed for the job	Design and place equipment to minimise transfer distances and make cleaning easy
Cellar: change placement of valves to eliminate total flushing of lines when bleeding	Use foam pigs to create an oxygen barrier when transferring juice and wine
Reuse stormwater for cleaning floors etc	Modify pumps on vacuum drum filters to enable recirculation of water
Check for leaks in equipment	Not required
Recirculate water used to keep seals of centrifuges and other equipment moist	
Maximize recycling of caustic/citric cleaning waters	
Treat water for reuse in the winery or for irrigation	
Separate recycled caustic and ion exchange wastes, lees and treat separately	
Minimise effluent requiring disposal	

5.2.2 *Material Use*

As with the Bakery Products Manufacturing sector, the main material input to the industry is raw ingredient, in this case grapes. In 2009 the total crush was 285,000 tonnes producing 205 million litres of wine in 2009[39]. Efficiencies within this area will similarly map onto those identified within the bakery sector and centre on waste reduction opportunities within the processing stream (see *Section 5.2.3* below).

Based on the resource use inventory prepared for the GHG footprinting project, packaging is the next most significant input to the sector, with glass at approximately 565 g/bottle, cardboard cartons at 390 g/case and screw caps at 5 g/bottle[42]. *Table 5.4* presents a projection of winery material use based on these figures.

Table 5.4: Projected Winery Material Use

	Tonnes
Grapes	285,000
Wine	205,000
Glass bottles	154,580
Cardboard cartons	8,890
Aluminium screw cap (80% of bottles)	1,180

Opportunities to reduce material use within this area are also constrained due to the nature in which wine is traditionally sold (i.e. by the single units such as bottles or cardboard casks), which reduces the opportunity for bulk packaging. Alternative bottle materials such as PET have been developed, however the resource efficiency benefits associated with their use arise more within the GHG emissions reduction opportunity (see *Section 5.2.4*).

5.2.3 *Waste Reduction*

The SWNZ CoP for Winery Waste Management[40] provides practical guidance on strategies for managing wastes generated by wineries. The overall goal is to promote cleaner production and sound environmental practices. A number of strategies are identified within the report for solid waste and wastewater reduction.

For wastewater, beneficial reuse as irrigation waters (e.g. for vineyards, fertigation, woodlot, pasture or landscaped areas) or low-quality process waters were the key options identified within the CoP. Whilst reuse of solid wastes as composting or soil materials, stock feed and even as by-products such as grape seed and vitamins were highlighted.

Major solid waste streams from the wine making process are identified in the CoP, with the main stream identified around harvest when marc[ix] is produced at the first crush. In New Zealand typically 1.0-1.5 tonne of marc is produced per 10 tonnes of grapes crushed. Nationally approximately 35,600 tonnes of marc needs to be disposed of and 855,000 m^3 of winery waste water treated. The marc is normally composted and used as a soil conditioner. Leachate from stockpiled marc is also identified as a key wastewater stream that needs to be captured and treated through winery effluent or pasture irrigation system.

Processing and cleaning generates on average 3 m^3 of wastewater per tonne of grapes. A target of 1.5 m^3/t has been set as a feasible target.

[ix] Marc consisting of stalks, seeds and skins from pressing of grapes

5.2.4 *GHG Emissions*

The MAF/NZ Wine project to develop a wine industry-specific GHG Product Accounting Guidelines[42] identified that total GHG emissions were 1,240 gCO_2e/bottle; of which 19% were in the vineyard, 19% in the winery (of which over 90% were electricity), 37% associated with packaging, and distribution was 22%. Refrigerant losses were not included in the case study, however a worked example within the associated GHG Reduction Report[43] showed this may add a further 330 gCO_2e/bottle, giving total emissions of 1,570 gCO_2e/bottle.

The two most significant winery GHG emissions were identified as refrigerant losses and glass bottle manufacture.

Reduction opportunities for refrigerant losses include retrofitting the plants to use a refrigerant with a lower GWP. For example, replacement of the refrigerant 'R404A' which has a GWP of 3,260 to the refrigerant 'R417A' with a GWP of 1,920 achieves GHG reductions of 40%. Major modifications to the refrigeration plant to accommodate refrigerants with zero GWP like ammonia were also identified within the study.

In a study conducted by Hennessy and McCurdy[44] very limited information on commercial coolstores was identified, mainly because it represents such a huge range of businesses, including hotels, restaurants, liquor stores, breweries, wineries, non-supermarket food retailers and primary produce storage of fruit, dairy, meat and seafood products. The New Zealand Cold Storage Association (www.coldstoragenz.org.nz) has only limited statistics on its members' range of coolstore sizes (not refrigerants), which is a small fraction of the total range. The projections presented in this report (see *Table 5.5*) are based on the worked example provided in MAF/NZ Wine GHG Reduction Report.

Packaging reductions can include using light weight glass. A typical 750 ml wine bottle weighs 560 g while light weight bottles are 270 g, consequently emissions are halved. Yealands Estate (www.yealands.com) are using a PET bottle that is purported to generate 54% less greenhouse gas emissions and use 19% less energy to produce than traditional glass bottles[45]. This seems to be on the high side as a study by Franklin Associates[46] had PET bottle life cycle emissions of 306 gCO_2e/bottle (899 pounds (**lbs**)/1000 litres), of which material and container production is approximately 250 gCO_2 e/bottle or a 28% reduction compared to glass. The lighter weight glass and PET bottles will also reduce transport fuel use and emissions.

Table 5.5: Winery Packaging and Refrigeration GHG Reduction Opportunities

GHG Reduction Opportunity	Potential GHG Savings	Potential Sector-Wide Savings (assuming 20% replication rate)		
		units	Quantity	Value
switch to R404A	40%	tCO_2e	7,100	$177,800
light weight bottles	52%	tCO_2e	10,100	$252,100
PET bottles	28%	tCO_2e	5,500	$136,800

Energy

The *Strategy for Improving Energy Use in the Wine Industry*[47] study established average winery energy use at 0.47 kWh/L of juice. Based on the wine production in 2009, winery energy use is shown in *Table 5.6*.

Table 5.6: Winery Energy Use

	NZ Benchmark		Extrapolated NZ Winery Energy Use	
Electricity	0.34	kWh/l	70,400	MWh
Natural gas	0.30	MJ/l	62,500	Gigajoules
Other	0.15	MJ/l	31,200	Gigajoules
Total energy use	0.47	kWh/l		

Once this benchmark had been established, the second stage of the project, conducted by The AgriBusiness Group, investigated energy efficiency measures through the use of the Californian BEST-Winery tool adapted to New Zealand conditions. In developing the BEST-New Zealand model, several of the efficiency opportunities identified in the original BEST-Winery documentation were subject to case study testing. These case studies identified significant energy savings in New Zealand wineries through the application of the following initiatives:

- Night time operation of refrigeration and reducing/capping peak load usage;
- Improved lighting control;
- Changing compressed air compressor sizes and installing variable speed drives on compressor motors;
- Adopting processes to reduce ambient temperature;
- Cold settling at warmer temperatures;
- Monitoring daily records to identify usage peaks and process areas;
- Use of gravity to move wine around;

- Heat exchange from:
  - Wine processed;
  - Recovery off operating refrigerating machinery;
- Improving storage, including:
  - More tanks inside;
  - Shading external tanks;
  - Changing vessel size;
  - Using ambient cool night time air; and
- Splitting refrigerant material between water and ethanol.

The wineries used to adapt the BEST-Winery tool to New Zealand conditions in the second part of the study were found to have an average energy use of 0.33 kWh/l, which was 30% less than the industry established benchmark. It is however recognised that their involvement in the study would indicate that they already had an interest in energy use that motivated them to be involved.

The energy use along with their associated reductions, together with the GHG reductions, are summarised in *Table 5.7*. Energy savings of 30% were assumed and the replication rate was 20%.

Table 5.7: Winery Energy and Associated GHG Reduction Opportunities

	units	Quantity	Value
30% savings and 20% replication rate			
Electricity	MWh	2,800	$440,400
Natural Gas	Gigajoules	2,500	$40,200
Other	Gigajoules	1,200	$20,100
Greenhouse gas emissions	tCO_2e	800	$20,000

5.3 *Economic Impact Assessment Modelling*

5.3.1 *Efficiency Gains*

Several areas of efficiency gains were modelled for the Wine [and other alcoholic beverage] Manufacturing sector corresponding to EIAM sector 14 *Beverage Malt and Tobacco Manufacturing* sector. First was a 25% reduction in electricity use replicated across 20% of the industry. This reduction fed into the model through the *electricity generation* sector of the model. The second efficiency gain modelled was a 5% reduction in natural gas consumption across 20% of industry. This reduction fed into the model through the *oil and gas extraction, production & distribution* sector of the model. A third efficiency gain modelled was a 52% reduction in glass packaging across 20% of industry (switching to light weight glass). This reduction fed into the model through the *non-metallic mineral production manufacturing* sector of the model.

Resource efficiency gains achieved within the Wine Manufacturing sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$6.2 million per annum**.

5.3.2 *Target Efficiency Areas*

The highest value material input for the *Beverage Malt and Tobacco Manufacturing* sector comes from *structural, sheet and fabricated metal product manufacturing*. At 10.6% of the value of total inputs this may represent opportunities for savings based on material use efficiency. Only two other material inputs are valued at over 1% of total sector inputs; 1.48% from *paper and paper product manufacturing* and 2.61% from the *non-metallic mineral product manufacturing*.

To extend this scoping approach, *Table 5.8* presents values of each of the key sectors top five inputs.

Table 5.8: Wine Manufacturing Top Five Inputs (2006)

Input	Input Value (NZ$ million)	% of Sector Inputs
14. Beverage, Malt and Tobacco Manufacturing *ANZSIC 2006 C113 Dairy ProductC121400 Wine [and other alcoholic beverage] Manufacturing*		
Wholesale and retail trade	196.121	12.2
Other business services	196.104	12.2
Structural steel and fabricated metal manufacturing	170.405	10.6
Beverage, malt and tobacco manufacturing	164.341	10.2
Horticulture and food growing	138.070	8.6

The top five valued inputs into the *Beverage, Malt and Tobacco Manufacturing* sector account for about 50% of the value of total inputs into this sector, with each of the top five accounting for about 10% individually of the value of total inputs. This implies that no single input sector can be targeted based on greatest value, but rather the choices could be supported by identification of possible savings activities within input sectors. Perhaps unsurprisingly, inputs from *horticulture and fruit growing* are highly valued as these are primary raw inputs to manufacturing alcoholic beverages and tobacco.

5.3.3 *Replication Rate Sensitivity Analysis*

In order to provide some context on the effect that the rate of efficiency measure replication can have on the overall scale of benefits accrued, a sensitivity analysis was undertaken using the EIAM. For the Wine Manufacturing sector, a 10% replication and a 50% replication rate for the reduction in electricity use, reduction in natural gas consumption and reduction in glass packaging was modelled. The results are presented in *Table 5.9* alongside the original estimate of a 20% replication rate.

Table 5.9: Wine Manufacturing Replication Rate Sensitivity Analysis

Inputs	10%	Original (20%)	50%
Total Increase in Output (NZ$ Million per annum)	3.10	6.22	15.55
Relative Increase from 10% Replication Rate	-	2.0	5.0
Relative Increase from 20% Replication Rate	-	-	2.5

The sensitivity modelling for the Wine Manufacturing sector mirrors that observed within the Bakery Products Manufacturing sector, whereby the effect of increasing replication rate on efficiency savings exhibits a linear trend. Thus by doubling the replication rate, there is a doubling in potential financial benefits even towards a 100% replication rate.

6. *BUILDING CONSTRUCTION*

As highlighted previously, two building construction related sub-sectors were included within the scope of the study:

- Residential Building Construction; and
- Non-Residential Building Construction.

6.1 *KEY DATA SOURCES*

Detailed case study information regarding resource efficiency in the Building Construction sector was typically available through regulatory authorities (often as part of a local regulatory initiative e.g. Christchurch City Council (**CCC**)'s Target Sustainability, www.targetsustainability.co.nz) or through not-for-profit organisations (e.g. BRANZ, www.branz.co.nz, BioRegional, www.bioregional.com and SMARTWaste. www.smartwaste.co.uk, in the UK). The not-for-profit groups were typically structured with the aim of promoting waste reuse, recycling and reduction across the sector. Limited carbon assessments were conducted on several case studies in the UK (see for example www.bioregional.com/news-views/publications/). New Zealand Industry-specific data detailing waste recycling figures on a project-specific basis was obtained direct from Fletcher Construction.

A key finding of the baseline data review and subsequent data collection process was the paucity of available information on resource efficiency opportunities within the construction in areas other than waste reduction. Relatively little attention appears to have been paid to reduction opportunities in water, electricity and/or fuel use compared to construction wastes. This finding is likely to be a reflection on the quantity and value of each resource used within the sector, i.e. that waste forms the largest and potentially most costly component of building construction and demolition (**C&D**). To reflect this focus, the baseline data analysis for the two sub-sectors was divided further into building construction activities and building demolition activities.

The baseline data review also identified that whilst aspects such as the types of material used within the building construction do vary between the sub-sectors, the major differences within the context of this study centre on project size and hence economies of scale and feasibility when implementing resource efficiency measures. Therefore to model and quantify the benefits associated with resource efficiency, both sub-sectors have been combined under the broader 'building construction' category, with a focus placed on the range of replication rate modelled in order to mirror the difference ease of uptake within the sub-sectors.

6.1.1 *Residential Building*

Construction

With respect to residential building construction in New Zealand, CCC has been running a target sustainability programme where assistance is provided to business in an effort to become *'sustainable through reducing waste and being energy and water efficient'*. This programme details several case studies which demonstrate the level of material re-use and recycling that can be achieved in residential building construction, and was the main source of waste minimisation data for the residential construction sector. A single case study of a large residential housing complex based in the UK detailed cost savings made through the construction phase of the project.

Demolition

Two New Zealand based case studies quantify waste material efficiencies during residential demolition projects, although determining a financial quantification was only undertaken in one of the two projects. A UK based assessment of a reclamation-led demolition project was sourced through BioRegional which provides detail on carbon dioxide savings and financial benefits of better waste management.

6.1.2 *Non-Residential Building*

Construction

Similar to data for residential construction case studies, information regarding non-residential construction is sourced through government and not-for-profit organisations promoting efficient waste management practices. SMARTWaste, the East Midland Centre for the Built Environment (www.emcbe.com) and BioRegional are the UK organisations from which data was obtained not only for UK projects but also Canadian and New Zealand projects. New Zealand case study data is sourced from the CCC Target Sustainability programme, BRANZ and a specialist New Zealand resource efficiency consultancy, Wilkensen Environmental, www.wenz.co.nz.

Demolition

The bulk of the case study data available provided quantification of resource efficiencies across the non-residential construction and demolition sector. Several case studies detail the approach a New Zealand based demolition contractor, Ward Demolition (www.ward-demolition.co.nz) has taken to waste minimisation in New Zealand and the not insignificant cost benefits of this approach. CCC also provides a New Zealand case study of resource efficiency in waste management for the demolition and reconstruction of a stand in a sports ground.

6.2 RESOURCE EFFICIENCY OPPORTUNITY

The data review identified a number of efficiency opportunities as highlighted in *Table 6.1* and discussed in the following sections.

Table 6.1: Building Construction Efficiency Opportunities

Resource Efficiency Measure	Efficiency Area	Efficiency Option
Water Use	Site wash down waters	- New equipment, e.g. low-volume, high-pressure hose - New practices, e.g. reuse wastewaters/stormwaters
Material Use	Raw material use	- Linked to waste production options - Design phase considerations - Material substitution
Waste Production	Construction	- Effective inventory management/near real-time supply ordering - Site waste management plan - Waste segregation - Use of precast and prefabricated products - Return of excess materials
	Demolition	- Deconstruction versus demolition
GHG	Plant use and vehicle movements	- Improved fleet management - Improved logistical planning - Material sourcing/waste disposal location
	Material use	- Waste minimisation - Material substitution

6.2.1 *Water Use*

As highlighted previously, there was limited information on the resource efficiency opportunity for water use in the construction sector. Data focussed on water in construction generally centred on the need to manage and mitigate stormwater run-off from construction sites to prevent pollution and sedimentation of water courses[48] or water efficiency in building design. However, it is clear that broader industrial water efficiency principles could be applicable to a construction site, such as:

- Reduction of water used for wash down of construction site/vehicles; and
- Use of wastewaters/stormwater runoff for lower quality water applications.

6.2.2 *Material Use*

Material use reduction is closely linked to a number of the waste reduction opportunities outlined in *Section 6.2.3* below. For example, provision for better project planning and near real-time material supply focuses on reducing waste production by minimising the volumes of material brought to site and similarly returning excess material to suppliers, which will effectively reduce material use onsite.

Material use reductions can also be implemented at the design phase of building construction, through the consideration and incorporation of standard material supply dimensions within the building design and alternative building materials. In the case of building material substitution, a full life-cycle analysis would be important in ensuring that the substitution does not result in increases in other resource inventories, such as GHG emissions.

6.2.3 *Waste Reduction*

The data collection process identified that the focus of resource efficiency to date within the Building Construction sector has been on improved waste management, particularly with respect to demolition and deconstruction projects. Waste reduction is the most visible and easily targeted aspect of any C&D project, and much attention has been paid to the vast quantities of C&D waste generated and its proportion of total waste volumes both within New Zealand and abroad.

The C&D component of total waste has been quantified at up to 50% of New Zealand's total waste stream[49]. Of this, it is estimated this may contribute 20% of total landfill waste, and 80% of cleanfill waste[50].

This presents the opportunity within the sector not only for a significant volume of C&D waste to be diverted from landfill or cleanfill for beneficial reuse, but also for significant cost savings (and even profit) associated with this. There is the clear cost efficiency linked directly with improved waste management on both C&D sites through reduced waste disposal costs, reduced requirement for raw or new materials, and offsets through resale of used building products. Whilst it is acknowledged that the UK, from which many of the case study data was sourced, has a larger market to support waste minimisation and hence a potentially greater cost incentive than New Zealand, several New Zealand studies have indicated that financial benefits from smart waste management can be achieved[49].

In addition to material cost benefits, there is also benefit associated with brand reputation and resulting improvement in tender opportunities, and environment values which are hard to quantify but have the potential for significant economic returns.

General Efficiency Opportunities

Case study information reviewed as part of this study suggests improvements in waste production can be achieved relatively simply through improved contractor awareness and waste management methodologies. These strategies include:

- Effective project planning that allows sufficient time for the project to be undertaken so that time-cost drivers do not outweigh resource-cost benefits, and ensures that material requirements are not oversupplied (e.g. through effective inventory management and near real-time ordering of supplies);
- Development of a site waste management plan, and agreement by all on site to the targets set out;
- Inclusion of waste management targets within subcontractors contracts;
- Provision for a waste segregation area on site in which sufficient numbers of clearly marked skips or bins to cater for the range of waste generated are located;
- Improved training and education of all staff;
- Use of appropriate tools for work (more relevant to deconstruction); and
- Arrangements with suppliers for returns of excess materials and reduction of supplied material packaging etc.

These savings can be achieved through all phases of a project from tendering, design, project management, C&D.

Demolition

Building demolition appears to be an aspect of the construction sector where simple improvements in methodology can be made to produce significant cost and resource efficiencies. Several of the demolition case studies, both residential and commercial, actually point to profits that can be made from a carefully planned deconstruction or reclamation-led demolition.

Benefits will vary depending on a range of factors, not least the quality of the building being demolished or deconstructed and the available market for reclaimed and recycled products. However, the key limiting factor preventing widespread adoption of improved methodologies is often time restraints, with 'deconstruction' being more labour and time intensive than the traditional demolition approach.

Efficiencies in the construction sector are likely to exist for other key resource areas, notably energy consumption and GHG emission reduction and material use reduction.

Table 6.2, *Table 6.3*, *Table 6.4* and *Table 6.5* summarise some of the potential waste-related efficiency savings identified through the baseline data review and supplemental information gathering phases of the project.

Table 6.2: Construction Case Study Mixed Waste Diversion Rates

Sector	Total Mixed Waste Diversion from Landfill (Case Study Ranges)
Commercial Building Demolition	20-99%
Residential Building Demolition	30-98%
Commercial Construction	40-65%
Residential Construction	50-85%

Table 6.3: Residential Building Construction Case Study Recycling Rates

% Recycled Material	Mike Greer Homes	Golden Homes	David Reid Homes	Benchmark Homes	
Concrete	-	100	100	100	
Brick and tiles	100	-	-	100	
Plasterboard	100	-	100	100	
Metal	100	100	100	100	
Pink batts (landfilled)	-	-	-	-	
Untreated timber	100	100	100	100	
Treated timber	0	0	100	100	
Plastics	100	87.5	-	100	
	GJ Gardener	**Jennian Homes**	**Orange Homes**	**Stonewood Homes**	**Case Study Average**
Concrete	-	0	100	100	83.3
Brick and tiles	100	0	0	0	50
Plasterboard	100	100	100	100	100
Metal	100	100	100	100	100
Pink batts (landfilled)	50	0	0	-	16.6
Untreated timber	100	100	100	-	100
Treated timber	0	100	100	100	62.5
Plastics	100	0	0	0	55.4

Table 6.4: Waste Arisings from the UK Construction Sector (DEFRA)[2]

	Total Waste Arisings (Mt)	Recycled (Mt)	Landfilled (Mt)	Exempt (Mt)	Burned (Mt)	% recycled versus landfilled
Hard CDEW	98.3	49.2	30.7	18.5	-	50.1
Plasterboard	1.3	0.4	0.9	-	-	30.8
Timber	1.1	0.6	0.2	-	0.4	54.5
Steel	2	1.9	0.1	-	-	95.0
Non-ferrous metals	0.02	0.02	-	-	-	100.0
Packaging	2.5	1.4	1.1	-	-	56.0
Total	105.22	53.52	33	18.5	0.4	-

Table 6.5: Commercial Site Waste Production (Fletcher Construction Data)

			Paper		Concrete	Concrete Rubble Mix	Scrap Steel		Co-Mingle
Site 1, May			11.91%		2.23%	0.00%	2.58%		0.72%
Site 1, June			6.27%		1.94%	0.00%	4.80%		0.18%
	Glass Wheelie Bin	**Plastic Wheelie Bin**	**Paper Wheelie Bin**	**Clean Soil**	**Concrete**	**Concrete/ Soil/ Rubbish Mix**	**Metal**	**Other**	**Mixed**
Site 2, June	0.03%	1.07%	0.25%	0.00%	25.05%	10.86%	1.87%	1.23%	28.83%
Site 3, June	0.08%	1.65%	2.61%	0.00%	10.97%	5.44%	1.99%	3.89%	18.85%
Site 4, June	0.00%	1.09%	3.85%	0.00%	0.00%	14.82%	3.49%	10.89%	6.69%

	Timber	Gib Board		Poly-styrene	Wood Treated	Wood Untreated	Green Waste	Recycle	Landfill	Total Waste Weight
Site 1, May	20.56%	23.70%		0.00%	0.00%	0.00%	0.00%	61.70%	38.30%	17465
Site 1, June	15.96%	23.62%		0.00%	0.00%	0.00%	0.00%	52.80%	47.20%	10840
	Mixed Timber	**Plaster-board**	**Plastic**	**Poly-styrene**	**Tiles/ Cells/ Bricks**	**Untreated Timber**	**Green Waste**	**Recycle**	**Landfill**	**Total Waste Weight**
Site 2, June	0.29%	9.53%	0.75%	0.00%	0.00%	18.14%	2.13%	67.81%	30.05%	10944
Site 3, June	27.28%	18.16%	1.48%	0.00%	1.12%	3.30%	3.19%	74.08%	22.73%	12760
Site 4, June	18.85%	32.41%	1.17%	0.00%	0.00%	3.99%	2.75%	79.67%	17.58%	8080

6.2.4 *GHG Emissions*

Opportunities for GHG emissions reduction in the Building Construction sector centre predominantly in two areas:

- Direct emissions reductions from plant use and associated vehicle movements; and
- Indirect emissions reductions from waste minimisation and material use selection.

Due to economies of scale, these GHG emissions efficiencies are likely to be more feasible and financially beneficial within larger non-residential construction projects where there are greater volumes of materials and waste transported to and from site, increased plant movements within the site and greater material use overall.

As with other sectors, low-cost efficiency gains within the areas of plant and vehicle use focus largely on improved fleet management and logistical planning, whilst technological improvements can provide benefits at higher investment costs.

Embedded GHG within construction materials can form a significant component of the overall footprint of a construction site, hence efficiencies in material use and waste management can also lead to GHG reductions. Alternative building products also provide an opportunity to reduce GHG emissions associated with the whole life-cycle of a building, whilst alternative construction methods required to incorporate such materials could increase or decrease direct GHG emissions. Consideration of aspects such as material source and/or disposal option distance from site will also affect GHG emissions.

6.3 *ECONOMIC IMPACT ASSESSMENT MODELLING*

6.3.1 *Efficiency Gains*

One area of efficiency gain was modelled for the ANZSIC (2006) E301 Residential and E302 Non-Residential Building key sectors corresponding to EIAM Sector 31: *Construction*. Considered here was a 57.5% increase in total mixed waste diverted from landfill for the whole of both industries. This was an aggregate average across commercial and residential building demolition and construction. This waste reduction fed into the model through the *sewage, drainage and waste disposal services* sector of the model.

Resource efficiency gains achieved within the Construction sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **NZ$24.3 million per annum**.

6.3.2 *Target Efficiency Areas*

Almost ten percent of inputs to the *Construction* sector come from *wood product manufacturing* (9.97%) while inputs from *non-metallic mineral product manufacturing* are also relatively large at 7.57%.

To extend this scoping approach, *Table 6.6* presents values of each of the key sectors top five inputs.

Table 6.6: Building Construction Top Five Inputs (2006)

Input	Input Value (NZ$ million)	% of Sector Inputs
31. Construction *(ANZSIC 2006 E301 Residential and E302 Non-Residential Building Construction)*		
Construction	7,876.812	43.5
Wholesale and retail trade	1,828.348	10.1
Wood product manufacturing	1,803.709	10
Non-metallic mineral product manufacturing	1,368.677	7.6
Other business services	881.448	4.9

Similar to the previous key sector, the *Construction* sector receives a large proportion of its inputs from within the sector. This sector has a large value of inputs from *wood product manufacturing* and *non-metallic mineral product manufacturing*.

6.3.3 *Replication Rate Sensitivity Analysis*

In order to provide some context on the effect that the rate of efficiency measure replication can have on the overall scale of benefits accrued, a sensitivity analysis was undertaken using the EIAM. For the construction sector, a 10% replication and a 50% replication rate for the increase in total mixed waste diversion from landfill was modelled. The results are presented in *Table 6.7* alongside the original estimate of a 100% replication rate.

Table 6.7: Building Construction Replication Rate Sensitivity Analysis

Inputs	10%	50%	Original (100%)
Total Increase in Output (NZ$ Million per annum)	2.43	12.15	24.31
Relative Increase from 10% Replication Rate	-	5.0	10.0
Relative Increase from 50% Replication Rate	-	-	2.0

As with the Wine Manufacturing and Bakery Products Manufacturing sectors, the sensitivity analysis for the Construction sector indicates that a linear relationship is present between replication rate and efficiency savings. Thus by doubling the replication rate, there is a doubling in potential financial benefits even towards a 100% replication rate.

7. *LIMITATIONS*

7.1 *DATA LIMITATIONS*

Initial analysis of the data gathered for the Dairy Cattle Farming and the Fruit and Tree Nut Growing sectors identified a potential limitation of the project associated with the nature of the data gathered and its integration with the benefits quantification methodology outlined in *Annex B*. Specifically, the scale of the resource savings calculated using the methodology for these sectors was unexpectedly small and potentially not significant when considered with the limitations of the study. There are several possible explanations for these results:

- *The potential resource savings are accurate and reflective of the nature of the primary sector being studied.*

  The rationale for this explanation is that for primary sectors such as Dairy Cattle Farming and Fruit and Tree Nut Growing, many resource efficiency practices are already embedded within the industry (albeit perhaps not explicitly referred to as 'resource efficiency' practices). This has resulted from the significant timescales over which these industries have developed, which has allowed for natural process refinement and the identification/quantification of the financial benefits that can be accrued from such practices.

  Additionally, the raw material resource usages within these industries are minimal compared to other sectors (such as manufacturing-based sectors), as are the practical waste minimisation opportunities. This hypothesis is aligned with the findings of the MAF GHG primary sector studies, which concluded minimal reduction opportunities within the sectors.

- *More data is required to effectively model resource savings within the sectors being studied.*

  The previous studies into resource efficiency quantification (such as those highlighted in *Annex A*) have been built on significantly more data than that available for the purposes of this review. For example, the DEFRA *Quantification of the Business Benefits of Resource Efficiency* study[1] was based on data collected through the implementation of several resource efficiency programmes over a number of years which had generated a large amount of resource-efficiency specific data.

  This project, and the previous *Resource Efficiency in New Zealand* project, has highlighted a paucity of data on sectoral resource use in New Zealand generally, which may affect the effectiveness of the resource efficiency quantification methodology used in the study.

There are two possible options to address this issue: modification of the methodology; or enhancing data availability. As the central consideration in building the methodology for this study has been the key deliverable of a robust methodological approach aligned with best practice, the focus turns to improved data availability. A potential future programme of work therefore could centre on the development and implementation of data collection structures intended for resource use, which would also benefit the effectiveness mapping of any resource efficiency measures/ initiatives implemented.

- *The most available data does not reflect the key resource efficiency opportunities for each sector.*

  For each sector studied, the resource efficiency quantification has been shaped by data availability at the resource efficiency measure levels as well as the sector level. As detailed in the Baseline Review Database highlighted within *Annex D*, data was not available for all resource efficiency measures in each of the sectors studied. For example, whilst data on energy usage and waste production has generally been available for most of the sectors, water efficiency data has been less easy to identify and obtain. This is to a certain extent reflective of the fact that water has not historically been an important resource efficiency metric for New Zealand, due to an absence of both financial and environmental drivers. Data streams within this resource efficiency measure are therefore limited, even though there may be significant opportunity for water efficiency, at least on a quantity and quality basis, if not necessarily a financial one at present.

  There is again an opportunity to undertake a more detailed review of data at both a sector and a resource efficiency measure level. A recent presentation given by MfE at a workshop on water footprinting hosted by the New Zealand Life Cycle Management Centre indicated there are some efforts to better understand water allocation and actual water use in New Zealand.

7.2 *MODEL LIMITATIONS*

As highlighted in *Annex C*, the sectors selected for attention in this report are defined in alignment with Level 3 or Level 4 ANZSIC 2006 codes. The EIAM sectors were constructed using selected combinations of ANZSIC 1993 Level 2 industries. This means that the total economic impacts are likely to be over-estimated within the current EIAM, as savings reductions are applied at a level which includes more Level 3 industries than those considered here. To accommodate an analysis using this modelling framework at ANZSIC 2006 Level 3 would necessitate disaggregation of the current model sectors requiring resources beyond the capacity of the current report.

A further limitation of the EIAM is the lack of monetary values for water as inputs to the 'Horticulture and Fruit Growing' and 'Dairy and Cattle Farming' sectors of the EIAM. The agricultural sector represents a major water user but only a small proportion of the overall water used is provided through public supply and none is charged volumetrically. In the absence of a price charged for water, a value has been derived from apportioning on farm electricity use, as the volume of water use is tied to the cost of operating irrigation pump equipment.

8. CONCLUSIONS AND RECOMMENDATIONS

This study has identified a range of potential resource efficiency opportunities within six focal industry sectors. These efficiency opportunities are summarised in *Table 8.1* below.

Extrapolation of the most promising of these efficiency options across each sector through the EIAM result in estimated potential efficiency savings ranging from **NZ$2.6 million per annum** (Dairy Cattle Farming) through to **NZ$24.3 million per annum** (Residential and Non-residential Building Construction).

There are, however, a number of limitations within these estimated values, associated with both the availability of data on resource efficiency methods within each focal sector and also within the EIAM itself. One key limitation of the EIAM is that the EIAM sectors were constructed using selected combinations of ANZSIC 1993 Level 2 industries. This means that the total economic impacts are likely to be over-estimated within the current EIAM, as savings reductions are applied at a level which includes more Level 3 industries than those considered here. To accommodate an analysis using this modelling framework at ANZSIC 2006 Level 3 would necessitate disaggregation of the current model sectors requiring resources beyond the capacity of the current report.

Additional modelling using the EIAM has also identified that those areas within each key sector which may provide greatest opportunity for resource efficiency are not necessarily those resource efficiency measures specified by MfE as focal points for this study. For example, the largest input to the Beverage, Malt and Tobacco sector comes from *structural, sheet and fabricated metal product manufacturing* at 10.6% of the value of total inputs. This input is likely to be associated with plant and infrastructure involved in the wine making process, which was not incorporated within this study.

Therefore, whilst this study has provided a framework and calculation methodology through which the benefits of resource efficiency to the New Zealand economy can be calculated, it is recommended that further work be undertaken centred on:

- Additional data gathering to obtain further real case study information on efficiency measures and savings opportunities in order to provide greater rigour around the EIAM outputs. In other similar studies reviewed through this project, it is clear that Government programmes that seek to encourage resource efficiency (such as the UK's Envirowise programme) can also help to further build the business case for continued resource efficiency through the real case study data that is generated by the programme;

- Disaggregation of the EIAM sectors in order to reduce over-estimation of the savings and provide more accurate quantification of the benefits of the efficiency measures within each sector. Alternatively, the sectors studied could be selected in order to better reflect the EIAM sectors;
- Targeting of the efficiency measures studied within each sector in light of the additional modelling undertaken using the EIAM to identify those areas within each key sector which may provide the greatest opportunity for resource efficiency; and
- Further analysis of the effect of efficiency measure replication rate within each sector in order to provide MfE with guidance on the level to which effort could or should be best used to increase the replication of efficiency measure within each sector to gain maximum financial benefit.

Table 8.1: Summary Efficiency Areas and Options

<table>
<tr><th rowspan="2">Resource Efficiency Measure</th><th colspan="5">Efficiency Areas and Options</th></tr>
<tr><th>Dairy Cattle Farming</th><th>Fruit and Tree Nut Growing</th><th>Bakery Products Manufacturing</th><th>Wine Manufacturing</th><th>Construction (Residential and Non-Residential)</th></tr>
<tr><td>Water Use</td><td><u>Irrigation</u>
- Water management plans
- Improved soil moisture monitoring
- Improved distribution uniformity</td><td><u>Irrigation water</u>
- Improved soil moisture monitoring
- Improved distribution uniformity across the orchard</td><td><u>Wash down waters</u>
- New equipment, e.g. low-volume, high-pressure hose system
- New practices, e.g. reuse water from high quality streams/dry cleaning/ equipment soakage
<u>Production waters</u>
- Recycling systems for non-product production waters, e.g. for mixer pumps</td><td><u>Process water</u>
- Replacement of single pass cooling with cooling tower
- Check for leaks
- Use of low-quality water for cooling
- Re-circulate low-quality process waters
<u>Wash waters</u>
- High pressure nozzles with auto-shutoff
- Use of brooms/mops
- Use of low quality water/ stormwater
- Minimise flushing of lines</td><td><u>Site wash down waters</u>
- New equipment, e.g. low-volume, high-pressure hose
- New practices, e.g. reuse wastewaters/stormwaters</td></tr>
<tr><td>Material Use</td><td><u>Fertiliser and feed</u>
- Related to GHG (nitrous oxides) emissions reduction</td><td><u>Fertiliser use</u>
- Limited opportunities
- Consolidation of variability across orchards</td><td><u>Ingredient use</u>
- Linked to waste production and GHG emissions options</td><td><u>Limited opportunities</u>
- Related to waste minimisation</td><td><u>Raw material use</u>
- Linked to waste production options
- Design phase considerations
- Material substitution</td></tr>
</table>

Resource Efficiency Measure	Efficiency Areas and Options				
	Dairy Cattle Farming	**Fruit and Tree Nut Growing**	**Bakery Products Manufacturing**	**Wine Manufacturing**	**Construction (Residential and Non-Residential)**
Waste Production	General farm wastes - Improve collection systems - Better integration with waste management service providers, e.g. scrap metal dealers, mobile service units for vehicle waste oils - Education/awareness building	*Limited opportunities e.g. potential for biofuel*	Ingredient wastage - Consolidation of manufacturing streams - Modification/ optimisation of food processing equipment Organic waste disposal - Diversion from landfill, e.g. to animal feed/anaerobic digestion plant Non-food waste - Bulk purchasing of input materials - Reusable output packaging/ transportation crates etc.	Solid waste - Use as compost or soil amendments - Use as stock feed - By-product production Wastewaters - Reuse as irrigation water or low quality process water	Construction - Effective inventory management/near real-time supply ordering - Site waste management plan - Waste segregation - Use of precast and prefabricated products - Return of excess materials Demolition - Deconstruction versus demolition
GHG Emissions	General - Energy efficiencies - Lift productivity Nitrous oxide - Restrict grazing - Efficient use of nitrogen fertiliser - Nitrification inhibitors - Use of dairy farm effluent - Low nitrogen feed supplements Methane - Antibiotic modification of rumen microflora	Fuel Use - Sheep grazing of orchards (limited) - Improved management/ planning of mowing and/or spray passes	Transport logistics - Delivery and ingredient sourcing planning Site energy reduction - Energy efficiency initiatives - Ovens and air compression improvements - Heat exchange on steam boilers	Refrigerant loss - Change of refrigerant - Modification of system Glass bottle manufacture - Use of light weight glass - Use of alternatives, e.g. PET	Plant use and vehicle movements - Improved fleet management - Improved logistical planning - Material sourcing/waste disposal location Material use - Waste minimisation - Material substitution

9. *REFERENCES*

[1] DEFRA (2007) *Quantification of the Business Benefits of Resource Efficiency*. Oakdene Hollins and Grant Thornton for United Kingdom Department for Environment Food and Rural Affairs. Nobel House, 17 Smith Square, London SW1P 3 JR.

[2] Statistics New Zealand (2010) *Industrial Classification*. Available from: www.stats.govt.nz/methods_and_services/surveys-and-methods/classifications-and-standards/classification-related-stats-standards/industrial-classification.aspx

[3] Statistics New Zealand (2010) *Global New Zealand – International Trade, Investment, and Travel Profile: Year ended December 2009*. Available from: www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/global-nz-dec-09/key-points.aspx

[4] Livestock Improvement Corporation and Dairy New Zealand (2009) *Dairy New Zealand Dairy Statistics*. Available from: www.lic.co.nz/pdf/dairy_stats/DAIRY_STATISTICS_08-09.pdf

[5] Ministry of Agriculture and Forestry (2010) *Greenhouse Gas (GHG) Footprinting Strategy*. Available from: www.maf.govt.nz/climatechange/slm/ghg-strategy/

[6] Ministry for the Environment (2010) *New Zealand's Greenhouse Gas Inventory*. Available from: www.mfe.govt.nz/publications/climate/new-zealand-greenhouse-gas-inventory/index.html

[7] Taranaki Regional Council (2005) *Investigation into Taranaki's Rural Waste Stream*, available from: www.maf.govt.nz/sff/about-projects/search/L03-025/index.htm

[8] See www.lic.co.nz/lic_Publications.cfm?

[9] Barber, A. (2010) *On-farm Greenhouse Gas Emissions from 23 Surveyed Organic and Conventional NZ Dairy Farms*. Report prepared for New Zealand Ministry of Agriculture and Forestry's SFF and ARGOS. www.maf.govt.nz/sff/about-projects/search/C08-014/ghg-report.pdf

[10] Lundie, S., Schulz, M., Peters, G., Nebel, B., and Ledgard, S. (2009) *Carbon Footprint Measurement Methodology Report*. Prepared for Fonterra Co-Operative Group Ltd. www.fonterra.com

[11] Aqualinc Research (2006) *Snapshot of Water Allocation in New Zealand*, prepared for Ministry for the Environment. Aqualinc Research Limited, Christchurch. www.mfe.govt.nz/publications/ser/snapshot-water-allocation-nov06/snapshot-water-allocation-nov06.pdf

[12] Lincoln Environmental (2000) *Information Water Allocation in New Zealand*, prepared for Ministry for the Environment. Lincoln Environmental,

Christchurch. www.mfe.govt.nz/publications/water/water-allocation-apr00.pdf

[13] Davoren A., and Scott, D. (2005) *Schedule WQN9 Revision Review of seasonal use approach included in Proposed NRRP*. Report U05/15/1. Prepared for Environment Canterbury.

[14] The Primary Sector Partnership (2010) *Primary Sector Water Leadership Document: Summary of the Plan of Action (Draft for Consultation)*. Available from: www.fedfarm.org.nz/f184,17642/17642_Water_Partnership.pdf

[15] UNFCCC (2010) *Reporting Requirements*. Available from: http://unfccc.int/national_reports/annex_i_ghg_inventories/reporting_requirements/items/2759.php

[16] Fonterra (no date) *Fonterra and the Environment*, 2nd edition. http://www.fonterra.com/wps/wcm/connect/fonterracom/fonterra.com/Our+Business/Sustainability/Fonterra+Environmental+Publications/

[17] www.stuff.co.nz/taranaki-daily-news/farming/3716798/Keeping-green-with-silage

[18] Barber, A. and Pellow, G. (2008) *The Total Resource Use and Greenhouse Gas Emissions of the Lincoln University Dairy Farm*. Report to MAF SFF, SIDDC, and Ravensdown. Prepared by The AgriBusiness Group, Pukekohe. www.maf.govt.nz/sff/about-projects/search/L07-057/ghg-footprint-report.pdf

[19] Basset-Mens C., Ledgard S. and Carran A. (2005) *First Life Cycle Assessment of Milk Production from New Zealand Dairy Farm Systems*. AgResearch Ltd. www.anzsee.org/anzsee2005papers/Basset-Mens_LCA_NZ_milk_production.pdf

[20] Basset-Mens, C., Ledgard, S., and Boyes, M. (2007) *Eco-efficiency of intensification scenarios for milk production in New Zealand*. Ecological Economics.

[21] Saunders, C., and Barber, A. (2008) *Comparative Energy and Greenhouse Gas Emissions of New Zealand's and the UK's Dairy Industry*. Research Report No. 297. Agribusiness & Economics Research Unit, Lincoln University, Lincoln.

[22] Swainson, N.M., Hoskin, O.S., Clark, H. and Brookes, I M. (2008) *The effect of coconut oil and monensin on methane mitigation agents for forage fed sheep*. Pastoral Greenhouse Gas Research Consortium. 5 year Science Progress Report 2002-2007. www.pggrc.co.nz/Research/AnnualReports/tabid/69/Default.aspx

[23] www.maf.govt.nz/sff/about-projects/search/09-079/index.htm

[24] Clough TJ, Kelliher FM, Clark H, and van der Weerden TJ. (2008) *Incorporation of the Nitrification Inhibitor DCD into New Zealand's 2009 National Inventory*. Report to the Ministry of Agriculture and Forestry. Wellington: Ministry of Agriculture and Forestry.

25 See for example www.zespri.com/sustainability-home/managing-carbon.html

26 www.maf.govt.nz/sff/about-projects/search/05-004/index.htm

27 See www.agrilink.co.nz/Technical-Reports.aspx

28 Hume, A., Barber, A., East, A. and McLaren, S.J., (2009) *Carbon Footprinting for the Apple Supply Chain Methodology and Scoping Study*. Prepared for MAF, Wellington.

29 www.stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/2007-agricultural-census-tables.aspx

30 Morgan, Y.J., (1997) *A Methodology for Determining Crop Water Requirements in Hawkes Bay*, Hawke's Bay Regional Council Report ISBN 1-877174-05-x, Hawke's Bay Regional Council library reference number WATREG 121, 11p.

31 www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/irrigation/the-economic-value-of-irrigation/index.htm

32 Mithraratne, N., McLaren, S.J., Barber, A., (2008) GHG Carbon Footprinting for the Kiwifruit Supply Chain: Report on Methodology and Scoping Study. Prepared for MAF, Wellington.

33 www.envirowise.gov.uk/uk/Our-Services/Publications/CS823-Bakery-improves-resource-efficiency.html

34 http://cleanerproduction.curtin.edu.au/local/resources/casestudies/tip-top.pdf

35
http://ww2.gpem.uq.edu.au/CleanProd/projects/Bakery%20Case%20Study%20Brisbane%201999.pdf

36 www.epa.vic.gov.au/bus/erep/erep_fact_sheets.asp

37 www.cs.waikato.ac.nz/~ml/publications/2004/wilson-etal.pdf

38
www.microsoft.com/casestudies/Case_Study_Detail.aspx?CaseStudyID=4000000542

39 NZ Wine (2009). *Annual Report 2009*. www.nzwine.com

40 MWH, 2010. *New Zealand Winegrowers Code of Practice for Winery Waste Management*. Prepared for Sustainable Winegrowing New Zealand and New Zealand Winegrowers

41 www.maf.govt.nz/sff/about-projects/search/06-096/

[42] Greenhalgh, S., Mithraratne, N., Sinclair, R., Smith, A., McConachy, E., Barber, A. (2008) *GHG Product Accounting Guidelines for the Wine Industry.* Landcare Research Report LC0809/036. Prepared for MAF, Wellington.

[43] Deurer, M., Clothier, B.E., Pickering, A., McDonald, R. (2008) Carbon Footprinting for Wine Supply Chain – Report on Reduction Opportunities. The Horticulture and Food Research Institute of NZ. Prepared for MAF, Wellington.

[44] Hennessy, W., McCurdy, M. (2009) *Inventory of HFC, SF6 and Other Industrial Process Emissions for New Zealand 2008*. Prepared by CRL Energy. Prepared for Ministry for the Environment, Wellington.

[45] Yealands, 26th April 2010. *Yealands plastic bottle Full Circle is a winner*. Media Release www.yealands.com

[46] Franklin Associates (2006). *Life Cycle Inventory of Container Systems for Wine*. Prepared for Tetra Pak, Inc. www.tetrapak.com/se/Documents/WineContainers_report%5B1%5D.pdf

[47] Report prepared by The Basement Up Company for NZ Winegrowers, March 2006.

[48] See for example http://cfpub.epa.gov/npdes/stormwater/const.cfm, www.waitakere.govt.nz/cnlser/bl/pdf/erosion.pdf, and www.smarterhomes.org.nz/construction/construction-site-practice/minimising-on-site-pollution/

[49] Inglis, M, (2007) *Construction and Demolition Waste – Best Practise and Cost Saving*. MfE Paper 057

[50] MfE for the Environment (2007). *Targets in the New Zealand Waste Strategy – 2006 Review of Progress*. Publication 802.

Annex A

Literature Review

A1 LITERATURE REVIEW

A1.1 <u>Introduction</u>

One of the key objectives for this project was to quantify the potential financial and resource use benefits to the New Zealand economy from various industry sectors undertaking cost-effective resource efficiency measures.

This type of assessment requires information on the potential cost savings by businesses in each relevant sub-sector. This information then needs to be aggregated up to the total sector. Unfortunately information is often limited on typical resource use. Information on efficiency measures apart from energy also tends to be very limited, and conversion of physical savings into dollars is not always immediately apparent. Clearly this value could include market and non-market impacts. For example, part of the value to a business from reducing waste is the savings in disposal costs, these are market prices that reflect a balance between the costs of services and what businesses are willing to pay. The reduction in waste may also have benefits that are not included in market prices such as improvements in environmental quality. Incorporating an assessment of the non-market impacts of resource savings activities produces a more precise measure of the economic value of particular activities. This study however includes only market values. Therefore to estimate cost savings of resource efficiency, data on physical savings is required and then the associated cost savings to the business.

Ideally this data should be based on a random sample[i] of a significant number of businesses drawn from each sub-sector (preferably by business size). However, the practicalities of data availability and the cost of collecting data can mean that alternative methods are often required. This chapter reviews three methods that have been used in other similar studies to undertake resource efficiency benefits quantification. This review was used to inform the development of the methodology employed within this study.

The first method is presented within the United Kingdom (**UK**) Department for Environment Food and Rural Affairs (**DEFRA**, www.defra.gov.uk)'s *Quantification of the Business Benefits of Resource Efficiency* study[ii]. This study formed the primary reference for the review as the general objectives of the DEFRA study match closest with those of this project. Moreover the DEFRA study was of particular practical relevance to this project as it presented a mixed method approach as data was available in a variety of forms and types, as is the case for this project.

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[i] Random sampling is used to maintain important statistical properties of samples that are required to draw inference on general populations. It requires that all members of a population have a positive chance of being selected into the sample. If we have previously conducted the same survey we can use estimates of the variance of chosen variables to find the optimum sample size for a given margin of error. By grouping-or stratifying, the sample into relevant sub-samples the practitioner can improve the quality of the overall sample.

[ii] DEFRA (2007) *Quantification of the Business Benefits of Resource Efficiency*. Oakdene Hollins and Grant Thornton for United Kingdom Department for Environment Food and Rural Affairs. Nobel House, 17 Smith Square, London SW1P 3 JR.

The second report drawn from was the *Survey of Industrial and Commercial Waste Arisings in Wales 2007*[iii], jointly commission by the Environment Agency Wales (**EAW**, www.environment-agency.wales.gov.uk) and the Welsh Assembly Government (**WAG**, www.wales.gov.uk). The third method reviewed was applied in the Environment Agency of England and Wales (**EA**, www.environment-agency.gov.uk) *The Benefits of Greener Business* study[iv]. The EA study focused on valuing waste reduction in the manufacturing industry in England and Wales. These two later reports were relevant as they were used as substantial inputs into the DEFRA study and so demonstrate underlying data collection methods in this field. In particular the EAW/WAG study demonstrated best practice in obtaining statistically robust samples for this kind of application.

The method employed to extrapolate observed resource savings rates from business level case-study/survey data to estimate savings for a population of businesses within an industry sector is conditional on several factors including the nature of data available. The main junction in type of method used occurs between random and non-random data collection processes. Typically, existing case study data contain businesses that self-select into the sample as they actively seek assistance from external agencies and case studies usually focus on the best opportunities within a business or sector. The EAW/WAG method presented is based on random sampling and can be regarded as a best practice approach to data collection providing statistically reliable estimates. This contrasted with the EA method presented that is based on case study data of representative businesses collected non-randomly. These two methods use 'bottom-up' approaches, that is, they analysed data of individual businesses at business level, whilst the DEFRA study included both 'bottom-up' and 'top-down' analysis of aggregated data describing total sector quantities.

A1.2 Wales Commercial and Industrial Waste Survey

This survey employed statistically robust methods in collecting waste stream data from a sample of Welsh businesses to estimate total business waste across sectors of the economy. The survey methodology was built on a foundation of previous commercial and industrial waste surveys conducted in Wales over the past decade. As such the method represented current best practice for estimating industry wide resource quantities for the EAW/WAG. Outputs of previous surveys provided researchers with the ability to utilise data that enhanced the accuracy of sampling (including reliable sampling frames and distributions of waste variance within sub-sectors).

[iii] EAW (2009) *Survey of Industrial and Commercial Waste Arisings in Wales*. Urban Mines for Environment Agency Wales. Cambria House, 29 Newport Road, Cardiff CF24 0TP.

[iv] EA (2003) *The Benefits of Greener Business*. Cambridge Econometrics and AEA Technology for United Kingdom Environment Agency.

The first step in the EAW/WAG method was to create a two-dimensional matrix with businesses grouped into one of 25 sectors based on Standard Industrial Classification (**SIC**) codes and one of eight size bands, defined by the number of employees. The employment band sizes were set to ensure that the size difference within each band had no significant impact on waste arisings. This 200 cell matrix formed the basis of the stratified random sampling scheme.

Data was collected from 1,547 commercial business sites throughout Wales using a structured face to face interview process and developed questionnaire. The survey was designed to log individual waste streams, their nature, form, classification based on Substance Orientated Classification method, tonnage and management method. The number of business sites to be surveyed in each cell was optimised using the total number of businesses in each cell (data from the UK Office of National Statistics (**ONS**), www.statistics.gov.uk) and the expected variation in waste arisings among businesses in each cell (using data collected in the 2002/03 National Waste Survey). A minimum of three businesses per cell were surveyed where possible. A total of 5,988 businesses were contacted yielding an effective response rate of 26%.

The second step was to use the survey data to calculate sector quantities. This started with the calculation of an average waste quantity for each cell of the sampling matrix. This average was then multiplied by the total number of businesses in the population for each cell. Total sector quantity was then simply the sum of each sub-sector cell average. See *Section A2.1* for details of statistical methods used.

Several data issues were noted by the EAW/WAG survey authors. A relatively large number of businesses surveyed were in a size-band or sector different to that assigned to them by the ONS. This meant continuous updating of the sampling matrix was required. The accuracy of waste stream measurement was enhanced by the use of written business recorded data such as invoices or weighbridge notes rather than reliance on business representative or surveyor estimates or calculations.

A1.3 <u>Benefits of Greener Business</u>

The aim of the EA's *Benefits of Greener Business* study was to establish broad estimates of the potential waste reduction savings that would be achieved if the experience of businesses examined by the UK government's Envirowise programme were to be replicated by others. Envirowise was a publicly funded independent agency offering free support to UK businesses to become more resource efficient and save money. From 1 April 2010, Envirowise, along with six other government funded UK resource efficiency schemes, was consolidated into the WRAP programme[v].

[v] http://envirowise.wrap.org.uk/

The EA study represented an alternative approach to that offered in the EAW/WAG survey. Instead of randomly sampling a population of businesses, the EA study focused on collecting data from businesses that had adopted best practice methods for the productive use of resources. They represented areas of significant savings and form an indication of possible savings for total sectors. As such the case studies were chosen based on previous analysis conducted by Envirowise in conjunction with industry bodies to identify processes where efficiency could improve.

Typical savings identified were: reduced purchase of raw materials, reduced costs of processing inputs that are ultimately wasted, reduced costs due to substitution, sale of recovered product, reduced management costs and reduced waste disposal costs.

For the EA study, data from 65 case studies of companies under the Envirowise programme were selected and assigned a SIC code. The case studies were reviewed to derive data on costs and cost-savings required for an annual savings calculation for each process improvement, and to assess data representativeness and scope for replication to other businesses. Typically the case studies suggested that the average payback period on the investment was twelve months or less. Each case study was designed to help a particular industry sector with a particular technique. This meant that each case study typically either showed a different technique or covered a different sector or industry. Each case study had to be justified on the basis of the savings it was likely to help stimulate and therefore was chosen as exemplars of resource savings. This relied on an assessment of how many companies within a sector could adopt the change in technique and a conservative estimate of average savings of adopting businesses.

The EA study calculated an estimate of the number of businesses yet to adopt best practice identified in case studies and assumed that average cost savings identified by Envirowise was valid for these businesses. In generalising from the case studies it was assumed that the number of companies that could replicate case history savings was restricted to companies within the sector covered by the case history. To calculate sector level savings, first the number of employees within the sector (excluding those of the case study) was weighted by the number of employees in the case study. This was multiplied by the percentage of businesses that were expected to achieve the same savings as the case study (replication rate). Then this was multiplied by the annual saving in the case study business. The sectors covered by case studies covered roughly half of the UK manufacturing industry (by employment). To account for the remaining portion, a range of values was calculated based the on average savings per employee across all case studies. *Section A2.2* contains more details of the calculation methods used.

The choice of replication rate indicated what percentage of the group was anticipated to be able to achieve the same saving as the case study business. In the determination of a realistic replication rate dialogue with industry stakeholders formed a foundation for identifying the number of businesses that could adopt a particular approach. Replication to date was assumed to be the highest estimated by Envirowise, so the potential for further replication was a conservative estimate. The EA study authors employed the assumption that "replication for the process improvement to other businesses was set at 20%.... In other words, 20% of all businesses (by employment) in the same sector were considered capable of achieving this saving".

Results highlighted benefits that businesses could gain from minimising waste and using resources more efficiently in productive processes. However, the EA study authors noted problems with the quality of data and recommend several areas for further work to improve estimates. This included extending the coverage of Envirowise studies to cover more than the current half of manufacturing employment, as well as promoting the use of key performance indicators for resource productivity and measurement to establish accurately the cost of unproductive resource use. For example, the EA study authors recommended the collection of data physically measuring reductions in waste resulting from resource productivity improvements. To this end the establishment of a standard methodology for measuring the processing costs embodied in waste was seen as beneficial.

A1.4 <u>Quantification of the Business Benefits of Resource Efficiency</u>

The scope of the DEFRA study was far greater than those presented above. The EAW/WAG and EA studies considered waste streams only while the DEFRA report considered waste, water and energy savings across the entire United Kingdom in all sectors, through low-cost/no-cost intervention. The types of data sets encountered in this process were varied, ranging from individual business level to top level aggregate data sets. Consequently this study employed a range of methods to calculate sector level estimates.

The first method presented utilised business level case study and survey data to estimate waste efficiency benefits. Businesses were grouped by SIC code and business size band (by employee) creating cells that were used as the basis for extrapolating business level data up to sector and national estimates. In the determination of an appropriate extrapolation method the DEFRA study authors examined the representativeness of some of the case study data. This preliminary analysis (i) quantified the mean waste arisings per cell; and (ii) compared case study data with this to determine the performance of the case studies relative to the sub-sector mean.

The DEFRA study authors applied the assumption that waste arisings were directly proportional to waste savings. Three quarters of case studies were found to lie below the mean waste arisings and therefore could be considered as better than average performers. Therefore multiplication of absolute values up to sector level would underestimate total savings opportunities. Instead of absolute savings, a percentage savings was estimated using econometric regression[vi] methodology.

Business level data and the method of Ordinary Least Squares[vii] were used to estimate a linear (in variables and parameters) equation describing resource savings opportunities as a function of resource consumption.

$$y_i = \beta x_i + \varepsilon_i \qquad (1)$$

Where: y_i = Quantity of resource savings by business *i*
x_i = Quantity of resource consumption (pre intervention) by business *i*
β = Coefficient on resource consumption
ε_i = Residual

Figure A1: Resource Savings as a Function of Resource Consumption

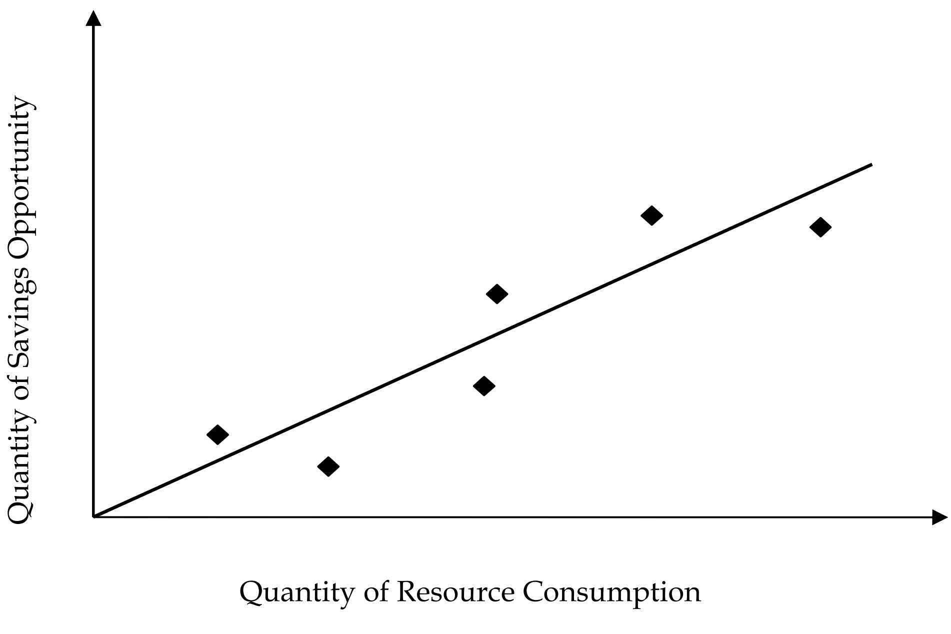

Figure A1 illustrates the estimated relationship. This specification allowed the coefficient on resource consumption to be interpreted as the percentage of resource savings opportunity. The study authors assessed the strength of the relationship using the coefficient of determination, R^2, which was a measure of

[vi] Regression analysis shows how a range of variables such as electricity and waste influence another variable such as output. A statistical data analysis method used to assess the statistical relationship between a dependent variable such as the quantity of a resource reduced, and an explanatory variable(s) such as the quantity of a resource before introduction of efficiency activities.

[vii] In statistics and econometrics, ordinary least squares is the simplest and most common method for estimating the unknown parameters in a linear regression model. This method fits a straight line to a sample of data by minimising the sum of the squares of the deviations of the data from the line.

fit based on the deviations between the observed values (shown in *Figure A1* as diamonds) and the estimated line. If the deviations were minimal then a high R^2 will result. The study authors considered that an R^2 greater than 0.7 was adequate for the estimate of the relationship to be reliable.

Note the zero incept as no savings are possible when consumption is zero. The standard error was calculated to determine the uncertainty in the estimate and to provide a range of estimates.

Table A1: Estimating Total Waste Savings Opportunity

SIC/ Employment Grouping	Sample Mean Waste Arisings (t)	β	Mean Waste Savings (t)	Number of Businesses	Total Waste Savings (t)
158 (250+)	7,150	0.1697	1,213	155	188,070

As an example consider *Table A1*. Total savings for the SIC/Employment group is calculated as the sample mean multiplied by the estimated coefficient, multiplied by the number of businesses in the group. The values of each SIC/Employment group are summed to obtain sector estimates.

For industry sectors where only top level data was available the approach taken was to base savings rates on previous analysis of savings potential, and to apply these rates to the aggregate data sets. This constituted what could be considered the simplest approach however it implied assumptions about the ability of all businesses to adopt particular resource savings activities that may have been unreliable. As an example, waste arising for the construction sector was in aggregate form. Based on savings estimated from the Quick Win study (an industry best-practice study)[viii] and the Smartstart benchmarking model (a UK Building Research Establishment (**BRE**, www.bre.co.uk) scheme)[ix], these savings were applied to estimate the total sector physical and cost savings. Clearly every individual business may not have been able to respond and achieve the same level of identified savings.

Water was the resource that was most difficult to obtain robust consumption data by sector. In addition it was considered inappropriate to use a method where a volumetric saving was converted to a fiscal saving using a standard water price. For example the agricultural sector represented a major water user but only a small proportion of the overall water used was supplied through public supply and charged at an urban rate. The study authors considered that this situation could lead to a considerable overestimate of savings. The study instead relied upon UK national accounts input-output table estimates of 'intermediate consumption' as an indicator of water consumption expenditure. This meant that the water data was defined in financial terms already. The study authors also noted particular data gap

[viii] WAS7-001 Final Report on Waste Management Quick Wins. WRAP 2007

[ix] www.smartwaste.co.uk

issues concerning water consumption in public administration, in process industrial water use and waste in the service sector.

The outputs of this study enabled DEFRA to rank industry sectors by the size of potential savings in energy and water use and reduction of waste. This information helped government departments prioritise efforts to meet policy targets for economy wide gains in resource efficiency utilising cost-effective activities.

A1.5 Discussion

The EAW/WAG study employed the most statistically robust method of the three methods presented. This was achieved through a comprehensive sampling strategy that was based on results of previous applications of the survey. The ability to immediately employ this approach in its entirety in the New Zealand context is hampered by the lack of relevant historic data on resource consumption and savings levels for SIC/Employment band combinations. The technique of random non-optimised sampling stratified by SIC/Employment band may be possible dependent on data availability.

If the sample is non-random then there is always the risk that the method of sampling has been somehow biased and the sample therefore contains a systematic error which is often quite difficult to detect without studying the entire population. One method to offset this concern is to study material describing the population and compare this against the existing sample. This was the approach taken by the DEFRA study.

To validate the choice of replication rate used in the EA method requires additional research. A choice of replication rate that is not statistically grounded undermines the robustness and reliability of subsequent results. Given that this method has not been duplicated since the EA study was conducted, information is lacking (outside the current application) corroborating the appropriateness of the replication rate employed. A certain level of subjectivity in the choice of replication rate is difficult to avoid with the EA method.

The use of employment size bands that are set to minimise variation in resource quantities within the band is a simple pragmatic approach to enhancing total estimate accuracy.

The use of the bottom-up business level data analysis method of DEFRA rests on the ability to estimate reliable econometric models. The number of data points required for any statistical model depends on at least two things: the number of model coefficients to estimate and the amount of randomness in the data.

From a purely statistical point of view it is always necessary to have more observations than parameters. Given that the models estimated have only one parameter, to estimate this requirement may be relatively straightforward to meet. To accurately estimate a model where the data contains a lot of random variation it is necessary to have a lot of data. On the other hand if the data has little explained variation it is possible to estimate a model relatively accurately with only a few observations. The use of employment bands constructed to minimise within band heterogeneity is one method to improve the ability to estimate models with few observations.

A2 STATISTICAL METHODS

A2.1 Statistical Methods from the Wales Commercial and Industrial Waste Survey 2007

The process of extrapolating the waste arisings of surveyed businesses to estimate total waste arisings at national level was performed following the same structure as the sampling matrix, i.e. on a cell by cell basis. For each sector and employment size band combination (*sb*) the average sample weight per business $\overline{w}_{sb}$ was calculated by dividing the total sample weight w_{sb} by the number of sample businesses n_{sb}:

$$\overline{w}_{sb} = \frac{w_{sb}}{n_{sb}} \tag{A1}$$

The estimate of total waste for each sector and employment size band combination W_{sb} was then calculated by multiplying the population N_{sb} by the average sample weight per business $\overline{w}_{sb}$:

$$W_{sb} = N_{sb} \times \overline{w}_{sb} = \frac{N_{sb} \times w_{sb}}{n_{sb}} \tag{A2}$$

The weights for each sector and employment size band combination W_{sb} were then added together to give the grand total weight W:

$$W = \sum_{s,b} W_{sb} \tag{A3}$$

This method is adapted to estimate a total weight for a local authority. The weight for a particular sector, band and local authority W_{sbl} is calculated as the sum of (i) the total sample weight at the sample businesses in that local authority w_{sbl}, and (ii) the national average sample weight per business $\overline{w}_{sb}$ times the number of unsurveyed businesses in that local authority $N_{sbl} - n_{sbl}$:

$$W_{sbl} = w_{sbl} + \frac{(N_{sbl} - n_{sbl}) \times w_{sb}}{n_{sb}} = w_{sbl} + (N_{sbl} - n_{sbl}) \times \overline{w}_{sb} \tag{A4}$$

Thus the waste arisings from unsurveyed businesses were estimated by the national average for that cell. The national grossed up weight for each local authority W_l is calculated as the sum of the total weights for each cell:

$$W_l = \sum_{s,b} W_{sbl} \tag{A5}$$

This approach is also used for estimating totals for particular waste types; the only difference is that w_{sbl} and w_{sb} represent the total sample weight for that waste type instead of local authority.

To take into account uncertainty arising from random sampling error, the variance of the total weights for each sector and employment size band combination $Var(W_{sb})$ are estimated by:

$$Var(W_{sb}) = \frac{Var(w_{sb})}{n_{sb}} \times \left(1 - \frac{n_{sb}}{N_{sb}}\right) \times N_{sb}^{2} \tag{A6}$$

Where $Var(w_{sb})$ is the variance in the weight among the n_{sb} businesses in that sector and employment size band combination and $\left(1 - \frac{n_{sb}}{N_{sb}}\right)$ is a finite population correction factor that ensures that the variance is zero when all businesses in a sector and employment size band combination are surveyed (i.e. $n_{sb} = N_{sb}$). The variance in the grand total weight $Var(W)$ is then estimated by summing the variance for all sector and employment size band combinations:

$$Var(W) = \sum_{s,b} Var(W_{sb}) \tag{A7}$$

This variance is then converted to a measure of precision expressed as a percentage (ρ_w , %):

$$\rho_W = 100 \times 1.65 \times \frac{\sqrt{Var(W)}}{W} \tag{A9}$$

The survey authors use a 10% level of significance therefore constructing a 90% confidence interval. Given a sample size allowing sufficiently large degrees of freedom the critical value for students-t distribution at this significance level is 1.65. This means that if we construct the interval 100 times, it is expected that 90 of these intervals will contain the true weight.

A similar set of calculations is performed for local estimates. Because the waste of the surveyed businesses is known without error the only uncertainty arises from the unsurveyed businesses. The variance of the total weight for each sector, band and local authority $Var\ (W_{sbl})$ is estimated by:

$$Var(W_{sbl}) = \frac{Var(w_{sbi})}{n_{sb}} \times \left(1 - \frac{n_{sb}}{N_{sb}}\right) \times (N_{sbl} - n_{sbl})^{2} \tag{A11}$$

The variance in the grand total weight for that local authority $Var\ (W_l)$ is estimated by summing the variances for all cells:

$$Var(W_l) = \sum_{s,b} Var(W_{sbl}) \tag{A12}$$

And converted to a measure of precision expressed as a percentage as before:

$$\rho_W = 100 \times 1.65 \times \frac{\sqrt{Var(W_l)}}{W_l} \tag{A13}$$

These precision calculations account for sampling error only and assume that all surveyed weights are normally distributed and independent.

A2.2 Statistical Methods from the Benefits of Greener Business 2003 Study

To extrapolate case study data to sector level the formula used was:

$$GS = \sum_{i=1}^{n} \left[\frac{El - EC_i}{EC_i} \times R_i \times S_i \right] \tag{A14}$$

Where: GS = Group savings
n = Number of case studies in group
El = Group employment
EC = Employment in the case study
R = Replication rate across group
S = Savings annually to the business

The sectors covered by case studies cover roughly half of manufacturing, by employment. To account for the remaining proportion of manufacturing a range of values for savings is calculated using the formula:

$$S = Q_i \times UE \tag{A15}$$

Where: S = Savings in the undetermined part of the subsection
UE = Employment in the undetermined part of the subsection
Q = Each of the lower quartile, median and upper quartile of the following statistic calculated from the case studies:

$$\frac{AS \times R}{E} \tag{A16}$$

Where: AS = Annual savings to the business
R = Replicability of the process improvement
E = Employment in the business

Annex B

Resource Efficiency Benefits Quantification Methodology

B1 RESOURCE EFFICIENCY BENEFITS QUANTIFICATION METHODOLOGY

B1.1 <u>Introduction</u>

To estimate the value of resource savings from low-no cost activities at the sector level promoting efficiency three main data sources are required. First is the base level of resource use currently experienced, second is the amount of savings that could be achieved, and third is the prices and/ or cost savings associated with each of the saved resources. To aggregate these estimates up to the national level and incorporate upstream and downstream impacts the Economic Impact Assessment model will be used as described later.

This data varies in the form it is collected and presented. In this context it will commonly differ by extent of aggregation, from completely disaggregated bottom-up business level data, to top-down aggregate form that may represent an industry sector or entire industry. Additionally, business level data may be provided on multiple businesses within an industry sector or as a standalone one off study. These observations suggest that a range of methods and approaches will be required to estimate savings across multiple resource types and focal sectors.

The approach to valuing savings follows the same fundamental steps for all data forms with the addition that business level data needs to be aggregated up to sector level. Studies that have incorporated business level data have approached this task based on the nature of the data collection method. Business level data that is collected employing random sampling, across different business sizes and types, can be aggregated up employing statistically robust procedures whilst alternative methods are required for non-random sampled businesses.

The values of resource savings presented include the direct savings of using fewer resources. For example in considering savings from reducing waste the direct savings are calculated from avoided disposal costs while indirect savings may include the avoided cost of raw materials, embedded manufacturing costs in discarded products and time and effort handling waste.

Overall the values of resource savings presented here do not include the values of non-market impacts. For example, a reduction in waste or waste water generation may have benefits to wider society through improvement in environmental quality. An exception is the pricing of carbon emissions within an emissions trading scheme which is a market mechanism attempting to internalise environmental values into prices for products and services associated with emissions, as well as incentivising reduction efforts.

An industry sector reducing resource use may have an impact on up-stream industries that provide those inputs. Likewise, a reduction in generation of waste may have an impact on down-stream industries that manage waste products. To form an assessment of up-stream and down-stream influences from industry resource savings an analysis will be undertaking utilising the Impact Assessment module of the Economic Impact Assessment Model. The Impact Assessment module provides outcomes based on informed scenarios that make it possible to determine the relative effects of an intervention on a sector. It will also be used through comparing baseline scenario results to results after an imposed change, the total impact on the New Zealand economy allowing for the immediate and flow-on effects to be included as discussed in more detail in the next section.

Thus the approach to estimating resource savings in each of the focal sectors will be dependent on the nature of available data. Ideally preference is given to data obtained at business level with a significant spread across businesses of differing sizes and types. Also preferable would be the collection of data across businesses of differing levels of resource efficiency. That is, basing resource savings estimates on businesses that are the best performers in terms of current resource efficiency would lead to an underestimate of possible future savings. Likewise, basing resource savings estimates on data from businesses that are the worst performers in terms of current resource efficiency would lead to an over estimate of possible future savings.

This study therefore intends to follow the general approach of matching the valuation method to available data. This follows the method employed in the Department for Environment Food and Rural Affairs (DEFRA) *Quantification of the Business Benefits of Resource Efficiency* study[i] and the current work seeks to follow their lead. Ideally data sources would have been obtained from a statistically significant method. This may be the case for top-down aggregate level data that is typically collected by government agencies, however use of other data sources is anticipated, and these may include one-off case studies considering a single resource in a single sector.

Where there are only single one-off case studies the method employed in the Environment Agency of England and Wales (EA) *The Benefits of Greener Business* study[ii] provides an approach to aggregating up to sector level. This method relies on the ability to obtain an estimate of how many other sector participants could be expected to achieve the same resource savings as the case study business. Where multiple case studies are available within sectors the regression method employed in the DEFRA study could be employed to estimate mean savings rates for the sector.

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[i] DEFRA (2007) *Quantification of the Business Benefits of Resource Efficiency*. Oakdene Hollins and Grant Thornton for United Kingdom Department for Environment Food and Rural Affairs. Nobel House, 17 Smith Square, London SW1P 3 JR.

[ii] EA (2003) *The Benefits of Greener Business*. Cambridge Econometrics and AEA Technology for United Kingdom Environment Agency.

Where top-down aggregate data is used the approach will focus on applying appropriate research findings from sector level analysis reporting general possible savings following the DEFRA approach. This may be the approach employed in estimating greenhouse gas emission savings as base line data is available through the GHG Inventory. This base line data could be supplemented with industry reporting of possible savings. Alternatively, where sector level reporting is not available, case study data could be used to indicate savings.

As an example of the top-down approach consider *Table B1* below showing the physical quantity of energy inputs, this could form part of the analysis of efficiency of material use. One of the focal sectors for analysis is included; Dairy Cattle Farming (and possibly alignment of Horticulture and Fruit Growing with Fruit and Tree Nut Growing sector). This data could be utilised as the base level of energy material use for this sector at national level. The next step would be to obtain an estimate of the physical quantity of savings that could be achieved for the sector. This could be obtained through case study analysis identifying savings to an individual business. This is then extrapolated to the entire sector using a replication rate that could be determined from consultation with industry stakeholders. Or the estimate of physical savings may be provided by sector level reporting. Once the replication rate is applied to the physical units, this can be multiplied by the market price of the particular energy resource. For example, a sector level report indicating that 5% reduction of electricity is achievable through low cost activities across the Dairy Cattle Farming sector equates to a physical saving of approximately 51,286 MWh per year. Multiplying this by an estimate of average commercial price of New Zealand electricity (15.2 cents/kWh[iii]) results in a financial estimate of savings of $7.8m.

[iii] Ministry of Economic Development (2009) *New Zealand Energy Data File 09*. Ministry of Economic Development, Wellington.

Table B1: Physical Quantity of Energy Units by Sector

Energy Source Physical unit									
	Electricity kWh(000)	Petrol L(000)	Diesel L(000)	Fuel oil L(000)	LPG kg(000)	Aviation Fuel L(000)	Natural Gas TJ	Coal Tonnes	Wood m³
Horticulture and fruit growing	150,814	14,510	42,083	58	523	1,122	43	9,130	8,220
Sheep, beef cattle, and grain farming	503,951	50,934	104,502	1,158	800	551	C	2,335	49,552
Dairy Cattle Farming	1,025,738	32,060	62,347	809	348	19	0	308	45,777
Poultry, deer, and other livestock farming	89,827	5,630	14,510	38	1,558	51	0	354	5,533
Forestry	15,106	1,345	3,219	575	15	0	C	4,838	4,173
Logging	906	5,780	44,855	1,488	3	335	C	C	C
Aquaculture	5,763	639	3,706	31	27	C	C	0	282
Fishing	3,236	1,625	64,951	47,751	24	0	0	0	350
Services to agriculture, forestry, and fishing	65,042	12,015	86,977	208	557	16,514	11	84	1,684
Mining	530,233	1,174	128,538	1,950	2,412	C	2,972	C	C
Total	2,390,618	125,712	555,688	54,067	6,268	18,998	3,027	20,969	115,767

Source: Statistics New Zealand, New Zealand Energy Use Survey 2008, available at www.stats.govt.nz.

In the remedying of data gaps, where there is the ability, statistically robust sampling procedure should be conducted to collect data. This entails surveying sector participants using a stratified sampling method and is the approach taken in the Environment Agency Wales (EAW) *Survey of Industrial and Commercial Waste Arisings in Wales 2007*[iv]. The strength of this approach is that it enables aggregation of sample survey results up to sector level in a statistically reliable manner.

[iv] EAW (2009) *Survey of Industrial and Commercial Waste Arisings in Wales*. Urban Mines for Environment Agency Wales. Cambria House, 29 Newport Road, Cardiff CF24 0TP.

B1.2 Economic Impact Assessment Model

The economic impact assessment model is based on an input output model of the New Zealand economy. This shows the inter-industry relations of the New Zealand economy and the inputs into a sector and how these are interrelated by value. It also shows the imports and exports, investment and household consumption associated with a sector. A given input is typically enumerated in the column of an industry and its outputs are enumerated in its corresponding row. This format, therefore, shows how dependent each industry is on all others in the economy both as customer of their outputs and as supplier of their inputs. Each column of the input-output reports the monetary value of an industry's inputs and each row represents the value of an industry's outputs.

The model therefore will be used to assess the economy wide impacts of changing input use in the sectors of interest to Ministry for the Environment in this study. The model includes 48 sectors, listed in *Table B2* below.

Table B2: Impact Assessment Model Sectors

Horticulture & fruit growing	Printing, publishing & recorded media	Furniture & other manuf
Livestock & cropping farming	Petroleum & industrial chem manuf	Central government
Dairy Cattle Farming	Rubber, plastic & other chem manuf	Gas supply
Other farming	Non-metallic mineral prod manuf	Water supply
Basic metal manuf	Svcs to agriculture, hunting & trapping	Construction
Forestry & logging	Sheet & fabricated metal prod manuf	Wholesale trade
Fishing	Trans equipment manuf	Retail trade
Mining & quarrying	Machinery & equipment manuf	Education
Business svcs	Owner-occupied dwellings	Road trans
Meat & meat prod manuf	Oil & gas exploration & extraction	Water & rail trans
Dairy prod manuf	Electricity generation & supply	Local government
Other food manuf	Air trans, svcs to trans & storage	Communication svcs
Beverage, malt & tobacco manuf	Accommodation, restaurants & bars	Finance
Textile & apparel manuf	Health & community svcs	Insurance
Wood prod manuf	Cultural & recreational svcs	Svcs to finance & investment
Paper & paper prod manuf	Personal & other community svcs	Real estate

The model is used to show impact of a change in either inputs of outputs on the sector of interest and also the New Zealand economy. There are three stages of impact which can then be aggregated together to determine the total impact of any change scenario. The initial impact shows how the primary inputs and outputs to the specified sector(s) are affected. The changes in the primary impact are then attributed to the secondary inputs and outputs. For example, a change in agricultural outputs may increase inputs from the water sector. This can be viewed as the primary impact. The secondary impact would then attribute those same changes, as incurred by the water sector, to the inputs and outputs of the water sector. This method therefore accounts for the initial changes induced by, or ripple effects that transpire in the remaining sectors.

The outcome of the Impact Assessment analysis makes it possible to determine the relative effects of an intervention on a sector. Through comparing baseline scenario results to results after an imposed change, the immediate and flow-on effects on sectors can be assessed. The model can be used in a number of ways to assess resource efficiency savings. Which method is appropriate will depend upon the data availability for the sectors identified in the project brief. Firstly, if data is available on the resource efficiency saving and the monetary value of this it may be possible to re calculate the technical input output coefficients underlying the model construction to determine the impact of resource efficiency savings. For example, if it is possible to reduce inputs per tonne of output then this implies reducing the underlying technical coefficient in the model. For this to be possible information would have to be available on the resource savings and the value of these as well as their contribution to output. If this is available then the model can be re run to assess the impact of this and how this feeds through to other sectors with the release of resources and enhances output. The methodological issue here however is that it would have to be assumed that changing the technical coefficients for part of the matrix would not impact on coefficients in the matrix which may be a restrictive assumption.

Another way in which the impact assessment model can be altered is to aggregate up from case studies or other sources of data resource savings to the sector level. This may include for example the estimation of savings from water usage to the whole of the economy and then estimating the flow on impacts from this. So a ten percent savings in water will lead to flow on impacts across the economy. This method will involve directly changing the inputs and outputs in the model matrix and comparing these with the baseline model results to obtain aggregate savings.

The model can also be used to determine the savings directly in sectors which are identified in the model such as water. This was the method used by DEFRA in the absence of other data. Thus the water savings were estimated and then applied directly into the model framework.

The model of course has restrictions, not least the sectors it represents and the degree of breakdown of these sectors. Therefore the current construction of the model does not explicitly contain for example greenhouse gas emissions so therefore to estimate the impact of savings in these requires secondary analysis.

The sector analysis model can then be used if required to assess how the sectors compare across different criteria as to those which should be concentrated upon for further analysis. The Sector Selection module identifies the most pertinent sectors and their contribution to the economy.

B1.3 Environmental Values

Most environmental goods and services, such as clean air and water, and healthy wildlife habitats and populations, are not traded in markets. Their economic value, how much people would be willing to pay for them, is not revealed in market prices. The only option for assigning monetary values to them is to rely on non-market valuation methods.

The work presented in this report does not aim to include the benefits of resource efficiency that are not captured in market prices. For example, part of the value to a business from reducing waste is the savings in disposal costs, these are market prices that reflect a balance between the costs of services and what businesses are willing to pay. The reduction in waste may also have benefits that are not included in market prices such as improvements in environmental quality. Incorporating an assessment of the non-market impacts of resource savings activities produces a more precise measure of the economic value of particular activities. This may have a significant influence in identifying which activities are favoured and promoted. Currently the framework employed here favours activities that result in high market savings. The value of these savings is captured by private businesses. Activities that produce high non-market values, captured by the wider public, are not given the priority they may warrant.

There is considerable international literature estimating non-market environmental values spanning over forty years, many countries and many environmental goods. This work is predominantly conducted by environmental and resource economists. Application in New Zealand is sufficiently established to demonstrate effective implementation locally for a diverse range of environmental resources. Combined international and local publications provide a strong evidence base for work in this area. In the context of addressing data gaps this is an area where significant gains can be realised.

Annex C

Resource Efficiency Measure and Focal Sector Selection

C1 RESOURCE EFFICIENCY MEASURE AND FOCAL SECTOR SELECTION

C1.1 Resource Efficiency Measures

In developing the scope for the project, MfE specified four resource efficiency measures that should form the focus of the study. These resource efficiency measures reflected the key opportunity areas identified in previous studies, such as the DEFRA *Quantification of the Business Benefits of Resource Efficiency* study, but took into consideration potential overlaps with existing schemes established within New Zealand, such as the Energy Efficiency and Conservation Authority (www.eeca.govt.nz). The four resource efficiency measures incorporated within the study were:

- Water use;
- Material use;
- Waste production; and
- Greenhouse Gas (**GHG**) emissions.

C1.2 Focal Sector Selection

C1.2.1 Sector Focus

Within the proposed project scope, MfE also identified a list of five key sectors within the New Zealand economy for consideration within the study. To maintain consistency with government statistics, these key sectors were defined in alignment with the Australian and New Zealand Standard Industrial Classification (**ANZSIC**) 2006[i]. The five key sectors initially identified by MfE were:

- Agriculture (ANZSIC Level 2 Subdivision A01);
- Food and Beverage Manufacturing (ANZSIC Level 2 Subdivisions C11 and C12 respectively);
- New Zealand-based Manufacturing (excluding food and beverage, ANZSIC Level 2 Subdivisions C13 to C25);
- Construction (ANZSIC Level 1 Division E); and
- Tourism (various ANZSIC classifications, such as Level 1 Divisions H (Accommodation and Food Services) and Division R (Arts and Recreation Services)).

During the project initiation phase, it was recognised that further focussing of these sectors would be required given the scope of the project, and potential overlap with various ongoing studies on resource efficiency being undertaken by other Government departments.

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[i] www.stats.govt.nz/methods_and_services/surveys-and-methods/classifications-and-standards/classification-related-stats-standards/industrial-classification.aspx

As such, MfE in collaboration with the Project Partners narrowed this initial list down to three focal sectors and two ANZSIC sub-categorisations within each sector. These sectors and sub-sectors were:

- Agriculture (ANZSIC Level 2 Subdivision A01):
  - Fruit and Tree Nut Growing (A013); and
  - Dairy Cattle Farming (A016).
- Food and Beverage Manufacturing (ANZSIC Level 2 Subdivisions C11 and C12 respectively):
  - Dairy Product Manufacturing (C113); and
  - Bakery Product Manufacturing (C117).
- Construction (ANZSIC Level 1 Division E):
  - Residential Building Construction (B301); and
  - Non-Residential Building Construction (B302).

C1.2.2 Baseline Data Review

To further refine the sub-sector selection, a baseline data review was undertaken. The review focussed on determining the availability and accessibility of resource efficiency data that could be used within the calculation framework.

The data review was integrated into an Excel database, the raw inputs of which are highlighted within *Annex D*. In addition to documenting the information sources identified and evaluated as part of the baseline data review, the database aggregated information on the quantity and nature of information available to facilitate the identification of data gaps. Specifically, the database:

- Assigned data to each of the sub-sectors and resource efficiency measures to give an overall indication of the quantity of available information;
- Reviewed whether the information source was based on the New Zealand or overseas contexts; and
- Identified whether the information source presented a case study or other data (e.g. financial quantification of resource efficiency benefits/indication of the specific scale and nature of the New Zealand focal sectors) that could be utilised within the calculation methodology.

Table C1 below provides the summary output page from the database, highlighting at a high level the available data identified through the baseline review. An outline of the key data gaps identified through the review is presented as *Table C2*.

Table C1: Summary Output of Baseline Review Database

Sector/ Subsector	All Data	Data Sources		Financial Benefits		Case Studies		Data Sources		Financial Benefits		Case Studies		Data Sources		Financial Benefits		Case Studies	
		Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ
		Water						**Wastewater**						**Material Use**					
Agriculture	**29**	**4**	3	2	2	1	1	**1**	1	1	1	0	0	**2**	1	0	0	0	0
Dairy Cattle Farming	18	**3**	3	2	2	1	1	**1**	1	1	1	0	0	**1**	1	0	0	0	0
Fruit and Tree Nut Growing	11	**1**	0	0	0	0	0	**0**	0	0	0	0	0	**1**	0	0	0	0	0
Food Product Manufacturing	**15**	**6**	0	3	0	6	0	**5**	0	1	0	5	0	**5**	0	2	0	5	0
Dairy Product Manufacturing	5	**2**	0	2	0	2	0	**2**	0	1	0	2	0	**1**	0	1	0	1	0
Bakery Product Manufacturing	10	**3**	0	0	0	3	0	**3**	0	0	0	3	0	**4**	0	1	0	4	0
Construction	**58**	**1**	1	0	0	0	0	**0**	0	0	0	0	0	**22**	16	2	1	7	3
Residential Building Construction	10	**0**	0	0	0	0	0	**0**	0	0	0	0	0	**2**	0	0	0	2	0
Non-Residential Building Construction	6	**0**	0	0	0	0	0	**0**	0	0	0	0	0	**3**	2	1	1	3	2
Other: Wine Manufacturing*	**22**	**5**	2	0	0	0	0	**4**	3	0	0	0	0	**6**	3	1	1	0	0

Sector/ Subsector	All Data	Data Sources		Financial Benefits		Case Studies		Data Sources		Financial Benefits		Case Studies	
		Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ	Total	NZ
		Waste Production						**GHG Emissions**					
Agriculture		**5**	3	1	1	0	0	**14**	7	2	2	1	1
Dairy Cattle Farming		**3**	3	1	1	0	0	**7**	7	2	2	1	1
Fruit and Tree Nut Growing		**2**	0	0	0	0	0	**7**	0	0	0	0	0
Food Product Manufacturing		**6**	0	3	0	6	0	**6**	1	4	0	5	0
Dairy Product Manufacturing		**2**	0	2	0	2	0	**4**	1	3	0	3	0
Bakery Product Manufacturing		**4**	0	1	0	4	0	**2**	0	1	0	2	0
Construction		**36**	29	4	3	18	14	**1**	0	0	0	0	0
Residential Building Construction		**10**	8	0	0	10	8	**0**	0	0	0	0	0
Non-Residential Building Construction		**6**	5	2	2	5	4	**0**	0	0	0	0	0
Other: Wine Manufacturing*		**7**	4	0	0	0	0	**15**	8	2	1	1	0

* see *Section C1.2.3* below regarding inclusion of Wine Manufacturing in baseline review database

Table C2: Baseline Data Review Key Findings

<table>
<tr><th>Sector</th><th>Data Availability and Gaps</th></tr>
<tr><td>Dairy Cattle Farming</td><td>

Good data availability on GHG emissions and reduction opportunities.
Indicative waste reduction focal areas are: rural household waste, plastic containers and wrap, agrichemicals and dead livestock. Material use, include the above resources before they become waste and fertiliser.
Some data on water usage/wastewater focusing on irrigation measures and energy recovery by anaerobic digestion of dairy farm waste.
</td></tr>
<tr><td>Fruit and Tree Nut Growing</td><td>

Good data availability on GHG emissions and reduction opportunities.
Limited information on resource use, key areas being fertiliser and agrichemicals use. Review highlighted this sector's use of fertiliser is extremely small component of New Zealand’s total fertiliser use.
Ongoing ZESPRI water footprinting study provides some context on water use (efficiency opportunities anticipated to focus on irrigation).
</td></tr>
<tr><td>Dairy Product Manufacturing</td><td>

Some information available; however data accessibility identified as a key limitation.
</td></tr>
<tr><td>Bakery Product Manufacturing</td><td>

Limited data specifically focused on New Zealand bakery sector.
</td></tr>
<tr><td>Residential Building Construction</td><td rowspan="2">

Good data availability on waste reduction, recycling and reuse, and waste minimisation. Information linking this data to raw material use and GHG production was limited.
Very limited information on mechanisms for water use/ wastewater reduction through construction process.
Data available both internationally and from New Zealand case studies.
</td></tr>
<tr><td>Non-Residential Building Construction</td></tr>
</table>

C1.2.3 Final Sector Selection

Following the baseline data review, the accessibility of data within the dairy product manufacturing sub-sector was identified as a potential limitation for the project. It was therefore decided by MfE and the Project Partners that this sub-sector would be replaced by a similarly high profile sector of the New Zealand food and beverage manufacturing sector, wine-making.

Table C3 lists each of the focal sectors and proposed ANZSIC 2006 sub-sector categorisations to be studied.

Table C3: Final Sectors Selected for the Review

<table>
<tr><th>Focal Sector</th><th>Proposed Primary ANZSIC Code/ Level(s)</th><th colspan="2">ANZSIC Definition</th></tr>
<tr><td rowspan="6">Agriculture</td><td rowspan="6">A013 Fruit and Tree Nut Growing (Level 3)</td><td rowspan="6">This section contains the following subsection :
• Class 0131 Grape Growing
• Class 0132 Kiwifruit Growing
• Class 0133 Berry Fruit Growing
• Class 0134 Apple and Pear Growing
• Class 0135 Stone Fruit Growing
• Class 0136 Citrus Fruit Growing
• Class 0137 Olive Growing
• Class 0139 Other Fruit and Tree Nut Growing</td><td>Class 0131 Grape Growing
This class includes units mainly engaged in growing table or wine grapes; or sundrying grapes.
Primary activities
• Grape growing
• Grape sundrying
• Table grape growing
• Vineyard operations
• Wine grape growing
Exclusions/References
Units mainly engaged in:
• Processing or crushing grapes are included in Class 1140 Fruit and Vegetable Processing; and
• Manufacturing wine are included in Class 1214 Wine and Other Alcoholic Beverage Manufacturing</td></tr>
<tr><td>Class 0132 Kiwifruit Growing
This class consists of units mainly engaged in growing kiwifruit.
Primary activities
• Kiwifruit growing</td></tr>
<tr><td>Class 0132 Berry Fruit Growing
This class consists of units mainly engaged in growing berry fruit.
Primary activities
• Berry fruit growing
• Blueberry growing
• Gooseberry growing
• Boysenberry growing
• Blackberry growing
• Cranberry growing
• Loganberry growing
• Blackcurrant growing
• Strawberry growing
• Redcurrant growing
• Raspberry growing</td></tr>
<tr><td>Class 0132 Apple and Pear Growing
This class includes units mainly engaged in growing apples, pears or other pome fruit such as nashi pears or quinces.
Primary activities
• Apple growing
• Quince growing
• Nashi pear growing
• Pear growing</td></tr>
<tr><td>Class 0136 Citrus Fruit Growing
This class consists of units mainly engaged in growing citrus fruit.
Primary activities
• Citrus fruit growing
• Citrus orchard operation
• Grapefruit growing
• Lemon growing
• Mandarin growing
• Orange growing
• Tangelo growing</td></tr>
</table>

Focal Sector	Proposed Primary ANZSIC Code/ Level(s)		ANZSIC Definition
			Class 0137 Olive Growing This class consists of units mainly engaged in growing olives. **Primary activities** • Olive growing **Exclusions/References** Units mainly engaged in manufacturing olive oil are included in Class 1150 Oil and Fat Manufacturing.
			Class 0139 Other Fruit and Tree Nut Growing This class consists of units mainly engaged in growing tree nuts, tropical fruit, subtropical fruit, and other fruit not elsewhere classified. **Primary activities** • Almond growing • Avocado growing • Banana growing • Brazil nut growing • Cashew nut growing • Chestnut growing • Coconut growing • Custard apple growing • Feijoa growing • Fig growing • Loquat growing • Macadamia nut growing • Mango growing • Passionfruit growing • Pawpaw growing • Pecan nut growing • Persimmon growing • Pineapple growing • Tamarillo growing • Walnut growing
Agriculture	*A016 Dairy Cattle Farming* (Level 3)	This section contains the following subsection : • Class 0160 Dairy Cattle Farming	**Class 0160 Dairy Cattle Farming** This class consists of units mainly engaged in farming dairy cattle. Also included are units mainly engaged in sharemilking i.e. where the unit is contracted to milk the herd and/or perform other farm duties for a share of the milk income. **Primary activities** • Dairy cattle farming • Raw cattle milk production • Sharemilking dairy cattle **Exclusions/References** Units mainly engaged in farming dairy cattle for replacement, or dairy cattle agistment service, are included in Class 0142 Beef Cattle Farming (Specialised).

Focal Sector	Proposed Primary ANZSIC Code/ Level(s)	ANZSIC Definition	
Manufacturing	*C117 Bakery Product Manufacturing* (Level 3)	This section contains the following subsection : • Class 1171 Bread Manufacturing (Factory based) • Class 1172 Cake and Pastry Manufacturing (Factory based) • Class 1173 Biscuit Manufacturing (Factory Based) • Class 1174 Bakery Product Manufacturing (Non-factory Based)	**Class 1171 Bread Manufacturing (Factory based)** This class consists of units mainly engaged in manufacturing leavened and unleavened bread from factory based premises. Units mainly engaged in manufacturing bread dough (either fresh or frozen), breadcrumbs, or baking bread from home are also included. **Primary activities** • Bagel manufacturing (factory based) • Bread roll manufacturing (factory based) • English muffin manufacturing (factory based) • Pita bread • Bread bakery operation (factory based) • Fruit loaf manufacturing (factory based) • Bread dough, frozen, manufacturing (factory based) • Panini manufacturing (factory based) • Breadcrumb manufacturing (factory based) • Bread, leavened or unleavened, manufacturing (factory based) **Exclusions/References** Units mainly engaged in: • Manufacturing cakes and pastries from factory based premises are included in Class 1172 Cake and Pastry Manufacturing (Factory based); • Manufacturing bread and selling directly to consumers from the same premises are included in Class 1174 Bakery Product Manufacturing (Non-factory based); and • Retailing bakery products not manufactured on the same premises are included in Class 4129 Other Specialised Food Retailing.

<table>
<tr><th>Focal Sector</th><th>Proposed Primary ANZSIC Code/ Level(s)</th><th colspan="2">ANZSIC Definition</th></tr>
<tr><td rowspan="2">Manufacturing</td><td rowspan="2">C117 Bakery Product Manufacturing (Level 3) (cont.)</td><td rowspan="2">This section contains the following subsection :
• Class 1171 Bread Manufacturing (Factory based)
• Class 1172 Cake and Pastry Manufacturing (Factory based)
• Class 1173 Biscuit Manufacturing (Factory Based)
• Class 1174 Bakery Product Manufacturing (Non-factory Based)</td><td>Class 1172 Cake and Pastry Manufacturing (Factory based)

This class consists of units mainly engaged in manufacturing cakes, pastries, pies or similar bakery products (including frozen bakery products) from either factory based premises or home. Also included are units mainly engaged in finishing cakes (such as adding icing or jam).

Primary activities
• Cake icing or decorating (factory based)
• Cake or pastry manufacturing (factory based)
• Pie manufacturing (including meat, fruit or vegetable pies; factory based)
• Doughnut manufacturing (factory based)
• Cake or pastry, frozen, manufacturing (factory based)
• Cake or pastry-based pudding and dessert manufacturing (factory based)
• Crumpet manufacturing (factory based)
• Cake or pastry-based slice manufacturing (factory based)
• Pastry manufacturing (includes frozen dough; factory based)

Exclusions/References
Units mainly engaged in:
• Manufacturing cake mixes are included in Class 1162 Cereal, Pasta and Baking Mix Manufacturing;
• Manufacturing and selling directly to consumers cakes or pastries manufactured on the same premises are included in Class 1174 Bakery Product Manufacturing (Non-factory based); and
• Retailing bakery products (not manufactured on the same premises) are included in Class 4129 Other Specialised Food Retailing.</td></tr>
<tr><td>Class 1173 Biscuit Manufacturing (Factory based)

This class consists of units mainly engaged in manufacturing biscuits from either factory based premises or home.

Primary activities
• Biscuit dough manufacturing (factory based)
• Biscuit manufacturing (except pet food biscuits; factory based)
• Ice cream cone or wafer manufacturing (factory based)

Exclusions/References
Units mainly engaged in:
• Manufacturing pet food biscuits are included in Class 1192 Prepared Animal and Bird Feed Manufacturing;
• Manufacturing and selling directly to consumers biscuits manufactured on the same premises are included in Class 1174 Bakery Product Manufacturing (Non-factory based); and
• Retailing bakery products (not manufactured on the same premises) are included in Class 4129 Other Specialised Food Retailing.</td></tr>
</table>

Focal Sector	Proposed Primary ANZSIC Code/ Level(s)	ANZSIC Definition	
Manufacturing	*C117 Bakery Product Manufacturing* (Level 3) (cont.)	This section contains the following subsection : • Class 1171 Bread Manufacturing (Factory based) • Class 1172 Cake and Pastry Manufacturing (Factory based) • Class 1173 Biscuit Manufacturing (Factory Based) • Class 1174 Bakery Product Manufacturing (Non-factory Based)	**Class 1174 Bakery Product Manufacturing (Non-factory based)** This class consists of units mainly engaged in manufacturing and selling directly to consumers from the same premises, bread and other bakery products. **Primary activities** • Manufacturing and selling bread from the same premises (non-factory based) • Manufacturing and selling other bakery products from the same premises (non-factory based) **Exclusions/References** Units mainly engaged in: • Manufacturing bread from factory based premises are included in Class 1171 Bread Manufacturing (Factory based); • Manufacturing cakes and pastries from factory based premises are included in Class 1172 Cake and Pastry Manufacturing (Factory based); • Manufacturing biscuits from factory-based premises are included in Class 1173 Biscuit Manufacturing (Factory based); and • Retailing bakery products (not manufactured on the same premises) are included in Class 4129 Other Specialised Food Retailing.
Manufacturing	*C121400 Wine* [*and Other Alcoholic Beverage*] *Manufacturing* (Level 4)		**Class 1214 Wine and Other Alcoholic Beverage Manufacturing** This class consists of units mainly engaged in manufacturing or blending wine, fermented cider or wine vinegar, or alcoholic beverages not elsewhere classified. **Primary activities** • Beverage n.e.c., alcoholic, manufacturing • Carbonated wine manufacturing • Cider, alcoholic, manufacturing • Mead manufacturing • Fortified wine manufacturing • Perry, alcoholic, manufacturing • Sparkling wine manufacturing • Sherry manufacturing • Wine-based fruit drink 'cooler' manufacturing • Wine vinegar manufacturing • Unfortified wine manufacturing • Wine manufacturing **Exclusions/References** Units mainly engaged in: • Manufacturing non-alcoholic grape juice or drink are included in Class 1211 Soft Drink, Cordial and Syrup Manufacturing; • Growing grapes only are included in Class 0131 Grape Growing; and • Bottling (but not blending) wine and other alcoholic beverages on a fee or contract basis are included in Class 7320 Packaging Services

<table>
<tr><th>Focal Sector</th><th>Proposed Primary ANZSIC Code/ Level(s)</th><th colspan="2">ANZSIC Definition</th></tr>
<tr><td rowspan="2">Construction</td><td rowspan="2">E301 Residential Building Construction (Level 3)</td><td rowspan="2">This section contains the following subsection :
• Class 3011 House Construction
• Class 3019 Other Residential Building Construction</td><td>Class 3011 House Construction
This class consists of units mainly engaged in the construction of houses (except semi-detached houses) or in carrying out alterations, additions or renovations to houses, or in organising or managing these activities.
Primary activities
• Garage construction
• House construction, alteration or renovation
• House, prefabricated, assembly, erection or installation (on site)
Exclusions/References
Units mainly engaged in:
• Off-site production of prefabricated buildings or building components are included in the appropriate classes of Group 222 Structural Metal Product Manufacturing;
• Providing special trade repair services such as electrical or plumbing repairs are included in the appropriate classes of Group 323 Building Installation Services; and
• Providing architectural or building consultancy services are included in the appropriate classes of Group 692 Architectural, Engineering and Technical Services.</td></tr>
<tr><td>Class 3019 Other Residential Building Construction
This class consists of units mainly engaged in the construction of residential buildings (except freestanding houses) or in carrying out alterations, additions or renovations to such buildings or in organising or managing these activities.
Primary activities
• Apartment construction
• High-rise flat construction
• Duplex house construction
• Renovation or alteration of residential building n.e.c.
• Flat construction
• Semi-detached house construction
Exclusions/References
Units mainly engaged in:
• Off-site production of prefabricated buildings or building components are included in the appropriate classes of Group 222 Structural Metal Product Manufacturing;
• The construction of hotels, hostels, hospitals and other public buildings are included in Class 3020 Non-Residential Building Construction;
• Providing special trade repair services such as electrical or plumbing repairs are included in the appropriate classes of Group 323 Building Installation Services; and
• Providing architectural or building consultancy services are included in the appropriate classes of Group 692 Architectural, Engineering and Technical Services.</td></tr>
</table>

Focal Sector	Proposed Primary ANZSIC Code/ Level(s)	ANZSIC Definition	
Construction	*E302 Non-Residential Building Construction* (Level 3)	This section contains the following subsection : • Class 3020 Non-Residential Building Construction	**Class 3020 Non-Residential Building Construction** This class consists of units mainly engaged in the construction of non-residential buildings such as hotels, motels, hostels, hospitals, prisons or other buildings, in carrying out alterations, additions or renovation to such buildings, or in organising or managing these activities. **Primary activities** • Commercial building construction • Industrial building construction • Office building construction • Prefabricated non-residential building assembly, erection or installation on-site (except sheds, garages or carports) • Prefabricated temperature controlled structures installation • Renovation or alteration of non-residential buildings **Exclusions/References** Units mainly engaged in: • Off-site production of prefabricated buildings or building components are included in the appropriate classes of Group 222 Structural Metal Product Manufacturing; • Providing special trade repair services such as electrical or plumbing repairs are included in the appropriate classes of Group 323 Building Installation Services; and • Providing architectural or building consultancy services are included in the appropriate classes of Group 692 Architectural, Engineering and Technical Services.

C1.3 Mapping of Sectors within the Economic Impacts Assessment Model

As highlighted in *Table C3,* the final sectors selected for attention in this report were defined in alignment with Level 3 or Level 4 ANZSIC 2006 codes. The EIAM sectors were constructed using selected combinations of ANZSIC 1993 Level 2 industries. To accommodate an analysis using this modelling framework at ANZSIC 2006 Level 3 would necessitate disaggregation of the current model sectors requiring resources beyond the capacity of the current report.

The approach taken within the study was therefore to map the key sectors identified in *Table C3* to the EIAM as highlighted in *Table C4*. As such, the total economic impacts are likely to be over-estimated within the current EIAM, as savings reductions are applied at a level which includes more Level 3 industries than those considered in the study.

Table C4: Sector Mapping to EIAM

Focal Sector	Proposed Primary ANZSIC Code/Level(s)	EIAM Sector
Agriculture	*A013 Fruit and Tree Nut Growing* (Level 3) *A016 Dairy Cattle Farming* (Level 3)	Sector 1 'Horticulture and Fruit Growing' Sector 3 'Dairy and Cattle Farming'
Manufacturing	*C117 Bakery Product Manufacturing* (Level 3) *C121400 Wine* [*and Other Alcoholic Beverage*] *Manufacturing* (Level 4)	Sector 13 'Other Food Manufacturing' Sector 14 'Beverage, Malt and Tobacco manufacturing
Construction	*E301 Residential Building Construction* (Level 3) *E302 Non-Residential Building Construction* (Level 3)	EIAM sector 31 'Construction'

Annex D

Baseline Data Review
Excel Database

Quantifying the Benefits of Resource Efficiency Project No: 116920
Baseline Data Review

Goals i) Review baseline data on current resource use and efficiency for the priority sectors in New Zealand against the data needs of the calculation methodology developed in Project Phase 1.
ii) Establish limitations and gaps within the available dataset and will used these to direct Project Task 2b: Supplemental Data Collection.

Data Summary

Sector/ Subsector	All Data	Water							Wastewater							Material Use							Waste Production							GHG Emissions						
		Data Sources		Financial Benefits		Case Studies		Notes	Data Sources		Financial Benefits		Case Studies		Notes	Data Sources		Financial Benefits		Case Studies		Notes	Data Sources		Financial Benefits		Case Studies		Notes	Data Sources		Financial Benefits		Case Studies		Notes
		Total	NZ	Total	NZ	Total	NZ		Total	NZ	Total	NZ	Total	NZ		Total	NZ	Total	NZ	Total	NZ		Total	NZ	Total	NZ	Total	NZ		Total	NZ	Total	NZ	Total	NZ	
Agriculture	**29**	4	3	2	2	1	1		1	1	1	1	0	0		2	1	0	0	0	0		5	3	1	1	0	0		14	7	2	2	1	1	
Dairy Cattle Farming	18	3	3	2	2	1	1		1	1	1	1	0	0		1	1	0	0	0	0		3	3	1	1	0	0		7	7	2	2	1	1	
Fruit and Tree Nut Growing	11	1	0	0	0	0	0		0	0	0	0	0	0		1	0	0	0	0	0		2	0	0	0	0	0		7	0	0	0	0	0	
Food Product Manufacturing	**15**	6	0	3	0	6	0		5	0	1	0	5	0		5	0	2	0	5	0		6	0	3	0	6	0		6	1	4	0	5	0	
Dairy Product Manufacturing	5	3	0	3	0	3	0		2	0	1	0	2	0		1	0	1	0	1	0		2	0	2	0	2	0		4	1	3	0	3	0	
Bakery Product Manufacturing	10	3	0	0	0	3	0		3	0	0	0	3	0		4	0	1	0	4	0		4	0	1	0	4	0		2	0	1	0	2	0	
Construction	**58**	1	1	0	0	0	0		0	0	0	0	0	0		22	16	2	1	7	3		36	29	4	3	18	14		1	0	0	0	0	0	
Residential Building Construction	10	0	0	0	0	0	0		0	0	0	0	0	0		2	0	0	0	2	0		10	8	0	0	10	8		0	0	0	0	0	0	
Non-Residential Building Construction	6	0	0	0	0	0	0		0	0	0	0	0	0		3	2	1	1	3	2		6	5	2	2	5	4		0	0	0	0	0	0	
Other																																				
Wine Making	**22**	5	2	0	0	0	0		4	3	0	0	0	0		6	3	1	1	0	0		7	4	0	0	0	0		15	8	2	1	1	0	

Quantifying the Benefits of Resource Efficiency Project No: 0116920
Baseline Data Review

Goals i) Review baseline data on current resource use and efficiency for the priority sectors in New Zealand against the data needs of the calculation methodology developed in Project Phase 1.
ii) Establish limitations and gaps within the available dataset and will used these to direct Project Task 2b: Supplemental Data Collection.

Database

Ref.	Sector	Efficiency: Water Use	Efficiency: Wastewater Production	Efficiency: Material Use	Efficiency: Waste Production	Efficiency: GHG Emission	Geography	Data Type	Financial Data?	Sector Info	Title	Author	Date	Notes	Source
BP001	BP	Y	Y	Y	Y	Y	UK	Case Study			*Bakery Improves Resource Efficiency*	Envirowise	2003	Case study highlighting various efficiency m	http://www.envirowise.gov.uk/uk/Our-Services/Publications/CS823-Bakery-
BP002	BP	Y	Y	Y	Y		AUS	Case Study			*Quality Bakers Australia*	EPA Victoria	n.d.	Environment and Resource Efficiency Plans	http://www.epa.vic.gov.au/bus/erep/erep_fact_sheets.asp
BP003	BP	Y	Y	Y	Y		UK	Case Study			*Allied Bakeries*	Microsoft	2005	Use of business intelligence IS to improve de	http://www.microsoft.com/casestudies/Case_Study_Detail.aspx?CaseStudyI
BP004	BP						Unknown	Website			*The Food Processing Industry: Improvement of Resource E*	Cleaner Product	n.d.	General website highlighting resource efficie	http://www.cleanerproduction.com/directory/sectors/subsectors/FoodProc.h
BP005	BP						NZ	Website			*Bakery Industry Association of New Zealand*	BIANZ	n.d.		http://www.bianz.co.nz/
BP006	BP			Y	Y		US	Case Study	Y		*General Mills Inc. Chanhassen Facility*	ERM	2004	ERM Resource Efficency Project at Bakery	http://cf.pca.state.mn.us/oea/p2/govaward04.cfm#generalmills
BP007	BP					Y	UK	Case Study	Y		*Sharing success: profiting from supply chain partnerships*	Envirowise	2008	Provides cost benefits of improved environn	http://www.envirowise.gov.uk/uk/Our-Services/Publications/EN784--Sharir
BP008	BP			Y	Y		NZ	Case Study			*Data mining bread quality and process data in a plant bake*	Crop and Food	n.d.	Summary of data mining techniques used to	http://www.cs.waikato.ac.nz/~ml/publications/2004/wilson-etal.pdf
BP009	BP					Y	AUS	Website			*Plastic crates the best thing since sliced bread*	Viscout Plantics	n.d.	Provides a marketing story of benefits of usi	http://www.viscountplastics.co.nz/news___case_studies/n___c_plastic_crate
BP010	BP		Y		Y		AUS	Case Study			*promoting managerial efficiency through cleaner productio*	UNEP	n.d.	Quantifies improvements in wastewater pro	http://ww2.gpem.uq.edu.au/CleanProd/projects/Bakery%20Case%20Study%
C001	C						UK	Website			*Better Waste Management and Resource Efficiency*	BRE	2010	General initiatives for reducing construction	http://www.bre.co.uk/page.jsp?id=5
C002	NRBC			Y	Y		UK	Case Study			*SMARTWaste Case Study: Chiswick Park*	BRE	n.d.	Waste/material use minimisation, commerci	http://www.smartwaste.co.uk/smartaudit/downloads/chiswick.pdf
C003	RBC			Y	Y		UK	Case Study			*SMARTWaste Case Study: Geenwich Millenium Village*	BRE	n.d.	Waste/material use minimisation, residential	http://www.smartwaste.co.uk/page.jsp?id=42
C004	C						NZ	Website			*Resource Efficiency in the Building and Related Industries*	BRANZ	n.d.	General website, including case studies	http://www.branz.co.nz/cms_display.php?sn=103&st=1
C005	C			Y	Y		NZ	Report			*Construction - Waste Reduction*	REBRI	2005	Guide on reducing waste on construction sit	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C006	NRBC			Y	Y		NZ	Case Study	Y		*Meridian Energy Headquarters, Wellington - Construction*	REBRI	2005	Commercial building construction, incl. volu	http://www.branz.co.nz/cms_display.php?sn=108&st=1&pg=4155
C007	C			Y	Y		NZ	Case Study			*Southern Tonar Block - North Shore, Demolition*	REBRI	2005	Residential demolition case study	http://www.branz.co.nz/cms_display.php?sn=108&st=1&pg=4156
C008	C			Y	Y		NZ	Report			*Guide to C&D Resource Recovery - Concrete*	REBRI	2005	Series of guides to reduction and reuse of co	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C009	C			Y	Y		NZ	Report			*Guide to C&D Resource Recovery - Metal*	REBRI	2005	Series of guides to reduction and reuse of me	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C010	C			Y	Y		NZ	Report			*Guide to C&D Resource Recovery - Plasterboard*	REBRI	2005	Series of guides to reduction and reuse of pla	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C011	C			Y	Y		NZ	Report			*Guide to C&D Resource Recovery - Wood*	REBRI	2005	Series of guides to reduction and reuse of wo	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C012	C			Y	Y		NZ	Report			*Demolition - Waste Reduction*	REBRI	2005	Guide on reducing waste on construction sit	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C013	C			Y	Y		NZ	Report			*Construction and Demolition Waste Reduction Project*	SKM	2004	Market Development Strategy for C&D Was	http://www.branz.co.nz/cms_display.php?sn=109&st=1&pg=4119
C014	C			Y	Y		NZ	Report			*Construction and Demolition Waste Reduction: SMF 4194*	SKM	2004	Sector Group Waste Reduction - Issues and (	http://www.branz.co.nz/cms_show_download.php?id=1259
C015	C			Y	Y		NZ	Report			*Construction and Demolition Waste Reduction: SMF 4194*	SKM	2004	Inventory of Regulatory Tools	http://www.branz.co.nz/cms_show_download.php?id=1260
C016	C			Y	Y		NZ	Report			*Construction and Demolition Waste Reduction: SMF 4194*	SKM	2004	Assessment of Markets for C&D Waste	http://www.branz.co.nz/cms_show_download.php?id=1261
C017	C			Y	Y		NZ	Report			*Construction and Demolition Waste Reduction: SMF 4194*	SKM	2004	Regulating Waste Management under the Lo	http://www.branz.co.nz/cms_show_download.php?id=1262
C018	C			Y	Y		NZ	Report			*Construction and Demolition Waste Reduction: SMF 4194*	SKM	2004	Review of Verification Programme Options	http://www.branz.co.nz/cms_show_download.php?id=1263
C019	C						UK	Website			*East Midlands Centre for Constructing the Built Environm*	emcbe	n.d.		http://www.emcbe.com/
C020	C			Y	Y		UK	Case Study			*Marriott Construction Resource Efficiency Pilot Project*	emcbe	2006		http://www.emcbe.com/REC-secure-folder/Marriott%20Construction%20ED
C021	C						NZ	Website			*New Zealand Centre for Advanced Engineering, Universit*	NZCAE			http://www.caenz.com/caeindex.html
C022	C			Y	Y		NZ	Report			*Rethinking Construction in New Zealand*	NZCAE		Brief summary of contribution construciton i	http://www.caenz.com/infrastructure/BP/downloads/Rethinking.pdf
C023	C						UK	Website			*SMARTWaste*	BRE	n.d.	BRE Suite of tools and consultancy service to	http://www.smartwaste.co.uk/index.jsp
C024a	C			Y	Y		UK	Report	Y		*BRE Waste Benchmark Data*	BRE	2010	Results of project to collect waste data based	http://www.smartwaste.co.uk/page.jsp?id=37
C025	C						NZ	Website			*ZeroWaste NZ - Construction and Demolition*	ZeroWaste			http://www.zerowaste.co.nz/default,242.sm
C026	C						NZ	Website			*BRANZ*	BRANZ	n.d.		http://www.branz.co.nz/cms_display.php?
C027	NRBC				Y		NZ	Report	Y		*Northern Busway Fletcher Construction Waste Minimisati*	Wilkinson Envir	2008	Report prepared in partnership with Fletche	Provided by Fletcher Construction
C028	C						NZ	Website			*New Zealand Green Building Council*	NZGBC	n.d.		http://www.nzgbc.org.nz/main/
C029	C						NZ	Website			*Smarter Homes*	Smarter Homes	n.d.		http://www.smarterhomes.org.nz/construction/
C030	C						NZ	Website			*Level*	BRANZ	n.d.		http://www.level.org.nz/
C031	C						NZ	Website			*Waitakere City Building Sustainably Information*	Waitakere City	n.d.		http://www.waitakere.govt.nz/abtcit/ec/bldsus/index.asp
C032	NRBC			Y	Y		NZ	Case Study			*Construction and Demolition Waste*	Hamilton City C	2009	Highlights case study of Hukanui School	http://hamilton.co.nz/page/pageid/2145848047
C033	RBC			Y	Y		UK	Case Study			*Construction Waste Minimisation in Housing*	Jones, P. and Gr	n.d.		http://www.cardiff.ac.uk/archi/programmes/cost8/case/waste/uk-waster.pdf
C034	C						UK	Website			*Best Practice for Sustainable Urban Infrastructures*	University of W	n.d.	Provides case studies from European Coope	http://www.cardiff.ac.uk/archi/programmes/cost8/index.html
C035	C				Y		NZ	Report			*Resource Stewardship and Waste Minimisation*	Stone, L.	2003	Provides information on resource efficiency	http://www.caenz.com/info/publications/books_reports/in_print/RSWM/RSV
C036	C						NZ	Website			*Target Sustainability*	Christchurch Ci	n.d.	Includes case examples on residential and no	www.targetsustainability.co.nz
C037	NRBC				Y		NZ	Case Study			*AMI Standium - East Stand Development*	Christchurch Ci	2010	Case study on AMI Stadium stand construct	http://www.targetsustainability.co.nz/CaseStudies/construction.asp
C038	NRBC				Y		NZ	Case Study			*Jellie Park Development*	Christchurch Ci	2009	Case study on Jellie Park development - Mai	http://www.targetsustainability.co.nz/CaseStudies/JelliePark.pdf
C039	RBC				Y		NZ	Case Study			*Benchmark Homes*	Christchurch Ci	2009	Case study on Benchmark Homes constructi	http://www.targetsustainability.co.nz/CaseStudies/BenchmarkHomes.pdf
C040	RBC				Y		NZ	Case Study			*David Reid Homes*	Christchurch Ci	2009	Case study on David Reid Homes constructi	http://www.targetsustainability.co.nz/CaseStudies/DavidReid.pdf
C041	RBC				Y		NZ	Case Study			*Golden Homes*	Christchurch Ci	2009	Case study on Golden Homes construction p	http://www.targetsustainability.co.nz/CaseStudies/GoldenHomes.pdf
C042	RBC				Y		NZ	Case Study			*GJ Gardner Homes*	Christchurch Ci	2009	Case study on GJ Gardner Homes constructi	http://www.targetsustainability.co.nz/CaseStudies/GJGardnerHomes.pdf

Ref.	Sector	Efficiency					Geography	Data Type	Financial Data?	Sector Info	Title	Author	Date	Notes	Source
		Water Use	Wastewater Production	Material Use	Waste Production	GHG Emission									
C043	RBC				Y		NZ	Case Study			Jennian Homes	Christchurch Ci	2009	Case study on Jennian Homes construction p	http://www.targetsustainability.co.nz/CaseStudies/JennianHomes.pdf
C044	RBC				Y		NZ	Case Study			Mike Greer Houses	Christchurch Ci	2009	Case study on Mike Greer Houses constructi	http://www.targetsustainability.co.nz/CaseStudies/MikeGreerHomes.pdf
C045	RBC				Y		NZ	Case Study			Orange Homes	Christchurch Ci	2009	Case study on Orange Homes construction p	http://www.targetsustainability.co.nz/CaseStudies/OrangeHomes.pdf
C046	RBC				Y		NZ	Case Study			Stonewood Homes	Christchurch Ci	2009	Case study on Stonewood Homes constructi	http://www.targetsustainability.co.nz/CaseStudies/StonewoodHomes.pdf
C047	C						NZ	Website			New Zealand Sustainable Building Conference	SB10	2007	Provides links to presentations from SB10 ar	http://www.cmsl.co.nz/default,5684,sb10_presentations.sm
C048	C						NZ	Report			Construction and demolition waste - Best practice and cost	Inglis, M.	2007	Provides overview of waste production in th	http://www.cmsl.co.nz/assets/sm/2260/61/057-INGLISMahara.pdf
C049	C			Y	Y	Y	US	Report			Field Guide for Sustainable Construction	Partnership for .	2004	Guidance for sustainable construction	http://www.p2pays.org/ref/41/40904.pd
C050	C				Y		NZ	Case Study	Y		NZTA SH20 Manukau Harbour Crossing Project	Fletcher Buildin	2009	Internal report on waste minimisation activi	Fletchers Intranet
C051	C	Y					NZ	Report			Polyheed 861HE liquid additive		2009	Details on an additive to add to concrete mix	http://www.productlink.co.nz/c/Basf-Construction-Chemicals-New-Zealand
C052	C						NZ	Report			Integrated Whole Building Design Guidelines	Ministry for the	2008		http://www.mfe.govt.nz/publications/sus-dev/integrated-whole-building-de
C053	C						NZ	Report			Value Case for Sustainable Building in New Zealand	Ministry for the	2005		http://www.mfe.govt.nz/publications/sus-dev/value-case-sustainable-buildi
C054	C						NZ	Website			Beacon Pathway Ltd	Beacon	n.d.	Research consortium working to find afford	http://www.beaconpathway.co.nz
C055	C						NZ	Report			The Environmental Impact of the Waitakere NOW Home: A	Beacon	2010	LCA of sustainable housing - most impacts i	http://www.beaconpathway.co.nz/images/uploads/Environmental_Impacts
C056	C						NZ	Report			Beacon's NOW Homes® - Building and Renovating for Su	Beacon	2007	Highlights key sustainable building techniqu	http://www.beaconpathway.co.nz/images/uploads/SB07_NOW_Homes_Eas
C057	C				Y		NZ	Report			Solid Waste Audit Programme (SWAP)	MfE	2008	Provides breakdown of waste accepted at se	http://www.mfe.govt.nz/publications/waste/solid-waste-audits-2007-2008/m
C058	C						NZ	Report			Reclamation led approach to demolition	DEFRA	2007	Provides case studies in UK and NZ	http://www.bioregional.com/files/publications/ReclamationtoDemolition_Ju
DC001	DC					Y	NZ	Report			On-farm Greenhouse Gas Emissions from 23 Surveyed Org	Barber, A.	2010	Report prepared for New Zealand Ministry o	MAF
DC002	DC					Y	NZ	Report			Eco-efficiency of intensification scenarios for milk productic	Basset-Mens, C.,	2007		Ecological Economics, Vol. 68, Iss. 6, pp. 1615-1625
DC003	DC						NZ	Report			First Life Cycle Assessment of Milk Production from New Z	Basset-Mens, C.,	2005	Paper presented at ANZSEE 2005 Confernec	http://www.anzsee.org/anzsee2005papers/Basset-Mens_LCA_NZ_milk_pro
DC004	DC						NZ	Website			Agriculture Research Group on Sustainability	ARGOS			http://www.argos.org.nz
DC005	DC					Y	NZ	Report			Comparative Energy and Greenhouse Gas Emissions of New Zealand's and the UK's Dairy Industry	Saunders, C., an	2008		
DC006	DC					Y	NZ	Report	Y		Food miles - comparative energy/emissions performance of	Saunders, C., Ba	2006	Provides background information on dairy a	http://www.jborganics.co.nz/saunders_report.pdf
DC007	DC				Y		NZ	Report			Resource Stewardship and Waste Minimisation	Stone, L.	2003	Provides information on resource efficiency	http://www.caenz.com/info/publications/books_reports/in_print/RSWM/RS
DC008	DC						NZ	Website			MAF Sustainable Farming Fund	MAF	n.d.		http://www.maf.govt.nz/sff/
DC009	DC	Y	Y				NZ	Report	Y		Dairy Farm Energy Systems - reducing waste and using a productive resource			A series of reports on the SFF website	http://www.maf.govt.nz/sff/about-projects/search/03-209/index.htm
DC010	DC				Y		NZ	Report		Y	Investigation into Taranaki's Rural Waste Stream – 2004	TRC	2005	Quantities and reductions - farm practices a	http://www.maf.govt.nz/sff/about-projects/search/L03-025/l03025-rural-wast
DC011	DC						UK	Report			Towards Sustainable Agricultural Waste Management	EA	2001	Waste streams, options and barriers	http://publications.environment-agency.gov.uk/pdf/GEHO0003BIEO-E-E.pc
DC012	DC			Y		Y	NZ	Report			The Total Resource Use and Greenhouse Gas Emissions of	Barber, A. and F	2008	Report prepared for SIDDC and MAF SFF	http://www.maf.govt.nz/sff/about-projects/search/L07-057/index.htm
DC013	DC				Y		NZ	Report	Y		Sustainable Management of waste agrichemicals and waste	MfE	2003	Report can't be found, but it is referenced in	http://www.maf.govt.nz/sff/about-projects/search/L03-025/l03025-rural-wast
DC014	DC	Y					NZ	Case Study	Y		Taking the guesswork out of irrigation	EECA	n.d.	Use of a soil moisture meter allows better ma	http://www.eeca.govt.nz/sites/all/files/taking-the-guesswork-out-of-irrigatic
DC015	DC					Y	NZ	Case Study	Y		Dairy farmers milk free energy	EECA	n.d.	Solar water heating and heat recovery syster	http://www.eeca.govt.nz/sites/all/files/dairy-farmers-milk-free-energy-june-(
DC016	DP	Y		Y	Y	Y	AUS	Case Study	Y		Warrnambool Cheese and Butter Factory	EPA Victoria	2009	Environment and Resource Efficiency Plans	http://epanote2.epa.vic.gov.au/EPA/Publications.nsf/2f1c2625731746aa4a256
DC017	DP					Y	NZ	Report			Carbon Footprint Measurement: Methodology Report.	Lundie, S., Schu	2009	Report prepared for Fonterra	http://www.fonterra.com/wps/wcm/connect/944cee00415ae42c834eebd11145
DC018	DP	Y	Y			Y	Other	Case Study	Y		Best LIFE-Environment Projects 2005-2006	European Comm	2006	Contains case study of DOC Kaas dairy proc	http://www.environment.fi/download.asp?contentid=58720&lan=en
DC019	DP	Y			Y	Y	UK	Case Study	Y		Resource efficiency at an organic dairy product company	Envirowise	2008	Demonstrates cost and environmental benef	http://www.envirowise.gov.uk/uk/Our-Services/Publications/CS891-Resour
DC020	DP		Y				US	Case Study			Wastewater treatment if Dairy Plants: does it save	North Carolina (	1996	Comparison of self treatment vs municipal t	http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/cd39.html
DC021	DC	Y					NZ	Report			Snapshot of Water Allocation in New Zealand	Aqualinc	2006		www.mfe.govt.nz/publications/ser/snapshot-water-allocation-nov06/snapsh
DC022	DC					Y	NZ	Report			New Zealand's Greenhouse Gas Inventory 1990–2007	MfE	2009		www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2009
DC023	DC						NZ	Report	Y	Y	New Zealand Dairy Statistics 2008-09	LIC and Dairy N	2009		www.lic.co.nz/pdf/dairy_stats/DAIRY_STATISTICS_08-09.pdf
FT001	F&T					Y	NZ	Report			Carbon Footprinting for the Kiwifruit Supply Chain: Repor	Mithraratne, N.,	2008	Plus associated GHG reduction report	MAF GHG Sector Study
FT002	F&T					Y	NZ	Report			Carbon Footprinting for the Apple Supply Chain Methodol	Hume, A., Barbe	2009	Report prepared for New Zealand Ministry o	MAF GHG Sector Study
FT003	F&T					Y	NZ	Report			GHG Product Accounting Guidelines for the Wine Industr	Greenhalgh, S., l	2008	Report prepared for New Zealand Ministry o	MAF GHG Sector Study
FT004	F&T						NZ	Website			Agriculture Research Group on Sustainability	ARGOS			http://www.argos.org.nz
FT005	F&T						NZ	Report			2008 Annual ARGOS Sector Report: Kiwifruit	ARGOS	2008		http://www.argos.org.nz/pdf_files/ARGOS_Annual_Kiwifruit_Sector_Repor
FT006	F&T						NZ	Report			Evaluation of the environmental impacts of apple productio	Milla I Canals, L	2006		Agriculture, Ecosystems and Environment, Vol. 114, Iss. 2-4, pp. 226-238
FT007	F&T				Y	Y	NZ	Report	Y		Biogas from Kiwifruit Waste	Wabnitz, G.	2008	Provides background information on kiwifru	http://www.biogas.org.nz/Publications/WhosWho/Zespri%20Report%20Fin
FT008	F&T					Y	NZ	Report			Food miles - comparative energy/emissions performance of	Saunders, C., Ba	2006	Provides background information on dairy a	http://www.jborganics.co.nz/saunders_report.pdf
FT009	F&T				Y	Y	NZ	Report	Y		Eco-efficiency of the Zespri System: Distributed biogas proc	Poole, Loren	2009	Report prepared for Zespri	Zespri
FT010	F&T	Y					NZ	Report			Draft form. Kiwifruit: water footprint and water-LCA	Hume, A., Barbe	2010	Draft due in July 09, orchard data complete	Zespri and MAF
FT011	F&T			Y		Y	NZ	Report			GHG footprinting and berryfruit production Methodology and Scoping Study		2010	Not publically available	MAF GHG Sector Study
W001	W						UK	Website			Wine Home Page	WRAP	n.d.		www.wrap.org.uk/retail/materials/wine/index.htm
W002	W					Y	UK	Website	N		Wine: Transportation and UK filling	WRAP	n.d.		www.wrap.org.uk/retail/materials/wine/transport_uk_filling.html
W003	W			Y	Y		UK	Website	N		Wine: Packaging Overview	WRAP	n.d.		www.wrap.org.uk/retail/materials/wine/packaging_overview.htm
W004	W					Y	UK	Case Study	N		Bottling Wine in a Changing Climate	WRAP	n.d.		www.wrap.org.uk/downloads/15149-07_BottlingWine_CS_lr.59a6dbbe.3807
W005	W					Y	UK	Report	Y		Glass Recycling – Life Cycle Carbon Dioxide Emissions	British Glass Ma	2003		www.wrap.org.uk/downloads/British_Glass_Glass_Recycling_-_Life_Cycle_
W006	W	Y		Y	Y	Y	Aus	Website			Resource Efficiency for smaller Wineries - A practical mode	Perth Region NI	2008	Series of fact sheets produced	www.perthregionnrm.com/default.aspx?MenuID=80
W007	W	Y				Y	Other	Website			Sustainable Wine Growing Program	The Wine Institu	n.d.	Provides links to a number of intiatives	www.wineinstitute.org/initiatives/sustainablewinegrowing
W008	W	Y	Y	Y	Y	Y	Other	Report			Sustainable Management of Winery Water and Associated	The Wine Institu	n.d.		www.wineinstitute.org/files/AVF-Guide.pdf
W009	W	Y			Y	Y	NZ	Website			Te Mata Winery	Te Mata Winder	n.d.	Provides qualitative information on sustaina	www.temata.co.nz/index.php?CID=100612

Ref.	Sector	Efficiency: Water Use	Efficiency: Wastewater Production	Efficiency: Material Use	Efficiency: Waste Production	Efficiency: GHG Emission	Geography	Data Type	Financial Data?	Sector Info	Title	Author	Date	Notes	Source
W010	W						NZ	Website			*Sustainable Wine Growing New Zealand*	NZ Wine			www.nzwine.com/swnz
W011	W		Y		Y	Y	NZ	Website			*Sanctuary Winery*	Sanctuary Wine	n.d.	Provides qualitative information on sustaina	www.sanctuarywine.co.nz/page/Sustainable-Practices
W012	W				Y	Y	NZ	Website			*Richmond Plains Winery*	Richmond Plain	n.d.	Provides qualitative information on sustaina	www.organicwines.co.nz/carbon.html
W013	W						NZ	ournal Article			*Corporate Social Responsibility: Environmental Concern i*	Gabzdylova, B.,	2007	Profiles CSR initiatives in New Zealand win	http://conferences.anzmac.org/ANZMAC2007/papers/B%20Gabzdylova_1a.
W014	W						NZ	ournal Article			*Qualitative evaluation of three 'environmental managemen*	Hugheya, K.F.D	2004	Highlights over 60% of NZ wineries have ad	Journal of Cleaner Production, Vol. 13, Iss. 12, pp. 1175-1187
W015	W		Y		Y	Y	NZ	Website			*Villa Maria*	Villa Maria Win	n.d.	Provides qualitative information on sustaina	www.villamaria.co.nz/Sustainability/Sustainability-at-Villa-Maria/default.as
W016	W			Y			NZ	Report		Y	*NZ Wine Annual Report, 2009*	NZ Wine	2009	Industry statistics	www.nzwine.com
W017	W			Y		Y	NZ	Report	Y		*Carbon Footprinting for Wine Supply Chain – Report on R*	HortResearch	2008	Not publically available	MAF GHG Sector Study
W018	W			Y		Y	NZ	Report	N		*GHG Product Accounting Guidelines for the Wine Industr*	Landcare Resear	2008	Not publically available	MAF GHG Sector Study
W019	W	Y	Y				NZ	Report			*New Zealand Winegrowers Code of Practice for Winery W*	MWH	2010		Sustinable Winegrowing NZ
W020	W					Y	NZ	Website			*Yealands plastic bottle Full Circle is a winner*	Yealands	2010	Use of PET wine bottles	www.yealands.com
W021	W					Y	Other	Report			*Life Cycle Inventory of Container Systems for Wine*	Franklin Associ	2006	PET bottle Life cycle GHG emissions	www.tetrapak.com/se/Documents/WineContainers_report%5B1%5D.pdf
W022	W					Y	NZ	Report			*Inventory of HFC, SF6 and Other Industrial Process Emis*	CRL Energy	2009	Refrigeration emissions, nationla inventory	MfE
		Y		Y	Y		UK	Report	Y	Y	*Quantification of the business benefits of resource efficienc*	DEFRA	2007	Contains quantification of financial benefit f	http://www.oakdenehollins.co.uk/pdf/Defra_Business_Benefits_of_Resourc
											The application of life cycle assessment for improving the e	Perth University	2002	Assesses the ability of LCA to be used in sup	http://gis.lrs.uoguelph.ca/AgriEnvArchives/bioenergy/download/LCA_vanb
		Y		Y	Y		UK	Report	Y		*The value of resource efficiency in the food industry: a wast*	Various	2004	Provides quantification of benefits regarding	http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VFX-49KH
							NZ	Case study	Y		*A good nose for energy savings*	EECA	n.d.	Details energy savings in a winery after reus	http://www.eeca.govt.nz/sites/all/files/heat-recovery-turns-wasted-heat-into
							NZ	Case study	Y		*Hot water boilers are worth getting steamed up about*	EECA	n.d.	Replacement of a boiler at an Auckland win	http://www.eeca.govt.nz/sites/all/files/hot-water-boiler-cuts-energy-bill-for-

Annex E

Environmental Impacts Assessment Model (EIAM) Outputs

E1 MODEL RESULTS

E1.1 <u>Total Economic Impacts</u>

Table E1 presents the results of using the Economic Impact Assessment Model (**EIAM**) to calculate the total economic impacts across the New Zealand economy of efficiency gains in the key sectors. Each column represents the EIAM sector in which the efficiency gains are realised and each row represents the inputs into that sector. The monetary amounts in each cell represent the increase in value to that input sector.

The increase in total output presented at the bottom of *Table E1* for each efficiency realising sector is the sum of the direct, indirect and induced impacts, and is commonly referred to as the *total economic impact*. The direct impact arises from the initial reallocation of saved expenditure to consumption of goods and services in other sectors. The indirect impact arises from increased spending by businesses as they purchase additional inputs so as to increase production to meet direct impact demand. This indirect impact can be envisaged as an expanding ripple effect. The induced impact is the result of increased household income being spent and leading to a further ripple effect of increased employment, output and income.

Efficiency gains in each key sector are modelled independently of gains in other key sectors so as to isolate impacts. This can be viewed as introducing efficiency gains within a single key sector in the absence of efficiency gains in other key sectors.

E1.1.1 Dairy Cattle Farming

Two areas of efficiency gains were modelled for the ANZSIC (2006) A016 Dairy Cattle Farming sector corresponding to EIAM Sector 3: *Dairy and Cattle Farming*. First was a 4% reduction in nitrogen fertiliser replicated over 20% of the industry (through the use of dicyandiamide). The second efficiency gain modelled was a 20% reduction in electricity use replicated across 20% of the industry. This reduction fed into the model through the *electricity generation* sector of the model.

Resource efficiency gains achieved within the Dairy and Cattle Farming sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **$2.6 million per annum**.

E1.1.2 Fruit and Tree Nut Growing

Two areas of efficiency gains were modelled for the ANZSIC (2006) A013 Fruit and Tree Nut Growing key sector corresponding to EIAM Sector 1: *Horticulture and Fruit Growing*. First was a 20% reduction in electricity, replicated across 20% of industry (primarily from improved irrigation management). Also modelled was a 25% reduction in diesel consumption across the entire industry. This reduction fed into the model through the *petroleum refining, product manufacturing* sector of the model.

When distributed across and consumed by other sectors of the economy, these resource efficiency gains achieve a total economic impact of **$3.9 million per annum**.

E1.1.3 Bakery Product Manufacturing

Several areas of efficiency gains were modelled for the ANZSIC (2006) C117 Bakery Product Manufacture focal sector corresponding to EIAM Sector 13: *Other Food Manufacturing*. First was an average reduction in electricity consumption of 15% across the entire industry. This reduction fed into the model through the *electricity generation* sector of the model. Second was an average 38% reduction of water consumption from production and wash-down waters across the entire industry. This reduction fed into the model through the *water supply* sector of the model. Third was an average 15% reduction of total waste disposed at landfill across the entire industry. This reduction fed into the model through the *sewage, drainage and waste disposal services* sector of the model.

Resource efficiency gains achieved within the *Other Food Manufacturing* sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **$9.3 million per annum**.

E1.1.4 Wine Manufacturing

Several areas of efficiency gains were modelled for the ANZSIC (2006) C121400 Wine [and other alcoholic beverage] Manufacturing sector corresponding to EIAM Sector 14: *Beverage Malt and Tobacco Manufacturing*. First was a 25% reduction in electricity use replicated across 20% of the industry. This reduction fed into the model through the *electricity generation* sector of the model. The second efficiency gain modelled was a 5% reduction in natural gas consumption across 20% of industry. This reduction fed into the model through the *oil and gas extraction, production & distribution* sector of the model. A third efficiency gain modelled was a 52% reduction in glass packaging across 20% of industry (switching to light weight glass). This reduction fed into the model through the *non-metallic mineral production manufacturing* sector of the model.

Resource efficiency gains achieved within the Wine Manufacturing sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **$6.2 million per annum**.

E1.1.2 Residential and Non-Residential Building Construction

One area of efficiency gain was modelled for the ANZSIC (2006) E301 Residential and E302 Non-Residential Building key sectors corresponding to EIAM Sector 31: *Construction*. Considered here was a 57.5% increase in total mixed waste diverted from landfill for the whole of both industries. This was an aggregate average across commercial and residential building demolition and construction. This waste reduction fed into the model through the *sewage, drainage and waste disposal services* sector of the model.

Resource efficiency gains achieved within the Construction sector, when distributed across and consumed by other sectors of the economy, achieved a total economic impact of **$24.3 million per annum**.

Table E1: Total Economic Impacts of Efficiency Gains

Inputs	Input Value (NZ$ million)				
	3. Dairy and Cattle Farming *(ANZSIC 2006 A016 Dairy Cattle Farming)*	**1: Horticulture and Fruit Growing** *(ANZSIC 2006 A013 Fruit and Tree Nut Growing)*	**13: Other Food Manufacturing** *(ANZSIC 2006 C117 Bakery Product Manufacture)*	**14. Beverage, Malt and Tobacco Manufacturing** *(ANZSIC 2006 C121400 Wine [and other alcoholic beverage] Manufacturing)*	**31. Construction** *(ANZSIC 2006 E301 Residential and E302 Non-Residential Building Construction)*
Horticulture and fruit growing	-	-	-	-	0.01
Livestock and cropping farming	-	-	0.01	0.01	0.02
Dairy and cattle farming	-	-	-	0.01	0.01
Other farming	-	-	-	-	-
Services to agriculture, hunting and trapping	-	-	0.01	0.01	0.01
Forestry and logging	0.01	0.01	0.02	0.03	0.03
Fishing	-	-	-	-	-
Coal mining	0.02	0.01	0.07	0.03	0.01
Oil and gas extraction, production & distribution	0.12	0.41	0.36	0.15	0.30
Other Mining and quarrying	0.01	0.02	0.03	0.19	0.13
Meat manufacturing	-	-	-	-	0.01
Dairy manufacturing	-	0.01	0.01	0.02	0.03
Other food manufacturing	-	-	-	0.01	0.01
Beverage, malt and tobacco man	-	-	-	-	0.01
Textiles and apparel manufacturing	-	-	0.01	0.01	0.01
Wood product manufacturing	0.01	0.01	0.05	0.06	0.05
Paper and paper product man	0.01	0.01	0.02	0.03	0.03
Printing, publishing and recorded media	0.01	0.01	0.04	0.05	0.13
Petroleum refining, product man	0.06	1.94	0.11	0.08	0.08
Fertiliser and other industrial chemical man	0.80	0.01	0.01	0.02	0.03
Rubber, plastic and other chemical product man	0.01	0.01	0.03	0.02	0.08
Non-metallic mineral product manufacturing	0.01	0.02	0.05	3.06	0.11

Inputs	Input Value (NZ$ million)				
	3. Dairy and Cattle Farming *(ANZSIC 2006 A016 Dairy Cattle Farming)*	**1: Horticulture and Fruit Growing** *(ANZSIC 2006 A013 Fruit and Tree Nut Growing)*	**13: Other Food Manufacturing** *(ANZSIC 2006 C117 Bakery Product Manufacture)*	**14. Beverage, Malt and Tobacco Manufacturing** *(ANZSIC 2006 C121400 Wine [and other alcoholic beverage] Manufacturing)*	**31. Construction** *(ANZSIC 2006 E301 Residential and E302 Non-Residential Building Construction)*
Basic metal manufacturing	0.01	0.01	0.03	0.06	0.06
Structural, sheet & fabricated metal product man	0.02	0.02	0.06	0.08	0.18
Machinery and other equipment man	0.01	0.02	0.05	0.03	0.11
Furniture and other manufacturing	-	-	0.01	0.01	0.02
Electricity generation	0.73	0.59	2.9	0.49	0.08
Electricity transmission and distribution	0.08	0.07	0.29	0.22	0.2
Water supply	-	-	1.12	-	0.01
Sewerage, drainage and waste disposal services	-	-	1.75	-	18.5
Construction	0.14	0.15	0.57	0.22	0.52
Wholesale and retail trade	0.06	0.07	0.19	0.17	0.89
Accommodation, restaurants and bars	-	-	0.01	-	0.02
Road freight transport	0.06	0.02	0.05	0.18	0.28
Road passenger transport	-	-	-	-	-
Rail transport	0.01	-	0.01	0.02	0.01
Water transport	0.01	0.04	0.02	0.07	0.1
Air transport and transport services	0.02	0.02	0.04	0.04	0.07
Communication services	0.03	0.02	0.08	0.07	0.28
Finance and insurance	0.06	0.06	0.17	0.14	0.43
Real estate	0.02	0.02	0.06	0.05	0.16
Equipment hire and investors in other property	0.01	0.01	0.05	0.03	0.19
Ownership of owner-occupied dwellings	-	-	-	-	-
Scientific research and computer services	0.15	0.17	0.55	0.17	0.18
Other business services	0.10	0.1	0.33	0.23	0.63

Inputs	Input Value (NZ$ million)				
	3. Dairy and Cattle Farming *(ANZSIC 2006 A016 Dairy Cattle Farming)*	**1: Horticulture and Fruit Growing** *(ANZSIC 2006 A013 Fruit and Tree Nut Growing)*	**13: Other Food Manufacturing** *(ANZSIC 2006 C117 Bakery Product Manufacture)*	**14. Beverage, Malt and Tobacco Manufacturing** *(ANZSIC 2006 C121400 Wine [and other alcoholic beverage] Manufacturing)*	**31. Construction** *(ANZSIC 2006 E301 Residential and E302 Non-Residential Building Construction)*
Central government administration and defence	-	-	0.01	0.01	0.03
Local government administration	-	-	0.02	0.03	0.14
Pre-school, primary and secondary education	-	-	-	-	-
Other education	-	-	0.02	0.01	0.01
Hospitals and nursing homes	-	-	-	-	-
Other health and community services	-	-	-	-	0.01
Cultural and recreational services	0.01	0.01	0.03	0.04	0.08
Personal and other community services	-	-	0.02	0.01	0.02
Total Increase in Output (NZ$ Million per annum)	**2.62**	**3.89**	**9.25**	**6.22**	**24.31**

E1.2 Target Efficiency Areas

In addition to calculating impacts of resource saving across the economy, the EIAM was utilised in a preliminary scoping exercise to identify potentially fruitful areas for targeting resource savings efforts across the key sectors. Of particular interest is whether the resources focused on in this report form a significant proportion of each key sector's inputs.

To aid in this objective *Table E2* presents values and percentages of key sector inputs for those industries in which resource efficiency measures could take place. These industries were chosen to represent the direct impact of efficiency gains. Water use, where available, feeds into the EIAM through the *water supply* sector. Waste production feeds into the EIAM through the *sewerage, drainage and waste disposal services* sector. Changes in material use feed into the EIAM through many sectors. The remaining sectors shown in *Table E2* represent how changes in materials such as diesel, wood, steel, plastics, and chemicals feed into the EIAM.

Table E2: Key Sectors Priority Inputs (2006)

Input	Input value (NZ$ million)	% of sector inputs
3. Dairy and Cattle Farming *(ANZSIC 2006 A016 Dairy Cattle Farming)*		
Water supply	Not Available	
Sewerage, drainage and waste disposal services	$0.024	0.00
Wood product manufacturing	$2.081	0.09
Paper and paper product manufacturing	$2.747	0.12
Fertiliser and other industrial chemical manufacturing	$217.289	9.67
Rubber, plastic and other chemical product manufacturing	$83.192	3.70
Basic metal manufacturing	$1.570	0.07
Non-metallic mineral product manufacturing	$6.472	0.29
Road freight transport	$28.180	1.25
Structural, sheet & fabricated metal product manufacturing	$35.895	1.60
Petroleum refining, product manufacturing	$49.706	2.21
Electricity generation	$48.261	2.15

Input	Input value (NZ$ million)	% of sector inputs
1. Horticulture and Fruit Growing *(ANZSIC 2006 A013 Fruit and Tree Nut Growing)*		
Water supply	Not Available	
Sewerage, drainage and waste disposal services	$0.011	0.00
Wood product manufacturing	$0.785	0.06
Paper and paper product manufacturing	$51.740	3.95
Fertiliser and other industrial chemical manufacturing	$59.448	4.53
Rubber, plastic and other chemical product manufacturing	$55.051	4.20
Basic metal manufacturing	$0.684	0.05
Non-metallic mineral product manufacturing	$2.317	0.18
Road freight transport	$52.890	4.03
Petroleum refining, product manufacturing	$16.390	1.25
Structural, sheet & fabricated metal product manufacturing	$14.798	1.13
Electricity generation	$48.300	3.68
13. Other Food Manufacturing *(ANZSIC 2006 C117 Bakery Product Manufacturing)*		
Water supply	$4.273	0.11
Sewerage, drainage and waste disposal services	$10.525	0.26
Wood product manufacturing	$0.797	0.02
Paper and paper product manufacturing	$10.248	0.26
Fertiliser and other industrial chemical manufacturing	$14.380	0.36
Rubber, plastic and other chemical product manufacturing	$181.870	4.54
Basic metal manufacturing	$18.994	0.47
Non-metallic mineral product manufacturing	$4.974	0.12
Road freight transport	$213.507	5.33
Structural, sheet & fabricated metal product manufacturing	$67.055	1.68
Petroleum refining, product manufacturing	$36.575	0.91
Electricity generation	$48.297	1.21
14. Beverage, Malt and Tobacco Manufacturing *ANZSIC 2006 C113 Dairy ProductC121400 Wine [and other alcoholic beverage] Manufacturing*		
Water supply	$11,450	0.71
Sewerage, drainage and waste disposal services	$0.069	0.00
Wood product manufacturing	$6.263	0.39
Paper and paper product manufacturing	$28.803	1.48
Fertiliser and other industrial chemical manufacturing	$3.955	0.25
Rubber, plastic and other chemical product manufacturing	$17.766	1.10
Basic metal manufacturing	$9.230	0.57
Non-metallic mineral product manufacturing	$42.016	2.61
Road freight transport	$50.649	3.15
Structural, sheet & fabricated metal product manufacturing	$170.405	10.6
Petroleum refining, product manufacturing	$10.666	0.66
Electricity generation	$11.500	0.72

Input	Input value (NZ$ million)	% of sector inputs
31. Construction *(ANZSIC 2006 E301 Residential and E302 Non-Residential Building Construction)*		
Water supply	$4.397	0.02
Sewerage, drainage and waste disposal services	$65.057	0.36
Wood product manufacturing	$1,803.709	9.97
Paper and paper product manufacturing	$58.733	0.32
Fertiliser and other industrial chemical manufacturing	$33.528	0.19
Rubber, plastic and other chemical product manufacturing	$377.126	2.08
Basic metal manufacturing	$96.814	0.54
Non-metallic mineral product manufacturing	$1,368.677	7.57
Road freight transport	$108.843	0.60
Structural, sheet & fabricated metal product manufacturing	$650.400	3.60
Petroleum refining, product manufacturing	$406.661	2.25
Electricity generation	$24.100	0.13

Overall this tabulation indicates that very few inputs constitute more than five percent of a sectors total input. Value of *water supply* input is not available for *Horticulture and Fruit Growing*, or *Dairy and Cattle Farming*, and is relatively low for the remaining sectors. Waste disposal services are also a very small percentage of total inputs for all sectors.

The dairy and cattle farming sector has a large percentage of input from the *fertiliser and other industrial chemical manufacturing* (9.67%) which is significantly larger than any other resource measures considered, indicating a possible area of focus for savings.

For the horticulture and fruit growing sector, inputs from *rubber, plastic and other chemical product manufacturing* (4.2%), *paper and paper product manufacturing* (3.95%), and *fertiliser and other industrial chemical manufacturing* (4.53%) represent the resources sectors that could be prioritised for saving potential.

The other food manufacturing sector, major material inputs come from *rubber, plastic and other chemical product manufacturing* (4.54%), and has significant input from the *road freight transport* (5.33%).

The highest value material input for the Beverage, Malt and Tobacco sector comes from *structural, sheet and fabricated metal product manufacturing*. At 10.6% of the value of total inputs this may represent opportunities for savings based on material use efficiency. Only two other material inputs are valued at over 1% of total sector inputs, 1.48% from *paper and paper product manufacturing* and 2.61% from the *non-metallic mineral product manufacturing*.

Almost ten percent of inputs to the construction sector come from *wood product manufacturing* (9.97%) while inputs from *non-metallic mineral product manufacturing* are also relatively large at 7.57%.

Some further key findings of these tabulations are that the *Dairy and Cattle Farming* sector is the highest value user of inputs from *fertiliser and other industrial chemical manufacturing* sector. The *Beverage, Malt and Tobacco Manufacturing* sector is the second highest value user of inputs from *structural, sheet & fabricated metal product manufacturing* outside of the construction sector. The *Construction* sector is the highest value user of inputs from: *sewerage, drainage and waste disposal services*; *wood product manufacturing*; *paper and paper product manufacturing*; *rubber, plastic and other chemical product manufacturing*; *basic metal manufacturing*; *non-metallic mineral product manufacturing*; *structural, sheet and fabricated metal product manufacturing*; and pet*roleum refining, product manufacturing*. This reveals that the construction is the highest value user of inputs compared to the other sectors studied.

Even though some sector inputs are a large proportion of their total inputs, and this proportion may be larger than the same input in a different sector, their absolute value may be smaller than in other sectors. This highlights the case for targeting sectors that represent higher values of total inputs rather than specific resources across multiple sectors. In this vein the construction sector constitutes the highest value of inputs of the sectors considered here, by approximately a third over the next sector, other food manufacturing. While the horticulture and fruit growing sector has the lowest value of inputs considered here, at approximately half that of the construction sector.

To extend this scoping approach, *Table E3* presents values of each of the key sectors top five inputs.

Table E3: Value of Each Key Sector's Top Five Inputs (2006)

Input	Input value (NZ$ million)	% of sector inputs
3. Dairy and Cattle Farming *(ANZSIC 2006 A016 Dairy Cattle Farming)*		
Wholesale and retail trade	$426.522	19.8
Livestock and cropping farming	$249.784	11.1
Fertiliser and other industrial chemical man	$217.289	10.1
Services to agriculture, hunting and trapping	$163.047	7.1
Horticulture and fruit growing	$130.731	5.8
1. Horticulture and Fruit Growing *(ANZSIC 2006 A013 Fruit and Tree Nut Growing)*		
Services to agriculture, hunting and trapping	$203.988	15.6
Wholesale and retail trade	$151.110	11.5
Finance and insurance	$143.150	11.1
Other business services	$107.990	8.2
Fertiliser and other industrial chemical manufacturing	$59.448	4.5

Input	Input value (NZ$ million)	% of sector inputs
13. Other Food Manufacturing *(ANZSIC 2006 C117 Bakery Product Manufacturing)*		
Other food manufacturing	$1,117.859	28.1
Fishing	$517.171	13.1
Wholesale and retail trade	$501.742	12.5
Other business services	$252.743	6.1
Road freight transport	$213.507	5.3
14. Beverage, Malt and Tobacco Manufacturing *ANZSIC 2006 C113 Dairy ProductC121400 Wine [and other alcoholic beverage] Manufacturing*		
Wholesale and retail trade	$196.121	12.2
Other business services	$196.104	12.2
Structural steel and fabricated metal manufacturing	$170.405	10.6
Beverage, malt and tobacco manufacturing	$164.341	10.2
Horticulture and food growing	$138.070	8.6
31. Construction *(ANZSIC 2006 E301 Residential and E302 Non-Residential Building Construction)*		
Construction	$7,876.812	43.5
Wholesale and retail trade	$1,828.348	10.1
Wood product manufacturing	$1,803.709	10
Non-metallic mineral product manufacturing	$1,368.677	7.6
Other business services	$881.448	4.9

Looking at *Table E3* tells us that inputs from goods sectors dominate the top five valued inputs into the *Dairy and Cattle Farming* sector. Inputs from *wholesale and retail trade* are the highest valued input and are about 71% greater than the value of the next highest valued input sector, *livestock and cropping farming*. Inputs from the *fertiliser and other industrial chemical manufacturing* are also considerably important to this sector.

Service sector inputs are of primary importance to the *Horticulture and Fruit Growing* sector, comprising three of the top five expenditures. Inputs from *wholesale and retail trade* are the second highest value. While inputs from *fertiliser and other industrial chemical manufacturing* are considerably lower than other top five inputs, at about half the value of the next highest value input, *other business services*.

The *Other Food Manufacturing* sector covers food production excluding meat and dairy. This sector's highest value inputs come from within the sector, with inputs from *fishing* encompassing less than half this value. Distribution of food products means that inputs from the *road freight transport* are of significant value.

The top five valued inputs into the *Beverage, Malt and Tobacco Manufacturing* sector account for about 50% of the value of total inputs into this sector with each of the top five accounting for about 10% individually of the value of total inputs. This implies that no single input sector can be targeted based on greatest value, but rather the choices could be supported by identification of possible savings activities within input sectors. Perhaps unsurprisingly, inputs from *horticulture and fruit growing* are highly valued as these are primary raw inputs to manufacturing alcoholic beverages and tobacco.

Like the previous key sector the *Construction* sector gets a large proportion of its inputs from within the sector. This sector has a large value of inputs from *wood product manufacturing* and *non-metallic mineral product manufacturing*.

E1.3 Replication Rate Sensitivity Analysis

To provide an indication of how results presented in *Table E3* are affected by changes in the number of businesses initiating a resource saving activity, this section examines the impact of varying replication rates.

For the ANZSIC (2006) A016 Dairy Cattle Farming sector corresponding to EIAM Sector 3: *Dairy and Cattle Farming*, a reduction in nitrogen fertiliser replicated over 20% of industry and a reduction in electricity use replicated across 20% of industry was modelled. For sensitivity analysis, a 10% replication rate for each activity and a 50% rate for each activity were modelled. Results are presented in *Table E4* alongside original estimates.

For the ANZSIC (2006) A013 Fruit and Tree Nut Growing sector corresponding to EIAM Sector 1: *Horticulture and Fruit Growing*, a reduction in electricity replicated across 20% of industry and a reduction in diesel consumption across the entire industry was modelled. For sensitivity analysis a 10% replication rate for each activity and a 50% rate for each activity were modelled. Results are presented in *Table E4* alongside original estimates.

For the ANZSIC (2006) C117 Bakery Product Manufacture sector corresponding to EIAM Sector 13: *Other Food Manufacturing*, a reduction in electricity consumption across the entire industry, a reduction of water consumption across the entire industry, and reduction of total waste disposed at landfill across the entire industry were modelled. For sensitivity analysis a 10% replication rate for each activity and a 50% rate for each activity were modelled. Results are presented in *Table E4* alongside original estimates.

For the ANZSIC (2006) C121400 Wine [and other alcoholic beverage] Manufacturing sector corresponding to EIAM Sector 14: *Beverage Malt and Tobacco Manufacturing*, a reduction in electricity use replicated across 20% of the industry, a reduction in natural gas consumption across 20% of industry, and a reduction in glass packaging across 20% of industry were modelled. For sensitivity analysis a 10% replication rate for each activity and a 50% rate for each activity were modelled. Results are presented in *Table E4* alongside original estimates.

For the ANZSIC (2006) E301 Residential Building Construction and E302 Non-Residential Building Construction sectors corresponding to EIAM Sector 31: *Construction*, an increase in total mixed waste diverted from landfill for the whole of both industries was modelled. For sensitivity analysis a 10% replication rate for each activity and a 50% rate for each activity were modelled. Results are presented in *Table E4* alongside original estimates.

In each industry sector, it is clear that the greater the rate of efficiency measure replication within the industry, the greater the potential financial benefits. However, the sensitivity modelling also demonstrates that the relationship between replication rate and financial benefit is not linear. In most cases doubling the replication rate results in more than twice the increase in financial output, although in some sectors, for example the Fruit and Tree Nut Growing sector, there appears to be a plateau point in the replication rate whereby the increase in rate of financial benefits slows.

Further analysis of the effect of efficiency measure replication rate by sector could provide MfE with guidance on the level to which effort could or should be best used to increase replication of efficiency measure within each sector in order to gain maximum financial benefit.

Table E4: Dairy and Cattle Farming Replication Rate Sensitivity Analysis

Inputs	**10%**	**Original (20%)**	**50%**
Horticulture and fruit growing	-	-	-
Livestock and cropping farming	-	-	
Dairy and cattle farming	-	-	-
Other farming	-	-	-
Services to agriculture, hunting and trapping	-	-	0.01
Forestry and logging	-	0.01	0.02
Fishing	-	-	-
Coal mining	0.01	0.02	0.05
Oil and gas extraction, production & distribution	0.06	0.12	0.30
Other Mining and quarrying	-	0.01	0.02
Meat manufacturing	-	-	-
Dairy manufacturing	-	-	0.01
Other food manufacturing	-	-	-
Beverage, malt and tobacco man	-	-	-
Textiles and apparel manufacturing	-	-	-
Wood product manufacturing	0.01	0.01	0.03
Paper and paper product man	-	0.01	0.02
Printing, publishing and recorded media	0.01	0.01	0.03
Petroleum refining, product man	0.02	0.06	0.12
Fertiliser and other industrial chemical man	0.21	0.80	1.05
Rubber, plastic and other chemical product man	-	0.01	0.02
Non-metallic mineral product manufacturing	0.01	0.01	0.03
Basic metal manufacturing	-	0.01	0.02
Structural, sheet & fabricated metal product man	0.01	0.02	0.04

Inputs	10%	Original (20%)	50%
Machinery and other equipment man	0.01	0.01	0.03
Furniture and other manufacturing	-	-	-
Electricity generation	0.43	0.73	2.17
Electricity transmission and distribution	0.03	0.08	0.17
Water supply	-	-	-
Sewerage, drainage and waste disposal services	-	0.01	
Construction	0.08	0.14	0.39
Wholesale and retail trade	0.03	0.06	0.13
Accommodation, restaurants and bars	-	-	-
Road freight transport	0.02	0.06	0.09
Road passenger transport	-	-	-
Rail transport	-	0.01	0.02
Water transport	-	0.01	0.01
Air transport and transport services	0.01	0.02	0.04
Communication services	0.01	0.03	0.06
Finance and insurance	0.02	0.06	0.12
Real estate	0.01	0.02	0.04
Equipment hire and investors in other property	0.01	0.01	0.03
Ownership of owner-occupied dwellings	-	-	-
Scientific research and computer services	0.08	0.15	0.41
Other business services	0.05	0.10	0.23
Central government administration and defence	-	-	-
Local government administration	-	-	-
Pre-school, primary and secondary education	-	-	-
Other education	-	-	0.01
Hospitals and nursing homes	-	-	-
Other health and community services	-	-	-
Cultural and recreational services	-	0.01	0.02
Personal and other community services	-	-	0.01
Total Increase in Output (NZ$ Million per annum)	**1.16**	**2.62**	**5.81**

Table E5: Fruit and Tree Nut Growing Replication Rate Sensitivity Analysis

Inputs	10%	Original (20%)	50%
Horticulture and fruit growing	-	-	-
Livestock and cropping farming	-	-	-
Dairy and cattle farming	-	-	-
Other farming	-	-	-
Services to agriculture, hunting and trapping	-	-	-
Forestry and logging	-	0.01	0.01
Fishing	-	-	-
Coal mining	0.01	0.01	0.03
Oil and gas extraction, production & distribution	0.07	0.41	0.34
Other Mining and quarrying	-	0.02	0.02

Inputs	**10%**	**Original (20%)**	**50%**
Meat manufacturing	-	-	-
Dairy manufacturing	-	0.01	0.01
Other food manufacturing	-	-	-
Beverage, malt and tobacco man	-	-	-
Textiles and apparel manufacturing	-	-	-
Wood product manufacturing	-	0.01	0.02
Paper and paper product man	-	0.01	0.01
Printing, publishing and recorded media	-	0.01	0.02
Petroleum refining, product man	0.2	1.94	1.01
Fertiliser and other industrial chemical man	-	0.01	0.01
Rubber, plastic and other chemical product man	-	0.01	0.01
Non-metallic mineral product manufacturing	-	0.02	0.02
Basic metal manufacturing	-	0.01	0.01
Structural, sheet & fabricated metal product man	-	0.02	0.02
Machinery and other equipment man	-	0.02	0.02
Furniture and other manufacturing	-	-	-
Electricity generation	0.29	0.59	1.45
Electricity transmission and distribution	0.02	0.07	0.1
Water supply	-	-	-
Sewerage, drainage and waste disposal services	-	-	-
Construction	0.06	0.15	0.28
Wholesale and retail trade	0.02	0.07	0.08
Accommodation, restaurants and bars	-	-	-
Road freight transport	-	0.02	0.02
Road passenger transport	-	-	-
Rail transport	-	-	-
Water transport	-	0.04	0.02
Air transport and transport services	-	0.02	0.02
Communication services	0.01	0.02	0.03
Finance and insurance	0.02	0.06	0.08
Real estate	0.01	0.02	0.03
Equipment hire and investors in other property	-	0.01	0.02
Ownership of owner-occupied dwellings	-	-	-
Scientific research and computer services	0.06	0.17	0.3
Other business services	0.03	0.1	0.15
Central government administration and defence	-	-	-
Local government administration	-	-	-
Pre-school, primary and secondary education	-	-	-
Other education	-	-	0.01
Hospitals and nursing homes	-	-	-
Other health and community services	-	-	-
Cultural and recreational services	-	0.01	0.01
Personal and other community services	-	-	0.01
Total Increase in Output (NZ$ Million per annum)	**0.84**	**3.89**	**4.19**

Table E6: Bakery Product Manufacturing Replication Rate Sensitivity Analysis

Inputs	**10%**	**50%**	**Origina l (100%)**
Horticulture and fruit growing	-	-	-
Livestock and cropping farming	-	-	0.01
Dairy and cattle farming	-	-	-
Other farming	-	-	-
Services to agriculture, hunting and trapping	-	-	0.01
Forestry and logging	-	0.01	0.02
Fishing	-	-	-
Coal mining	0.01	0.03	0.07
Oil and gas extraction, production & distribution	0.04	0.18	0.36
Other Mining and quarrying	-	0.02	0.03
Meat manufacturing	-	-	-
Dairy manufacturing	-	-	0.01
Other food manufacturing	-	-	-
Beverage, malt and tobacco man	-	-	-
Textiles and apparel manufacturing	-	-	0.01
Wood product manufacturing	-	0.02	0.05
Paper and paper product man	-	0.01	0.02
Printing, publishing and recorded media	-	0.02	0.04
Petroleum refining, product man	0.01	0.06	0.11
Fertiliser and other industrial chemical man	-	0.01	0.01
Rubber, plastic and other chemical product man	-	0.01	0.03
Non-metallic mineral product manufacturing	0.01	0.03	0.05
Basic metal manufacturing	-	0.01	0.03
Structural, sheet & fabricated metal product man	0.01	0.03	0.06
Machinery and other equipment man	0.01	0.03	0.05
Furniture and other manufacturing	-	0.01	0.01
Electricity generation	0.29	1.45	2.9
Electricity transmission and distribution	0.03	0.15	0.29
Water supply	0.11	0.56	1.12
Sewerage, drainage and waste disposal services	0.17	0.87	1.7
Construction	0.06	0.28	0.57
Wholesale and retail trade	0.02	0.09	0.19
Accommodation, restaurants and bars	-	-	0.01
Road freight transport	0.01	0.03	0.05
Road passenger transport	-	-	-
Rail transport	-	-	0.01
Water transport	-	0.01	0.02
Air transport and transport services	-	0.02	0.04
Communication services	0.01	0.04	0.08
Finance and insurance	0.02	0.08	0.17
Real estate	0.01	0.03	0.06
Equipment hire and investors in other property	-	0.02	0.05
Ownership of owner-occupied dwellings	-	-	-
Scientific research and computer services	0.05	0.27	0.55

Inputs	10%	50%	Original (100%)
Other business services	0.03	0.17	0.33
Central government administration and defence	-	-	0.01
Local government administration	-	0.01	0.02
Pre-school, primary and secondary education	-	-	-
Other education	-	0.01	0.02
Hospitals and nursing homes	-	-	-
Other health and community services	-	-	-
Cultural and recreational services	-	0.02	0.03
Personal and other community services	-	0.01	0.02
Total Increase in Output (NZ$ Million per annum)	**0.92**	**4.62**	**9.25**

Table E7: Wine Manufacturing Replication Rate Sensitivity Analysis

Inputs	10%	50%	Original (100%)
Horticulture and fruit growing	-	-	0.01
Livestock and cropping farming	-	0.01	0.02
Dairy and cattle farming	0.01	0.01	0.03
Other farming	-	-	-
Services to agriculture, hunting and trapping	-	0.01	0.02
Forestry and logging	0.01	0.03	0.06
Fishing	-	-	-
Coal mining	0.02	0.03	0.08
Oil and gas extraction, production & distribution	0.07	0.15	0.37
Other Mining and quarrying	0.10	0.19	0.48
Meat manufacturing	-	-	0.01
Dairy manufacturing	0.01	0.02	0.06
Other food manufacturing	-	0.01	0.02
Beverage, malt and tobacco man	-	-	0.01
Textiles and apparel manufacturing	-	0.01	0.01
Wood product manufacturing	0.03	0.06	0.16
Paper and paper product man	0.02	0.03	0.08
Printing, publishing and recorded media	0.02	0.05	0.12
Petroleum refining, product man	0.04	0.08	0.20
Fertiliser and other industrial chemical man	0.01	0.02	0.05
Rubber, plastic and other chemical product man	0.01	0.02	0.06
Non-metallic mineral product manufacturing	1.53	3.06	7.66
Basic metal manufacturing	0.03	0.06	0.16
Structural, sheet & fabricated metal product man	0.04	0.08	0.20
Machinery and other equipment man	0.01	0.03	0.07
Furniture and other manufacturing	-	0.01	0.02
Electricity generation	0.25	0.49	1.24
Electricity transmission and distribution	0.11	0.22	0.56
Water supply	-	-	0.01

Inputs	10%	50%	Original (100%)
Sewerage, drainage and waste disposal services	-	0.01	
Construction	0.11	0.22	0.56
Wholesale and retail trade	0.09	0.17	0.43
Accommodation, restaurants and bars	-	-	0.01
Road freight transport	0.09	0.18	0.45
Road passenger transport	-	-	0.01
Rail transport	0.01	0.02	0.06
Water transport	0.04	0.07	0.18
Air transport and transport services	0.02	0.04	0.10
Communication services	0.04	0.07	0.18
Finance and insurance	0.07	0.14	0.36
Real estate	0.02	0.05	0.12
Equipment hire and investors in other property	0.02	0.03	0.08
Ownership of owner-occupied dwellings	-	-	-
Scientific research and computer services	0.08	0.17	0.42
Other business services	0.12	0.23	0.58
Central government administration and defence	-	0.01	0.02
Local government administration	0.01	0.03	0.07
Pre-school, primary and secondary education	-	-	-
Other education	-	0.01	0.02
Hospitals and nursing homes	-	-	-
Other health and community services	-	-	0.01
Cultural and recreational services	0.02	0.04	0.1
Personal and other community services	-	0.01	0.02
Total Increase in Output (NZ$ Million per annum)	**3.10**	**6.22**	**15.55**

Table E8: Construction Replication Rate Sensitivity Analysis

Inputs	10%	50%	Original (100%)
Horticulture and fruit growing	-	-	0.01
Livestock and cropping farming	-	0.01	0.02
Dairy and cattle farming	-	0.01	0.01
Other farming	-	-	-
Services to agriculture, hunting and trapping	-	0.01	0.01
Forestry and logging	-	0.01	0.03
Fishing	-	-	-
Coal mining	-	-	0.01
Oil and gas extraction, production & distribution	0.03	0.15	0.30
Other Mining and quarrying	0.01	0.07	0.13
Meat manufacturing	-	-	0.01
Dairy manufacturing	-	0.01	0.03
Other food manufacturing	-	0.01	0.01
Beverage, malt and tobacco man	-	-	0.01
Textiles and apparel manufacturing	-	0.01	0.01

Inputs	10%	50%	Original (100%)
Wood product manufacturing	-	0.02	0.05
Paper and paper product man	-	0.02	0.03
Printing, publishing and recorded media	0.01	0.06	0.13
Petroleum refining, product man	0.01	0.04	0.08
Fertiliser and other industrial chemical man	-	0.02	0.03
Rubber, plastic and other chemical product man	0.01	0.04	0.08
Non-metallic mineral product manufacturing	0.01	0.05	0.11
Basic metal manufacturing	0.01	0.03	0.06
Structural, sheet & fabricated metal product man	0.02	0.09	0.18
Machinery and other equipment man	0.01	0.06	0.11
Furniture and other manufacturing	-	0.01	0.02
Electricity generation	0.01	0.04	0.08
Electricity transmission and distribution	0.02	0.10	0.20
Water supply	-	0.01	0.01
Sewerage, drainage and waste disposal services	1.85	9.24	18.50
Construction	0.05	0.26	0.52
Wholesale and retail trade	0.09	0.44	0.89
Accommodation, restaurants and bars	-	0.01	0.02
Road freight transport	0.03	0.14	0.02
Road passenger transport	-	-	-
Rail transport	-	-	0.01
Water transport	0.01	0.05	0.10
Air transport and transport services	0.01	0.03	0.07
Communication services	0.03	0.14	0.28
Finance and insurance	0.04	0.21	0.43
Real estate	0.02	0.08	0.16
Equipment hire and investors in other property	0.02	0.10	0.19
Ownership of owner-occupied dwellings	-	-	-
Scientific research and computer services	0.02	0.09	0.18
Other business services	0.06	0.31	0.63
Central government administration and defence	-	0.02	0.03
Local government administration	0.01	0.07	0.14
Pre-school, primary and secondary education	-	-	-
Other education	-	0.01	0.01
Hospitals and nursing homes	-	-	-
Other health and community services	-	-	0.01
Cultural and recreational services	0.01	0.04	0.08
Personal and other community services	-	0.01	0.02
Total Increase in Output (NZ$ Million per annum)	**2.43**	**12.15**	**24.31**

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