# Energy saving potential in the New Zealand agricultural sector with emphasis on the vegetable greenhouse industry

A thesis presented in partial fulfilment of the requirements
for the degree of Master of Applied Science
in Natural Resource Management
in conjunction with the Centre for Energy Research
at Massey University, Palmerston North,
New Zealand

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**2005**

## Acknowledgements

I would like to acknowledge the time and guidance of my supervisors: Dr John Holland of the Institute of Natural Resources and Professor Ralph Sims of the Centre for Energy Research. I would also like to acknowledge the expertise and input of Dr Nigel Jollands, Dr Elly Nederhoff, Richard Hectors, Andrew Barber, Ken Robertson and Johnnie Barrie, the financial support of EECA and Vegfed, and Bradley Mclellan for his patience and understanding.

I would also like to thank the growers who participated and took such an interest in my research.

## Abstract

In the last decade, the energy demand of New Zealand's horticultural and agricultural sub sectors has increased as a result of land use conversion, intensity of production, the use of irrigation and an increase in energy intensive horticulture, such as greenhouse vegetable production. This has highlighted the sector's reliance on fossil fuels leaving it susceptible to future shortages, higher prices and the forthcoming carbon charge. As part of a contract with the Energy Efficiency Conservation Authority, which aimed to compile, estimate and analyse information from a wide variety of sources on energy end uses and patterns of energy consumption within the agricultural sub-sectors, available literature on energy demand by fuel type and the various uses to which energy is put in the New Zealand primary production sub-sectors was collated in matrices. Through the compilation of these matrices it was evident that limited energy related research was available relating to the greenhouse sub sector.

The New Zealand greenhouse industry is a relatively energy intensive sub-sector of the primary production industry and relies heavily on the use of fossil fuels. The impending carbon charge may result in a cost which growers may be unable to pass on due to competition on the domestic and export markets from non-Kyoto countries. It follows that reducing energy consumption and consequently avoiding the emissions charge would be a means of increased viability for the industry. This part of the research was funded and conducted in conjunction with the New Zealand Vegetable and Potato Grower's Federation Inc. A walk-through energy audit was designed and conducted with 22 greenhouse vegetable growers. This provided an in-depth case study perspective in terms of what technologies and practices are currently used by the New Zealand's protected cropping industry. The findings from the energy audit show that location and the heating system type are significant factors in determining energy use. The main areas identified where potential energy saving could be made were minimising heat loss, through the cladding, the heat distribution system and the flue, and improving heating efficiency, through improved heater maintenance.

An energy saving model was designed using Microsoft Excel for the purpose of encouraging the user to think about potential energy savings that could be made within their individual greenhouse operation, and also the potential cost of the carbon charge

on to their business. Recommendations from the model were based on best practice and use of energy saving technologies identified through the energy audits, review of current literature and consultation with manufacturers.

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# Abbreviations and SI Units

**Units**

| | |
|---|---|
| kJ | kilojoule 1,000 joules |
| MJ | megajoule 1,000,000 joules |
| GJ | gigajoule 1,000,000,000 joules |
| TJ | terajoule 1,000,000,000,000 joules |
| PJ | petajoule 1,000,000,000,000,000 joules |
| kWh | kilowatt-hour = 3.6 MJ |
| W | watt = 1 joule per second |
| kW | kilowatt = 1,000 watts |
| ha | hectare 10,000 square metres |
| m | metres |
| kg | kilogram |
| t | tonne |
| l | litre |

**Abbreviations**

| | |
|---|---|
| $CO_2$ | carbon dioxide |
| EECA | Energy Efficiency and Conservation Authority |
| MAF | Ministry of Agriculture and Forestry |
| Vegfed | New Zealand Vegetable and Potato Grower's Federation Inc. |
| NZCCO | New Zealand Climate Change Office |
| MED | Ministry of Economic Development |

## 1.0 Introduction

The New Zealand primary production sector (agriculture, horticulture, fishing and forestry) account's for 4-5% of national consumer energy (Eastwood and Sims, 2003). While this is only a small fraction, the New Zealand economy is heavily dependent on primary product exports, including fisheries and forestry, which provide over 55% of all export earnings (Fig. 1).

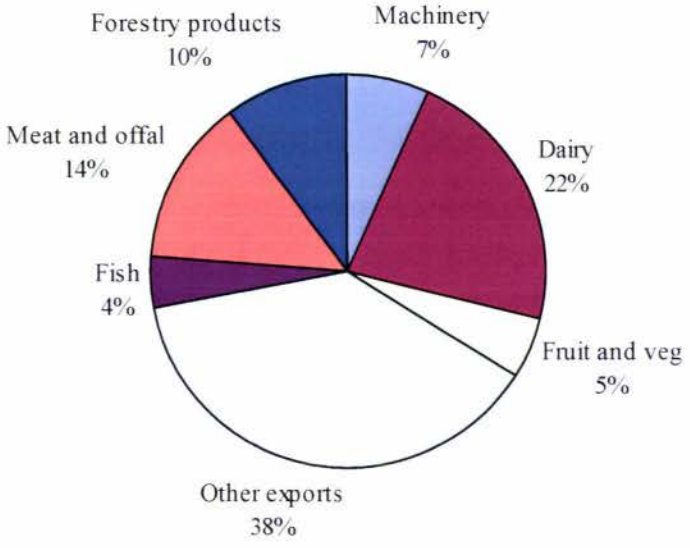


**Figure 1. Major commodities exported by New Zealand.**

(Source: Statistics NZ, 2004)

In the last decade, the energy demand of New Zealand's horticultural and agricultural sub sectors has increased as a result of land use conversion, intensity of production, the use of irrigation and an increase in energy intensive horticulture, such as greenhouse flower and vegetable production. This increase in energy demand has highlighted the sector's reliance on fossil fuels leaving it susceptible to future shortages and higher prices. The sustainability of farming systems and the ratio of energy input to output has drawn international attention as environmental sustainability is used increasingly as a marketing tool with the threat of a potential trade barrier for agricultural exports.

International concern at possible global warming effects from the release of greenhouse gases resulted in the 1997 *Kyoto Protocol*, being ratified in 2005. New Zealand has

agreed to reduce its total greenhouse gas emissions back down to 1990 levels. A New Zealand inventory of greenhouse gases shows that primary production contributes 54% of New Zealand's total emissions mainly from ruminant methane (Keedwell, Robertson and Barnett, 2004).

To recognise the environmental impact of fossil fuel use the New Zealand Government has introduced a charge of $15/tonne of $CO_2$ equivalent will be applied in April of 2007. The uncertainties of the proposed carbon charge, future security of oil supplies and possible cuts in electricity supply by line companies to many rural areas past 2013, under the Electricity Act (1993) meant that New Zealand farmers and growers must now operate within a climate of increasing economic instability and environmental awareness, both nationally and globally. Consequently there has recently developed a strong interest by the agricultural and horticultural sectors in the utilisation of energy saving and on-farm energy production technologies.

The New Zealand greenhouse industry is a relatively energy intensive sub-sector of the primary production industry. Energy use can be influenced by a number of factors including management, location, seasonal production, the design of greenhouse structure, greenhouse age, crop type and heating requirements (EECA, 2004). A report by Barber & Wharfe (2004) highlighted how dependent the greenhouse industry is on energy, particularly fossil fuel inputs with a total national annual consumer energy demand of 2.6-3.5 PJ/yr.

Many growers within the industry have significantly improved their production output in recent years in terms of units of product/$m^2$ of greenhouse. This has resulted in an improved return on investment for what is a high capital investment sector. The industry is now concerned about the forthcoming carbon charge. Barber & Parminter (2004) estimated a carbon charge of $25/tonne $CO_2$ will increase the price of petrol by 6%, diesel by 12%, electricity by 16%, gas by 24% and coal by 44%. This will result in a cost which growers may be unable to pass on due to competition on the domestic and export markets from non-Kyoto countries. It follows that reducing energy consumption and consequently avoiding the emissions charge would be a means of increased viability for the industry.

A number of options have been suggested for reducing the impact of the carbon charge such as Negotiated Greenhouse Agreements and small-medium enterprise policy packages. The solution proposed by Pete Hodgson, when Minister of Energy, was to minimise the impact of the carbon charge by using energy more wisely. For some growers this solution may be a viable option whereas others are already utilizing energy efficient production methods, and would find it difficult to reduce further.

## 1.1 Problem statement

When compared with other sectors of the primary production industry in New Zealand, horticultural greenhouses are highly energy intensive. Barber & Wharfe (2004) clearly showed how dependent the industry is on energy inputs. The industry is now concerned with the forthcoming carbon charge for fossil fuels which threatens to reduce both the profitability and viability of greenhouse production and potentially encourage the industry to shift to Australia where no carbon charge is proposed at this stage.

## 1.2 Aim

This research aims to identify ways in which the New Zealand greenhouse vegetable production sector can implement energy saving technologies to reduce energy use and associated carbon emissions.

## 1.3 Objectives

1. To determine energy demand by fuel type and the various uses to which energy is put in the New Zealand primary production sub-sectors, with emphasis on New Zealand greenhouse vegetable production.

2. To review current and emerging energy efficient related technologies in greenhouse vegetable production.

3. To conduct an energy audit to determine the current energy efficient technologies used by the greenhouse production sub-sector.

4. To discuss the potential for the further and widespread application of energy saving technologies in the New Zealand greenhouse sub-sector.

5. To develop a computer model to determine the potential energy savings that could be made by growers as a decision making tool.

## 1.4 Limitations

This research was conducted in conjunction with the fulfilment of two contracts. A review of energy use in New Zealand agriculture for the Energy Efficiency and Conservation Authority (Chapters 2 and 3), and an on-site energy audit to determine potential opportunities for energy savings in the greenhouse industry for the New Zealand Vegetable and Potato Growers' Federation (Vegfed). The contract with Vegfed also included designing a model that growers could potentially enter their own data and use as a decision making tool to implement energy saving technologies and practices within their business. The fulfilment of these contracts influenced the approach taken to solving the problem and the choice of methodology.

A postal survey was originally proposed to Vegfed as the data collection method, however this was later changed to a walk-through, on site, energy audit because Vegfed had recently commissioned a national survey of New Zealand vegetable and flower greenhouse growers (Barber and Wharfe, 2004). Concerns were raised that a postal survey would repeat many of the questions used in this study. Restrictions were also placed on access to membership data bases, which meant that the survey participant selection was not truly representative of the New Zealand greenhouse production industry which would have biased the results. A walk-through energy audit was eventually chosen, with participants selected to cover a range of greenhouse sizes, locations, crop type and heating fuel types.

Due to the time involved in conducting the energy audits only a limited number of greenhouse operations were selected, whereas a greater number of participants would probably have strengthened the results and better represented the industry.

## 1.5 Research approach

Two different approaches to minimising energy consumption in greenhouses have been identified by previous studies; reducing energy consumption per $m^2$ of floor area and reducing energy consumption per unit of produce (Breuer, 1985; Barber and Wharfe, 2004). The latter addresses the more desirable end result for the industry and can be

implemented through both greenhouse technology design and increasing crop production. Crop production techniques fall outside the scope of this research. Consequently the focus was on the development and utilisation of energy efficient greenhouse technologies and practices under New Zealand conditions.

A case study approach to data collection was taken in the form of an energy audit, conducted to determine what steps growers are currently taking to reduce their energy demand. Data collected from the energy audit was used along with existing data to develop a model that allows the user to input his/her own data. The model benchmarks the user against other growers and recommends specific energy savings measures for the user.

## 1.6 Thesis outline

The structure and content of each chapter is outlined together with a brief overview of the content of each chapter.

***Chapter 2***

Energy use in New Zealand's agricultural sector outlines the context for this study including the role of energy and energy research in New Zealand's agricultural and horticultural sector, it discusses climate change in relation to the New Zealand agricultural sector.

***Chapter 3***

Describes the different primary production sub-sectors, including their energy use, patterns of energy consumption and the outlook until 2012.

***Chapter 4***

Energy use in greenhouse production relates to energy conservation and energy efficient technologies in greenhouse production it focuses specifically on the areas of greenhouse design and heating.

***Chapter 5***

The methodology describes the development and design of the proposed postal survey and the energy audit. The rationale behind the hypotheses is explained and the

statistical tests used to prove them are described. The content and structure of the energy saving model is also described.

***Chapter 6***

Results are presented from the analysis of the hypotheses.

***Chapter 7***

Describes the limitations of the study so the methodology and the results can be placed in the context of the literature. The focus of this chapter is on the steps growers are currently taking to reduce their energy demand for heating.

***Chapter 8***

Discusses the findings of this study in the context of the research aim and objectives. Areas for further research are identified.