New Zealand
Electric Energy-Efficiency Potential Study
Volume 1

Electricity Commission
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E.1 Executive Summary

This study assesses the electric energy-efficiency potential for the residential, commercial, and industrial sectors in New Zealand. The study was commissioned by the Electricity Commission of New Zealand to better understand the market for energy-efficiency. The goals of this study were to determine levels of cost-effective energy efficiency available in the New Zealand economy and to assess the ability of Electricity Commission programs to achieve these potentials. The study scope included new and existing residential and non-residential buildings, as well as industrial process saving for the ten-year period 2007-2016. Given the near- to mid-term focus, the study was restricted to energy-efficiency measures that are presently commercially available.This study provides a good initial look at the New Zealand energy-efficiency marketplace and demonstrates that cost-effective programme alternatives are available to the Electricity Commission.

E.1.1 Scope and Approach

In the study, three types of energy-efficiency potential are estimated:

- **Technical potential,** defined as the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an engineering perspective;
- **Economic potential,** defined as the *technical potential* of those energy-efficiency measures that are cost-effective when compared to supply-side alternatives; and
- **Achievable programme potential,** the amount of savings that would occur in response to specific programme funding and measure incentive levels.

In addition, naturally occurring energy-efficiency impacts are estimated. These are savings that result from normal market forces. Achievable programme potential reflects savings that are projected beyond those that would occur naturally in the absence of any market intervention.

The method used for estimating potential is a “bottom-up” approach in which energy-efficiency costs and savings are assessed at the customer segment and energy-efficiency measure level. For cost-effective measures [based on the total resource cost (TRC) test], programme savings potential is estimated as a function of measure economics, rebate levels, and programme marketing and education efforts. The modeling approach was implemented using KEMA’s DSM ASSYST^{TM} model. This model allows for efficient integration of large quantities of measure, building, and economic data as the determination of energy-efficiency potential.

To assess achievable potential we constructed three energy-efficiency programme funding scenarios. The first scenario assumes 33 percent of incremental measure costs are paid out in end user incentives and uses base levels of programme marketing and administrative expenditures. The second scenario includes incentives covering 50 percent of incremental measure costs, with increased marketing and administration budgets. The final scenario includes incentives covering 75 percent of incremental measure costs with an additional increase in programme marketing and administration budgets.

In order to conduct the energy-efficiency potential study many different types of data are required, including: measure data (such as costs, savings, and current saturation levels), building/market data (such as building stocks and end use saturation and consumption levels), and economic data (such as avoided costs, inflation rates, and discount rates). Gaps in data for New Zealand were identified during initial stages of the project, and primary data collection activities were conducted to close these gaps.

Ultimately, data for the study were developed from a number of different sources, including primary data collected for this project, data provided by the Electricity Commission and other government entities, Energy Efficiency and Conservation Authority (EECA), BRANZ and other third parties. The primary data collection effort included 621 telephone surveys with commercial end-users, discussion with identified experts, surveys and in-depth interviews with equipment contractors, distributors, and residential builders, in-store visits, and on-site visits to industrial facilities.

E.1.2 Results

E.1.2.1 Aggregate Results

Energy and demand savings potential estimates are presented in Figure 1 and Figure 2. Technical potential is estimated at 11,179 GWh per year. Over half of this potential, 6,437 GWh per year, is estimated to be economically viable. Achievable programme potentials range from 840 GWh per year for the 33 percent incentive scenario to 2,256 GWh per year in the 75 percent incentive scenario.

Peak demand savings potential estimates are provided in Figure 2. Technical potential is estimated at 3,199 MW and economic potential is estimated at 1,738 MW. Achievable programme potential ranges from a high of 470 MW in the 75 percent incentive case down to 183 MW in the 33 percent incentive case.

Figure 1
Estimated Energy Saving Potential
2007-2016

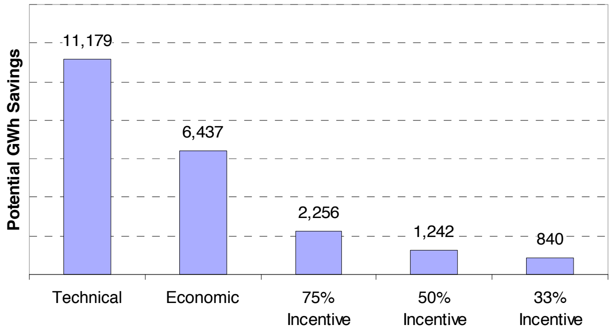


Figure 2
Estimated Peak Demand Saving Potential
2007-2016

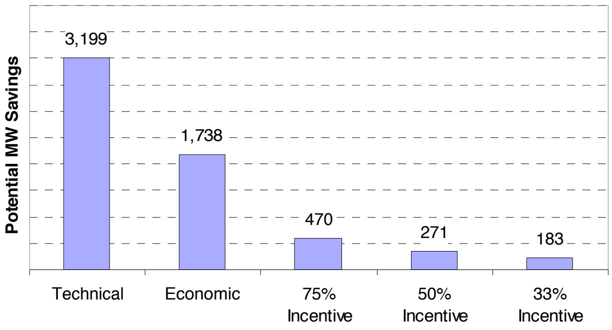


Figure 3 and Figure 4 show estimates of achievable potential energy and peak demand savings over time. These figures show naturally occurring savings that are expected to proceed in the absence of Electricity Commission program, and incremental savings from each programme scenario developed for the study. Savings potential, especially in the higher incentive cases, tends to increase at a decreasing rate over time. In the early years programs can target the most cost-effective and easy-to-achieve measures and markets.

Over time (in the absence of significant new technologies) the programs must penetrate harder-to-reach markets and influence end users to adopt less attractive measures.

Figure 3
Achievable Energy Savings: All Sectors

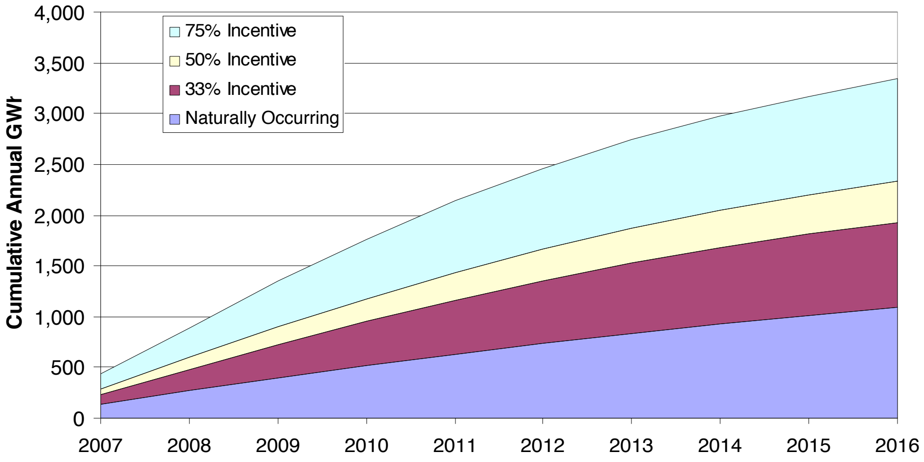


Figure 4
Achievable Peak-Demand Savings: All Sectors

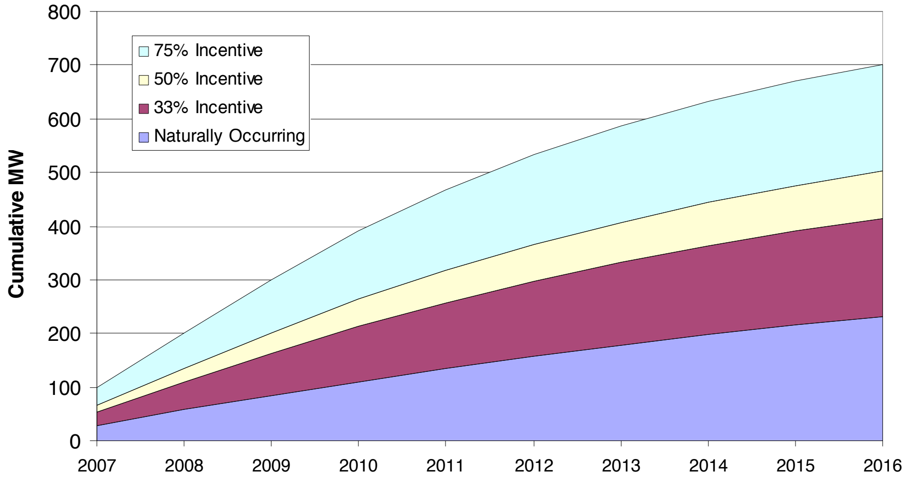
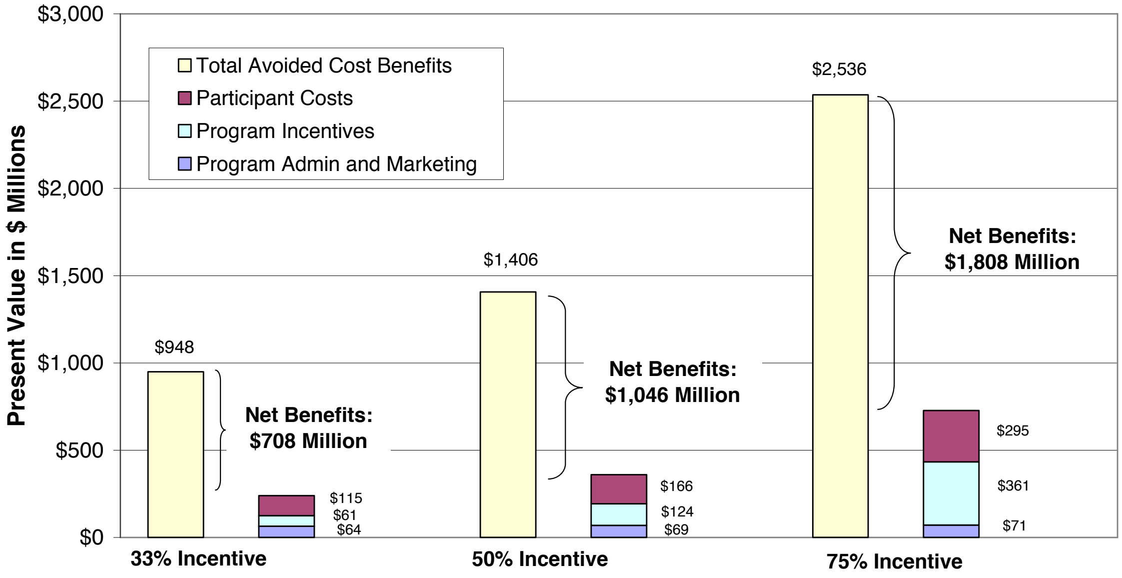


Figure 5 depicts costs and benefits under each program-funding scenario from 2007 to 2016. The present value of programme costs (including administration, marketing, and incentives) is $125 million under the 33 percent incentive scenario, $193 million under the 50 percent incentive scenario, and $432 under the 75 percent incentive scenario. The present value of total avoided-cost benefits is $948 million for the 33 percent incentive scenario, $1,406 million under the 50 percent incentive scenario , and $2,536 under 75 percent incentives. The present value of *net* avoided-cost benefits, i.e., the difference between total avoided-cost benefits and total costs (which include participant costs in addition to programme costs), is $708 million under 33 percent incentives, $1,046 million under 50 percent incentives, and $1,808 million under 75 percent incentives.

All three of the programme funding scenarios are cost-effective based on the TRC test, which is the test used in this study to determine programme cost-effectiveness. The TRC benefit-cost ratios are 4.0 for the 33 percent incentive scenario, 3.9 for the 50 percent incentive scenario, and 3.5 for the 75 percent incentive scenario. This indicates that programme cost-effectiveness declines somewhat with increasing programme effort, reflecting penetration of more measures with lower cost-effectiveness levels. Key results of our efficiency scenario forecasts from 2007 to 2016 are summarized in Table 1.

Figure 5
Benefits and Costs of Energy Efficiency Savings—2007–2016*



* Present value of benefits and costs over normalized 20-year measure lives; nominal discount rate is 7.0 percent, inflation rate is 2.5 percent.

Table 1
Summary of Achievable Potential Results—2007–2016

	33% Incentives	50% Incentives	75% Incentives
Net Energy Savings - GWh	840	1,242	2,256
Net Peak Demand Savings - MW	183	271	470
Programme Costs - Real			
Administration - $mil.	$49	$49	$45
Marketing - $ mil.	$28	$34	$41
Incentives - $ mil.	$73	$149	$429
Total Programme Costs- $ mil.	$150	$232	$515
PV Net Avoided Costs - $ mil.	$948	$1,406	$2,536
PV Annual Marketing and Admin Costs - $ mil.	$64	$69	$71
PV Net Measure Costs - $ mil.	$176	$291	$656
TRC	4.0	3.9	3.5

PV (present value) of benefits and costs is calculated over a 20-year normalized measure life for 2007–2016 programme years, nominal discount rate = 7.0 percent, inflation rate = 2.5 percent; GWh and MW savings are cumulative through 2016.

E.1.2.2 Results by Sector

Cumulative net achievable potential estimates by sector for the period 2007–2016 are presented in Figure 6 and Figure 7. These figures show results for each funding scenario. Under the programme assumptions developed for this study, achievable energy savings are highest for the commercial sector in the 33 and 50 percent incentive scenarios and highest for the industrial sector in the 75 percent incentives scenario. Peak demand savings is highest for the residential sector in all scenarios due to large lighting savings that occur at the time of the winter evening peak.

Figure 6
Net Achievable Energy Savings (2016) by Sector—GWh per Year

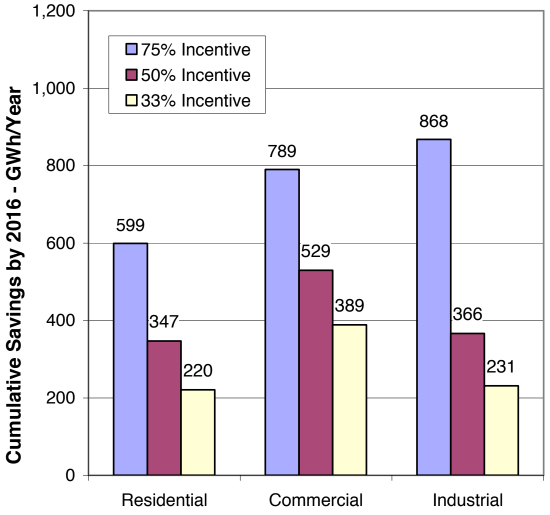


Figure 7
Net Achievable Peak Demand Savings (2016) by Sector—MW

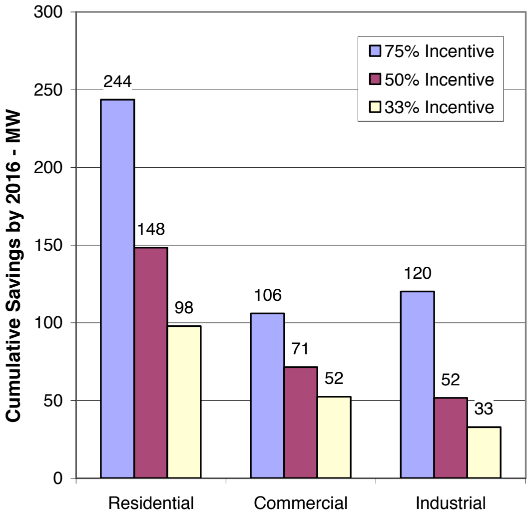


Figure 8 and Figure 9 show the residential end use distribution of energy and peak demand savings for the 33 percent incentive programme scenario. Lighting contributes most to the energy savings potential, mainly due to CFLs (compact fluorescent lamps). These savings are even more pronounced for peak demand, as many residential lights are on at the time of the winter evening peak. Towel rail timers provide the next largest share of expected savings, followed by water heating and space heating.

Figure 8
Residential Net Energy Savings Potential End Use Shares (2016) – 33% Incentives

(based on 220 GWH potential)

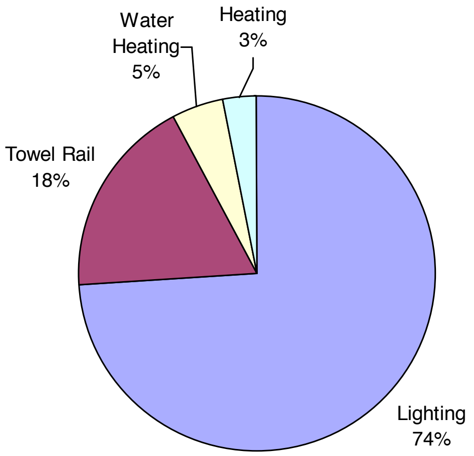
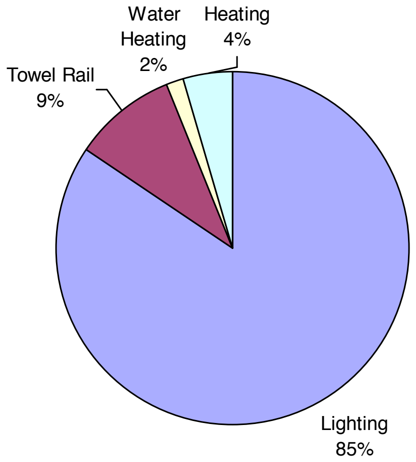


Figure 9
Residential Net Peak Savings Potential End Use Shares (2016) – 33% Incentives

(based on 98 MW potential)



Figures 10 and 11 show the commercial end use distribution of energy and peak demand savings for the 33 percent incentive programme scenario. Lighting contributes most to both the energy and peak demand savings potential, followed by HVAC and refrigeration measures. Energy and peak demand savings shares are similar for energy and peak demand. While office equipment measures contribute to net savings, these results include the effects only of programme marketing and education efforts to increase consumer awareness of the benefits of equipment power management capabilities.

Figure 10
Commercial Net Energy Savings Potential
End Use Shares (2016) – 33% Incentives
(based on 389 GWH potential)

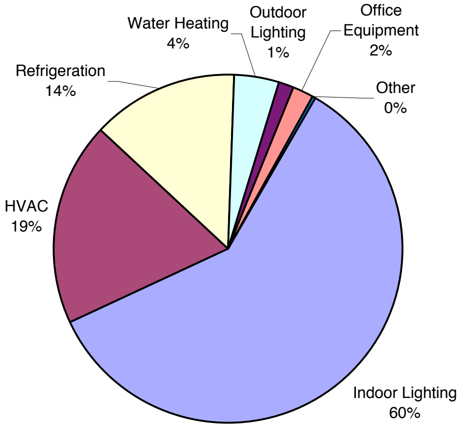


Figure 11
Commercial Net Peak Savings Potential
End Use Shares (2016) – 33% Incentives
(based on 52 MW potential)

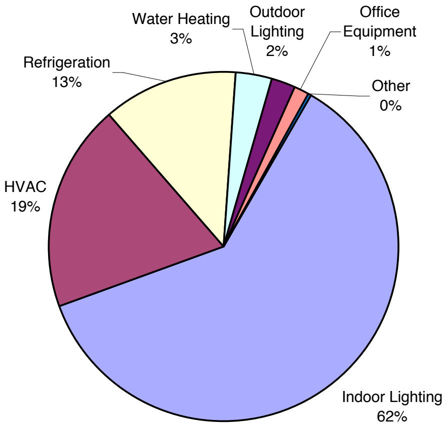


Figure 12 and Figure 13 show the industrial end use distribution of energy and peak demand savings for the 33 percent incentive programme scenario. Compressed air system measures contribute most to both the energy and peak demand savings potential, followed by pumping and fan system measures.

Figure 12
Industrial Net Energy Savings Potential End Use Shares (2016) – 33% Incentives
(based on 231 GWH potential)

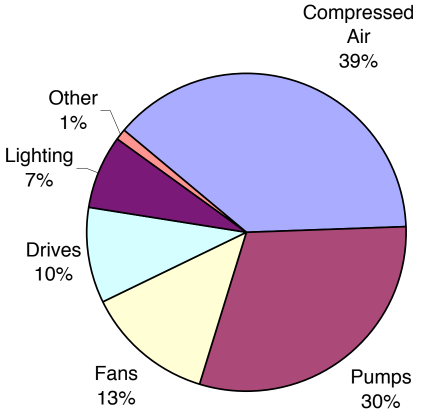
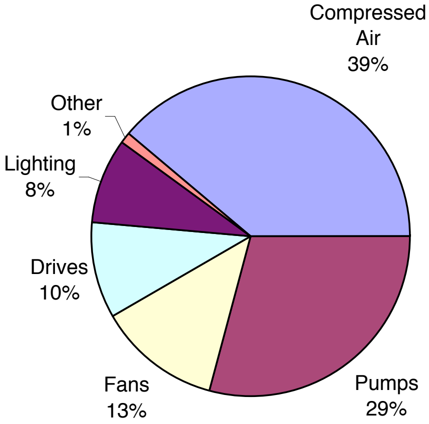


Figure 13
Industrial Net Peak Savings Potential End Use Shares (2016) – 33% Incentives
(based on 33 MW potential)



E.1.3 Recommendations for Future Study

This study made significant inroads into understanding electric energy-efficiency potential in New Zealand and serves as an excellent starting point. Over the next several years, the Electricity Commission will be expanding its programs and gaining a better understanding of end user response to programme marketing/education activities and financial incentive offerings. We believe it would be useful to revisit DSM potential in New Zealand in several years in order to incorporate NZ specific knowledge obtained from this program experience to improve estimates of energy-efficiency potential.

In conducting the electric energy-efficiency potential study, the KEMA team encountered a number of data limitations, especially in the non-residential sector. These limitations were addressed through a combination of primary research, discussions with industry experts in New Zealand, and application of secondary data where necessary. We recognize that the development of additional New Zealand-specific data could significantly improve the understanding of energy efficiency and building energy use. We recommend that the Electricity Commission and others in New Zealand conduct other research as discussed below.

On-site surveys of commercial facilities: While the KEMA team conducted a number of commercial telephone surveys to get a better understanding of commercial buildings and their energy use, there is still uncertainty in these findings, especially at the technology level. A data collection effort similar to the BRANZ HEEP project would greatly improve the understanding of New Zealand's commercial building stock.

Audits of key industrial facilities: New Zealand's industrial sector is dominated by a relatively few large facilities. Gaining a better understanding of these facilities would greatly enhance New Zealand's ability to target products and services towards these end users. We recommend that the Electricity Commission investigate the feasibility of conducting comprehensive audits of the large industrial end users, and possibly partner with these users to tap into the cost-effective energy-efficiency measures identified in these audits.

Non-residential load shape research: While the KEMA team had access to relatively good residential end use load shape data through the BRANZ HEEP project, there were virtually no data on non-residential load shapes at either the facility or end use level. We believe there is considerable uncertainty in our estimates of peak demand savings, as they require an understanding of hourly energy usage as well as annual consumption values. While fairly cost-prohibitive, we suggest that the Electricity Commission investigate studies to develop a better understanding of non-residential load shapes.

Avoided cost study analysis: The avoided energy and capacity costs used in this analysis were developed from fairly simplistic analyses. In addition, these costs do not include environmental externalities that would increase the value of energy saved and lead to higher potential estimates. We recommend that the Electricity Commission consider a study of the various costs avoided by energy-efficiency projects, including future energy costs, capacity costs (generation, transmission, and distribution), and externality costs.

1. Introduction

1.1 Overview

In early 2006 the Electricity Commission of New Zealand (the Commission) issued a request for proposals (RFP) to conduct an electricity efficiency potential study. The study will serve as the foundation on which the Commission will build an overall programme to support the uptake of electricity efficiency to reduce load growths. The purpose of the efficiency potential study, as stated in the RFP, is to answer the following questions:

- How much cost-effective electricity efficiency resource is available in the New Zealand economy? Electricity efficiency resource is defined in terms of capacity reductions (MW) at peak times and total consumed energy reduction (MWh) by region, by sector, by end-use and by end-use technology.
- How could the Electricity Commission prudently act in order to realise cost effective electricity efficiency improvements?

A team headed by KEMA Inc., which included Itron (formerly Quantum Consulting), Rational Energy Network and Energy Solutions, (hereafter referred to as the KEMA team, or KEMA) was retained to conduct this study. This study includes three main activities:

- Identification of existing data on New Zealand energy usages, aggregate and at the end-user level,
- Development of energy-efficiency potential estimates, and
- Programme design.

An additional task was to determine the potential for switching residential electric consumers to natural gas or LPG for selected end-uses (cooking, water heating and space heating).

KEMA completed the data identification task and identified substantial gaps in available data. We conducted substantial primary data collection activities in New Zealand to fill these gaps. The data identification gap results are reported separately. The primary collection activities are discussed in this document and the results are incorporated into the data analysis. The programme design is provided in a subsequent document.

This document is a report on the results of developing the energy-efficiency potential estimates. It provides estimates of potential electricity and peak demand savings from energy-efficiency measures in New Zealand by sector, end-use and end-use technology[1]. To develop these estimates KEMA used DSM ASSYST™ model (the model). The model uses a "bottom-up" approach. In this approach, we assess costs and savings at the market segment and energy-efficiency measure level.

The scope of this study includes new and existing residential and non-residential buildings, as well as industrial process savings. The study is limited to assessing potential energy savings from the installation of energy-efficiency measures, such as compact fluorescent lamps, insulation, and premium efficiency

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[1] We were unable to estimate the electric energy-efficiency potential by region due to insufficient regional level data.

motors. The study does not address the potential savings from customer behavioral changes, such as increased conservation. While behavioral changes can lead to reductions in energy consumption, it is not clear how permanent and dependable such reductions would be. The focus of the study was on the ten-year, 2007–2016 periods. Given the near- to mid-term focus, the study was restricted to energy-efficiency measures that are presently commercially available.

Data for the study come from a number of different sources, including primary data collected for this project, data provided by the Electricity Commission and other government entities, Energy Efficiency and Conservation Authority (EECA), BRANZ and other third parties. The primary data collection effort included 621 telephone surveys with commercial end-users, discussion with identified experts, surveys and in-depth interviews with equipment contractors, distributors, and residential builders, in-store visits, and on-site visits to industrial facilities.

1.2 Study Approach

This study involved identification and development of baseline end-use and measure data and development of estimates of future energy-efficiency impacts under varying levels of programme effort. The baseline characterization allowed us to identify the types and approximate sizes of the various market segments that are the most likely sources of energy-efficiency potential in New Zealand. These characteristics then served as inputs to a modelling process that incorporated energy cost parameters and specific energy-efficiency measure characteristics (such as costs, savings, and existing penetration estimates) to provide more detailed potential estimates.

To aid in the analysis, we utilized the KEMA DSM ASSYST™ model. This model provides a thorough, clear, and transparent documentation database, as well as an extremely efficient data processing system for estimating technical, economic, and achievable potential. We estimated technical, economic, and achievable programme potential for the residential, commercial, and industrial sectors, with a focus on energy-efficiency impacts over the next 10 years.

1.3 Layout of the Report

This report is provided in eight sections as described below.

Section 2: Methods and Scenarios—discusses the methodology and concepts used to develop the technical and economic potential estimates.

Section 3: Baseline Data and Results—provides baseline data and results developed for the study.

Section 4: Technical and Economic Potential Results—discusses the results of the DSM technical and economic potential analysis, providing overall and sector level technical and economic potential, and economic potential by end-use.

Section 5: Achievable (Programme) Potential—discusses the achievable potential results based on three funding scenarios. Overall and sector level results are discussed.

Section 6: Summary and Recommendations—Summarizes the results of the potential analysis results and provides recommendations for further research.

Section 7: Glossary of Acronyms

Section 8: References and Data Sources

The report contains the following appendices:

Appendix A:	Detailed Methodology and Model Description—Further detail of what was discussed in Section 2.
Appendix B:	Measure Descriptions—Describes the measures included in the study.
Appendix C:	Economic Inputs—Provides avoided cost, electric rate, discount rate, and inflation rate assumptions used for the study.
Appendix D:	Building and time-of-use (TOU) Factor Inputs—Shows the base household counts, square footage estimates for commercial building types, and base energy use by industrial segment. This appendix also includes TOU factors by sector and end-use.
Appendix E:	Measure Inputs—Lists the measures included in the model with the costs, estimated savings, applicability, and estimated current saturation factors.
Appendix F:	Non-Additive Measure Level Results—Shows energy-efficiency potential for each measure independent of any other measure.
Appendix G:	Supply Curve Data—Shows the data behind the energy supply curves provided in Section 4 of the report.
Appendix H:	Achievable Programme Potential—Provides the forecasts for the achievable potential scenarios.

2. Methods and Scenarios

This section provides a brief overview of the concepts, methods, and scenarios used to conduct this study. Additional methodological details are provided in Appendix A.

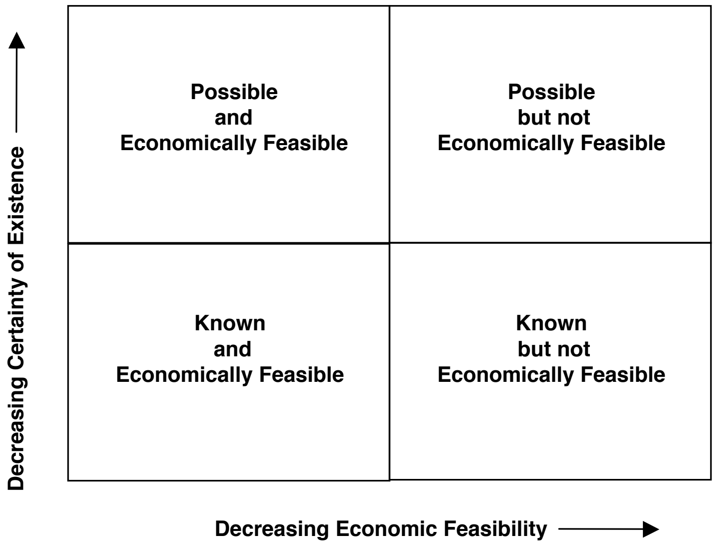
2.1 Characterizing the Electric Energy-Efficiency Resource

Energy-efficiency has been characterized for some time now as an alternative to energy supply options, such as conventional power plants that produce electricity from fossil or nuclear fuels. In the early 1980s, researchers developed and popularized the use of a conservation supply curve paradigm to characterize the potential costs and benefits of energy conservation and efficiency. Under this framework, technologies or practices that reduced energy use through efficiency were characterized as "liberating 'supply' for other energy demands" and therefore could be thought of as a resource and plotted on an energy supply curve. The energy-efficiency resource paradigm argued simply that the more energy efficiency or "nega-watts" produced, the fewer new plants would be needed to meet end users' power demands.

2.1.1 Defining Electric Energy-Efficiency Potential

Like any resource, there are a number of ways in which the energy-efficiency resource can be estimated and characterized. Definitions of energy-efficiency potential are similar to definitions of potential developed for finite fossil fuel resources, like coal, oil, and natural gas. For example, fossil fuel resources are typically characterized along two primary dimensions: the degree of geological certainty with which resources may be found and the likelihood that extraction of the resource will be economic. This relationship is shown conceptually in Figure 14.

Figure 14
Conceptual Framework for Estimates of Fossil Fuel Resources

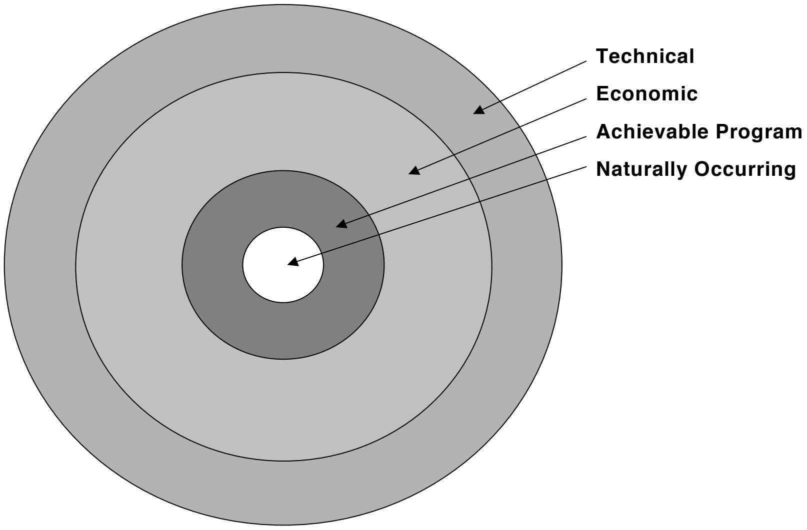


Possible and Economically Feasible	Possible but not Economically Feasible
Known and Economically Feasible	Known but not Economically Feasible

Somewhat analogously, this energy-efficiency potential study defines several different *types* of energy-efficiency *potential*, namely, technical, economic, achievable programme, and naturally occurring. These potentials are shown conceptually in Figure 15 and described below.

- **Technical potential** is defined in this study as the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an *engineering* perspective.
- **Economic potential** refers to the *technical potential* of those energy conservation measures that are cost effective when compared to supply-side alternatives.
- **Achievable programme potential** refers to the amount of savings that would occur in response to specific programme funding and measure incentive levels. Programme interventions include end user awareness and education activities and various types of funding to reduce the cost of energy-efficiency measures in order to encourage investment in these efficient equipment and practices. Examples of financial incentives include end use rebates, upstream equipment-cost buy-downs, and provision of low interest loans for energy-efficiency investments. Savings associated with programme potential are savings that are projected beyond those that would occur naturally (in the absence of any market intervention.)
- **Naturally occurring potential** refers to the amount of savings estimated to occur as a result of normal market forces; that is, in the absence of any utility or governmental intervention.

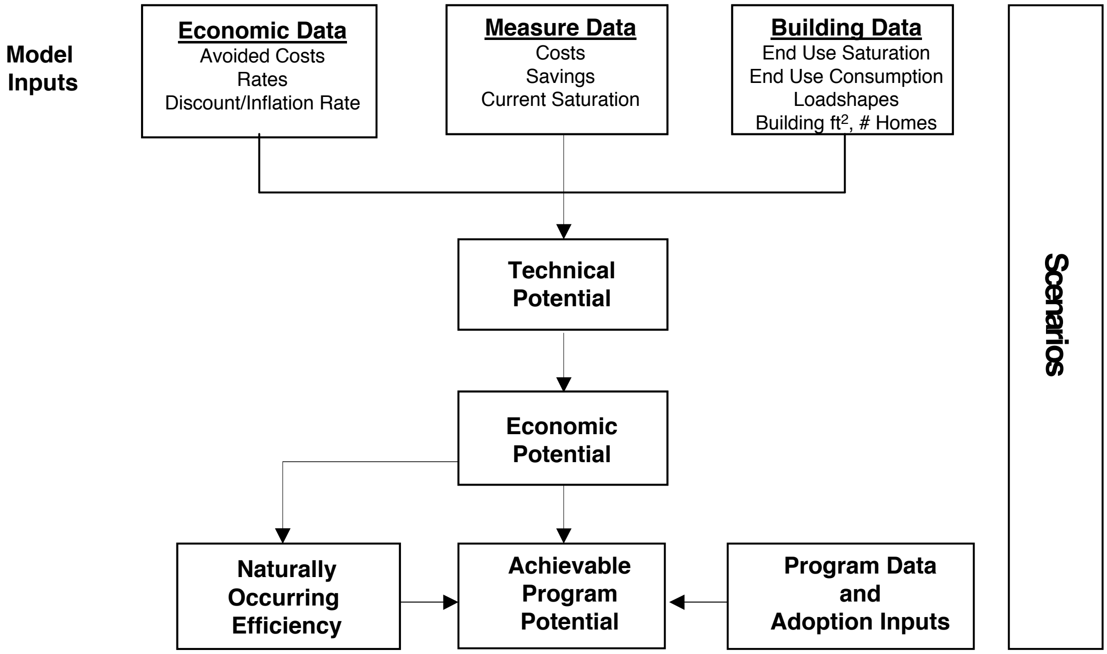
Figure 15
Conceptual Relationship among Energy-Efficiency Potential Definitions



2.2 Summary of Analytical Steps Used in this Study

The crux of this study involves carrying out a number of basic analytical steps to produce estimates of the energy-efficiency potentials introduced above. The basic analytical steps for this study are shown in relation to one another in Figure 16.The bulk of the analytical process for this study was carried out in a model developed by KEMA for conducting energy-efficiency potential studies. Details on the steps employed and analyses conducted are described in Appendix A. The model used, DSM ASSYST™, is a Microsoft Excel®-based model that integrates technology-specific engineering and customer behaviour data with utility market saturation data, load shapes, rate projections, and marginal costs into an easily updated data management system.

Figure 16
Conceptual Overview of Study Process



The key steps implemented in this study were:

Step 1: Develop Initial Input Data

- Develop a list of energy-efficiency measure opportunities to include in scope. In this step, an initial draft measure list was developed and provided to the Commission for internal and external review. The final measure list was developed after incorporating comments.
- Gather and develop technical data (costs and savings) on efficient measure opportunities. Data on measures was gathered from a variety of sources. Measure descriptions are provided in Appendix B, and detail on measure inputs is provided in Appendix E.
- Gather, analyze, and develop information on building characteristics, including total square meters or total number of households, electricity consumption and intensity by end use, end-use consumption load patterns by time of day and year (i.e., load shapes), market shares of key electric consuming equipment, and market shares of energy-efficiency technologies and practices. Section 3 of this report describes the baseline data developed for this study.
- To aid in development of baseline data for the project multiple primary data collection efforts were undertaken. These efforts included:
    - In-depth interviews with identified experts in New Zealand including:

    - Computer Aided Telephone Interviews (CATI surveys) with commercial end users (621),
    - In-depth interviews with lighting contractors (10),
    - Telephone surveys with lighting contractors and distributors (50),
- In-depth interviews with heating, ventilation, and air-conditioning (HVAC) contractors and distributors (10)
- Telephone interviews with HVAC contractors and distributors (50),
- Telephone interviews with motor rewinders and distributors (10),
- In-depth interviews with commercial builders and designers (10),
- Interviews with residential builders,
- In-store visits at appliance retailers (50 stores), and
- On-site surveys of 10 large industrial end users.

Additionally, we collect data on economic parameters: avoided costs, electricity rates, discount rates, and inflation rate. These inputs are discussed in Section 3.1.1 and provided in Appendix C of this report (Volume 2).

Step 2: Estimate Technical Potential and Develop Supply Curves

- Match and integrate data on efficient measures to data on existing building characteristics to produce estimates of technical potential and energy-efficiency supply curves.

Step 3: Estimate Economic Potential

- Match and integrate measure and building data with economic assumptions to produce indicators of costs from different viewpoints (e.g., societal and consumer).
- Estimate total economic potential.

Step 4: Estimate Achievable Programme and Naturally Occurring Potentials

- Screen initial measures for inclusion in the programme analysis. This screening may take into account factors such as cost effectiveness, potential market size, non-energy benefits, market barriers, and potentially adverse effects associated with a measure. For this study measures were screened using the total resource cost (TRC) test, while considering only electric avoided-cost benefits.
- Gather and develop estimates of programme costs (e.g., for administration and marketing) and historic programme savings, when available. This includes data on pilot programs and from other exogenous sources, when study-area specific data are not available.
- Develop estimates of customer adoption of energy-efficiency measures as a function of the economic attractiveness of the measures, barriers to their adoption, and the effects of programme intervention.
- Estimate achievable programme and naturally occurring potentials.

Step 5: Scenario Analyses

- Recalculate potentials under alternate programme scenarios.

2.3 Scenario Analysis

Scenario analysis is a tool commonly used to structure the uncertainty and examine the robustness of projected outcomes to changes in key underlying assumptions. This section describes the alternative scenarios under which energy-efficiency potential is estimated in this study. We developed these scenarios of energy-efficiency potential for two key reasons:

1. Our estimates of potential depend on future adoptions of energy-efficiency measures that are a function of data inputs and assumptions that are themselves forecasts. For example, our projections depend on estimates of measure availability, measure cost, measure savings, measure saturation levels, retail rates, and avoided costs. Each of the inputs to our analysis is subject to some degree of uncertainty.
2. The ultimate achievable energy-efficiency potential depends, by definition, on policy choices, including the level of resources and strategies used to increase measure adoption.

The cost components of programme funding that vary under each scenario include:

Marketing and Education Expenditures

- Customers must be aware of efficiency measures and associated benefits in order to adopt those measures. In our analysis, programme marketing expenditures are converted to increases in awareness. Thus, under higher levels of marketing expenditures, higher levels of awareness are achieved.

Incentives and Direct Implementation Expenditures

- The higher the percentage of measure costs paid by the program, the higher the participants' benefit-cost ratios and, consequently, the number of measure adoptions.

Administration Expenditures

- Purely administrative costs, though necessary and important to the programme process, do not directly lead to adoptions; however, they have been included in the programme funding because they are an input to programme benefit-cost tests.

For this study, three program-funding scenarios were considered: 33, 50, and 75-percent measure incentive levels. These scenarios are discussed below.

Thirty-three-percent Incentive Scenario

In the 33-percent incentive scenario, base incentive levels are set to 33 percent of incremental measure costs. For example, if a high-efficiency water heater costs $125 more than a standard-efficiency water heater, a rebate of $42 would be available to end users in this scenario. In addition to incentives, marketing/customer education and programme administration budgets are set at amounts roughly corresponding to current programme support levels for existing programs (as planned or in early implementation stages) and at minimum levels for additional programs.

Fifty-percent Incentive Scenario

In this scenario, incentives were increased to cover 50-percent of incremental measure costs. Marketing/education budgets were also increased from the base amounts by 12.5 percent in years two and three, and held steady at the resulting higher amount (adjusted for inflation) for the rest of the analysis.

Seventy-five-percent Incentive Scenario

In this scenario, incentives were increased to cover 75-percent of incremental measure costs. Marketing/education budgets were also increased from the base amounts by 25 percent in years two and three, and held steady at the resulting higher amount (adjusted for inflation) for the rest of the analysis period.

Summary of Scenarios

Table 2 shows average spending for each of the scenarios for the 2007–2016 forecast period.

Table 2
Scenario Average Annual Spending
2007–2016 Forecast Period ($1,000s)

Funding Level	Market Segment	Cost Components ($1,000)			
		Admin	Marketing	Incentives	Total
33% Incentives	Residential Existing	$762	$475	$788	$2,025
	Residential New Construction	$119	$100	$228	$448
	Commercial Existing	$786	$400	$2,620	$3,806
	Commercial New Construction	$306	$245	$1,029	$1,579
	Industrial	$2,146	$1,100	$1,830	$5,076
	Total	**$4,119**	**$2,320**	**$6,496**	**$12,934**
50% Incentives	Residential Existing	$782	$582	$1,421	$2,786
	Residential New Construction	$131	$123	$555	$809
	Commercial Existing	$796	$490	$5,609	$6,895
	Commercial New Construction	$306	$245	$1,873	$2,424
	Industrial	$2,092	$1,348	$4,014	$7,454
	Total	**$4,108**	**$2,787**	**$13,474**	**$20,368**
75% Incentives	Residential Existing	$687	$701	$3,819	$5,206
	Residential New Construction	$148	$148	$1,813	$2,108
	Commercial Existing	$757	$590	$15,204	$16,551
	Commercial New Construction	$306	$295	$3,842	$4,443
	Industrial	$1,915	$1,623	$14,454	$17,991
	Total	**$3,813**	**$3,356**	**$39,131**	**$46,299**

3. Baseline Data and Results

3.1 Overview

Estimating the potential for energy-efficiency improvements requires a comparison of the energy impacts of standard-efficiency technologies with those of alternative high-efficiency (HE) equipment. This, in turn, dictates a relatively detailed understanding of the energy characteristics of the marketplace. Baseline data that were required for each studied market segment included:

- Total count of energy-consuming units (floor space of commercial buildings, number of residential dwellings, and the base kWh-consumption of industrial facilities)
- Annual energy consumption for each end use studied (both in terms of total consumption in GWh and normalized for intensity on a per-unit basis, e.g., kWh/m^2)
- End-use load shapes (that describe the amount of energy used or power demand over certain times of the day and days of the year)
- The saturation of electric end uses (for example, the fraction of total commercial floor space with electric air conditioning)
- The market share of each base equipment type (for example, the fraction of total commercial floor space served by T-8 fluorescent lighting fixtures with magnetic ballasts.)
- Market share for each energy-efficiency measure in scope (for example, the fraction of total commercial floor space already served by T-8 fluorescent lighting fixtures with electronic ballasts.)

Data for the baseline analysis comes from a number of sources, including secondary source data from prior New Zealand studies, additional New Zealand surveys and studies that were performed as part of this project, and data elements from various U.S. and worldwide sources that were used when New Zealand-specific data were not available. Baseline data sources vary by sector and are described further below.

3.1.1 Economic and Related Inputs

The key economic inputs utilized in the forecasting process are electricity rates, avoided costs, discount rates, and inflation rates. In addition, an estimate of the line loss rate is utilized in the analysis to provide generation-level efficiency potential estimates.

Based on discussions with the Electricity Commission, a nominal program-administrator discount rate of 7.0 percent and a nominal inflation rate of 2.5 percent per annum were utilized in the analysis. These rates are consistent with those used in other studies. For all sectors, we used a customer discount rate of 15 percent per annum. While we recognize that a wide range of customer discount rates are plausible, the DSM ASSYST measure penetration module has been calibrated in past studies to a 15 percent rate, and this rate was retained for the current study.

Average retail electricity rates (including GST for residential customers) were developed for the base year from recorded price series data maintained by the Ministry of Economic Development (MED).[2] We used a simple average of quarterly prices for the four-quarter period ending in September 2006. Prices are reported for each sector as a weighted average price for that sector. The 2006 base prices were escalated in real terms using the price forecast from the MED 2030 Outlook report. Prices were also translated into nominal terms by applying the 2.5 percent inflation rate.

Avoided cost assumptions were provided by the electricity commission. Base year avoided energy costs were set at $0.07 per kWh based on wind farm generation costs of approximately $0.06 to $0.08 per kWh. Base year avoided generation capacity costs were developed using a $1000 per kW cost for peaking gas turbine. This cost was levelized over a 20-year period using the 7 percent discount rate to arrive at a levelized cost of $94.4 per kW. Base year avoided transmission capacity costs were developed using a $300 per kW cost based on recent grid upgrade information. This cost was levelized over a 35-year period at the 7 percent discount rate to arrive at a levelized cost of $23.2 per kW. Hence the combined base year capacity cost estimate is approximately $118 per kW. The avoided energy costs were applied evenly throughout the year, while the avoided capacity costs were only applied to the winter peak period.

All economic assumptions are provided in Appendix C.

3.2 Summary Energy Usage and Peak Demand

Baseline energy and peak demand estimates were required to provide a starting point for developing energy-efficiency estimates. Two sources of data were used to develop the base energy savings estimates:

- The New Zealand Energy Data File (MED, 2006) that reported retail energy sales by ANZSIC category for the period ending March 2005; and
- The Electricity Commission's 2005 Statement of Opportunities (SOO) (EC, 2005) that provided forecasts of energy and peak demand for the 2005 through 2025.

The New Zealand Energy Data File provided the business-specific energy consumption data that was required for the detailed analysis of energy-efficiency potential. However, these data were only available for the period ending March 2005. In order to update usage to the base 2006 starting for the analysis, the Electricity Commission's 2005 SOO forecast for the year 2006 were utilized to calibrate the MED data in the Energy Data File to the more current period.

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[2] See the MED website at: http://www.med.govt.nz/templates/ContentTopicSummary____21609.aspx

The MED Energy Data File loads for the period ending March 2005 and the 2005 SOO forecast are shown in Table 3. Note that each data source treats the breakdown of commercial and industrial aggregations differently.

Table 3
Sources for Baseline Energy Consumption Data

MED Energy Data File (Table 12) **Annual Usage for Period Ending March 2005**		**Electricity Commission 2005 SOO** **Grid Exit Point Forecast for 2006**	
Sector	**GWh**	**Sector**	**GWh**
Residential	12,733	Residential	12,635
Commercial	7,975	Commercial and Light Industrial	17,127
Industrial	16,190	Heavy Industrial	8,362
Total Energy	**36,898**	**Total Energy**	**38,124**
Total Peak Demand MW	**N/A**	**Total Peak Demand MW**	**6,503**

Table 4 shows the demand time periods. We used these time periods for determining energy costs (and savings). For peak demand savings we used a smaller peak period from 6 – 7 p.m on weekdays from May through September. In this study we refer to this smaller peak period as peak, peak demand or system coincident peak demand.

Table 4
Demand Time Periods

Summer	**October-April**
On Peak	7 am - 10 pm weekdays
Off Peak	10 pm - 7 am weekdays, and all weekends
Winter	**May-September**
On Peak	7 am - 9 pm weekday and weekends
Off Peak	9 pm - 7 am

In order to utilize data from both sources, assumptions were required regarding the split of the "Commercial and Light Industrial" segment for the 2005 SOO forecast into commercial and industrial pieces. To do this, we assumed that the forecasted growth rate of 4.5 percent per year for commercial and light industrial from the 2005 SOO could be applied to the Energy Data File commercial usage. Then the difference between the commercial and light industrial forecast from the SOO and the escalated commercial usage was assumed to be light industrial. Combining the light industrial with the heavy industrial then provided the industrial baseline estimate.

Next, the peak demand estimate for 2006 from the SOO was disaggregated into residential, commercial, and industrial segments. Load shape data from BRANZ (BRANZ, 2006) were utilized to estimate the residential sector peak demand. Analysis of grid exit point data associated with large industrial customers from the Electricity Commission's Centralised Dataset (CDS) were used to develop industrial load shapes and subsequently industrial peak demand. Finally commercial peak demand was calculated as the remaining peak demand after subtracting the calculated residential and industrial peaks from the total peak demand estimate (6,503 MW in Table 3 above). The commercial peak demands were then cross-checked against bottom up estimates of commercial peak demand to ensure reasonableness.

Table 5 shows the calculated baseline energy and peak demand estimates developed for the study, and Figure 17 and Figure 18 show graphically how the energy and peak demands are distributed across sectors. For energy, the industrial sector accounts for the most energy use at about 44 percent. The residential sector accounts for the largest portion of peak demand (52 percent), which occurs on a cold winter evening.

Table 5
Energy Consumption and Peak Demand by Sector in 2006

Sector	GWh	MW
Residential	12,635	3,384
Commercial	8,626	1,091
Industrial	16,863	2,028
Total	**38,124**	**6,503**

Figure 17
Estimated Energy Consumption by Sector
(38,124 GWh in 2006)

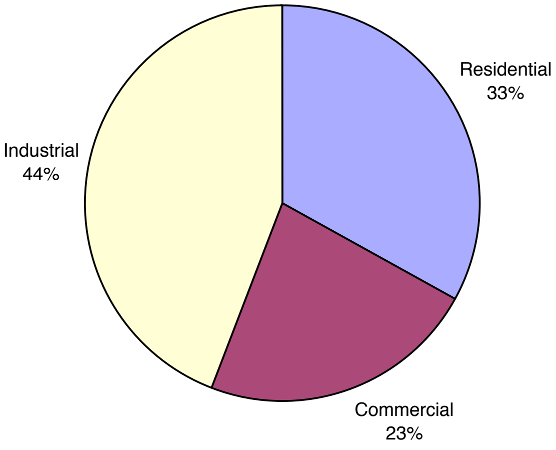
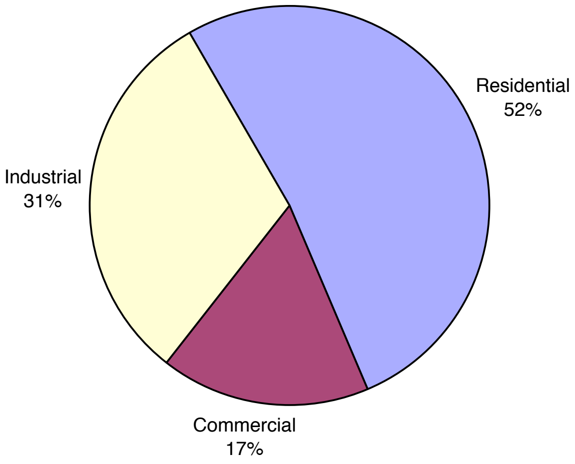


Figure 18
Estimated Peak Demand by Sector
(6,503 MW in 2006)



3.3 Residential

The primary data source for the residential analysis was the Household Energy End-use Project (HEEP), as provided by BRANZ (2006). HEEP collected monitored energy-use data and household characteristics for approximately 400 randomly-selected New Zealand Homes.

Little data, however, was available for new homes. To fill in this gap, we surveyed home builders throughout New Zealand about their building practices. While this data provided saturation and equipment densities, it did not provide heating energy use for new homes. We were forced to rely on the HEEP data for existing homes, assuming that increases in floor space would be offset by improvements in insulation and windows.

To obtain cost information for baseline and energy-efficient equipment, KEMA employed a New Zealand survey research firm (TNS) to conduct on-site observation of retail prices for high and standard efficiency refrigerator/freezers, clothes washers, dishwashers, and heat pumps. Water heaters and dehumidifiers were also included in the survey but not enough data were collected to be used. The purpose of the on-site data collection was to access the price difference between standard and HE equipment at retail locations. The general methodology was to identify units of the same size and brand, but with different efficiency levels, to determine the incremental cost of high efficiency appliances. For other products, cost data was obtained from New Zealand on-line retailers, or if local prices could not be found, was estimated from U.S. cost data.

3.3.1 Baseline End-Use Consumption and Peak Demand

Figure 19 summarizes residential electric energy consumption and peak demand by end-use. Water heating and miscellaneous plug loads are the largest end uses in terms of electricity consumption, followed by refrigeration, space heating, and lighting. Space heating is the largest end use in terms of peak demand.

Baseline technology saturation data and UECs (Unit Energy Consumption in kWh per home per year) for existing homes were derived primarily from BRANZ (2006). New home saturations were obtained from the builder survey, while UECs were estimated from the BRANZ data, correcting for such factors as the larger size and increased thermal integrity of new homes. Table 6 summarizes the residential end-use saturations and energy use for households having that end-use.

Figure 19
Residential Electricity Usage and Peak Demand by Use

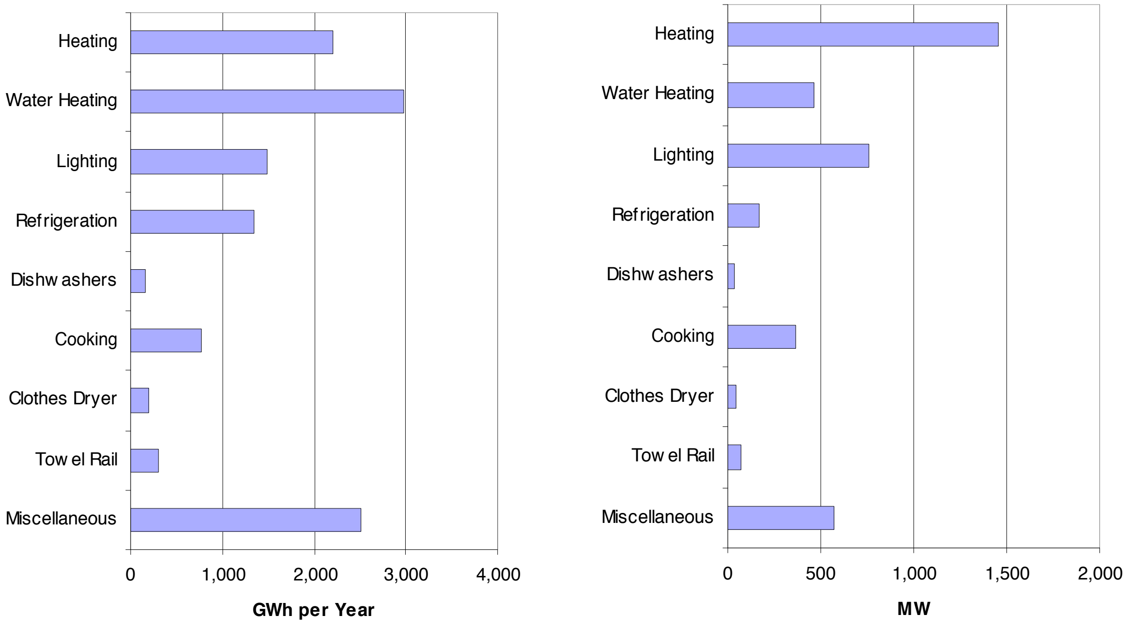


Table 6
Residential End-use Saturation and Household Electricity Consumption

End Use	Single Family	
	Saturation	kWh/household*
Electric Resistance Heating	93%	919
Refrigerator	31%	440
Refrigerator/Freezer	80%	696
Freezer	64%	749
Water heat	87%	2,780
Dishwasher	48%	211
Clothes dryer	70%	174
Lighting	100%	920
Cooking	93%	540
Heated Towel Rail	42%	440
Miscellaneous	100%	1501

*For homes having this end-use

Estimating electric space heating in New Zealand proved to be a challenging task. The HEEP data paint a complex picture of heating equipment and fuels in existing homes. Table 7 provides heating statistics for Wellington, as an example. Heating equipment saturations total to 280 percent, indicating that the average home has 2.8 types of heating equipment and often more than one fuel type. Combining saturations with equipment densities indicates that the average home in Wellington has an average of 3.8 heating devices. Heating usage in other regions is similarly complex.

Table 7
Heating Equipment Saturations in Wellington

Heating Equipment	Percent of homes having as most-used heating type	Saturation (%)	Density
Portable Electric	24	76	**1.74**
Fixed Electric	6	61	**1.48**
Heat Pump	0	0	**-**
Enclosed Solid Fuel	21	34	**1.00**
Open Solid Fuel	0	22	**1.00**
Gas	18	34	**1.36**
Gas Central	12	12	**1.00**
Kerosene	NA	2	**1.00**
Liquefied Petroleum Gas (LPG)	21	39	**1.00**
Solid or Liquid Fuel Central	**0**	**0**	**-**

Source: BRANZ (2006), Tables 9 and 10.

Because this study only looked at electricity savings in determining the cost-effectiveness of a measure, measures which would be cost-effective in an all-electric home might not be cost-effective in a home with multiple fuels. For this reason, we segmented the housing stock according to the fuel of the most-used heater in the home: electric (30 percent of homes) or other fuel (70 percent). BRANZ (2007a) was able to provide the necessary breakdown. Table 8 shows the BRANZ data weighted into the three climate zones of the New Zealand building code (New Zealand Standard NZS4218:2004). For the two market segments, the table shows both electric heating consumption and total heating energy (all fuels). Total heating energy in electrically heated homes is significantly lower than in homes predominantly heated with other fuels. According to Michael Camilleri of BRANZ (2007b) this is because electrically heated homes "are heated to lower temperatures on average than those heated by gas or solid fuel, and for less hours, and fewer rooms." He speculates that, given cheaper heating, these homes would increase the amount of heating energy, a significant concern when designing programs to reduce energy use.

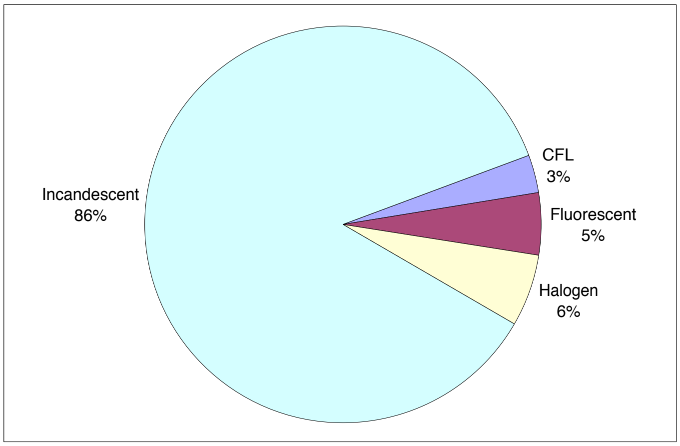
Table 8
Household Space Heating Energy Consumption (kWh/yr)

	Most-Used Heater Fuel Type			
	Electric		Other Fuel	
	Electricity	All Fuels	Electricity	All Fuels
CZ 1	1,538	1,949	1,117	**3,259**
CZ 2	1,651	2,036	1,273	**3,065**
CZ 3	**3,105**	**3,423**	**1,349**	**3,594**

Electric heating, particularly heat pumps, dominated in new homes. New homes were segmented into homes with resistance heating and homes with heap pumps. The baseline energy consumption for resistance heating was drawn from Table 8, above, using values for homes with primarily electric heat. To estimate baseline energy for heat pump homes, we reduced the electric resistance baselines by 33 percent, which takes into account both the higher efficiency of heat pumps and the evidence of take-back from the HEEP data (that given lower heating costs, households will choose to heat to a higher temperature).

BRANZ (2006) provides saturations and densities for compact fluorescent (CFLs), incandescent, fluorescent and halogen lamps. From these data we estimated that an average of 26.8 lamps per home, of which 23.9 are screw-based (23 incandescent lamps and 0.9 CFLs).

Figure 20
Distribution of Lamp Types in New Zealand



Because lighting usage tends to be highly skewed, with a large share of energy use being concentrated in relatively few lamps (Vorsatz, et al. 1997), incandescent lighting was divided into three base measures according to usage (low, medium and high). The weighting factors for these usage bins were initially set based on U.S. data (Vorsatz, et al. 1997). We then modified them to calibrate overall lighting energy to 920 kWh/year, the average household lighting energy consumption reported by BRANZ (2006). Table 9 shows the final calibrated assumptions used in the analysis.

Table 9
Residential Lighting Usage

	Usage (hrs/day)	Wattage	# per household	Unit Energy Consumption (kWh/yr)	Household Energy Consumption (kWh/yr/hh)
CFLs					
low	0.50	20	0.68	3.65	**2.5**
medium	2.00	20	0.15	14.60	**2.2**
high	3.00	20	0.08	21.90	**1.7**
Incandescent					
low	0.50	100	17.19	18.25	**313.7**
medium	2.60	100	3.88	73.00	**283.5**
high	6.90	100	1.94	109.50	**212.5**
Fluorescent tubes	1.35	40	1.32	19.70	**26.0**
Halogen	2.80	50	1.53	51.10	**78.0**
Total					920.1

3.3.2 Measure data

The residential analysis included fuel-switching measures (electricity to gas or LPG) for heating, water heating and cooking. Electricity savings to the consumer for these measures are offset by installation and fuel costs. Discounted lifetime fuel and installation costs are included in the model as operation and maintenance (O&M) costs for these measures. Line and retail charges for natural gas were based on a MED survey of gas suppliers (MED, 2006). The retail price of LPG is assumed to be 7 percent higher than gas. Fixed charges for LPG were based on tank rental charges, an estimated $126 per year.

Fixed charges for gas and LPG were divided between heating, water heating and cooking, proportional to base equipment usage. This assumption is predicated on all three end-uses using gas or LPG, and minimizes the fixed cost per home by each end-use. In other words, it is a low estimate if one or more of the end-uses are not switched to the gas fuel. If a fuel-switching measure fails the TRC test under this assumption it is clearly not cost effective. If an end-use passed the TRC under these conditions we looked at the cost effective for the other end-uses. If the other end-uses did not pass the TRC then the fixed cost initially assigned to the measure were too low. In this analysis, LPG cooking initially passed the TRC test with this cost allocation, while LPG water heating and space heating both failed. However, if only the cooking measure is installed, cooking must bear the full fixed cost of fuel switching. Under this revised cost allocation, fuel-switching for cooking fails the TRC test.

The cost survey yielded a negative incremental cost for high-efficiency dishwashers. This result is at odds with information about product characteristics and manufacturing costs, and may result from sample bias or may represent a short term pricing situation. In the analysis we ultimately used incremental costs adapted from U.S. data and found dishwashers uneconomical at these costs.

High efficiency clothes washers have been promoted in the United States for their low water use and for water heater savings. The savings would be significantly less in New Zealand, as HEEP data indicate that most New Zealanders use a cold wash. While high efficiency clothes washers use less energy and reduce dryer energy use by the reducing clothing moisture content, these savings, in the absence of water heater savings, were insufficient to merit inclusion in the model.

Detailed measure data is provided in Appendix E.

3.4 Commercial

During Task 2 of this project (Data Identification), the KEMA team assessed the availability of existing data describing energy use in New Zealand's commercial building stock and the applicability of these data to the bottom-up assessment of efficiency potential. The KEMA team identified very few sources of usable input data for the commercial sector.

To address the most important of these data gaps, the Electricity Commission approved a suite of primary data collection activities that were conducted between September 2006 and January 2007. The central piece of the data collection activities was a series of telephone-based surveys with commercial end users and end-use equipment vendors to develop estimates of technology saturations and current penetration of key energy-efficiency measures.

The KEMA team developed survey instruments and sample designs for each target population and contracted with a New Zealand-based market research firm (TNS) to administer the surveys. TNS fielded the surveys between November 2006 and January 2007 and completed the following activities:

- 621 interviews with commercial end users,
- 50 interviews with lighting contractors and distributors, and
- 50 interviews with HVAC contractors and distributors.

To supplement these high-volume surveys, the KEMA team also conducted a series of in-depth interviews. These included in-depth interviews with:

- lighting contractors (10),
- HVAC contractors and distributors (10), and
- commercial builders and designers (10).

In addition to the data collected in the surveys described above, the KEMA team also directly solicited primary data from various agencies and market actors in New Zealand. Members of the Lighting Efficiency Stakeholder Group (LESG) provided estimates of average costs and wattages for key commercial lighting technologies and measures.[3] The EECA provided data on the annual sales and energy consumption characteristics of equipment classes regulated under New Zealand's Minimum Energy Performance Standards (MEPS). Finally, Energy Solutions (an energy engineering consultancy based in Wellington) provided estimates of the costs and energy savings associated with specific heating and cooling efficiency measures in commercial buildings.

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[3] The LESG is a collaborative group composed of the Electricity Commission, EECA, and the New Zealand Lighting Council, formed in 2006 to facilitate the development of an efficient lighting strategy for New Zealand.

To supplement the primary data collected for this study, the KEMA team also leveraged key secondary data sources that represent the most current state-of-understanding related to end-use energy consumption and efficiency opportunities in commercial buildings in California and the U.S. These secondary sources included the Database for Energy Efficient Resources (DEER),[4] the California Commercial End Use Survey (CEUS),[5] and the technical reports published by the U.S. Department of Energy's (USDOE) Building Technologies Program.[6]

In the sections below, we describe the sources and methods used to develop the key input data used in this study.

3.4.1 Baseline Consumption, Peak Demand, and Floor Area

Total base year annual electricity consumption for the commercial sector was derived from MED's most recent edition of the New Zealand Energy Data File (MED, 2006). The Energy Data File provides a breakdown of commercial electricity use by ANZSIC category for the year ending March 2005. To establish a base year value for total commercial electricity consumption, we first removed electricity consumption associated with sectors that are outside the scope of the DSM ASSYST analysis framework.[7] After this adjustment, the total consumption value was then inflated at 4 percent per year over two years in order to produce an estimate of total electricity consumption in the commercial sector for calendar year 2006. The 4 percent per year inflator was used to be consistent with the demand forecasts for the commercial and industrial sectors in the Commission's 2005 SOO (EC, 2005).

Direct estimates of the commercial sector's contribution to system peak demand were not immediately available for this study. In order to derive an estimate of system coincident peak demand from commercial buildings, we used grid exit point data from the Commissions' CDS to first identify total system peak demand and the system peak hour. We then estimated system peak demand contributions from New Zealand's largest industrial customers based on grid exit points associated with these customers. Next we estimated contributions to system peak demand from the residential sector based on hourly load shapes for the residential sector developed by BRANZ. Finally, contributions to system peak demand from the commercial sector were estimated as the difference between total system peak and contributions from industrial and residential customers. Our final estimates of base year (2006) total

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[4] DEER was developed jointly by the California Public Utilities Commission and the California Energy Commission to serve as a central source for measure cost and savings data for utility program filings and efficiency-related research. The DEER database contains average cost and energy savings data for over 250 energy-efficiency measures currently available in the California market.

[5] The California CEUS is a comprehensive study of commercial sector energy use, primarily designed to support the state's energy demand forecasting activities and funded by the California Public Utilities Commission and the California Energy Commission. The study provides estimates of end-use saturations, end-use energy intensities, and hourly load profiles for multiple market segments based on a stratified sample of 2,800 on-site surveys of commercial facilities in California.

[6] The Building Technologies Programme has funded several state-of-the-art assessments of commercial end-use energy consumption and savings opportunities, notably a series of studies quantifying energy consumption and savings potential associated with office and telecommunications equipment in the U.S.

[7] These sectors include Road Freight Transport (I611), Road Passenger Transport (I612), Rail Transport (I62), Water Transport (I63), Air Transport (I64), and Other Transport and Services to Transport (I65-66). Together, these sectors accounted for 5.6 percent of total annual electricity consumption in the commercial sector for the year ending March 2005.

consumption and system coincident peak demand from the commercial sector are shown in Table 10 below.

Table 10
Commercial Base Year Consumption (2007)
and System Coincident Peak Demand

Total Annual Consumption (GWh)	8,135
as a share of all sectors	*21%*
System Coincident Peak Demand (MW)	1,091
as a share of all sectors	*17%*

For this study, we purchased floor area data for the commercial sector from Quotable Value, Ltd.[8] The floor area data maintained by Quotable Value are based on New Zealand's property valuation rolls and contain business type identifiers that allowed segmentation of commercial floor area into eight building types – Offices, Restaurants, Non-food Retail, Food Stores, Education, Healthcare, Lodging, and Miscellaneous. In order to treat colleges and universities separately from primary and secondary education in our potential analysis, we allocated the floor area in Education to Schools/ Colleges and Tertiary Education. Also, in order to account for an incomplete disaggregation of the retail sector, we allocated a portion of the floor area in Retail to Restaurants and Food Stores. This resulted in nine building types that are used throughout this study.

We used two other data sources to provide reasonable benchmarks for these inter-segment allocations. First, we solicited business counts by segment from Statistics New Zealand in order to calculate and compare the implied average floor area per business (m^2/premise) across segments. We also used segment-level annual electricity consumption data from the EDF to calculate whole-building energy intensities (kWh/m^2). We then benchmarked these energy intensities to analogous values for U.S. and California buildings based on the results of the California CEUS and the US DOE's 2003 Commercial Building Energy Consumption Survey.

3.4.2 Baseline Results

Using base technology saturations, EUIs, and end-use load shapes (discussed in detail below) produces bottom-up estimates of total annual consumption and system coincident peak demand for New Zealand's commercial sector. These bottom-up estimates of total annual consumption and system coincident peak demand come to within 5 percent of the estimated base year values. Below we summarize the key results of our baseline analysis of New Zealand's commercial sector and highlight the key characteristics of the commercial customer base that are relevant to the assessment of energy-efficiency potential.

Figure 21 summarizes commercial electric energy consumption and peak demand by building type. Miscellaneous building types account for the largest share of electric energy usage, followed by food stores, office buildings, hospitals, and retail. These five account for over 80 percent of commercial energy use. The building type breakdown of system coincident peak demand is quite similar to total annual electricity use. At first blush, this result implies that the overall load profile of New Zealand's commercial buildings is quite flat. However, it should be noted that this result mostly reflects the fact that New

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[8] Quotable Value was formerly Valuation New Zealand, a central government department responsible for allocating value to all land for purposes of property taxes.

Zealand is currently a winter-peaking system and that the system peak hour currently falls at the end of the business day, from 6-7pm, when commercial building loads are declining. Considered alone, commercial load profiles tend to peak significantly during the early-to-mid afternoon period and be dominated by lighting and space conditioning.

Figure 21
Commercial Electricity Usage by Building Type

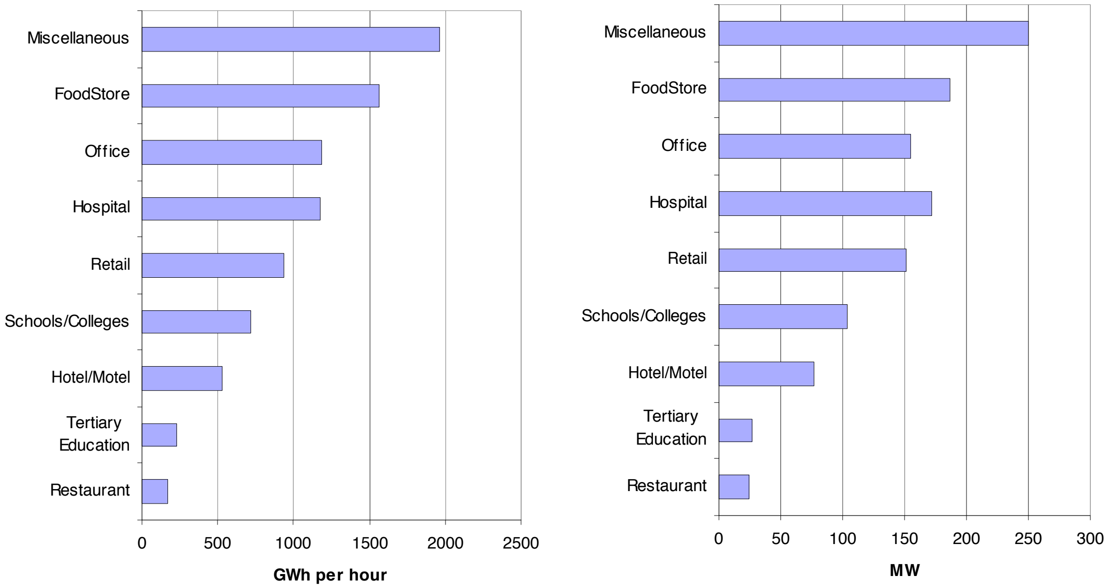
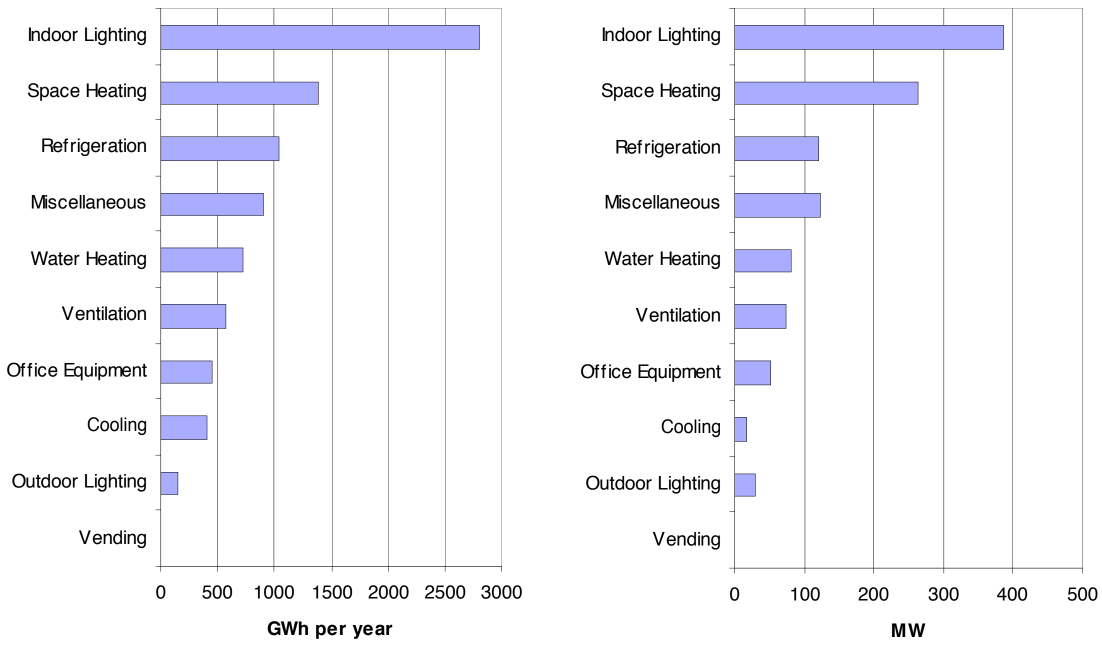


Figure 22 shows the distribution of total annual electricity consumption and system coincident peak demand in the commercial sector by end use. As the figure shows, indoor lighting accounts for the largest portion of commercial electricity consumption, representing 33 percent of total commercial electricity use. Space heating accounts for the next largest share of commercial electricity use, reflecting the high penetration of electric space heating in New Zealand's commercial buildings. Cooling and ventilation account for relatively small shares of commercial energy use, reflecting the moderate penetration of mechanical cooling and ventilation in New Zealand compared to what is typically seen in the U.S.

Figure 22
Commercial Electricity Usage by End-Use



Interestingly, refrigeration accounts for a significantly larger share of total commercial electricity use relative to what is commonly experienced in the U.S. This result, however, is consistent with the fact that the Food Store segment accounts for a significantly larger share of total commercial electricity sales in New Zealand compared to the U.S. (19 percent compared to 7 percent for the U.S. as a whole) and that electricity use in the Food Store segment is dominated by refrigeration.

Table 11 shows electricity consumption by end-use and commercial building type. Indoor lighting is a major end use of electricity in all commercial building types and is particularly important in the Retail and Lodging segments, accounting for approximately 60 percent and 40 percent of total electricity use in those segments, respectively. Table 11 also shows that heating, cooling, and ventilation are most important in building types that tend to be dominated by internal gains, e.g. Offices and Hospitals. Water heating accounts for a relatively small share of commercial electricity use overall but is a significant end use of electricity in segments where building occupancy levels tend to be very high during operating hours, e.g. Hospitals, Lodging, and Miscellaneous.9

Table 12 shows the corresponding information for peak demand. In Figure 23 and Figure 24we graphically show each building type's contribution to commercial energy use and peak demand.

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[9] The Miscellaneous segment includes libraries, museums, cultural centers, child care facilities, sports complexes, gambling facilities, religious assembly, and other services.

Table 11
Commercial Electricity Consumption by Building Type and End Use (GWh/Year)

	Office	Restau-rant	Retail	Food Store	Schools/ Colleges	Tertiary Education	Hospital	Hotel/ Motel	Miscel-laneous	Total
Indoor Lighting	420	26	561	282	253	60	311	225	660	**2,798**
Outdoor Lighting	5	2	11	16	34	6	3	14	56	**148**
Cooling	132	8	47	17	12	12	75	11	92	**405**
Ventilation	130	7	77	55	25	46	110	24	96	**569**
Refrigeration	0	49	0	994	0	0	0	0	0	**1,043**
Office Equipment	146	2	61	14	153	6	43	13	20	**457**
Space Heating	245	7	58	55	174	64	351	68	370	**1,392**
Water Heating	19	12	18	28	37	10	149	85	364	**722**
Vending	3	0	0	0	2	1	1	1	2	**11**
Miscellaneous	84	54	100	103	24	21	133	92	298	**909**
Total	**1,183**	**167**	**933**	**1,565**	**714**	**225**	**1,177**	**533**	**1,958**	**8,454**

Table 12
Commercial Peak Demand by Building Type and End Use (MW)

	Office	Restau-rant	Retail	Food Store	Schools/ Colleges	Tertiary Education	Hospital	Hotel/ Motel	Miscel-laneous	Total
Indoor Lighting	56	5	89	39	26	6	42	28	96	**386**
Outdoor Lighting	1	0	2	3	7	1	1	3	12	**30**
Cooling	7	1	2	1	0	1	5	0	1	**17**
Ventilation	16	1	12	8	1	5	13	3	13	**73**
Refrigeration	0	6	0	114	0	0	0	0	0	**120**
Office Equipment	18	0	10	2	11	1	5	2	3	**52**
Space Heating	46	0	17	3	54	11	67	17	50	**264**
Water Heating	2	1	3	4	3	1	22	11	34	**81**
Vending	0	0	0	0	0	0	0	0	0	**1**
Miscellaneous	9	10	16	13	1	2	18	13	40	**122**
	155	**25**	**151**	**186**	**104**	**27**	**171**	**77**	**250**	**1,146**

Figure 23
Building Type Contribution to Commercial Energy Use

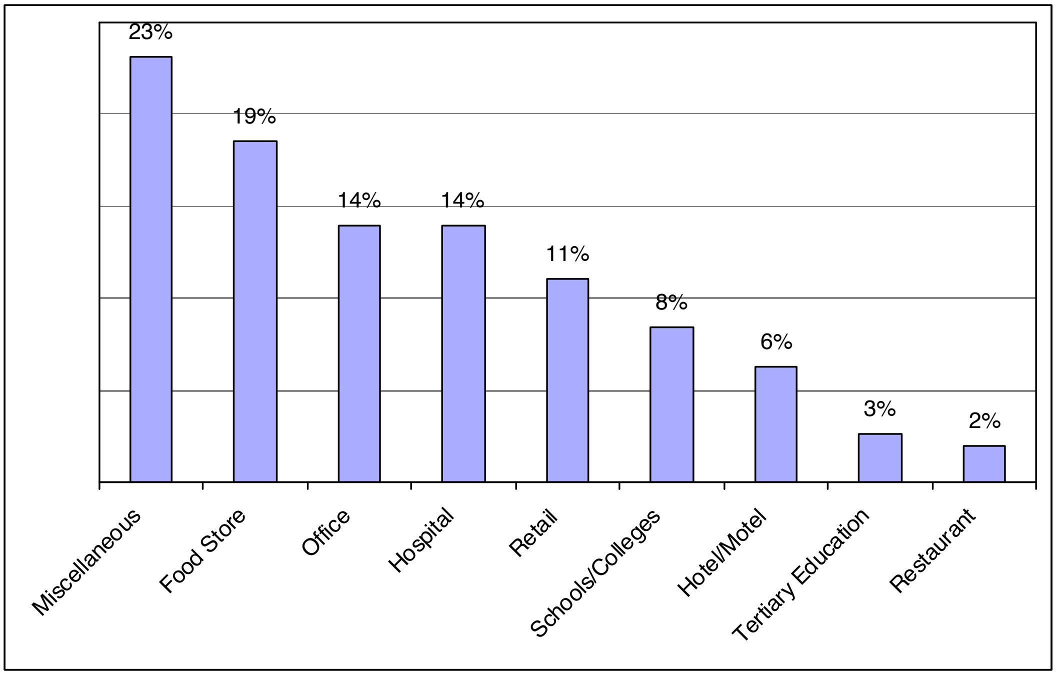
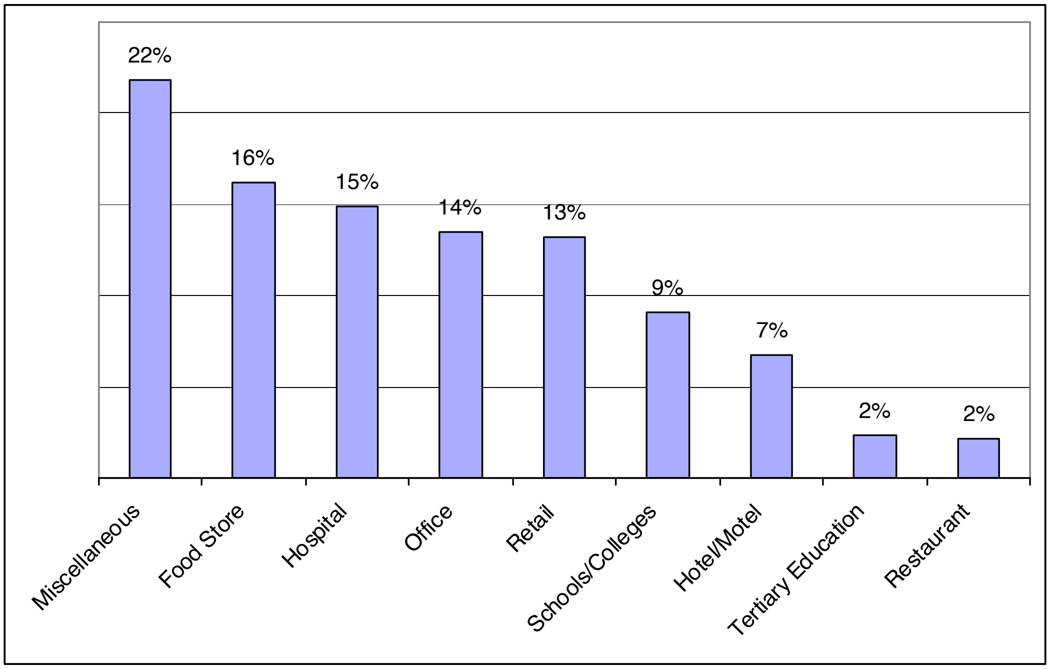


Figure 24
Building Type Contribution to Commercial Peak Demand



3.4.3 Baseline Technology Saturations

The KEMA team was unable to identify any comprehensive source of end-use equipment saturations in commercial buildings in New Zealand. The KEMA teamed used the telephone-based end-user surveys discussed above to form the basis of the baseline technology saturation estimates used in this study.[10] Below we summarize some of the key technology saturation estimates derived from the commercial end-user survey. While the use of a telephone survey provided reasonable initial estimates of technology saturations in the commercial buildings, we recognize that these more technical aspects of the survey are less reliable, as end users have more difficulty identifying specific types of equipment. We expect that the technology estimates could be improved significantly through the use of on-site surveys by trained surveyors. Project budget and timeline constraints precluded these more rigorous surveys.

Figure 25 shows the self-reported shares of the major lighting technologies in commercial buildings in New Zealand. As the figure shows, linear fluorescent tube lighting is the predominant lighting technology, accounting for two thirds of commercial lighting overall. Incandescent lighting accounts for approximately 20 percent of total commercial lighting but accounts for significantly higher shares of lighting in the Hospital and Lodging segments. Low-voltage halogen lamps and CFLs account for small shares of total commercial lighting in New Zealand (6 percent and 5 percent, respectively), with the highest saturation of halogens occurring in the Miscellaneous segment (16 percent) and the highest saturation of CFLs occurring in the Lodging segment (23 percent).

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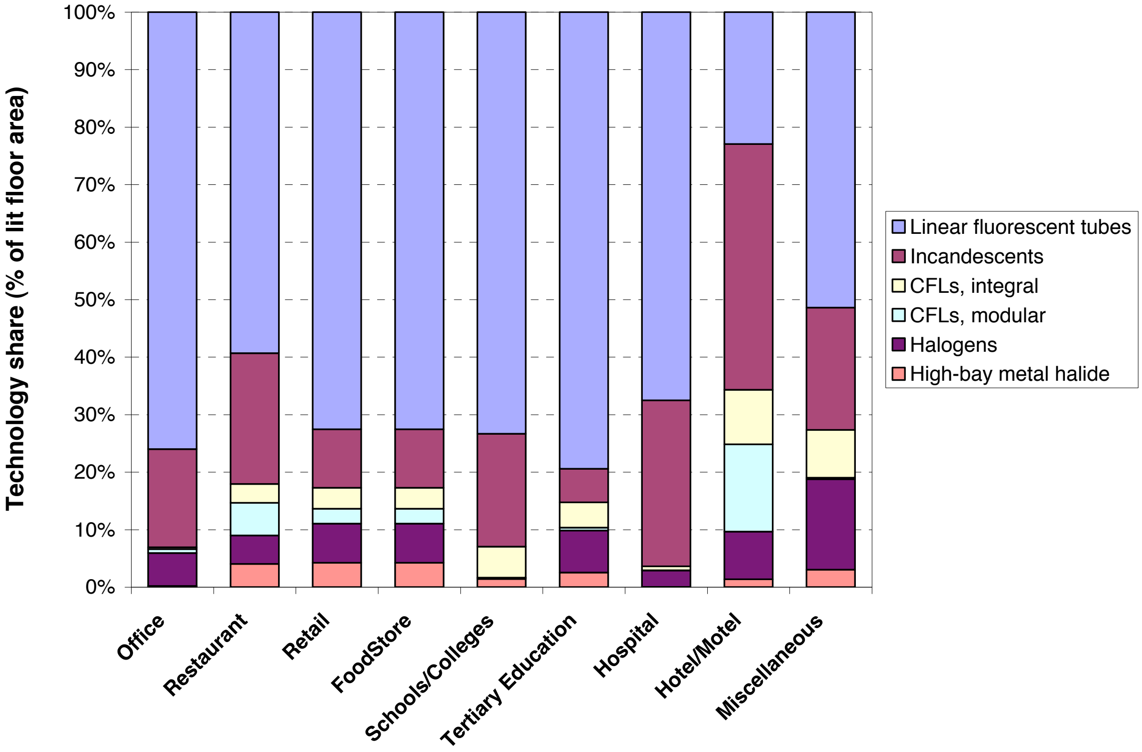
[10] One exception was the saturation of electronic versus magnetic ballasts. These saturations were derived from data on ballast sales provided by EECA.

Figure 25
Self-Reported Shares of Major Lighting Technologies in Commercial Buildings



Within linear fluorescent tube lighting, Figure 26 shows that T8 lamps (26mm diameter tubes) account for the majority of fluorescent lamps currently installed in the commercial sector. T12 lamps (38mm diameter tubes), however, still account for a significant share of linear fluorescent lamps despite not being sold in New Zealand as a result of the efficacy requirements in the 2001 MEPS. T5 lamps (16mm diameter tubes) currently account for only a small overall share of linear fluorescent lamps in commercial buildings in New Zealand (less than 5 percent). There is some concern that the end-user reported instances of T-12 lamps might be overstated, given the 2001 MEPS and the limited lamp lifetimes[11]. An over-reporting of T-12 lamps would lead to an overestimation of energy-efficiency potential for commercial lighting. Additional research on lighting technologies in the commercial sector might be merited.

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[11] This issue was raised by EECA in comments on the draft report.

Figure 26
Self-Reported Shares of Linear Fluorescent Lamp Types in Commercial Buildings

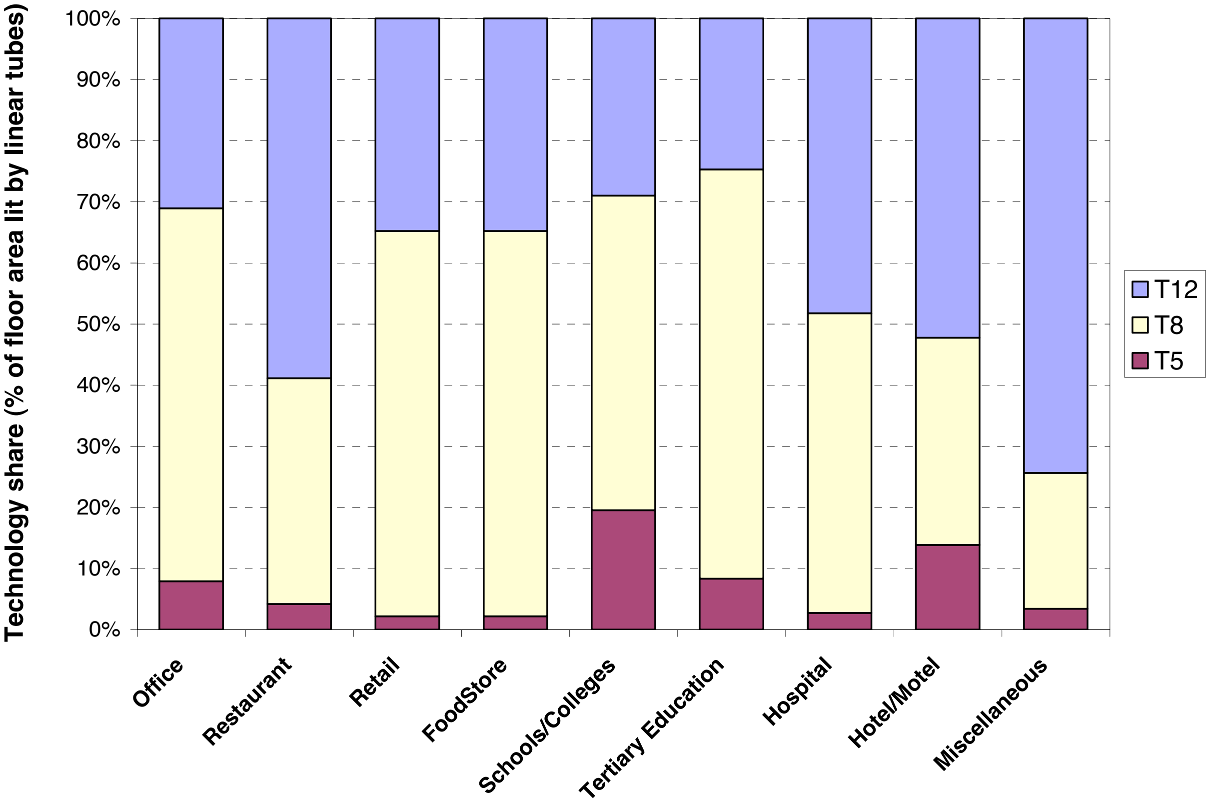

Figure 27 shows the self-reported shares of primary space heating fuels in commercial buildings[12]. The figure shows that electricity is the dominant fuel used for space heating in New Zealand's commercial buildings. This aspect of New Zealand's commercial sector differentiates it significantly from the commercial sector in California and the U.S. where natural gas tends to be the dominant space heating fuel. Natural gas and LPG play more significant roles in space heating in the Restaurant, School, College, and Miscellaneous segments, accounting for 20 to 40 percent of space heating in those segments. Outside of those segments, however, natural gas, LPG , solid fuels, and oil products play very minor roles in commercial space heating in New Zealand.

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[12] EECA disputes the self-reported dominance of electric space heating, particularly for hospitals and schools. The KEMA team relied on these self-reported shares in the absence of any current and more reliable data sources. The self-reports of electric space heating were consistent with the self-reports of heating technology (incidence of boilers.)

Figure 27
Self-Reported Shares of Primary Space Heating Fuels in Commercial Buildings

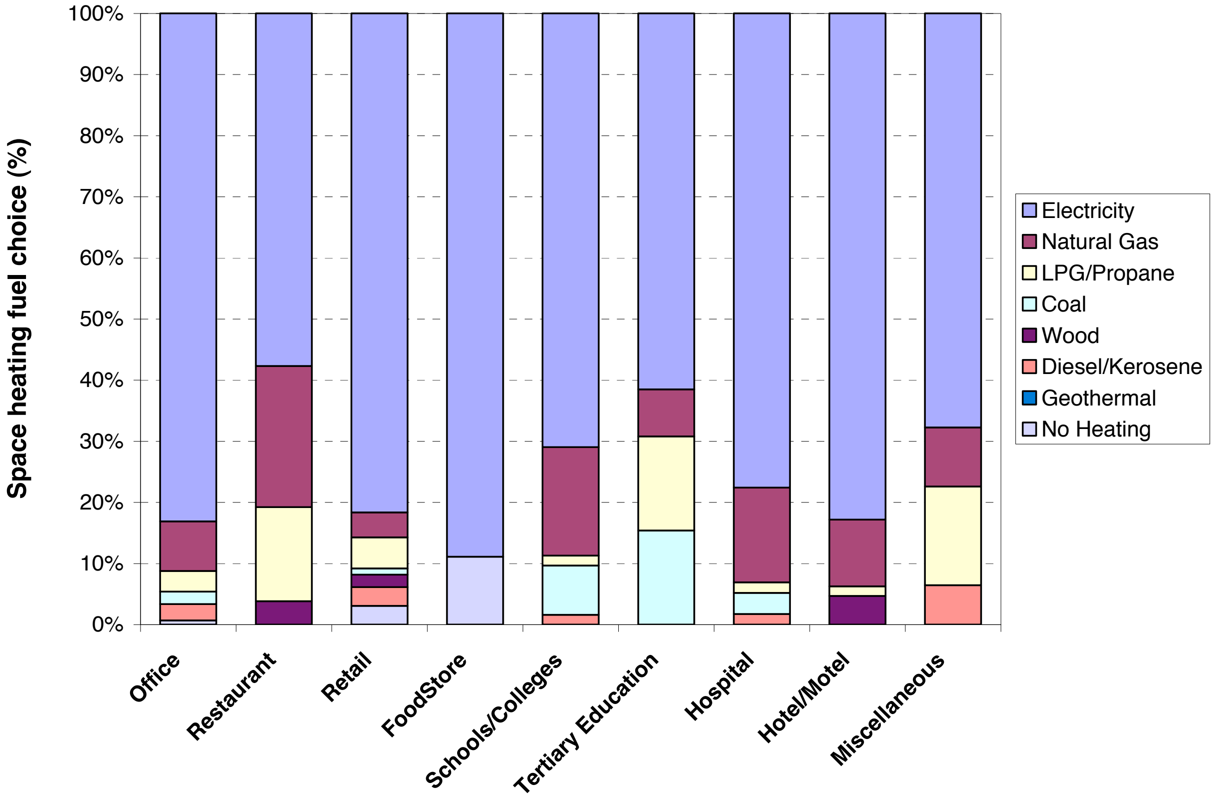


Figure 28 shows the breakdown of the main electric space heating technologies used in commercial buildings. As the figure shows, there appears to be no one dominant electric space heating technology used in New Zealand's commercial sector. Split-system heat pumps and electric resistance reheat coils each account for approximately 20 percent of the installed electric heating capacity in commercial buildings, while wall-mounted fan heaters account for approximately 25 percent of installed electric heating capacity. The remaining share of electric heating capacity is composed of a mix of other technologies, including portable resistance heaters, electric boilers, and electric furnaces.

It is important to note that when applying the results shown in Figure 27 and Figure 28 to our baseline analysis, we weighted the saturation results by the self-reported share of floor space heated during the winter at each premise in order to avoid overestimating heating loads in segments where heat is not regularly provided to all indoor spaces (e.g. grocery stores).

Figure 28
Self-Reported Shares of the Main Electric Heating Technologies in Commercial Buildings

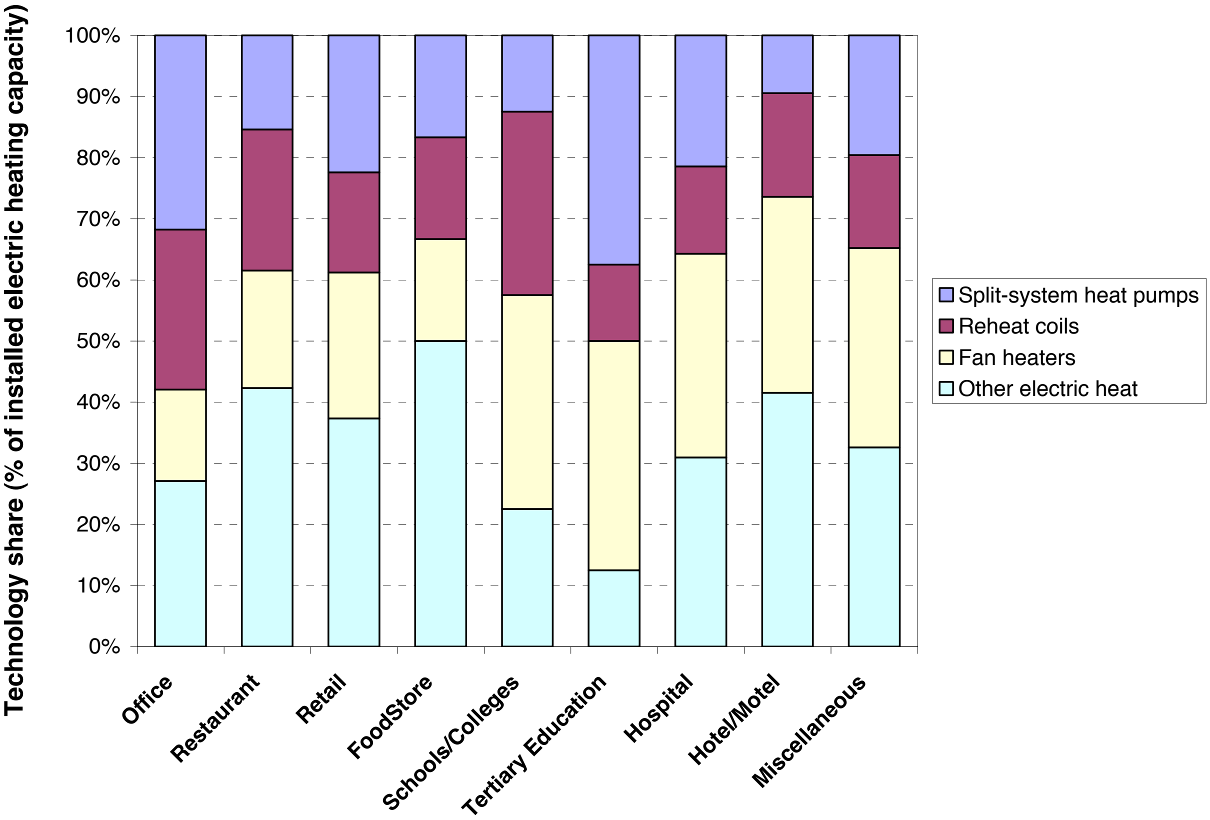
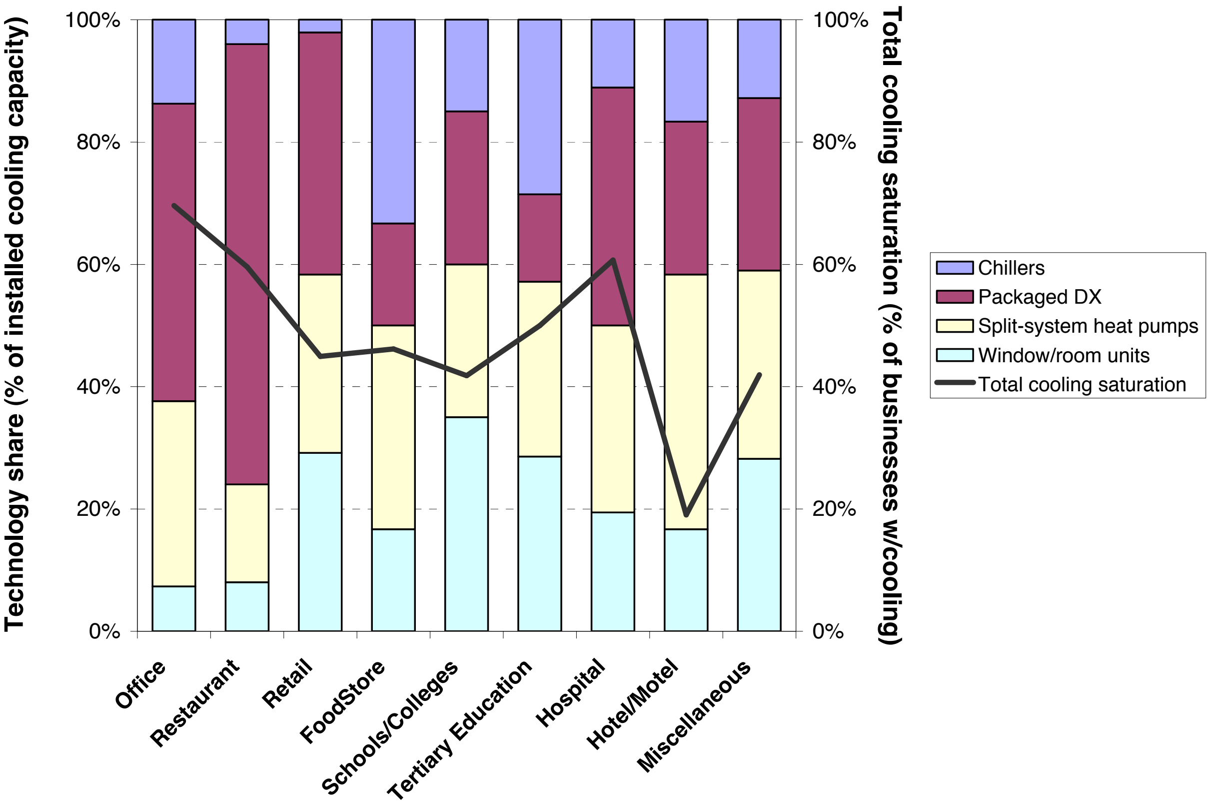


Figure 29 shows the self-reported saturation of air-conditioning in commercial buildings and the shares of the main cooling technologies currently used. As the figure shows, the overall saturation of air-conditioning in New Zealand's commercial sector is modest, with just over 50 percent of commercial premises reporting to use air-conditioning during the summer months. At the segment level, however, this saturation varies significantly, with Offices reporting 70 percent saturation of air-conditioning and Lodging reporting only 20 percent.

Figure 29 also shows the breakdown of the main air-conditioning technologies currently used in commercial buildings in New Zealand. Overall, packaged direct expansion (DX) systems account for the largest share (40 percent) of the installed cooling capacity in commercial buildings based on customer self-reports, while chilled water plants and individual window/room units account for 12 percent and 18 percent of installed capacity, respectively. Interestingly, split-systems account for nearly a third of installed cooling capacity, representing another unique and important aspect of New Zealand's commercial sector compared to California and the U.S. where the use of split-systems in commercial buildings is far less frequent.

Figure 29
Self-Reported Saturation of Air Conditioning
and Shares of the Main Cooling Technologies in Commercial Buildings



As with the space heating saturations, it is important to note that when applying the results shown in Figure 29 to our baseline analysis, we weighted the saturation results by the self-reported share of floor area air-conditioned during the summer at each premise in order to avoid overestimating cooling loads in segments where cooling is not regularly provided to all indoor spaces.

3.4.4 End-Use Energy Intensities

During Task 2, we identified a small set of end-use energy intensity (EUI) estimates for certain commercial building types in New Zealand.[13] However, these estimates were mostly developed in the mid-1990s before or shortly after efficiency requirements were first introduced into the New Zealand Building Code and well before MEPS were established for fluorescent tubes, fluorescent ballasts, air conditioners, motors, and water heaters.

To address this critical data gap, we leveraged the results of the California CEUS – a comprehensive, multi-year study of end-use energy consumption in commercial buildings in California. One of the key

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[13] These estimates are documented and summarized in *The Dynamics of Energy-efficiency Trends in New Zealand: a Compendium of Energy End-Use Analysis and Statistics* (EECA, 2000).

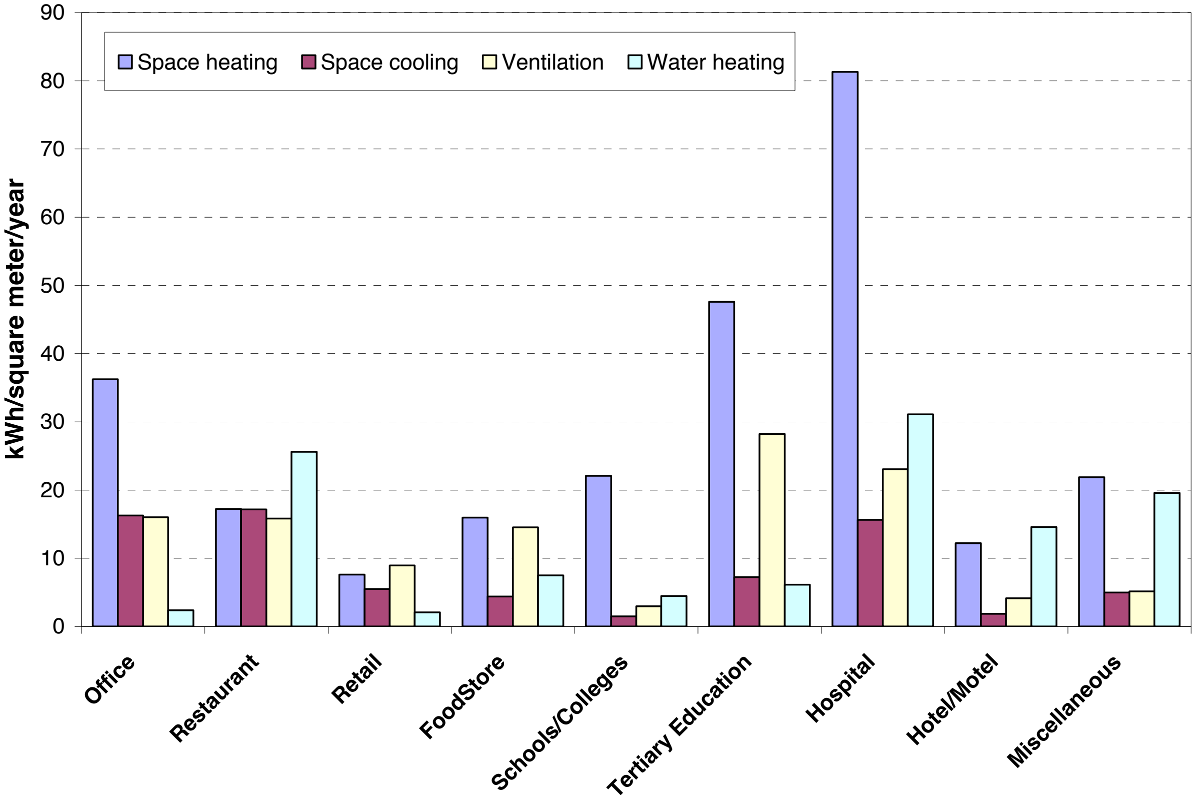
features of the California CEUS relative to this study is that the sample size was large enough to support the development of EUIs and other energy use indicators for 12 distinct building types across 16 different climate zones in California. Since the building types defined for this study are consistent with those used in the California CEUS, the key step required to appropriately leverage the CEUS results for this study was to identify the California climate zone that most resembles New Zealand's climate. To do this, we collected average annual cooling and heating degree-day data for New Zealand's primary population centres – Auckland, Christchurch, and Wellington. We then compared this data to average annual degree-day data for each CEUS climate zone to determine the extent to which any of the California climate zones provide a reasonable approximation of New Zealand's average climate. As Table 13 shows below, it became evident that CEUS climate zone 5 (San Francisco Bay Area) provided a remarkably close proxy to New Zealand's average climate.

Table 13
Comparison of Summary Weather Data for Major New Zealand Cities and San Francisco

	Auckland	Christchurch	Wellington	Population weighted average	San Francisco
CDD (18°C baseline)	131	58	25	**99**	**28**
HDD (18°C baseline)	1163	2441	1849	**1518**	**1438**
CDD (10°C baseline)	1909	984	1218	**1617**	**1555**
HDD (10°C baseline)	21	447	121	**116**	**45**

For weather-sensitive commercial end uses (e.g. space heating and cooling), we thus adopted the EUI estimates for CEUS climate zone 5 for use in this study. These estimates are shown by building type in Figure 30.

Figure 30
Weather-Sensitive End-Use EUIs Applied to New Zealand's Commercial Sector

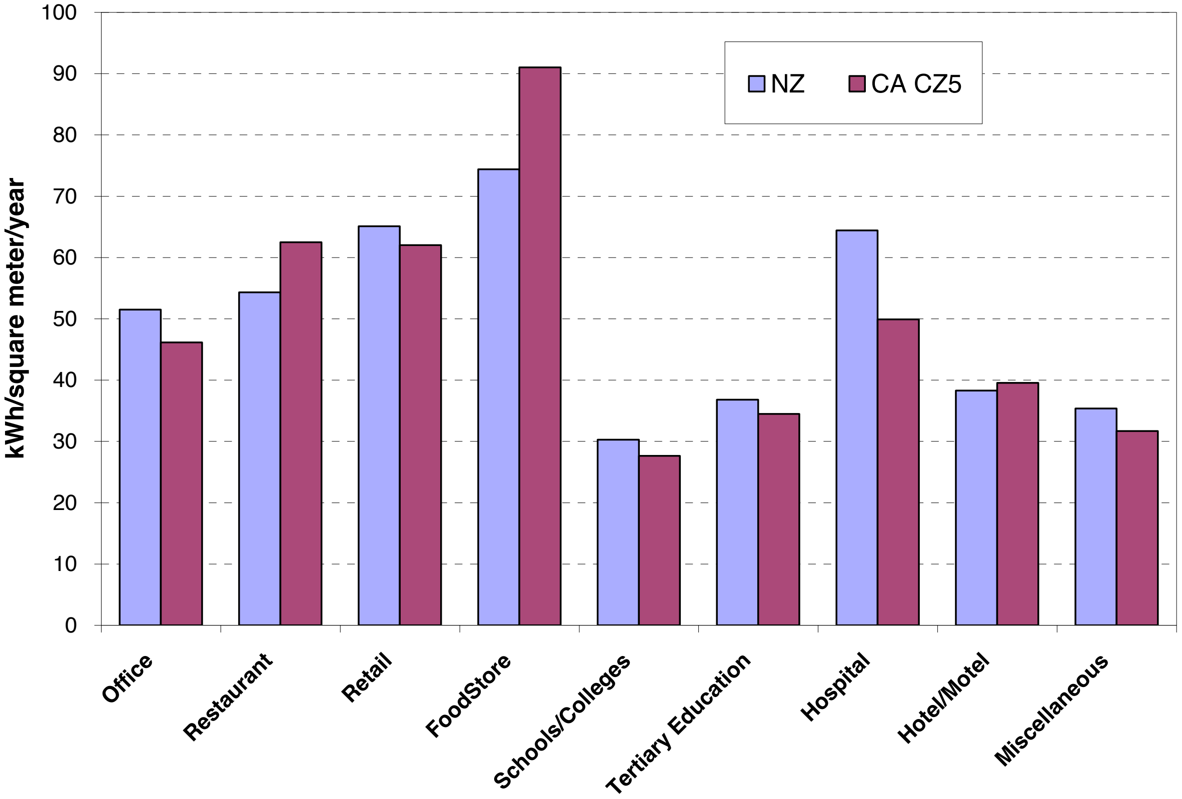


It is important to note that the heating and cooling EUIs shown in Figure 30 are "diversified" EUIs, i.e. they reflect the mix of heating and cooling technologies currently installed in New Zealand based on estimated EUIs for each base technology (e.g. split systems, reheat coils, or fan heaters) and the shares of each base technology shown previously in Figure 28 and Figure 29.

For commercial lighting, we decided to develop bottom-up EUI estimates rather than directly adopt EUIs from the California CEUS due to known significant differences in the design and performance of fluorescent ballasts in New Zealand that stem from higher line voltages. We began by constructing estimates of equivalent lighting power densities (W/m^2) for each main lighting technology in New Zealand based on the following data: 1) installed lighting power density by building type from CEUS climate zone 5, 2) estimates of average fixture wattages for each main lighting technology provided by the LESG, and 3) estimates of the average light output (lumens/lamp) for each main lighting technology as reported in the *Advanced Lighting Guidelines* (New Buildings Institute, 2003). Combining these estimates with estimated annual lighting hours for each building type (derived from the commercial end-user survey) then produces EUI estimates for each main lighting technology in each building type. Applying the self-reported shares of commercial lighting technologies (shown previously in Figure 27) to our respective EUI estimates allows us to benchmark the total estimated EUI for commercial lighting in New Zealand against the estimated value in California.

Figure 31 below shows this comparison.

Figure 31
Lighting EUIs Developed for New Zealand's Commercial Sector
Compared to Estimates for California Climate Zone 5
(San Francisco Bay Area)



As the figure shows, the total estimated lighting EUIs are 5-10 percent higher, in general, across commercial building types than those in California climate zone 5. These results are consistent with the higher lighting power density limits in the New Zealand Building Code (18 W/m^2) compared to those in California's Title 24 building standards for most commercial building types (11-15 W/m^2).[14]

For office equipment, we developed EUIs based on the self-reported densities of office equipment (units/m^2) from the commercial end-user survey and recent unit energy consumption (UEC) estimates

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[14] The exceptions are retail and wholesale showrooms, which are allowed 18 W/m^2, and museums & exhibition halls, which are allowed 21.5 W/m^2 (CEC, 2005).

(kWh/unit) developed by TIAX for the US DOE's Building Technologies Program.[15] Combining these two sets of data produces EUI estimates for each main category of office equipment in each commercial building type.

3.4.5 End-use Load Shapes

The KEMA team was unable to identify any comprehensive source of end-use load shapes for commercial buildings in New Zealand. To address this data gap, we again leveraged the results of the California CEUS study for climate zone 5, which include estimates of hourly demand by end use, building type, and climate zone for all hours of the year. In order to properly apply this load shape data to New Zealand buildings, however, we first mapped the CEUS data to correspond to New Zealand seasons and TOU definitions based on monthly heating and cooling degree-day (CDD) data for climate zone 5 and New Zealand's major population centres. The resulting mapping is summarized below in Table 14.

Table 14
New Zealand Mapped to California TOU Periods

	NZ TOU Period:	Equivalent CA CEUS Period:
Summer	October 1 – April 30	April 1 – October 31
Winter	May 1 – September 30	November 30 – March 31

Using this mapping, we then calculated the share of annual electricity consumption in each TOU period (winter peak, winter off-peak, summer peak, and summer off-peak) for each end use in each building type. These shares are shown in Appendix F. We also calculated the ratio of average demand during the winter peak period to the demand at the system peak hour for each end use in order to properly attribute avoided cost benefits for efficiency measures that reduce coincident peak demand. These ratios are also shown in Appendix F.

3.4.6 Measure Data

Having established the baseline data for New Zealand's commercial sector, the final key inputs required for potential modelling are the data that describe the costs, energy savings, and current saturation of the efficiency measures being considered.

For this study, we developed an initial list of efficiency measures for inclusion in the forecast based on past potential studies for other utilities in the U.S. We then shared this list with members of the Electricity Commission during the early stages of the project. Based on feedback received from the Electricity Commission and the KEMA team, we produced a revised measure list. The final list of efficiency measures considered in the study is shown in Appendix A along with brief descriptions of how each measure produces energy savings.

For each of the efficiency measures on the final measure list, we then compiled corresponding measure cost data. During the initial phases of this project, the KEMA team was unable to identify any

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[15] See *Energy Consumption by Office and Telecommunication Equipment in Commercial Buildings, Volume I: Energy Consumption* (TIAX, 2002) and *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings, Volume II: Energy Savings Potential* (TIAX, 2004).

comprehensive sources of measure costs for the commercial sector in New Zealand.[16] To address this data gap, the ideal solution is to conduct measure cost studies. However, such studies are expensive and time-consuming efforts that extend well beyond the budget and time constraints of this study. In the absence of jurisdiction-specific measure cost studies, one low-cost option often employed for potential studies of U.S. utilities is to leverage the DEER developed jointly by the California Public Utilities Commission and the California Energy Commission. The DEER database contains average cost and energy savings data for over 250 energy-efficiency measures currently available in the California market. Using DEER measure cost data exclusively in this study, however, no doubt introduces significant bias to the analysis of energy-efficiency potential in New Zealand. In order to minimize such bias, we developed New Zealand-specific measure cost estimates for the most important commercial end uses and measures (i.e. lighting and space heating) wherever feasible within the constraints of this study and used DEER as the basis for all other measure cost estimates.

For lighting, we solicited estimates of the average costs of prototypical commercial lighting technologies directly from members of the LESG. For split-system heat pumps, we used the incremental cost assumptions that were developed to assess the cost-benefit impacts of the (then proposed) 2005 MEPS.[17] For space heating and air-conditioning control measures, estimates of measure costs were provided by Energy Solutions, an energy engineering consultancy based in Wellington and member of the KEMA team for this study. The full set of measure cost data used in this study is shown in Appendix B on the Measure Costs pages.

For measure savings, we used a parallel approach – we developed New Zealand-specific savings estimates for lighting and space heating measures wherever feasible and used DEER as the basis for all other measure cost estimates. For lighting, we solicited estimates of the average wattages of prototypical commercial lighting technologies directly from members of the LESG. For split-system heat pumps, packaged DX, and window air-conditioners, we calculated savings from more efficient units based on differences in the rated Energy-efficiency Ratio (EER) of units that comply with MEPS minimum EER levels and highest-efficiency units currently available in the New Zealand market. For all other measures in this study, we used DEER as the basis for measure savings estimates, with some adjustments based on the experience of Energy Solutions' engineering team with specific measures in New Zealand. The measure savings rates used in this study are shown in Appendix B on the Energy Savings pages.

Finally, we compiled estimates of the current saturation of efficiency measures in New Zealand's commercial sector. For most commercial measures, we drew directly from the results of the surveys of commercial end users and equipment vendors to estimate current measure saturations. For equipment types that are regulated under MEPS, we leveraged data on sales volumes and energy consumption characteristics provided by EECA to estimate saturations of HE split-system heat pumps, packaged DX, window air-conditioners, and electric storage water heaters. The key measure saturation estimates used in this study are shown in Appendix B on the Incomplete Factor pages and are summarized in Figure 32 and Figure 33 below.[18]

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[16] The KEMA team identified an EECA database of energy-efficiency audits as one potential source of measure cost, savings, and penetration data. However, the EECA audit database contains information only at the facility level. In other words, it does not contain specific measures, costs, or savings for specific end uses and efficiency measures.

[17] A 10 percent increase in efficiency is assumed to be accompanied by 2.5 percent increase in purchase cost (Syneca Consulting, 2004). This assumption is based on a detailed review of engineering studies conducted for Australian and US heat pump efficiency standards.

[18] Note that in the potential modeling, 'incomplete factors' are calculated as one minus the measure saturation.

Figure 32
Self-Reported Saturation of Key Commercial Energy-efficiency Measures

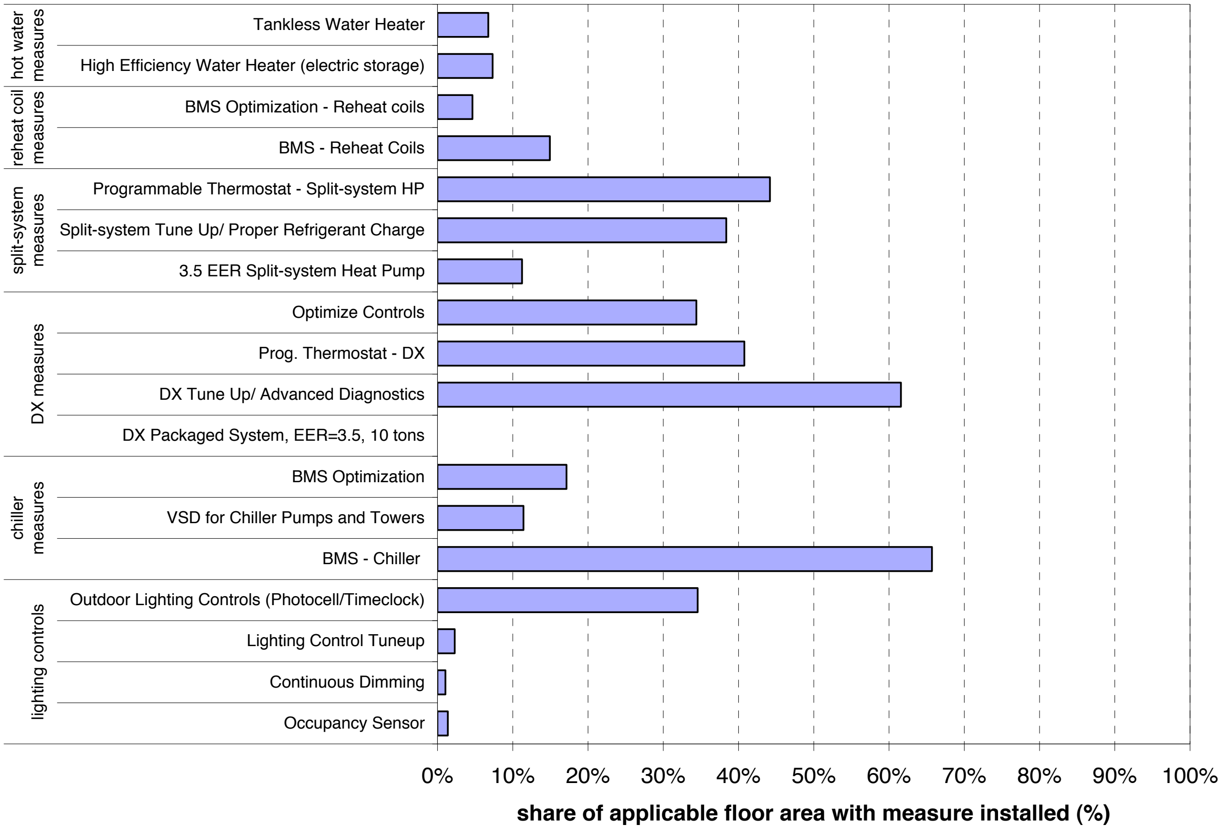
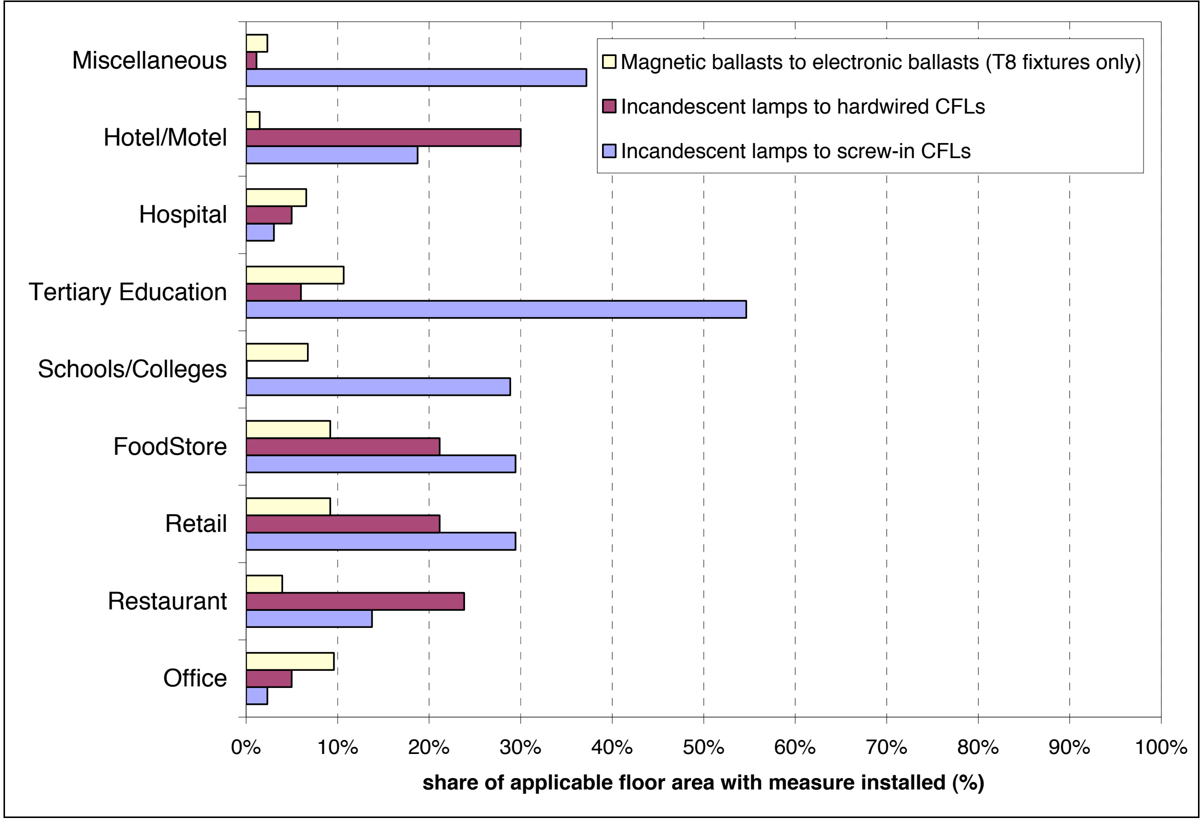


Figure 33
Self-Reported Saturation of Key Efficient Lighting Technologies by Commercial Building Type



3.4.7 Commercial New Construction

In the commercial new construction analysis, we sought to take into account differences in the nature of efficiency opportunities between existing and new commercial buildings. In existing commercial buildings, efficiency opportunities mostly take the form of retrofitting or replacing individual end-use technologies (e.g., high efficiency packaged DX units) or individual components of end-use systems (e.g., variable-speed drives and pumps). In contrast, the most significant efficiency opportunities in new commercial buildings often involve integrating and optimizing multiple end-uses during the design and commissioning phase (e.g., integrated cooling and ventilation strategies). These approaches effectively bundle multiple measures. To take this practice into account, we modelled two different design "packages" each for lighting systems, HVAC systems, and refrigeration systems, respectively, in our commercial new construction forecasts.

In order to correctly model these design packages for new construction, we first needed to estimate baseline EUIs at aggregation levels that align with the costs of and savings derived from such packages. Starting with the technology-level EUIs developed for existing buildings (e.g. T8 fixtures and split-system heat pumps), we estimated EUI estimates for total lighting and total HVAC using EUI adjustment factors and technology shares developed from the results of the market actor surveys. The EUI adjustment factors describe the share of HE equipment currently being installed in new commercial buildings and the energy use of such equipment relative to the base-efficiency technology. The technology shares describe the relative share of technologies within each end use that are currently being installed in new buildings (e.g. share of electronic versus magnetic ballasts and the share of split-system heat pumps versus electric resistance reheat coils). We then needed to recalculate the end-use load shapes for the aggregate HVAC end use. This was accomplished by simply summing the hourly demand data for HVAC for CEUS climate zone 5 and recalculating the TOU period shares and system peak factors using this aggregated data set. Finally, we produced incremental cost estimates based on data developed in previous potential studies.

3.5 Industrial

During the data identification stage of the project determined that there were limited industrial data available for the assessment of energy-efficiency potential. Key New Zealand data elements that were available and used for this project included:

- The New Zealand Energy Data File (MED, 2006) that reported retail energy sales by ANZSIC category; and
- The Electricity Commission's CDS that reported half-hourly load data for each grid exit point for the January 2003 through March 2006 period.

Given the limited information on industrial end use consumption and energy efficiency in New Zealand, we relied significantly on several U.S. data sources to provide initial approximations for the New Zealand industrial sector:

- The USDOE's 1998 Manufacturing Energy Consumption Survey (MECS 1998) provided data on end use energy consumption shares by industry. These data was modified somewhat for New Zealand industry using summarized audit data provided by Energy Solutions.
- The 1998 MECS end use share data for motors was further disaggregated into compressed air, pumping, fans, and other drives using data from the USDOE Motors Assessment Study (USDOE 1998a).
- An industrial energy-efficiency dataset provided by Lawrence Berkeley Nation Laboratory (LBNL) that provided various industry and measure-specific attributes (feasibility, saturation, cost, and savings). This industrial dataset was developed from numerous data sources to provide a world-wide characterization of industrial energy-efficiency.

In order to provide more New Zealand-specific estimates of energy-efficiency potential, Energy Solutions conducted one-day walk through surveys of 10 large industrial facilities. From these surveys, key model parameters, measure feasibility and current measure saturation, were refined for the analysis. Additionally, a telephone survey of 13 motor rewinders and distributors was conducted to develop measure costs for motor replacement measures as compared to motor rewinding.

3.5.1 Baseline End Use Consumption and Peak Demand

Electricity consumption for the industrial sector was extracted from the New Zealand Energy Data File and adjusted to the 2005 SOO demand forecast as discussed above. We then removed several industrial usage categories that were outside of the scope of the DSM ASSYST analysis framework.[19] Finally end use share estimates were applied, by industry, to the total usage in each industry to provide end consumption estimates. As discussed above, U.S. data were utilized for the end use shares, with New Zealand adjustments made where data were available for the Food, Paper, Chemicals, and Metals industries.

There were no readily available load shape data to derive peak demand estimates by industry and end use. To estimate peak demand, grid exit point data associated with the larger industrial loads from the Electricity Commission's CDS were analyzed to develop approximate industrial load shapes. Industry-specific load shapes estimates were developed for the following industries: Aluminium, Cement, Chemicals, Dairy, Food, Irrigation, Mining, Paper, Steel, Wood, Wastewater (WW) Treatment, and Oil Refining. For the remaining industries, a general industrial load shape was developed. The estimated load shapes were then applied to each end use in a given industry. Given the lack of information on end-use-specific load shapes, the industry-specific load shapes were applied to all end uses in a given industry.

Figure 34 summarizes industrial electric energy consumption and peak demand by industry type. The aluminium industry accounts for the largest single share of electric energy usage and peak demand. Steel, paper, dairy, food processing, wood, and agriculture also account for significant shares of industrial electric energy usage and peak demand.

Figure 35 shows energy consumption and peak demand estimates by industrial end use. Process Other accounts for the largest single share of energy consumption. This end use is dominated by the aluminium manufacturing process. The next largest end uses in terms of energy consumption and peak demand are process drives and pumping systems The process drives end use includes motor-driven systems for materials handling (conveyor belts, lifts, etc.) and materials processing (grinding, crushing, cutting, moulding, mixing, extruding, etc.)..

Table 15 provides energy usage and peak demand estimates by industry and end use. Process drives include all motor driven machinery associated with industrial process (such as conveyor belts and lifts).

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[19] These industries include: Forestry and Logging (A03), Commercial Fishing (A04), Coal Mining (B11), Oil and Gas Extraction (B12), Electricity Supply (D361), Gas Supply (D362), and Construction (E). These sectors accounted for 3.8 percent of the total annual industrial electricity consumption.

Figure 34
Industrial Electricity Usage by Industry Type

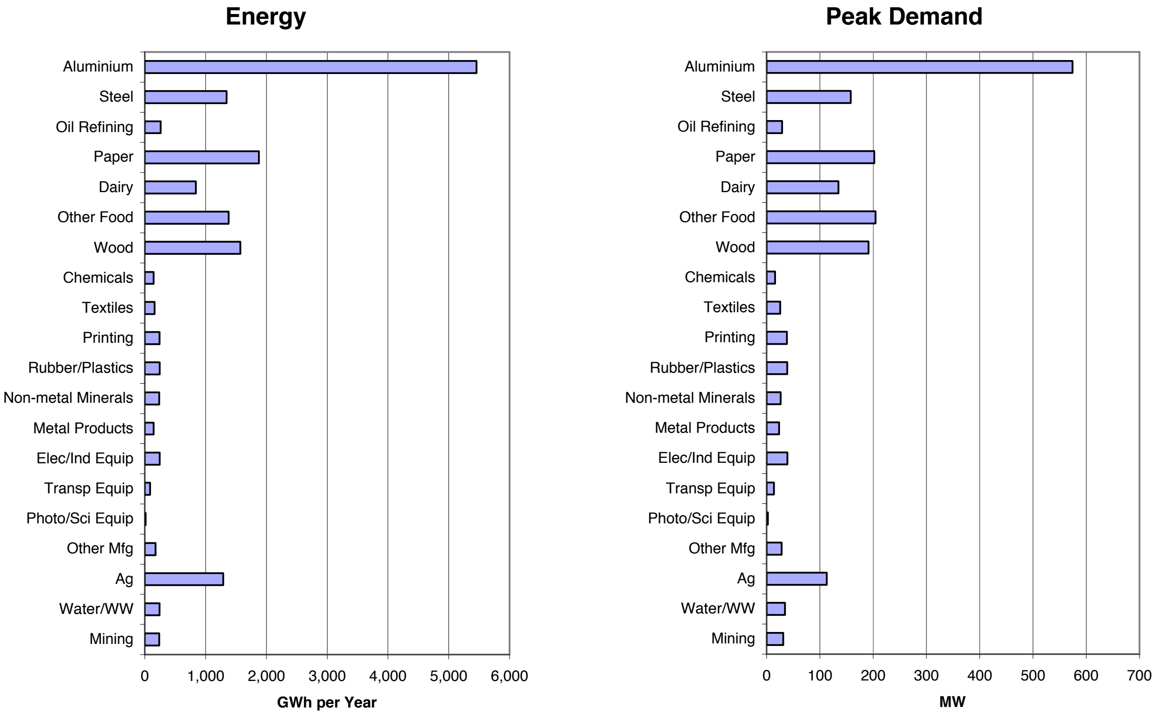

Figure 35
Industrial Electricity Usage by End Use

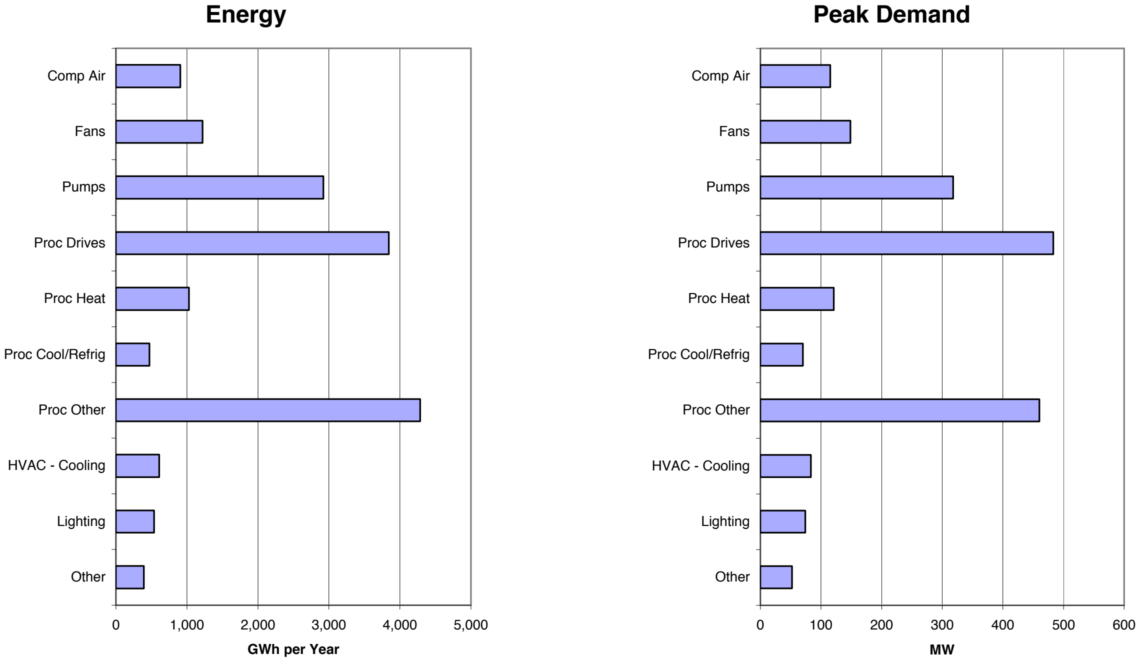

Table 15
Industrial Electricity Consumption by Industry Type and End Use (MWh/Year)

Industry	Comp Air	Fans	Pumps	Proc Drives	Proc Heat	Proc Cool/ refrig	Proc Other	HVAC - Cool	Lighting	Other	Total
Aluminium	101,945	109,074	62,022	425,602	627,687	5,458	3,902,575	98,247	76,414	49,123	**5,458,147**
Steel	192,852	206,339	117,330	805,125	17,462	1,325	0	3,664	3,664	858	**1,348,618**
Oil Refining	34,181	21,224	132,082	36,384	5,218	12,002	0	9,132	7,567	2,609	**260,401**
Paper	86,379	371,806	589,632	538,932	25,787	9,377	199,048	17,582	16,996	22,857	**1,878,396**
Dairy	64,752	63,071	137,914	270,783	21,831	127,512	56,343	34,235	32,250	32,746	**841,437**
Other Food	106,131	103,374	226,044	443,819	35,781	208,995	92,347	56,111	52,859	53,672	**1,379,132**
Wood	95,634	176,808	50,065	756,526	94,239	14,136	3,141	124,081	130,363	127,222	**1,572,214**
Chemicals	41,157	17,681	38,631	37,146	1,030	4,771	2,674	3,364	1,819	309	**148,583**
Textiles	13,397	14,971	14,160	43,508	8,163	11,101	653	26,937	19,101	11,265	**163,255**
Printing	8,299	18,099	1,595	85,213	7,983	12,337	968	44,992	51,282	11,127	**241,894**
Rubber/Plastics	16,748	7,241	32,361	72,275	39,765	20,374	2,209	19,637	24,546	10,555	**245,710**
Non-metal Minerals	35,381	35,756	5,626	62,760	56,428	6,905	476	11,190	13,095	10,714	**238,330**
Metal Products	17,622	6,059	8,955	39,718	22,537	2,817	7,710	14,678	21,795	6,524	**148,415**
Elec/Ind Equip	17,278	1,924	44,413	12,453	37,786	20,136	11,932	54,690	33,311	14,667	**248,589**
Transp Equip	6,778	7,875	6,776	14,862	8,586	3,718	3,718	15,490	14,073	6,550	**88,423**
Photo/Sci Equip	549	983	451	2,954	1,691	876	362	3,730	2,778	740	**15,115**
Other Mfg	20,346	7,496	9,995	37,123	18,383	9,638	1,963	30,162	28,377	14,992	**178,474**
Agriculture	0	0	1,293,758	0	0	0	0	0	0	0	**1,293,758**
Water/WW	36,509	36,509	124,132	0	0	0	0	36,509	4,868	4,868	**243,396**
Mining	11,937	16,138	27,352	159,431	0	0	0	5,968	5,968	11,937	**238,731**
Other - (not in study)											**635,649**
Total	**907,875**	**1,222,427**	**2,923,296**	**3,844,611**	**1,030,355**	**471,476**	**4,286,121**	**610,399**	**541,127**	**393,333**	**16,866,669**

Table 16
Industrial Peak Demand by Industry Type and End Use (MW)

MW	Comp Air	Fans	Pumps	Proc Drives	Proc Heat	Proc Cool/refrig	Proc Other	HVAC - Cool	Lighting	Other	Total
Aluminium	10.7	11.5	6.5	44.8	66.0	0.6	410.6	10.3	8.0	5.2	**574.3**
Steel	22.6	24.2	13.7	94.3	2.0	0.2	0.0	0.4	0.4	0.1	**158.0**
Oil Refining	3.8	2.4	14.8	4.1	0.6	1.3	0.0	1.0	0.8	0.3	**29.2**
Paper	9.3	40.0	63.4	58.0	2.8	1.0	21.4	1.9	1.8	2.5	**202.1**
Dairy	10.4	10.1	22.2	43.5	3.5	20.5	9.1	5.5	5.2	5.3	**135.2**
Other Food	15.7	15.3	33.5	65.8	5.3	31.0	13.7	8.3	7.8	8.0	**204.4**
Wood	11.6	21.5	6.1	92.1	11.5	1.7	0.4	15.1	15.9	15.5	**191.5**
Chemicals	4.5	1.9	4.2	4.1	0.1	0.5	0.3	0.4	0.2	0.0	**16.2**
Textiles	2.1	2.4	2.2	6.9	1.3	1.8	0.1	4.3	3.0	1.8	**25.9**
Printing	1.3	2.9	0.3	13.5	1.3	2.0	0.2	7.1	8.1	1.8	**38.3**
Rubber/Plastics	2.7	1.1	5.1	11.5	6.3	3.2	0.3	3.1	3.9	1.7	**38.9**
Non-metal Minerals	3.9	4.0	0.6	7.0	6.3	0.8	0.1	1.2	1.5	1.2	**26.5**
Metal Products	2.8	1.0	1.4	6.3	3.6	0.4	1.2	2.3	3.5	1.0	**23.5**
Elec/Ind Equip	2.7	0.3	7.0	2.0	6.0	3.2	1.9	8.7	5.3	2.3	**39.4**
Transp Equip	1.1	1.2	1.1	2.4	1.4	0.6	0.6	2.5	2.2	1.0	**14.0**
Photo/Sci Equip	0.1	0.2	0.1	0.5	0.3	0.1	0.1	0.6	0.4	0.1	**2.4**
Other Mfg	3.2	1.2	1.6	5.9	2.9	1.5	0.3	4.8	4.5	2.4	**28.3**
Ag	0.0	0.0	113.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**113.0**
Water/WW	5.2	5.2	17.7	0.0	0.0	0.0	0.0	5.2	0.7	0.7	**34.7**
Mining	1.6	2.1	3.6	21.0	0.0	0.0	0.0	0.8	0.8	1.6	**31.4**
Other - (not in study)											**100.7**
Total	**115.4**	**148.5**	**318.3**	**483.4**	**121.1**	**70.4**	**460.2**	**83.5**	**74.1**	**52.3**	**2,028.0**

3.5.2 Measure Data

Given the limited availability of measure data (costs, savings, feasibility, and current saturations) for this study, we relied significantly on industrial energy-efficiency potential developed by Lawrence Berkeley National Laboratory (LBNL). Key New Zealand-specific measure data that were developed for the study include motor replacement costs (based on a telephone survey of rewinders and distributors) and measure feasibility and saturation data that were developed from focused on-site surveys of 10 industrial facilities by Energy Solutions. In addition, measure costs and savings parameters that were developed for the commercial analysis were also utilized in the industrial analysis.

Measure costs (excluding motor replacement, HVAC, and lighting measures), on a dollar per base kWh basis, were taken from recent U.S. work, but were escalated 10 percent to cover general price increases over the past few years and to cover expected price premiums that face New Zealand due to factors such as transport costs. An exchange rate of $0.65 US dollars per New Zealand dollar was also applied to the U.S. measure costs.

Measure data is provided in Appendix E.

4. Technical and Economic Potential Results

In this section, we present estimates of electric energy-efficiency potential. Technical potential assesses the potential for savings for all measures (commercially available) based on the applicability of this measure in the New Zealand market. In general terms, applicability refers to the population that uses that electric end-use, does not currently have the energy-efficiency measure installed, and for which it is feasible to install it. The economic potential assesses the measures included in the technical potential for cost effectiveness. In this study we used the TRC to assess cost effectiveness.

The potential estimates do not account take-back[20], as we hold levels of energy-efficiency services constant before and after installation of measures. Take-back (sometimes referred to as snap-back or rebound) occurs when an end user installs an energy-efficiency measure, realizes a lower cost for the service (such as heating), and as a result purchases more of that energy service.

By excluding take-back effects we more accurately reflect the full benefits to society of installing energy-efficiency measures. All benefits show up as avoided cost savings. If savings were reduced to account for take-back, the benefits of increased energy services received as part of the take-back are not included in the benefit-cost calculation and energy efficiency would be undervalued. Because we do not account for take- back, however, achievable programme potentials, in terms of kWh and kW, might be somewhat overstated. Take-back will most likely affect residential heating the most, followed by water heating and lighting.

Estimates of overall electric energy-efficiency *technical* and *economic* potential are discussed in Section 4.1. Next, in Section 4.2 we discuss technical and economic potential by sector, followed by economic potential by sector and end-use in Section 4.3. Overall energy-efficiency supply curves are shown in 4.4.

4.1 Overall Technical and Economic Potential

Figure 36 presents our overall estimates of total technical and economic potential for electrical energy and peak-demand savings for New Zealand. *Technical potential* represents the sum of all savings from all the measures deemed applicable and technically feasible. *Economic potential* is based on efficiency measures that are cost-effective based on the TRC test—a benefit-cost test that compares the value of avoided energy production and power plant construction to the costs of energy-efficiency measures and programme activities necessary to deliver them. The values of both energy savings and peak-demand reduction are incorporated into the TRC test.

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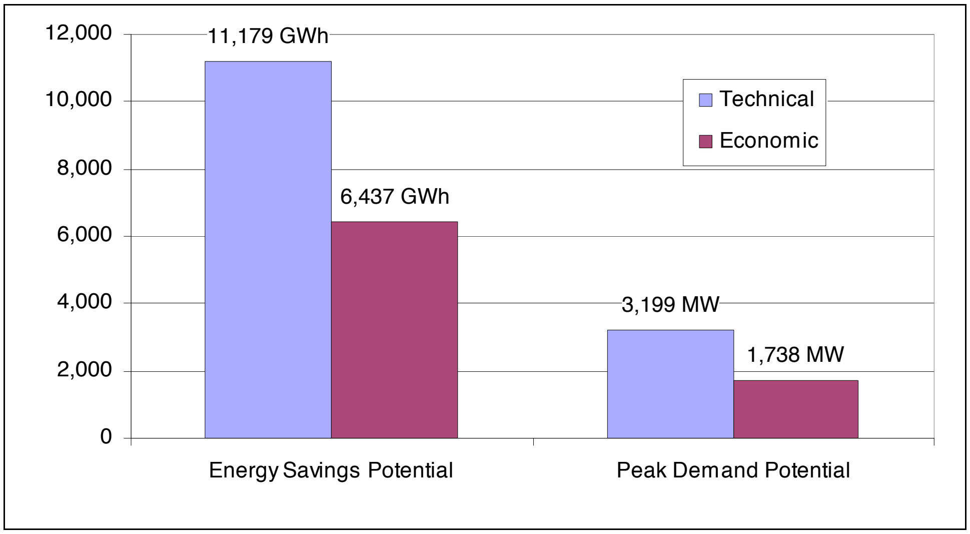
[20] We did account for take-back in baseline energy estimates for heat pumps in new construction, as discussed in Section 3.3.1.

Figure 36
Total Estimated Electric Technical and Economic Potential, 2016



Energy Savings. Technical potential is estimated at about 11,179 GWh per year and economic potential is 6,437 GWh per year by 2016. This represents approximately 23 and 14 percent of projected base 2016 energy usage, respectively.

Peak-Demand Savings. Technical potential is estimated at about 3,199 MW and economic potential is 1,738 MW by 2016. This represents approximately 39 and 21 percent of projected base 2016 peak demand, respectively.

4.2 Technical and Economic Potential by Sector

Figure 37 and Figure 38 show estimates of technical and economic energy and peak demand savings potential by sector. Figure 39 and Figure 40 show the same potentials as a percentage of 2016 base energy and base peak demand.

The residential sector provides the largest contribution to both technical and economic potential for energy savings, accounting for 62 percent of technical and 41 percent of economic potential. The residential sector also contributes most to the technical and economic potential for peak demand savings, accounting for 82 and 71 percent respectively.

Figure 37
Technical and Economic Potential (2016)
Energy Savings by Sector – GWh per year

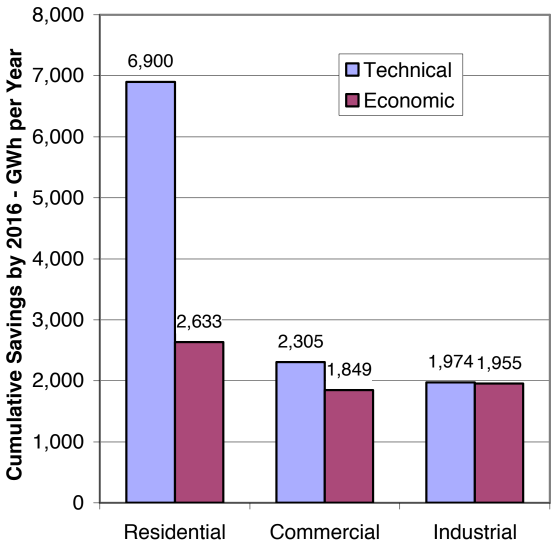
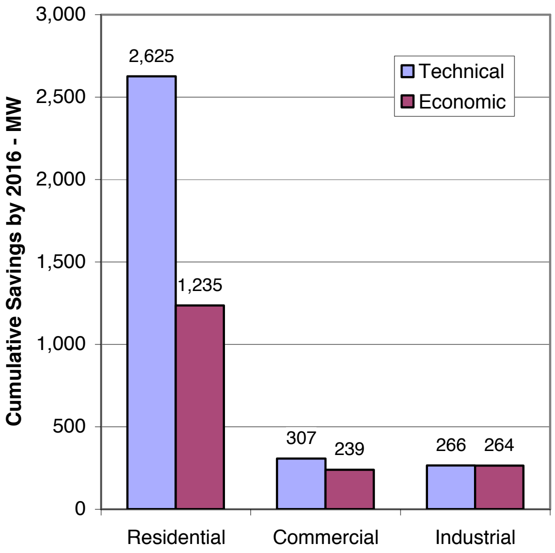


Figure 38
Technical and Economic Potential (2016)
Peak Demand Savings by Sector- MW



The residential figures show substantial differences between technical and economic potential for both energy and peak demand savings. This is a function of two factors. First, we included switching to gas for cooking, space and water heating in the technical potential numbers. The technical potential for this switch is substantial, since it results in eliminating all electric consumption for these end-uses. The economic potential for switching to gas proved to be zero, substantially reducing the potential for electric savings. Second, residential technical potential relative to economic potential for the residential sector is often high when compared to other sectors. In New Zealand this is especially true for space heating (including building envelope improvements) due to the mild heating climate, and for appliances, for which there are relatively high standards, low usage habits, and estimated high incremental costs.

Figure 39
Technical and Economic Potential (2016)
Percentage of Base Energy Use

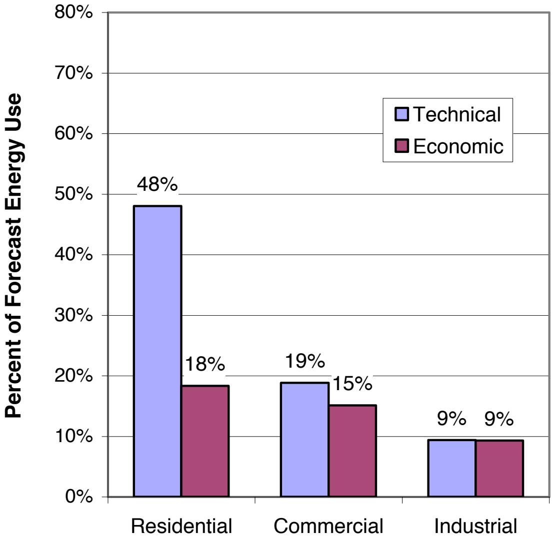
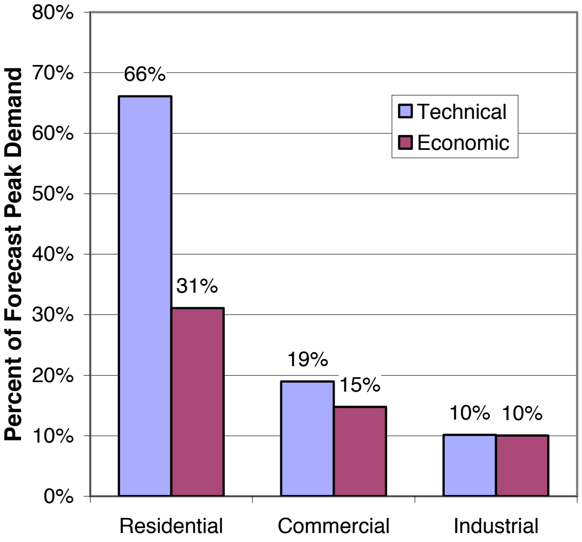


Figure 40
Technical and Economic Potential (2016)
Percentage of Base Peak Demand



4.3 Economic Potential by End-Use

Figure 41 and Figure 42 show the end-use breakdown for economic potential in the residential sector. Most of the energy savings potential is in heating and lighting end uses, followed by water heating and towel rack timers. Heating and lighting also dominate the demand potential, with heating representing more than 50 percent of the potential for demand savings. The heating savings are attributable to a variety of energy-efficiency measures, including the installation of high efficiency heat pumps and wall and ceiling insulation. Efficient water heating and towel rack timers however, also represent substantial opportunities for energy savings. While we investigated a number of energy-efficient appliances in the study (refrigerators, freezers, and dishwashers), we did not find the higher efficiency models to be cost effective compared to models meeting minimum MEPS.

Figure 41
Residential Economic Energy Savings Potential by End Use (2016)

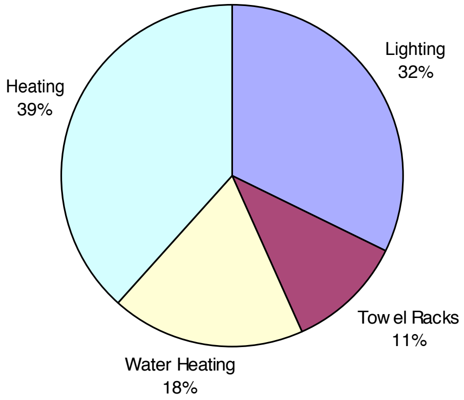


Figure 42
Residential Economic Peak Demand Savings Potential by End Use (2016)

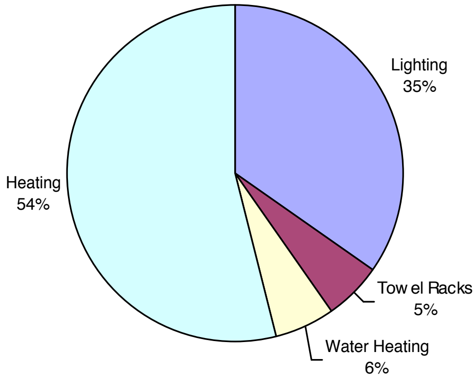


Figure 43 and Figure 44 show the end-use breakdown of economic potential in the commercial sector. As the figures show, the indoor lighting end use accounts for approximately half of the economic energy and peak demand savings potential in the commercial sector. The majority of economic potential from indoor lighting is attributable to CFL replacements for incandescent lamps, with smaller but significant economic potential provided by early replacement of remaining T12 linear fluorescent lamps with next generation T8 lamps and retrofitting magnetic ballasts with electronic ballasts. Figures 4-8 and 4-8 also show that the refrigeration and HVAC end uses each account for approximately one fifth of the economic energy and peak demand savings potential in the commercial sector. Within these end uses, the important measures include HE split-system heat pumps, HE packaged DX systems, HE fan motors and anti-sweat (humidistat) controls for commercial refrigeration systems.

Figure 43
Commercial Economic Energy Savings Potential by End Use (2016)

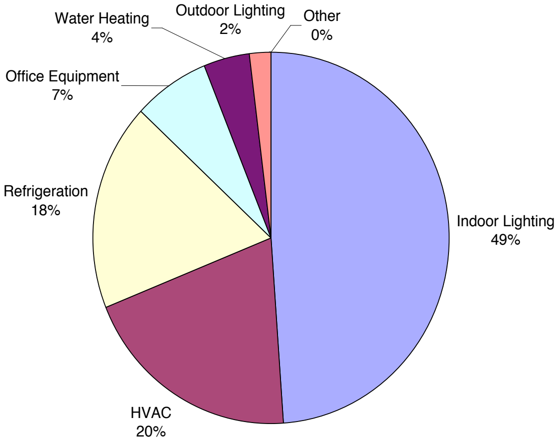


Figure 44
Commercial Economic Peak Demand Savings Potential by End Use (2016)

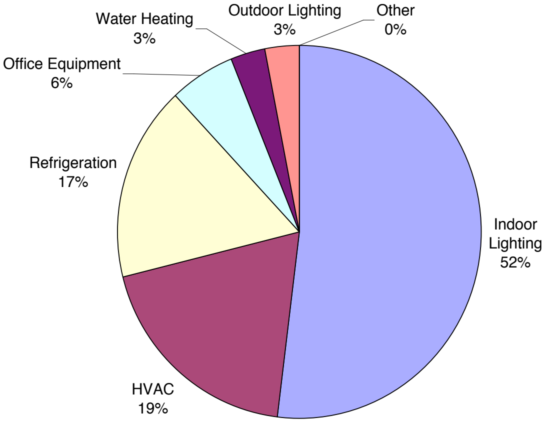


Figure 45 and Figure 46 show the end-use breakdown of industrial economic potential. Pumping system measures provide the largest source of economic potential, followed by fans, drives, and compressed air. These are all motor driven systems that also comprise a very large share of industrial energy usage. Key measures that contribute to industrial economic potential include motor replacement (versus rewinding), installation of controls, and system optimization.

The end use shares do not vary much between energy and peak demand potentials. This is because the industrial load shapes used for the analysis are the same, in a given industry, for all end uses. Slight variations between peak and energy shares occur because some measures contribute differently towards energy savings versus peak demand savings. The same facility load shapes were applied to all end uses because of the lack of end-use specific shapes. This approach was deemed reasonable because there are limited weather-sensitive loads in the industrial sector, which would cause larger variations in the HVAC end use, and the industrial facilities seem to have fairly high operating levels throughout the day.

Figure 45
Industrial Economic Energy Savings Potential by End Use (2016)

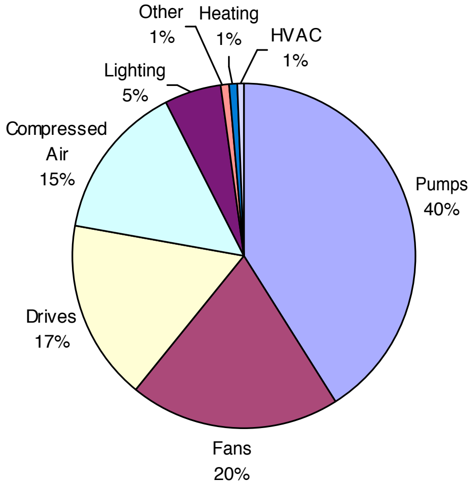
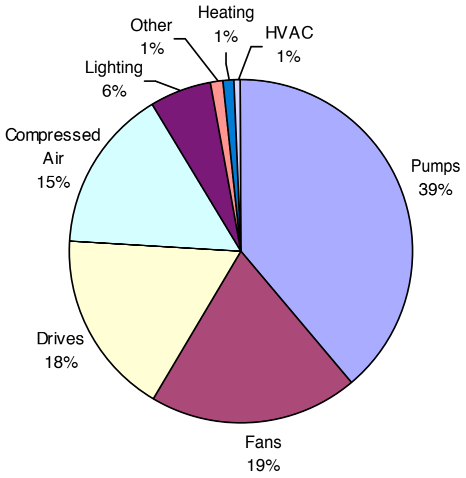


Figure 46
Industrial Economic Peak Demand Savings Potential by End Use (2016)



4.4 Energy-Efficiency Supply Curves

A common way to illustrate the amount of energy savings per dollar spent is to construct an energy-efficiency supply curve. A supply curve typically is depicted on two axes—one captures the cost per unit of saved electricity (e.g. levelized $/kWh saved) and the other shows energy savings at each level of cost. Measures are sorted on a least-cost basis, and total savings are calculated incrementally with respect to measures that precede them. The costs of the measures are levelized over the life of the savings achieved.

Figure 47 and Figure 48 present the New Zealand supply curves for energy and peak demand savings, respectively. Each curve represents savings as a percentage of total energy or peak demand. These curves show that energy savings of about 12 percent are available at or below $0.10 per kWh and peak demand savings of about 20 percent are available at or below $100 per kW. Savings potentials and levelized costs for the individual measures that comprise the supply curves are provided in Appendix G.

Figure 47
Energy Supply Curve

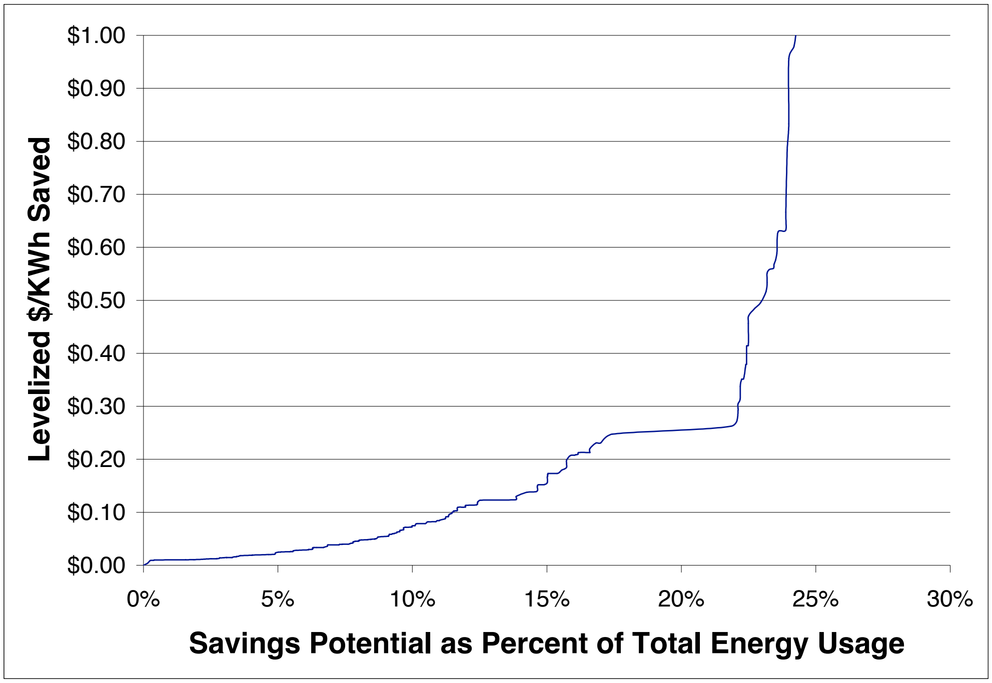
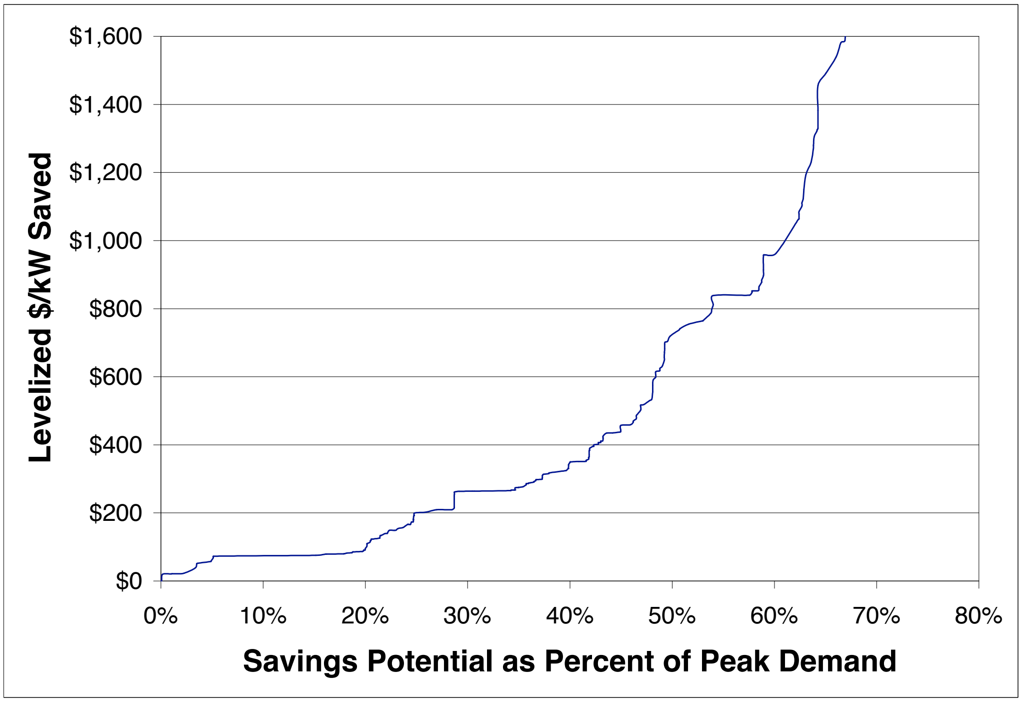


Figure 48
Peak Demand Supply Curve



5. Achievable (Program) Potential

This section presents results for achievable potential. In contrast with technical and economic potential estimates, achievable potential estimates account for market and other factors that affect adoption of efficiency measures. We estimate achievable potential for only those measures that passed the economic screening and described in Section 4. Our method of estimating measure adoption takes into account market barriers and reflects actual consumer- and business-implicit discount rates. More detail on achievable programme potential is show in Appendix H.

Achievable potential refers to the amount of savings that would occur in response to one or more specific programme interventions. *Net* savings associated with programme potential are savings that are projected beyond those that would occur naturally in the absence of any market intervention. Because achievable potential depends on the type and degree of intervention applied, we developed potential estimates under alternative funding scenarios.

We refer to the funding scenarios as the 33, 50 and 75 percent incentive funding levels. These scenarios reflect the percent of incremental measure cost that is assumed to be paid in customer incentives. The 33 percent scenario is based upon the EC approved budget for energy-efficiency programmes of approximately $13 million per year. Thus, this scenario represents what is achievable under current funding levels. Descriptions of the funding scenarios provided in Section 2.3 of this report are repeated for reader clarity.

Thirty-three-percent Incentive Scenario

In the 33-percent incentive scenario, base incentive levels are set to 33 percent of incremental measure costs. For example, if a high-efficiency water heater costs $125 more than a standard-efficiency water heater, a rebate of $42 would be available to end users in this scenario. In addition to incentives, marketing/customer education and programme administration budgets are set at amounts roughly corresponding to current programme support levels for existing programs (as planned or in early implementation stages) and at minimum levels for additional programs.

Fifty-percent Incentive Scenario

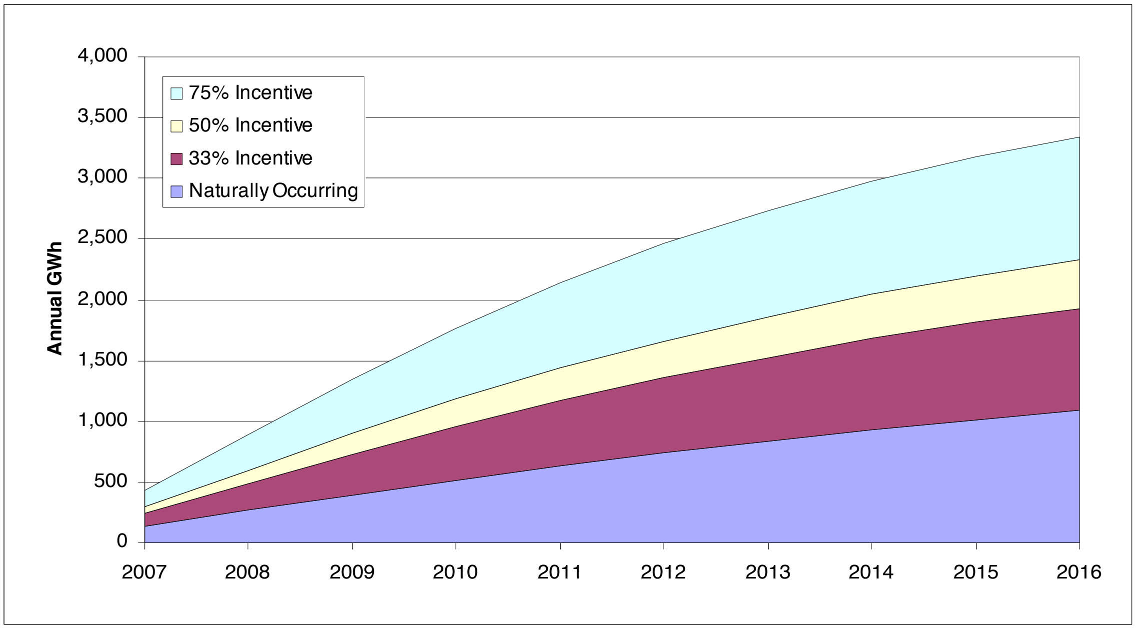
In this scenario, incentives were increased to cover 50-percent of incremental measure costs. Marketing/education budgets were also increased from the base amounts by 12.5 percent in years two and three, and held steady at the resulting higher amount (adjusted for inflation) for the rest of the analysis.

Seventy-five-percent Incentive Scenario

In this scenario, incentives were increased to cover 75-percent of incremental measure costs. Marketing/education budgets were also increased from the base amounts by 25 percent in years two and three, and held steady at the resulting higher amount (adjusted for inflation) for the rest of the analysis period.

Figure 49 and Figure 50 show our estimates of achievable potential savings and their effect on projected peak demand and energy consumption. Cumulative net[21] energy savings are projected to be 840 GWh under the 33 percent incentive scenario, 1,242 GWh under the 50 percent incentive scenario, and 2,255 GWh under the 75 percent incentive scenario. Figure 50 depicts projected net peak demand saving of 183 MW under the 33 percent incentive scenario, 271 MW under the 50 percent incentive scenario, and 470 MW under the 75 percent incentive scenario.

Figure 49
Achievable Energy Savings: All Sectors



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[21] Throughout this section, *net* refers to savings beyond those estimated to be naturally occurring; that is, from customer adoptions that would occur in the absence of any programs or standards.

Figure 50
Achievable Peak Demand Savings: All Sectors

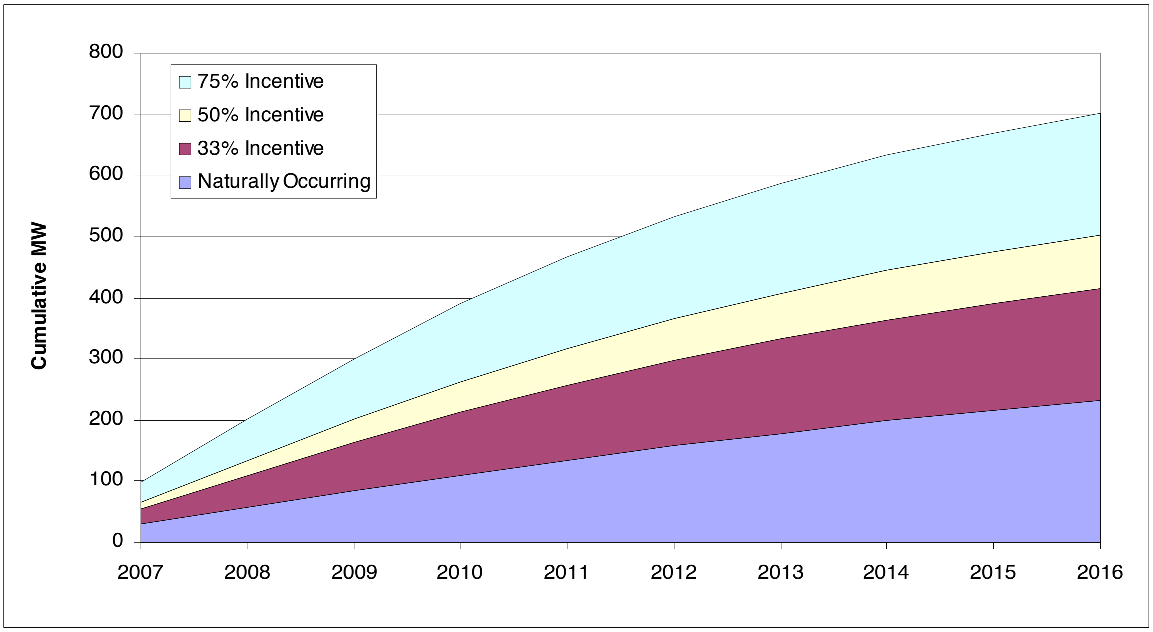


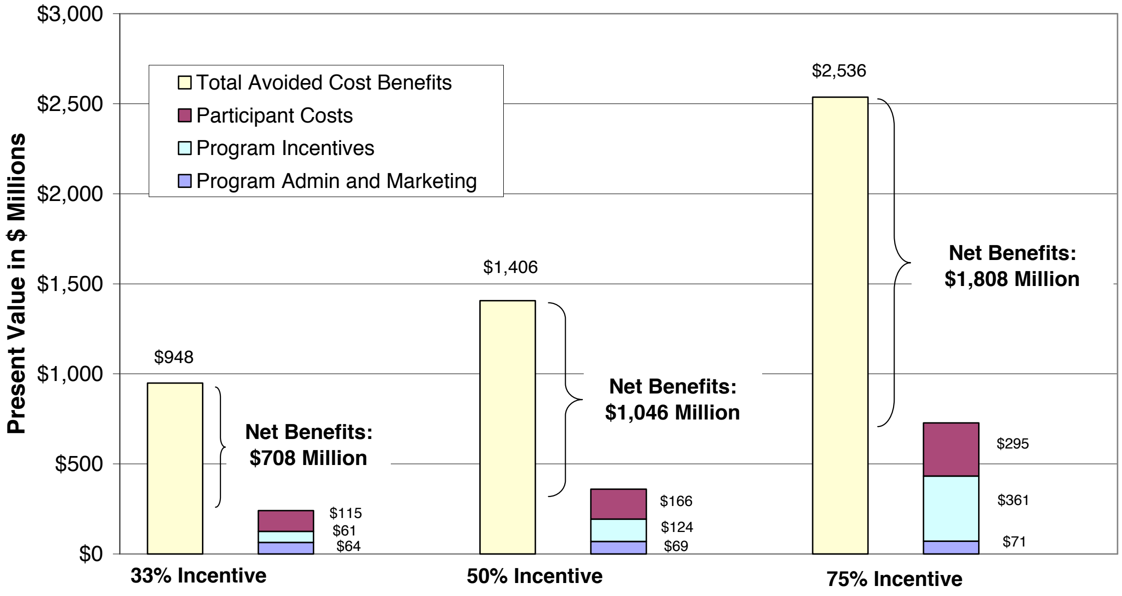
Figure 51 and Table 17 depict costs and benefits under each funding scenario for 2007 to 2016. All three funding scenarios are cost effective based on the TRC test, the test used in this study to determine programme cost effectiveness. The TRC benefit-cost ratio is 4.0 for the 33 percent scenario, 3.9 for the 50 percent scenario, and 3.5 for the 75 percent scenario. Programme cost-effectiveness declines somewhat with increasing programme effort, reflecting penetration of more measures with lower cost-effectiveness levels. This result reflects the assumption that the most cost-effective measures are targeted first, both by the programs and by end users who are seeking to lower their electricity bills in the most cost-effective manner.

The programme costs are the costs to the Electricity Commission for the program. These include administration, marketing/education and financial incentives to the customer. The present value of programme costs is $125 million under the 33 percent incentive scenario, $193 million under the 50 percent incentive scenario, and $432 million under the 75 percent incentive scenario. The present value of programme administration and marketing/education costs (considered programme overhead costs) is $64 million in the 33 percent incentives scenario, $69 million in the 50 percent incentives scenario, and $71 million in the 75 percent incentives scenario. The remainder of the programme costs are the incentive costs paid to programme participants to encourage investment in energy-efficiency measures. These incentive costs are transfer payments and do not affect the programme cost effectiveness calculations.

Participant costs are the costs born by the programme participants. They are calculated as the incremental costs associated with the high efficiency equipment minus the incentives paid by the program. These are added to the programme costs to capture all the costs associated with the installation of programme induced measures (generally, participant plus the Electricity Commission). Participant costs are $115 million for the 33 percent scenario, $166 million for the 50 percent scenario and $295 million for the 75 percent scenario.

The difference between the total avoided cost benefits and the programme and participant costs are the net benefits to society provided by the program. The net benefits are calculated based on the avoided cost of generation (based on energy saved) and the avoided cost of additional capacity (based on the peak demand savings). (Avoided cost assumptions are discussed in Section 3.1.1.) For all three scenarios the net benefits of the programs are substantial, ranging from $708 million to $1,808 million for the 10 year time frame, depending upon funding scenario. The net benefits improve substantially with larger incentives for two reasons. First, a greater percentage of the programme savings is attributable to the programme (a lower percentage of participants are those who are free-riders – naturally occurring savings). In other words, net savings per incentive dollar spent is higher. Second, the programme administrative and marketing costs go up only incrementally relative to the incentives, again increasing the ratio of benefits to costs. Key results of our efficiency scenario forecast from 2007 to 2016 are summarized in Table 17.

Figure 51
Benefits and Costs of Energy-efficiency Savings – 2007-2016*



* Present value of benefits and costs over normalized 20-year measure lives; nominal discount rate is 7.0 percent, inflation rate is 2.5 percent.

Table 17
Summary of Achievable Potential Results – 2007-2016

	33% Incentives	50% Incentives	75% Incentives
Net Energy Savings - GWh	840	1,242	2,256
Net Peak Demand Savings - MW	183	271	470
Programme Costs - Real			
Administration - $mil.	$49	$49	$45
Marketing - $ mil.	$28	$34	$41
Incentives - $ mil.	$73	$149	$429
Total Programme Costs- $ mil.	$150	$232	$515
PV Net Avoided Costs - $ mil.	$948	$1,406	$2,536
PV Annual Marketing and Admin Costs - $ mil.	$64	$69	$71
PV Net Measure Costs - $ mil.	$176	$291	$656
TRC	4.0	3.9	3.5

PV (present value) of benefits and costs is calculated over a 20-year normalized measure life for 2007–2016 programme years, nominal discount rate = 7.0 percent, inflation rate = 2.5 percent; GWh and MW savings are cumulative through 2016.

In addition to Table 17, which shows 10-year results, we provide Table 18, which focuses on the first three programme years. Table 18 shows the same information as Table 17 for a shorter time horizon that is consistent with the Electricity Commission funding cycle. As Table 18 shows, about 40-45 percent of the 10-year programme impacts (GWh and MW) are expected to be captured in the first three years, while expending only about 30-35 percent of the programme costs. This result occurs because we expect the most cost-effective energy-efficiency opportunities to be captured in the early programme years, while less cost-effective measures and for harder-to-reach markets (requiring higher marketing/education costs) will be targeted later, after the more cost-effective options are depleted.

Table 18
Summary of Achievable Potential Results – 2007-2009

	33% Incentives	50% Incentives	75% Incentives
Net Energy Savings - GWh	334	503	952
Net Peak Demand Savings - MW	79	117	216
Programme Costs - Real			
Administration - $mil.	$15	$15	$15
Marketing - $ mil.	$8	$9	$10
Incentives - $ mil.	$23	$46	$140
Total - $ mil.	$46	$70	$165
PV Net Avoided Costs - $ mil.	$428	$642	$1,206
PV Annual Marketing and Admin Costs - $ mil.	$22	$23	$24
PV Net Measure Costs - $ mil.	$63	$105	$256
TRC	5.04	5.00	4.30

5.1 Achievable Potential by Sector

Cumulative net achievable potential estimates by sector for the period 2007-2016 are presented in Figure 52 and Figure 53 for each funding scenario. Under the programme assumptions developed for this study, achievable energy savings are highest in different sectors, depending on the funding level. The residential sector provides the greatest peak demand savings regardless of funding scenario.

Figure 52
Net Achievable Energy Savings (2016) by Sector

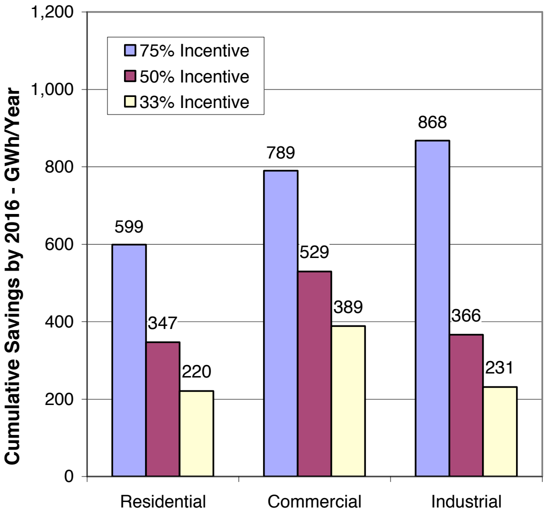
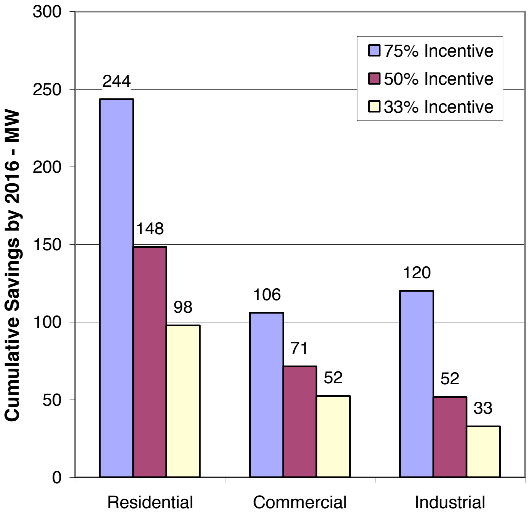


Figure 53
Net Achievable Peak Demand Savings (2016) by Sector



5.2 Residential Achievable Potential

Figure 54 and Figure 55 shows cumulative savings in each of the residential programme scenarios, over time. The bottom portion of the graphic shows the naturally occurring efficiency, and each consecutive band shows the additional savings for the three incentive levels modelled. For all funding scenarios cumulative naturally occurring energy and peak savings are 243 GWH and 115 MW, respectively.

A total energy savings of almost 850 GWh by 2016 is possible. Net programme achievable in the residential sector can reach 220 GWh by 2016 in the 33-percent incentive scenario, 347 GWh by 2016 in the 50-percent incentive scenario, and 599 GWh by 2016 in the 75-percent incentive scenario. For peak demand (Figure 55), net savings increases from 98 MW in the 33-percent incentive scenario to 148 MW in the 50-percent incentive scenario, and 252 MW in the 75-percent incentive scenario.

The residential lighting achievable scenarios were modeled somewhat differently than the other programme areas. The existing CFL programme was designed to include incentives (in the form of buy downs before purchase) from the Electricity Commission (at roughly $1 per lamp) and from the programme partners (an additional $1 per lamp). The complete buy down is reflected in the model to capture the cost per lamp to the consumer. Because this overstates the cost to the Electricity Commission, incentive costs were estimated at $1 per bulb based on the total number of bulbs sold under each of the scenarios. Table 19 below shows the costs and incentive amounts per lamp for each of the scenarios.

Table 19
CFL Scenario Modeling

	33% Incentive	50% Incentive	75% Incentive
Cost of Lamp	$6.00	6.00	6.00
Incremental cost	$5 00	$5.00	$5.00
Total incentive	$1.65	$2.50	$3.75
Programme Incentive (cost to EC)	$1.00	$1.00	$1.00
Incremental cost to consumer	$3.35	$2.50	$1.25
Total cost to consumer	4.35	3.50	2.25

We did not increase the incentive amount paid by the Commission in the two higher scenarios because a higher incentive is not needed for CFLs. Prices are low relative to other efficiency measures and programme partners are providing other reductions in cost. The resulting estimates provide a reasonable range for potential savings from residential lighting, with the estimates for the 33 percent scenario being particularly conservative.

Figure 54
Achievable Energy Savings: Residential Sector

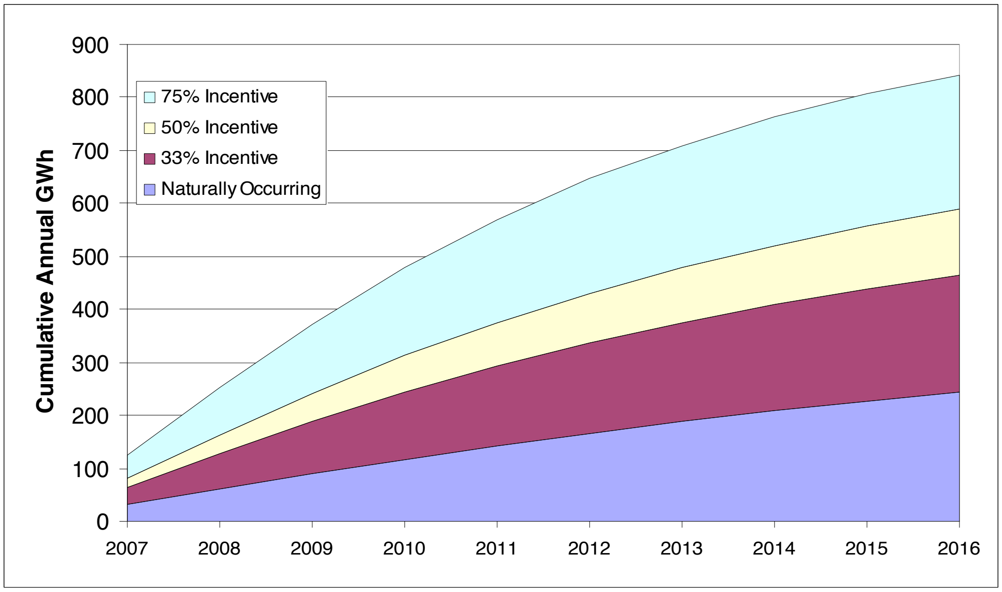


Figure 55
Achievable Peak Demand Savings: Residential Sector

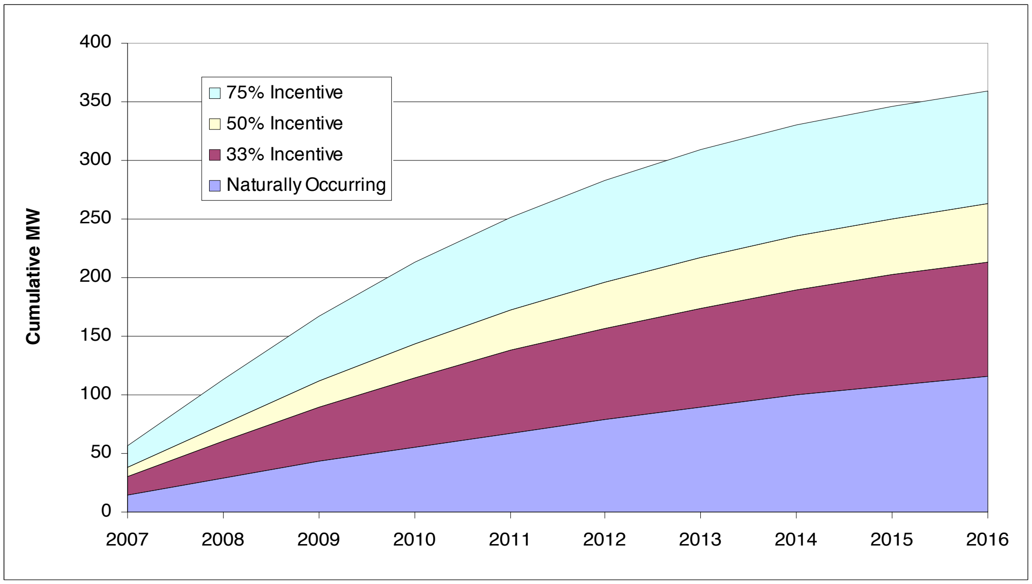


Figure 56 and Figure 58 show the end-use distribution of energy and peak demand savings for the 33-percent incentive scenario. Lighting (replacement of incandescent lamps with CFLs) contributes to the majority of the achievable energy and peak demand savings potential, followed by towel rail timers (to limit the amount of time that the heating elements are on). Water and space heating represent a relatively low percentage of residential savings, as modelled. This result is partly due to the programme budgets used to model the estimates of achievable potential, with relatively low programme funding for residential measures beyond lighting.

Figure 56
Residential Net Energy Savings Potential End Use Shares (2016) – 33% Incentives
(based on 220 GWH potential)

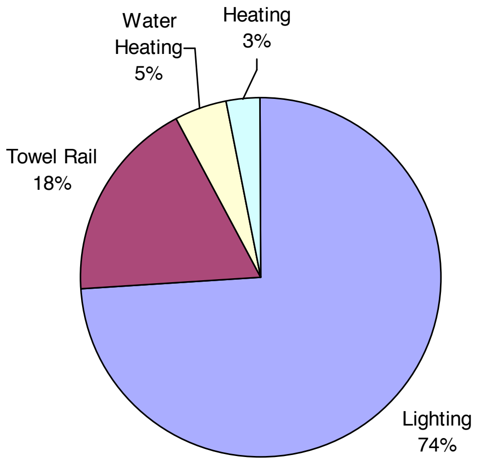


Figure 57
Residential Net Peak Demand Savings Potential End Use Shares (2016) – 33% Incentives
(based on 98 MW potential)

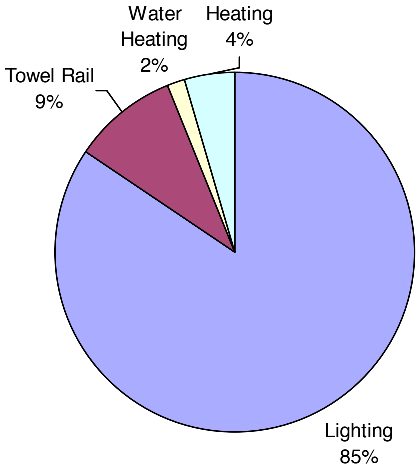


Figure 58 and Figure 59 show the end-use distribution of energy and peak demand savings by incentive level. In all three scenarios energy and peak savings in this sector are dominated by lighting savings. Additional savings is achieved through towel rail timers, water heater savings (insulated tanks and pipes) and various heating reduction measures. The relative share of savings from lighting decreases over the three funding scenarios, as the most cost effective lighting applications are achieved with the lower incentive amounts.

These figures are followed by a detailed Table 20 that shows technical, economic and net achievable savings by residential measure for each of the three funding scenarios. The table is sorted in descending order of economic potential and includes only those measures that passed the economic screening. These same data are provided for Residential New Construction in Table 21.

Figure 58
Residential Net Energy Savings Potential By End Use (2016)

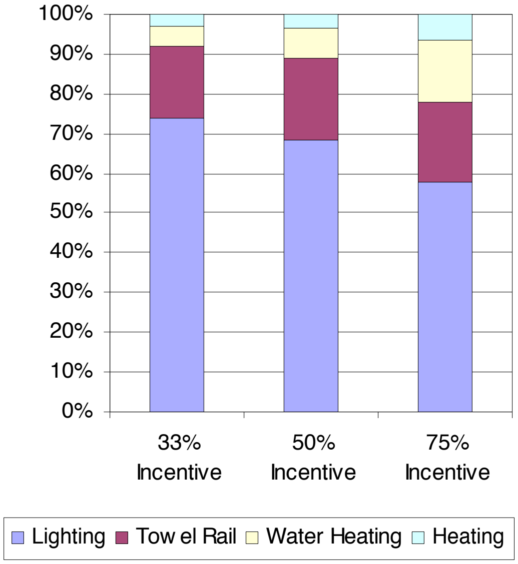


Figure 59
Residential Net Peak Demand Savings Potential By End Use (2016)

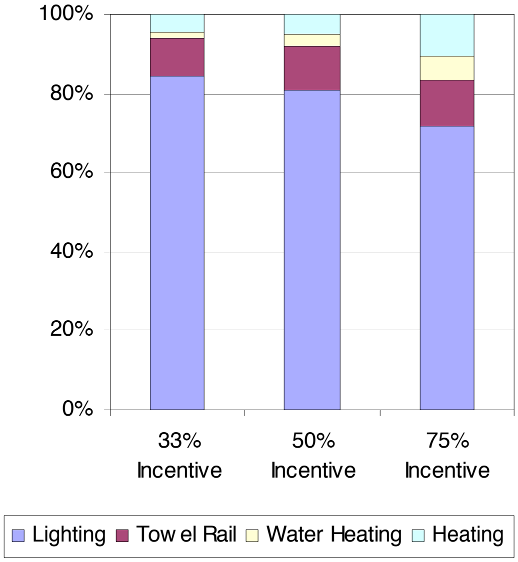


Table 20
Residential (Existing) Results By Measure
(Cumulative to 2016)

	Cumulative Energy Savings – GWh					Peak Demand Savings - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Lighting	618.88	618.88	162.90	236.08	344.84	314.23	314.23	82.71	119.87	175.09
Towel Rail Timer	216.60	216.60	38.08	69.54	117.91	49.48	49.48	8.70	15.88	26.93
Wall Insulation R-0 to R-2.3 (R-13)	724.88	214.77	0.15	0.43	3.80	476.23	141.09	0.10	0.28	2.50
High Efficiency Heat pump	698.34	209.87	0.01	0.02	0.21	458.79	137.88	0.01	0.02	0.14
Ceiling Insulation R-0 to R-1.9 (R-11)	172.83	172.83	0.88	2.56	17.24	113.54	113.54	0.58	1.68	11.32
HE Water Heater	145.78	145.78	0.02	0.06	0.56	22.75	22.75	0.01	0.02	0.14
Water Heater Blanket	132.88	132.88	7.72	19.34	62.11	20.74	20.74	1.21	3.02	9.69
Pipe Wrap	26.44	26.44	0.31	0.89	5.67	4.13	4.13	0.05	0.14	0.88
Low Flow Showerhead	60.86	60.86	1.57	4.33	20.64	9.50	9.50	0.24	0.68	3.22

Table 21
Residential New Construction Results By Measure
(Cumulative to 2016)

	Cumulative Energy Savings – GWh					Peak Demand Savings – MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
High Efficiency Heat pump	19.16	19.16	2.23	2.89	3.90	12.59	12.59	0.51	0.66	0.89
Towel Rail Timer	2.59	2.59	4.64	7.64	16.38	0.59	0.59	3.05	5.02	10.76
Slab Insulation perimeter	2.42	2.26	0.82	1.28	2.49	1.59	1.49	0.54	0.84	1.64
HE Water Heater (0.90 to 0.94 EF)	1.20	1.20	0.35	0.57	1.18	0.19	0.19	0.05	0.09	0.18
Low Flow Showerhead	0.93	0.93	0.60	0.84	1.33	0.14	0.14	0.09	0.13	0.21
Pipe Wrap	0.24	0.24	0.13	0.19	0.32	0.04	0.04	0.02	0.03	0.05
Lighting*	7.10	7.10	0.00	0.00	0.00	3.60	3.60	0.00	0.00	0.00

* Lighting is not modeled separately for new construction.

5.3 Commercial Achievable Potential

Figure 60 and Figure 61 show cumulative naturally occurring and net achievable programme savings in each of the commercial programme scenarios considered. For all funding scenarios cumulative naturally occurring energy and peak savings are 646 GWH and 87 MW, respectively. Cumulative net energy savings in the commercial sector reaches 368 GWh by 2016 in the 33-percent incentive scenario, 508 GWh by 2016 in the 50-percent incentive scenario, and 797 GWh by 2016 in the 75-percent incentive scenario.

Cumulative naturally occurring peak savings is 87 MW for all scenarios. Net peak demand savings increases from 49 MW in the 33-percent incentive scenario to 69 MW in the 50-percent incentive scenario, and to 107 MW in the 75-percent incentive scenario. Both the forecasted net cumulative energy and peak demand savings taper off in all commercial programme scenarios as the lighting measures begin to reach high saturation levels and increased programme penetration becomes more difficult. This dynamic substantially reduces the benefit-cost ratios for commercial lighting measures (and thus commercial overall). The model produces very high forecasts of naturally-occurring savings potential (because of the economic benefits to customers) and impinges on sustained increases in programme penetration.

Figure 60
Achievable Energy Savings: Commercial Sector (2016)

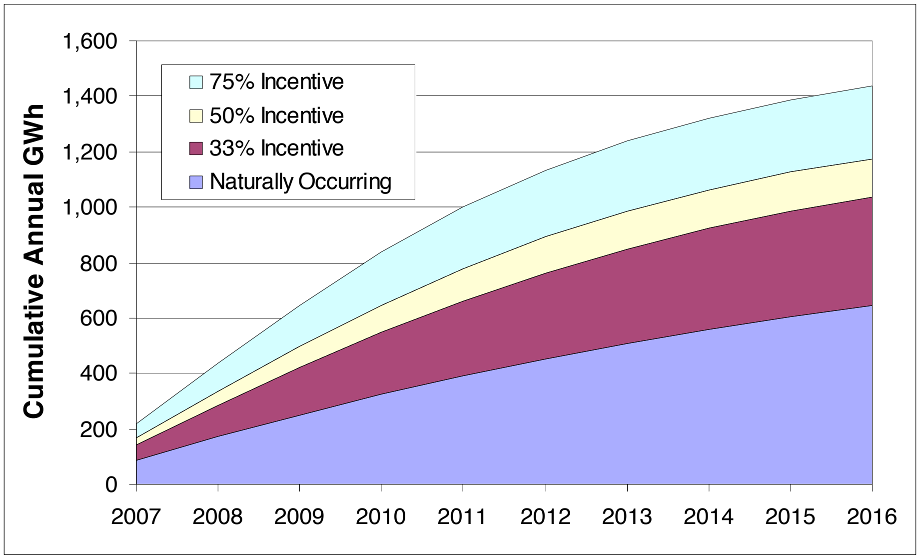


Figure 61
Achievable Peak Demand Savings: Commercial Sector (2016)

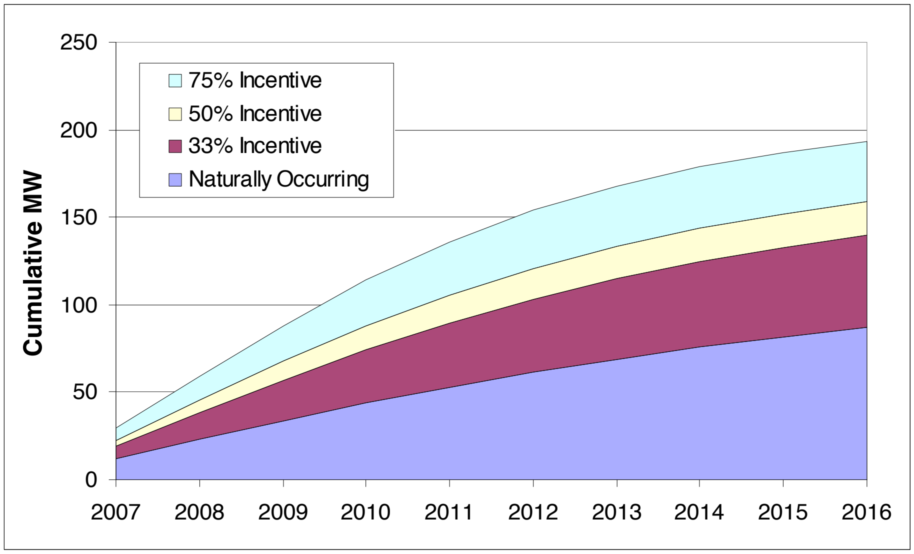


Figure 62 and Figure 63 show the end-use distribution of energy and peak demand savings for the 33-percent incentive scenario. Indoor lighting measures again contribute to the majority of the achievable energy and peak demand savings potential, followed by HVAC and refrigeration measures. Interestingly, HVAC measures do not contribute a relatively higher share of peak demand savings potential compared to energy savings potential, as is typically the case in the western region of the US. This results exclusively from the fact that New Zealand's system peak is driven largely by the residential sector and occurs at the very end of the typical business day (6-7 pm), which reduces the peak demand impacts from HVAC measures. While office equipment measures are shown to be a contributor to net savings, no incentives are provided for measures affecting this end use. Rather, the results below show the effects of marketing and education efforts to make customers more aware of the benefits of implementing equipment power management capabilities.

Figure 62
Commercial Net Energy Savings Potential End Use Shares (2016) – 33% Incentives
(based on 389 GWH potential)

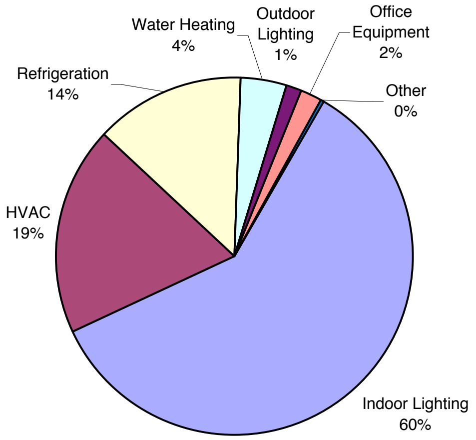


Figure 63
Commercial Net Peak Demand Savings Potential End Use Shares (2016) – 33% Incentives
(based on 52 MW potential)

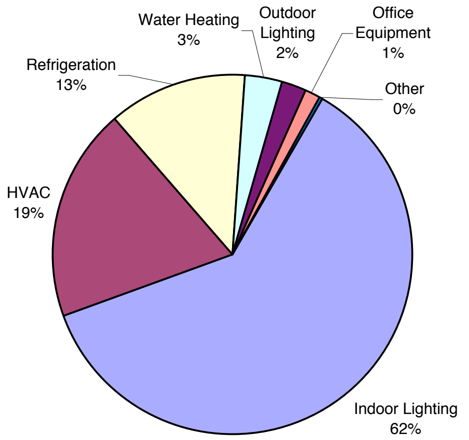


Figure 64 and Figure 65 compare the end-use shares of net achievable potential across the three programme scenarios. As the figures show, the end-use shares of achievable energy and peak demand savings potential are relatively constant across all three scenarios. The only notable change is a small relative increase in the share of achievable savings from commercial refrigeration measures in the higher incentive scenarios. This result largely reflects more pronounced slow-down of cumulative energy savings from HVAC and lighting measures resulting from higher saturation levels forecasted in higher-incentive programme scenarios.

Figure 64
Commercial Net Energy Savings Potential by End Use (2016)
All Programme Scenarios

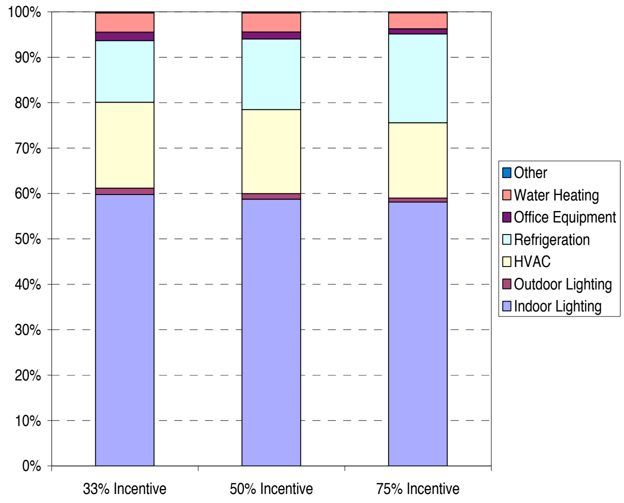


Figure 65
Commercial Net Peak Demand Savings Potential by End Use (2016)
All Programme Scenarios

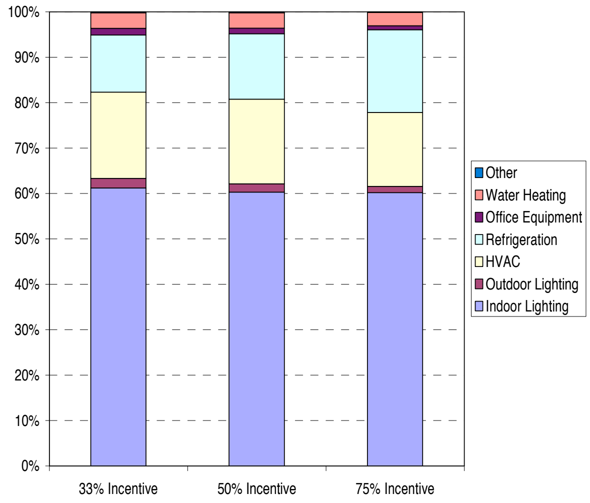


Table 22 lists the technical, economic, and achievable energy and peak demand savings potentials for all commercial measures that passed cost-effectiveness screening. As the table shows, lighting measures, particularly CFL replacements for incandescent lamps, account for much of the savings potential in the commercial sector[22]. Refrigeration measures also account for a large share of commercial savings potential. This result primarily reflects the fact that the Food Store segment accounts for a significantly larger share of total commercial electricity use relative to what is commonly experienced in the U.S. and that electricity use and savings opportunities in the Food Store segment are dominated by refrigeration. The limited achievable programme potential shown for office equipment measures reflect the fact that the forecasted programme savings assume information-based programme designs, since the incremental costs of both power-management measures and ENERGY STAR measures are close to zero. Finally, while the achievable programme potentials for control-related HVAC measures are significant, the achievable programme potentials for HE HVAC equipment measures (e.g. efficient split-system heat pumps) are modest and reflect the fact that the latter measures are replace-on-burnout measures that have limited opportunities due to long equipment lifecycles.

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[22] The dominance of CFL savings is due to two factors: the cost-effectiveness of CFLs and high per-lamp savings. Although commercial lighting is dominated by linear tube fixtures, there is a significant share of non-tube lighting and CFLs are very cost effective option for much of this. In modeling adoption of the measures the extremely short payback times for CFLs contributes to higher penetration relative to other measures (both lighting and other end-uses).

Table 22
Measure-specific Potential Results for Commercial Sector (Cumulative to 2016)

	Cumulative Energy Savings – GWh					Peak Demand Savings - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
CFL	743.1	599.4	141.6	180.1	270.6	100.6	81.6	19.1	24.3	36.5
Refrigeration Measures	321.7	296.8	39.5	65.7	137.3	39.2	36.2	5.0	8.4	17.2
Office Equip Power Management	109.3	108.7	6.8	7.9	9.0	11.9	11.9	0.7	0.8	1.0
Next Gen T8, 1EB	90.4	85.3	18.7	35.9	69.0	12.6	12.1	2.6	5.1	9.6
HE Split-System Heat Pump	85.2	85.2	3.5	5.2	8.5	9.0	9.0	0.4	0.5	0.9
BMS Optimization	72.7	72.0	16.2	21.6	26.9	12.7	12.7	3.0	4.1	5.1
Lighting 15% More Efficient Design	68.1	68.1	22.0	25.9	33.6	9.4	9.4	3.1	3.6	4.7
Next Gen T8, EEMAG	61.4	61.4	20.0	27.7	35.3	8.6	8.6	2.8	3.9	4.9
HVAC 10% More Efficient Design	56.9	56.9	17.4	20.8	27.6	5.3	5.3	1.7	2.0	2.6
HVAC 30% More Efficient Design	47.3	21.0	3.9	5.3	8.7	4.5	4.5	0.4	0.5	0.9
Lighting 25% More Efficient Design	38.6	38.6	8.5	11.1	16.8	5.4	5.4	1.2	1.6	2.3
Tankless Water Heater	38.2	33.9	9.3	12.5	16.2	4.2	3.8	1.0	1.4	1.8
Occupancy Sensor	36.5	34.0	7.0	13.6	27.4	5.9	5.5	1.2	2.2	4.4
High Pressure Sodium 250W Lamp	36.4	36.4	5.1	6.1	7.1	7.4	7.4	1.0	1.2	1.4
HE Packaged DX Unit	34.9	34.9	1.9	2.7	4.0	1.6	1.6	0.1	0.1	0.2
Variable Speed Drive Control	32.5	31.6	8.6	11.9	16.1	4.9	4.9	1.3	1.9	2.5
Programmable Thermostat	31.0	0.4	0.2	0.4	1.2	4.5	0.0	0.0	0.0	0.1
BMS	26.1	23.5	6.1	8.6	12.2	4.6	4.1	1.1	1.5	2.2
Refrigeration 10% More Efficient Design	18.1	17.2	3.5	4.7	7.3	2.1	2.1	0.4	0.5	0.8
HE Room A/C Unit	19.7	19.7	0.8	1.3	2.3	0.7	0.7	0.0	0.0	0.1
Air Handler Optimization	18.8	18.3	5.3	7.4	10.0	2.9	2.8	0.8	1.1	1.5

	Cumulative Energy Savings – GWh					Peak Demand Savings - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Refrigeration 20% More Efficient Design	18.1	17.2	3.5	4.7	7.3	2.1	2.1	0.4	0.5	0.8
Demand Controlled Circulating Systems	16.5	15.7	4.0	5.4	7.0	1.8	1.7	0.4	0.6	0.7
A/C Tune Up/Diagnostics	13.5	12.1	3.0	3.8	4.6	1.7	1.7	0.4	0.6	0.7
High Efficiency Water Heater (Electric)	12.6	11.2	0.6	0.8	1.4	1.4	1.2	0.1	0.1	0.1
Lighting Control Tuneup	10.8	9.6	1.7	3.7	8.3	1.8	1.6	0.3	0.6	1.4
Advanced Efficiency Fan Motor	10.0	9.5	0.5	0.7	1.2	1.3	1.3	0.1	0.1	0.2
Optimize DX Controls	9.4	7.5	1.6	3.2	6.9	0.5	0.5	0.1	0.2	0.4
Hot Water Pipe Insulation	7.0	6.2	1.8	2.6	3.6	0.8	0.7	0.2	0.3	0.4
Energy Star Office Equipment	4.5	4.5	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0
HE Chiller	3.2	3.2	0.4	0.1	0.3	0.1	0.1	0.0	0.0	0.0
Vending Misers (Cooled Machines Only)	2.8	2.8	1.0	1.4	1.7	0.3	0.3	0.1	0.1	0.2
VSD for Chiller Pumps and Towers	1.6	0.4	0.3	0.6	1.0	0.1	0.0	0.0	0.0	0.0

Note: measures sorted by descending technical potential energy savings

5.4 Industrial Achievable Potential

Figure 66 and Figure 67 show cumulative naturally occurring and net achievable programme savings by industrial programme scenario. For all funding scenarios cumulative naturally occurring energy and peak savings are 201 GWH and 29 MW, respectively. By 2016, net energy savings reach 231 GWh under the 33 percent incentive scenario, 366 GWh under the 50 percent incentive scenario, and 868 GWh under the 75 percent incentive scenario. For peak demand, net savings increase from 33 MW under 33 percent incentives to 52 MW under 50 percent incentives to 120 under 75 percent incentives.

Note that savings begin to taper off somewhat during the second half of the forecast period. This is most evident in the 75 percent incentive scenario, but occurs to some degree in all scenarios. This result is due to the attainment of high market saturation levels for some measures, which makes it more difficult to reach the same levels of programme penetration in later years. The tapering off effect is not as pronounced as in the commercial sector due, in part, to the large diversified measure mix available to the industrial sector and the fact that many industrial measures are tied to longer-lived equipment replacement cycles (versus measure such as lighting retrofits, which are significant in the residential and commercial sectors and can be implemented at any moment in time).

Figure 66
Achievable Energy Savings: Industrial Sector

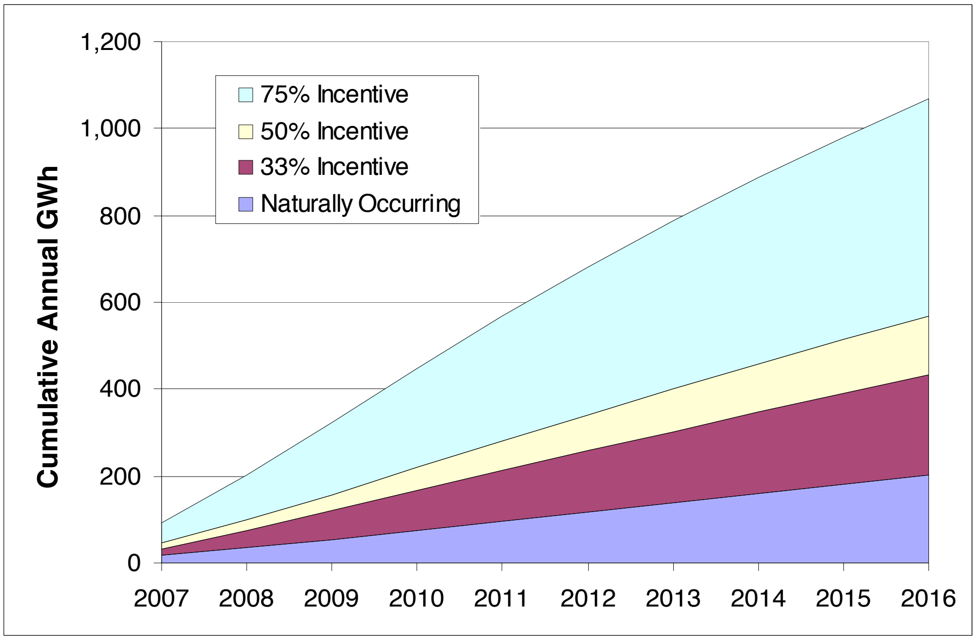

Figure 67
Achievable Peak Demand Savings: Industrial Sector

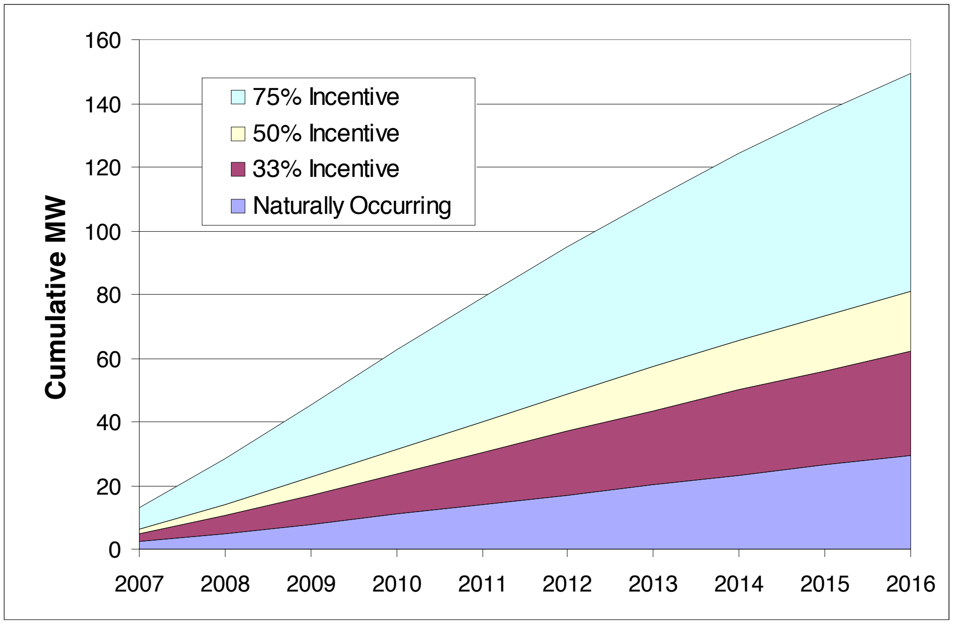

Figure 68 and Figure 69 show the end use distribution of energy and peak demand savings for the 33 percent incentive scenario. Compressed air system measures contribute most to both the energy and peak demand savings potential, followed by pumping and fan measures. Similar to the economic potential results shown above, the end uses contribute a similar share to annual energy savings and to peak demand savings.

Figure 68
Industrial Net Energy Savings Potential End Use Shares (2016) – 33% Incentives
(based on 231 GWH potential)

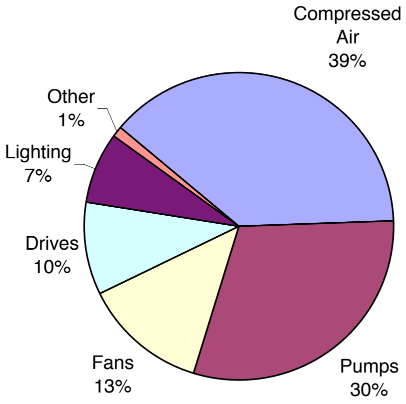

Figure 69
Industrial Net Peak Demand Savings Potential End Use Shares (2016) – 33% Incentives
(based on 33 MW potential)

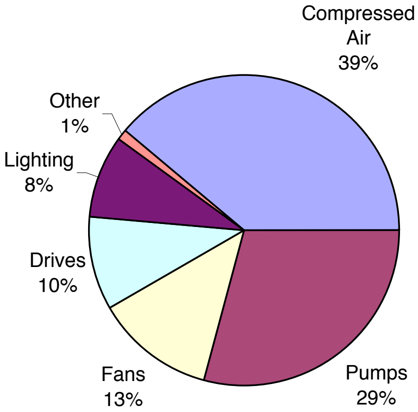

Figure 70 and Figure 71 show end use shares of net achievable potential across the three programme scenarios. The major changes in shares across scenarios involve increased pumping and fan shares and decreased compressed air and lighting shares. Both the compressed air and lighting measures tend to be very cost effective, so it is expected that they will be implemented more so at lower incentive levels. At higher incentive levels, other measures in the pumping and fan end uses begin seeing higher market penetration.

Figure 70
Industrial Net Energy Savings Potential by End Use (2016) – Across Scenarios

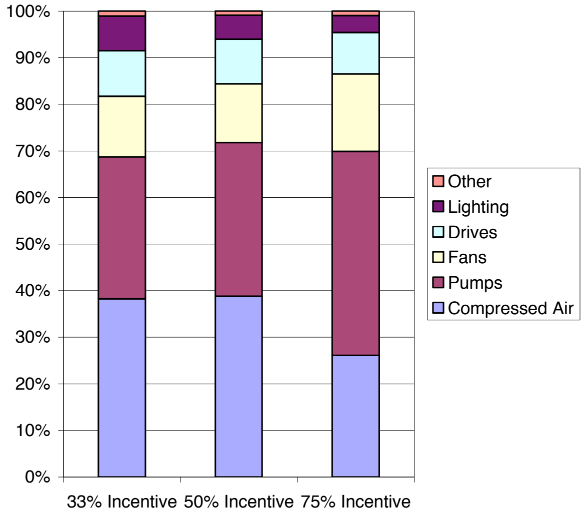

Figure 71
Industrial Net Peak Demand Savings Potential by End Use (2016) – Across Scenarios

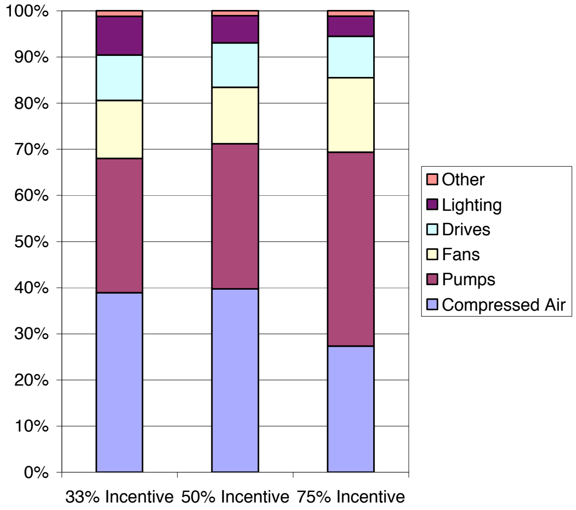

Table 23 lists the various potentials for industrial measures that passed cost-effectiveness screening. As shown, there are a large number of industrial measures that contribute to industrial savings potential. Key measures that contribute to achievable potential include: system optimization and the addition of controls to pumping, fan, and compressed air systems; motor replacement (versus rewind) measures, and adjustable speed drives (ASDs.)

Table 24 shows the various potentials by primary measure group. Since the Electricity Commission's early industrial focus in on motor replacement and compressed air system efficiency, these programme components are broken out separately. As shown, the motor and compress air measures, together, contribute between 30 percent and 45 percent of the achievable industrial potential, depending on which programme scenario one looks at.

Table 23
Industrial Results by Measure
(Cumulative to 2016)

Measure	Energy - GWh					Peak Demand - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Pumps - Controls	232.72	232.72	25.25	50.13	177.38	31.68	31.68	3.53	7.00	24.58
Drives - Replace motor	158.33	158.33	10.73	19.36	39.33	22.28	22.28	1.52	2.74	5.58
Pumps - System Optimization	145.72	145.72	14.69	27.29	97.25	20.12	20.12	2.06	3.83	13.63
Low Pressure Nozzle	126.82	126.82	2.72	5.87	37.86	12.34	12.34	0.26	0.57	3.68
Fans - Controls	108.48	108.48	4.57	8.92	45.15	14.28	14.28	0.61	1.20	6.04
Fans - System Optimization	104.49	104.49	3.73	7.32	39.06	13.28	13.28	0.49	0.95	5.06
Compressed Air - System Optimization	88.83	88.83	33.10	51.58	71.27	12.42	12.42	4.68	7.29	10.09
Pumps - Replace motor	85.51	85.51	4.58	8.86	20.08	12.46	12.46	0.68	1.31	2.96
Fans - Replace motor	78.23	78.23	5.12	9.32	19.19	10.80	10.80	0.71	1.30	2.67
400W MV to 250W HPS	72.40	72.40	16.90	16.88	20.97	10.89	10.89	2.63	2.63	3.27
Micro Watering System	66.74	66.74	0.04	0.08	0.65	6.49	6.49	0.00	0.01	0.06
Compressed Air-O&M	61.28	61.28	23.90	38.26	52.87	8.89	8.89	3.50	5.62	7.78
Comp Air - Replace motor	53.85	53.85	2.74	5.34	12.30	7.64	7.64	0.39	0.76	1.76
Pumps - Sizing	43.99	43.99	2.57	3.98	9.48	6.34	6.34	0.37	0.58	1.38
Air conveying systems	33.24	33.24	2.57	3.08	5.23	4.51	4.51	0.35	0.42	0.71
Pump Retrofit - Irrigation	33.03	33.03	8.54	14.75	28.75	3.21	3.21	0.83	1.43	2.80
Fans - ASD	30.99	30.99	12.75	15.61	23.47	4.33	4.33	1.80	2.20	3.32
Pumps - ASD	30.10	30.10	11.47	15.04	25.00	4.44	4.44	1.71	2.25	3.74
Compressed Air - Controls	28.34	28.34	4.14	9.28	23.89	4.04	4.04	0.60	1.34	3.45
Pumps - O&M	27.27	27.27	4.17	2.60	3.06	4.03	4.03	0.62	0.39	0.46
Fans- Improve components	26.21	26.21	2.17	2.76	5.30	3.41	3.41	0.28	0.36	0.69

Measure	Energy - GWh					Peak Demand - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Compressed Air- Sizing	26.04	26.04	8.36	10.81	12.90	3.68	3.68	1.20	1.55	1.85
Gap Forming paper machine	21.33	21.33	1.03	1.21	2.15	2.55	2.55	0.12	0.15	0.26
Comp Air - ASD	19.68	19.68	5.51	9.66	16.67	2.85	2.85	0.80	1.41	2.45
Optimization control PM	19.08	19.08	0.92	1.79	8.62	2.28	2.28	0.11	0.21	1.03
Efficient drives - rolling	17.35	17.35	0.73	1.11	2.86	2.18	2.18	0.09	0.14	0.36
Optimize drying process	16.95	16.95	1.01	1.93	8.58	2.30	2.30	0.14	0.26	1.16
High Consistency forming	16.43	16.43	0.83	0.95	1.65	1.97	1.97	0.10	0.11	0.20
Replace V-Belts	15.40	15.40	1.21	1.56	3.05	2.09	2.09	0.16	0.21	0.41
Drives - Process Control	15.35	15.35	0.13	0.22	0.94	1.94	1.94	0.02	0.03	0.12
Efficient Transformers	14.03	14.03	0.09	0.16	0.62	1.93	1.93	0.01	0.02	0.09
Lighting Controls	13.03	13.03	2.44	3.89	9.84	2.54	2.54	0.49	0.77	1.95
Optimization Refrigeration	9.96	9.96	0.33	0.66	3.75	1.68	1.68	0.06	0.11	0.63
Fans - Motor practices-1	9.37	9.37	1.06	1.85	6.00	1.29	1.29	0.15	0.25	0.83
DX Packaged System, EER=3.5, 10 tons	8.96	8.96	0.70	0.74	1.24	1.31	1.31	0.10	0.11	0.18
Bakery - Process	8.58	8.58	0.46	0.67	1.39	1.46	1.46	0.08	0.11	0.24
Pumps - Motor practices-1	8.51	8.51	0.62	1.14	4.66	1.25	1.25	0.09	0.17	0.69
RET T8 to Next Gen T8, 1EB	7.74	7.58	0.74	1.29	4.49	1.19	1.17	0.12	0.20	0.70
Comp Air - Motor practices-1	6.90	6.90	0.43	1.07	4.08	0.99	0.99	0.06	0.15	0.59
Fans - O&M	5.56	5.56	0.78	0.49	0.57	0.77	0.77	0.11	0.07	0.08
Bakery - Process (Mixing) - O&M	5.43	5.43	0.82	0.51	0.60	0.92	0.92	0.14	0.09	0.10
Extruders/injection Moulding-multipump	5.09	5.09	0.09	0.16	0.59	0.90	0.90	0.02	0.03	0.10

Measure	Energy - GWh					Peak Demand - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Efficient Refrigeration - Operations	4.08	4.08	0.51	0.56	0.93	0.68	0.68	0.09	0.09	0.16
Efficient practices printing press	3.93	3.93	2.06	2.54	3.43	0.69	0.69	0.36	0.45	0.61
O&M - Extruders/Injection Moulding	3.78	3.78	0.10	0.06	0.07	0.67	0.67	0.02	0.01	0.01
RET - Screw-in 18W CFL	3.72	3.72	1.18	1.24	1.50	0.58	0.58	0.18	0.19	0.23
Efficient Printing press (fewer cylinders)	3.19	3.19	0.02	0.04	0.22	0.56	0.56	0.00	0.01	0.04
RET T12 to Next Gen T8, 1EB	2.87	2.87	0.34	0.59	1.86	0.44	0.44	0.05	0.09	0.29
Efficient Curing ovens	2.82	2.82	0.03	0.06	0.23	0.50	0.50	0.01	0.01	0.04
Power recovery	2.66	1.09	0.02	0.04	0.26	0.33	0.14	0.00	0.01	0.03
Direct drive Extruders	2.62	2.62	0.02	0.03	0.17	0.46	0.46	0.00	0.01	0.03
Optimize HVAC Controls	2.24	0.61	0.17	0.25	0.54	0.34	0.10	0.03	0.04	0.09
Refinery Controls	2.01	2.01	0.30	0.53	1.46	0.25	0.25	0.04	0.07	0.18
Injection Moulding - Impulse Cooling	1.85	1.85	0.02	0.04	0.17	0.33	0.33	0.00	0.01	0.03
O&M/drives spinning machines	1.74	1.74	0.02	0.01	0.01	0.31	0.31	0.00	0.00	0.00
Efficient processes (welding, etc.)	1.69	1.69	0.07	0.10	0.24	0.30	0.30	0.01	0.02	0.04
New transformers welding	1.65	1.65	0.07	0.10	0.23	0.29	0.29	0.01	0.02	0.04
Injection Moulding - Direct drive	1.62	1.62	0.01	0.01	0.07	0.29	0.29	0.00	0.00	0.01
Prog. Thermostat	1.52	0.21	0.01	0.01	0.06	0.07	0.01	0.00	0.00	0.00
Process optimization	1.36	1.36	0.07	0.13	0.64	0.19	0.19	0.01	0.02	0.09
Drives - Optimization process (M&T)	0.93	0.93	0.48	0.61	0.84	0.16	0.16	0.09	0.11	0.15

Measure	Energy - GWh					Peak Demand - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Efficient drives	0.73	0.73	0.03	0.05	0.14	0.13	0.13	0.01	0.01	0.02
Clean Room - Controls	0.72	0.72	0.01	0.01	0.06	0.11	0.11	0.00	0.00	0.01
Heating - Optimization process (M&T)	0.62	0.62	0.32	0.40	0.56	0.11	0.11	0.06	0.07	0.10
Drives - Scheduling	0.57	0.57	0.08	0.14	0.48	0.10	0.10	0.01	0.03	0.08
Drying (UV/IR)	0.54	0.54	0.01	0.02	0.09	0.09	0.09	0.00	0.00	0.02
Clean Room - New Designs	0.51	0.51	0.00	0.00	0.02	0.06	0.06	0.00	0.00	0.00
Machinery	0.48	0.48	0.02	0.03	0.09	0.09	0.09	0.00	0.01	0.02
Heating - Process Control	0.43	0.43	0.00	0.00	0.02	0.06	0.06	0.00	0.00	0.00
Efficient electric melting	0.42	0.42	0.00	0.01	0.03	0.05	0.05	0.00	0.00	0.00
Top-heating (glass)	0.28	0.28	0.03	0.04	0.08	0.04	0.04	0.00	0.00	0.01
Heating - Scheduling	0.15	0.15	0.03	0.05	0.13	0.03	0.03	0.00	0.01	0.02
Efficient Machinery	0.15	0.15	0.01	0.01	0.03	0.03	0.03	0.00	0.00	0.00
Process Drives - ASD	0.13	0.13	0.02	0.03	0.09	0.02	0.02	0.00	0.00	0.01
Near Net Shape Casting	0.11	0.11	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00
Other Process Controls (batch + site)	0.10	0.10	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
Membranes for wastewater	0.05	0.05	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Process control	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1,959.63	**1,954.95**	**230.81**	**365.98**	**867.51**	**264.34**	**263.83**	**32.80**	**51.65**	**120.13**

Note: measures are sorted by descending technical energy savings potential.

Table 24
Industrial Results By Measure Group
(Cumulative to 2016)

Measure Group	Energy - GWh					Peak Demand - MW				
	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive	Technical Potential	Economic Potential	33% Incentive	50% Incentive	75% Incentive
Motors	375.92	375.92	23.17	42.88	90.90	53.17	53.17	3.30	6.12	12.97
Compressed Air (except Motors)	231.08	231.08	75.45	120.67	181.68	32.86	32.86	10.84	17.37	26.21
Other Measures	1,367.47	1,347.96	132.19	202.43	594.93	180.32	177.80	18.66	28.17	80.95

6. Summary and Recommendations

Key conclusions from this study are summarized below:

- There is substantial economic potential savings in NZ for the next ten years. We estimated 23 percent of base energy and 14 percent of peak demand (projected for 2016) passes the total resource cost test. This represents

- There is significant achievable and cost-effective potential for electric energy-efficiency savings in all sectors in New Zealand.

- **Key Residential Findings**

    - The residential sector represents the greatest economic potential with savings estimated at 2,633 GWH and 1,235 MW.

    - The economic potential in this sector is driven by space heating, lighting, space, water heating and towel rail timer measures, with more than half the potential demand saving from heating measures.

    - The achievable potential for this sector is driven by lighting (switching incandescent lighting to CFLs), which comprises more than 60 percent of both energy and demand savings.

    - Additional achievable potential from other measures, especially those addressing space heating measures. These are, however, harder to obtain. They involve high initial costs and are a hassle to install.

    - Timers for towel rails and water heating measures

    - The achievable potential estimates point to programs addressing residential space heating measures such as high efficiency heat pumps and increased insulation levels in NZ homes.

- **Key Commercial Findings**

    - The commercial sector has the lowest economic potential, with savings estimated at 1,849 GWH and 239 MW.

    - Approximately half the achievable commercial energy and demand savings is from indoor lighting, and a substantial portion of this is from switching incandescent lighting to CFLs,

    - Additional substantial achievable savings is from HVAC measures and refrigeration.

    - In the commercial sector energy-efficiency measure contributions to savings do not vary between energy and demand, reflecting end-use load shape assumptions that have much equipment operating during both peak and non-peak periods.

  - The load shapes for the commercial sector were estimated using available secondary data sources and thus contain a high degree of uncertainty.

  - The achievable potential estimates point to programs addressing commercial lighting measures, including switching incandescent to compact fluorescent lamps and upgrading fluorescent tube lighting and controls. Additional programs are suggested for addressing HVAC equipment in all sectors, and refrigeration in grocery stores and restaurants.

- **Key Industrial Findings**

  - The industrial sector has economic savings estimated at 1,955 GWH and 264 MW.

  - Pumps comprise 40 percent of the economic potential, with fans, drives and compressors contributing between 15 and 20 percent each for both energy and demand potential.

  - The achievable potential for the industrial sector is dominated by improvements to compressed air systems (approximately 40 percent of achievable savings in all but the highest funding scenario) and more efficient pumps (approximately 30 to 40 percent of achievable savings).

  - In the industrial sector energy-efficiency measure contributions to savings do not vary between energy and demand, reflecting end-use load shape assumptions that have much equipment operating during both peak and non-peak periods.

  - The load shapes for the industrial sector were estimated using available secondary data sources and thus contain a high degree of uncertainty.

  - The achievable potential estimates point to programs addressing compressed air systems and pumps in the early years of implementation, expanding to fans and drives in later years.

Achievable potential over a ten-year period is well below the total economic potential in all sectors. There are a number of factors that contribute to this result, including the following:

- Lack of information about measures will limit customers' energy-efficiency uptake. Programmes can help to inform customers about the costs and savings provided by different measures, but budget constraints often limit the number of customers that are well enough informed to make energy-efficiency purchase decisions within the forecast timeframe.
- Even with good information, many customers are not willing to invest in energy-efficiency. They tend to focus on initial equipment cost versus lifecycle cost. The use of incentives can help overcome this cost-related barrier, but some customers will not make the desired investments, even at fairly high incentive levels.
- Equipment turnover rates can also limit the penetration of energy-efficiency measures over a given forecast horizon. For example, for equipment with a 15-year lifetime, one might expect that only about two-thirds of the total savings potential could possibly be achieved over a 10-year forecast horizon, even with 100 percent penetration when that equipment is ready for replacement.

- Finally, there are a number of additional market barriers that will limit measure penetration. (See Table A-5 in Appendix A for a list of key barriers.)

A subsequent program design report based upon this analysis will include more specific direction regarding program designs and approaches to overcoming these barriers

6.1 Recommendations for Future Study

This study made significant inroads into understanding electric energy-efficiency potential in New Zealand and serves as an excellent starting point. Over the next several years, the Electricity Commission will be expanding its programs and gaining a better understanding of end user response to programme marketing/education activities and financial incentive offerings. We believe it would be useful to revisit DSM potential in New Zealand in several years in order to incorporate NZ specific knowledge obtained from this program experience to improve estimates of energy-efficiency potential.

In conducting the electric energy-efficiency potential study, the KEMA team encountered a number of data limitations, especially in the non-residential sector. These limitations were addressed through a combination of primary research, discussions with industry experts in New Zealand, and application of secondary data where necessary. While use of adjusted secondary data (sometimes based on U.S. studies for lack of other sources) allowed us to fill in gaps, e recognize that the development of additional New Zealand-specific data could significantly improve the understanding of energy efficiency and building energy use. We recommend that the Electricity Commission and others in New Zealand conduct other research as discussed below.

On-site surveys of commercial facilities: While the KEMA team conducted a number of commercial telephone surveys to get a better understanding of commercial buildings and their energy use, there is still uncertainty in these findings, especially at the technology level. For example, the saturation of T-12 fluorescent lighting seems high despite limited sales of this lighting technology in recent years. There was also some concern about the extent of electric heating. These types of technology-specific issues can only be adequately addressed through on-site survey, where trained surveyors assess the building and equipment stock in a statistically representative sample of buildings. A data collection effort similar to the BRANZ HEEP project would greatly improve the understanding of New Zealand's commercial building stock.

Audits of key industrial facilities: New Zealand's industrial sector is dominated by a relatively few large facilities. Gaining a better understanding of these facilities would greatly enhance New Zealand's ability to target energy-efficiency products and services towards these end users. We recommend that the Electricity Commission investigate the feasibility of conducting comprehensive audits of the large industrial end users, and possibly partnering with these users to implement the cost-effective energy-efficiency measures identified in the audits.

Non-residential load shape research: While the KEMA team had access to relatively good residential end use load shape data through the BRANZ HEEP project, there were virtually no data on non-residential load shapes at either the facility or end use level. The KEMA team used a combination of hourly electric system data for New Zealand, combined with adjusted U.S end use load shape data to develop load shape estimates that were used in this study. Hence, we believe there is considerable uncertainty in our estimates of peak demand savings, as they require an understanding of hourly energy usage as well as annual consumption values. While fairly cost-prohibitive, we suggest that the Electricity

Commission investigate studies to develop a better understanding of non-residential load shapes. This type of work might be combined with the commercial on-site survey study that was recommended above.

Avoided cost study: The avoided energy and capacity costs used in this analysis were developed from fairly simplistic analyses. Base year avoided energy costs were based on wind farm generation costs and avoided generation capacity costs were based on cost for a peaking gas turbine. These costs do not include environmental externalities that would increase the value of energy saved and lead to higher economic potential estimates. We recommend that the Electricity Commission consider a study of the various costs avoided by energy-efficiency projects, including future energy costs, capacity costs (generation, transmission, and distribution), and externality costs.

7. Glossary of Acronyms

In this section we provide a list of acronyms used in the document, sorted alphabetically.

BMS	Building Management System
CATI	Computer Aided Telephone Interviews
CDD	cooling degree-day
CDS	Centralised Dataset from Electricity Commission of grid exit point electricity
CEUS	Commercial End Use Survey
CFL	Compact Fluorescent Lamp
CDD	cooling degree-day
DEER	Database for Energy Efficient Resources
DHW	Domestic Hot Water
DX	direct expansion
EECA	Energy Efficiency and Conservation Authority
EER	Energy Efficiency Ratio
EUI	end-use energy intensity
EUI	end-use energy intensity
HDD	Heating degree-day
HE	High Efficiency
HEEP	Household Energy End-use Project
HVAC	heating, ventilation, and air-conditioning
LBNL	Lawrence Berkeley National Laboratory
LESG	Lighting Efficiency Stakeholder Group - a collaborative group formed in 2006 to facilitate the development of an efficient lighting strategy for New Zealand.
LPG	Liquefied Petroleum Gas
MED	Ministry of Economic Development
MEPS	Minimum Energy Performance Standards
O&M	operation and maintenance
RFP	request for proposals
SOO	Statement of Opportunities
TRC	Total Resource Cost test
USDOE	U.S. Department of Energy
UEC	Unit Energy Consumption
VSD	Variable-speed-drive
WW	Wastewater

8. References and Data Sources

Below is a list of selected references and data sources used to develop the estimates of potential for this report. Other individuals, organizations and publicly available reports contributed information and data pertinent to the analysis.

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