Electric Efficiency Potential Down-Under: New Zealand in Perspective

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Abstract

The New Zealand Electricity Commission is responsible for regulating the country's electricity industry and for promoting electric energy efficiency and conservation. The Commission funded a study to identify the potential for electric energy efficiency in all sectors, over a 10 year planning period, and to develop programme designs for implementation of continuing national energy efficiency efforts. This paper is based on the preliminary results from that study.

The paper starts by providing an overview of the New Zealand electricity industry. We discuss the basic approach and terminology used to identify efficiency potential. We discuss consumption characteristics and then focus on the economic potential for electric energy efficiency in New Zealand. Throughout the paper we discuss characteristics specific to New Zealand, including those that affect identifying the efficiency potential and in realizing energy efficiency savings through programs.

Introduction

The New Zealand Electricity Commission is responsible for regulating the country's electricity industry and for promoting and facilitating the "efficient use and conservation of electricity (including funding programmes that provide incentives for cost-effective energy efficiency and conservation.)" [1] In this capacity the Commission funded a study of the potential for electric energy efficiency in all sectors, over a 10 year planning period. The potential study was designed not only to determine the efficiency potential, but to develop initial programme designs for implementation of continuing national energy efficiency efforts.

New Zealand's energy efficiency efforts are motivated by several issues: capacity constraints, limited availability of low cost gas, and more recently, green house gas emissions. New Zealand generated 59 percent of its electricity from hydro and wind (mostly hydro) in 2006. Drought conditions during several recent years have raised concern of rolling outages. In addition, there may be transmission capacity issues as evidenced by Transpowers (the transmission entity) efforts to obtain approval for additional capacity. Finally, the Maui gas field, a source for low cost fuel for generating thermal electricity, is running low.

The Approach

In this energy-efficiency potential study (and paper) we define several different types of energy efficiency potential: technical, economic, achievable program, and naturally occurring. These potentials are shown conceptually in Figure 1 and described below.

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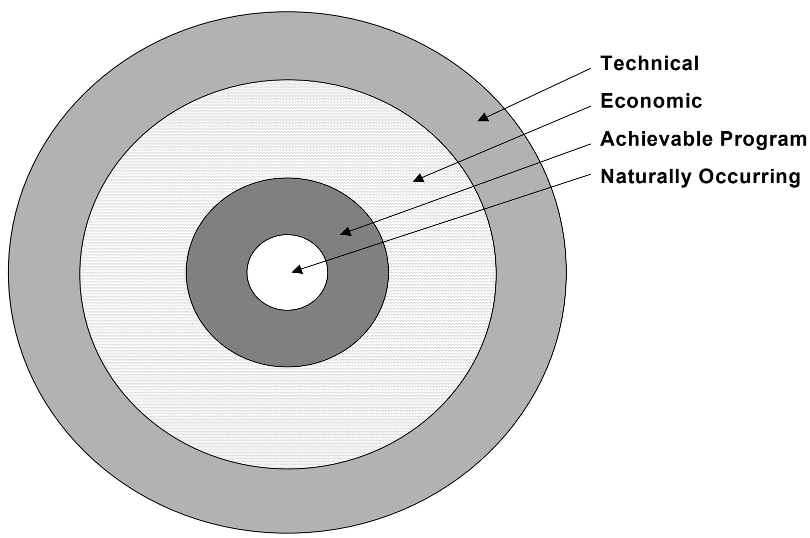
[1] Section 172O(1)(f) of the Electricity Act 1992.

- **Technical potential** is defined 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. We used the total resource cost (TRC) ratio to determine economic cost effectiveness. Generally speaking, the TRC assesses all the costs and the benefits of the energy efficiency, regardless of who receives them, to determine cost effectiveness. In the New Zealand study we did not include economic benefits from environmental externalities in the test.

- **Achievable program potential** refers to the amount of savings that would occur in response to specific program funding and measure incentive levels. Savings associated with program 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 1
Conceptual Relationship among Energy-Efficiency Potential Definitions



The research team used DSM ASSYST©, a proprietary model developed by KEMA, to estimate the potential in New Zealand. The approach had five major steps.

Step 1: Develop Initial Input Data. In this step we first developed a list of energy-efficiency measure opportunities to include in the model. Next we gathered and developed technical data, including costs and savings for these energy efficiency opportunities. We also gathered and analyzed information on building characteristics, electricity consumption and intensity by end-use, load patterns, and market shares. There were many gaps in the data available for New Zealand and we collected primary data, especially to obtain information regarding the commercial sector. In addition, we collected data on economic parameters: avoided costs, electricity rates, discount rates, and inflation rate.

Step 2: Estimate Technical Potential. We matched and integrated data on efficient measures to data on existing building characteristics to produce estimates of technical potential.

Step 3: Estimate Economic Potential. We matched and integrated measure and building data with economic assumptions to produce indicators of measure cost effectiveness using the Total Resource Cost (TRC) ratio.

Step 4: Estimate Achievable Program and Naturally Occurring Potentials. We screened measures for inclusion in the program analysis based on the TRC ratio. We then gathered and developed estimates of program costs (e.g., for administration and marketing) and program savings. We developed estimates of customer adoption (naturally occurring and program) of energy-efficiency measures as a function of the economic attractiveness of the measures, barriers to their adoption, and the effects of program intervention.

Step 5: Scenario Analyses. We recalculated potentials under three alternate program scenarios. The scenarios increased in overall programme expenditures and in the level of incentives provided to customers.

New Zealand Overview

The New Zealand electricity market was restructured in the mid-1990s to create competition in generation and retailing. The current structure consists of seven generators (a mix of private and state owned), a single transmission company, Transpower, (state-owned), 28 lines companies who own the local distribution networks, and retailers (the same companies who own the generators) who sell energy to consumers. In general, lines companies sell their distribution services to retailers. The retailer's charges to the consumer include the cost of the electricity supplied, as well as charges for transmission and line services. Some commercial and industrial consumers purchase directly from the wholesale market and are supplied via the transmission system.

New Zealand's land area is roughly equal to that of California, with a population of approximately 4 million people in about 1.7 million households. The population is concentrated in three main urban areas, Auckland and Wellington in the North Island, and Christchurch on the South Island. The climate is varied, but mild by US standards, with peak demands occurring on weekday evenings in the winter, driven by residential loads.

Findings

Below we report New Zealand consumption characteristics and economic efficiency potential. We start by discussing the national consumption and efficiency potential. This is followed by more detailed discussion for each of the three major sectors (residential, commercial and industrial), with a focus on end-use contribution to consumption, load and efficiency potential.

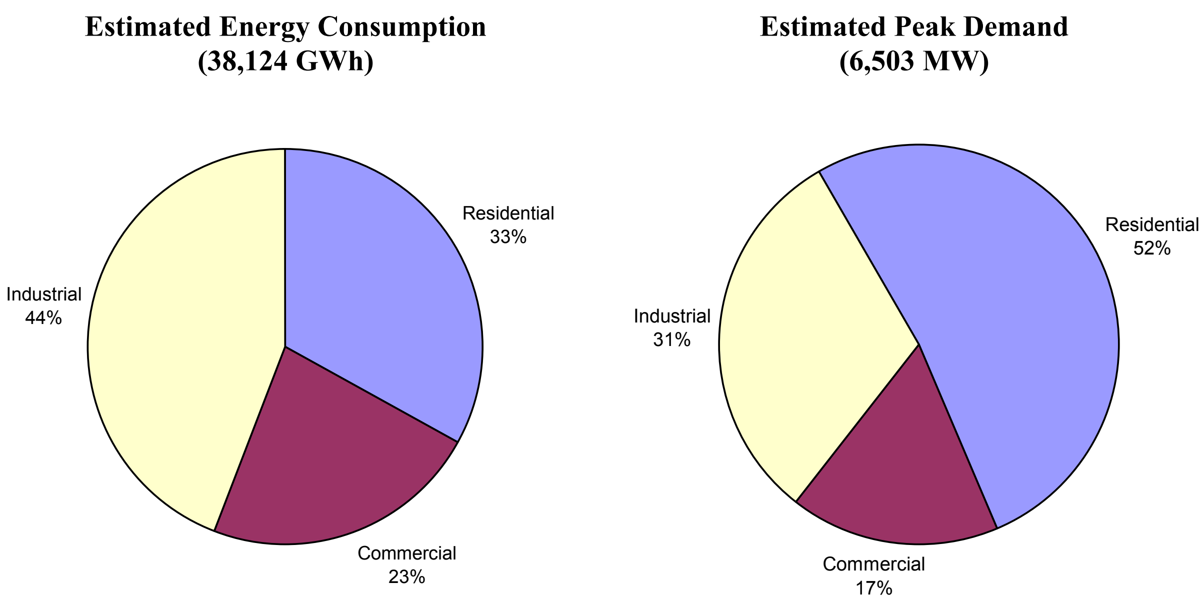
We obtained electricity consumption data from transmission grid exit points to obtain overall usage, peak time periods, and peak usage. Load shape data from BRANZ (BRANZ, 2006) were used to estimate the residential sector peak demand. Analysis of grid exit point data associated with large industrial customers from the Electricity Commission's Centralised Dataset 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.

End-use estimates were derived from a mixture of primary and secondary data sources. Due to a substantial lack of consumer data for the commercial and industrial sectors we conducted primary data collection. Much of the commercial saturation data were obtained from a combination of expert and market actor interviews, combined with end-user survey data. We conducted site visits at 10 of the largest industrial facilities in NZ. Savings estimates, applicability factors and other variables were sometimes extrapolated from US data, with adjustments for NZ characteristic for all sectors.

Overall

New Zealand is a winter peaking utility system due to the high incidence of electric space heating in all sectors and the low cooling load. 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.

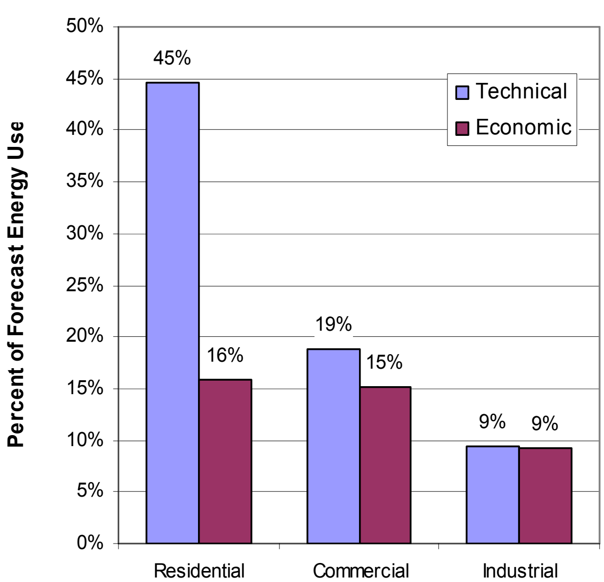
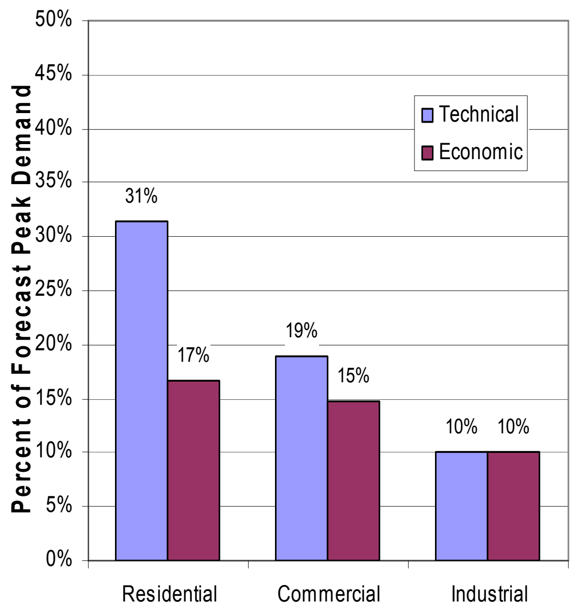
Figure 2
Estimated Energy and Demand Consumption
by Sector (2006)



In Figure 3 we show the technical and economic potential for both energy and demand, by sector. The difference between technical and economic potential is a function of two factors; the measures that are considered in the model and their cost effectiveness. For the residential secotr we included multiple measures to address electric space heating. Some of these measures caused double counting of savings for technical potential, which led to a substantial drop between technical and economic potential. For the industrial sector, it is unlikely that we included *all* technically feasible measures, as many are industry specific. The second factor is the cost effectiveness. Not all technically feasible measures pass the TRC test.

Overall, economic energy and demand potential is between 15 and 17 percent of base energy use for the residential and commercial sectors, and approximately 10 percent for the industrial sector. This economic potential, however, does not factor in the program activities and expenditures necessary to achieve this potential in the 10 year planning frame. In other words, this represents the maximum 10 year potential if all measures that pass the TRC test were implemented. Program achievable is likely to be lower, with savings dependent on program expenditures.

Figure 3
Estimated Technical and Economic Potential
as a Percent of Base (2016)

Energy Savings Potential Technical and Economic	Demand Savings Potential Technical and Economic
	

Residential

Water heating comprises the largest residential energy use, but space heating is the biggest single contributor to peak demand. (See Figure 4.) New Zealand has approximately 1.7 million households, with a small percentage of these having access to natural gas lines or using propane tanks for space or water heating, and cooking. Ninety-three percent of households have some form of electric heating, generally unit heaters that may be used in combination with other heating sources. The incidence of residential air conditioning is very low, but at risk of increasing due to the introduction of heat pump units for heating purposes (that can easily be reversed to provide cooling in the summer.) Eighty seven percent of households heat water with electricity, most with tank water heaters (referred to as cylinders in NZ.)[2]

The challenges of reducing space heating use in NZ are several. First, many houses are under-heated—below World Health Organization (WHO) standards for indoor temperatures. Insulation and other heat loss reduction measures may lead to increased comfort within the homes, but not necessarily (nor desirable) decreases in electric energy consumption. Also, the mild climate, relatively low electric rates and the practice of heating only rooms that are being used reduce the cost effectiveness (to the consumer) of making substantial improvements in the building envelope. Standards (and standard practice) for new construction have substantially improved, with better windows (tighter throughout the country and double-paned on the South Island) and higher insulation levels.

2 There is ripple control of residential water heaters for load management.

Figure 4
Residential Consumption by End Use

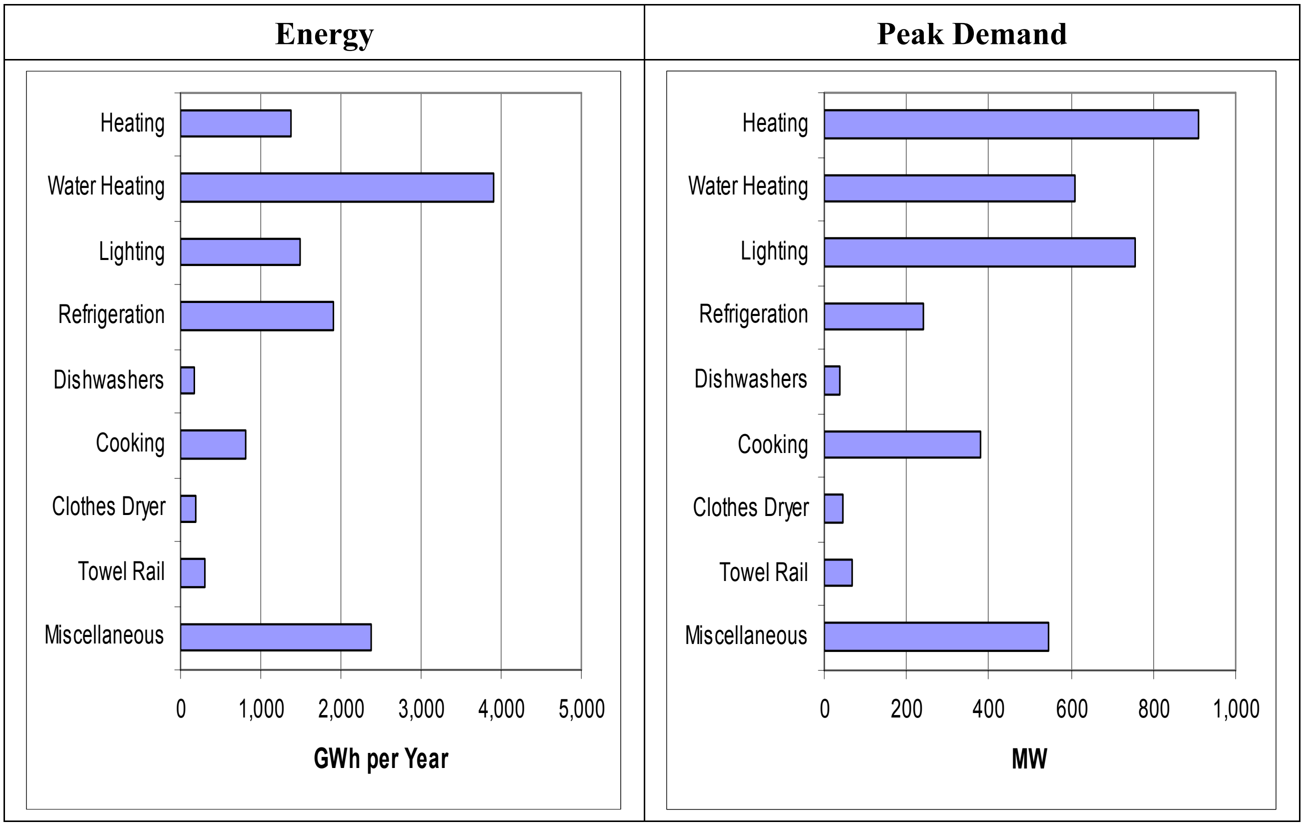
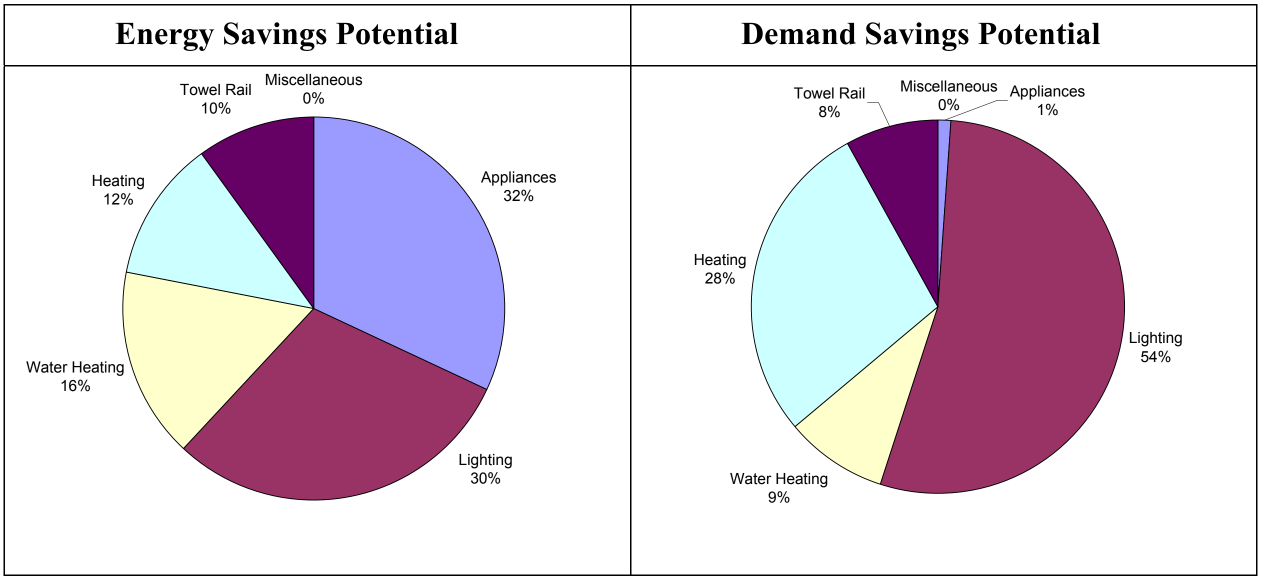


Figure 5 (below) shows the percent of economic potential in the residential sector by end-use. Opportunities for reducing water heater electricity consumption are somewhat limited as Minimum Energy Performance Standards (MEPS) require new cylinder water heaters to be Grade A, the highest efficiency available. Insulation of older cylinders, and pipe wrap offer some opportunity for program savings. Appliances are also subject to MEPS, but the standards allow some room for increasing the efficiency of new units.

Opportunities for reducing lighting use and demand, are substantial. Compact fluorescent lamps (CFLs) have been available at reduced cost in selected pilot areas. A nationwide program is currently underway that will substantially increase the incidence of high quality (low cost) CFLs in NZ homes.

Roughly four percent of residential electricity consumption is for heated towel racks. Given the low ambient temperature in NZ homes, approximately 40 percent contain heated towel racks in the bathroom. Many of these towel racks are kept on 24 hours per day. The installation of timers would substantially reduce this consumption.

Figure 5
Residential Economic Energy and Demand Savings Potential
by End Use (2016)



Commercial

As shown in Figure 6, indoor lighting, space heating and refrigeration are the three single largest end uses of electricity in the commercial sector. Linear fluorescent tube lighting is the predominant lighting technology, accounting for two thirds of commercial lighting overall. The majority of this lighting is T8 lamps with magnetic ballasts. Incandescent lighting accounts for approximately 20 percent of total commercial lighting but accounts for significantly higher shares of lighting in the hospitals and lodging. Low-voltage halogen lamps and compact fluorescent lamps (CFLs) account for small shares of total commercial lighting in New Zealand (6 percent and 5 percent, respectively).

Electricity is the dominant fuel used for space heating in NZ's commercial buildings. Natural gas and LPG play more significant roles in space heating in restaurants, schools, colleges, and miscellaneous commercial establishments, 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.

The overall saturation of air-conditioning in New Zealand's commercial sector is modest, with just over 50 percent of commercial premises reporting the use of 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 6
Commercial Consumption by End Use

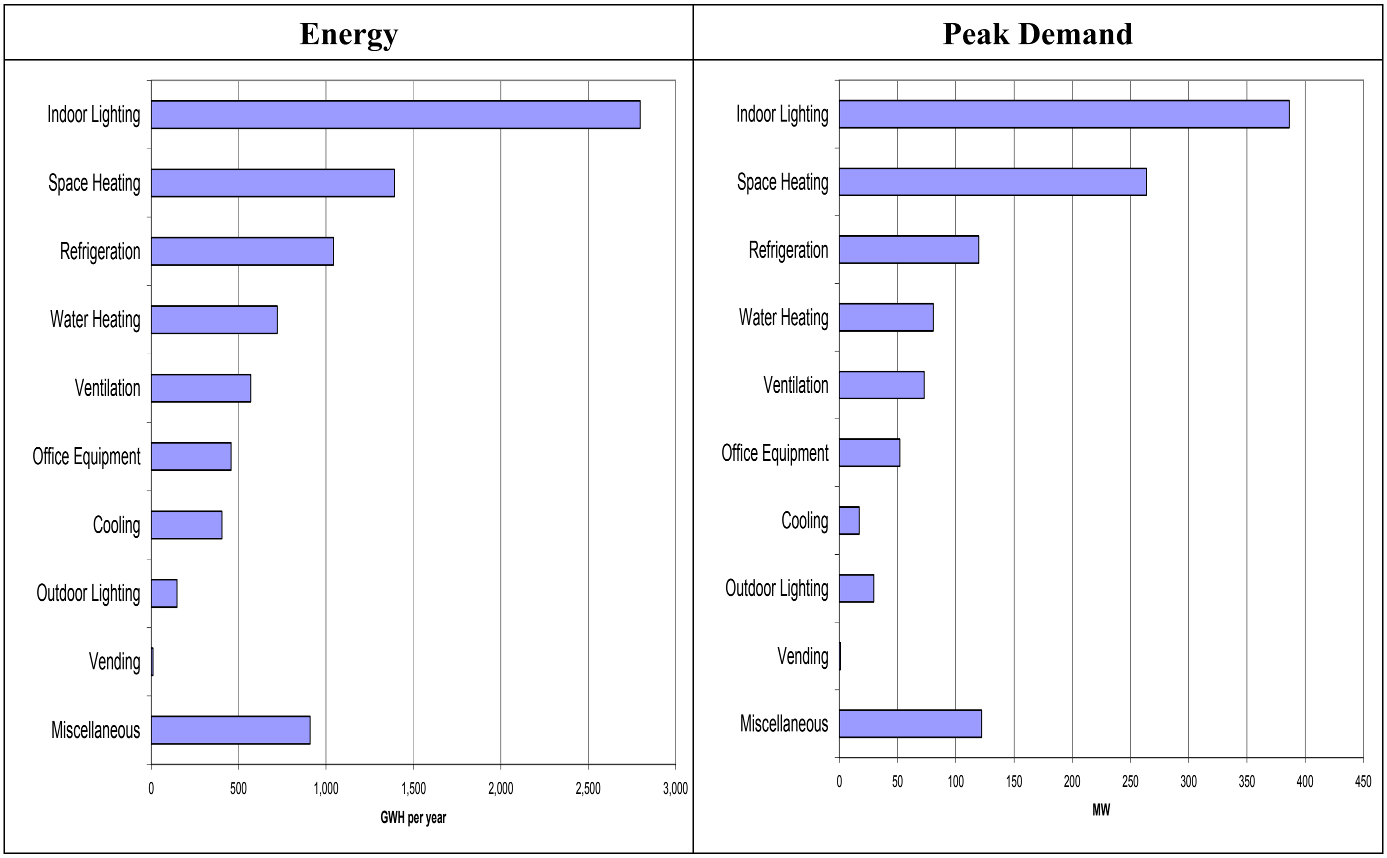
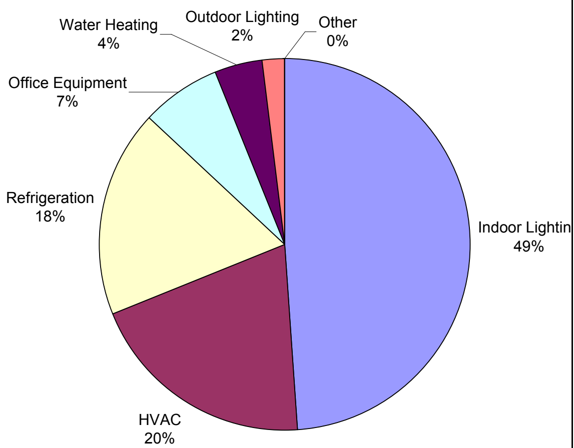
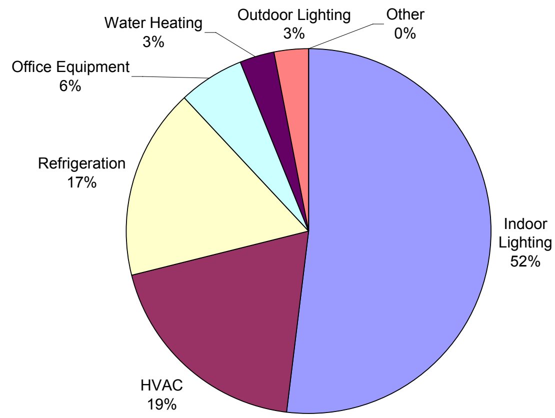


Figure 7 shows the end-use breakdown of economic potential in the commercial sector. As the figures show, the indoor lighting end use accounts for approximately half of the economic energy and peak demand savings potential in the commercial sector. The majority of economic potential from indoor lighting 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. Figure 7 also shows that the refrigeration and heating, ventilation, and air conditioning (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 high-efficiency split-system heat pumps, high-efficiency packaged DX systems, high-efficiency fan motors and anti-sweat (humidistat) controls for commercial refrigeration systems.

Figure 7
Commercial Economic Energy and Demand Savings Potential by End Use (2016)

Energy Savings Potential	Demand Savings Potential
	

Industrial

Figure 8 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 aluminum manufacturing process. The next largest end uses in terms of energy consumption and peak demand are process drives and pumping systems.

Figure 8
Industrial Energy Usage by End Use Type

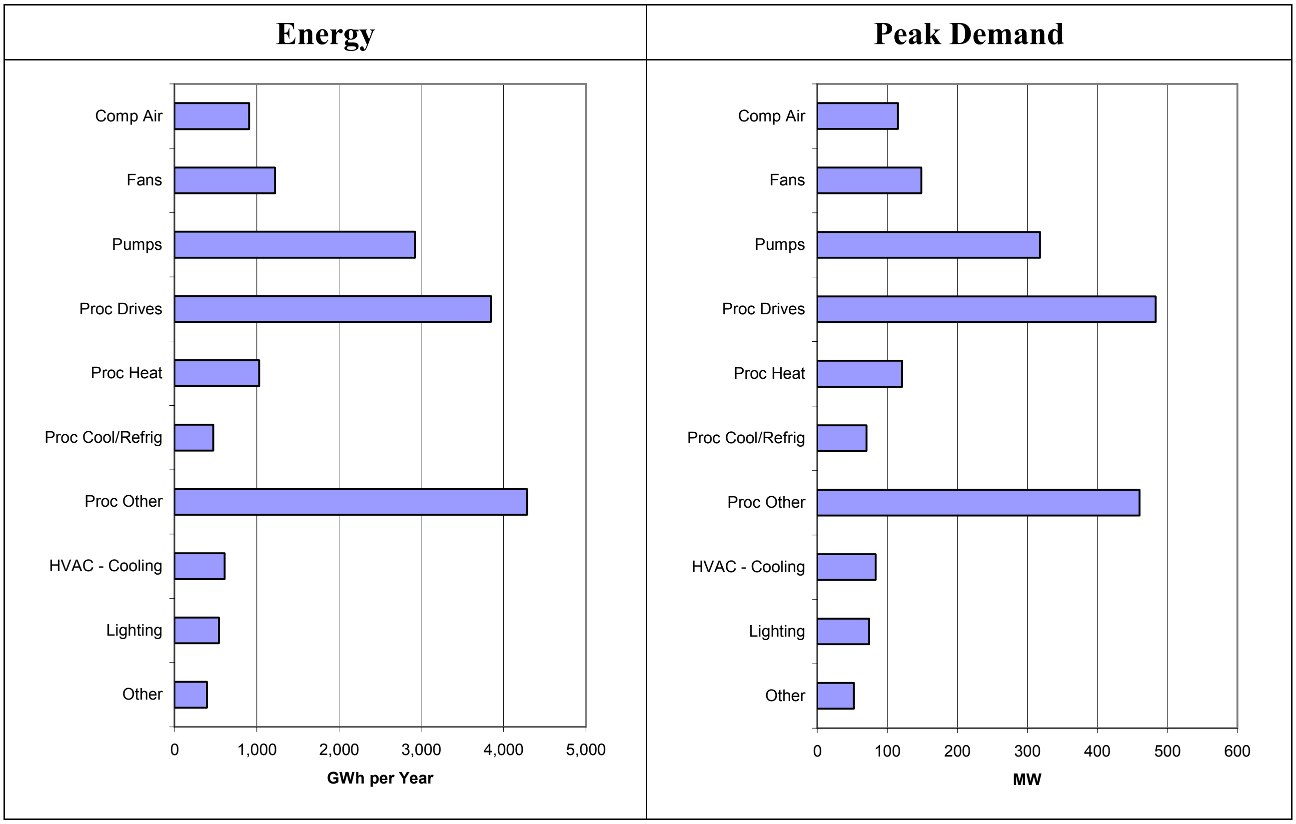
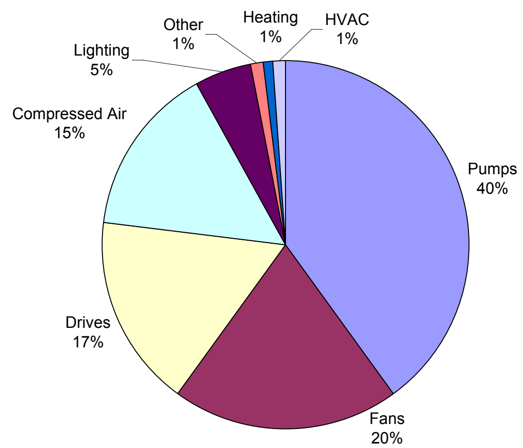


Figure 9 show the end-use breakdown of industrial economic potential. Pumping system measures provide the largest source of economic potential, followed by fans, drives, and compressed air. These are all motor driven systems that also comprise a very large share of industrial energy usage. Key measures that contribute to industrial economic potential include motor replacement (versus rewinding), installation of controls, and system optimization.

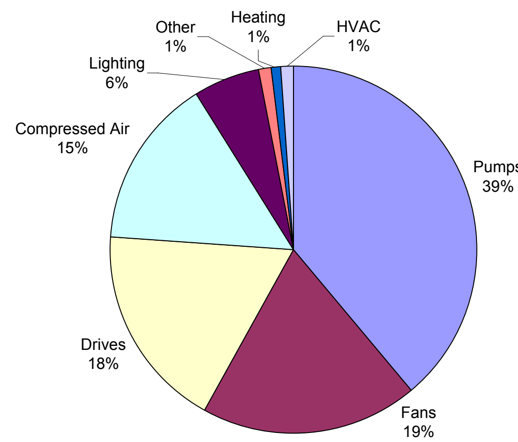
The end use shares do not vary much between energy and peak demand potentials. This is because the industrial load shapes used for the analysis are the same, in a given industry, for all end uses. Slight variations between peak and energy shares occur because some measures contribute differently towards 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 9
Industrial Economic Energy and Demand Savings Potential
by End Use (2016)

Energy Savings Potential



Demand Savings Potential



Summary

The characteristics of electricity use in NZ differ from the US in some significant ways. NZ experiences an early evening winter peak electric load, due to the high incidence of electric space heating. The residential sector represents slightly more than one-half of peak demand, with electric space and water heating, as well as lighting, dominating peak demand in that sector. The commercial sector, dominated by small businesses with usage more similar to residences (lighting and space heating comprising a large percentage of electricity use and demand, and with low air conditioning loads) is the smallest contributor to peak demand and represents less than one-quarter of energy use.

The potential for electric energy savings in NZ is substantial. Overall, the 10 year economic potential is approximately 6,000 GWh and 1,200 MW. The residential sector offers the greatest economic potential for demand reduction through improved lighting (adoption of CFLs) and reduced heating (primarily through envelope improvements). Space heating improvements may be mitigated by a "snap back" effect if residential consumers increase indoor temperatures to more comfortable levels. In the industrial sector pumping system measures provide the largest source of economic potential, followed by fans, drives, and compressed air. Substantial improvements in the industrial sector can be achieved through the replacement of motors with more efficient units in lieu of rewinding, the standard practice in NZ. In the commercial sector, lighting and space heating (replacing heating systems with more efficient equipment) provide the largest opportunities.

There were substantial challenges to identifying the electric efficiency potential in New Zealand. The biggest challenge was identifying baseline characteristics – usage characteristics and the saturation of equipment (efficient and otherwise) in the commercial and industrial sectors. Substantial and high quality data were available for the residential sector through BRANZ. Data problems are partly a result of a highly disaggregated and "lightly" regulated retail market from which little consumer and end-use data is available. In the past decade NZ has not emphasized electric energy efficiency because of low cost and plentiful hydro electricity, thus limiting both research on consumption characteristics and data on consumer response to program incentives.

There are also significant challenges with designing programs to realize NZ's electric efficiency potential. Substantial improvements in efficiency will be realized due to higher building standards, MEPS for appliances, motors and other electric equipment, which require programs to promote incremental efficiency gains beyond the standards. New Zealand's small size and relative isolation provide challenges and opportunities. Consumer options are limited — field research showed that within a given store consumers have limited product options that rarely vary in efficiency. This requires programs that work upstream to get products in to the NZ market that exceed MEPS. The small market, however, means that programs can have a substantial impact on markets (it is a smaller market to transform), which is good. However, political and social realities require sensitivity to potential unintended consequences of program actions, such as adverse effects on small businesses supplying energy products.

An additional challenge is low indoor winter temperatures in NZ homes that are likely to rise with efficiency improvements. This increase in comfort and the associated health benefits are desirable, but are a challenge to reducing peak demand. A trend towards larger homes, with more and bigger electricity using equipment, although not unique to NZ, could mitigate some of the savings.

Despite these challenges, the opportunities for electric efficiency in New Zealand are real. The Electricity Commission and other agencies (such as the Energy Efficiency Conservation Authority – EECA) are prepared to meet the challenge. They have already embarked on efforts to increase national efficiency through pilot electric efficiency programs, load management efforts and non-electric programs. Funding mechanisms for efficiency are in place and a national interest in reducing greenhouse gas emissions bode well for improved electric efficiency.

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