Process Heat in New Zealand

Business Investment Decision Making

Large process heat users and energy efficiency in New Zealand

Prepared for the Energy Efficiency and Conservation Authority by PwC

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EECA Energy Efficiency and Conservation Authority Te Tari Tiaki Pūngao

Disclaimer

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Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

Executive Summary

The Energy Efficiency and Conservation Authority (EECA) engaged PwC to update and extend its existing research into business investment decision making, as it relates to increasing energy efficiency and reducing carbon emissions in New Zealand.

The report will contribute to the evidence base for the Process Heat in New Zealand (PHINZ) project, a joint programme between EECA and the Ministry of Business, Innovation and Employment (MBIE). The PHINZ project will develop policies and programmes to reduce energy emissions of process heat users in New Zealand.

This research involved:

- a review of literature regarding decision making around energy efficiency and carbon reduction interventions and case studies; and
- interviews with nine process heat users identified by EECA that focussed on their decision-making processes, including the barriers to investment in energy efficiency, and measures that have overcome these barriers.

Literature review

The literature review found that market and behavioural barriers prevent investment in technologies and practices that increase energy efficiency and reduce carbon emissions, despite the private and public benefits for doing so. This phenomenon is commonly called the energy efficiency gap. Estimates by MBIE and EECA that show New Zealand process heat users could make efficiency improvements by 4 - 12 percent between 2010 and 2030 suggest that there is an energy efficiency gap here.

Overseas case studies show that the energy efficiency gap can be alleviated by:

- senior-level corporate commitment to achieving energy efficiency in facilities;
- the availability of internal or externally-sourced (contracted) capability to identify and implement improvements; and
- access to internal finance to fund the most appropriate energy efficiency projects.

Interviews

We interviewed nine large process heat users in New Zealand that partner with EECA. They represent a wide range of sectors including the dairy, meat, and other food processing sectors, the wood processing and cement sectors, as well as healthcare.[1] They have different ownership and decision-making structures, and include both private and public entities. A common factor among all of them is that energy costs are in their top three operating costs, so energy savings is the main driver for new investment in energy efficiency projects.

Our findings must be read in the context of the organisations we interviewed. We targeted large process heat users who are engaged with EECA around energy efficiency and carbon emissions reduction, therefore we were more likely to find considered decision making.

The interviews revealed that plant and energy managers are often the staff members who identify energy efficiency opportunities (sometimes following audits by external energy consultants). It was also found that

[1] Sectors included dairy (Fonterra Limited), meat and other food processing (New Zealand Sugar Company Limited, McCain Foods (NZ) Limited, Alliance Group Limited), wood processing (Oji Fibre Solutions (NZ) Limited), cement (Golden Bay Cement), public healthcare (Canterbury District Health Board), and glass manufacturing (O-I Glass).

it is uncommon for senior managers to have the role of energy champions. This suggests there may be a lack of strategic focus on energy efficiency at a high level.

Another insight is that energy efficiency or carbon emissions-reducing projects compete for funding with other capital projects of a similar scale. For small capital projects, payback periods of 12 to 18 months were required to meet investment thresholds. Some energy efficiency projects met these requirements and others did not. Larger capital investments, such as replacement projects, focussed on business survival and making returns on the investment. Energy efficiency was generally seen as an additional benefit of the overall project. Most organisations in our sample do not explicitly incorporate the price of carbon and the risk of it changing into their analyses, although some did in business cases for large capital projects.

Two organisations had specific funding mechanisms in place for environmental initiatives. Some larger privately-held companies were willing to reduce their private optimal risk-return requirements for a better environmental outcome.

Organisations in our sample appear to be involved in decision making that is financially and economically sensible, with some consideration of investment in energy efficiency and carbon emissions-reducing technologies at a privately optimal level.

However, that does not mean that they are maximising energy efficiency. The ‘frontier’, as described in economics, is ‘lumpy’; new technologies, and to a lesser extent upgraded practices, cannot be implemented as soon as they are identified without significant production disruption. Production disruption is very important to organisations, so decision making takes time. Such lead times can also be exacerbated by infrequent upgrade, maintenance and asset replacement cycles.

Implications

Our findings suggest that investment in energy efficiency can be good for organisations, but business decision-making processes do not necessarily consider it as the best or optimal outcome.

Additionally, even when energy efficiency opportunities passed cost-benefit tests for large process heat users, they did not pass the prioritisation test when put up against non-energy capital projects.

Further investment in energy efficiency and carbon reduction projects would be encouraged if:

- there were dedicated funding or financing channels, which would overcome competition for funding from other projects;
- businesses made a strategic commitment to energy efficiency; and
- more consideration was given to low-emission alternatives in replacements of large end-of-life strategic assets.

Table of contents

Introduction

Background

Climate change is a significant global challenge. Under the United Nations Framework on Climate Change and the Paris Agreement, there is a renewed focus on transitioning towards a lower-emissions economy (Ministry for the Environment, 2017; MBIE and EECA, 2017). The sectors with process heat users provide one of the biggest opportunities to improve energy efficiency and reduce emissions in New Zealand.

Process heat users are industrial and commercial businesses that utilise large amounts of heat in their production processes, often in the form of steam, hot water or hot gases. They are typically characterised as energy-intensive or semi-energy-intensive with a significant proportion of expenditure going to meet energy costs. For example, dairy processors use steam from boilers to sanitise equipment and process raw products, such as converting milk into milk powder.

MBIE and EECA note that process heat users contribute approximately nine per cent of gross emissions, and 60 per cent of process heat is supplied using fossil fuels. Understanding how businesses make investment decisions around improving energy efficiency and reducing carbon emissions provides information that can be used to influence large process heat users through public policy, and thereby support New Zealand's energy efficiency objectives.

Purpose and methodology

EECA engaged PwC to support it in updating and extending its existing research into business investment decisions, as it relates to increasing energy efficiency and reducing carbon emissions. The wider aims of the research are to explore and understand:

1. how process heat users currently identify energy efficiency opportunities, and how they cost, prioritise and fund them;
2. which factors, if any, trigger investment in energy efficiency and carbon emissions-reducing technologies;
3. the processes businesses use and the key criteria for decision making; and
4. the effect of carbon pricing on business cases and decisions to reduce carbon emissions, and the potential responses to future carbon prices.

The project involved research in the form of:

1. a review and appraisal of the literature around decision making in relation to investing in energy efficiency and carbon emissions-reducing technologies and practices
2. a workshop with EECA's Market Engagement Team to identify the process heat users to interview, and the common issues they face in decision making around energy efficiency and carbon emissions reduction (Appendix A); and
3. interviews with those process heat users to review and understand their decision-making processes, including the barriers they face in investing in energy efficiency and carbon emissions-reducing technologies, as well as any measures that have proved successful in overcoming these barriers.

The semi-structured interview guide is presented in Appendix B.

Structure

Following this section, this report is structured as follows:

1. **Literature review** – This section provides a review and appraisal of the literature and an international case study around decision making, including a review of the barriers and enablers to adoption of energy efficiency and carbon emissions-reducing technologies.

2. **Interview findings** – This section outlines the main findings from interviews with process heat users, including the barriers they face in investing in energy efficiency and carbon emissions-reducing technologies, as well as any measures that have proved successful in overcoming these barriers.

3. **Discussion** – This section relates, within an economic framework, the findings from interviews to observed barriers found in the literature review and the issues identified by participants in the workshop.

4. **Conclusion** – This section concludes the research report and makes recommendations to EECA and the PHINZ project for further areas of research.

This report is about decision-making processes around energy efficiency and carbon emissions-reducing technologies and practices. In the remaining sections, we refer to these more simply as energy efficiency technologies.

Literature review

In theory, energy efficiency and carbon emissions reduction can be achieved through adopting new technologies or assets, or enhancing existing management practices. In some sectors, improvements in energy management may lead to significant cost-savings without the need for capital investment (MBIE and EECA, 2017). Examining the barriers that prevent the adoption of energy efficiency technologies and practices forms the foundation for understanding what may be preventing investment decision making towards energy efficiency activities by New Zealand's process heat users.

Traditional economic theory says that markets are the most efficient way to allocate the use of resources in the economy. 'Most efficient' holds not just for individuals and businesses, but for society as a whole. Under the standard set of assumptions about markets, resources and businesses, the privately optimal use of energy (and carbon) resources will also be the socially optimal use.

However, these assumptions do not hold in practice. There are many observed imperfections and complexities embedded in decision making. As a result, private decision making about energy use and carbon emitted may not be socially optimal, or even privately optimal.

One reason for the difference can be market failures – ways in which the markets do not lead to efficient outcomes. Another reason is barriers – features of business, technology, control and decision making that prevent private actors from making better decisions.

This understanding leads to an approach to energy efficiency focussed on failures and barriers. If the failures can be corrected and the barriers can be removed, businesses should make decisions that are both privately optimal and socially optimal.

Is there an energy efficiency gap in New Zealand?

Implementing energy efficiency technologies can have both private benefits to the businesses and public benefits to society. Private benefits include reduction in operating and maintenance costs, increased competitiveness through better prices and quality, increased energy productivity, and increased health and safety (MBIE and EECA, 2017).

Although there are private benefits, many investments in energy efficiency and carbon-emissions reducing technologies and practices are not undertaken (DeCanio, 1993). Through an economic lens, there is an observed difference between:

- the theoretically optimal level of cost-effective energy efficiency a business can attain; and
- the observed level of energy efficiency a business actually adopts in practice.

The literature on investment in energy efficiency focusses on a phenomenon commonly known as the energy efficiency gap. The energy efficiency gap has two elements. They occur when market actors:

- **Decide not to act** – Barriers and market failures cause actors to make sub-optimal decisions, but which they perceive as optimal
- **Take time to act** – Processes cause a delay between the effective deployment of energy efficiency technologies and the uptake of these technologies by others.

There is evidence that an energy efficiency gap exists for many process heat users in New Zealand. For example, MBIE and EECA (2017) estimate that the efficiency of the industrial sector's process heat use could improve by 4 to 12 per cent between 2010 and 2030. This suggests process heat users are currently not making decisions that maximise energy efficiency and minimise carbon emissions.

Barriers have been used to explain the gap

Historically, energy policy decision making has been based on economic theory (Thollander & Palm, 2013). Business investment decision making as it relates to energy efficiency and carbon emissions reduction has tended to be explained through traditional and behavioural economics lenses. The energy efficiency gap arises from the existence of market failures and barriers (both of which are commonly referred to as barriers). These failures and barriers prevent levels of investment in energy efficiency that society as a whole would desire, and the energy efficiency gap is the commonly cited as a reason for policy interventions (Brown, 2001).

Barriers are the factors that inhibit investment in technologies that are both energy efficient and economically efficient (Sorrell, O'Malley, Schleich, & Scott, 2004). They are embedded in the private decision-making process that may prevent investment in energy efficiency technologies and practices at socially optimal, or even socially desirable, levels.

Sorrell, et al (2004) categorise barriers based on the discipline from which they arise:

- **Market and organisational failures** – These are economic barriers that violate the foundations of traditional economic theory, including imperfect and asymmetric information across multiple actors.
- **Barriers arising from rational behaviour** – They refer to a situation in which economic actors, due to the existence of these barriers, rationally decide not to adopt energy efficiency technologies at a socially optimal level.
- **Behavioural barriers** – These are additional barriers identified in the behavioural research, including behavioural economics and psychology.
- **Organisational barriers** – These are additional barriers identified in the organisational theory literature, that arise out of the premise that organisations are a collection of actors with various degrees of control over the business.

Table 1 lists the barriers to energy efficiency based on the taxonomy from Sorrell, et al (2004); and Thollander & Palm (2013). Eight of the theoretical barriers relate to a traditional economics framework and five relate to a behavioural framework.

Table 1. Classification of barriers used to explain the energy efficiency gap

Category	Theoretical barriers	Comment
Market and organisational failures	Imperfect information	Information imperfections, for example, lack of information, may lead to cost-effective energy efficiency measures not being undertaken
	Asymmetric information	If a seller knows more about the energy performance of a technology than the buyer does, the buyer may select goods on the sole basis of price or visible aspects such as colour and design
	Principal-agent relationship	Monitoring and control by the principal, since he or she cannot observe what the agent is doing, may result in the overlooking of energy efficiency measures
	Split incentives	If a person or department cannot benefit from an energy efficiency investment, the most likely outcome is the non-adoption of the measure
Barriers arising from rational behaviour	Hidden costs	Hidden costs include overhead costs related to the investment, cost of collecting and analysing information, and production disruptions
	Limited access to capital	Limited access to capital may inhibit cost-effective energy efficiency measures from being implemented
	Risk	Risk aversion may result in cost-effective energy efficiency measures not being undertaken

Category	Theoretical barriers	Comment
	Heterogeneity	A technology or measure may be cost-effective in most locations but not in others, leading to excessive potential being claimed for the technology
Behavioural	Form of information	Research has demonstrated that to increase the diffusion and acceptance of information on cost-effective energy efficiency technologies, the information should be specific, vivid, simple and personal
	Credibility and trust	The source of information must be considered credible and trustworthy by the receiver in order to successfully deliver information about cost-effective and energy-efficient technologies
	Values	Individuals motivated by environmental values may give a higher priority to efficiency improvements than those that are not. Efficiency improvements are most likely to be successful if championed by a key individual within top management. The environmental values of key individuals is a relevant variable in explaining organisational performance on energy efficiency
	Inertia	Individuals are often hesitant to change, which may, in turn, result in the overlooking of cost-effective energy efficiency measures
	Bounded rationality	Decisions are made with imperfect information and incomplete rationality. Decisions are not privately optimal from a fully rational point of view
Organisational	Power	Low status of energy managers may lead to energy issues being assigned a low priority in industrial organisations
	Culture	The core values of an industrial organisation may inhibit or promote energy efficiency. Over time, organisations may encourage energy efficiency investments by developing a culture characterised by environmental values

Sources: Sorrell, et al (2004) and Thollander & Palm (2013).

Descriptive case studies and statistical analysis of barriers have been undertaken to explain the existence of the energy efficiency gap and the barriers that cause it in various countries and regions.

Schleich & Gruber (2008) provide an example of testing the impact of barriers using statistical analysis. Schleich & Gruber analysed the German commercial and services sectors and found that the most important barriers are the investor-user dilemma (a type of split incentive) and lack of information about energy consumption. Fleiter, et al (2012) provided another example and found that, in Germany, high investment costs and lack of access to financial capital impede the adoption of energy efficiency measures, primarily for large investments.

Rohdin, Thollander, & Solding (2006) analysed the results of a survey questionnaire of the Swedish foundry industry, an industry categorised by high energy intensity and large process heat use. They investigated the existence of different barriers to and driving forces for the implementation of energy efficiency measures. Rohdin et al. (2006) found that limited access to capital is the largest barrier to energy efficiency. Further, except for capital constraints, barriers within group-owned companies are more related to organisational problems, and barriers within privately-held companies are more related to information problems. They found that that energy consultants working on energy issues with foundries play an important role in overcoming the largest barriers, and gained the trust of the foundry staff. The two most important drivers were found to be people with high levels of motivation to improve energy efficiency and long-term energy strategies.

Large overseas businesses have overcome some barriers

There are several key examples of large overseas businesses overcoming barriers to the adoption of energy efficiency technologies. The State and Local Energy Efficiency Action Network (SEE Action) in the United States demonstrates the key factors that enabled large energy-intensive industrial businesses to overcome some of the barriers to investing in energy efficiency technologies.[2] The companies studied in SEE Action (2017) were J.R. Simplot Company, General Motors Company, General Mills, Inc. and Intel Corporation.

These case studies have shown the following factors can alleviate or mitigate the impact of these barriers on the adoption of energy efficiency technologies:

1. **High-level corporate commitment to energy efficiency** – senior management can demonstrate commitment to achieving visible and clear energy efficiency goals, with targets allocated down to key facility level.

2. **Personnel available to identify and implement energy efficiency projects** – staff with the right knowledge and skills, or outsourced or borrowed experts, can work at the facility level to continually identify site-specific, profitable energy efficiency measures and to follow through on implementation.

3. **Clear and effective internal financing systems for energy efficiency projects** – effective internal systems operating regularly can allocate funding to the energy efficiency technology deemed most attractive to the organisation.

These organisations adopted energy efficiency technologies and practices because of the potential for cost reduction and enhanced reputation through energy efficiency programmes (State and Local Energy Efficiency Action Network, 2017). The starting point was to assess the private benefits for each organisation. The study found that cost reduction is a growing incentive, although reputational concerns are gaining prominence as the public is beginning to pay greater attention to issues such as climate change. See Appendix C – Overcoming barriers.

Process heat barriers in New Zealand

Capital intensity

Capital-to-labour ratios in New Zealand are low compared to other OECD countries. The effect of low capital intensity is lower productivity (Conway & Meehan, 2013). Lower capital intensity suggests less ability to invest in plant capital, perhaps because organisations are relatively more capital constrained. This may mean there is currently less opportunity for investment in energy efficiency and carbon emissions-reducing projects, and greater competition for capital amongst energy and non-energy related projects.

Energy behaviour of SMEs in New Zealand

We looked for equivalent research on energy efficiency of New Zealand organisations and their decision-making processes for adopting energy efficiency technologies. We found some research on small-to-medium enterprises (SMEs).

Watson (2015) examined the energy behaviour of SMEs in New Zealand. They reported the result of a survey-based research project that examined how SMEs generally use energy and what actions are taken to reduce energy consumption. The aim of the research was to identify high-impact opportunities for energy saving in SMEs in New Zealand.

The perceptions and attitude of SMEs towards energy use were found to be the following:

- energy and electricity bills are significant expenses
- society needs to reduce energy consumption (suggesting there is a perception amongst the businesses of an energy efficiency gap in New Zealand)
- around half of the participants have already taken action to save energy

2 SEE Action undertook a similar study several years earlier. SEE Action (2015) outlined the three key success factors that allowed programme administrators to generate value to industrial business and deliver low-cost energy savings.

- most organisations were interested in new opportunities to save money or profit from energy efficiency
- most organisations' customers and clients were not concerned about their environmental commitment.

Watson found that SMEs are incentivised to invest in energy efficiency technologies primarily if there are potential cost savings. They also reported a general consensus that change is not resisted but would be better embraced if technology costs were the same or less. Key barriers that come out of the study are:

- **Limited access to capital** – Constrained capital can hinder proposed investments in energy efficiency projects.
- **Prioritisation** – There is a lack of prioritisation for energy efficient projects. Larger businesses were more likely to consider energy efficiency technologies because energy costs tended to be larger.
- **Production disruption** – Energy efficiency technologies also have to be proven and production disruption needs to be considered before a technology is seen to be safe to adopt.

Interview findings

Structure of interviews

PwC held a workshop with EECA staff to identify potential interviewees and key issues to investigate in the interviews. The workshop process and outcomes are outlined in Appendix A. Following the workshop, EECA shortlisted the 22 identified candidates into 10 large process heat users that could be interviewed. PwC contacted the 10 organisations and nine agreed to an interview in person or over the phone. Semi-structured interviews were conducted with key staff in each organisation. Each interview was based on a set of 13 questions agreed by both PwC and EECA, which provided the foundation for each semi-structured interview. The interview questions are listed in Appendix B.

One organisation interviewed preferred to have the interview conducted anonymously. The remaining eight organisations that agreed to be named in this report are:

- Alliance Group Limited
- Canterbury District Health Board
- Fonterra Limited
- Golden Bay Cement (a division of Fletcher Concrete and Infrastructure Limited)
- McCain Foods (NZ) Limited
- New Zealand Sugar Company Limited
- O-I Glass Limited
- Oji Fibre Solutions (NZ) Limited

When organisations invest in energy efficiency

Organisations reported investing in specific technologies and activities, including reducing leaks through maintenance, general asset replacement, retrofitting and upgrading technology to recover and recycle heat, and upgrading technology to less carbon-intensive technology, such as biofuel and biomass boilers.

Below we set out the findings from the interviews, which are structured around four areas embedded in the decision-making process:

1. Drivers of investment
2. Identification of technologies and practices
3. Assessment and prioritisation of projects
4. Financing projects.

Drivers of investment

This section outlines the parts of organisations that drive energy efficiency and the factors that impact strategic or management decisions to invest in energy efficiency technologies. Large process heat users have energy-intensive production processes. The organisations interviewed ranked energy cost in the top three operational expenditure items and an area of potentially significant cost savings. Energy cost is a significant driver of new investments in energy efficiency and carbon emissions-reducing technologies. There are strong financial benefits in the form of energy cost savings, as well as environmental and reputational benefits.

The parties driving energy efficiency

For the New Zealand-owned companies interviewed, the decision-making process, as it relates to energy efficiency technologies, starts with employees at the plant level and below senior management. Investment opportunities are generally identified and costed by plant or energy managers, or small teams. Opportunities are generally fed up to senior management and buy-in is more likely to occur once an idea has been assessed through a business case or proposal.

Globally-owned firms interviewed stated that energy efficiency is predominantly driven from senior management at the Asia-Pacific or global level. Businesses that are New Zealand branches or subsidiaries had globally driven standards and decision-making processes that set the direction for energy efficiency and carbon emissions-reducing investments and activities.

We further observed that, for privately-held businesses, owners took an active role in setting the strategic direction around investment, including in energy efficiency. For two organisations interviewed, the energy efficiency programme arose out of the expectations and direction set by the owners.

The reasons for energy efficiency

Where energy efficiency technologies were adopted by the nine companies, a wide range of drivers impacted the decision-making processes. These included:

- **Financial** – Energy is a major operational cost for large process heat users and was the major driver for implementation of energy efficiency measures. The financial returns sought from energy cost-savings provided the underlying rationale for investment in energy efficiency technologies.
- **Strategy** – Four organisations identified that environmental impacts were embedded as a consideration in their decision-making processes. For example, McCain Foods has a dedicated energy team to support energy champions and set additional environmental criteria, of one kilogram of carbon emissions savings per dollar of capital expenditure, on a carbon emissions-reducing project.
- **Customer and public demands** – Three organisations reported that customer relations influenced their decisions to invest in energy efficiency technologies. The customers wanted to know the environmental impact and carbon footprint of the operation. The other remaining organisations stated that their customers simply care about price and quality, so environmental concerns did not motivate decisions. There was no indication that these organisations believe customers were paying greater attention to the environmental impacts of the organisation's activities than to the price and quality of product.
- **Reputational opportunities** – Two organisations reported that their reputations in relation to their environmental impact were an incentive to invest in energy efficiency technologies.
- **Staff** – Three organisations stated that the decision to invest in energy efficiency technologies was driven by staff wanting to see positive change in the organisation. Staff in these organisations encouraged energy efficiency because they wanted their organisations to be socially responsible or aware.

Identification of technologies and practices

Interviewees generally identified energy efficiency and carbon emission-reducing projects at the plant level. This is done by day-to-day energy or plant managers, and results from data collection and analysis processes and energy audits by external energy service providers.

Energy data is a frequent topic of conversation

Energy data are frequently monitored, reported and used. The majority of organisations interviewed stated that their energy data are actively monitored, both in terms of the energy used (e.g., in gigajoules) and energy productivity (e.g., in gigajoules per tonne of product). The frequency of monitoring ranges from hourly to weekly.

Energy data are reported to senior management and energy use is a frequent topic of internal discussion. For example, one organisation reported having energy information systems that not only monitor but also cross-reference with financial systems to identify where opportunities for improvement may lie.

Only one organisation stated that it did not monitor energy use particularly well on a day-to-day basis. The interviewee was aware that their daily limits on production inputs, including electricity use, were part of the plant's KPIs but did not actively monitor this and would, if necessary, exceed this limit if required to meet production demand.

External energy consultants help identify opportunities

Organisations identified that external consultants played a key role in identifying opportunities for investment. They provide useful services such as energy audits, which are used to identify a number of opportunities to increase energy efficiency and reduce carbon emissions through investment in technologies and adjustments to practices. Other interviewees supported that independent audits are given more credence by senior managers.

Organisations use different technologies and have complex production activities. Some interviewees reported that it can take time for consultants to fully understand the operation or production process, as well as build trusted relationships with the plant staff. Following this period of familiarisation, the audits have been effective in identifying opportunities. Many organisations have undertaken the identified opportunities and see value in this process. One organisation relied heavily on outsourced energy experts to identify and support project implementation.

Other external parties have a role as well

Enviro-Mark Solutions, the Bioenergy Association of New Zealand and the Energy Management Association of New Zealand were raised as key actors that help organisations with their optimal use of energy and carbon emissions.

Three organisations reported they had attained the ISO 14001 certification for their environmental management systems. One of them noted there was a large cost to becoming certified.

Two organisations also identified having working relationships with universities across New Zealand as partners in energy efficiency. This shows that research institutions can have a role in the decision-making processes.

Assessment and prioritisation of projects

The role of the energy champion

We observed that, generally, the energy champion role falls on plant or energy managers, who monitor and control energy on a day-to-day basis. It is uncommon for senior management to have this role, although some organisations had, or were introducing, the sustainability manager roles.

Energy champions are generally the proponents of energy efficiency opportunities. The champion helps identify opportunities for investment and improvement, reports to senior management and raises issues around energy in production. For capital projects, the energy champion will put together a business case or capital expenditure proposal, often with the assistance from other business segments (such as the finance function) and from external energy consultants who conducted the energy audit that identified the opportunity.

In some cases, the role of energy champion is supported by a dedicated energy team. For example, for one multi-site business, the role of energy champion resides with each plant team leader. However, the energy champions have access to a support team that can look into various opportunities and report back. For some organisations, there is a growing desire to get more plant-level staff engaged in energy use, management and efficiency. The aim of getting this involvement is to ensure there are advocates who can identify and drive increases in energy efficiency and carbon emissions reduction.

Prioritisation processes

For capital projects, a typical business case is prepared for approval by decision makers at the senior management level. The business case typically assesses the costs, risks and benefits (predominantly energy savings) that the technology is forecast to deliver. Preparation of the business case is often supported by the energy consultant who helped identify the opportunity.

Organisations noted a number of ways management prioritise investments. These are common project finance metrics, and include payback periods, internal rates of return and net present value.

Interviewees reported that some smaller energy efficiency capital projects did not meet funding requirements because the project financing criteria – typically a payback period of 12 to 18 months – was not met. In these cases, there was no suggestion that proposed energy efficiency or carbon emissions-reducing projects were treated differently from other proposed capital projects.

In one case, where energy efficiency was driven from the top down, management were willing to sacrifice some risk-adjusted return if the business case could demonstrate a positive environmental impact.

The business cases for larger capital projects, such as replacements of large plant equipment, were focussed towards business survival (stay-in-business investments), and making returns on the investment. These follow the same business case processes, but project finance metrics cited included net present value, internal rates of return and longer payback periods. In this case, energy efficiency was generally seen as an additional benefit of the overall project, but not the central focus.

For Fonterra Limited (Fonterra), bundling a group of proposed smaller energy efficiency projects into one large capital project helped to justify the investment, as shown in the following case study.

Case Study 1: Fonterra Limited

Fonterra Limited (Fonterra) has been running an energy efficiency programme since 2003. Recently, Fonterra installed condensing economisers on the new gas-fired boilers that were installed at the Pahiatua and Lichfield site expansions to enhance heat recovery and energy efficiency. Condensing economisers recover otherwise lost heat from boilers by condensing moisture and transferring that latent heat back into the process.

Following the successful installation at two sites, Fonterra began looking to roll out condensing economisers into other sites.

Fonterra found the business case did not stack up when assessing this technology on a site-by-site basis. However, by bundling the proposed installations across numerous sites into a single project, it could be funded as a large capital investment due to the strategic benefits of undertaking these activities.

Fonterra is planning to install further condensing economisers on existing boilers in the winter shut-down period next season, so any risk to production disruption is minimised.

Fonterra views heat recovery as a good energy efficiency activity to undertake that typically has a good return on investment. However, it does have some technical challenges at times to ensure that it is recovered and used efficiently within operations, so good technical design planning is required to integrate improvements efficiently.

Smaller projects that do not warrant a business case are typically funded through plant-level operational budgets. These are typically adjustments to existing practices or production equipment that increase energy efficiency or reduce carbon emissions. Incremental changes are typically approved by plant managers where the change is expected to improve to a plant's KPI. KPIs include energy consumption and energy productivity (energy use per unit of production).

Health and safety and product quality are paramount

Health and safety was seen by interviewed organisations as a prevailing concern when assessing new technologies and practices. They reported that the focus on health and safety in recent years was a priority, driven by changes in regulatory requirements. A side effect of this is the historical under-investment in energy efficiency and carbon emissions-reducing technologies.

Some organisations reported that some proposed energy efficiency and carbon emissions-reducing projects had additional benefits of increased health and safety, staff wellbeing and product quality. For example, insulation on hot pipes can also prevent injury and therefore improve plant health and safety. These considerations increase the non-energy benefits of the project, thereby increasing the attractiveness of the business case for implementing the technology. In these cases, energy efficiency technologies complemented other aspects of the operation.

The quality of product was a paramount consideration for organisations. Although no specific examples were given, we raised the question of whether there was a possibility of quality compromise. Organisations reported that they were not willing to trade product quality for energy efficiency or carbon emissions reduction benefits.

Production disruption is an important consideration

Production disruption is important to organisations, but has the potential to impact organisations in different ways according to how they undertake maintenance and upgrades. There was a preference to upgrade existing technologies instead of implementing new technologies. If technology had been proven or a successful small-scale pilot had been conducted, the perceived operational risk of a new technology decreased. Further, it potentially reduces the change costs associated with drawn out implementation.

For some organisations that operate continuously, there tends to be a set period when they implement large-scale changes, to mitigate any potential risks and impacts from disrupted production. The shut-down period is generally for two to three weeks on an annual basis, but can be longer.

There are also operational risks in the supply chain for technologies that many of the organisations reported having. For example, wood biomass boilers require security, proximity and availability of appropriate fuel. This creates ongoing operational risk that the organisation has to manage. For example, one organisation has backup diesel boilers that can run entire sites. The boilers are intended to reduce the risk of the impacts of the biomass boilers option failing. The case study below shows Golden Bay Cement's experience with the supply chain around obtaining wood biomass.

Case Study 2: Golden Bay Cement

Golden Bay Cement uses wood biomass to generate heat. It uses sawdust, woodchip and wood shavings from timber mills and processors, and demolition timber from the Auckland and Northland regions.

There can be supply chain issues arising from limited supply. This is driven from factors such as competition from saw-mills, farmers for livestock wintering and feed pads, factories that can use wood chip as a raw material, mulch and compost producers, and landscapers. Limited supply is also created because there are lower-cost disposal options available, such as landfills.

There is also inconsistency in supply. The different materials are heterogeneous: they have a wide range of moisture contents, bulk densities and therefore energy values, and vary between one source supplier and another. This can impact the way in which it is transported, meaning transportation costs can vary.

Distance is a major factor in wood waste fuelling decisions. Golden Bay Cement generally sources wood biomass from within a 20 to 30 kilometre radius of the plant. Supply from further away can become uneconomic as the transport costs begin to outweigh the cost savings from using wood waste. The economics depends on the delivered cost. Maximum distance is dependent on factors such as the specific wood-waste stream, moisture content,

Case Study 2: Golden Bay Cement

energy value and bulk density, all of which are variable. Given that the materials are low density and high volume, specialised transportation units are often required which adds to transport rates.

Carbon pricing is rarely a factor in the decision-making process

The carbon price is rarely factored into decision making by organisations. Organisations are aware of the potential impact of the carbon price on their operations. However, only some organisations actively manage and account for the carbon price. They rarely factor the risk of the carbon price changing into assessment of the costs and benefits of a proposed investment.

Reasons that the carbon price is not factored into the decision-making process include:

- senior decision makers are not engaged with its implications for the organisation
- there is perceived to be too much uncertainty around how the carbon price will change
- an organisation's emissions profile from its energy sources means carbon price risk has a small impact on the economics of a project.

The organisations that account for carbon price risk tend to model future carbon prices and use this forecast to assess the returns and financial impacts on the operation of a proposed project. Organisations described examples where carbon price risk was factored into decisions about larger investments in strategic assets. In one case, the risk-adjusted return from including the projected carbon price risk justified the project. The case study below illustrates Canterbury District Health Board's how carbon price risk modelling was incorporated into the decision-making process to implement wood biomass boilers.

Organisations that actively monitor the carbon price reported that modelling is undertaken by running high and low scenarios or sensitivity analyses on how the project economics change when the carbon price changes. Time horizons for forecasting and scenario analysis were reported between 3 and 10 years.

Case Study 3: Canterbury District Health Board

The Canterbury District Health Board (CDHB) had been operating two coal-fired boilers at Burwood Hospital since 1964. CDHB needed to upgrade the 50-year-old boilers and the earthquake-prone boiler house as part of the expansion of Burwood Hospital.

It made sense to look at different options that were available in 2014 when they started the project. They had some experience by then with a 1.5MW woodchip boiler at Hillmorton Hospital that replaced expensive LPG. Coal was anticipated to become more expensive with the carbon price.

The carbon price was included in the decision-making process around the replacement of the coal-fired boilers at Burwood Hospital. The carbon price was modelled up to a price of $25 per tonne of emissions to incorporate the environmental impacts of different options into a cost-benefit analysis. At the modelled carbon price, the biomass boilers were the more economic option on a risk-adjusted basis. The business case was signed off, and the biomass boilers were constructed in 2015 and commissioned in 2016.

CDHB is now taking the experience of Burwood Hospital into a similar but bigger situation with the new Energy Centre at Christchurch Hospital.

Financing projects

Owners are not demanding energy efficiency or carbon emissions reduction

Owners are generally not demanding energy efficiency and carbon emissions-reducing solutions. Of the publicly-listed companies interviewed, there was a large amount of uncertainty around how owners perceive investment in energy efficiency and carbon emissions-reducing projects, and it is not a prevalent topic of conversation.

One interviewee observed that shareholders brought up its carbon emissions for the first time in a recent shareholder meeting. However, this is currently the exception. For some larger global companies, the business is one part in a portfolio of operations, and owners have only a small fraction of the resources for oversight and influencing strategic direction for the New Zealand operation.

One organisation stated that the previous CEO made environmental commitments to stakeholders in public meetings. However, this organisation did not state that members had either expressly called for energy efficiency or carbon emissions reductions to be made by the organisation.

There was an acknowledgement of organisations' environmental responsibility by privately-held businesses. This enables energy efficiency and carbon emissions reduction to be explicitly factored into their decision making, whether through the use of environmental requirements or specific funding mechanisms.

Few organisations have specific funding mechanisms in place

Most organisations said they use their general capital pools to fund energy efficiency technologies. Energy efficiency projects sit alongside other capital projects and compete for a set pool of capital funding.

Further, the same risk and return requirements are used to prioritise energy efficiency projects along with other capital projects. This means that, even if they meet the pre-specified project metrics or pass a risk-adjusted cost-benefit test, energy efficiency and carbon emissions-reducing projects may be prioritised behind non-energy projects with greater net benefits for the organisation.

Two organisations we interviewed had specific funding mechanisms in place, which allowed energy efficiency projects to compete only among themselves. The following case study shows how McCain Foods (NZ) Limited accesses its specific funding mechanism for energy efficiency projects.

Case Study 4: McCain Foods (NZ) Limited

McCain Foods (NZ) Limited is part of a privately-held global business that internally funds most capital projects. Within the New Zealand operation, capital projects compete for the same set of funding given the same project finance hurdles of payback periods and internal rates of return, whether or not they relate to energy efficiency or carbon emissions reductions. However, it has access to the global business's Energy Fund.

The Energy Fund is a specific funding mechanism set up by the global business for energy efficiency. Funding for projects can be submitted and access gained to this fund. The eligibility criterion for the projects is they must be shown to reduce carbon emissions by one kilogram per dollar of capital expenditure. If the project can satisfy this criterion, the internal rate or return and payback period hurdles are lower for this fund than for general capital pools. This makes it easier for carbon emissions-reducing projects to be approved and allows projects with positive environmental impacts to compete only with each other.

Lender appetite is not an inhibiting factor

The interviewees acknowledged that capital is always constrained. However, they reported that these organisations did not see lender appetite as inhibiting investment in energy efficiency and carbon emissions-reducing projects. This did not necessarily limit their access to capital.

For large organisations, financing is mostly internal. For example, three organisations have self-funded capital projects. Therefore, capital can be accessed if proper capital budgeting processes are followed. Borrowing of capital also increases the overall enterprise value, by shifting debt closer to target levels and lowering the overall cost of capital across the whole organisation.

One organisation identified Westpac's CleanTech lending as a key initiative toward the organisation's funding of energy efficiency and carbon emissions-reducing projects. Although the cost of funds was higher for this organisation to access this debt capital, it chooses to utilise this financing mechanism, rather than internally fund energy efficiency projects. This decision is made so they can prioritise their internal funding towards other non-energy projects that yield higher returns.

Discussion

Based on findings from the literature review, workshop and interviews, there are three objectives an organisation could have when deciding whether or not to invest in energy efficiency and carbon emissions reduction:

1. **Profit** – Organisations could seek to increase profit from producing goods and services (including by reducing costs), regardless of the environmental and societal impact of their operation.

2. **Investment returns** – Organisations may, on behalf of their capital providers, balance investment returns (including through saving energy costs) from a production technology with the risks of that investment.

3. **Environmental impact** – Organisations may produce goods and services with the most energy efficient technologies to minimise the impact of their activities on the environment and society.

The objective that an organisation has will influence the decisions it makes and the process through which it goes to arrive at those decisions. Even if an organisation focuses on a profit or investment returns objective, an investment may still be justified.

The three strands of research conducted as part of this research project all provide valuable input into understanding decision-making processes of large process heat users:

- **Literature review** – Economics suggests that people are rational and make privately optimal decisions, but there are barriers to privately and socially optimal levels of energy efficiency.

- **Workshop** – Participants identified that there are energy efficiency technologies that organisations have the opportunity to take up but do not adopt.

- **Interviews** – The organisations we interviewed said they are looking at energy efficiency technologies alongside other business concerns, and in the context of what is best for the survival of the organisation.

What does this say about privately optimal and socially desirable outcomes?

The interviews suggest that organisations are operating near their frontiers – the point of production where they are utilising energy efficiency as much as possible, given other commercial and operational constraints. They appear to make decisions that are privately optimal for their operations.

Traditional economics says that the decision is made at 'the margin' – additional investment is made where the marginal benefit outweighs the marginal cost. However, organisations are saying that the marginal investment profile is lumpy – there are infrequent and large adjustments to capital investment and therefore, energy efficiency. As a result, there is occasional large capital expenditure on energy efficiency and carbon emissions reduction.

Further, organisations do not have perfect forward-looking information, but understand the processes in place and monitor their energy use and efficiency frequently. As a result, there is a gap between when an improvement is identified and when it is implemented.

Organisations take time to act. Capital planning and budgeting is cyclical, which creates delays between identification and implementation of energy efficiency technology. In addition, there are asset cycles that prevent immediate and continuous investment in energy efficiency and carbon emission reduction.

Consequently, at first glance it could appear that organisations are not implementing privately optimal or socially desirable levels of energy efficiency technologies. However, by discussing this issue in the interviews, we observed that organisations appear to making a conscientious effort to optimise energy efficiency within certain organisational constraints. In a nutshell, the main issue is funding, while information is less of an issue.

What drives these investment results?

Opportunities to improve energy efficiency and reduce carbon emissions are ongoing, in the sense that market and customer demands change and new technologies arise. If there is sub-optimal investment from a societal perspective, what is driving this energy efficiency gap for process heat users in New Zealand?

Energy cost savings is the main driver of new investment for the large process heat users interviewed. With potential ongoing cost reduction, the organisations stated their decisions were sensible, and were being made through well-established decision-making processes. However, they faced some barriers within the scope of this decision-making process.

These rational barriers include:

1. Risk aversion
2. Limited access to capital
3. Hidden costs and production disruption.

As a result, the investment results are driven by business concerns, such as maintaining continuity of activity, and considered financial criteria. Our observations about the impact of these barriers on process heat users in New Zealand are detailed below.

1. Risk aversion

Traditional economics and finance say that owners and lenders who contribute capital to projects experience some level of risk aversion. Not only do they want to be compensated for investing their funds, but the required rate of return increases with risky projects. Risk aversion is therefore a barrier, arising out of the preferences towards trading off risk and return. This barrier is embedded in rational decision-making processes according to privately optimal outcomes.

As detailed in Appendix A, workshop participants reported that energy efficiency may be seen as a risk and there are often short payback periods and high internal hurdle rates applied to energy efficiency projects. This may suggest that there are financial barriers due to investment preferences towards risk and return, and organisations are making decisions according to these preferences.

The organisations interviewed discussed the risk and return requirements of smaller capital projects as having short payback periods and high required rates of return. However, these requirements were the same across all energy and non-energy capital projects. There was no suggestion the required returns or payback periods were higher for energy efficiency and carbon emissions-reducing projects.

Some larger privately-held companies were willing to reduce their private optimal risk-return requirements for a socially better outcome. This suggests some organisations are trading their return requirements for an environmental value.

2. Limited access to capital

Workshop participants recognised that lack of funding is an issue for some process heat users. Organisations did not report that owners or lenders were unwilling to finance projects oriented towards energy efficiency or carbon emission reduction. However, they recognised that capital budgets are limited in each period and were therefore constrained.

Limited access does not necessarily prevent the implementation of energy efficient and carbon emissions-reducing projects and most interviewees have capital they can access for these projects. Decision making processes are substantially the same as other projects with respect to accessing this capital. Businesses decide how much to invest, and then prioritise projects until the budget is expended. These are essentially two separate processes.

Further, capital is limited because it is imperfectly accessible. As found in the interviews and international case studies, decision making takes time: there are lags in the process from the beginning (identification) to the end (implementation) of the decision-making process. Further, in some cases, maintenance and upgrades cycles can stagnate the implementation of new technologies. This creates a marginal investment profile that is lumpy. Continuously maintaining privately optimal levels of energy and carbon emissions is not possible.

3. Hidden costs and production disruption

Introducing energy measures can have an impact on normal activity. The imperative to maintain energy output in energy-intensive production may outweigh the energy savings payback from implementing a new energy efficiency technology.

Organisations reported that a factor in the decision-making process was the operational risk and cost of lost production. The most important thing for an organisation is whatever it does: producing products or providing a public service. Temporary loss of energy can result in production delays and loss of economic value to the organisation's stakeholders. Accordingly, organisations consider these factors when assessing an energy efficiency technology and will not upgrade or retrofit a technology unless there is no or minimal risk of disrupted production.

Organisations rarely disrupt their production process out of the ordinary maintenance and upgrade cycles, showing an aversion to the operational risk of incurring these costs. The perceived opportunity cost of lost production value outweighs the private benefits of upgrading or retrofitting technologies out of this cycle.

Is irrationality embedded in decision-making processes?

Above, we questioned whether the decision-making processes incorporate barriers that are leading to sub-optimal outcomes for both the organisation and society. These barriers include:

1. lack of information;
2. bounded rationality; and
3. power and culture.

While these issues exist to some degree in the organisations interviewed, they appear to have good mechanisms and processes in place to limit their impacts on investment decision making. We discuss below our observations of the impacts of these barriers on the large process heat users we interviewed.

1. Lack of information

Decision making, to some extent, is driven by the information available about opportunities, energy use and the private benefits that could be gained from energy efficiency technologies. Lack of information can create sub-optimal investment for organisations and society.

Organisations stated they did not appear to lack information regarding energy efficiency technologies. Most interviewees:

- had conducted energy audits, with many plants identifying opportunities and implementing recommendations from the audits; and
- regularly monitor, control and report energy use (including energy productivity metrics) and factor it into their decision-making processes.

The interviews suggested that, while organisations do not have perfect information, systems and processes were in place to ensure information available to them was properly incorporated in decision making around energy efficiency technologies. Moreover, organisations appeared to have sophisticated systems for monitoring energy and energy productivity and they reported using external energy consultants to help draft business cases in a way that translates information for senior decision making.

2. Bounded rationality

Bounded rationality involves making decisions without perfect information or perfect rationality, which may lead to privately sub-optimal outcomes for the economic actor (and society).

External plant advisers, including engineers and energy consultants, are well embedded in the organisations. Workshop participants stated that external engineers focus more on the maintenance of equipment rather than the energy efficiency and carbon-reducing potential of new technologies and practices. This may be evidence of bounded rationality, where decisions may be made with limited information and incomplete rationality.

While this may be the case, we found that separate functions are in place to help ensure the decision-making process was sensible and factored in sufficient information to support a business case. This included the use of frequently monitored energy data to help inform business casers and external energy consultants to help identify opportunities and draft business cases.

We note that the organisations and energy consultants appeared to have a good understanding of common energy efficiency technologies, regardless of whether they had been implemented. However, both consultants and organisations may not have all the information about new or emerging technologies. These technologies could improve their operations and, especially around longer-term, high-cost investments, investment may need to be driven from a strategic management level.

3. Power and culture

Organisations reported that, although senior management was not against energy efficiency, the majority of opportunities are driven from the bottom up and the main narrative to senior management is around cost savings. This appears to be linked to the organisation’s capacity, where management resources are scarce and may be prioritised to the business’s survival instead of energy efficiency.

Management buy-in is commonly driven by potential energy savings and cost reduction. Generally, energy efficiency and carbon emissions reduction are not strategic priorities driven from the top, but rather means to achieving cost savings, higher productivity, more profit and greater returns on investment in the organisation.

The issues identified may indicate a culture where management are not driving environmental values from the top down and energy efficiency and carbon emissions-reducing activities are not receiving attention, being seen as low priorities. This could also be linked to the organisation’s capacity, where management’s resources are scarce and prioritised to the organisation’s survival (including satisfying risk and returns requirements for capital provider) instead of energy efficiency.

In most cases, management resources and attention were focussed on business survival or continuity (e.g., through health and safety or product quality). In these cases, energy efficiency was an additional benefit. However, this attitude did not represent a push towards carbon emissions reduction or environmental values, and investment in energy efficiency was largely a means, not an end.

Conclusion

Increasing energy efficiency in production and service provision could have a significant impact on New Zealand's greenhouse gas emissions. It is therefore critical to understand what drives these decisions, especially those factors preventing adoption of energy efficiency and carbon emissions-reducing projects.

Theory suggests there are failures and barriers in markets and organisations that prevent the adoption of technologies and practices to increase energy efficiency and reduce carbon emissions. International case studies, however, show there are also components of decision making that alleviate and mitigate these failures and barriers. The common success factor is having an effective combination of strategic, financing and implementation processes. This combination can help overcome the most commonly-cited barriers and narrow the energy efficiency gap for each business.

For large process heat users that we interviewed, the decision-making process begins with identification by plant and energy managers, with the assistance of energy audits carried out by external energy consultants. Organisations generally seem to do a good job of identifying opportunities. However, it is uncommon for senior management to have an energy champion role, although some organisations had the role of sustainability manager at a senior level. Thus, the element of strategic focus may be missing in some organisations.

The process for costing and prioritising projects is generally the same for other capital projects, and these projects compete for capital with other projects. However, this does not necessarily impede decision making itself. Cost-benefit analysis is undertaken and the projects must meet certain financial criteria, which are usually no different from other projects. The carbon price and the risk of it changing are rarely incorporated into this analysis. Our research shows that energy efficiency measures are being considered, but the prioritisation mechanisms can lead organisations to select other projects for implementation.

Organisations appear to make sensible decisions. However, the rational barriers they face affect the way in which organisations are willing and able to allocate capital. The barriers derive from risk and return preferences, as well as from embedded processes that ensure good investment decisions are made inside organisations. The decision-making processes take into consideration many factors, including environmental impacts.

There are energy efficiency technologies that large process heat users are not adopting, even though they are able to identify them. Those opportunities are either not as attractive as other investments, or they have dependencies that make the decision complex, such as production risks.

Time is also a factor. Decision making takes time, which means there are lead times between identification and implementation. Further, this lead time can be extended by upgrade and maintenance cycles and asset replacement cycles. Overall, organisations reported decision-making processes that appear sensible. Organisations attempt to operate at a privately optimal level of investment. However, that frontier is lumpy because technologies and practices cannot be implemented as soon as they are identified. Although implementing these technologies would be beneficial in the medium term for businesses and New Zealand, the issues outlined in this report are reasons why they are not being adopted.

Organisations indicated that they had identified opportunities that passed the organisation's cost-benefit tests, but were not prioritised over other projects that compete for the same funding. This finding suggests that organisations might invest more in energy efficiency and carbon emissions reduction if there were specific funding mechanisms or channels. These channels would require explicit consideration of the environmental and social benefits and costs. Separate funding mechanisms would reduce competition for finance, making it possible for energy efficiency investments to have priority. Separate funding need not be in the form of a traditional subsidies. Instead, it could be access to dedicated financing that is designed to lower the opportunity cost of the investment in energy efficiency and carbon emission-reducing technologies. The terms of the funding could be set based on an assessment of the socially-optimal level of energy efficiency.

Some of the opportunities are unique to an organisation, and external consultants and energy champions can help identify strategies and funding tailored to their individual situations. Services that are tailored to unique circumstances of each organisation can help minimise management resources towards environmental concerns and provide a step to resolving organisational culture barriers that may be embedded in some decision-making processes.

Our conclusion about sensible business decision making must be read in the context of the organisations we interviewed. We targeted large process heat users who are engaged with EECA around energy efficiency and carbon emissions reduction, therefore we were more likely to find considered decision making.

References

Andrews, R. N., & Johnson, E. (2016). Energy use, behavioral change, and business organizations: Reviewing recent findings and proposing a future research agenda. *Energy Research & Social Science, 11*, 195-208. doi:10.1016/j.erss.2015.09.001

Brown, M. A. (2001). Market failures and barriers as a basis for clean energy policies. *Energy Policy, 29*, 1197–1207.

Conway, P., & Meehan, L. (2013, September). *Productivity by the numbers: The New Zealand experience.* New Zealand Productivity Commission.

DeCanio, S. J. (1993). Barriers within firms to energy-efficient investments. *Energy policy, 21*(9), 906-914.

Elliot, R. N. (2007). *Energy investment decisions in the industrial sector.* Washington DC: American Council for an Energy-Efficient Economy.

Fleiter, T., Schleich, J., Ravivanpong, P., & Gruber, E. (2012). Adoption of energy-efficiency measures in SMEs – An empirical analysis based on energy audit data from Germany. *Energy Policy, 51*, 863-875. doi:doi.org/10.1016/j.enpol.2012.09.041

Gillingham, K., Newell, R. G., & Palmer, K. (2009). Energy efficiency economics and policy. *Annual Review of Resource Economics*, 597-620.

MBIE and EECA. (2017). *Unlocking our energy productivity and renewable potential: New Zealand energy efficiency and conservation strategy 2017–2022.*

Ministry for the Environment. (2017). New Zealand's greenhouse gas inventory 1990–2015.

Reinaud, J., & Goldberg, A. (2012). The Boardroom Perspective: How does energy efficiency policy influence decision making in industry? *IEA Energy Papers, No. 2012/02*.

Rohdin, P., Thollander, P., & Solding, P. (2006). Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy, 35*(1), 672-677. doi:10.1016/j.enpol.2006.01.010

Schleich, J., & Gruber, E. (2008). Beyond case studies: Barriers to energy efficiency in commerce and the services sector. *Energy Economics, 30*, 449-464.

Sorrell, S., O'Malley, E., Schleich, J., & Scott, S. (2004). *The economics of energy efficiency: Barriers to cost-effective investment.* Cheltenham: Edward Elgar.

State and Local Energy Efficiency Action Network. (2015). *Sustained energy savings achieved through successful industrial customer interaction with ratepayer programs: Case studies.* Retrieved from seeaction.energy.gov

State and Local Energy Efficiency Action Network. (2017). *Saving energy in industrial companies: Case studies of energy efficiency programs in large U.S. industrial corporations and the role of ratepayer-funded support.* Retrieved from seeaction.energy.gov

Thollander, P., & Palm, J. (2013). *Improving Energy Efficiency in Industrial Energy Systems.* London: Springer-Verlag.

Watson, S. (2015). *Energy behaviours of SMEs in New Zealand.* Dunedin: Energy Cultures, Centre for Sustainability, University of Otago.

Appendix A – Workshop

On 19 March 2018, PwC held a workshop with members of EECA's market engagement and strategy teams. The purpose of the workshop was, with reference to large process users in New Zealand, to:

- draw on the experience of industry-facing staff to identify which organisations would be best to interview to understand the decision-making processes around energy efficiency and carbon emissions reduction
- understand business investment decision making generally
- understand the barriers and enablers that EECA staff encounter and any factors driving energy efficiency.

We had participants run through a process in the workshop. A short description of the workshop process is outlined in below.

Process at the workshop

The workshop began with an introduction and a quick ice-breaker. The workshop was then broken into two main activities role-playing and a word cloud.

Drawing on their experiences, participants were invited to think about past client engagements that have gone well and some that may not have and, in both cases, why this may have been. The key was to understand the issues in terms of barriers and enablers to EECA selling its energy efficiency products.

In pairs, participants were invited to discuss these experiences and create a short role-play of a scenario to share with the rest of the room. There were four groups, and each group was assigned to present what a successful or unsuccessful engagement looks like for EECA.

Once all role-plays were performed for the wider group, participants were asked to identify common themes. The aim was to identify the issues around adoption of new technology and processes, and identify what is driving the issues.

Working together, participants were asked to create a short list of current clients and the issues they may face. Participants were asked to consider five process heat users with which they engage and note down the client and the issues they may face.

Issues and clients identified in the workshop

In undertaking the activity and discussing the results, the following factors were identified as common impediments to the adoption of energy efficiency technologies:

- **Understanding the problem** – There is limited capability to understand the measurements and inputs. This extends to business having incomplete information about where energy efficiency savings can be made when assessing projects. This lack of understanding flows into the role of sustainability within the organisation.
- **Time** – The decision-making process for implementing an energy efficiency project requires employee time, senior management time, and time to assess equipment and downtime. Organisations often do not have sufficient time to commit at the outset. Downtime can be particularly disruptive. Taking process-heat equipment offline for a temporary inspection or upgrade creates issues with delivering on obligations for production or service delivery.
- **Staff resource** – Closely related to time, there is a trade-off between people and capital, and hunting for energy savings is often perceived as not the best use of employee time. There is also an issue with having limited access to senior management in the decision-making process.

- **Financial pressures** – The business process in place for assessing energy efficiency or carbon emissions-reducing opportunities often follows ordinary project finance processes, with high hurdle rates and low payback periods (identified as less than two years) required for an energy efficiency project to be approved.

The selection criteria for inviting companies to participate was to ensure a mix of:

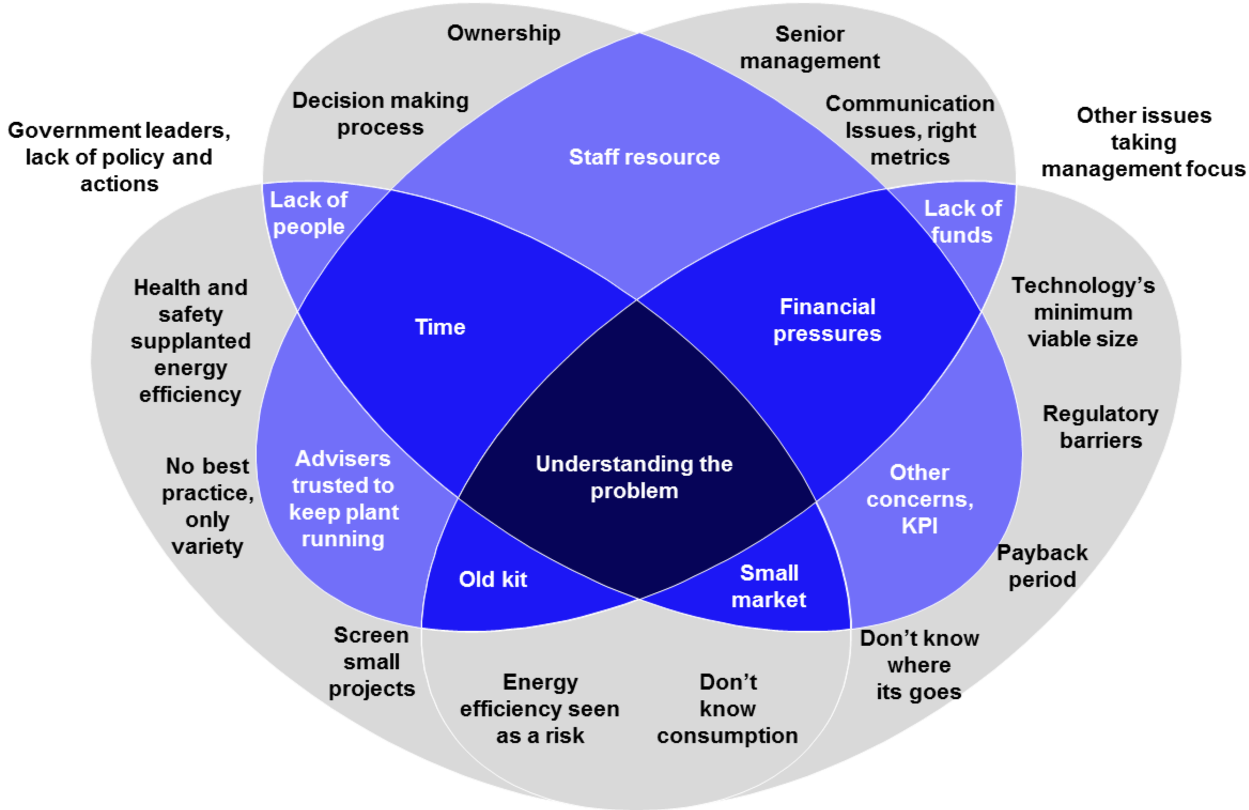
- **Ownership structure** – whether different ownership structures face different challenges in making energy efficiency and carbon emissions-reducing investments.

- **Type of production** – whether different production activities of process heat users have an impact on the decision-making process.

- **Public versus private** – whether organisations providing public services made decisions differently than private organisations.

Figure 1 shows the issues participants identified that are commonly faced by process heat users.

Figure 1. Issues specific to New Zealand process heat users



Most of the issues can be explained with reference to a commonly-cited failure or barrier. For example, past changes in health and safety legislation became a central focus for businesses in maintaining and upgrading equipment. A consequence identified by participants was that energy efficiency became less of a priority behind health and safety. This reflects the impacts of limited access to capital, where energy efficiency has to compete with other business priorities for funding.

Appendix B – Semi-structured Interview Guide

1. Do you invest in energy efficiency and carbon emissions-reducing technology, specific to the process heat side aspects of your business?

2. Where in your business is energy efficiency driven from?

    a. Is energy efficiency driven from the top down or bottom up?

    b. What are the main drivers of energy efficiency? For example, is it energy savings, customer driven, reputational opportunities?

    c. Are other issues taking priority in management's view? For example, health and safety, or labour issues.

3. Can you please describe to me the process you undertake to make investment decisions, particularly how you factor in energy efficiency?

4. Are you able to describe to me any carbon-emission reducing projects you have or are undertaking?

    a. What kind of project approvals are required? From whom?

5.

    a. How do you usually identify energy efficiency/carbon reduction opportunities?

    b. How do you usually cost energy efficiency/carbon reduction opportunities?

    c. How do you usually prioritise energy efficiency/carbon reduction opportunities? Do you use payback periods or hurdle rates? What are they?

    d. How do you usually implement energy efficiency/carbon reduction opportunities?

    e. Do energy efficiency and carbon emissions-reducing opportunities have a champion in the business?

6.

    a. How are you managing the risk of the carbon price changing?

    b. Does the carbon price factor into assessing investment opportunities?

7. What are your practices towards borrowing for energy efficiency and carbon emissions-reducing projects?

    a. Does your business have a general appetite for this borrowing?

    b. If so, how easy is it to access finance for these projects?

8. Do you have in place specific funding mechanisms for energy efficiency projects? Do these differ within capital and operating budgets?

9. How do your business owners perceive investing in energy efficiency and carbon emissions-reducing projects?

   a. Do investors prioritise or place constraints on investing in energy efficiency and carbon emissions-reducing projects?

10.

   a. Do you identify and account for risks or potential costs of interrupted production from retrofitting or upgrading equipment with energy efficient technology?
   b. How significant are the risks to production from energy efficient projects?

11.

   a. How does your business respond to reputational opportunities around energy efficiency?
   b. Does your business participate in voluntary or third party initiatives? Can you please describe them?
   c. Do your customers or clients have any expectations around your energy efficiency?

12. What has been your experiences with external expertise and energy service companies (ESCOs)?

13. Do you actively monitor and control energy data? If so, how?

   a. If so, how frequently are you monitoring this data?

Appendix C – Overcoming barriers

The following section relates the above three requirements back to the barriers identified in the previous section, identifying the common barriers for the organisations to alleviate or mitigate. They can be considered implied priorities for improving energy efficiency.

How do the success factors relate to the barriers?

SEE Action (2017) describes cases of successful implementation of energy efficiency programmes where the companies did not rely solely on financial incentive support to reduce initial investment costs. Although financial support can reduce payback periods, there are also non-financial barriers that organisations must overcome to enable these investments. Businesses do not make decisions in the same way as individuals because there are multiple levels of decision making within an organisation. Operations are conducted and decisions made through the interaction of different departments and staff groups, each of which has different responsibilities (State and Local Energy Efficiency Action Network, 2017). SEE Action (2017) highlights that the combination of different organisational levels and functions can overcome these barriers.

Corporate commitment

Corporate commitment entails senior management voicing the importance of energy efficiency, allocating responsibility and having the internal capacity to identify and implement energy efficiency opportunities. SEE Action (2017) explains this is best achieved by establishing clear energy efficiency strategy and targets, and making employees of all levels responsible for achieving them.

Organisational barriers can be significant hurdles to adopting energy efficiency technologies and practices. Corporate commitment alone is insufficient to create a successful programme if it is not accompanied by financing and personnel to implement the commitment. However, having this commitment helps to overcome organisational barriers of power and culture. The case studies show that senior management buy-in can drive a culture of commitment and prioritises energy efficiency at the strategic decision making level.

As well as overcoming the organisational barriers, having senior management buy-in, and targeted performance reporting that comes from it, can work to align split preferences by shifting targets and KPIs to focus on energy efficiency. Split preferences arise where one person has more information about a technology and can benefit from the investment, but it may be difficult to convey this to the party that makes the decision about the investment, who does not directly benefit from it. Having the right level of corporate commitment overcomes the behavioural barriers of values and inertia, creating real ambition in the organisation and a reason for change at the plant level.

For example, General Mills has corporate energy efficiency targets, which are translated into targets throughout the corporate structure. Each plant's performance against their energy efficiency targets plays a direct role in the plant manager's performance evaluation, creating a direct incentive to demonstrate the benefits of energy efficiency (State and Local Energy Efficiency Action Network, 2017).

Staff capability

Owing to the time, training and value of firm-specific human capital, businesses have historically seen little economic justification in allocating staff resource to energy efficiency which is not a core business-related cost-saving project. Successful energy efficiency programmes require a large time commitment and clear accountability from staff members of all levels (DeCanio, 1993; MBIE and EECA, 2017; State and Local Energy Efficiency Action Network, 2017).

Having capable staff or outsourced experts to work continuously to identify specific energy efficiency measures and to follow through with their implementation is imperative. From an economic perspective, having capable staff helps alleviate the behavioural barriers, as well as some market and organisational failures.

For example, J. R. Simplot Company, a large food manufacturer, employs both partand full-time plant-level energy engineers. They observe and understand the plants' operations to identify potential energy savings and report to a headquartered energy efficiency team. Each engineer covers either one large site or multiple small sites, and receives support from business-unit-level energy engineers to compete for funding (State and Local Energy Efficiency Action Network, 2017).

Having staff capable of implementing management's commitment helps alleviate:

- **Organisational capacity** – it enables the organisation to have sufficient time and resources to explore and implement energy efficiency projects.
- **Information asymmetry** – capability reduces imperfect information, including lack of information and information asymmetries. Expanding capability can increase a business's information set and reduce information asymmetries (and the potential for adverse selection of technologies) when assessing projects in which to invest.
- **Form of information** – building staff capability at the implementation level allows projects to be pitched to the senior decision makers in specific, vivid, simple and personal ways. This enhances the form of information, translating it from an engineering concept into commercial decision-making concept. For example, staff can translate and summarise information into metrics that decision makers commonly encounter, including dollars and volumes of carbon emissions saved, rather than energy (eg in gigajoules) saved.
- **Bounded rationality** – energy managers can expand the information base and improve decision-making processes to encourage decisions that are more sensible and closer to privately and socially optimal levels of energy efficiency and carbon emissions.

Having an aligned energy manager can also create a credible and trustworthy source of information that can successfully deliver information about energy-efficient technologies.

Efficient project process system

In many organisations, energy efficiency projects have the same financial metrics as other projects. Investments in energy efficiency technologies are treated much like any other investment decision.

There can be a low priority associated with projects with relatively low cost savings, including smaller projects identified as energy efficiency investments. Further, high internal hurdle rates and longer payback periods further deter management from investing in favour of these technologies. The situation is reinforced by the difficulties in monitoring the savings achieved, meaning the true profitability of the project often remains unknown (DeCanio, 1993; Gillingham, Newell, & Palmer, 2009; State and Local Energy Efficiency Action Network, 2017).

SEE Action (2017) shows that some economic, behavioural and organisational barriers were mitigated through effective decision-making processes and systems. However, there remained barriers arising from investment preferences embedded in the decision-making process. Each business assessed potential projects using common financial metrics that take into account the economic trade-off between risk and return. Of the four case studies, two organisations used an internal rate of return, while one organisation used a simple payback period and one used net present value to assess projects (State and Local Energy Efficiency Action Network, 2017). This suggests these organisations attempt to select projects that were privately optimal for them, given considerations other than the environmental impact.

Having clear processes and systems ensures that the energy efficiency team knows how to package energy efficiency projects for internal approval, what financial profile they should look for in projects, and how to get projects funded. Having effective project process systems helps manage enterprise risk and increases access to capital.

In some cases, these systems included a specific funding mechanism that allowed for a dedicated bucket of funds for energy efficiency. For example General Motors and Intel had dedicated pools of funds for energy efficiency retrofits. Further, having systems that create a specific bucket of funding helps increase access to capital, allowing some cost-effective energy efficiency measures to be implemented, even if the projects had not been prioritised when competing with non-energy projects (State and Local Energy Efficiency Action Network, 2017).

Appendix D Restrictions

This report has been prepared solely for the purposes stated herein and should not be relied upon for any other purpose. PwC accepts no liability to any party should it be used for any purpose other than that for which it was prepared.

To the fullest extent permitted by law, PwC accepts no duty of care to any third party in connection with the provision of this report and/or any related information or explanation (together, the Information). Accordingly, regardless of the form of action, whether in contract, tort (including without limitation, negligence) or otherwise, and to the extent permitted by applicable law, PwC accepts no liability of any kind to any third party and disclaims all responsibility for the consequences of any third party acting or refraining to act in reliance on the Information.

PwC has not independently verified the accuracy of information provided to it, and has not conducted any form of audit in respect of the organisation for which work is completed. Accordingly, PwC expresses no opinion on the reliability, accuracy, or completeness of the information provided to it and upon which it has relied.

The statements and opinions expressed herein have been made in good faith, and on the basis that all information relied upon is true and accurate in all material respects, and not misleading by reason of omission or otherwise.

The statements and opinions expressed in this report are based on information available as at the date of the report.

PwC reserves the right, but will be under no obligation, to review or amend the report, if any additional information, which was in existence on the date of this report, was not brought to our attention, or subsequently comes to light.

This report is issued pursuant to the terms and conditions set out in the Contract for Services between PwC and EECA dated 4 March 2018.