EECA
TE TARI TIAKI PŪNGAO
ENERGY EFFICIENCY & CONSERVATION AUTHORITY

Productive and low emissions business

Food product manufacturing energy insights

Quantifying the energy use for food product manufacturing in New Zealand.

LUMEN

December 2022

Authors

Anand Krishnan*, Mitchell Trezona-lecomte*, George Gray^, Paul Farrelly^, Ben Thomson^, Alelign Gessese^

* = EECA ^ = Lumen Ltd

Citation

Energy Efficiency and Conservation Authority 2022.

Food Product Manufacturing Energy Insights – Quantifying the energy use for food product manufacturing in New Zealand .

Wellington, New Zealand.

Published in December 2022 by Energy Efficiency and Conservation Authority (EECA), Wellington, New Zealand.

Acknowledgements

The authors would like to acknowledge Kate Kolich, Insa Errey, Dr Gareth Gretton, Glenn Wellington, Cory Sutherland, Chiraag Ishwar, and Tyler Byers for their contributions to this work. We would also like to thank all those who participated in interviews and responded to the surveys.

Creative Commons Licence

This work is licensed under the Creative Commons Attribution 4.0 International licence. In essence, you are free to copy, distribute and adapt the work, as long as you attribute the work to the Crown and abide by the other licence terms. Use the wording ‘Energy Efficiency & Conservation Authority’ or ‘EECA’ in your attribution, not the EECA Logo.

To view a copy of this licence, visit Creative Commons — Attribution 4.0 International — CC BY 4.0.

Liability

While all care and diligence has been used in processing, analysing and extracting data and information in this publication, the Energy, Efficiency & Conservation Authority gives no warranty it is error free and will not be liable for any loss or damage suffered by the use directly, or indirectly, of the information in this publication.

Disclaimer

The information contained in this document was produced by Lumen Ltd and is solely for the use of the Client identified on the cover sheet for the purpose of which it was prepared. Lumen Ltd undertakes no duty to or accepts any responsibility to any third party who may rely upon this document.

© Lumen 2022

Table of contents

1 Foreword

In New Zealand, a significant amount of our stationary (non-transport) energy is used for food and beverage manufacturing. The sectors that manufacture food and beverage products are diverse and cover a wide range of energy-using processes, encompassing the processing of fruits, vegetables and grains, to the manufacturing of alcoholic beverages and pet food. However, prior to this study, information about the breakdown of energy consumption by sector and end-use was limited (with the exception of dairy, meat, and seafood sectors, which are excluded from this research).

EECA is pleased to have collaborated with Lumen Ltd to deliver this research, which aims to improve our understanding of how energy is used across these diverse food processing sectors. Results show that 70% of energy consumed in this sector is from fossil fuels and is used to power boilers systems, most of which is for intermediate temperature process heat.

The results from this research will improve the accuracy of EECA's Energy End Use Database, which is due to be updated before the end of 2022. Insights from this research will also inform ongoing work by EECA and across government to decarbonise industry in New Zealand.

Mitchell Trezona-lecomte
Manager Evidence Insights and Innovation

EECA

2 Executive summary

2.1 Overview

The food product manufacturing sector (sector) (defined in this study as excluding dairy, meat, and seafood product manufacturing) is large, accounting for 7.0PJ[1] of energy consumption, but not a well-understood segment in terms of energy use in New Zealand.

To gain a better understanding of the energy use in this sector, EECA commissioned Lumen in July 2021 to carry out bottom-up research that involved surveying 79 organisations across 15 industry classes[2] within the sector that were expected to have medium to large energy use (defined as > 0.5 GWh in stationary energy use). The survey cohort represents 4.3PJ out of the total 7.0PJ of sector energy consumption.

Along with energy consumption, this research collected information on the technology and end uses of energy, users' energy efficiency and decarbonisation plans, and the drivers and barriers to decarbonise for food manufacturing organisations.

2.2 Summary of key insights

- The majority of the energy used in the sector comes from fossil fuels (70%) to power boiler systems which provide process heat. Most of the energy end-use is for intermediate temperature process heat[3].
- 42% of the energy within the survey cohort is from natural gas, 33% from coal and 22% from electricity
- Of the surveyed organisations, fruit and vegetable processors have the largest share of total energy (27%)
- Only 35% of the survey cohort are currently measuring their GHG emissions
- Most surveyed organisations (91%) plan to improve their energy efficiency
- Just over half (51%) the surveyed organisations are interested in decarbonisation
- Reducing operating costs is the primary driver for energy efficiency and decarbonisation
- High capital costs (27%) and practicality (product quality risk) (27%) concerns are the largest barriers to decarbonisation.

[1] Energy Efficiency and Conservation Authority (EECA) 2021. Energy End Use Database – Key insights and methodology. Wellington: Energy Efficiency and Conservation Authority

[2] Industry classes are level 4 ANZSIC classifications

[3] Low Temperature is defined as <100°C and Intermediate Temperature as 100 – 300°C

2.3 Sector wide decarbonisation opportunities

- Heat recovery is often overlooked in this sector and maximising the use of heat recovery systems and technologies to reduce thermal energy demand would have a significant impact not only on energy costs but also on the CAPEX required for fuel switching. Heat recovery on dryers, wastewater streams, refrigeration systems, and ovens are some opportunities that exist in this sector. Moreover, some low to intermediate temperature heat loads could be effectively satisfied by heat recovery systems.
- It is often simple and cost effective to decarbonise low to intermediate process heating requirements currently generated using steam systems or direct fossil fuel heating. This could be achieved by implementing highly efficient technologies such as high temperature heat pumps that can generate hot water and hot air to meet process heat requirements. For example, low-temperature water heating demand could be met by hot water heat pumps which have efficiencies of ~300% compared to traditional fossil fuel boiler-based systems of ~80%.[4]
- Process heat consumers with old and outdated technologies that have high energy intensity per production unit should investigate their system performance and look for more efficient systems that will provide lower energy intensity per unit of production.
- There are efficient and low carbon technologies that can help reduce the use of fossil fuels for cooking/roasting in this sector. Existing fossil fuel-based technology can be replaced by industrial electric ovens, electric fryers, microwave and radiofrequency heating technologies and electric coffee roasters.
- Once the above opportunities are fully exhausted, the remaining fossil fuel use of the site could be decarbonised by fuel switching with low carbon technologies such as electric boilers, and biomass boilers.

2.4 Steps to decarbonise

Some steps food manufacturing organisations can take to decarbonise carbon intensive process heat systems include the following suggestions.

1. **Implement monthly energy management:** many energy users in this sector do not currently track their energy use and carbon emissions. Tracking performance over time will help users to identify trends in energy usage and to understand the associated carbon emissions.
2. **Consider installing electricity sub-meters and thermal energy meters:** these collect data at a granular level and will lead to a better understanding of how and when energy is used on a site and how different processes and systems affect energy use. This will allow the most energy intensive opportunities to be identified. Thermal meters allow for accurate assessment of process heat demand. This is important when considering the sizing of new low emissions technologies or boilers. Often lower capacity assets can be used to replace fossil fuel infrastructure that is sometimes oversized.
3. **Improve energy efficiency:** identify energy efficiency projects and implement them to produce the same production output with less energy input (lower energy intensity).
4. **Implement demand reduction opportunities:** identify and implement demand reduction opportunities that utilise less energy such as replacing steam use with hot water (which is easier to decarbonise).
5. **Technology/process change:** regularly scan what new technologies are available for key processes and implement the most cost, energy, and carbon effective technology.
6. **Fuel switching:** identify the most cost-effective low carbon fuel option to replace fossil fuel.

[4] Compared to combustion boilers, heat pumps produce 3-4x more heat per unit of energy consumed.

3 Introduction

The food product manufacturing sector is a large, but not well-understood segment in terms of energy use in New Zealand.

To gain a better understanding of the energy use in this sector, EECA commissioned Lumen in July 2021 to carry out bottom-up research that involved surveying many organisations within the sector that were expected to have medium to large energy use (defined as > 0.5 GWh in stationary energy use).

For this study, food product manufacturing is defined using the Australian and New Zealand Standard Industrial Classification (ANZSIC) as the Food Product Manufacturing (C11) and Beverage and Tobacco Product Manufacturing (C12) industry subdivisions. It excludes the Dairy Product Manufacturing (C113), and Meat and Meat Product Manufacturing (C111), and Seafood Processing (C112) industry groups.

The goal of this study was to develop the evidence base and further the understanding in this area in response to the existing gap in energy end-use information for the Government.

This work aligns with EECA's strategic focus to support productive and low-emissions businesses as well as supporting central government to inform programme and policy design that encourages clean and clever energy use.

3.1 Purpose of this study

This research was commissioned to support the improvement of the datasets used by government agencies for modelling and analysis.

This research aims to provide detailed insights, evidence, and data on:

- The annual amount of delivered energy used by fuel type, for use in food product manufacturing, for each of the 2019 and 2020 calendar years.
- The organisations and industry classes that use this fuel, in stationary energy processes or motive power for onsite usage (e.g., forklifts).
- The key applications and technologies that use this fuel.
- Organisations' perspectives (barriers, challenges, opportunities) on energy reduction or decarbonisation activities.

3.2 Overview of current understanding

Before undertaking this study, EECA had estimated that the sector consumes approximately 7.0 petajoules (PJ[5]) annually for stationary energy in 2020 (mostly natural gas and coal for process heat requirements), EECA 2021[6].

This estimate was formed from March year-end (MYE) electricity retail data, as well as coal and natural gas retail data from the Ministry of Business and Innovation (MBIE) for the Energy End-Use Database (EEUD).

3.3 Limitations of current understanding

The food product manufacturing sector researched here is not well-understood in terms of energy use in New Zealand. From the current energy data and end-use information, it was unclear whether the energy split of the largest users, on which EECA had some energy data, was truly representative of the energy use across all the ANZSIC industry groups within this diverse sector.

As a top-down approach only, the information may be misrepresenting the energy use and split of medium-sized organisations from these industry groups, which do not always have the necessary scale and production volumes to invest in the latest technology. For example, craft brewing beer manufacturers are likely to use more energy per litre of beer produced than the larger beer manufacturers due to efficiencies of scale.

Therefore, there was a need to gather information directly from organisations across different industry groups and classes to gain a true understanding of the energy consumption and end-use of the food product manufacturing sector.

Averaged data across 2019 and 2020 is presented in this report

This study uses primary data averaged across both 2019 and 2020. Primary data means the collection of detailed energy data directly from energy users. It was anticipated that the COVID-19 lockdowns of 2020 may have impacted production levels within the sector. However, as the sector was classified as essential services, many producers operated through the lockdowns and in fact, many organisations grew during this period. As a result, the reported user energy use increased between 2019 and 2020.

This increase is potentially a result of restaurants and bars being unable to operate during lockdowns in 2020 and the consumption of 'at home' food products being higher than normal. Most of the surveyed organisations primarily produce food (or beverages) that can be consumed 'at home', so there is some chance that this increased demand will eventually subside as hospitality picks up again. Therefore, an average of the two years was used to best capture energy usage before and during COVID-19.

[5] Petajoule (PJ) is equivalent to the energy consumption of approximately 25,000 New Zealand households annually.

[6] Energy Efficiency and Conservation Authority (EECA) 2021. Energy End Use Database – Key insights and methodology. Wellington: Energy Efficiency and Conservation Authority

4 Key findings

A majority of the energy used in the sector comes from fossil fuels to power boiler systems which provide process heat (70%).

Some of the larger energy users (equating to 80% of the fossil fuel energy used in the survey) are already considering moving away from fossil fuels through EECA's Energy Transition Accelerator (ETA) programme. If these users progress with changes, this will significantly alter the energy mix of the overall sector.

Other smaller users, who do not typically have access to government funding, may find it harder to decarbonise as they may lack the resources to drive business change.

However, there are still likely to be plenty of opportunities for improved energy efficiency, process change and fuel switching for this sector.

Opportunities exist for:

- **Active energy management:** many users do not actively track their energy consumption. Energy consumption could likely be reduced through monthly energy management to better understand energy use and to set targets for reductions.
- **Monitoring and targeting:** very few users are using sub-meters or thermal energy meters which would help with the overall decarbonisation process by confirming which processes and activities use the most energy. Better data would allow for energy efficiency and demand reduction projects to be targeted and for business cases to be well founded. Thermal metering can help with process heat decarbonisation by informing energy efficiency, demand reduction and sizing for new low carbon equipment.
- **Energy efficiency:** energy for heat loads (low and intermediate) could be used more efficiently through heat recovery. This is also likely to have the lowest marginal abatement cost (MAC)[7].
- **Demand reduction:** intermediate process heating requirements could be reduced by replacing steam use with hot water (which is easier to decarbonise). For example, low-temperature water heating (especially from coal) demand could be met by hot water heat pumps which have efficiencies of ~300% compared to traditional fossil fuel boiler-based systems (~80%).
- **Technology/process change:** reducing fossil fuel energy demand by shifting technology to industrial electric ovens, electric fryers, microwave and radiofrequency heating technologies, and electric coffee roasters.
- **Fuel switching:** the exploration of low emissions technologies such as electric boilers and biomass boilers.

[7] Ministry for the Environment. 2020. Marginal abatement cost curves analysis for New Zealand: Potential greenhouse gas mitigation options and their costs. Wellington: Ministry for the Environment.

Many of the users we spoke to did not see a compelling need to decarbonise their operations in the near-term. Although, in most cases it is something that they are thinking about and something they recognise they will need to do eventually.

Barriers to decarbonising include:

- **Capital cost:** high capital cost of low carbon technologies
- **Energy cost:** low emissions energy (electricity or biomass) often has a higher unit cost than the existing fossil fuel, at least in the near-term
- **Fuel security concerns:** some users are reluctant to consider biomass options due to concerns about the future availability of fuel. Business owners have an expectation that if a significant number of users switch from fossil fuels to biomass, then future supply will likely be constrained
- **Electrical capacity:** switching fossil fuel to electricity often requires an increase in the site's electrical capacity. In many cases, there is limited additional capacity available at the site level and the cost to upgrade can be expensive
- **Practicality (product quality risk):** producing a high-quality product is critical for food and beverage manufacturers. As such there is an aversion to risking product quality by changing the production process or trying 'new' technologies
- **Asset condition:** if existing fossil fuel equipment is in good condition, or is relatively new there is less incentive to change
- **Return on investment:** organisations in this sector typically have high investment rate hurdles and/or require investments to have a relatively short payback period (< 5 years). If energy efficiency/decarbonisation investments do not meet financial criteria, they are unlikely to be progressed.
- **Lack of resource:** most businesses we spoke to are heavily resource constrained, and very short on time. With many other competing priorities, decarbonisation is currently seen by many as a 'nice to do' and is typically not the number one priority
- **Production disruption:** food and beverage manufacturers typically do not hold large inventories and tend to produce to meet demand. There are concerns that if major site-works are required for decarbonisation, production levels could suffer.

The two largest barriers to decarbonisation are high capital costs and practicality (product quality) concerns. Overcoming these concerns is going to be key for the sector to decarbonise.

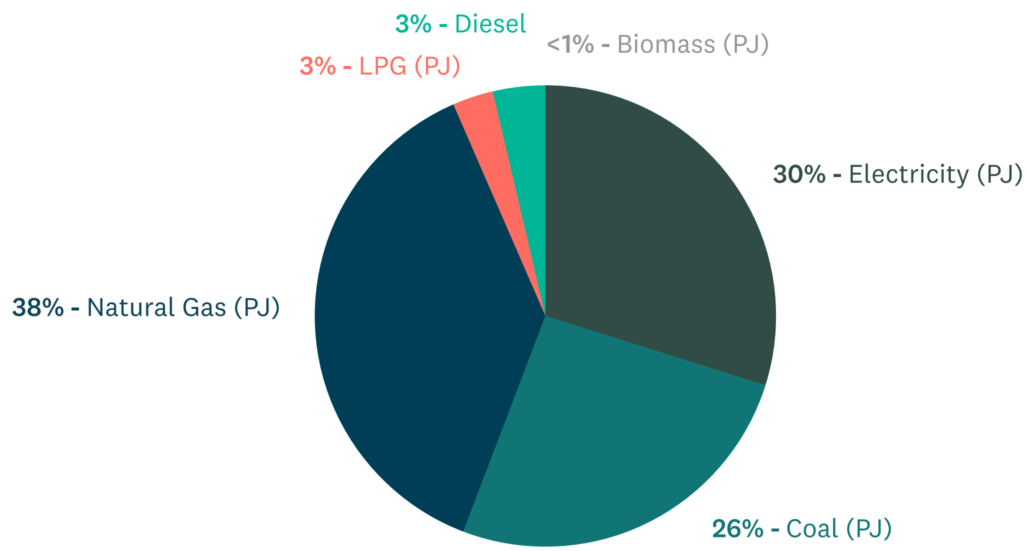
5 General insights

When total energy consumption is extrapolated to a national level estimate, the majority of energy used is fossil fuels, in particular natural gas

Thirty eight percent (38%) of the total energy used in the sector is estimated to be from natural gas, 30% from electricity, and 26% from coal. The remainder comes from diesel (3.6%), LPG (2.8%), and biomass (0.0011%).

Figure 1:

Total sector energy consumption by fuel



This estimate was derived from extrapolating the primary energy data collected through the user survey (4.3PJ) to create a total sector view. Three methods were used: based on production, market share, or organisation count.

Where reliable production values were available, along with benchmark values from survey responses, the production extrapolation method was used.

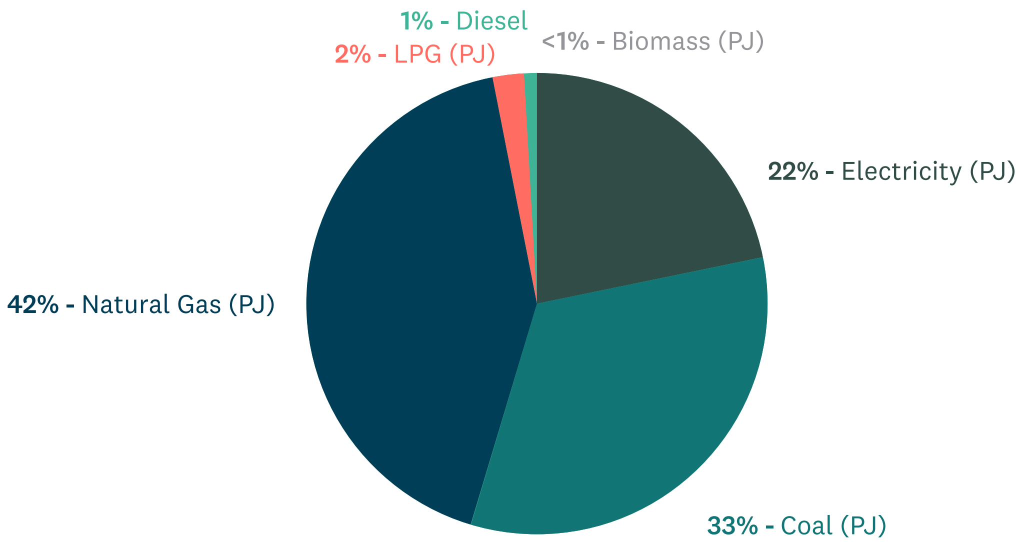
For industry classes with organisations that make up a large proportion of the industry class (by revenue or employee count), the data was extrapolated using an estimated market share that was covered in the survey data.

For industry classes with many medium-sized users that were covered in survey data, linear extrapolation was used based on the number of organisations in the industry class from Stats NZ (further details of the extrapolation methodology can be found in Appendix 3).

The surveyed energy consumption has a higher proportion of energy produced by fossil fuels than the total sector. This is because most of the largest fossil fuel consuming organisations in the sector are already working with EECA, and there was a relatively high participation rate from these organisations. All other data presented in this report is based on the results from the surveys.

Figure 2:

Primary data energy consumption by fuel (4.3PJ)



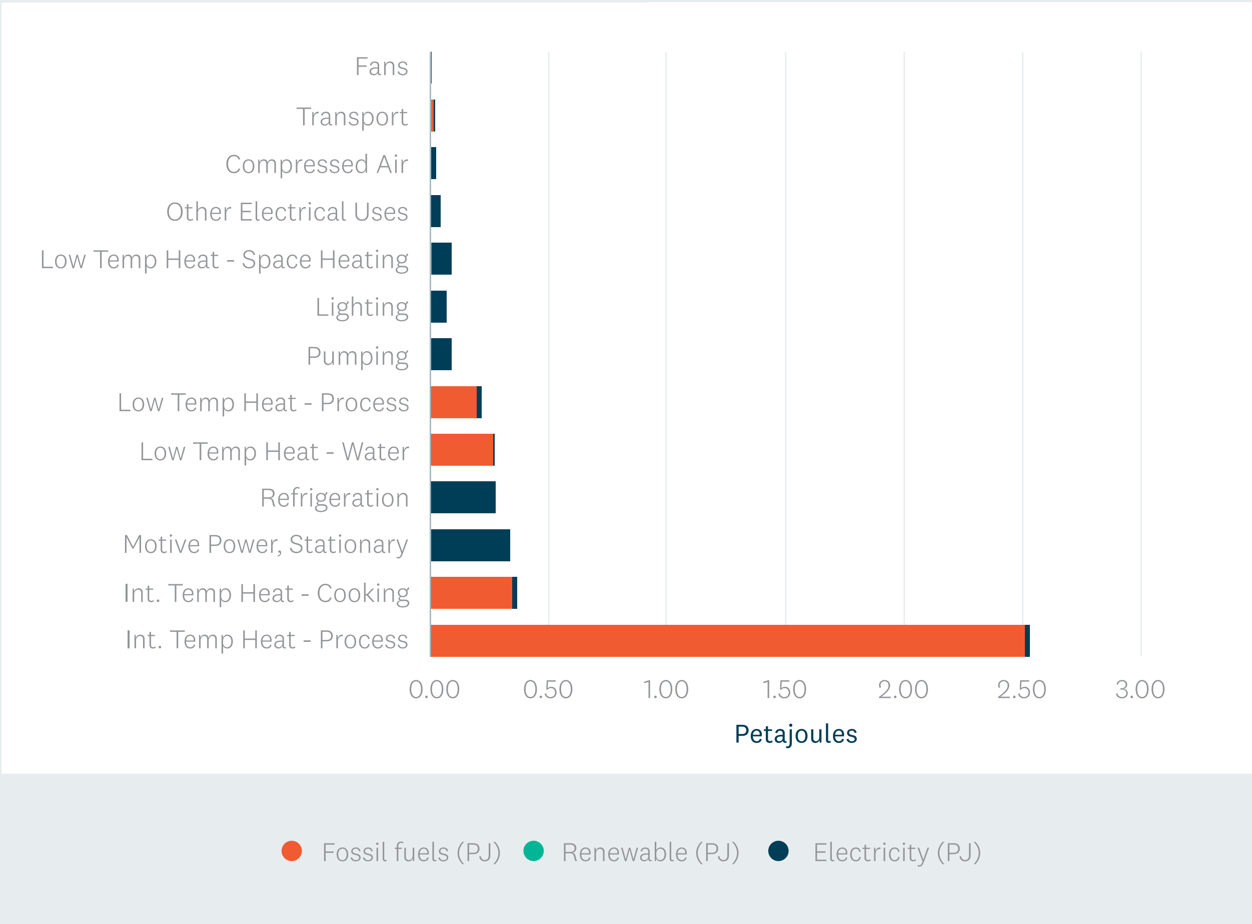
This shows us that there is a lot of work to be done in decarbonising processes that currently use natural gas, coal and to a much lesser degree LPG and diesel. In addition, improving energy efficiency in electricity use could also help with sector wide decarbonisation.

Most of the energy is consumed in boiler systems

Most of the energy end-use is intermediate temperature heat process requirements. This includes steam generation which is almost entirely provided by fossil fuelled boiler systems.

Figure 3:

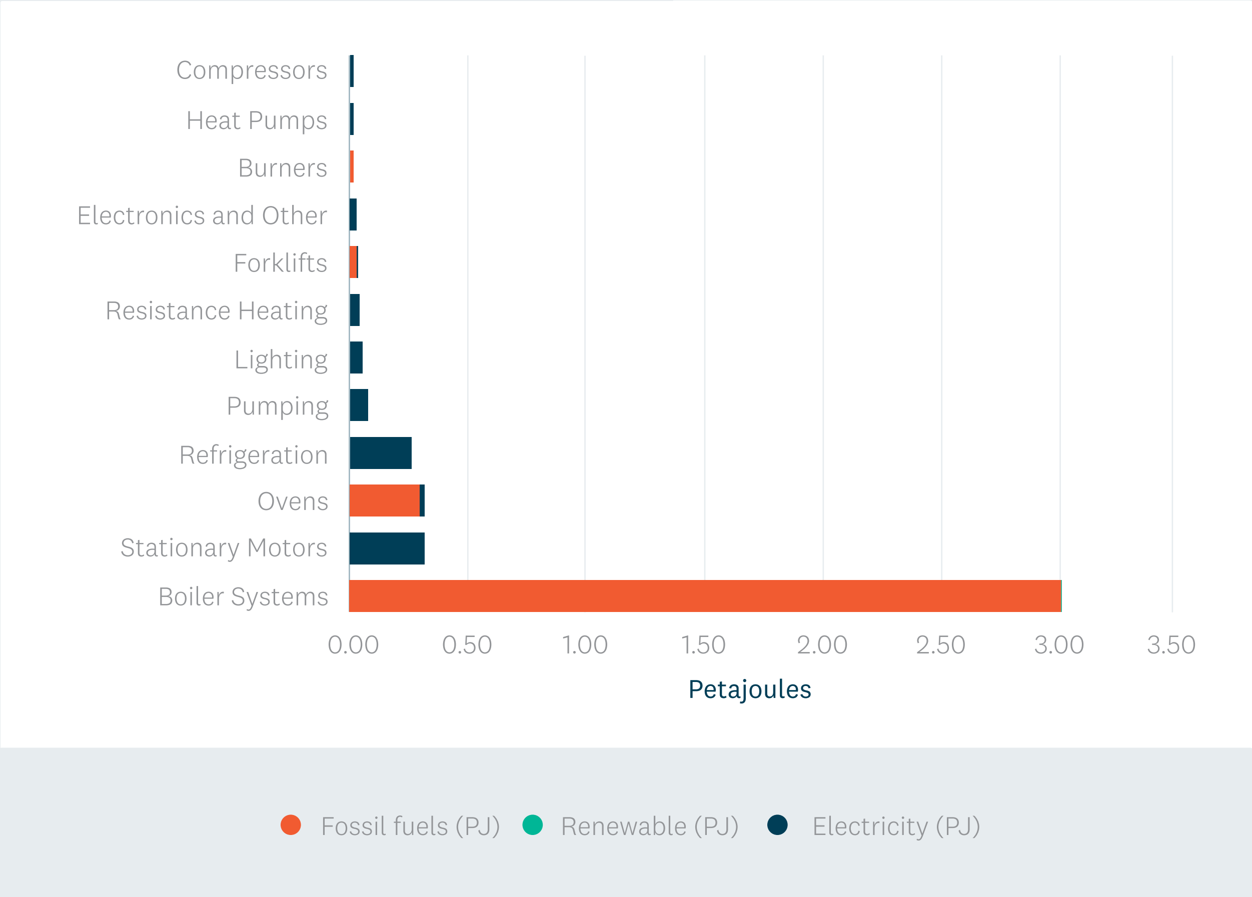
Survey energy consumption by end-use (4.3PJ)



This suggests that fuel switching existing fossil fuel boiler systems that produce intermediate temperature heat for process requirements should be the primary focus for sector wide decarbonisation. In addition, fuel switching fossil fuel oven systems (intermediate temperature heat) should also be targeted.

Figure 4:

Survey energy consumption by technology[8] (4.3PJ)



[8] Burners refer to direct-fired cooking and heating

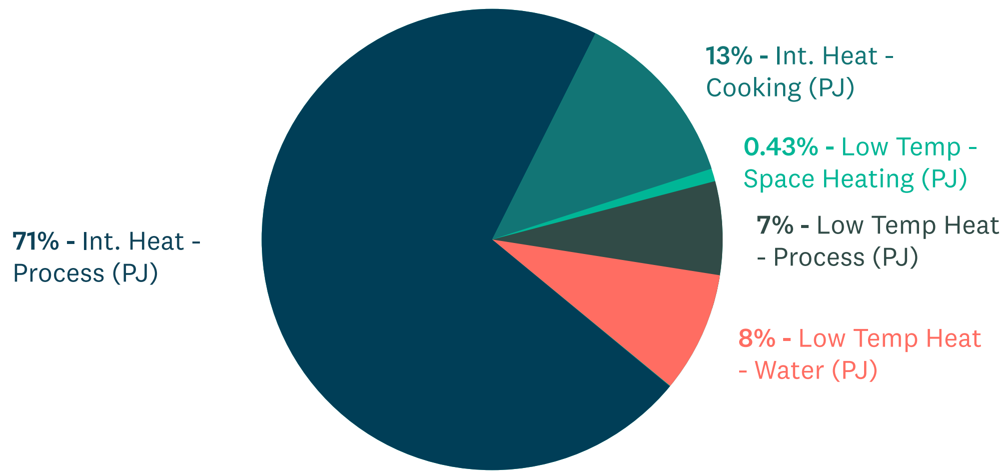
6 Fuel insights

6.1 Natural gas

Forty two percent (42%) of the total energy use within the survey cohort is from natural gas (1.8 PJ), all in the North Island. Of the natural gas consumed, 71% or 1.3 PJ is used to produce intermediate temperature process heat requirements. The remainder is from intermediate temperature cooking (13%), low temperature water heating (8.2%), low temperature process heat (6.8%) and low temperature space heating (0.43%).

Figure 5:

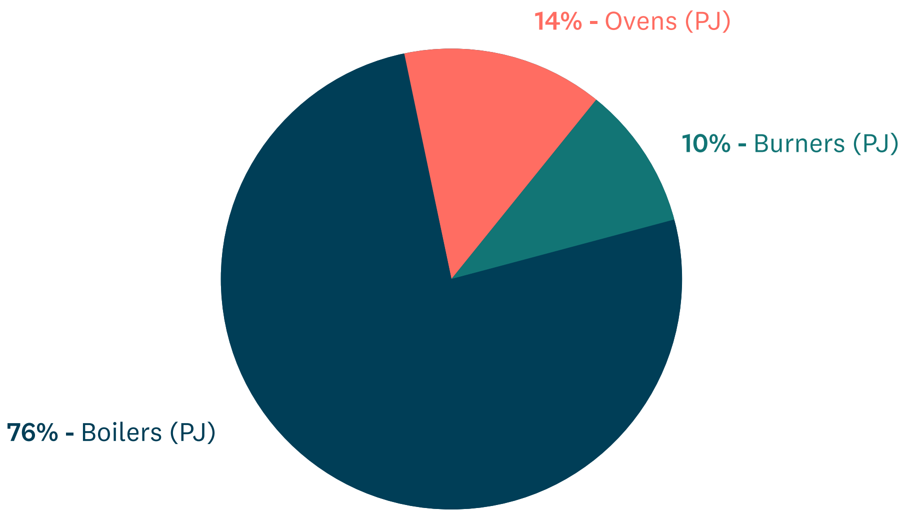
Natural gas by end use



In terms of technology, 76% of the natural gas consumption takes place within boiler systems (1.3 PJ) with 14% in ovens (0.25 PJ) and 10% in burners (0.18 PJ).

Figure 6:

Natural gas by technology



There are opportunities for heat loads (low and intermediate temperature) to be met more efficiently through heat recovery. Often heat recovery opportunities generate low to intermediate heat and can significantly reduce the use of natural gas. It is important to investigate all heat recovery opportunities available for their potential use onsite. Examples of these opportunities include exhaust heat recovery on ovens, dryers, fryers, and roasters, refrigeration heat recovery, and wastewater heat recovery. The recovered heat could be used for preheating air, product, and/or generating hot water.

The use of heat pumps has the potential to effectively remove the use of steam, direct natural gas hot water heating, and direct natural gas air heating. It is often the easiest and most cost-effective way of decarbonising process heat systems, given the right application.

Not only would using heat pumps be the most energy efficient way of meeting the heating demands, but it should become increasingly more cost effective as a substitute for natural gas with New Zealand's natural gas production expected to peak in 2024 and then decline[9], likely leading to higher future fuel costs.

Natural gas is perceived to be a reliable fuel by users. Many surveyed organisations mentioned that using natural gas allows for precise temperature control leading to high quality food products. Because of this sentiment, there was some hesitancy to consider fuel switching especially in manufacturing processes involving toasting or roasting.

[9] Ministry of Business, Innovation and Employment (MBIE) 2021. Energy in New Zealand 2021.

6.2 Coal

Thirty three percent (33%) of the total energy in the survey is from coal (1.4 PJ) and all the coal users are in the South Island. Compared to natural gas users (39 in total) there are fewer coal users (8 in total). However, a coal user on average consumes 3.8 times the energy of a natural gas user.

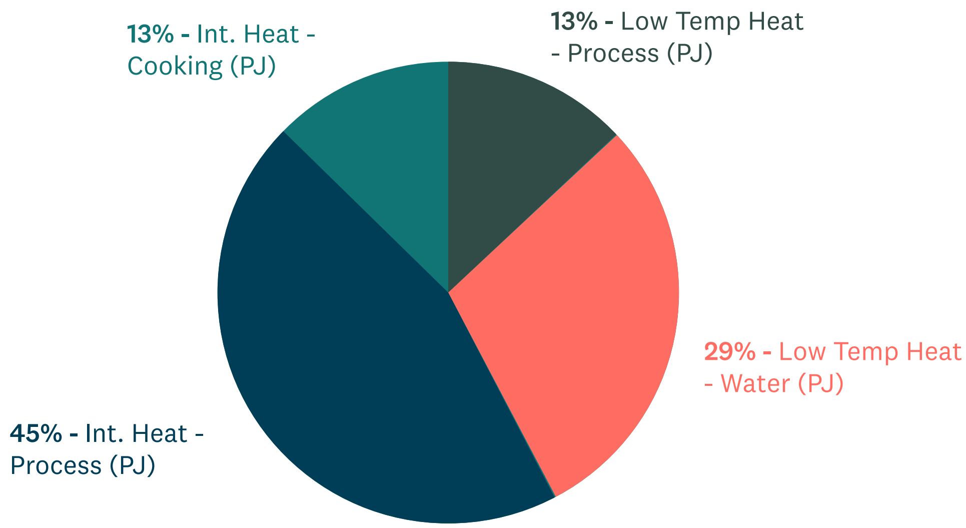
Several large coal users have received EECA support to develop an Energy Transition Accelerator, which provides a roadmap to improve energy efficiency and eventually switch away from coal to a low-carbon renewable alternative. Other coal users (generally smaller producers) are not as advanced in their plans to eliminate coal, although all recognised that it is something they will (eventually) need to do.

Of the coal that is consumed, 45% or 0.63PJ is used to produce intermediate temperature process heat requirements.

The remainder is from low temperature water heating (29%), intermediate temperature cooking (13%), and low temperature process heat (13%).

Figure 7:

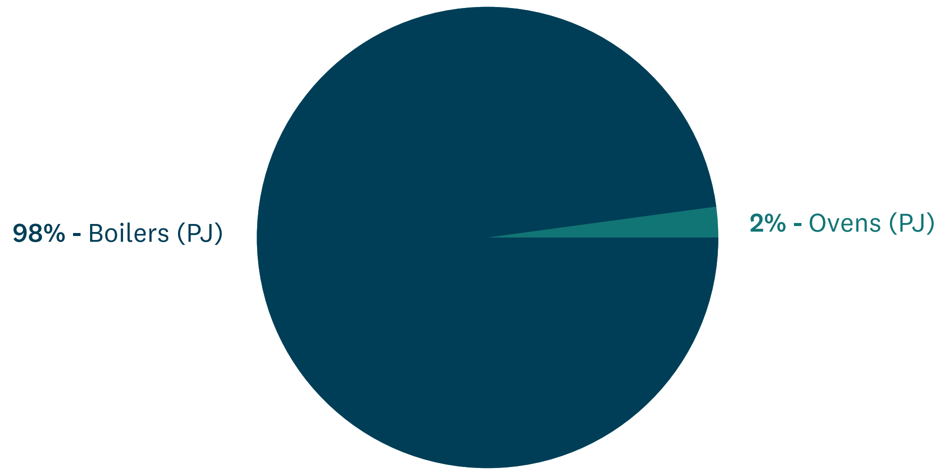
Coal by end-use



In terms of technology, 98% of the coal consumption takes place within boiler systems (1.4 PJ) with a further 1.9% in ovens (0.027 PJ).

Figure 8:

Coal by technology



As with heating loads from natural gas, there are opportunities to improve energy efficiency through heat recovery for coal. As detailed in section 7, decarbonisation opportunities for coal exist to shift intermediate temperature (e.g., steam) demand to lower temperature demand (e.g., hot water) which is easier to decarbonise with technologies such as heat pumps. See section 7 for details on decarbonising either gas or coal fuelled heat loads.

Most coal users when asked about decarbonisation were interested to learn more about how they might decarbonise. There was a lot more willingness than natural gas users to consider switching to alternative technologies. This is likely due to the recent increases in coal and Emissions Trading Scheme (ETS) costs as well as more public opposition to coal (e.g., through the likes of Coal Action Network Aotearoa).

It is also likely that the business cases for fuel switching from coal would have a better return on investment and marginal abatement cost (MAC) than natural gas due to the lower energy efficiency of coal boilers (especially where assets are older) and the ongoing increases in fuel and ETS costs.

6.3 Electricity

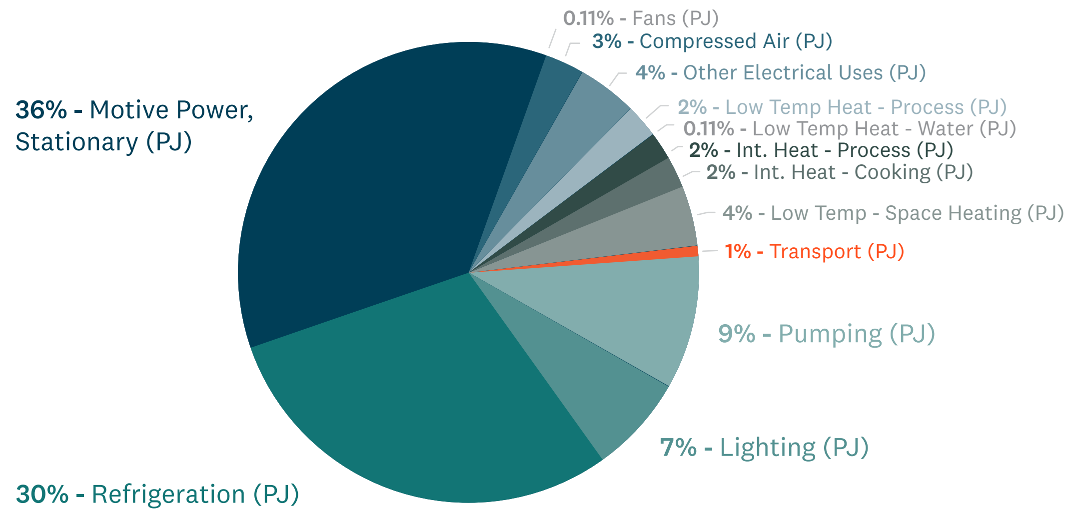
Twenty two percent (22%) of the total energy used, within the survey cohort, is from electricity (0.93 PJ). Thirty six percent (36%) of electricity is used for stationary motive power, 30% in refrigeration, 9.3% in pumping, and 6.7% in lighting.

Stationary motive power relates to machinery used in the production process, such as conveyers and mixers, for example.

In comparison to natural gas and coal, much less heating demand is met with electricity. However, as organisations implement their decarbonisation plans, we would expect this to increase.

Figure 9:

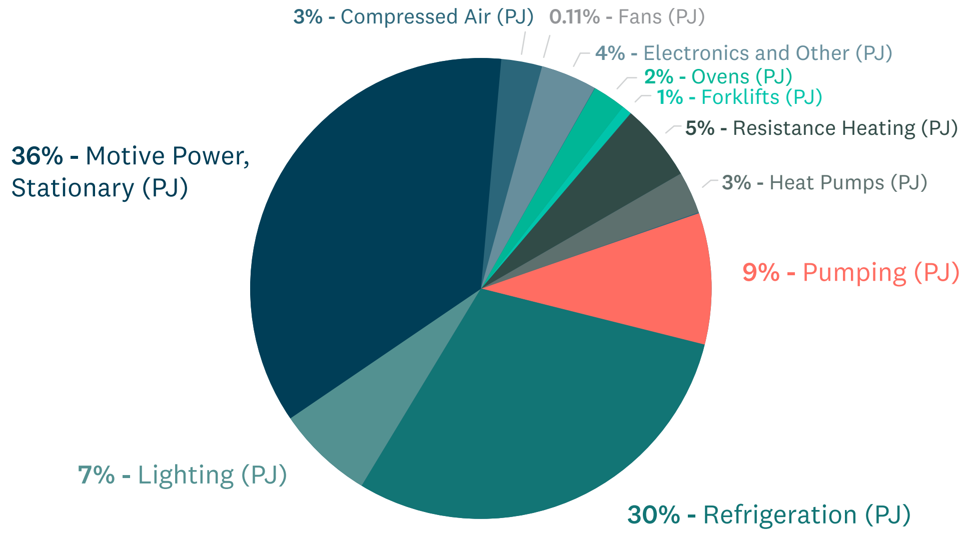
Electricity by end-use



In terms of technology, the picture looks very similar to end use except for different types of heat requirements being split into resistance heating (5.6%) and heat pumps (2.9%).

Figure 10:

Electricity by technology



There are likely to be energy efficiency opportunities around refrigeration through improved insulation, compressor performance, and heat recovery. This would likely have the biggest impact on overall electricity consumption.

Hot water or hot air generation using a heat pump technology that utilises the waste heat from the refrigeration plant would have a big impact on thermal energy consumption and efficiency if there is significant hot water consumption onsite. Assessments related to the integration of the heat pump system with the existing process heat and refrigeration systems would be required to optimise and maximize the impact. Often in this sector, the refrigeration systems and process heat systems are standalone systems, but by integrating them, one can achieve a significant energy productivity gain and improve the energy efficiency of the site.

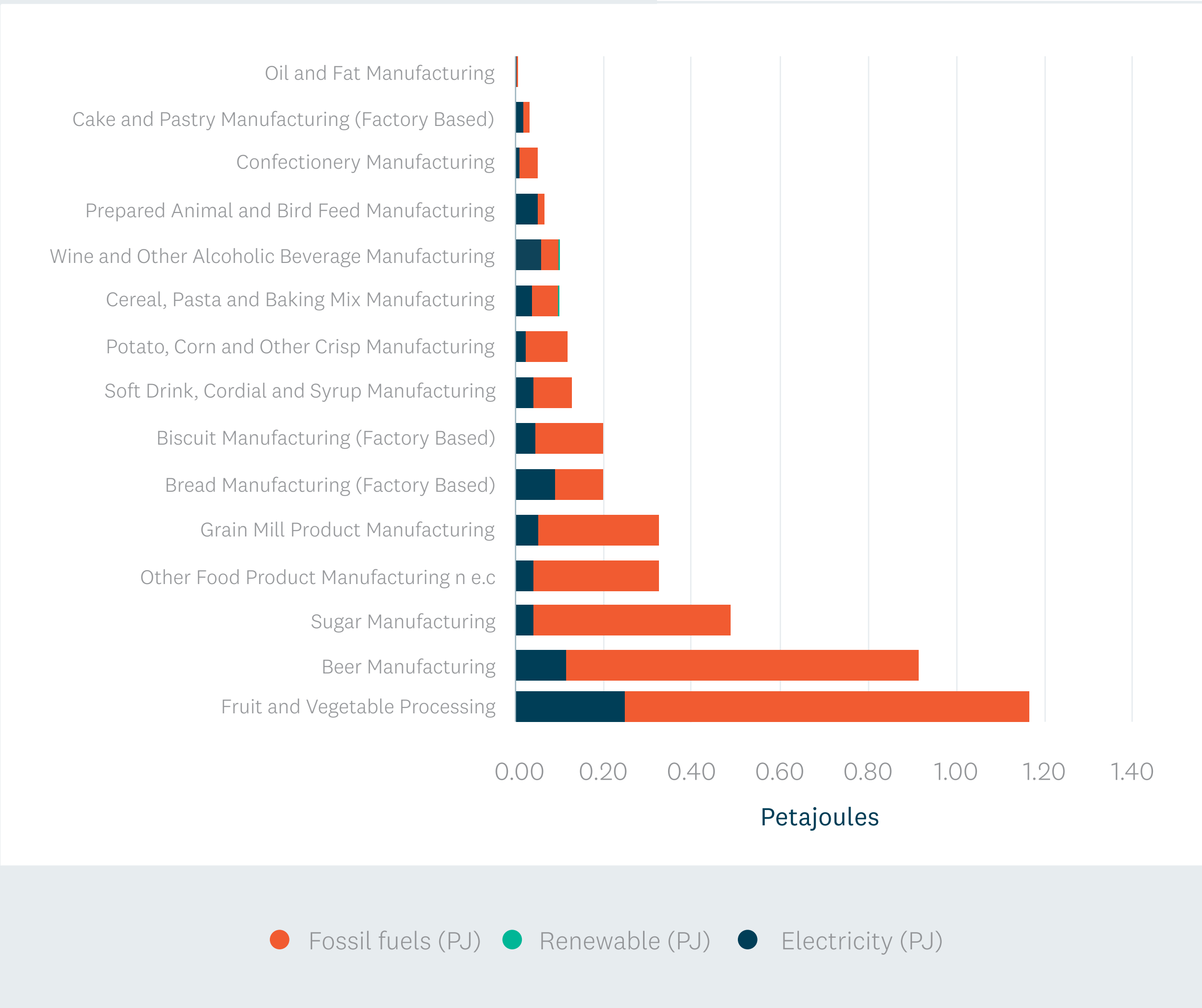
In addition, many surveyed organisations had not yet upgraded to LED lighting which would be another great opportunity for sites to reduce electricity use. For sites with significant amounts of pumping and fans, Variable Speed Drives (VSDs) can be used to improve energy efficiency.

7 Sector insights

Of the industry classes in the survey, fruit and vegetable processors have the largest share of total energy (27%). Followed by beer manufacturing with 22%, sugar manufacturing with 12%, other food product manufacturing N.E.C[10] with 7.8%, grain mill product manufacturing with 7.7%, and other industry classes making up the remaining 24%.

Figure 11:

Survey energy use by ANZSIC industry class (4.3 PJ)

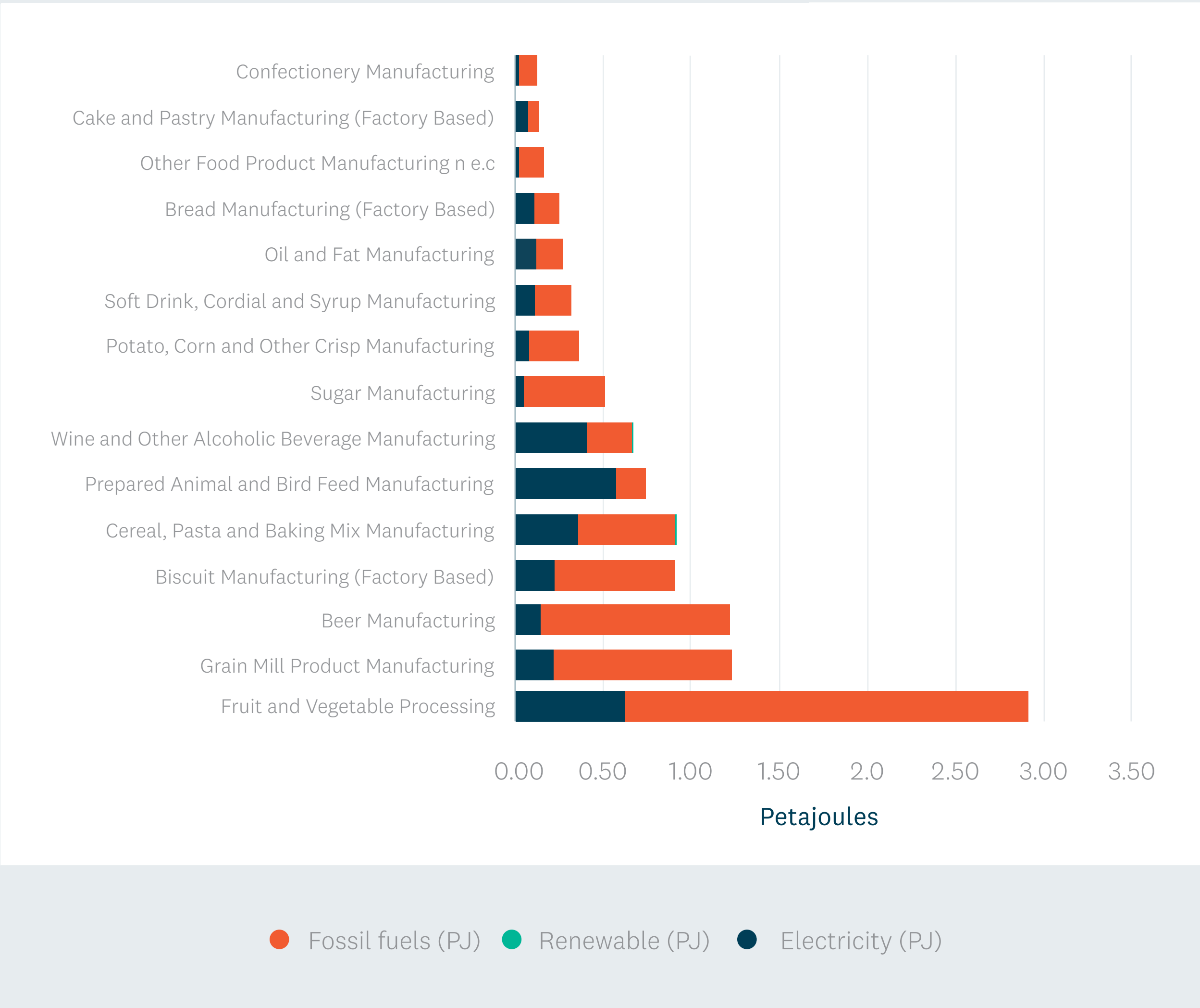


[10] N.E.C. stands for 'Not Elsewhere Classified'

Some industry classes were proportionally overrepresented in the survey, for instance, wine and other alcoholic beverage manufacturing, prepared animal, and bird feed manufacturing (petfood), and other food product manufacturing N.E.C (e.g., coffee). This was in part due to support from the respective industry associations for these industry classes who helped to support the survey.

Figure 12:

Sector-wide energy use by ANZSIC industry class (extrapolated)



When the survey results are extrapolated out to the total sector level (see Figure 12), we see that grain mill product manufacturing moves up to the second largest (11%) consumer of energy after fruit and vegetable processing (29%). Grain mill product manufacturing includes products manufactured from grains (wheat, oats, barley) such as flours, malt, and starches (further details of the extrapolation methodology can be found in Appendix 3).

Following those two industry classes are beer manufacturing (11%), biscuit manufacturing (9.1%), cereal, pasta, and baking mix manufacturing (9.1%), prepared animal and bird feed manufacturing (7.5%), wine and other alcoholic beverage manufacturing (6.7%), and the other industry classes making up the remaining 20%.

From the sector-wide view, we see that five industry classes - fruit and vegetable processing, grain mill product manufacturing, beer manufacturing, biscuit manufacturing, and cereal, pasta and baking mix manufacturing make up two thirds (67%) of total sector fossil fuel consumption. By targeting fuel switching in these four industry classes, we would expect the overall sector emissions to halve.

Additionally, opportunities for decarbonisation exist in sugar, and other product N.E.C. manufacturing as these industry classes have the highest proportion of their energy consumption from fossil fuels.

In discussions with organisations, we found specific challenges to decarbonising each product type within the various industry classes.

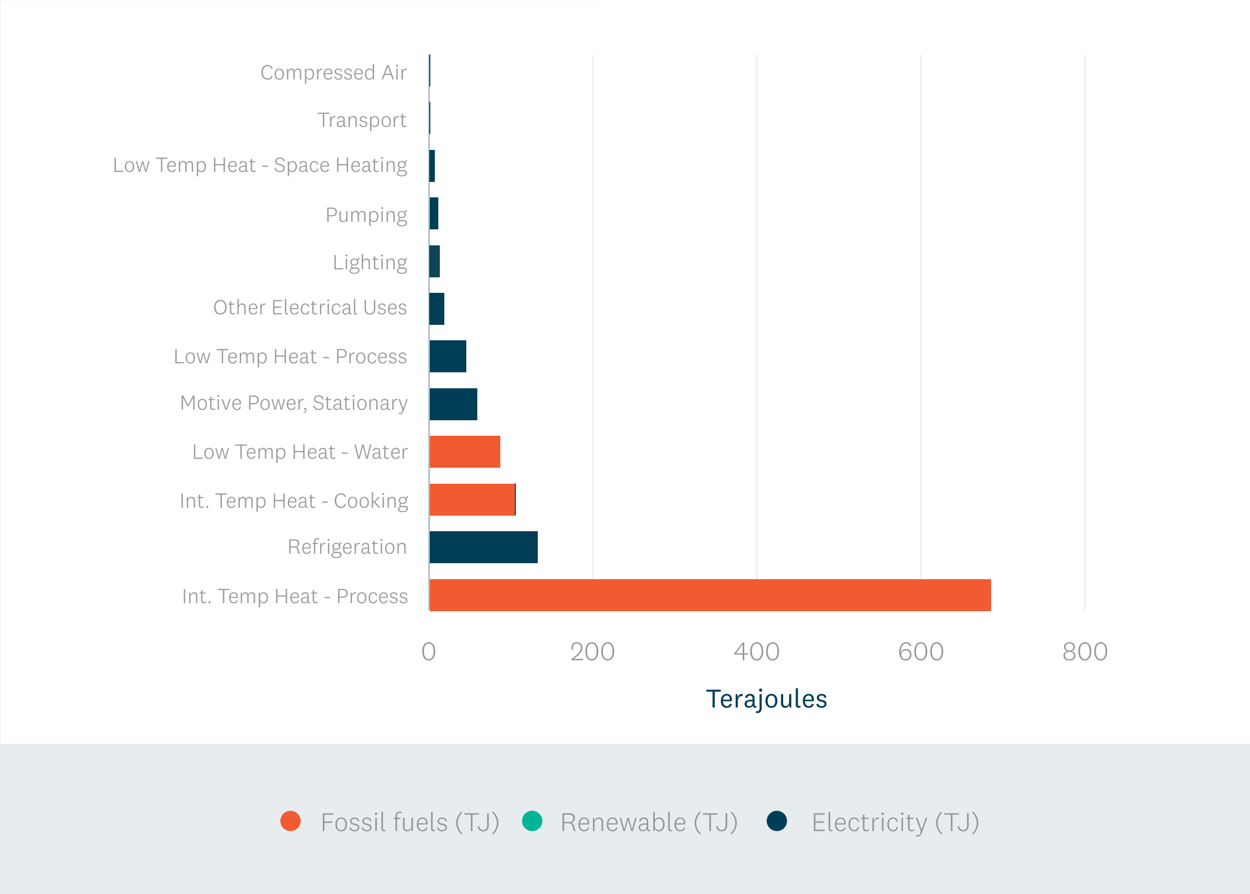
For example, for coffee manufacturers there are not yet electric roasters available that can meet production demand. The electric roasters that exist today are too small and prohibitively expensive to allow for complete fuel switching away from natural gas. However, there are new technologies such as single gas burner systems that eliminate the need for afterburners and therefore can reduce gas consumption by up to 80%.

7.1 Fruit and vegetable processing

The majority (73%) of energy used in the fruit and vegetable processing industry class is consumed in boiler systems. The remainder is used in refrigeration (11%), ovens (5.8%), stationary motors (5.1%), electronics and other (1.6%), lighting (1.2%), pumping (1.0%), and heat pumps (0.64%).

Figure 13:

Fruit and vegetable processing end use split

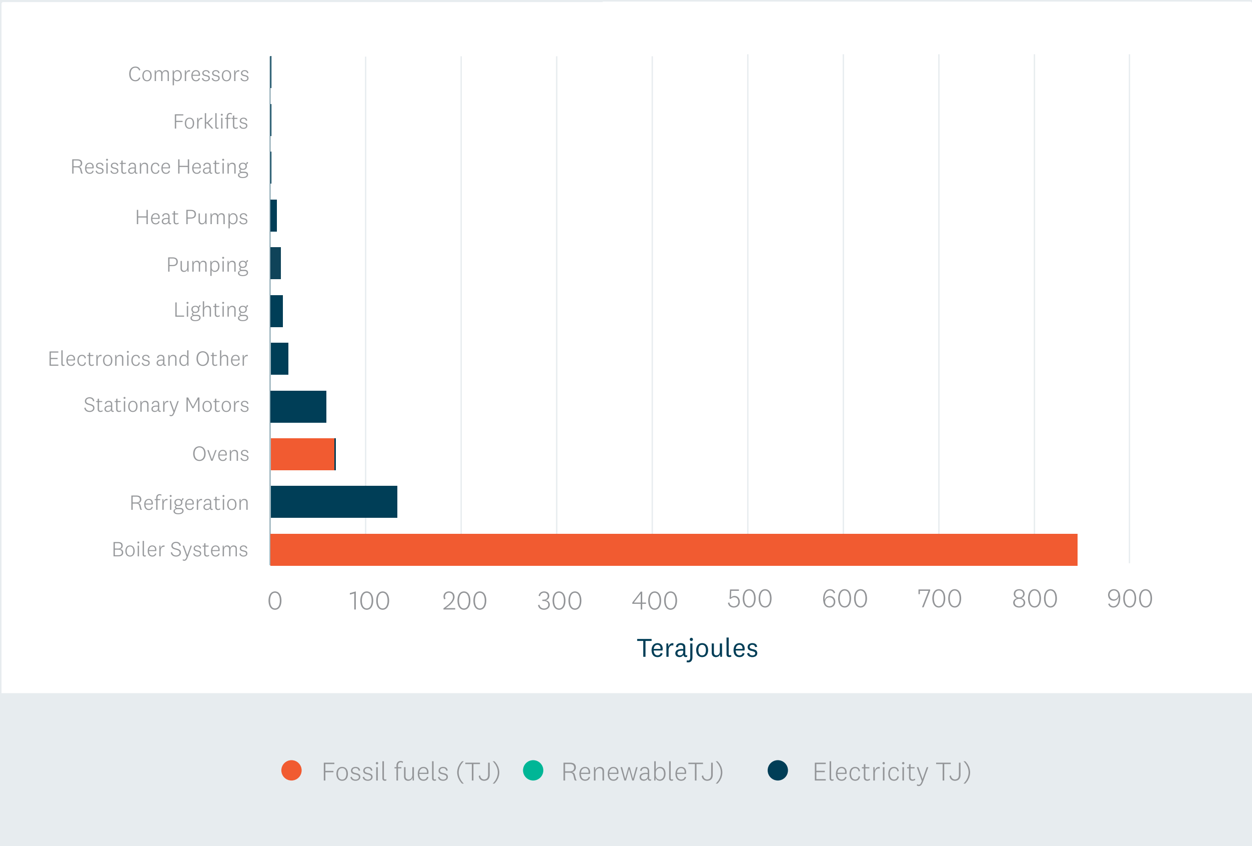


Of the energy used by this industry class the most predominant end-use is intermediate temperature heat process requirements (59%) which is produced by fossil fuel boiler systems. This is typically steam generation.

The next largest end-use is refrigeration (11%) to store processed goods followed by intermediate temperature cooking (9.0%), low temperature water heating (7.4%), and stationary motive power (5.1%).

Figure 14:

Fruit and vegetable processing end use split

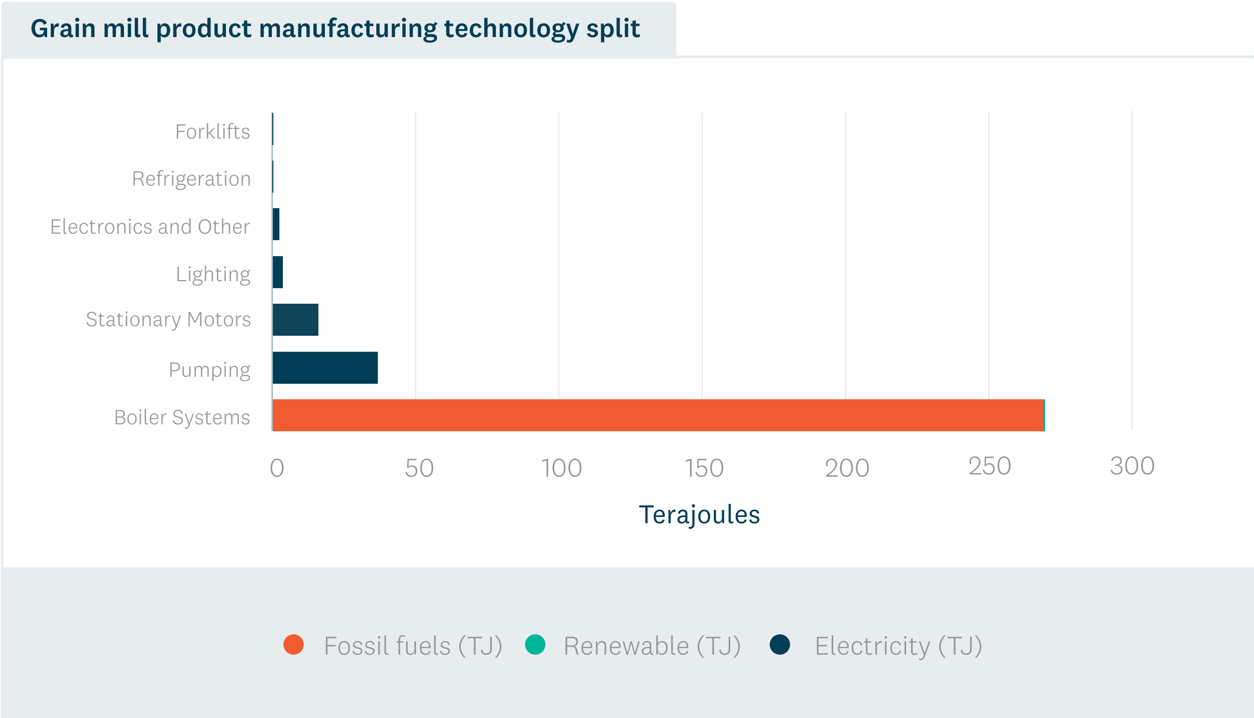


This industry class uses significant amount of hot water for fruits and vegetables processing while refrigeration is also used for conditioning and storing the final product. We see opportunities for decarbonising this industry class using hot water heat pumps that can reduce the use of steam and fossil fuels for hot water production. Substituting steam and fossil fuel-based hot water systems or hot air systems with a heat pump technology would have a significant impact to improving energy productivity and plant energy efficiency. Integration of the refrigeration plant, if available, with the heat pump system for hot water or hot air would be a preferred option over a standalone heat pump system as the waste heat from the refrigeration plant would provide better heat pump performance. The remaining steam or process heat loads can be met with electric or biomass systems.

7.2 Grain mill product manufacturing

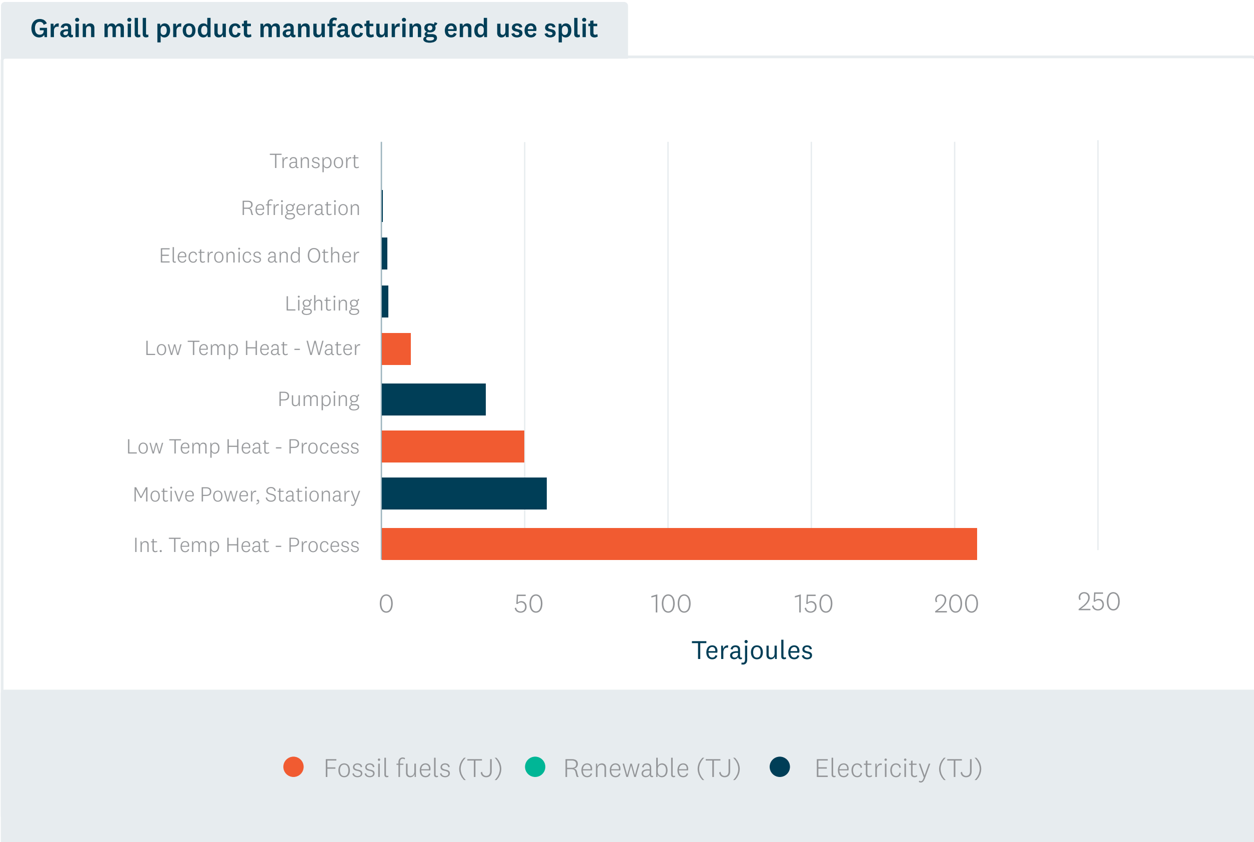
The majority (73%) of energy used in the fruit and vegetable processing industry class is consumed in boiler systems. The remainder is used in refrigeration (11%), ovens (5.8%), stationary motors (5.1%), electronics and other (1.6%), lighting (1.2%), pumping (1.0%), and heat pumps (0.64%).

Figure 15:



Of the energy used by this industry class the most predominant end use is also intermediate temperature heat process requirements (56%) which is produced by fossil fuel boiler systems. This is for direct-fired ovens and steam generation.

Figure 16:



Decarbonisation opportunities exist for fuel switching fossil fuelled direct fired ovens to industrial electric ovens and reducing steam demand before switching to electric or biomass steam boilers. Low temperature hot water or hot air loads could be met with hot water or hot air heat pumps as outlined in section 7.

8 Decarbonisation insights

The survey included a range of questions relating to users' progress and intentions around decarbonisation, energy efficiency, and measuring their emissions.

The following summarises some of the insights captured from these questions.

Only a third of organisations are currently measuring their Greenhouse Gas emissions

Only 35% of surveyed organisations in the food product manufacturing sector currently measure their greenhouse gas (GHG) emissions, with 5% in the process of compiling their first emissions measurement. A further 38% of survey cohort are intending to measure their footprint in the future.

Twenty two percent (22%) don't measure their emissions, nor do they plan to in the future.

Of those users who do measure their emissions, 83% confirmed that stationary energy use is a significant contributor to their overall emissions.

Most organisations have plans to improve their energy efficiency

Ninety one percent (91%) of surveyed organisations have identified energy efficiency opportunities. The most common plans include upgrading lighting to LEDs (28%), heat recovery (15%), and compressed air improvements (10%). The survey did not elicit details about when users intend to make these improvements. Given that most users identified that they are currently extremely busy, it is probable that external support and or access to suitably skilled resources to help drive progress would encourage users to improve their energy efficiency sooner.

Figure 17:

Surveyed organisations' energy efficiency plans

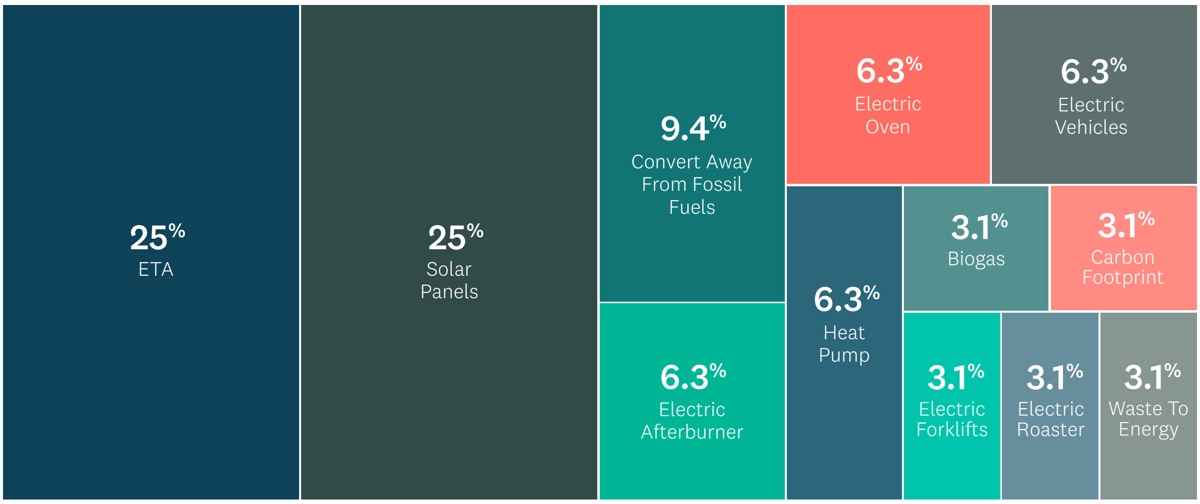
Half of organisations are aware of opportunities to reduce their emissions

Fifty one percent (51%) of surveyed organisations have future plans to switch from fossil fuels to low emissions energy sources. Twenty five percent (25%) of those are currently participating in EECA's Energy Transition Accelerator (ETA) programme (3.2 PJ total, 2.7 PJ from fossil fuels) which considers all low emissions energy alternatives, 25% are considering solar panels, 9.4% are looking at electric roasters and afterburners (for coffee roasting).

A further 9.4% are considering electric vehicles (forklifts and vans), 6.3% are looking at electric ovens, 6.3% at heat pumps, and a further 6.3% are considering biogas, and waste-to-energy.

Figure 18:

Surveyed organisations fuel switching plans



Many of the users have already looked at solar panels but expressed the view during interviews that the business case for solar did not stack up. Many business owners we spoke to are reluctant to invest capital unless there is a short pay-back period, often cited as 3-5 years.

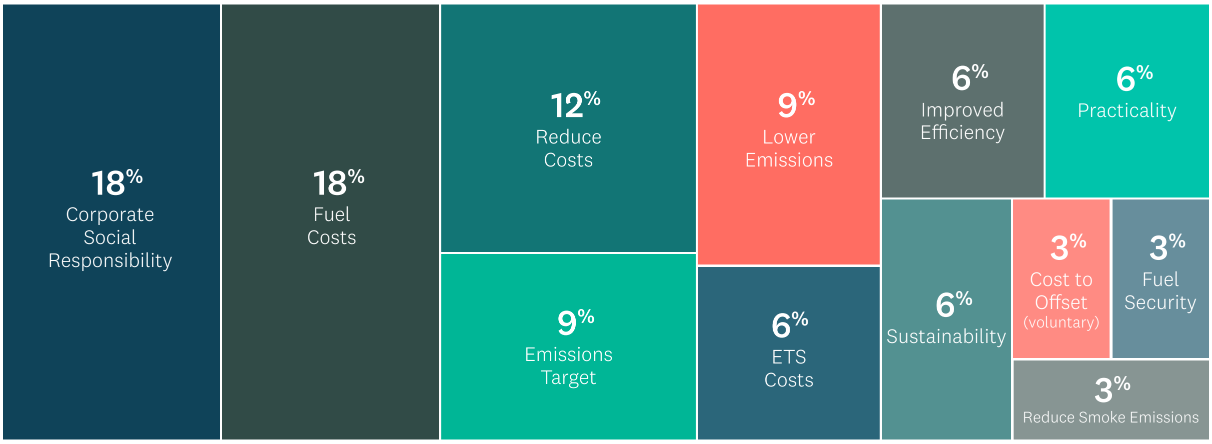
There are a range of drivers for organisations that are looking to decarbonise

The most common drivers for users that are looking to progress energy efficiency and decarbonisation opportunities are rising fuel costs (18%) and corporate social responsibility[11] (18%). As fuel costs continue to rise in 2022, this cost driver is likely to increase further in importance.

Other drivers include wanting to reduce costs (12%), meet an emissions target (9.1%), lower emissions (9.1%), reduce ETS charges (6.1%), improve efficiency (6.1%), improve practicality (6.1%), improve sustainability (6.1%), reduce fuel security concerns (3.0%), reduce offset costs (voluntary) (3.0%), and meet smoke (air quality) regulations (3.0%).

Figure 19:

Survey drivers for decarbonisation



When accounting for fuel costs, reducing costs, ETS costs and voluntary offset costs together, the largest driver for energy efficiency or decarbonisation (39%) is to reduce operating costs.

Some key barriers are preventing organisations from decarbonising

High capital costs (27%) and practicality (product quality risk) (27%) concerns are the largest barriers to decarbonisation.

Other barriers include insufficient electrical capacity (12%), fuel security and cost (10%), aversion to trying new (unknown) technologies (10%), lack of knowledge (4.9%), fuel costs (2.4%), council costs (2.4%), lack of funds available for consultants/research (2.4%), and unreliability (2.4%).

[11] Corporate Social Responsibility (CSR) is when a company holds itself accountable for its social, economic, and environmental impact.

Figure 20:

Survey barriers for decarbonisation

Decarbonisation opportunities

The decarbonisation process outlined in section 3 applies to all fossil fuels including the two most common, natural gas and coal. Below are some specific opportunities that apply to many food product manufacturers.

Energy efficiency through heat recovery

As fossil fuels are mostly used for producing process heat, heat recovery opportunities should be explored at all food product manufacturing sites. Examples of these opportunities include exhaust heat recovery on ovens, dryers, fryers, and roasters, refrigeration heat recovery, and wastewater heat recovery. The recovered heat could be used for preheating air, product, and/or generating hot water.

Demand reduction through using lower temperatures

Once heat recovery opportunities are exhausted, there are opportunities to reduce intermediate temperature demands, which reduces energy consumption significantly due to the ability to then use heat pumps for hot air and hot water applications.

Technology/process change

Heat pumps can provide low-cost heat (more than three times cheaper than direct electric heating) in the form of hot air up to 120°C and hot water up to 90°C. The use of heat pumps in this sector has the potential to effectively remove the use of steam and reduce the energy required for hot water and air heating. It is often the easiest and most cost-effective way of decarbonising process heat systems, given the right application. Hot water and hot air heat pumps have efficiencies in the range of 300% compared to traditional fossil fuel boiler-based systems that are in the range of 80%.

New and emerging energy efficient technologies should also be considered as options to decarbonise processes. For instance, microwave technology, radiofrequency, and infrared heating are all technologies that can be used now. Manufacturers should regularly research available technologies, as new solutions are emerging all the time.

Fuel switching

Where higher temperatures cannot be avoided through energy efficiency, demand reduction, and process change opportunities – then electric boilers, biomass boilers, and biogas systems (if applicable) could be used to generate steam for the energy intensive processes within the sector such as cooking, frying, and drying.

Fuel switching opportunities are available for all processes. Decisions on fuel switching can be made based on the business case of the project. Factors like availability of electrical capacity, electricity cost, fuel cost, and security of biomass would need to be considered as part of the decision-making process.


DANGER
HIGH VOLTAGE
Unattended Electrode Boiler

9 Glossary of terms

Term	Definition
Food Product Manufacturing (sector)	Food Product Manufacturing is defined using the Australian and New Zealand Standard Industrial Classification (ANZSIC) as the Food Product Manufacturing (C11) and Beverage and Tobacco Product Manufacturing (C12) industry subdivisions. It excludes the Dairy Product Manufacturing (C113), and Meat and Meat Product Manufacturing (C111), and Seafood Processing (C112).
Industry Division	Level 1 ANZSIC classification (e.g., C1)
Industry Subdivision	Level 2 ANZSIC classification (e.g., C11)
Industry Group	Level 3 ANZSIC classification (e.g., C119)
Industry Class	Level 4 ANZSIC classification (e.g., C1199)
Decarbonise	Switching from fossil fuel energy sources to low greenhouse gas (GHG) emissions energy sources, such as electricity or biomass.
Bottom-up data	The data collected in the survey phase of this research.
Top-down data	Energy balances and estimates that are created from fuel imports and electricity retail data.
Stationary Energy	The energy that is consumed in electricity generation, production of process heat, as well as geothermal energy and motive power.
Renewable	Refers to energy produced by biomass, biogas boilers.
PJ	1 Petajoule (PJ) is equivalent to energy consumption of 24,000 New Zealand households annually.
Burners	Burners refer to direct-fired cooking and heating.

10 References

1. Energy Efficiency and Conservation Authority (EECA) 2021. Energy End-Use Database – Key insights and methodology. Wellington: Energy Efficiency and Conservation Authority
2. Ministry for the Environment. 2020. Marginal abatement cost curves analysis for New Zealand: Potential greenhouse gas mitigation options and their costs. Wellington: Ministry for the Environment.

11 Appendix

Appendix 1: energy tables

Forty two percent (42%) of the total energy use within the survey cohort is from natural gas (1.8 PJ), all in the North Island. Of the natural gas consumed, 71% or 1.3 PJ is used to produce intermediate temperature process heat requirements. The remainder is from intermediate temperature cooking (13%), low temperature water heating (8.2%), low temperature process heat (6.8%) and low temperature space heating (0.43%).

Figure 21:

Survey energy consumption by ANZSIC industry class (Average of 2019, 2020)

ANZIC Code	ANZIC Category	Electricity (PJ)	Coal (PJ)	Natural Gas (PJ)	LPG (PJ)	Diesel (PJ)	Biomass (PJ)	Total (PJ)
C1140	Fruit and Vegetable Processing	0.252	0.710	0.202		0.000		1.164
C1150	Oil and Fat Manufacturing	0.003				0.004		0.007
C1161	Grain Mill Product Manufacturing	0.058	0.050	0.216	0.003			0.328
C1162	Cereal, Pasta and Baking Mix Manufacturing	0.040		0.052	0.009	0.000	0.000	0.101
C1171	Bread Manufacturing (Factory based)	0.092		0.109	0.001	0.000		0.202
C1172	Cake and Pastry Manufacturing (Factory based)	0.021		0.009	0.005			0.035
C1173	Biscuit Manufacturing (Factory based)	0.051		0.146	0.003			0.200
C1181	Sugar Manufacturing	0.047		0.443				0.490
C1182	Confectionery Manufacturing	0.012		0.041				0.053
C1191	Potato, Corn and Other Crisp Manufacturing	0.029		0.082	0.012			0.122

ANZIC Code	ANZIC Category	Electricity (PJ)	Coal (PJ)	Natural Gas (PJ)	LPG (PJ)	Diesel (PJ)	Biomass (PJ)	Total (PJ)
C1192	Prepared Animal and Bird Feed Manufacturing	0.053		0.007	0.006	0.003		0.069
C1199	Other Food Product Manufacturing n.e.c.	0.043	0.029	0.244	0.013	0.000		0.330
C1211	Soft Drink, Cordial and Syrup Manufacturing	0.045		0.087				0.132
C1212	Beer Manufacturing	0.118	0.607	0.150	0.037	0.003		0.915
C1214	Wine and Other Alcoholic Beverage Manufacturing	0.062		0.004	0.004	0.030	0.000	0.100
	Totals (PJ)	**0.926**	**1.397**	**1.791**	**0.092**	**0.041**	**0.00001**	**4.25**

Figure 22:

Extrapolated energy consumption by ANZSIC industry class

ANZIC Code	ANZIC Category	Electricity (PJ)	Coal (PJ)	Natural Gas (PJ)	LPG (PJ)	Diesel (PJ)	Biomass (PJ)	Total (PJ)
C1140	Fruit and Vegetable Processing	0.629	1.775	0.506		0.000		2.91
C1150	Oil and Fat Manufacturing	0.127				0.148		0.27
C1161	Grain Mill Product Manufacturing	0.218	0.189	0.811	0.010			1.23
C1162	Cereal, Pasta and Baking Mix Manufacturing	0.361		0.466	0.080	0.000	0.000	0.91
C1171	Bread Manufacturing (Factory based)	0.115		0.136	0.001	0.000		0.25
C1172	Cake and Pastry Manufacturing (Factory based)	0.083		0.036	0.021			0.14
C1173	Biscuit Manufacturing (Factory based)	0.233		0.662	0.013			0.91

ANZIC Code	ANZIC Category	Electricity (PJ)	Coal (PJ)	Natural Gas (PJ)	LPG (PJ)	Diesel (PJ)	Biomass (PJ)	Total (PJ)
C1181	Sugar Manufacturing	0.050		0.466				0.52
C1182	Confectionery Manufacturing	0.031		0.102				0.13
C1191	Potato, Corn and Other Crisp Manufacturing	0.086		0.245	0.036			0.37
C1192	Prepared Animal and Bird Feed Manufacturing	0.577		0.072	0.061	0.035		0.75
C1199	Other Food Product Manufacturing n.e.c.	0.021	0.015	0.121	0.007	0.000		0.16
C1211	Soft Drink, Cordial and Syrup Manufacturing	0.114		0.216				0.33
C1212	Beer Manufacturing	0.157	0.810	0.201	0.049	0.004		1.22
C1214	Wine and Other Alcoholic Beverage Manufacturing	0.410		0.027	0.028	0.202	0.000	0.67
	Totals (PJ)	**3.1**	**2.3**	**3.9**	**0.3**	**0.4**	**0.0001**	**10.8**

Appendix 2: research methodology

This research was conducted by Lumen, on behalf of EECA. It was undertaken in four phases:

1. identify and engage energy users
2. data collection and user surveys
3. data analysis
4. insights, segmentation, and report.

Identify and engage energy users

A list of 254 energy users across different ANZSIC industry classes were identified as being likely to have >0.5GWh energy use per annum. These users were identified from a wide range of sources, including Lumen and EECA databases, supermarket brand listings, industry code lists and various other methods. Users were contacted, initially via email, to participate in the survey.

Users were contacted several times by email and by phone to ensure that the participation rate was as high as possible. Given the timing of this project, and in particular the ongoing challenges that COVID-19 presented businesses during the project timeframe, it proved challenging to achieve a high participation level.

In addition, relevant industry associations were contacted to distribute the energy survey to their members for increased participation.

Data collection and user surveys

In total, data from 98 sites and 79 organisations was included in the survey. The data was collected through a questionnaire, phone calls, and site visits with energy users.

For many users, energy data was collected directly from energy retailers with their permission. Surveyed organisations were required to sign a data consent form to be included in the aggregated database.

Data analysis

Energy data had been collected in the most typical invoiced units and then converted to petajoules (PJ) and terajoules (TJ) for consistency.

End-use and technology splits were determined by responses however some judgement was used to align the answers from 'other' so that overall energy balances were complete.

Percentages from end-use and technology splits were then taken and multiplied by energy consumption by fossil fuel (natural gas, LPG, diesel, and coal), renewable (biomass, biogas), and electricity to create the graphs included in this report.

Totals were summed and double-checked to make sure the results were reasonable.

Insights, segmentation, and report

Results from data analysis were collated by the industry class to display the results by industry classes This included total energy consumption by fuel, fuel type (fossil fuel, renewable or electricity), end-use, and technology.

Appendix 3: extrapolation methods

The method of extrapolation was determined based on the survey responses, to give an industry class view of energy consumption. Three methods were used: based on production (preferred), market share, or organisation count.

Based on production

Where reliable production values were available, along with benchmark values from survey responses, the production extrapolation method was used. For example, production-based extrapolation was used for wine and other alcoholic beverage manufacturing.

Based on market share

For industry classes with organisations that make up a large proportion of the industry class (by revenue or employee count), the data was extrapolated using an estimated market share that was covered in the survey data. For example, it was estimated that 95% of total NZ sugar manufacturing was captured, as the major sugar producers in NZ were included in the survey. For other industry classes (e.g. grain mill product manufacturing) the survey coverage was assessed to be much lower, and in these cases, judgement was required to extrapolate the data to a national level.

Based on organisation count

For industry classes with many medium-sized users that were covered in survey data, linear extrapolation was used based on the number of organisations in the industry class (taken from Stats NZ).

Figure 23:

Extrapolation methods by industry class

ANZIC Code	ANZIC Industry Class	Total (PJ)	Methodology
C1140	Fruit and Vegetable Processing	2.91	Based on market share
C1150	Oil and Fat Manufacturing	0.27	Based on organisation count
C1161	Grain Mill Product Manufacturing	1.23	Based on organisation count
C1162	Cereal, Pasta and Baking Mix Manufacturing	0.91	Based on organisation count
C1171	Bread Manufacturing (Factory based)	0.25	Based on market share
C1172	Cake and Pastry Manufacturing (Factory based)	0.14	Based on market share
C1173	Biscuit Manufacturing (Factory based)	0.91	Based on organisation count
C1181	Sugar Manufacturing	0.52	Based on market share
C1182	Confectionery Manufacturing	0.13	Based on market share
C1191	Potato, Corn and Other Crisp Manufacturing	0.37	Based on organisation count
C1192	Prepared Animal and Bird Feed Manufacturing	0.75	Based on organisation count
C1199	Other Food Product Manufacturing n.e.c.	0.16	Based on organisation count
C1211	Soft Drink, Cordial and Syrup Manufacturing	0.33	Based on organisation count
C1212	Beer Manufacturing	1.22	Based on market share
C1214	Wine and Other Alcoholic Beverage Manufacturing	0.67	Based on production
	Totals (PJ)	**10.8**	

Appendix 4: survey questionnaire

1. Site Details:	
ENERGY USER (Business Name):	Date: Time:
Summary of site operations:	
Physical Address (City/Region):	
Contact:	
Role:	
Phone Number:	
Email Address:	
Key Contact Phone Number:	

2. Description of Site
Approximately how many staff are employed at this site?
What are the main products produced on this site?
What factors most directly influence your energy consumption? (e.g. production volumes, mix of products, cost of energy)
Does your energy consumption change across the year? If so, why. (E.g. harvesting/summer demand for product etc.)
Do you measure your energy usage against any particular value? e.g. kWh per tonne, kWh per litre produced etc.
If so, what is this value for your site (approx.) for the past 12 months)?

3. Energy Use per annum				
	2019 Annual energy use and unit (e.g. Tonnes/type of Coal, GJ of gas, litres of diesel, kWh electricity)		**2020** Annual energy use and specify unit (e.g. Tonnes/type of Coal, GJ of gas, litres of diesel, kWh electricity)	
Fuel Type	**Annual quantity**	**Unit**	**Annual quantity**	**Unit**

Electricity				
Coal - Bituminous				
Coal – Sub-Bituminous				
Coal - lignite				
Coal – type unknown				
Natural Gas				
LPG				
Diesel				
Fuel oil (waste oil)				
Biomass				
Geothermal				

4. What is thermal fuel used for on site?

For each of the following fuel types used at your site, please provide an approximate percentage split of what this fuel is used for:

End use type (input energy)	Coal	Natural Gas	LPG	Diesel	Fuel Oil	Biomass
Low Temperature Heat (<100 °C), Process Requirements						
Low Temperature Heat (<100 °C), Water Heating						
Intermediate Heat (100-300 °C), Process Requirements						
Cooking (ovens) or frying						
Other (specify)						
Total (should add to 100% per column)						

5. For electricity used at your site, please provide an approximate percentage split for how this electricity is used

End use type	% of Electricity Use
Resistance heating/boilers: Low Temperature Heat (<100 °C), Process Requirements	
Resistance heating/boilers: Intermediate Heat (100-300 °C), Process Requirements	
Ovens: Intermediate Temperature Heat 100-300 °C)	
Heat pumps: Low Temperature Heat (<100 °C), Process Requirements	
Heat pumps: Intermediate Temperature Heat (100-300 °C), Process Requirements	
Heat pumps: Low Temperature Heat (<100 °C), Water Heating	

5. For electricity used at your site, please provide an approximate percentage split for how this electricity is used	
Heat pumps: Low Temperature Heat (<100 °C), Space Heating	
Other Space Heating	
Pumping	
Refrigeration	
Lighting	
Stationary Motive Power (Air compressors/fans)	
Other (specify)	
Total (sum to 100%)	100%

6. For any mobile plant (e.g. forklifts) used exclusively at your site please provide details of the number of vehicles you have and annual fuel use. (Do not include trucks that transport goods to/from your site)

Mobile Plant Type	**Number of vehicles**	**Approx. fuel usage per annum and unit (e.g. litres, or kWh if known)**
Forklift - electric		
Forklift - LPG		
Forklift – petrol/diesel		
Other vehicles - electric (please specify vehicle type)		
Other vehicles - LPG (please specify vehicle type)		
Other vehicles – petrol/diesel (please specify vehicle type)		

7. Energy Efficiency and Decarbonisation
Do you currently measure your Greenhouse Gas Emissions/Carbon Footprint?
(If yes) is energy use a significant contributor to your footprint?
What energy efficiency initiatives have you undertaken? Do you have plans to further improve your energy efficiency? Please describe.

7. Energy Efficiency and Decarbonisation
What does the future energy load look like for the site? Is it likely to stay the same, increase or decrease?
Are you looking at replacing fossil fuels with a lower emissions energy source (e.g. convert coal or natural gas to electricity?). What is driving this and what do you see as the key challenges in converting from fossil fuels?
Have you considered solar for your site/do you have future plans to install solar? What about any other sort of onsite generation (e.g. digesters, geothermal)?

8. Data consent:
Have talked through the Consent Release Form and sent it through for approval ☐ Yes ☐ No
Have received signed Consent Form Back ☐ Yes ☐ No

9. Any other Comments/discussion points?

TE TARI TIAKI PŪNGAO
ENERGY EFFICIENCY & CONSERVATION AUTHORITY