Shell ENERGY

FINAL REPORT

Advancing Renewables in the Manufacturing Sector

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This project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program.

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1. Executive Summary

In 2020-21, Shell Energy undertook the Advancing Renewables in Manufacturing Project with funding from ARENA, the Queensland State Government and Australian Industry Group (AiG). The aim of the Project was to develop a web-based, digital, education platform that shared data, analysis and insights generated from energy assessments at twenty manufacturing sites in Queensland, to help overcome investment barriers that exist for the uptake of renewable energy and energy productivity improvement initiatives in the manufacturing sector. A focus of the Project was to identify opportunities to electrify gas-based processes in the sector. The Project also aimed to build support to catalyse further action within the Queensland manufacturing sector.

Shell Energy carried out energy assessments across twenty Queensland manufacturing sites, including seven sites with gas-based manufacturing processes and thirteen with electricity-based manufacturing processes. The representative set of manufacturing businesses were selected from 45 applicants, across four regions (Cairns, Townsville, Rockhampton and South-East Queensland) and six sub-sectors (Metal, Polymer, Food, Construction, Chemical and Wood). Furthermore, these sites were selected to provide good coverage across the different business profiles in terms of energy consumption and employment as shown in the table below.

Table 1: Site participant summary

Energy Cost ($ p.a.)	No. Participants	No. of Employees	No. Participants
less than $500,000	9	1-50	6
$500,001 – $750,000	4	51-100	8
greater than $750,001	7	greater than 101	6

Each business selected had an energy management plan designed for them that identified and ranked energy productivity improvement opportunities that were unique to their operational environment, energy use and cost profile. Individual energy management plans were then deidentified and synthesised into case studies. A web-based digital education platform[1] was designed and built specifically for the manufacturing sector to remove information barriers, build energy skills and knowledge through the curation of a collection of relevant information, case studies and interactive tools. Three on-line energy productivity educational forums were delivered to share the knowledge gained in undertaking the project and assist other manufacturers reduce their energy use, costs and emission footprints.

This report discusses the key findings from the project, including the potential energy productivity gains available to the Australian manufacturing sector and the areas that are considered most worthwhile for further investigation by relevant Government agencies.

The key findings from the project are:

- Project participants have the opportunity to reduce annual energy costs by an average of 27% with a collective capital investment of $29m ($5.7m per year savings; simple payback of 5.0 years).
- Extrapolated to cover the whole sector, there is the opportunity to reduce manufacturing energy costs in Queensland by $88m[2] per year (based on an estimated $560m per year of current costs). Including demand reduction opportunities, annual energy savings that can be achieved within the manufacturing sector is over $93m (refer to Table 5). Gas efficiency alone can reduce gas consumption within the manufacturing sector by 20%, at an average simple payback of 4.6 years. Electricity efficiency alone can reduce electricity consumption within the manufacturing sector by 14%, at an average simple payback of 5.9 years.

[1] https://energysustainability.com.au/
[2] Direct energy cost savings, not including actions that only save demand costs

- Manufacturing businesses are very diverse in operation, scale and production plant used; however, five common opportunities are replicable across the different manufacturing sub sectors and have attractive business cases (payback of less than 5 years / 20% cost saving): Lighting, Variable speed drives (VSD), Heat recovery, Burner controls and Compressed air.
- Only 10% of businesses assessed had solar installed, demonstrating a low rate of solar PV adoption, despite participants having good awareness of potential benefits. On-site renewable energy generation could reduce the grid energy consumption by about 9% with an average simple payback of 5 to 7 years.
- Eight potential electrification or decarbonisation of gas-based processes projects were identified across seven sites with gas-based manufacturing processes. The suitability of electrification projects is highly project and site dependent - for the right projects, the technology is available, and the investment case can be compelling. Careful design and implementation are required to optimise financial returns to make electrification solutions economically viable. Two large scale electrification projects had acceptable returns of less than 5 years simple payback, without accounting for any potential price of emissions.

2. Project Background

2.1 Project Objectives

Objectives for the project	Extent Measure achieved the Outcome
1. Improved understanding of energy productivity and opportunities for the integration of renewable energy generation technologies through the identification of repeatable opportunities with significant energy cost savings (targeting a minimum 20% cost saving per site)	■ Project participants have the opportunity to reduce annual energy (electricity and gas) costs by \$5.7m or an average of 27% with a collective capital investment of \$29m on projects that have a simple payback of 5 years or less. ■ Extrapolated to cover the whole sector, there is the opportunity to reduce manufacturing energy costs in Queensland by \$88m per year (based on an estimated \$560m per year of current costs). – Gas efficiency alone can reduce gas consumption within the manufacturing sector by 20%, at an average simple payback of 4.6 years. – Electricity efficiency alone can reduce electricity consumption within the manufacturing sector by 14%, at an average simple payback of 5.9 years. ■ Only 10% of businesses assessed had solar PV installed, demonstrating a low rate of solar PV adoption, despite participants having good awareness of potential benefits. On-site renewable energy generation could reduce the grid energy consumption by about 9% with an average simple payback of 5 to 7 years.
2. Improved understanding of how to overcome investment barriers to the implementation of energy productivity and renewable energy initiatives by developing a robust evidence base to support investment decisions.	■ Energy Management Plans were prepared for each participant to provide a robust evidence base to support investment across efficiency, renewables and electrification projects. ■ Energy Management Plans were distilled into case studies available on the website[3]. This knowledge sharing activity improved the understanding of the cost and potentials benefit from various technologies across sub-sectors and geographies. This was complimented by the solar energy calculator tool[4] that was designed to provide users with a cost / benefit analysis of the potential of installing solar, as well as a guidance on how to find solar suppliers to turn this information into action. ■ 3 Industry workshops were delivered to share program outcomes, build energy knowledge and share the 'lived' experience of how other local businesses overcome investment barriers to improve their energy productivity. 87 people registered to attend the workshops. ■ For government and industry stakeholders, key barriers identified by participants and our engineering team are provided in this report, alongside future opportunities program recommendations to overcome investment barriers.

[3] https://www.energysustainability.com.au/
[4] https://www.energysustainability.com.au/solar-energy-calculator

Objectives for the project	Extent Measure achieved the Outcome
3. Improved understanding of how to develop accurate, robust, evidence-based methodologies to estimate the potential cost-savings delivered by energy productivity and renewable energy initiatives.	■ The Energy Management Plan template developed in consultation with the Steering Committee subject matter experts improved the identification and assessment of Energy Conservation Measures (ECM) for participants. ■ In-line with objective 1, our focus was to identify repeatable opportunities with significant energy cost savings (targeting a minimum 20% cost saving per site), as well as the "low hanging fruits" in terms of available and emerging technologies for different sectors, based on how/where the sites used energy. ■ Data was obtained from participants and combined with publicly available data sets and Shell Energy's market/sector/technical insights to quantify the potential scale and economic benefit of energy productivity and renewable energy opportunities within this report. ■ Sub-sector benchmarks were developed to identify the greatest scope for energy efficient technology, adoption of renewables and transitioning gas-based processes to electrification. These have identified the short-term pathway to electrification of heat using high temperature heat pumps and also the circumstances which it would be financially viable now. ■ Shell Energy and AiG will continue to undertake knowledge sharing activities with government and industry stakeholders to share the insights captured from undertaking the project to further support for the sector.
4. Improved understanding of how to develop skills, capacity and knowledge regarding energy productivity and renewable energy initiatives facilitated by data sharing on the web-based, digital, educational platform.	■ The website[5] was developed specifically for manufacturers as a target group. It was designed to overcome the communication challenges identified for the target group: low energy literacy, being time poor, and perceived lack of credible information. ■ Case studies educates the target group by clearly communicating the cost and benefits of efficiency, renewable and electronification opportunities. By framing this in the context of what their peers are doing we believe this will be a strong call to action. ■ Website content was curated to provide high quality information from trusted, credible sources for the target group – making it quick and easy to find, digest and continue on the pathway to action. ■ Content can be sorted by sector, geography, technology making it easy to the user to get to information relevant to them in a timely and interesting way. Interactive tools provide points of interest and personalised outputs for users to build basic energy literacy, skills and knowledge.
5. Improved understanding of how to increase stakeholder engagement and advocacy for sharing energy data, improving energy productivity and integrating renewable energy generation	■ Recommendations in Energy Management Reports helped participants to identify and understand their unique opportunities and improve their energy knowledge. This, coupled with workshops and the website where we can continue to share success stories, will inspire businesses to turn that information into action. ■ Three workshops were delivered in November 2021 to increase stakeholder engagement and advocacy for improving energy productivity and integrating renewable energy generation. Additional stakeholder engagement is planned in 2022. ■ The website provides an on-going positive platform for stakeholder engagement by sharing case studies and content as it is developed in the future. ■ On-going engagement with Queensland State Government and broader industry stakeholders has been undertaken throughout the delivery of the project to advise how market challenges can addressed, share lessons learned and support the manufacturing sector.
6. Improved understanding of how to design effective policy targeted at sub-sectors to ensure the most efficient deployment of public funds and resources in future initiatives	■ Analysis and insight derived from undertaking project activities has been fed into evidence-based future opportunities and program recommendations in this report. This included the quantification of the scale of opportunity for productivity gains across State-wide deployment by sector and technology type to ensure the most efficient deployment of resources in future initiatives.

[5] https://www.energysustainability.com.au/

2.2 Project Method

From February 2020 – November 2021 Shell Energy worked with Australian Industry Group (AiG), Department of State Development, Manufacturing Infrastructure and Planning and ARENA to deliver the following across the 20 selected pilot manufacturer businesses:

1. Steering Committee formed of key contacts and subject matter experts in Queensland Government, AiG and ARENA. Twelve Steering committee meetings were held throughout the project.
2. Shell Energy developed a business selection framework and criteria to identify eligible participants. To be eligible for the shortlist, applicants had to meet the following selection criteria:
   - The primary business purpose was manufacturing, as defined by Australian and New Zealand Standard Industrial Classification (ANZSIC) codes.
   - The site was located in the state of Queensland.
   - A "gas user" site achieved process heat of less than 800 degrees Celsius.
   - An "electricity user" site consumed between 500MWh – 100GWh.
3. AiG engaged the sector through a two-week application process, 45 applications were received and assessed. 25 complying applicants were selected based on the selection criteria. The top 20 highest energy consumers were selected and endorsed by the Steering Committee to form the pilot group, with the remaining 5 allocated to a waitlist.
4. A desktop analysis of participants was undertaken on electricity and gas data received.
5. An Energy Management Plan (EMP) template was developed with assessment of Energy Conservation Measures (ECM) and endorsed by the Steering Committee.
6. The Energy Sustainability web-based digital education platform[6] was designed and built, including the curation of a collection of relevant information and interactive tools.
7. Shell Energy in consultation with AiG Group and Queensland State Government prepared a draft engagement plan to direct traffic to the web based digital Platform.
8. Energy assessment site visits across the 20 pilot sites have been completed by Shell's Engineering Team. COVID-19 restrictions impacted parts of the project schedule.
9. 20 Energy Management Plans (EMP) were developed and distributed to participants that identified and ranked opportunities that were unique to their operations, energy use and cost profile. Follow-up coaching sessions were offered and undertaken with relevant stakeholders and case studies developed for knowledge sharing activity.
10. An internal Summary Report was prepared to identify benchmarks, themes and insight across fuel source, sub-sectors and geographical profiles. This analysis of results formed the basis of the final report.
11. Three on-line energy productivity educational forums were delivered to share the knowledge gained in undertaking the project and assist other manufacturers improve their energy productivity and reduce their emission footprint.

[6] https://energysustainability.com.au/

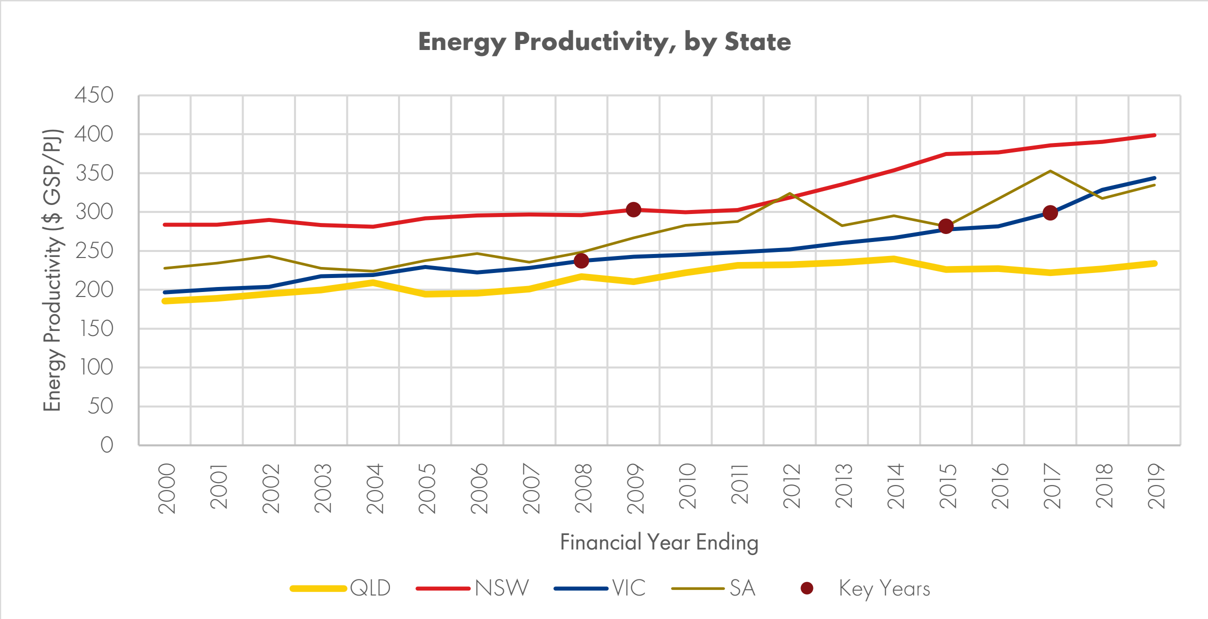
2.3 Background - Queensland's Energy Productivity

A broad look into Queensland's **energy productivity** (defined here as Gross State Product unadjusted for inflation relative to energy consumption from all fuels) using available data shows that Queensland has historically been behind most states. However, this measure accounts for all industry sectors and does not adjust for the fact that Queensland relies proportionately more on agriculture, mining, and manufacturing more than other states. What is important to note is that, compared to VIC, NSW, and SA (top three most productive states), the difference in energy productivity for Queensland has grown significantly since year 2000. One of the reasons for this growing gap may be that all three states have introduced long running programs targeting **energy efficiency**. Energy efficiency relates to actions that allow businesses to operate using less energy. This has a direct impact of increasing Energy Productivity. Critically, these programs differ materially from the Queensland Affordable Energy Plan in the fact that the programs mentioned above are funded through energy retailers and is open to both households and businesses without funding quota restrictions. The years which these programs were enacted are shown in Figure 1 below. Specifically, these relate to:

1. Victorian Energy Efficiency Target for Households in 2008 and for Businesses in 2017 – This program designed to reduce household electricity bills through subsidising energy efficiency upgrades in the residential sector. This program incentivised energy efficiency projects with over 6.5M certificates (worth around $400M) created for eligible upgrades in 2021 alone[7]. This program has been gradually expanded on since 2008 and is legislated to continue until 2030.
2. NSW Energy Saving Scheme Legislation in 2009 – a program designed to incentivise electricity (and later gas) efficiency in households and businesses in NSW. This program has provided over $108M of incentives for energy efficiency actions in 2021 through the creation of over 4M certificates[8]. This program is legislated to run until 2050, with scope and targets increasing annual since its inception.
3. SA Retail Energy Efficiency Scheme in 2015 – this is an expansion of the original program targeting households in 2009 and has been replaced in 2020 by the new Retailer Energy Productivity Scheme (REPS). The objective of the REPS is to 'improve energy productivity for households, businesses and the broader energy system, with a focus on low-income households.

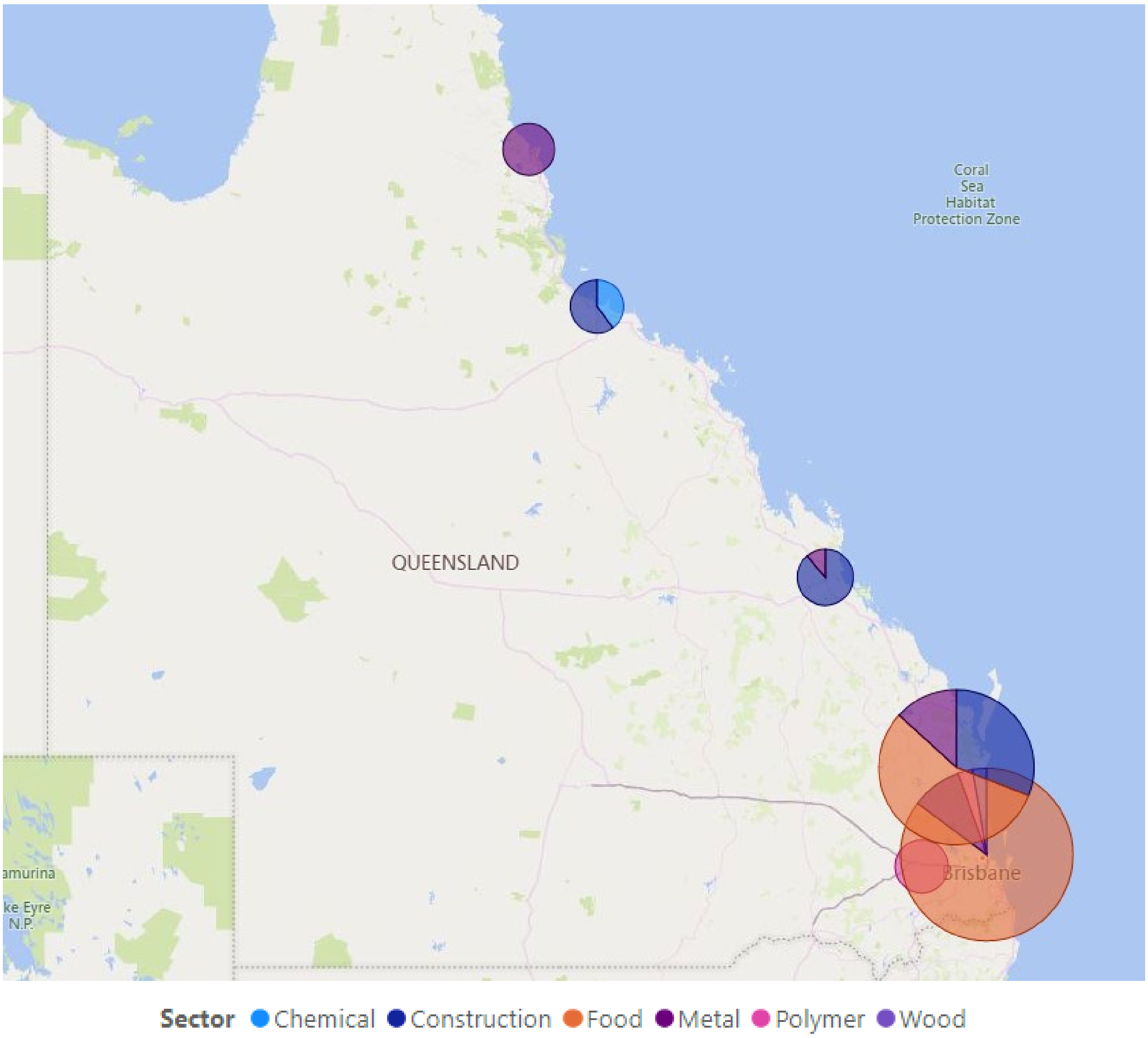
[7] https://www.victorianenergysaver.vic.gov.au/__data/assets/pdf_file/0026/505673/DELWP-Fact-sheet-VEU-2022-25-targets-and-program-expansion-181220.pdf
[8] https://www.ggas-registry.nsw.gov.au/general/login.aspx?ReturnUrl=%2f

Figure 1: Energy Productivity by State (Department of Industry, Science, Energy and Resources, 2020)



Shell Energy conducted a series of detailed investigations around the energy use of 20 manufacturers in Queensland. A total of 946,489 GJ of energy use was assessed, with the geographical distribution of this shown in Figure 2. Based on available data, we estimate that the total energy consumption of Queensland manufacturers to be 369 PJ. This means that this program directly captured 0.24% of the state's manufacturing energy footprint.

Figure 2: Total Energy Use by Sector and Geography

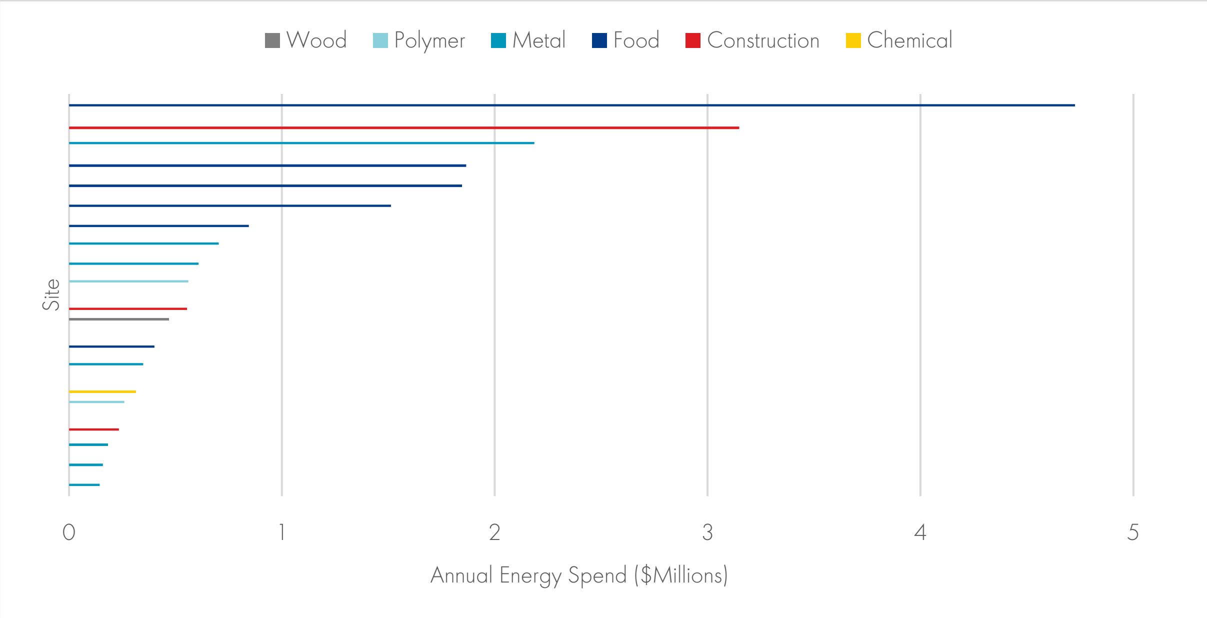


Whilst non-ferrous metals manufacturing and petroleum and chemical manufacturing were the two highest energy consuming subsectors in Queensland (Chamber of Commerce & Industry Queensland, 2016), the largest energy users within this program are from primarily food and beverage participants. This discrepancy is reflective of the recruitment approach that specifically targeted at least six sub-sectors to explore potential energy efficiency and renewable opportunities across a broad and representative mix of manufactures.

2.4 Summary of Participants

The program's 20 participants consumed over $21m in energy costs. These are broken down by subsector and by company in Figure 3.

Figure 3: Annual Energy Cost by Site and Sector



Program participants were recruited from four geographical regions across the state - Cairns, Townsville, Rockhampton and South-East Queensland. Participants have been grouped into broader geographical descriptors to align within the geographical descriptions applied within web site tool to assist with knowledge sharing activity i.e. broadens the application of knowledge to potential users who are not located in the specific towns defined in the Funding Agreement. The regions are aligned with Queensland State Government geographical regions as follows:

- Far North Queensland,
- North Queensland,
- Central Queensland,
- Wide Bay Burnett,
- Darling Downs Southwest and
- Southeast Queensland.

It can be observed that a majority of the energy use for program participants is in the South East Queensland region (Figure 4 and Figure 5) because this is where the larger manufacturers are located. Please note that, in the context of this report, the Construction subsector refers to buildings products manufacturing.

Figure 4: Annual Electricity Use by Sector and Location

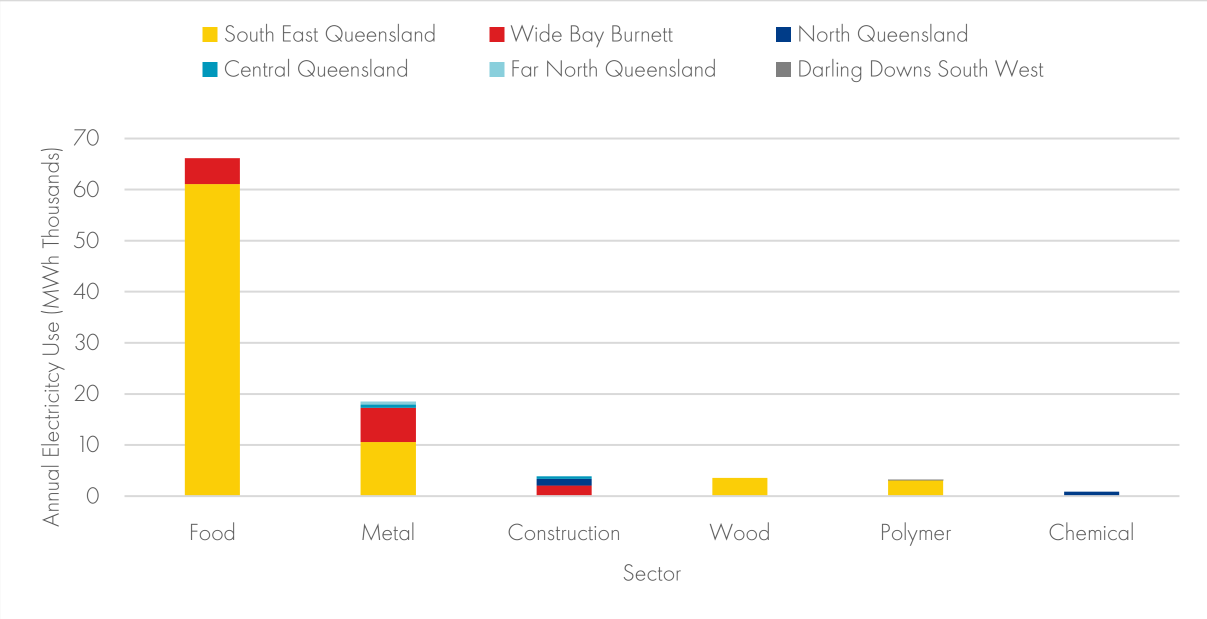
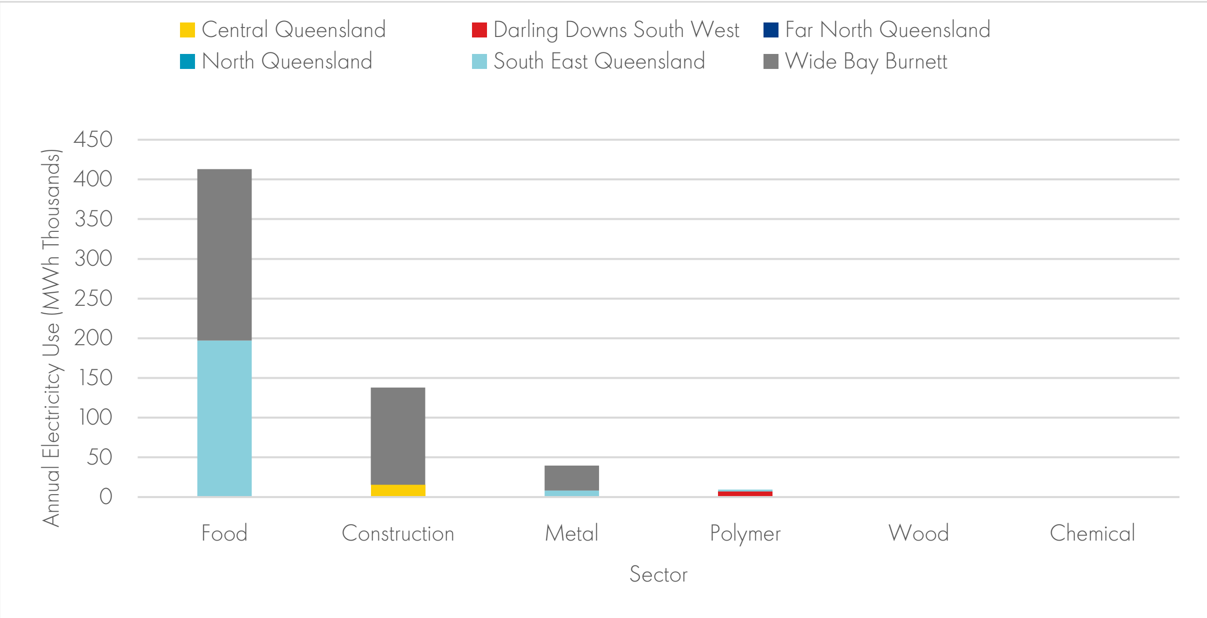


Figure 5: Annual Gas Use by Sector and Location



Key assumptions and limitations in the datasets provided:

- Slight mismatch of data. Most of the data is from 2019 calendar year to avoid showing the dramatic impacts of Covid-19 on energy use. However, some sites had undergone significant changes to the site/moved sites in 2019 which means that 2020 had to be used. These sites confirmed that, other than the initial few weeks of lockdown, operations continued as usual, so the impact of this mismatch is expected to be small.
- The data captured does not include non-stationary uses of energy.
- The site's annual production revenue data was not collected as part of this program. This would be a useful metric to use to compare productivity between different businesses and sectors. This may be an area that ARENA or the Queensland State Government could pursue further research in the future to gain a deeper understanding of energy productivity across different sub-sectors.

2.5 Baseline Energy Use

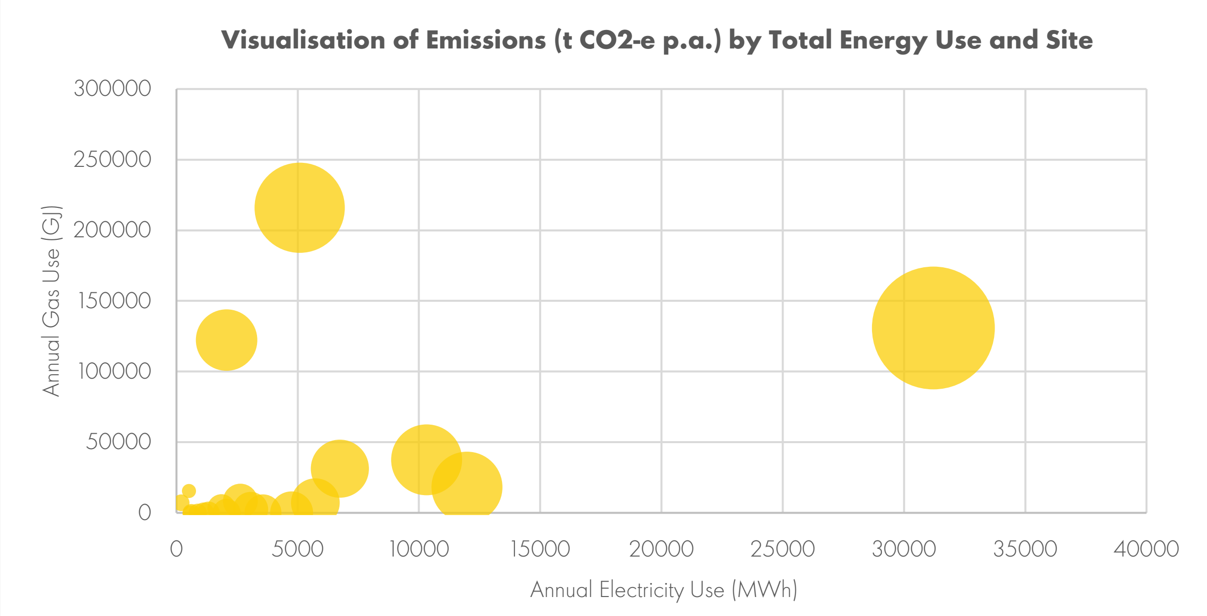
A summary of baseline energy use is shown in the table below. Whilst the site's overall stationary energy use is captured as part of this program, energy productivity opportunities developed focuses on a specific fuel source (e.g. electricity or gas).

Table 2: Participant Energy Baseline

Deidentified Site	Annual Electricity Use (MWh)	Annual Electricity Cost ($)	Annual Gas Use (GJ)	Annual Gas Cost ($)	Emissions (t CO2-e p.a.)	Assessment Focus
Business 1	4,748	609,134	0	0	3,894	Electricity
Business 2	2,636	462,501	8,317	240,816	2,565	Electricity and Gas
Business 3	6,738	1,399,881	31,265	786,623	7,132	Gas
Business 4	192.4	49,154	7,141	211,174	589	Gas
Business 5	10,315	970,230	37,527	876,122	10,630	Gas
Business 6	11,979	1,497,319	18,202	368,360	10,639	Gas
Business 7	3,057	473,526	2,422	86,794	2,602	Electricity and Gas
Business 8	5,728	784,187	7,200	59,760	5,009	Electricity and Gas
Business 9	2,065	347,976	0	0	1,672	Electricity
Business 10	5,081	957,467	215,961	554,692	17,203	Electricity and Gas
Business 11	3,566	468,977	0	0	2888	Electricity
Business 12	31,212	3,170,552	130,858	1,555,083	31,900	Gas
Business 13	1,124	183,469	0	0	910	Electricity
Business 14	1,857	290,438	3,254	111,173	1,673	Electricity
Business 15	611	144,471	0	0	659	Electricity
Business 16	516	119,880	15,471	434,900	418	Electricity and Gas
Business 17	2,067	506,566	122,305	2,641,853	7,976	Gas
Business 18	878	313,149	0	0	711	Electricity
Business 19	572	159,031	0	0	463	Electricity
Business 20	1,326	234,223	0	0	1,074	Electricity

We can visualise the baseline data in Figure 6 below. This figure shows the annual energy consumption (horizontal and vertical axis for electricity and gas use respectively) and the emissions impact of these businesses (the size of the bubble, largest bubble represents 31,900 tonnes and smallest is about 400 tonnes). A broad spread of energy users, by size, sector and location, were desired by the design of this program and this has been achieved with the sample collected.

Figure 6: Emissions Impact by Total Energy Use and Site (each colour represents a business)



Another useful benchmark is to understand the variable cost of the fuel (electricity and gas) versus the total volume of consumption of the fuel (Figure 7 and Figure 8 respectively). This benchmark confirms that the variable cost component of the energy bills are dependent on a large number of factors, resulting in difficulty in understanding the impact of energy reduction actions.

Figure 7: Variable Electricity Cost by Location and Annual Electricity Use

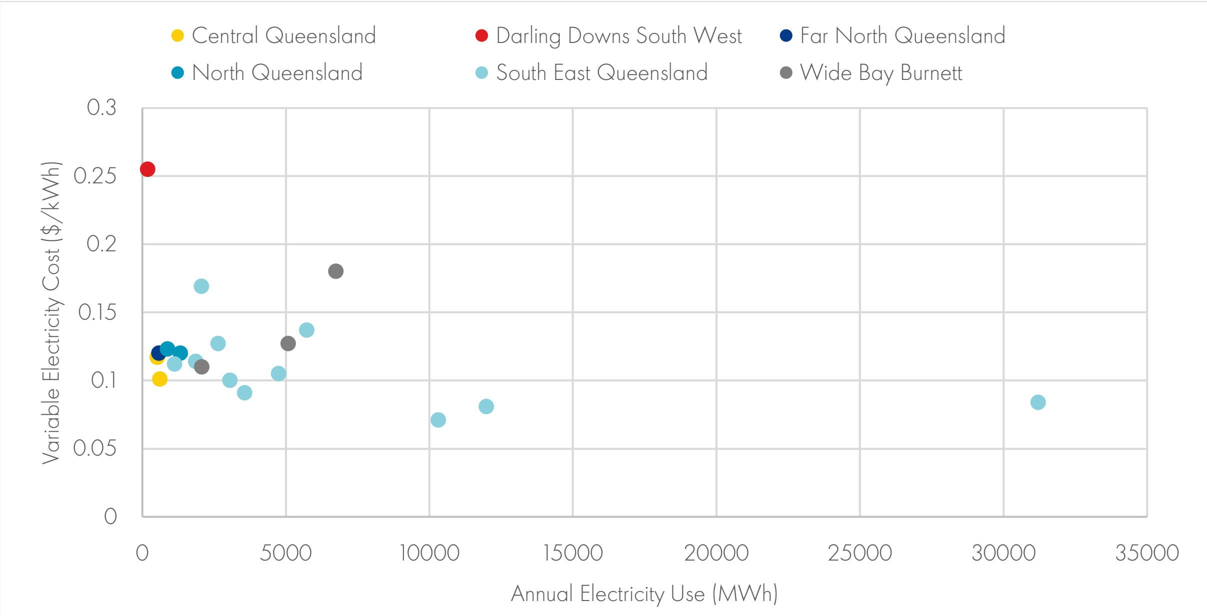
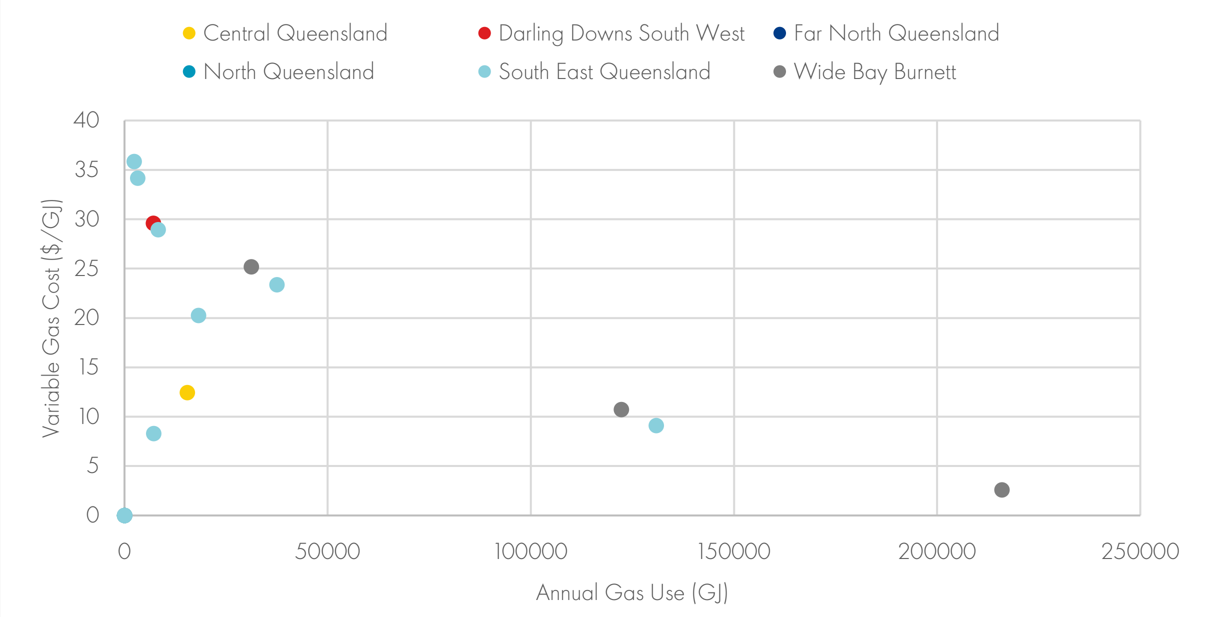
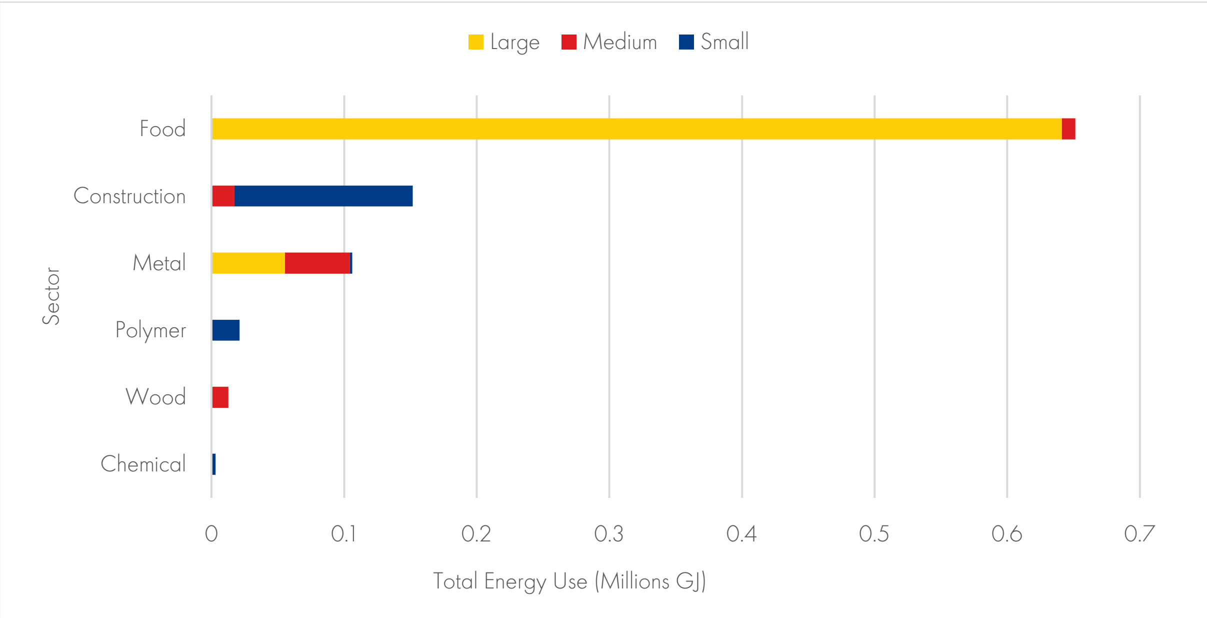


Figure 8: Variable Gas Cost by Location and Annual Gas Use



To understand the spread of business sizes captured in this program, the following figure classifies the businesses based on the number of employees on site. Large represents greater than 201 employees, Medium represents 51 – 200 employees and Small is 0 – 50 employees.

Figure 9: Total Energy Use by Sector and Size (for 20 sites)



General observations and insight are:

- Gas costs for some small to medium sized gas consumers can be very high, far greater than the typical $15/GJ used in most benchmarks. Some of this is a result of overrun costs as the site exceeds their daily usage limits. These overruns add an additional $10/GJ to the base cost of gas. However, there are cases where the site's gas costs genuinely exceed $20/GJ because of where they are on the gas network. At this rate, and assuming an 80% burner efficiency (which is on the high side of what is typically seen on site), the cost of gas for every unit of useful energy is at least $0.09/kWh. This can often exceed $0.14/kWh when other system losses, such as leaks and distribution, are factored in. This is comparable to most variable electricity costs and would support detailed investigations to electrify processes as soon as possible.
  - These businesses are primarily in the Southeast Queensland region and this may provide a case for localised Government support to maximise the returns on funding.
- There is high variability in the variable electricity cost, though larger consumers all tend to pay about $0.08/kWh as a standard rate. For smaller electricity consumers (those with annual consumption less than 10,000MWh) the average variable electricity cost is $0.13/kWh, a 60% increase from the rate paid by the larger consumers. A higher electricity cost makes energy productivity improvement opportunities more attractive in terms of financial returns. To maximise the cost savings of efficiency actions, a priority should be made for smaller consumers with annual electricity use of less than 10,000 MWh.
- In general, the following benchmarks can be used as a simplified comparison of the stratified energy costs of different fuels and different levels of consumption for the sample of 20 businesses:

Table 3: Fuel cost by business size

	Gas Cost ($/GJ)[9]	Electricity Cost ($/GJ)
Small consumers	22.43	35.92
Large consumers	6.51	22.43
Difference Small Consumers are paying	15.92 / GJ or 245% more	13.49 / GJ or 60% more

3. Key Findings / Recommendations

The key findings from the project are:

- The 20 project participants have the opportunity to reduce annual energy costs by an average of 27% with a collective capital investment of $29m ($5.7m per year savings; simple payback of 5.0 years).
- Extrapolated to cover the whole sector, there is the opportunity to reduce manufacturing energy costs in Queensland by $88 m[10] per year (based on an estimated $560m per year of current costs). Including demand reduction opportunities, annual energy savings that can be achieved within the manufacturing sector is over $90m (Table 5)
  - Gas efficiency alone can reduce gas consumption within the manufacturing sector by 20%, at an average simple payback of 4.6 years.
  - Electricity efficiency alone can reduce electricity consumption within the manufacturing sector by 14%, at an average simple payback of 5.9 years.

[9] Small consumers have less than 50,000GJ p.a. of gas consumption
[10] Direct energy cost savings, not including actions that only save demand costs

Manufacturing businesses are very diverse in operation, scale and production plant used; however, five common opportunities are replicable across the different manufacturing sub sectors and have attractive business cases (payback of less than 5 years):

- Lighting
- Variable speed drives (VSD)
- Heat recovery,
- Burner controls; and
- Compressed air.

- Only 10% of businesses assessed had solar installed, demonstrating a low rate of solar PV adoption, despite participants having good awareness of potential benefits. On-site renewable energy generation could reduce the grid energy consumption by about 9% with an average simple payback of 5 to 7 years.
- Eight potential electrification or decarbonisation of gas-based processes projects were identified across seven sites with gas-based manufacturing processes. The suitability of electrification projects is highly project and site dependent - for the right projects, the technology is available, and the investment case can be compelling. However, careful design and implementation is required to optimise financial returns to make electrification solutions economically viable. Of the 20 sites assessed, two large scale electrification projects had acceptable returns of less than 5 years simple payback, without accounting for any potential price of emissions. The suitability of decarbonisation of gas processes through biomass also often have excellent economic returns based purely on energy benefits and capital costs. However, these projects introduce additional energy security risks in the long term which needs to be assessed before a site can commit.

3.1 Barriers to energy efficiency improvement within the sector

The primary barriers to the implementing energy productivity improvement opportunities are:

Barrier # 1 - Energy Data

While energy was identified by all participants as a significant cost of business, it was not measured, monitored or managed with the same focus as a unit of labour or inventory. Only one site had a modern submetering system and the remaining sites had either minimal or no submetering. Most participants only track basic usage and costs from bills – meaning energy data for the management of energy has a material lag in timing and lacks specificity i.e. measured at gate meter, rather than production line or at a machine level. This makes it difficult to identify energy waste, measure and verify savings from undertaking improvement of capital projects.

Inconsistent energy savings and emissions reduction calculations from suppliers reduces the perceived credibility of solutions– thereby reducing the likelihood of investment, even if the business cases are genuinely good.

Insight:

Access to good quality data is the first step to better energy management. Timely, quality data helps manufacturers identify the sources of energy waste from electricity, gas and other fuel use, as well as steam or compressed air and other utilities used within the production process.

In most large manufacturing businesses, a Supervisory Control and Data Acquisition (SCADA) system is used to track high level production metrics. Extending this system to energy management through the installation of electricity submeters that feed data into the same SCADA system would often be the first step in improving the data quality on site. Additional meters that monitor heating and cooling streams that feed the production process would also help build an understanding of energy flows throughout site. Sites can then develop meaningful metrics that combine the available energy and production data to track ongoing use and identify possible efficiency gains. Integrating energy specific data into other production data provides insight into energy productivity - not just energy use. For example, energy per unit throughput, or economic output.

Barrier # 2 – Low energy literacy levels and organisational resources

During site assessments, participants communicated to our Engineers that they found electricity bills difficult to understand. Low energy literacy makes it difficult to understand complex tariff structures, manage energy use (consumption and demand) which also feeds into uncertainty when assessing proposed energy projects and investment cases. For example, participants also reported energy efficiency measures and solar PV measures include fixed network costs in their computation of savings.

Energy tariffs (electricity and gas) form a geographical barrier that prevents replicability of opportunities. That is, a strong business case on one set of tariffs may have zero impact on others (e.g. power factor correction), even if the sites are of similar size.

Most businesses communicated a lack of organisational resources to investigate and manage the delivery of energy productivity improvements. Often, the responsibility to manage energy consumption is split between finance and operations staff. This lack of a single responsible point means that opportunities need to be driven from outside of the organisation, for example by Government or suppliers.

Insight:

Not understanding the treatment of variable costs of electricity can result in the returns being overstated, sometimes by significant margins – creating a barrier to investment in energy efficiency or renewable projects. Low energy literacy and co-ordination barriers will compound as technologies become more complex, integrated and require on-going management to realise benefits. For example, to fully realise the benefits of battery systems, a site would require knowledge of peak demand, basics of the wholesale electricity market, and potential interactions with other elements of the site like EV car chargers. Often, low literacy in these complex systems leads to potential benefits being unrealised due to not knowing how, or benefits being overstated because the system installed is not able to access the revenue streams promised. Similarly, with the rapid changes in electrification technologies that are becoming available, sites would need to understand the heating, cooling, electricity, and process flexibility requirements to properly design and optimise solutions such as heat recovery, high temperature heat pumps, and electrode boilers.

Sites that have longer term planning around energy reaped more benefits due to their ability to tap into fixed cost and demand savings over time. Better levels of energy literacy were observed in gas-based businesses.

ISO 50,001 Energy Management Systems (EMS) standard helps with this issue, by assisting businesses develop a systematic approach to achieving continual improvements in energy efficiency, emissions reduction, and cost savings. Adopting this standard would provide manufacturing businesses a strong framework to upskill energy literacy and energy benchmarking (enabled by increased data availability).

Barrier # 3 – Capital constraints and lack of long-term support for energy efficiency activity

Access to capital and/or willingness to invest capital for project opportunities with longer (greater than 3 years) paybacks were significant impediments for many businesses. Investing in energy efficiency activity faces two major hurdles, the first is for the business to first have sufficient capital to consider these projects. Where capital is available this often must compete with non-energy related expenditures and is therefore rationed through the use of short paybacks. Both issues need to be addressed to unlock 56% of the savings opportunities ($49m per year in Queensland, estimated by extrapolating the energy savings identified in the 20 participants to their respective manufacturing subsectors using 2019 ABS data)

Insight:

The lack of an enduring long-term program of support for energy reduction activities in Queensland means there is inconsistent investment. Funding and support have largely been around one-off projects. Government Programs (e.g. Energy Savings Scheme, Victorian Energy Upgrades[11]) in NSW, VIC and now SA provide a level of

[11] These two schemes incentivise energy efficiency by allowing 1 certificate to be created for approximately 1 MWh of energy savings achieved. Each certificate has a freely traded market price.

certainty that allows innovation and long-term savings to be achieved. This can be evidenced by the popularity of the schemes in place, with 41.8 million[12] NSW Energy Saving Scheme certificates created since the program commenced. For the VEU, 76.4 million [13] certificates created since program inception. The schemes incentivise eligible energy efficiency to improve energy productivity and emissions reductions as well as delivering material co-benefits such as unlocking capital investment, jobs creation, economic stimulus created through the supply and distribution of equipment and appliances.

3.2 Energy efficiency technologies earmarked for immediate implementation

Drawing on the detailed data gathered from the 20 manufacturing sites that participated in this program and extrapolating the results on electricity and gas savings to the 2020 Queensland energy consumption by sector[14], we can see that there are repeatable projects that are financially viable (less than 5 years simple payback) and provide significant energy and emissions savings. These projects are primarily centred around the following technologies:

- **Lighting** – the replacement of inefficient lighting with Light Emitting Diode (LED) technology is well known within maintenance circles within the manufacturing industry. The main opportunities are to bring forward end of life replacements to immediately access the energy and emissions savings. This is typically capital cost intensive as opposed to gradual operational expedition through maintenance replacements. Cost is the single largest barrier for adoption.
- **Variable Speed Drives (VSDs)**– the use of VSDs to control motor loads is common practice within the manufacturing industry. However, this is typically only done on the largest (and/or most visible) motors used on site. The correct identification of VSD opportunities in smaller motors (less than 50kW in size) often requires a detailed study of process flow and a good understanding of the mechanics of motors. As a result, opportunities for the application of VSDs beyond the most visible assets are missed and significant energy savings remain unrealised.
- **Heat Recovery** – The capture and reuse of heat in waste streams such as exhaust gasses from burners, used hot/cold water and refrigerant, is one of the most impactful ways for sites to reduce energy consumption. However, like the use of VSDs, the identification of these opportunities is restricted to those with a deep understanding of both the site process and the heat recovery technologies required.

The following table summarises the potential savings of these key technologies within the different Queensland manufacturing subsectors. This data is extrapolated using 2020 ABS energy consumption data.

Table 4: Key Energy Efficiency Technologies, by Sectors within Queensland

Subsector Energy Savings by Technology in $m p.a. (Projects with less than 5 - year payback only)						
Site Sectors	Lighting	VSD	Heat Recovery	Burner Controls	Heat Pump	Compressed Air
Metal	$0.2	$0.4	$0.3	$0.3	$0.0	$0.2
Food	$0.3	$2.1	$12.4	$1.1	$5.6	$0.2
Construction	$0.0	$0.3	$2.7	$1.3	$0.0	$0.5
Wood	$5.2	$3.0	$0.0	$0.0	$0.0	$0.0
Polymer & Chemical	$0.9	$4.9	$9.5	$1.5	$0.0	$0.4

[12] https://www.ggas-registry.nsw.gov.au/general/login.aspx?ReturnUrl=%2f
[13] https://www.veu-registry.vic.gov.au/Public/Public.aspx?id=Home
[14] Department of Industry, Science, Energy and Resources, Australian Energy Statistics, Table F, September 2020

The assumptions and calculations used to produce the table above are:

1. Total Energy use of the relevant subsectors are sourced from the Australian Energy Statistics 2020, Table F4 (**link**)
2. Subsector total energy cost is calculated using Fuel Consumption from Step 1 x Weighted Average Fuel Cost of subsectors based on the 20 participating businesses
3. Annual energy savings of projects (with less than 5 years simple payback) within each technology category and each subsector are taken from actual projects developed for the 20 participating businesses
4. This annual energy saving for each item are then divide by the subsector site total energy costs to produce % cost savings for each category by subsectors
5. The total energy cost savings for each is derived by multiplying the % savings from step 4 with the subsector energy costs in step 2.

In terms of the ease of rapid deployment of technology, Lighting, VSD, and Heat Recovery are all readily understood and commercialised. Given that these technologies can deliver over $42m of annual savings within the Queensland manufacturing sector, manufacturing businesses should be supported in the identification and implementation of these critical and cost-effective solutions.

The table below summarises the general applicability of economically viable technologies within each manufacturing sub sector based on the 20 energy assessments undertaken. The data from the 20 sites has been extrapolated and the technologies with less than 5 years simple payback has been highlighted to show their significance to each subsector.

Table 5: Applicability of technologies within subsectors (expressed as Annual Energy Cost Savings / Typical Simple Payback Years)

Annual Savings / Typical Simple Payback Years	Lighting	VSD	Heat Recovery	Burner Controls	Heat Pump	Compressed Air	Solar	Batteries	Refrigeration	PFC	Demand Management
Metal	$0.2m / 1.6	$0.4m / 2.5	$0.3m / 2.4	$0.3m / 3.7	$0m / 0	$0.2m / 1.5	$1.9m / 8.8	$0.2m / 6.8	$0m / 0	$0.1m / 1.9	$0m / 0.2
Food	$0.4m / 3.8	$2.1m / 2	$13.5m / 1.7	$2.1m / 5.1	$5.7m / 5	$0.2m / 0.5	$8.6m / 8	$0m / 0	$2.1m / 1.2	$0.2m / 8.9	$0m / 0
Construction	$0.1m / 5.8	$0.3m / 4	$2.7m / 3.7	$2.6m / 3.8	$0.2m / 16.1	$0.5m / 1.8	$2.5m / 10.9	$1.7m / 7.5	$0m / 0	$0m / 0	$2.8m / 1.5
Wood	$5.2m / 2.9	$3.3m / 4	$0m / 0	$0m / 0	$0m / 0	$0m / 0	$1m / 8.7	$0m / 0	$0m / 0	$0.8m / 2.9	$0m / 0
Polymer & Chemical	$1.1m / 2.1	$4.9m / 3.3	$9.5m / 2.6	$1.5m / 3.5	$0m / 0	$0.5m / 1.6	$3.6m / 9.6	$0m / 0	$0m / 0	$0m / 0	$3.6m / 9.5

The assumptions and calculations used to produce the table above are:

1. Total Energy use of the relevant subsectors are sourced from the Australian Energy Statistics 2020, Table F4 (**link**)
2. Subsector total energy cost is calculated using Fuel Consumption x Weighted Average Fuel Cost of subsectors based on the 20 participating businesses
3. Annual energy savings of projects within each technology category and each subsector are taken from actual projects developed for the 20 participating businesses
4. This annual energy saving for each item are then divide by the subsector site total energy costs to produce % cost savings for each category by subsectors
5. The total energy cost savings for each is derived by multiplying the % savings from step 4 with the subsector energy costs in step 2
6. Simple paybacks are established from program participant data

Energy efficiency can also be used over a longer time horizon to cut energy emissions of studied industries. Table 6 shows the total energy savings achievable from projects identified within different manufacturing sectors for financially feasible projects (less than 5 years simple payback), and potentially feasible projects (5 – 10 years simple payback).

To understand what this could mean at an individual site level, the following table expresses the approximate level of capital investment required to achieve the typical energy savings available within the manufacturing business. As an example, a typical metal products manufacturer can expect to require an investment of 18% of the site's annual energy spend to achieve an 8% energy reduction, using only projects with less than 5 years simple payback.

Table 6: Energy Savings and Capital Impacts for Energy Efficiency Projects, by Sectors

	Projects with less than 5 Years Simple Payback		**Projects with 5 to 10 Years Simple Payback**	
Sectors	Total Site Energy Savings	Capital Cost of Projects/ Annual Energy Cost	Total Site Energy Savings	Capital Cost of Projects/ Annual Energy Cost
Metal	8%	18%	1%	6%
Food	10%	31%	5%	59%
Construction	5%	7%	1%	4%
Wood	31%	80%	1%	6%
Polymer & Chemical	22%	49%	0%	1%

The assumptions and calculations used to produce the table above are:

- Total Site Energy Savings = All energy savings from projects within payback criteria (GJ) / Annual site energy use (GJ) (from participating businesses)
- Capital Cost of Projects / Annual Energy Cost are calculated using dollar figures from participating businesses

3.3 Solar and BESS for measurable short-term reduction

Solar PV Systems and Battery Energy Storage Systems (BESS) have a growing role to play in the decarbonisation of Queensland's manufacturing industry. Based on the data from this program, a well-designed solar system (without any BESS) can reduce the site's grid energy consumption by about 9% on average and has a simple payback of 8.5 years without any government support. The availability of Renewable Energy Certificates from the Federal Renewable Energy Target reduces this payback to between 5 – 7 years. This is consistent across all parts of the Queensland manufacturing sector.

Despite the favourable economics that surround the implementation of solar PV, and the strong solar PV market in Queensland, there is a relatively low rate of adoption of solar PV within the participants of this program. Whilst all participants understand the need for solar, only 10% of participants had solar installed, compared to 33% of Queensland residential households having solar in 2019[15]. The main barriers to increased penetration of solar within manufacturing are:

- Inertia driven by the expectation that solar PV system prices will come down further in the future. Whilst this expectation has been proven to be true for the past decade, the incremental decreases in price may not broadly justify the opportunity costs of delaying the installation of the system.
- Capital cost associated with large solar systems that are required to offset the large energy use of manufacturing sites

[15] https://www.powerlink.com.au/sites/default/files/2020-04/2019%20Queensland%20Household%20Energy%20Survey%20Report.pdf

- Manufacturing businesses may rent their buildings, therefore they cannot install renewables without the permission of the owner. Lease periods can also be for shorter periods than the payback and the cost of installing solar
- Difficulty in comparing quotes due to non-uniform and sometimes opaque ways which solar contractors provide system quotes, size systems, calculate energy savings, and financial outcomes. This often results in a large variance in system costs and simple payback metrics.

In general, a well-designed solar PV system with minimal electricity exported to the grid will have the following simple paybacks. The financial viability of the solar system is heavily dependent on the site's current electricity costs (retail, network, and market components combined).

Table 7: Simple Payback of Solar Systems (years)

Average cost of electricity (c/kWh inc retail, network & market charges)	8c	11c	14c	17c	20c	23c	26c
Typical simple payback of solar[16]	11.5	8.3	6.6	5.4	4.6	4.0	3.5
Typical simple payback of solar with small-scale technology certificates (STCs)	9.2	6.7	5.2	4.3	3.7	3.2	2.8
Typical simple payback of solar with large-scale generation certificates (LGCs)	9.0	6.5	5.1	4.2	3.6	3.1	2.8

The assumptions and calculations used to produce the table above are:

- Levelised Cost of Electricity from Solar PV = $45.89/MWh
  - Based on Capital Cost of $7,852,437 (from program participants, before any subsidies, and is a mix of roof mount, ground mount and solar car park systems. Provisions for mandatory electrical infrastructure upgrades costed in)
  - Annual Energy Generation of 8,555 MWh p.a.
  - System Life = 20 years
- Simple Payback = Capital Cost ($) / (Grid Electricity Cost – Cost of Electricity from Solar PV)
- = Capital Cost ($) / (Annual Energy Generation x Grid Electricity Cost – 0)
- Impact of STCs = -20% of capital cost (assumed based on real projects)
- Impact of LGCs = reduction of $10/MWh in Levelised Cost of Electricity from Solar PV (assumed based on real projects)

The availability of financial support from the Renewable Energy Target (RET) scheme, combined with the already favourable financial returns of solar PV systems means that additional intervention from government is unlikely to be required. A solar PV system would also reduce the business's exposure to fluctuating energy prices. This risk mitigation impact is not quantified in the financial analysis of Table 7. Another useful metric to visualise solar PV systems is that it is able to provide electricity at a fixed cost, typically expressed as the Levelised Cost of Electricity, of between 4 – 5c/kWh. It is clear that the cost of electricity provided by a solar PV system is lower than even the lowest tariff available from the electricity grid.

Unlike solar PV systems, Battery Energy Storage Systems (BESS) are a relatively new technology for the manufacturing sector. A BESS is able to store electricity and discharge it on command. This is useful when there is a cheap, but time restricted, source of electricity (such as from a rooftop solar system or from off peak night time periods) that can be stored in the BESS for use when the electricity prices are high. This could be for reduction in the site's peak demand, or for participation in the wholesale market if the system is sufficiently large. There is considerable interest for this technology due to the prevalence of high-profile utility scale projects and strong marketing from the solar industry. Investigations into the application of BESS (with and without solar PV) for the program participants show that the financial return of this system is generally poor if used purely as a demand response and/or load shifting mechanism. The following table shows the typical simple payback of such a BESS over the range of possible demand costs.

[16] Based on updated 2021 solar PV pricing

Table 8: Typical Simple Payback of BESS

Average demand cost ($/kVA)	$4.17	$8.33	$12.50	$16.67	$20.83
Typical simple payback of BESS (years)	38.0	19.0	12.7	9.5	7.6

The assumptions and calculations used to produce the table above are:

- Capital cost of Battery Energy Storage Systems = $950 / kWh of storage capacity (from conservative market estimates)
- Max peak hours per day = 2
- Demand cost range aims to cover most medium to large demand based tariffs across the National Energy market

For a BESS to be economically viable, other revenue streams such as deferred capital cost of grid upgrades, Frequency Control Ancillary Services (FCAS) support, and Reliability and Emergency Reserve Trader (RERT) must be applicable. These revenue streams are typically applicable only to large BESS systems (greater than 1MW) and requires professional advisory services to design and assess its viability.

Due to the current economics of batteries, the primary justification for the deployment of this technology should be to address operational risks such as:

- The need for increased demand for new production machinery. Often the use of a BESS (with or without a solar system) is many times more economical than to pay the network to upgrade the supply transformer.
- The need to provide electric vehicle charging for staff and client vehicles. High-capacity EV charging stations place considerable strain on a site's electricity demand and a BESS is necessary to ensure that there is sufficient power for the site at maximum loads.
- Provide operational backup for critical infrastructure. The economics of this application no longer becomes the value of electricity provided, but the size of the loss if electricity is not provided. This often makes the use of BESS highly attractive.

At present, there is little need for intervention to support the implementation of BESS behind the meter, as the drivers are related to the individual site operations, rather than a sub-sector or geographical region. Batteries provide most benefit to stabilising the electricity network and should be investigated as a utility project instead. However, the cost of procuring and installing BESS is decreasing at a rapid rate and there may be a point in time in the near future where small interventions from government could drive widescale adoption of this technology.

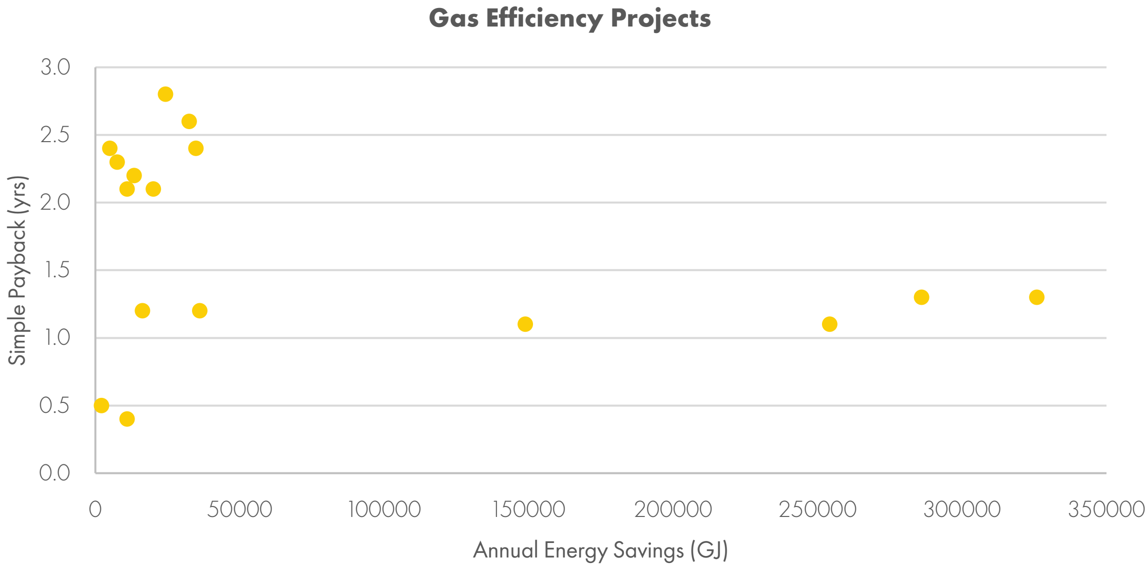
Another consideration is that BESS is not a passive, set and forget technology, it requires on-going management to realise benefits that result in changing electricity market regulations and the technology landscape. For example, the increase in uptake of EVs would likely require existing BESS owners to reconfigure their controls to account for this new technology. Therefore, gaps in energy literacy and coordination identified will continue to form a barrier to BESS investment and operation within the sector.

3.4 Opportunities for electrification of gas-based processes in the longer term

One of the biggest challenges to emissions reduction in manufacturing is the need for heat in processing. This often requires natural gas or other hydrocarbons for combustion. The electrification of gas-based processes will be crucial in manufacturing businesses reaching net zero. This is especially significant for the Food and Beverage and Construction subsectors as they consume over 94% of all gas used in Queensland's manufacturing sector.

The most cost-effective way to reduce greenhouse gas (GHG) emissions from the use of gas in the short term is to undertake efficiency projects that improve the burner's performance or to utilise waste heat and minimise burner output (this includes projects that reduce standing losses through insulation and steam leak reduction). Figure 10 shows the distribution of gas efficiency projects in terms of the size of the energy savings. There exists an economy of scale for larger projects that have paybacks of between 1 and 1.5 years which should be immediately implemented. Based on the data from this program, gas efficiency alone can reduce gas consumption within the manufacturing sector by 7%, at an average simple payback of 1.3 years.

Figure 10: Simple Paybacks of Identified Gas Efficiency Projects



Large Carbon Impact Opportunities

Once efficiency has been maximised, the next available technology for decarbonisation of gas is to electrify hot water production. Hot water (less than 85°C) production using gas is relatively inefficient and electrical processes to do this (such as heat pumps) are readily available. The suitability of electrifying hot water is dependent on the application. The cost effectiveness depends on factors including: the ratio of electricity and gas prices, the number of hours of heat demand per year, the efficiency of the boiler/steam distribution system and the coefficient of performance of the electric heating option.

To illustrate the impact of the electricity and gas prices at the site and the variability of hot water electrification, the following table has been produced using a typical electrification project. For this table, the ancillary cold stream produced the heat pump system in the process of generating hot water is assumed to be fully utilised on site as well. This has an impact of displacing electricity use in the existing refrigeration system on site. The inclusion of the usage of the cold stream to displace onsite electrical cooling has a significant (positive) impact on the simple payback of the hot water electrification projects, and results in improved paybacks at high electricity rates as well as high gas rates since both fuels are being displaced.

Table 9: Simple Payback of Hot Water Electrification Through High Temperature Heat Pumps (With Cooling Also Utilised)

	Average cost of electricity (inc network and market) ($/kWh)							
Average cost of gas ($/GJ)	$0.05[17]	$0.08	$0.11	$0.14	$0.17	$0.20	$0.23	$0.26
$6	7.4	6.1	5.3	4.7	4.2	3.8	3.4	3.2
$9	5.4	4.7	4.2	3.8	3.5	3.2	2.9	2.7
$12	4.3	3.8	3.5	3.2	3.0	2.8	2.6	2.4
$15	3.5	3.2	3.0	2.8	2.6	2.4	2.3	2.2
$18	3.0	2.8	2.6	2.4	2.3	2.2	2.1	2.0
$21	2.6	2.5	2.3	2.2	2.1	2.0	1.9	1.8
$24	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6
$27	2.1	2.0	1.9	1.8	1.7	1.7	1.6	1.5

[17] Typical Levelised Cost of Energy from behind the meter rooftop solar systems

	Average cost of electricity (inc network and market) ($/kWh)							
Average cost of gas ($/GJ)	$0.05[17]	$0.08	$0.11	$0.14	$0.17	$0.20	$0.23	$0.26
$30	1.9	1.8	1.7	1.7	1.6	1.5	1.5	1.4
$33	1.7	1.7	1.6	1.5	1.5	1.4	1.4	1.3

The assumptions and calculations used to produce the table above are:

- Capital Cost of heat pumps per GJ of thermal energy displaced per annum = $77.12 (from energy assessments of participating businesses)
- Average utilisation rate of heat pump system of 31% (i.e. heat pump is operational for 31% of 8760 hours per year) – this is a relatively low utilisation rate and current best practice design would include the use of thermal storage to increase this utilisation rate. This would further improve the business case of heat pumps
- Coefficient of Performance of heat pump = 3-heating, 2.5-cooling (assumed based on real systems)
- Efficiency of existing boiler system for hot water production = 80% (assumed based on real systems)
- Coefficient of Performance of existing refrigeration system for chilled water production = 4.4 (assumed based on real systems)

The exact calculations for Simple payback are:

Simple Payback (years) = Capital cost of system / Energy Cost Savings per annum

= Capital cost per thermal GJ x Thermal GJ / (Current Gas Cost – Electricity Cost of Heat Pump + Electricity Cost Savings from Refrigeration)

= Capital cost per thermal GJ / (Cost of Gas / Boiler Efficiency – Cost of Electricity x (1 / Heating COP - COP Cooling / COP refrigeration)

As a comparison, Table 10 below is a reproduction of Table 9, but without any of the ancillary cooling streams produced by the heat pump being utilised (i.e. Coefficient of Performance of heat pump equals 3 for heating, 0 for cooling). This clearly shows the importance of maximising heat pump cooling usage if sites are to electrify hot water.

Table 10: Simple Payback of Hot Water Electrification Through High Temperature Heat Pumps (With Cooling NOT Utilised)

	Average cost of electricity (inc network and market) ($/kWh)							
Average cost of gas ($/GJ)	$0.05	$0.08	$0.11	$0.14	$0.17	$0.20	$0.23	$0.26
$6	23.7	889.9	N/A	N/A	N/A	N/A	N/A	N/A
$9	11.0	20.1	73.0	N/A	N/A	N/A	N/A	N/A
$12	7.2	10.2	16.0	38.1	N/A	N/A	N/A	N/A
$15	5.3	6.8	9.0	13.4	25.7	356.0	N/A	N/A
$18	4.2	5.1	6.3	8.1	11.4	19.4	65.0	N/A
$21	3.5	4.1	4.8	5.8	7.3	10.0	15.6	35.8
$24	3.0	3.4	3.9	4.5	5.4	6.7	8.9	13.1
$27	2.6	2.9	3.3	3.7	4.3	5.1	6.2	8.0
$30	2.3	2.6	2.8	3.1	3.5	4.1	4.8	5.8
$33	2.1	2.3	2.5	2.7	3.0	3.4	3.9	4.5

Based on this data, and other bodies of work carried out by organisations such as the Australian Alliance for Energy Productivity (A2EP), it is clear that a well-designed high temperature heat pump that is able to utilise both the hot and cold streams is cost effective now. This should be the primary focus for electrification of process heat. This technology is applicable to manufacturing sectors that use hot water to some degree. However, the Food & Beverage industry (which consumes 26% of all gas consumed in the manufacturing sector in Queensland) would have the largest use for hot water, and it is expected that heat pumps in this industry would be most impactful.

These electrification projects require detailed scoping feasibilities to be carried out before the economics of the technology is known. This remains the single biggest barrier to decarbonising and electrifying process heat.

As an illustration of this site variability, five heat pump projects for the electrification of heat were considered within the 20 participants. Of these five systems, two large heat pump projects were financially viable (Table 11). Key design considerations to make heat pumps financially attractive for industry electrification of heat are:

- The ability to utilise the cooling potential of high temperature heat pumps. For some sites, the heat pump can be integrated into the site's cooling systems. This causes the Coefficient of Performance (COP) of the high temperature heat pump to increase from about 3 to 5.
- The use of thermal storage to increase heat pump utilisation where possible, instead of increasing the capacity of the heat pump system. This is considered best practice in the design of new heat pump systems for industrial heating. Quantitatively, an increase in the utilisation rate from the 31% seen in the systems produced for this body of work (without thermal storage) to 50% using thermal storage would reduce the simple payback by around 40%. This would reduce a 7.4 year simple payback project to 4.6 years (both with cooling utilised).
- Prevalence of high site gas supply costs, which increases the dollar savings of gas reduction through electrification

Table 11: Summary of Viable Heat Pump Projects

Sector	Energy Savings (GJ)	Total Savings ($)	Capital Cost ($)	Emissions Reduction	Simple Payback (years)
Food	8,703	215,692	1,060,000	527	4.9
Food	6,092	119,644	380,000	-57[18]	3.3

Due to the applicability of this technology, it is clear is that there is a technological path for significant decarbonisation of the Food and Beverage sub sector in Queensland. There is a clear bias for larger systems in terms of the economic viability of heat pumps, and Shell Energy believes that this is due to:

- The relatively low electricity prices that are obtainable for large sites, resulting in low operating costs of electric heat pumps. Please note that only grid electricity is considered for the heat pump evaluations. The use of electricity from a rooftop solar PV system would further improve on the simple payback of these systems, though quantifying this impact requires a clear understanding on when and the rate that each of the sites require hot water on a typical production day. Table 9 above shows the impact of low-cost electricity from solar PV systems on the viability of heat pumps
- There are few suppliers of these heat pump systems in Australia, and even fewer in Queensland. This results in each project being bespoke, increasing the relative cost for smaller systems.

The extrapolation of the program results shows that more than 260,000 GJ p.a. of gas (140,000 t of CO_2) can be electrified within the Queensland Food and Beverage manufacturing sector. This represents 7% of the current natural gas used by the sub sector. To fully access these opportunities, direct government subsidies may be required for high-cost projects, especially for smaller manufacturers, to overcome the investment return issues highlighted above.

[18] Negative emissions reduction due to the use of grid electricity to power heat pumps.

Other Technologies for Decarbonisation of Gas

Another potential pathway to decarbonise gas processes is to use available biomass. This can either be directly combusted to produce heat or converted to biogas in anaerobic digesters. Based on the program results, 4 of the 20 sites can benefit from the use of biomass that is available on site (Table 12). Please note that the energy savings figures for the biomass boilers presented are a result of fuel switching, and that the actual energy intensity of the sites' operation does not change as a result of these upgrades.

Table 12: Decarbonisation of gas projects summary (excluding electrification)

Sector	Project	Energy Savings (GJ)	Total Savings ($)	Capital Cost ($m)	Emissions Reduction	Simple Payback (years)
Polymer	2.5 MW biomass burner	4,285	126,700	$0.9m	424	7.1
Food	5 MW biomass boiler	37,527	688,486	$1.9m	2,229	2.9
Food	Anaerobic digester (for existing biogas burner)	4,062	136,610	$3.3m	227	24.6[19]
Food	10MW biomass boiler	24,970	816,783	$5.6m	3,955	6.4

Utilising biomass that is generated on site is an effective way to decarbonise heat. However, significant modifications are required and the capital burden of this can be a significant barrier. In addition, the use of biomass may introduce energy supply risks that must be assessed and managed by each site. Cost subsidies are available for biomass projects through the Federal Government's Emissions Reduction Fund, resulting in relatively strong simple paybacks.

Barriers identified for the implementation of biomass include:

- Typically, these are large, complex and capital-intensive projects to design, engineer and construct.
- Manufacturing production may be impacted or need halt during construction reducing output over the short term.
- On-going technical knowledge and expertise is required to manage and operate biomass burners and boilers as these are typically classified as attended boilers.
- Risks surrounding fuel security (availability of biomass/biogas) in the medium to long term

To overcome these barriers, projects need to be carefully scoped and designed. However, this type of pre-feasibility work has no return for site owners if it results in the project not going ahead. Government programs to increase the access to these large decarbonisation opportunities should be around the project feasibility and design stage.

3.5 Future Opportunities and Program Recommendations

Through the engagement of program participants and those businesses participating in knowledge sharing activity, there is clear interest and need to adopt energy efficiency and electrification within the manufacturing sectors. Energy efficiency remains one of the most cost-effective means of reducing emissions and trade exposed industries, such as manufacturing, are in need of specific support. This aligns and compliments Government's policy and ambition to decarbonise the economy. Queensland has joined Victoria, New South Wales, South Australia, Tasmania and the Australian Capital Territory in setting zero net emissions by 2050 target[20]. Queensland is almost halfway to reaching its 2030 emissions reduction target having reduced emissions by 14% since 2005 based on the latest 2019 data.[21] The following section identifies possible opportunities and program concepts that address the barriers identified in Section 3, to accelerate action and investment within the

[19] Only energy financial returns considered (i.e. waste management and other environmental benefits were not assessed).
[20] Queensland Climate Transition Strategy
[21] https://www.des.qld.gov.au/climateaction

manufacturing sector to contribute to the transition Queensland's economy to a zero emissions future, as well as making business more sustainable (economically and environmentally) into the future.

Opportunities to scale and drive action in Queensland

Other states (including Victoria, New South Wales, and South Australia) are running programs that reduce energy consumption by creating financial incentives in the form of tradeable certificates, to install, improve or replace energy savings equipment and services. This type of program has had a broad state-wide remit that has extended beyond the manufacturing sector. However, it has assisted manufacturing businesses in overcoming capital barriers to facilitate the implementation of the technologies identified in this report.

A similar type of program could potentially interface with and compliment existing Queensland state government programs like ecoBiz, Business Energy Savers Program and Large Customer Adjustment Program by helping businesses generate certificates based on energy savings delivered from projects identified and undertaken through program activity. These programs could potentially drive uptake of the certificate scheme, which may create a virtuous cycle by driving deeper on-going participation in these programs that results in increased scale and action delivered.

Introducing a certificate program may assist in addressing the growing gap in energy productivity between Queensland and states such as NSW and VIC (illustrated in Figure 1). Table 13 demonstrates the current economic disadvantage between implementing energy efficiency projects across the focus areas identified in Queensland versus NSW and VIC due to the ability to access subsidies through the NSW Energy Saving Scheme and the Victorian Energy Upgrade programs. This illustration highlights that deploying projects that reduce the same amount of energy would have considerably different economics based on the state in which a business is located.

Smaller businesses operating only in Queensland are paying more for these projects compared to interstate competitors. For larger manufacturing businesses with multi-state operations, capital allocation is more likely to be prioritised in the states where the business case is more viable, making equivalent Queensland based manufacturing facilities less efficient comparatively. This is especially true for technologies such as lighting, VSDs, compressed air, and refrigeration upgrades where the equivalent project in NSW and VIC are close to cost neutral to the business, thereby eliminating cost barriers to these energy efficiency solutions.

Benefits of introducing a certificate program

- Creates financial incentives for businesses in the form of tradeable certificates, to install, improve or replace energy savings equipment and services.
- Potential to significantly reduce energy use and emissions across Queensland
- It may help address the gap in Queensland's energy productivity as described in Figure 1 (page 9).
- Create material co-benefits such as incentivising business to overcome capital investment barriers, jobs creation, economic stimulus created through the supply and distribution of equipment and appliances.

Table 13: Example Energy Efficiency Project Business Cases in Queensland, NSW, and VIC

	Base Assumption			Queensland			NSW			VIC		
Focus Areas*	Energy Savings (GJ p.a.)	Energy Savings ($ p.a.)	Capital Cost	Queensland Rebate	Net Capital Cost ($)	Simple Payback (Years)	ESS Rebates ($)[22]	Net Capital Cost ($)	Simple Payback (Years)	VEU Rebates ($)[23]	Net Capital Cost ($)	Simple Payback (Years)
Lighting	400	$12,500	$33,000	Nil	$33,000	2.6	($16,500)	$16,500	1.3	($25,000)	$8,000	0.6
VSD	500	$21,400	$57,000	Nil	$57,000	2.7	($20,600)	$36,400	1.7	($31,300)	$25,700	1.2
Compressed Air	100	$3,100	$4,000	Nil	$4,000	1.3	($4,100)	-$100	0.0	($6,300)	-$2,300	0.0
Refrigeration	900	$25,700	$30,000	Nil	$30,000	1.2	($37,100)	-$7,100	0.0	($56,300)	-$26,300	0.0
Burner Controls	1,000	$16,400	$72,000	Nil	$72,000	4.4	($10,800)	$61,200	3.7	($20,800)	$51,200	3.1
Heat Recovery	3,100	$64,300	$123,000	Nil	$123,000	1.9	($33,600)	$89,400	1.4	($64,600)	$58,400	0.9
Heat Pump	4,300	$70,200	$359,000	Nil	$359,000	5.1	($46,600)	$312,400	4.5	($89,600)	$269,400	3.8

*Descriptions of each focus area can be found in section 3.2 of this report.

[22] Assumed ESC price of $20
[23] Assumed VEEC price of $50

Energy coaching and technical support

Working out how to reduce energy bills (electricity and gas) can be daunting for manufacturing businesses. Businesses often don't have the means or expertise to identify and understand the source of their energy waste. Interaction with participants of this project supports industry research that even when opportunities have been identified, many projects are not actioned because operational teams are unable to compete with 'core' business priorities for scarce capital.

Support that provides technical and industry experience may overcome the barriers and catalyse action by turning existing reports or projects into shovel-ready projects. Bridging the gap between the identification of a project and acquiring budget commitment through business case development or additional technical feasibility support with pre-qualified energy experts may help businesses to:

- develop energy efficiency, renewables, electrification business cases for energy-savings projects and support project sponsors to gain senior management commitment to shovel-ready projects.
- get project-ready by assisting with project planning, scoping and technical support such as the preparation of technical specifications, process improvements and design services.

This type of program provides a flexible approach to supporting manufacturing businesses that are diverse in operation, scale and production plant used even within a sub-sector. Rather than focusing on a single technology, this approach tackles barriers identified in this report to catalyse action by supporting business to develop a robust evidence base to support investment decisions. Scale across the manufacturing sector could be achieved across two different dimensions, either by providing 'Coaching type support' through a program that supports focused, low cost, non-intrusive type interventions (e.g. LED lighting upgrade) or 'Technical support' for larger scale projects/efficiency opportunity to drive greater energy and emissions savings.

'Coaching type support' targeted to the manufacturing sector is similar to existing programs offered under the Queensland Government's Affordable Energy Plan, for example the Energy Savers Plus Program Extension that provided more than 300 energy audits for agricultural customers. and the Large Customer Adjustment Program for large electricity users in rural and regional Queensland. For this type of 'Coaching support' program, the application and assessment process can be structured in a way to reduce the cost of assessment, administration, risk and speed of implementation. A co-contribution funding model can ensure businesses/recipients put 'skin-in-the-game' to follow through with action and ensure efficient deployment of public funds. Alternatively, this could be delivered through an extension of the ecoBiz program, targeting manufacturing specific businesses.

Background – ecoBiz Program

ecoBiz is a fully subsidised program implemented by the Chamber of Commerce and Industry of Queensland (CCIQ) and the Queensland Government's Department of Environment and Science (DES). The program provides a one-on-one coaching session and a report tailored to each business's needs and ambitions. Participating businesses receive an action plan that identifies no, low, and higher cost options for efficient practices. Between late 2017 and early 2020, the program delivered personalised one-on-one coaching sessions to over 700 businesses with over 220 completed initial program requirements and achieved a minimum 10% reduction in their energy, water and/or waste use. The ecoBiz program has high levels of cost savings and economic impact resulting from eco-efficiency initiatives. If the program were to be scaled up with corresponding investment, large scale impacts on SMEs and the economy can be expected[24].

The 'Technical support' recommended would aim at bridging the gap between large scale conceptual energy efficiency projects identified through audits and the detailed assessments necessary for manufacturing businesses to make investment decisions. This addresses the unique needs of the manufacturing sector whereby energy efficiency opportunities often interact with, and affect, the operations of the site. Without detailed technical

[24] Financial and resource performance of small to medium sized businesses (SMEs) in the ecoBiz program 2017-2020, Page 5

support to identify and mitigate the operating risks of these opportunities, it will be unlikely that capital is allocated. This form of support could take the form of:

- Ongoing energy management support that helps manufacturing businesses understand and act on energy data within the context of their operations. The aim of this support would be to align the capabilities of manufacturing businesses to the requirements of an energy management system as described by ISO50,001 and implement a continuous improvement framework around energy use. This level of support would also require an element of funding to unlock the accessibility of energy data through the installation of sub-metering and integration of this data with the site's SCADA systems and dashboards.
- Specialised opportunity support to fully understand the risks and returns of an energy efficiency or energy productivity improvement opportunity. This would be necessary to uncover and resolve interconnected issues where the project has the risk of materially impacting the business e.g. production has to go off line for a period of time, may cause down time, or on-going expense if not executed correctly. An example of a project that requires this type of support would be the utilisation of renewable biomass boilers to decarbonise industrial heat. This type of project would have dramatic impacts on the immediate operation of the site as well as its ongoing energy security.

Benefits of Energy coaching and technical support

This activity aims to identify and quantify energy waste saving opportunities at each business and through coaching activities, creating a stream of viable, investment-ready projects that will create jobs as well as improving the competitiveness and sustainability of the sector.

Electrification of gas-based process heat

The electrification of gas-based process heat in the manufacturing sector is an opportunity to improve the commercial sustainability of businesses and reduce climate change related risk. Approximately 51% of energy consumed by industry is for process heat, of which approximately 46% is fuelled by natural gas[25]. The use of gas for process heat leaves many businesses exposed to volatile gas market conditions including price swings and challenging supply chains.

The development of a program to support the electrification of gas-based process heat presents an opportunity to underpin the commercial viability of many manufacturing businesses in Queensland. Electrification of gas-based process heat also allows for greater penetration of renewables. When coupled with behind the meter solar PV, this can assist with the transition to a lower carbon economy and achieve significant emission reductions. Analysis undertaken across the project suggests technology exists to electrify this low-level process heat at less than 5-year paybacks. However, the suitability of electrifying hot water is dependent on the application and commercial outcomes will be dependent on a range of factors including the ratio of electricity and gas prices, the number of hours of heat demand per year, the efficiency of the boiler/steam distribution system and the coefficient of performance of the electric heating option. Understanding the unique needs of each manufacturing site requires significant pre-project work and investment without the certainty of returns, thus forming a barrier to adoption.

Therefore, the development of programs supporting the 'pre-project' analysis, engineering, and design work in the manufacturing sector to overcome this barrier, would accelerate the adoption of electrification projects. Furthermore, growing local market demand for this technology would attract overseas technology suppliers to increase their presence in Australia, reducing the cost over the medium to long term. ARENA funded the Australian Alliance for Energy Productivity (A2EP) to undertake a series of heat pump feasibility studies and pilot projects [26] targeting large manufacturers across Tasmania, South Australia, Victoria and New South Wales, learnings could be adopted in the Queensland manufacturing sector.

[25] https://arena.gov.au/assets/2019/11/renewable-energy-options-for-industrial-process-heat.pdf
[26] https://arena.gov.au/news/arena-helping-reduce-emissions-in-manufacturing-industry-through-renewable-energy-in-process-heating/

Benefits of Electrification of gas-based process heat

Government funding will reduce paybacks to unlock greater investment.

- Underpin market demand to develop local heat pump manufacturing businesses.
- Materially increase renewable energy penetration in Queensland and reduce emissions from the manufacturing sector (51.4kg CO2-e for every GJ of natural gas saved).
- Reduce local demand for gas or enable new industry and job creation

Energy Management Systems (EnMS) Benchmarking

Manufacturing businesses increasingly want to reduce the amount of energy they consume. This is driven by the need to reduce costs, reduce the impact of rising costs, meet legislative or self-imposed carbon targets, reduce reliance on fossil fuels, and enhance the entity's reputation. An emerging trend observed in this program from our interactions with the participants, has been an increased focus on "emissions reduction" versus the sole focus on "saving energy costs." This trend will open the door for greater need to measure and verify savings to enable certification under reporting frameworks, as well as public statements to be made.

The challenge for the sector is that energy management is not core business, external experts are engaged to conduct audits and identify opportunities, however many of these remain unactioned. Large energy users are also stuck in this cycle and need support to seek out a systematic way to address the challenge to unlock both short-term and long-term benefits.

Further education of energy intensive manufacturers regarding benchmarking against the ISO 50,001 Energy Management Systems (EnMS) standard may provide benefits. This standard helps businesses develop a systematic approach to achieving continual improvements in energy efficiency, emissions reduction and cost savings. This process is designed to alert decision makers and management to the immediate and long-term energy management gains that can be made, and gain their commitment (time, resources and capital) to unlocking potential savings and competitive advantages.

Benefits of Energy Management Systems (EnMS) Benchmarking

Energy intensive manufacturers will benefit from material opportunities to reduce energy costs or create revenue by taking advantage of demand response. Consistent energy management helps organisations to eliminate energy waste, build resilience to rising energy costs and realise untapped energy efficiency potential. Manufacturing business benefit from cost savings and make a significant contribution to environmental and climate protection, by the permanent reduction of greenhouse gas emissions.

Access to data identifying energy waste

The poor level of access to energy data (only one in twenty sites sub-metered) observed is representative of our experience undertaking numerous audits across Australian manufacturers, our engineering team continually encounter businesses that do not have the ability to identify the main users of energy. For example, how much electricity a production line or gas a large piece of machinery uses. The only data available is via the gate meter or on energy bills. This makes it impossible to measure, benchmark or evaluate the performance of individual items of a plant.

Data is the key to unlocking energy efficiency. Providing businesses with access to good quality data is the first step in overcoming the information failure barrier. Data helps to identify sources of energy waste, to focus maintenance team's efforts (i.e. low cost or no cost preventative maintenance) or base line data and evidence required to construct a business case for capital investment. Manufacturers of various sizes and efficacy can benefit from the installation of sub-meters and collection of good quality longitudinal data.

Business and policy makers should examine initiatives that enable businesses to gain access to data to identify and quantify wastage from electricity, natural gas and other fuel use, as well as steam, water, refrigerant, compressed air and other utilities used within the production process. Furthermore, the aim should be to integrate energy specific data with production data to provide insight into energy productivity – making businesses smarter, more efficient and competitive. This may include funding to install new metering on energy intensive equipment. Activities that may be funded may include for example: a power meter on each compressor in the plant room, airflow meter on the common outlet, pressure sensors before and after the air receiver, dew point sensor on the common outlet or data logger.

Benefits of Access to data identifying energy waste

- reduce energy waste and use, lower electricity bills and improve energy productivity.
- improve visibility of energy use and quantifying benefits building confidence in results from investing in energy efficiency.
- reduce operating costs and improve the productivity of manufacturers and the sector in general.
- reduce carbon footprint.

Compressed air and steam system services incentive

Compressed air and steam systems can be very inefficient and experience high energy losses, which are hard to measure and manage on an ongoing basis. Energy losses can be up to 90% when energy consumed by a compressor is compared to the energy required to deliver end tasks (based on data from participating businesses and corroborated by general industry knowledge).

For businesses and policy makers, optimising or replacing these systems offer proven, low-risk quick wins to reduce energy waste with short paybacks to stimulate activity on-site. Improving compressed air in businesses across Queensland, would have broad application across multiple sub-sections (as per Table 5) and is relatively low cost to deliver. For example, a targeted program may stimulate on-site activity with greater options, by enabling business to select from a menu of options to bundle critical activities funded under this program. Examples of activities that could be included (but not limited to) are:

- Compressed air system metering: Educational and awareness support to install new metering on energy intensive equipment to help cut energy bills. Activities that may be funded include a power meter on compressors in plant rooms, airflow meter on the common outlet, pressure sensors before and after the air receiver, dew point sensor on the common outlet or data logger.
- Compressed Air Use Review: Map compressed air system and services provided by air and assess current performance to identify opportunities to reduce the use of compressed air.
- Compressed Air Leak Survey: Find and tag all leaks in the compressed air system. Provide a leak report including details of estimated energy losses/cost and repair recommendations.
- Thermal imaging survey: Review the steam system using thermal imaging equipment. Provide a report which quantifies heat loss in the system and recommends areas for insulation.
- Steam trap survey: Assess all steam traps in the system. Provide a report listing all failures, including estimated energy losses/cost and repair recommendations.

Benefits of Compressed air and steam system services incentive

- proven, low-risk quick wins to reduce energy waste with short paybacks to stimulate activity on-site.
- improve visibility of energy use, improve system and machinery reliability.
- create momentum and success stories.
- reduce operating costs and improve the productivity of manufacturers.

4. Analysis of the results

4.1 Energy productivity and renewable energy opportunities

The energy productivity improvement and renewable energy opportunities for the 20 sites are summarised in Figure 11 and Figure 12 below. The following definitions are used to prepare these figures:

Table 14: Glossary of terms

Term	Definition
Burner Controls	Upgrades related to the control of burners, including O_2 trim, automated TDS, supply fan controls, etc.
Compressed Air	Compressed air system related upgrades
Energy	Upgrades related to changing the source of the fuel (other than solar), batteries, demand response, and general tariff reviews and standby load reviews.
Gas	Natural gas, butane, and LPG savings
Heat Pump	The use of heat pumps for heating as the primary purpose
Heat Recovery	Any project that uses waste heat available on site
Lighting	Lighting upgrade using LEDs and/or control devices
Other (Focus Area)	Unique opportunities that do not fit within other Focus Areas
Other (Fuel)	Non-stationary fuels
Power Factor Correction	All power factor correction related opportunities
Refrigeration	Refrigeration system related upgrades
Solar	Energy from solar PV systems that are directly used on site
VSD	Installation of variable speed drives as well as general motor control upgrades

Figure 11: Summary of Emissions Reduction (t CO2-e) by Fuel for all 20 sites

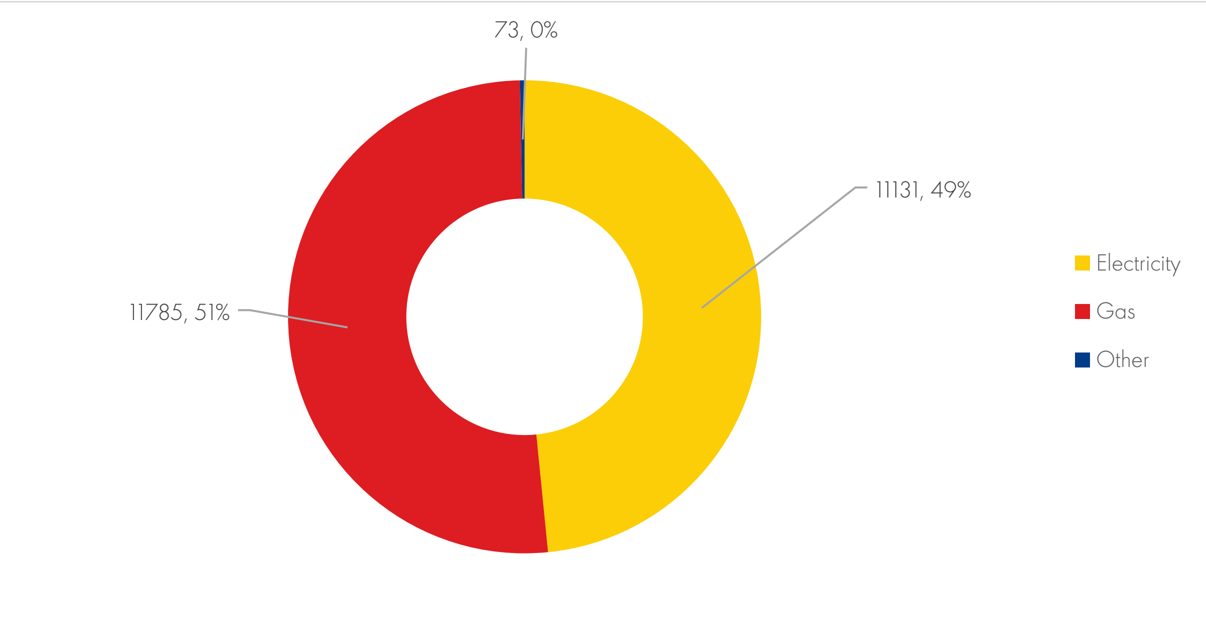
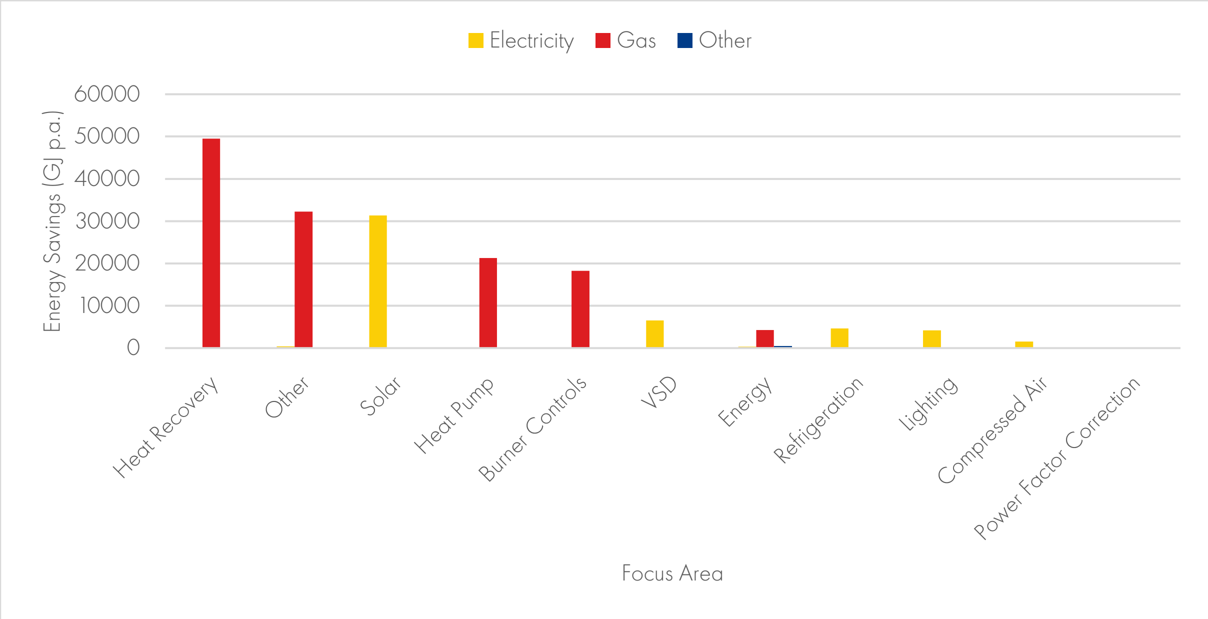


Figure 12: Energy Savings (GJ) by Focus Area and Fuel Type for all 20 sites



There are significant gas efficiency opportunities within a relatively small subset of technologies. Support programs should prioritise Heat Recovery, Heat Pumps and Burner Controls to expedite their adoption. The gas savings found in the "Other" Focus Area are from a single project upgrading a gas boiler to a biomass boiler.

In terms of GJ of energy savings, electricity saving opportunities have a lower value compared to gas, but the emissions impact is almost equal to gas efficiency opportunities. This is due to the higher emissions factors associated with electricity use compared to onsite combustion of gas. Any support for energy efficiency should cover both fuel types as a minimum.

These opportunities should be analysed with the economic returns associated to each project. This is summarised in figures 14 – 16 below. These have been split to show only opportunities that have simple paybacks of less than 5 years and between 5 – 10 years as these are the primarily opportunities that would be funded by the organisations.

Figure 13: Cost Savings per Annum by Focus Area, Projects with less than 5 Year Simple Payback[27]

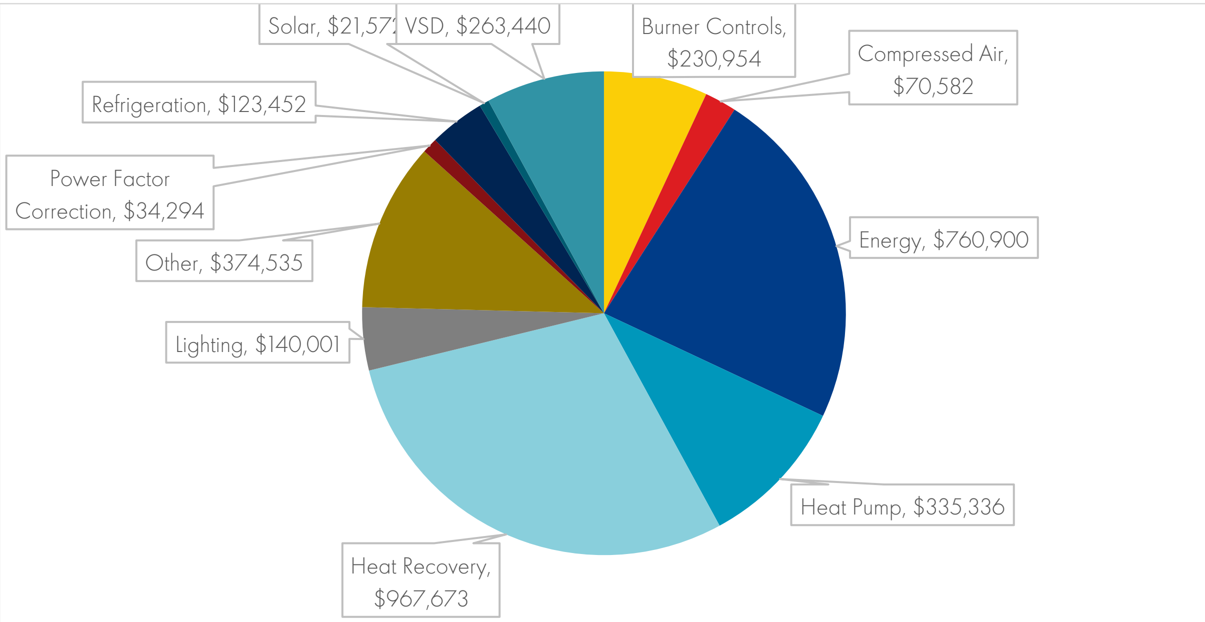
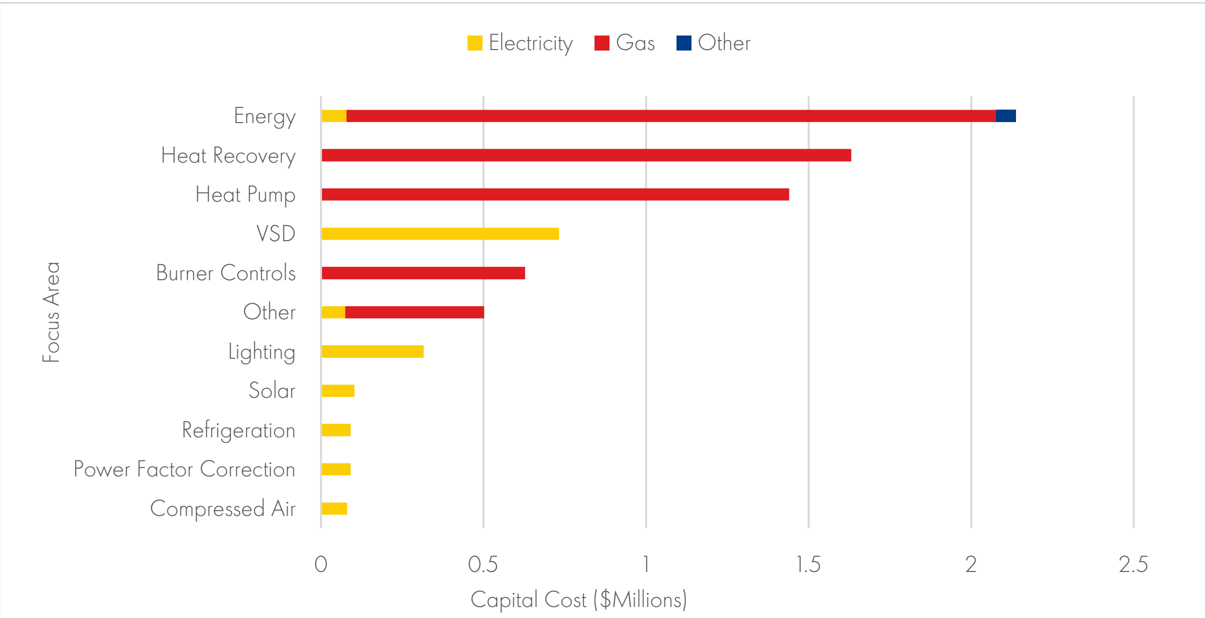


Figure 14: Capital Cost by Focus Area, Project with less than 5 Year Simple Payback



[27] "Energy" projects refers to demand management, thermal and electrical batteries, tariff reviews, and use of biomass boilers

Figure 15: Cost Savings per Annum by Focus Area, Projects with 5 to 10 Year Simple Payback

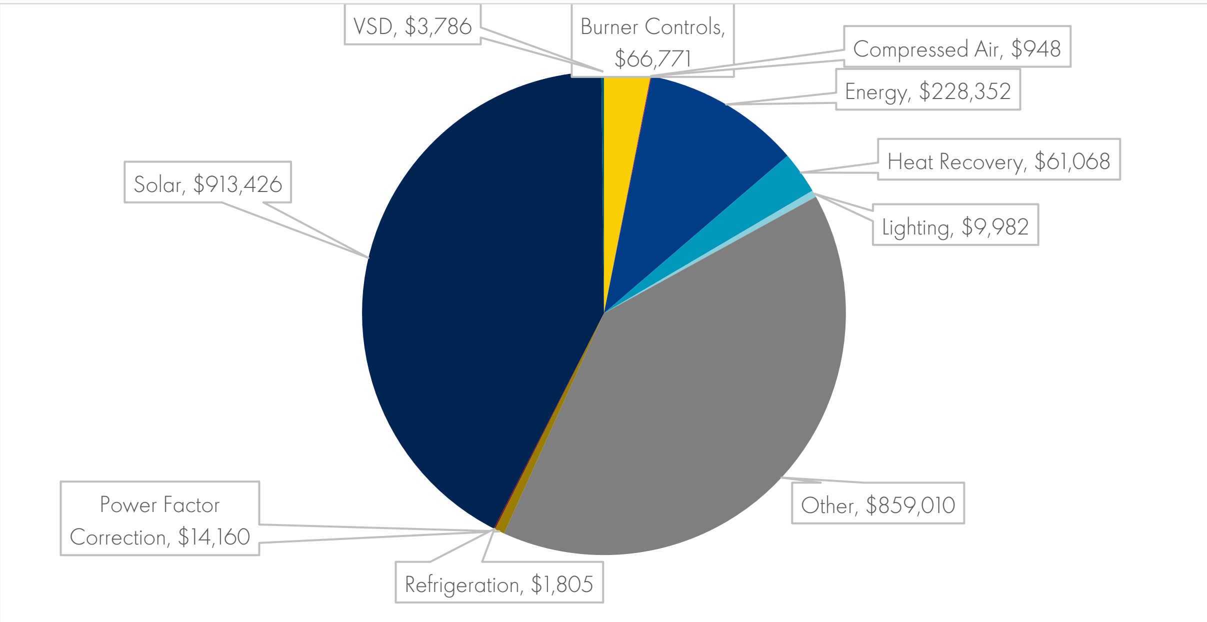
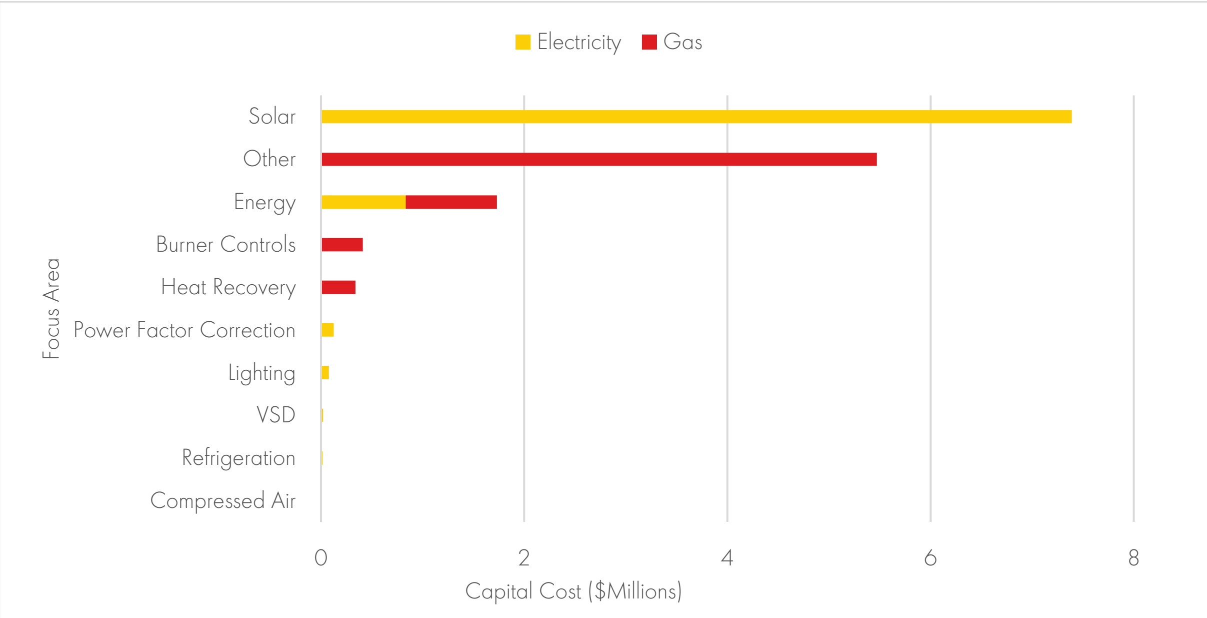


Figure 16: Capital Cost by Focus Area, Project with 5 to 10 Year Simple Payback



At the sub 5-year payback segment, heat recovery and boiler equipment upgrade accounts for greater than 50% of the annual dollar savings. Approximately $3.3m of annual energy savings opportunities have been identified through projects such as biomass boilers (shown as the large project in Energy Focus Area), Heat Recovery, Heat Pumps, and Variable Speed Drives (VSD).

These projects have relatively strong business cases, therefore the level of government support required to encourage business's uptake is expected to be small relative to the overall cost of the project.

At the 5 to 10 year simple payback segment, solar is the dominant technology. However, a significant amount of specialised technology solutions is needed to unlock 39.7% in the "Other" segment. A technology agnostic approach in support would be needed for all opportunities other than solar.

4.2 Gas Use Segmentation

Analysis of annual gas consumption by subsectors (Figure 17) shows that Food and Beverage, along with Construction materials manufacturing, contributes to over 90% of the gas used by the 20 sample sites. Across the state, the gas consumption of these two subsectors shows a similar trend, contributing to over 94% of the total gas used in manufacturing This suggest that a more targeted approach to providing support in improving gas efficiency and/or electrification could be adopted in the design of government support programs and policy.

Figure 17: Annual Gas Use (GJ) by Sector

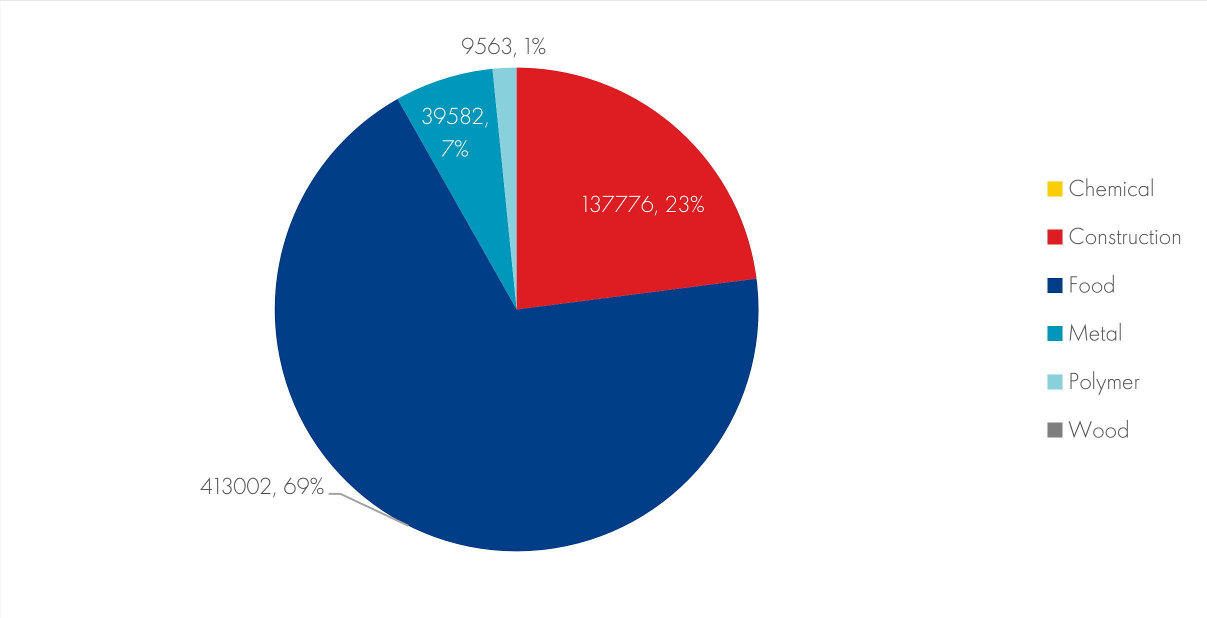
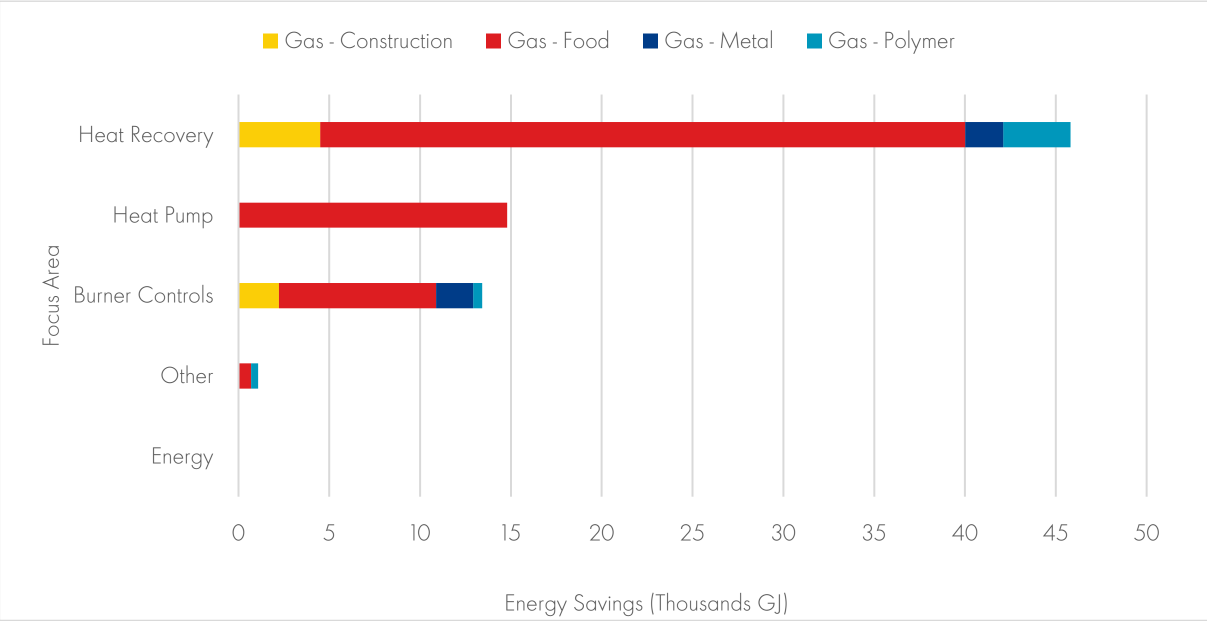
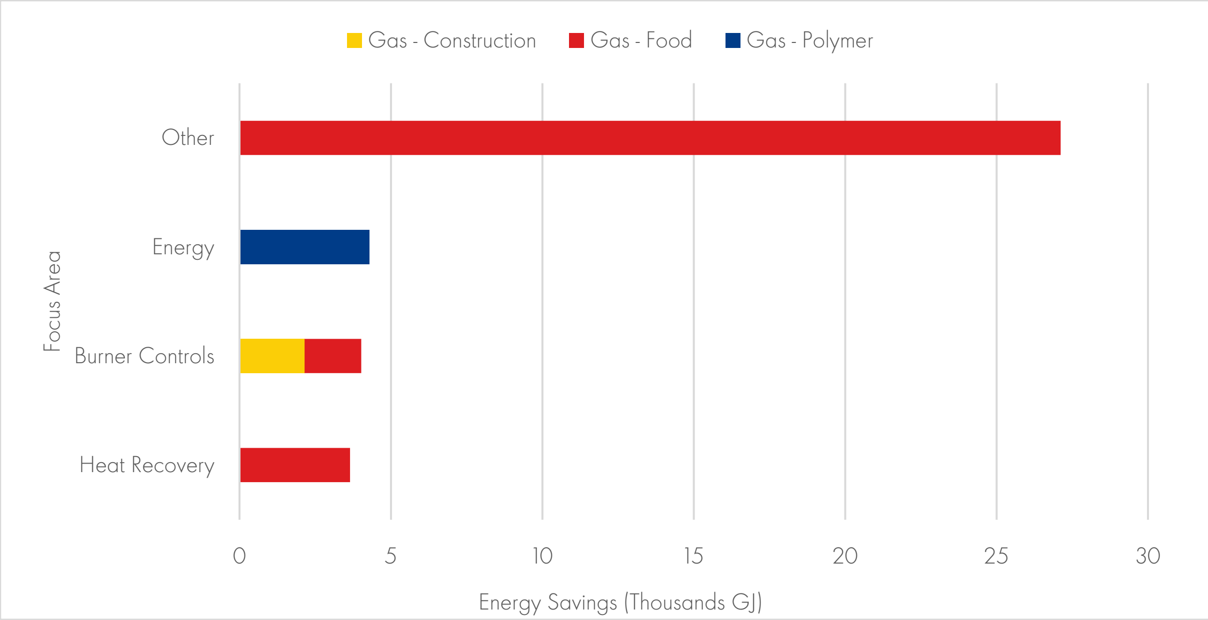


Figure 18: Energy Savings (GJ) by Focus Area, Projects with Payback less than 5 Years



The largest opportunity within all subsectors is Heat Recovery. The opportunities with Simple Payback less than 5 Years are shown in Figure 18. This is followed by the use of Heat Pumps, and Burner Controls. These three areas should be the key focus for any immediate gas efficiency/electrification support programs.

Figure 19: Energy Savings (GJ) by Focus Area, Projects with Payback Between 5 – 10 Years



As identified in earlier sections, smaller gas consumers (e.g., those with annual gas consumption less than 50,000GJ) do have a large variability to their variable gas costs. These costs can range as high as $35/GJ and averages $22/GJ based on the data collected. This high gas cost is not seen in the larger gas consumers. As seen in Table 9 in the earlier sections of this report, this high gas cost means that the electrification of heat can be highly attractive financially. Therefore, smaller gas consumers should be a natural target for any program aimed at accelerating the electrification of gas loads.

Overall, the knowledge regarding gas efficiency projects on site is generally quite high. The main barrier to adopting these is usually a lack of dedicated management resources, such as an energy manager, driving these incremental improvements. Where a business does not have a dedicated energy manger (as is the case for most SMEs) energy management should be delegated to someone in the Maintenance or Operational teams, this will drive accountability and the improved measurement of energy efficiency and productivity and on-going continuous improvement.

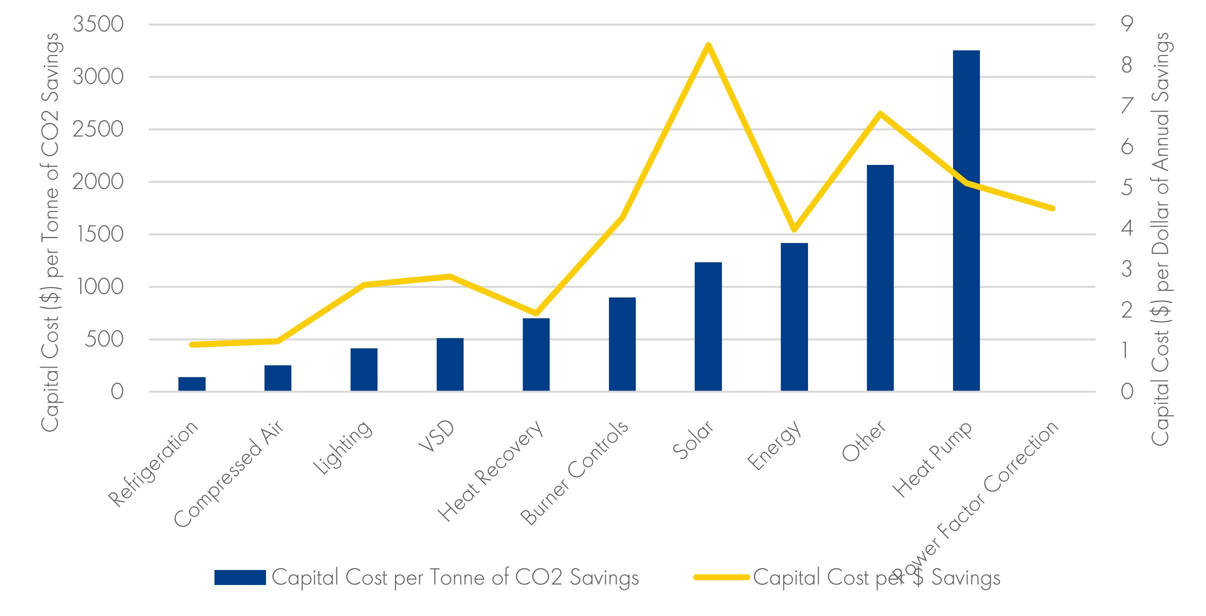
- To achieve this, there needs to be a continual push and consistent messaging from governments and industry groups to increase energy literacy and capability within the Queensland manufacturing sector.
- The lack of a dedicated personnel responsible for energy productivity may also be a contributing factor to the high gas costs experienced by smaller gas consumers. The wide variability of costs suggests that there is more to the cost that static factors such as network location, and that a more competitive tendering process can lead to lower rates if carried out by the participant.

Due to the large geographical spread of manufacturers in Queensland, and the variability of gas costs, it is rare for suppliers of particular technologies to be able to market their services to the right people. As such, these projects must be driven entirely by the client organisations.

4.3 Industry Benchmarks

To understand the costs and benefits of different technology types, we plot the capital costs of identified projects against their annual GHG emissions abatement and annual dollar savings (Figure 20). This shows the importance of supporting common technologies as they provide the best CO_2 savings per dollar spent. The mechanisms to drive these upgrades would likely need to be different to the mechanisms that drive more expensive abatement technologies such as heat pumps.

Figure 20: Capital Cost per Dollar and Tonne of CO2 Savings



Energy Productivity Improvement benchmarks:

Section 3.2 summarises and benchmarks the economic viable technologies (Projects with less than 5 year payback only) within each manufacturing sub-sector based on the 20 energy assessments undertaken, which was then extrapolated using 2019 ABS energy consumption data. The following data sets provide benchmarks by technology, sub-sector:

- Table 4: Energy Savings ($m p.a.) per Technology, by Sectors within Queensland
- Table 5: Applicability of technologies within sub-sectors (expressed as Annual Energy Savings / Typical Simple Payback Years)
- Table 6: shows the total energy savings achievable from projects identified within different manufacturing sectors for financially feasible projects (less than 5 years simple payback), and potentially feasible projects (5 – 10 years simple payback)

Section 3.3 explored the barriers to solar and BESS and in Table 7 (Simple Payback of Solar Systems) established payback benchmarks for Solar PV Investment based on average a site's current electricity costs (retail, network, and market components combined). Table 8 (Simple Payback of BESS) the typical simple payback benchmarks for BESS over the range of possible demand costs.

Section 3.4 explores the impact of the electricity and gas prices at the site and the variability of hot water electrification financially viability (less than 3 years simple payback). Table 9 Simple Payback of Hot Water Electrification Through High Temperature Heat Pumps.

Industry benchmarks established were used to shape evidence-based policy and program development recommendations in section 3.5. Whist we recognise the sample offered by the pilot is a small sample, Shell Energy has been able to draw through industry experience and broader data sets to support the position presented.

5. Conclusion

The project objectives were achieved through the following project outcomes:

1. Improved understanding and insight into repeatable efficiency, renewable and electrification opportunities that can provide energy cost savings and improved energy productivity across the sector. Project participants can reduce annual energy costs by an average of 27% with a capital investment of $29m. Extrapolated to cover the whole sector, there is the opportunity to reduce manufacturing energy costs in Queensland by $88m per year.
2. Improved understanding of energy productivity opportunities for the integration of renewable energy generation technologies categorised by technology, sub-sector and implementation horizon.
3. Improved understanding of investment barriers to the implementation of energy productivity and renewable energy initiatives.
4. Project participants have improved knowledge regarding efficiency, renewable and electrification opportunities through tailored energy management plans. This insight was turned into case studies, along with curated content and tools on the website[28] to educate the manufacturing sector.
5. Through the delivery of Industry workshops and on-going knowledge sharing activity, stakeholder engagement has increased support to catalyse further positive action within the Queensland manufacturing sector.

Knowledge sharing activities will continue with business, energy industry stakeholders and government to share the findings of the project, advocate for support to overcome investment barriers identified to catalyse further action within the Queensland manufacturing sector.

[28] **www.energysustainability.com.au**

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