This online textbook provides free access to a comprehensive education and training package that brings together the knowledge of how countries, specifically Australia, can achieve at least 60 percent cuts to greenhouse gas emissions by 2050. This resource has been developed in line with the activities of the CSIRO Energy Transformed Flagship research program, which is focused on research that will assist Australia to achieve this target. This training package provides industry, governments, business and households with the knowledge they need to realise at least 30 percent energy efficiency savings in the short term while providing a strong basis for further improvement. It also provides an updated overview of advances in low carbon technologies, renewable energy and sustainable transport to help achieve a sustainable energy future. While this education and training package has an Australian focus, it outlines sustainable energy strategies and provides links to numerous online reports which will assist climate change mitigation efforts globally.

Chapter 6: Energy Efficiency Opportunities in Light Industry/Commercial Sectors

Lecture 6.2: Opportunities for Energy Efficiency in the Food Processing and Retail Sector
The Natural Edge Project (TNEP) is an independent non-profit Sustainability Think-Tank based in Australia. TNEP operates as a partnership for education, research and policy development on innovation for sustainable development. TNEP's mission is to contribute to, and succinctly communicate, leading research, case studies, tools, policies and strategies for achieving sustainable development across government, business and civil society. Driven by a team of early career Australians, the Project receives mentoring and support from a range of experts and leading organisations in Australia and internationally, through a generational exchange model.
The International Energy Agency forecasts that if policies remain unchanged, world energy demand is set to increase by over 50 percent between now and 2030.1 In Australia, CSIRO has projected that demand for electricity will double by 2020.2 At the same time, The Intergovernmental Panel on Climate Change (IPCC) has warned since 1988 that nations need to stabilise their concentrations of CO\textsubscript{2} equivalent emissions, requiring significant reductions in the order of 60 percent or more by 2050.3 This portfolio has been developed in line with the activities of the CSIRO Energy Transformed Flagship research program; ‘the goal of Energy Transformed is to facilitate the development and implementation of stationary and transport technologies so as to halve greenhouse gas emissions, double the efficiency of the nation’s new energy generation, supply and end use, and to position Australia for a future hydrogen economy’.4 There is now unprecedented global interest in energy efficiency and low carbon technology approaches to achieve rapid reductions to greenhouse gas emissions while providing better energy services to meet industry and society’s needs. More and more companies and governments around the world are seeing the need to play their part in reducing greenhouse gas emissions and are now committing to progressive targets to reduce greenhouse gas emissions. This portfolio, The Sustainable Energy Solutions Portfolio, provides a base capacity-building training program that is supported by various findings from a number of leading publications and reports to prepare engineers/designers/technicians/facilities managers/architects etc. to assist industry and society rapidly mitigate climate change.

The Portfolio is developed in three modules;

**Module A: Understanding, Identifying and Implementing Energy Efficiency Opportunities for Industrial/Commercial Users – By Technology**

**Chapter 1: Climate Change Mitigation in Australia’s Energy Sector**

* Lecture 1.1: Achieving a 60 percent Reduction in Greenhouse Gas Emissions by 2050
* Lecture 1.2: Carbon Down, Profits Up – Multiple Benefits for Australia of Energy Efficiency
* Lecture 1.3: Integrated Approaches to Energy Efficiency and Low Carbon Technologies
* Lecture 1.4: A Whole Systems Approach to Energy Efficiency in New and Existing Systems

**Chapter 2: Energy Efficiency Opportunities for Commercial Users**

* Lecture 2.1: The Importance and Benefits of a Front-Loaded Design Process
* Lecture 2.2: Opportunities for Energy Efficiency in Commercial Buildings
* Lecture 2.3: Opportunities for Improving the Efficiency of HVAC Systems

**Chapter 3: Energy Efficiency Opportunities for Industrial Users**

* Lecture 3.1: Opportunities for Improving the Efficiency of Motor Systems
* Lecture 3.2: Opportunities for Improving the Efficiency of Boiler and Steam Distribution Systems
* Lecture 3.3: Energy Efficiency Improvements available through Co-Generation

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Module B: Understanding, Identifying and Implementing Energy Efficiency Opportunities for Industrial/Commercial Users – By Sector

Chapter 4: Responding to Increasing Demand for Electricity

Lecture 4.1: What Factors are Causing Rising Peak and Base Load Electricity Demand in Australia?
Lecture 4.2: Demand Management Approaches to Reduce Rising ‘Peak Load’ Electricity Demand
Lecture 4.3: Demand Management Approaches to Reduce Rising ‘Base Load’ Electricity Demand
Lecture 4.4: Making Energy Efficiency Opportunities a Win-Win for Customers and the Utility: Decoupling Energy Utility Profits from Electricity Sales

Chapter 5: Energy Efficiency Opportunities in Large Energy Using Industry Sectors

Lecture 5.1: Opportunities for Energy Efficiency in the Aluminium, Steel and Cement Sectors
Lecture 5.2: Opportunities for Energy Efficiency in Manufacturing Industries
Lecture 5.3: Opportunities for Energy Efficiency in the IT Industry and Services Sector

Chapter 6: Energy Efficiency Opportunities in Light Industry/Commercial Sectors

Lecture 6.1: Opportunities for Energy Efficiency in the Tourism and Hospitality Sectors
Lecture 6.2: Opportunities for Energy Efficiency in the Food Processing and Retail Sector
Lecture 6.3: Opportunities for Energy Efficiency in the Fast Food Industry

Module C: Integrated Approaches to Energy Efficiency and Low Emissions Electricity, Transport and Distributed Energy

Chapter 7: Integrated Approaches to Energy Efficiency and Low Emissions Electricity

Lecture 7.1: Opportunities and Technologies to Produce Low Emission Electricity from Fossil Fuels
Lecture 7.2: Can Renewable Energy Supply Peak Electricity Demand?
Lecture 7.3: Can Renewable Energy Supply Base Electricity Demand?
Lecture 7.4: Hidden Benefits of Distributed Generation to Supply Base Electricity Demand

Chapter 8: Integrated Approaches to Energy Efficiency and Transport

Lecture 8.1: Designing a Sustainable Transport Future
Lecture 8.2: Integrated Approaches to Energy Efficiency and Alternative Transport Fuels – Passenger Vehicles
Lecture 8.3: Integrated Approaches to Energy Efficiency and Alternative Transport Fuels - Trucking

Chapter 9: Integrated Approaches to Energy Efficiency and Distributed Energy

Lecture 9.3: Beyond Energy Efficiency and Distributed Energy: Options to Offset Emissions
Lecture 6.2: Opportunities for Energy Efficiency in the Food Processing and Retail Sector

Educational Aim

The aim of this lecture is to outline the financial benefits to be gained from seeking to reduce greenhouse gas emissions in the food processing sector and major food retail (supermarket) outlets. This lecture overviews the many energy efficiency opportunities in the food processing and food retail industries and highlight where to find freely available online energy efficiency manuals and resources for the food processing sector.

Essential Reading

Reference


Learning Points

Food Processing is one stage in the full production and consumption cycle for these food and grocery products. To be able to deliver comprehensive and unambiguous environmental improvements, we need to understand the role of each stage and the full environmental system for each product. It is important to develop a whole-of-system rather than a partial approach to environmental management to ensure policies and strategies reflect the full environmental and economic costs and benefits.6

Mike Adams Chairman Environment Committee
Australian Food and Grocery Council

1. The core business of food processing plants is converting raw food, chemical and energy inputs into useful food products, and there is an increasing range of options available to do this. Many of these options save energy and increase productivity, including the use of low pressure vacuum systems, centrifuges, and membranes to de-water foods - each litre of water that is not evaporated saves 2.3 MJ plus the losses in the system involved in providing that heat. Induction cooking and other options can save in cooking processes. Understanding the overall services required at a plant is the first step to energy efficiency. Modern monitoring systems such as thermographic imaging and ultrasonic monitoring can be used to optimise temperature distributions, identify leaks or faults, and support more precise process management.

2. Food processing plants are large users of energy for refrigeration, cooking, heating, sterilising, air-conditioning and handling, and for operating processing and auxiliary equipment. The main energy sources for Australian food processing plants are typically coal–generated electricity, natural gas and/or LPG, and to a lesser degree combustible fuels (coal and fuel oil). Gas is mainly used to produce steam or hot water for heating, sterilisation, or cleaning. Refrigeration is often the largest user (up to 60 percent of total use), especially in sectors such as the meat industry. Careful attention should be paid to insulation and minimisation of heat gain of refrigerated storage and pipes delivering refrigeration services. Other large electricity users are air-conditioning systems and motor systems that drive the processing equipment, pumps, fans, and conveyors and compressed air systems. Where large amounts of food or liquid are stored, there is significant potential to manage peak electricity demand by managing the storage temperatures: this reduces refrigeration plant capacity and peak energy charges billed by energy suppliers.

3. A recent survey by the Australian Food and Grocery Council7 found that ‘energy consumption for some Australian food and grocery companies is higher than relative international standards,’ indicating that there is scope to reduce energy usage.8 UNEP Working Group for Cleaner Production in Food, based at the University of Queensland, Australia have researched energy efficiency opportunities in the Food Processing industry in detail.9 They have found that the main energy efficiency opportunities in the Food Processing sector are as follows:

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- Reducing the amount of steam and hot water needed to process food.
- Optimising the operation of energy-consuming equipment such as boiler systems.
- Using the most energy efficient commercial refrigeration, motor systems, lighting and HVAC systems.
- Eliminating leaks from air compressors.
- Recovering heat energy, and using co-generation and alternative sources of energy.
- Considering less energy-intensive products.

4. **Reducing the amount of steam and hot water:** Energy usage and costs in food processing increase if excess steam is produced. Process steam installations are independent energy systems, where the steam boiler is the power source, generating steam at the required pressure. If the pressure and flow control systems are correctly sized and good control systems used, then the system can always deliver the required energy effectively on demand. This can lead to significant savings.

5. **Boiler systems:** Steam generated by boilers is generally used for heating via heat exchangers, or is applied directly into or onto the product. There are a number of basic factors that contribute to the efficient operation of a boiler:10
   - The boiler should operate as close as possible to the pressure to which it was designed to run at an optimal level. The pressure can be maintained by means of back-pressure valves, which reduces the amount of energy used.
   - The feedwater tank temperature must be kept at 80–90°C. Significant energy is lost if the temperature rises above this and the water starts to boil. Many feedwater tanks are poorly insulated with thermal bridging – effective insulation is important.
   - The feedwater supply will save energy if it delivers water at a rate at which steam is consumed.
   - A steam accumulator can be used to supplement peak demand for a short period of time.
   - Good communication between the boiler operator and production operator is vital to ensuring that the boilers are run at the right level to meet fluctuating demand. (See Lecture 3.2 for more details on Energy Efficiency and Boilers)

6. **Refrigeration Systems:** Refrigeration systems are often significant users of energy in food processing. In a refrigeration system most energy is used by the compressor, which usually consumes between 80 percent and 99 percent of the system’s total energy use. It is important, therefore, that the optimum compressor is used and that it (or they) is managed correctly. The amount of energy used by a compressor is affected by:

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- the type of compressor;¹³
- the compressor load (e.g. reciprocating compressors are efficient at peak load, whereas screws, scrolls and centrifugals operate best between 80 percent and 90 percent); and
- the temperature difference of the system — that is, the initial temperature and the number of degrees by which the system is required to cool. Online manuals provide a detailed overview of these options for refrigeration for the food processing sector.¹⁴

7. **Efficient Motors Systems**: As Lecture 3.1 showed, an electric motor uses 4–10 times its purchase price in electricity annually.¹⁵ When choosing a motor, therefore, it is essential to consider the operating costs as well as the initial purchase price. High-efficiency motors cost up to 40 percent more than standard motors; however energy savings quickly recover the extra cost, usually within two years. Lecture 3.1 also emphasised the benefits of investing in Variable Speed Drives (VSDs) to reduce energy consumption by adjusting the motor speed to continually match the load of equipment such as pumps, fans and compressors.¹⁶ Tracking load on motors in real time also allows you to determine whether a smaller motor or VSD could be useful. Also where a smaller motor has been fitted, it allows any unusual increase in load to be identified before the motor is damaged - since such changes in load are typically caused by failures downstream, such as failing bearings and pump faults. This also allows preventive maintenance to be pursued instead of waiting till a failure, when production time would be lost.

8. **Lighting Systems**: As Lecture 2.2 showed there are now highly efficient fluorescent and metal halide lighting on the market now in Australia that are up to 4-5 times more energy efficient than traditional incandescent lighting. Installing these can provide dramatic energy savings from lighting. Also further savings are possible through ensuring that lights are turned off when not needed and utilising day-lighting.¹⁷ Rapidly changing LED technologies offer an increasing range of opportunities. For example, a drop-in LED replacement for T8 fluorescent tubes uses only 14 watts and produces 50 percent more light while having a much longer life. New and improved solutions are appearing all the time, while their cost is declining and performance improving.

9. **Air-Conditioning and Handling Systems**: Air-conditioning systems serve to maintain humidity and temperature levels in the plant. It is possible to reduce the load on the system through better insulation of the plant and heat/coolth distribution systems, and by examining ways to reduce the generation of heat from food processing within the plant. As Lecture 2.3 showed, this ‘whole of system’ approach will help to reduce the load on the air-conditioning and handling system. When it is time to replace the air-conditioning and handling system there will be more efficient models on the market. Online manuals exist which explore the options for air-conditioning and handling systems in detail.¹⁸

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¹⁷ Ibid, p 135.
¹⁸ Ibid, pp 137-141.
10. **Air Compressor Systems**: Compressed air systems in food processing can contribute up to 10 percent of electricity costs. Compressed air systems are inefficient, with around 80 percent of energy used lost as waste heat. It is vitally important then that compressed air systems are correctly designed, sized and that their operational efficiency is optimised. Online manuals exist which explore the energy efficiency options in detail. Ultrasonic sensors can be used to identify leaks.

11. **Heat Recovery Systems**: Heat can be recovered from heated water in boilers or from commercial refrigeration systems, or from food or other products and waste leaving a process. In some cases, effective heat recovery can replace the need for expensive steam systems, because the amount of energy required becomes much smaller, so that a local heat generator can be used.

12. **Cogeneration Systems and Alternate Energy Sources**: As Lecture 3.3 outlined, co-generation or combined heat and power (CHP) systems use heat or steam or waste gases to produce both electrical and thermal energy. This also provides the food processing industry with options to save energy. Alternate Energy Sources should also be investigated. Solar thermal systems, anaerobic digesters and biofuels can be used to preheat water and thus significantly reduce greenhouse gas emissions. Pagan et al. outline the following case study that shows how this can be effective:

   A solar heating system at Novartis Consumer Health in Victoria includes 36 solar panels, nine gas burners to supplement the solar heat and one 3000 L insulated hot water holding tank. The water is used for cleaning and must be at least 75°C. The solar panels heat the water to between 50° and 60°C and a gas booster heater increases the temperature a further 20°C. Gas consumption has dropped by about 50% as a result of solar heating.

   Pagan et al, UNEP Working Group for Cleaner Production in Food, 2004

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21 Ibid, p 127.

22 Ibid, p 152.

23 Ibid, p 146.
Brief Background Information

The National Farmers Federation (NFF) in August 2007 called for greater government action on climate change, saying agriculture was probably the economic sector in Australia most exposed to the problem of climate change. This is true all over the world. Climate change threatens to significantly reduce water availability and lead to greater frequency of droughts in Asia, Australia, Africa, Mid West USA, and South America. This will threaten agricultural production and the food processing industry which significantly depends on water availability. The IPCC Chair Dr Pauchari has stated that, ‘Glaciers in the Himalayas provide the water source for one-sixth of humanity. Their decline threatens the water supply of billions…The gross per capita water availability in India is projected to decline from 1820 cubic meters per year in 2001 to 1140 cubic meters per year in 2050.’ Figure 6.2.1 shows that climate change is leading to a significant loss of glaciers and snow in the Asian High Mountains, NW USA and South West California. Figure 6.2.2 shows to what extent the glaciers of the Himalayas are already melting. And at the same time global demand for water continues to rise in most regions of the world.

![Graph showing cumulative total mass balance over the years](image)

**Figure 6.2.1.** Loss of glaciers and snow in the Asian High Mountains, NW USA and South West California

*Source: Pauchari, R.K, 2007*

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25 Ibid.
Analysis of future emissions trajectories show that under business as usual scenario’s human GHG emissions will increase significantly over the 21st Century. As a consequence, global annual average temperatures are projected to increase 0.4–2.0°C above 1990 levels by the year 2030, and 1–6 °C by 2100. Changes in precipitation and, subsequently water availability and run off into rivers, are particularly critical factors affecting the future farming productivity of the landscape and food processing industries. Already significant change in the climate and water availability is occurring around the world and in Australia. The Bureau of Meterology’s September 2007 Drought Statement stated that, ‘This is the first time in the record dating from 1900 that an El Niño-drought in the MDB has not been followed by at least one three-month period with above normal rainfall (basin average) by the end of the following winter.’ Prime Minister John Howard announced on 19 April 2007 that unless there was substantial rain in soon no water will be allocated to irrigators in the Murray-Darling basin for the coming year. Currently most farmers in the Murray Darling Basin of Australia are on less than 20 percent of their normal water allocations. The result is directly affecting the 50,000 farmers of the Murray Darling Basin and the economy with the price of food in Australia rising. 

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Already farmers in the Murray Darling Basin are pruning and cutting down significant parts of their orchards to try to survive the drought. Food production is down dramatically in water affected sectors such as cotton, wine and dairy. The Australian government estimates the drought shaved 0.75 points from Australia’s economic growth in 2006. This drought, the worst ever in Australia’s history, is being made worse by the higher average temperatures due to climate change that further dry out the land.  

**Food/Beverage Processing and Retail Industry: Risks and Threats from Climate Change**

As well as risks from reduced water availability and run off into rivers and streams, climate change threatens the Food Production/Beverage and Food Retail Sector in many additional ways:

- **Rising price increases for basic ingredients**: Reduced farming capacity and production leads to shortages in different basic ingredients and foods leading to price rises throughout the supply chain. In September 2007, the ABC reported that, ‘For the third year in a row, bakers are confronting big increases in the price of flour and other ingredients directly related to shortages caused by the drought...Shoppers should get used to the high prices, even if the drought breaks soon. Food industry analysts and economists say prices of certain foods will stay high into next year.’

- **A higher frequency of extreme weather events**: Cyclones, bushfires, hail storms all lead to crop and animal losses. In 2006 Cyclone Larry devastated Queensland's banana industry, destroying fruit worth AUD$300 million and leaving up to 4,000 people out of work.

- **Higher temperatures lead to heat stress on livestock production**: This significantly reduces production per animal. As CSIRO scientists have written, ‘Rising temperatures are likely to lower milk yield from cows. For example, dairy cows in the Hunter Valley that are kept in the open produce up to 3 per cent less milk than those kept under shelter. This loss represents about 230 litres of milk per cow each year for a high-yielding herd. By 2030, annual milk losses are likely to be between 250 and 310 litres per cow, depending on the rate of warming. Adaptation using shade sheds and sprinklers would limit annual milk losses to about 60 to 90 litres per cow.’

- **Fishing and Seafood industries are threatened by coral bleaching and ocean acidification**.

Scientists warn that greenhouse gas emissions are needed to be reduced by 90-100 percent to ensure that such catastrophic events do not eventuate. Under business-as-usual scenarios ocean acidification will threaten much of the fishing and seafood industries. A Dutch-led 2007
study suggests ocean acidification might result in significant losses of the World's mussels and oysters.\textsuperscript{34}

The Australian farming sector has begun to respond by forming new organisations, like the Agricultural Alliance on Climate Change (AACC), which is focused on raising awareness of win-win options for the sector to be part of the solution to climate change. In September 2007, CSIRO published a major report\textsuperscript{35} for the Agricultural Alliance on Climate Change, showing that farmers could be enjoying up to an extra AUD$2.94 billion every year by getting involved in delivering Australia's clean energy economy. The AACC asked the CSIRO to look at the opportunities of providing fuel, as well as more greenhouse friendly food and fibre and environmental services into the Australian and global economies. CSIRO identified a number of opportunities:

- Providing renewable energy infrastructure like wind and bioelectricity under policies such as a clean, renewable energy target of 25 per cent by 2020;
- Assisting the agricultural sector with finding and delivering greenhouse gas savings from its own activities by rewarding early action;
- Creating (accredited and verified) environmentally-sound offsets in the rural sector as part of a national emissions trading scheme; and
- Increasing active biodiversity conservation on private land from six to fourteen per cent across Australia.\textsuperscript{36}

Just as there are significant opportunities to reduce greenhouse gas emissions in the agricultural sector, there are significant opportunities for the food processing and retail industries to dramatically reduce greenhouse gas emissions, through the following steps:

- \textit{Energy Efficiency}: The Australian DITR 1998-2003 Energy Efficiency Best Practice program\textsuperscript{37} found between 30-60 percent energy efficiency savings were often possible in Breweries, Bakeries, Dairy, Wineries, Supermarkets, and Soft-Drink Processing.

- \textit{Renewable Energy}: Wind Farms can co-exist with livestock, providing farmers and processors with extra income from leasing their land to wind farm companies. Many of the windiest sites for wind farms in Australia are in rural WA, SA, Tasmania and Victoria (see Lecture 7.4). Biomass production can also be integrated into agriculture to produce solid or gaseous fuels or transport fuels.


\textsuperscript{36}Ibid.

Carbon Offsets: There are numerous studies which show that livestock production – cattle, dairy, chickens etc. – is improved through tree planting to provide shade and reduce temperature extremes. Tree planting helps to reduce heat stress significantly in livestock (see Lecture 9.3). Planting trees to create tree belts on bare paddocks can dramatically boost productivity for the dairy, beef and sheep industries. Western Port Catchment Landcare Network has proven the point by monitoring the effects of temperatures on livestock in unsheltered areas compared with areas protected by Landcare-funded shelter belts. ‘Dairy cattle with shelter produce 17 per cent more milk compared to cattle with no shelter. On a 27 degree day, unsheltered cows will have 26 per cent less milk than shaded stock.’ Tree planting helps to reduce heat stress significantly in livestock. Simply due to the fact that when it was 32 degrees in the shade the temperature was 40 degrees in the sun. While methodologies are still being developed, carbon storage in soils is also an emerging area of opportunity.

This lecture now overviews the energy efficiency and greenhouse gas reducing opportunities in a number of areas of food processing. For those interested in more detail on any of these opportunities see the referenced reports, especially those by the Department of Industry, Tourism and Resources (DITR) Energy Efficiency Best Practice Program, the University of Queensland UNEP Centre on...
Cleaner Production in Food, the UK Carbon Trust,42 the Ernest Orlando Lawrence Berkeley National Laboratory’s Environmental Energy Technologies Division43 and the UNIDO.44 The reports listed throughout this discussion not only have detailed explanation of energy efficiency and renewable energy opportunities but often they have useful checklists as well. For instance, The UNEP Centre on Cleaner Energy have produced a succinct checklist of opportunities to reduce greenhouse gas emissions in the food processing area that is useful for quickly checking that you have not missed any opportunities.45 We now explore some of these opportunities in the remaining discussion of this lecture.

**Dairy Processing Industry - Energy Efficiency Opportunities**

The Australian dairy industry is one of the largest value adding industries in Australia. In 2002-03 annual production was valued at AUD$2.8 billion (farm gate), while downstream processing produced AUD$9 billion (ex-factory). AUD$2.5 billion of this ex-factory production was exported, making Australia the world’s third largest dairy exporter, with a 17 percent share of the international market. Dairy is one of Australia’s leading rural industries in terms of value-adding through downstream food processing.

Dairy Processing uses significant amounts of energy. Energy is used throughout the processing of milk to turn it into new products and extend its saleable life. Energy is used in the preparation of all dairy products - butter, hard cheese, yoghurts, ice-cream – which are stored in energy using refrigerators. Geoff Andrews, an Australian energy efficiency expert, has carried out studies showing that if the small dairy with the highest electricity consumption per cow could improve its energy efficiency to that of the small dairy with the lowest consumption, it would achieve an 80 percent reduction in consumption.46 A range of studies47 and reports have covered energy efficiency opportunities within dairy processing in detail.48 The National Dairy Council of Canada report,49 for instance, considers energy efficiency opportunities in detail in all six key dairy processing types: fluid milk, cultured products, cheese, butter, and ice cream and other frozen products, and evaporated/dried products. Given that the National Dairy Council has covered all six major areas of the dairy industry, here we simply consider the following sample of some of the energy efficiency savings available in dairy processing:50

- **Lighting in Dairies**: Fluorescent lighting will provide the most cost-effective lighting solution in most dairies, especially if the roof is lower than 5 metres. Use well-designed single lamp fittings with high efficiency, long life, tri-phosphor lamps. These will reduce the power required to achieve

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48 Ibid.

the 240 lux lighting level recommended in dairy sheds. Emerging LED technologies may further reduce this energy use.

- **Reducing Electricity Needed for Water Heating.**\(^5\) Dairy processing plants can use up to 80 percent of their total energy requirement to produce the steam and hot water needed for evaporative, heating and drying processes. The low-cost ways of reducing water heater electricity use are:

  - When steam is not required ensure that the thermostat is not set too high and causing the water to boil. Boiling water and producing steam uses 10 times as much energy as heating it from cold to 95°C and the water is lost from the system (a matter of concern in these times of drought).
  
  - Maintain the water heater and piping to eliminate leaks and use insulation to reduce heat losses.
  
  - Boilers should be appropriately sized to meet, and then operated at, maximum possible design pressure.
  
  - Improved communication between the boiler house and production can help meet demand more efficiently. Boilers should be started up as late as possible and shut down as early as possible, while still meeting production needs. Multiple boilers may be scheduled so that the smallest boiler operates at times of low demand and others are shut down. Running large boilers at low load is often very inefficient.

- **Recovering Heat from Milk:** The heat removed from milk is a renewable source of energy. It is also a heat source which is well matched to the demand for heat, i.e. when the dairy is being used, the heat from milk is available. The heat removed from the milk from 200 cows in one day is about 163 kWh or enough energy to heat over 1500 litres of water from 15°C to 95°C (over double the amount required). A de-superheater which can be fitted to refrigeration equipment is capable of heating water to 70°C, and so some boosting is required to reach the required end-use temperature of 80°C. Heat can also be recovered from the milk pre-cooler heat-exchanger. The achievable water temperature will be much lower (around 30°C, depending on milk and water flow rates). This tempered water can be used for udder washing or as feed water to the main heater or de-superheater. De-superheaters cost around AUD $500 plus installation, but are normally supplied as a component of a complete water heating system. An energy efficient water heating system with de-superheater, tanks and controls costs about AUD$4000 compared with about AUD $2000 for a standard system of similar capacity.

- **Solar Pre Heating to Help Heat Water and Utilising Gas Boosters:** Solar hot water heating has been used successfully in the residential sector, but its use in the industrial sector has been limited to date. There are, however, a few examples of solar heating being used to pre-heat boiler feed water in steam boilers and power stations. This type of application could be worth considering for boilers at meat plants. Boiler feed make-up water could be heated in solar panels up to 80°C before being fed to the boiler. LPG can be used to heat water to the temperatures required in dairies. It is well suited to boosting the temperature of water which has been preheated by heat recovered from the milk. LPG water heaters can heat water at the same rate that it is consumed, and so there is no need to store hot water. This reduces heat losses, and

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allows for more precise control of water temperature. Therefore, LPG is a cost-competitive method of heating water in dairies, providing that the price is around 80 cents per litre, and an instantaneous LPG water heater is used to heat water as the water is required for use. This will reduce the heat losses to a minimum and so compensate for LPG’s higher cost. LPG-fired water heating will also emit 70 percent less CO₂ than electric water heating.

- **Milk Cooling and Refrigeration:** The cost of operating a refrigeration system can be up to 20 percent of the total energy costs in a dairy processing plant. Dairy processors typically use the vapour compression cycle refrigeration system, consisting of a compressor, a condenser, evaporator and expansion valve. The efficiency of a refrigeration system is measured by the ‘Coefficient of System Performance’ (COSP), which is the quantity of refrigeration produced divided by the total energy required by the system. Most of the work in a refrigeration system is done by the compressor, which usually consumes between 80 percent and 98 percent of the total energy use. The role of the compressor is to take low-pressure refrigerant vapour from the evaporator and compress it so that the vapour can be condensed into a liquid. The liquid refrigerant is then reused to absorb heat from a chilled medium. It is important that you choose a refrigeration system which is suited to the refrigeration load and that the COSP is high. Prasad *et al* highlight the opportunities for energy efficiency in this area through a case study of the Nestlé ice-cream processing plant in Victoria.

Prasad *et al* report that the operators of this plant,

> Found that the compressors were operating when there was no load, there was a large number of start-ups, and the suction temperature of 12°C into the compressors was far above the design temperature of 3°C due to incorrect valve selection. The minimum condenser pressure was also being maintained at around 1000 kPa over the winter months. The plant improved the valve selection by upgrading the control system to correct the suction gas temperature, enabling the compressor to operate at a higher loading and minimise stopping. The condenser pressure was also modified to 750 kPa. The project cost $59 000 and now saves $100 000 annually in electricity costs. Compressor start-ups were reduced by 92% and the run hours by 22%. There was a 20% overall reduction in maintenance costs for the refrigeration plant.²⁴

**Featured Case Study: Rochester (Victoria) Branch of Murray Goulburn Cooperative**

The work of the Rochester (Victoria) Branch of Murray Goulburn Cooperative, with the team from the DITR Energy Efficiency Best Practice Program, has shown what potential savings to Dairy processors are possible through energy efficiency initiatives. So far energy efficiency projects have yielded savings of AUD$180,000 per year, reducing 1,536 tons of greenhouse gas emissions. Additional short-term future savings, based on projects currently being implemented, are forecast to be AUD$223,000 per year with a reduction in greenhouse gas emissions of 1,895 tons. Some of the ways this has been achieved include:

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²⁴ Ibid.
- Improving boiler steam efficiency through clearer communication protocols: These protocols enabled technicians in the boiler room to have greater advance warning of when higher than usual supplies of steam were required. As a result of better communication, savings are estimated to be AUD$180,000 per year.

- Improving start up procedures for the evaporator and dryer: Murray Goulburn Rochester currently produces milk powder on site in their Niro Evaporation and Spray Drying plants. These plants produce five tons of whole milk powder per hour. They also produce whey and skim powders. Since start up procedures use large quantities of steam to heat stainless steel equipment they are an energy intensive part of the overall process. Therefore they are a good area to focus on to reduce energy usage. Murray Goulburn Rochester found that the Evaporator was spending too much time on heat mode and stabilise mode during the start up of the evaporator from cold mode. They also found that plant temperatures had stabilised well before the next mode began, and that the Dryer had a similar problem of spending too much time on the stabilise mode. Reducing the time required to start up both the evaporator and dryer reduces the amount of steam required in the plant and saves up to AUD$23,000 annually on energy costs.

- Improving condensate return, fixing steam leaks and improving lagging: Steam is piped to various locations throughout the Rochester site for many heating purposes. Some heat from steam, once transferred to product or equipment, condenses to hot water. This ‘condensate’ contains usable energy. Project savings from addressing these issues was found to be AUD$200,000 per year.

Meat Processing and Rendering Industry - Energy Efficiency Opportunities

The meat processing and rendering industry includes the slaughter of animals and fowl, processing of the carcasses into cured, canned, and other meat products, and the rendering of inedible and discarded remains into useful by-products such as lards and oils. The Australian Greenhouse Office has published estimates of greenhouse gas emissions per kilo of product for a small range of agricultural products. Of those, beef from cattle is estimated to have the highest CO₂ emissions at 52 kilos per kilo of meat, followed by sheep meat (14 kilos per kilo) and pig meat (4 kilos per kilo). By comparison, the primary production of grains was estimated to add about 0.4 kilos per kilo. The need to reduce greenhouse gas emissions is acknowledged by the industry. In 2001, Australia’s multi-billion dollar red meat industry joined the AGO Greenhouse Challenge committing to reduce its greenhouse gas emissions by more than 100,000 tons a year.

Energy is an important input for meat processing. The perishable nature of meat and processed meat means that it needs to be frozen. Refrigeration typically uses 40-50 percent of electricity at meat plants. The other large area of use is the multitude of motors that drive pumps, fans, conveyors and hydraulic systems. Another area of energy use arises from the need to heat water. Maintaining food hygiene standards requires the use of hot water for sterilisation of plant and equipment. Steam is used by plants that render by-products. Steam is produced in on-site steam boilers fuelled by fossil fuels (with coal the most commonly used fuel since it is the cheapest). Around 30-40 percent of water used at meat plants is warm (43°C) or hot (82°C). For plants with rendering, water is usually heated using heat recovered from the cooker, with some additional heating. Plants with no rendering usually

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use gas to heat water directly. As Pagan et al.\(^5\) outline, the main energy efficiency opportunities for the meat processing industry lie in:

- Reducing demand for steam in the first place.
- Improving the efficiency of steam production through using high efficiency boilers while utilising better insulation and reducing leaks.
- Fuel conversion from coal to natural gas or LPG. LPG-fired water heating emits less CO\(_2\) than electric water heating.
- Solar pre-heating of boiler feed water. There are a few examples of solar heating being used to pre-heat boiler feed water in steam boilers and power stations. This type of application could be worth considering for boilers at meat plants.
- Improving heat recovery. Meat processing plants that do rendering already usually recover heat from the rendering process to produce hot water. Optimising heat recovery reduces the amount of additional energy required to bring the hot water temperature up to 85ºC. In addition to the recovery of heat from the rendering process, there are a number of other waste heat sources from which useful heat can be recovered. Figure 6.2.4 lists potential sources of waste heat and those applications where the recovered heat could be used.
- Where hot water (i.e. temperatures under 100ºC) is required, it can be far more efficient to use distributed hot water generators in key locations in the plant instead of steam. These also have lower maintenance costs. This can be particularly efficient where a process is located a long distance from the existing boiler.

<table>
<thead>
<tr>
<th>Potential sources of waste heat</th>
<th>Available volume (MJ/day)</th>
<th>Potential area of recovered heat</th>
<th>Heat requirement (MJ/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rendering cooker</td>
<td>30,000</td>
<td>Hot water (82ºC) production</td>
<td>30,000</td>
</tr>
<tr>
<td>Lubrication oil cooler for screw compressors</td>
<td>5,250</td>
<td>Warm water (43ºC) production</td>
<td>5,000</td>
</tr>
<tr>
<td>Refrigeration desuperheater and condenser</td>
<td>120,000</td>
<td>Pre-heating boiler feed</td>
<td>335,000</td>
</tr>
<tr>
<td>Condensate return</td>
<td>50,250</td>
<td>Maintaining temperature in pig scald tanks</td>
<td>5,000</td>
</tr>
<tr>
<td>Boiler blowdown</td>
<td>5,025</td>
<td>Hook wash tanks</td>
<td>1,000</td>
</tr>
<tr>
<td>PNG singeing oven</td>
<td>2,175</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air compressor exhaust</td>
<td>1,450</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.2.4. Opportunities for heat recovery in the meat processing industry

Source: UNEP Cleaner Production Working Group (2004)\(^6\)

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Reducing demand for electricity from commercial refrigeration, freezers, motor systems (see Lecture 3.1), and compressed air.

Exploring opportunities for co-generation (see Lecture 3.3).

All these opportunities are explored in detail by Pagan, Renouf, and Prasad, in their 2004 *Meat Processing Eco-Efficiency Manual*.

**Grain Processing – Energy Efficiency Opportunities**

Roughly 20 percent of the world’s grain production is lost after harvest because of inefficient handling and poor post-harvest technologies. For the last 30 years in Australian stored grain, insect pests have been controlled by chemical methods as the grain was loaded into grain stores. Environmental considerations are leading to some chemicals being phased out, such as methyl bromide, which destroys the ozone layer. In addition, consumers do not want toxins and pesticide residues in food grains. Therefore new non-chemical methods are needed to control insect pests in food grain stores. One simple non-chemical method to control insects is to cool grain using aeration.

Cooling grain with refrigerated air is an effective insect control measure in areas where the ambient air temperature is high, but the process is fairly energy intensive and a high initial investment is required. To overcome this problem, a solar desiccant system has been developed at Victoria University of Technology (VUT), Melbourne by Graham Thorpe and this team for cooling bulk stored grains. This has been tested in a number of conditions now. One such test took place in the Darling Downs in Queensland, where the temperature of ambient air at night is typically 16°C degrees, which is too high to control insect pests by ambient aeration. This new solar desiccant system reduced the temperature to 9.4°C degrees. Another test on 50 tons of barley reduced the temperature from 23.5°C to 12.5°C degrees using this device. Under these conditions most insect species cannot breed.

Solar energy approaches are used to help dry main crops. Many do-it-yourselfers have built effective solar hot-air dryers for fruits and vegetables, grains, herbs, and even lumber. Fruit, wheat and rice are all grown on a large scale in central NSW and northern Victoria. Gas-fired crop drying is widely used. Substituting solar thermal energy (see Lectures 7.1 and 7.3) for gas is a logical application to investigate. A solar assisted crop drying facility has been constructed in Griffith NSW, in collaboration with the ANU, to reduce reliance on gas for drying prunes. The energy savings due to reduced air heating by the gas furnace are potentially in the order of 60 percent.

**Bakery – Energy Efficiency Opportunities**

Around 4,500 bakeries supply the Australian market with bread products. These bakeries spend approximately AUD$30 million each year on energy and produce about 0.2 percent of the

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61 Ibid.


greenhouse gas emissions from Australian manufacturing industry. Energy costs represent about 3 percent of the total and 6 percent of the controllable costs in this industry. The Department of Industry, Tourism and Resources, as part of their 1998-2003 Energy Efficiency Best Practice Program worked with Baker’s Delight to explore energy efficiency opportunities. The project has achieved 32 percent savings in annual energy costs and a reduction of 48 percent in greenhouse gas emissions per year compared to a standard Bakers Delight bakery. The knowledge learnt through the experience is starting to be similarly applied across the Bakers Delight’s franchise.

Learning about and maximising energy efficiency is good business and what we have learned will be important as we continue to build our business.

David Bayes, CEO of Bakers Delight

The following are the main energy efficiency opportunities in the baking industry as identified in two reports published by the Australian Baking Industry.66

**Small Independent Bakeries - Savings of at least 20 percent can be achieved.**

Most shop bakeries can achieve energy efficiency savings through:

- switching off unused decks in the oven with the thermostat;
- switching off oven and prover when finished;
- not using air-conditioning on cool days;
- thinking about production scheduling so that equipment run time is optimised;
- loading mixers to maximum capacity; and
- reducing radiated heat from ovens and other hot baking equipment.

**Large Independent Bakeries - Quick Wins**67

Energy efficiency opportunities with a rapid rate of return on investment include the following:

- reducing compressed air usage for skinning dough;
- reducing loaf depanner compressed air usage;
- reducing compressed air usage for clean-up;
- considering energy use in plant shutdown procedures;
- monitoring oven and griddle flame characteristics;
- minimising steam delivery pressure;
- minimising compressed air delivery pressure;
- maintaining compressed air hoses; and
- monitoring power factor correction.

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67 Copies of the two reports: ‘Energy Efficiency Opportunities in the Bread Baking Industry: Small Independent Bakeries’ and ‘Energy Efficiency Opportunities in the Bread Baking Industry: Large Independent Bakeries’ can be obtained from the Baking Industry Association of Victoria’s secretariat, Administration Building/Melbourne Showgrounds, 386 Mount Alexander Road, ASCOT VALE VIC. 3032, Tel: 03 9370 3177, Fax: 03 9370 7633.
In small bakeries, improved design of ovens and cold rooms can significantly reduce energy requirements and improve comfort of staff. Some of these measures were pursued in the Department of Industry Tourism and Resources work with Bakers Delight.  

### Supermarkets – Energy Efficiency Opportunities

A US study on supermarket retailing estimated that 673 kilowatts of energy are consumed per year per square metre of floor space. This estimate probably overstates heating costs when applied to Australia, but we have higher refrigeration energy requirements. In 1999, there were almost 5 million square metres of supermarket floor space in Australia. Using US data as a guide, this is equal to about 3.3 billion kilowatts per year, or 3.7 megatons of CO₂. It is estimated that about 52 percent of this is caused by in-store refrigeration. Auditing between 2002-2003 by the Big Switch team of Australian supermarkets suggests that Australian supermarkets are using significantly more than the US value.

Allocating this total energy to household food consumption of about 28 kilos per week results in a greenhouse gas rate for retailing of about 0.3 kilos of CO₂ per kilo of food. Clearly, this rate will be higher for frozen and refrigerated products, and lower for dry goods.

![Figure 6.2.5. Energy consumption in supermarkets](source)

George Monbiot in his bestselling book Heat explains why supermarkets use so much energy. ‘As you come through the door of a supermarket, a unit above your heat blasts you with hot air in the winter and cold air in the summer. You must stand blinking for a moment as your eyes adjust to the strong artificial lights. Then you walk past banks of fridges and freezers which have no doors. This

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71 Pears. A. Private Communication.


would be impossible to believe, if it were not by now one of the most ordinary facts of life. But, though you walk through valleys of ice, you remain warm. All day long the freezers and heaters must fight each other. They must do so in a building that is huge, poorly insulated and that is capable, in other words, of trapping neither heat nor cold.’

Through energy efficient lighting (see Lecture 2.2), which emits far less heat, better insulation, and more natural day-lighting, much energy can be saved. Fifteen to twenty percent of the average supermarkets energy is used just for lighting. A supermarkets heating bill can be slashed through adding glass screens to the fridges and freezers. As stated above roughly 60 percent of energy usage in a supermarket is from refrigeration but much of the refrigeration equipment is comprised of open vertical cabinets. Modelling and empirical testing has shown that if those commercial refrigeration display cabinets had glass doors, or glass covers which we simply opened and closed upon picking up food, it would save 68 percent in energy used, preserve food more effectively and provide a host of other benefits.74 The normal commercial refrigeration case without a glass door leads to extreme air leakage cooling the store and thus making it necessary to have space heating. It dramatically increases defrost energy due to moist air from surroundings ~ 0.9 kWh/litre flowing into the case. It makes temperature control both in the case and outside it very difficult, wasting over 70 percent of energy. US engineer Faramarazi75 has done a great deal of work on how to implement this idea while avoiding problems of the glass fogging up or becoming steamy. There are a range of resources on the web advising companies on where to start on these issues.76 The Department of Industry Tourism and Resources Energy Efficiency Best Practice program identified up to 40 percent energy savings were possible in a standard Coles Supermarket store.77

**Conclusion**

This lecture has demonstrates the case for action on climate change and provided an overview of the wide range of energy efficiency, co-generation and renewable energy opportunities for the Food Processing and Retail Sectors.

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Optional Reading


Keywords for Online Searching

Food Processing energy efficiency opportunities, Dairy and Meat Processing energy efficiency opportunities, Beverage industry energy efficiency opportunities.