FACTOR 5: Transforming the Global Economy through 80% Improvements in Resource Productivity

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Factor 5 in the Food and Hospitality Sector

As it is impossible to cover every sub-sector in the food and hospitality industry in this one book we have chosen a progression from 'farmer to fast food' to demonstrate the significant opportunities for improving resource efficiency in the food and hospitality sector. In this chapter we follow a progression from dairies, to bakeries, to supermarkets, to restaurants, and then to fast food outlets, highlighting a whole system approach to improving both energy and water productivity, and showing a strong nexus between them.

1) Industry Sector Study – Food Industry (Dairies)

The Potential for Factor 5 Improvements in Dairy Farming Resource Productivity

Current forms of farming practices around the world have significant opportunities for improving resource productivity. For instance, farms account for approximately 70 per cent of the world's global freshwater use, and much of this can be saved through a range of options. Within the farming sector dairy farms are seen as a relatively large user of both water and energy. For instance, according to Australian Dairy Farmers Limited, Australian dairy farming uses about 25 per cent of the water allocated to surface irrigation, as well as being is a major user of ground water. Farms also use significant amounts of energy both directly, through electricity and vehicle fuels, and indirectly, through their use of energy intensive inputs like fertilisers and pesticides. For instance the indirect energy demand from the use of artificial nitrogen fertilisers is between 28-35 Gj per ton,[1] which is more energy per ton than required to make a ton of steel or cement.[2] Direct energy usage on dairy farms has grown gradually in the past 20 years due to increases in farm sizes, the use of automated equipment, and around-the-clock operation in some places. Dairies in the US, for instance have a typical energy consumption per cow of between 800 and 1,200 kWh per year, and to put this into perspective, this is enough to power the average home in the US (936 kWh) for a month.[3] The majority of this energy is used for milk production equipment, about 50 per cent, with the rest consumed mostly for lighting and ventilation (see Figure 1.1).[4] Energy costs can represent as much as 6 per cent of total farm costs,[5] and a medium to large dairy could typically spend US$1.4-2.1 million on energy per year.[6] Hence reductions in energy use on dairy farms can provide lucrative cost cutting opportunities, especially in years when profit margins are tight.

[1] Worrell, E., Neelis, M., Price, L., Galitsky, C. and Nan, Z. (2007) *World Best Practice Energy Intensity Values for Selected Industrial Sectors,* Ernest Orlando Lawrence Berkeley National Laboratory.
[2] Worrell, E., Neelis, M., Price, L., Galitsky, C. and Nan, Z. (2007) *World Best Practice Energy Intensity Values for Selected Industrial Sectors,* Ernest Orlando Lawrence Berkeley National Laboratory.
[3] Energy Information Administration (2007) 'U.S. Average Monthly Bill by Sector, Census Division, and State 2007 - Table 5', www.eia.doe.gov/cneaf/electricity/esr/table5.html, accessed 20 March 2009.
[4] ESource (2008) 'Managing Energy Costs in Dairy Farm Facilities', *Commercial Energy Advisor*, ESource, www.esource.com/BEA/demo/PDF/CEA_10_DairyFarms.pdf, accessed 31 March 2009.
[5] ESource (2008) 'Managing Energy Costs in Dairy Farm Facilities', *Commercial Energy Advisor*, ESource, www.esource.com/BEA/demo/PDF/CEA_10_DairyFarms.pdf, accessed 31 March 2009.
[6] Prasad, P., Pagan, R., Kauter, M. and Price, N. (2004) *Dairy Processing Eco-Efficiency Manuals,* UNEP Working Group for Cleaner Production in Food, Meat and Livestock Australia, Dairy Australia, www.gpa.uq.edu.au/CleanProd/dairy_project/Eco-efficiency_manual%202.pdf, accessed 16 November 2008.

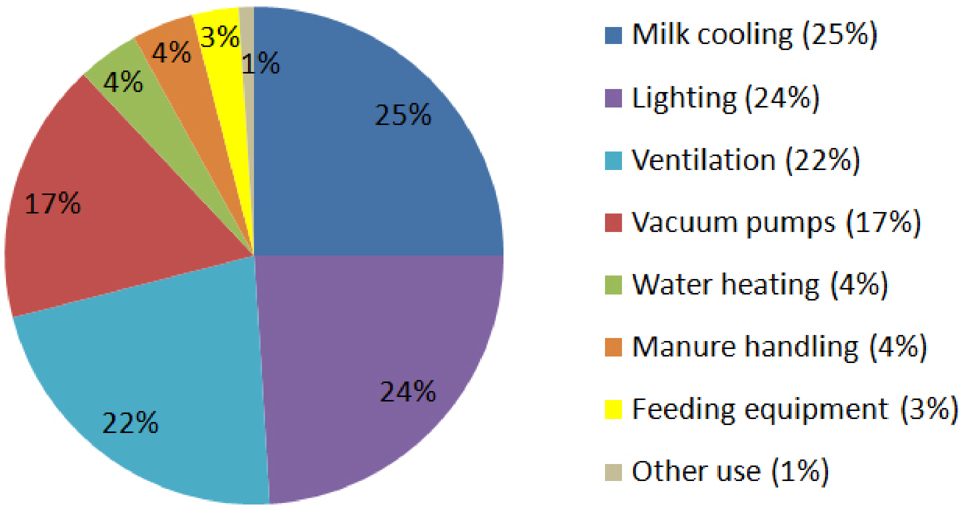

Figure 1.1: Major areas of Energy Consumption for a Dairy Farm

Source: Based on data from the New York State Research and Development Authority, as cited in ESource (2008)[7]

As economies around the world are heading into a future that will inevitably involve increasing energy costs from carbon intensive energy sources, this poses significant risks to industries that have not optimised their energy productivity, and that are not taking steps to source their energy from non-carbon sources, preferably onsite. Also, the IPCC *Fourth Assessment Report* predicts that in many regions of the world water availability will be reduced, and as the dairy industry relies on significant amounts of water this also provides a tangible risk.[8]

Hence the future for the dairy industry will include efforts to improve energy and water productivity and this will require a whole system approach if current inefficient practices are to be improved. Yet in many ways dairy farms are positioned better than most to turn these challenges into an opportunity. As Glenn MacMillan says, *"For starters a dairy farm has the ability to source all of their energy needs from its waste steams. This is possible through conversion of waste manure from cows, waste woody biomass, wind, and sunlight into energy, and most of all 'fuel' for cows from renewable pastures and feeds. With today's technologies this is feasible which allows a move away from reliance on a central electricity grid.*"[9] Also, dairy farms have many significant energy efficiency opportunities which make it possible to achieve up to Factor 5. As Geoff Andrews explains, based on studies and surveys of many dairies in Victoria, Australia, '*What these surveys showed was that there was potential for the least efficient dairy farms to achieve up to 80 per cent energy productivity improvements for their direct energy use on site. These surveys also showed significant potential for improvement even on the more efficient dairy farms*.'[10] There are also significant potential water productivity improvements available for the dairy farming sector. To-date many dairy farms have used the least efficient method of irrigation – i.e. flood irrigation. Hence there is great potential for the more efficient irrigation strategies outlined in the sector study on agriculture to be used in the dairy sector to achieve large reductions in water usage.

Despite such opportunity, progress in improving energy and water productivity in the dairy sector has been slow, partly due to the lack of real incentives, such as the low cost of energy and water,

[7] ESource (2008) 'Managing Energy Costs in Dairy Farm Facilities', *Commercial Energy Advisor*, ESource, www.esource.com/BEA/demo/PDF/CEA_10_DairyFarms.pdf, accessed 31 March 2009.
[8] IPCC (2007) *Climate Change 2007: Mitigation of Climate Change*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.
[9] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009.
[10] Genesis Now (undated) 'Dairy Energy', www.genesisnow.com.au/html/dairy.htm, accessed 16 February 2009.

as well as the low minimum energy performance standards or direct government financial subsidies to encourage improvements. This is starting to change, for instance, in some countries like Australia where a long term drought is forcing dairy farmers to review and improve their water usage practices. Once dairies around the world start to investigate opportunities for profitably improving their energy and water productivity they will find there are many technologies and strategies available, however, to-date none have done so to Factor 5 levels to our knowledge. Hence this sector study does not present a particular case study of a leading dairy as with other sector studies, but rather outlines the range of options to significantly improve resource productivity. These include:

- Using energy efficient lighting with timers for dairy facilities, especially reducing artificial light levels in the morning as the natural light levels increase.
- Installing the latest high efficiency refrigeration compressors and insulation.
- Improving building design to improve natural ventilation and shading to reduce space cooling or heating to maintain conditions for milk storage or processing.
- Using variable speed drives to better match the flow requirements of milk through the system to reduce pumping costs.
- Reducing leaks in equipment such as air compressors and HVAC systems.
- Avoiding the need to heat water for cleaning purposes by using low energy intensive methods such as closed loop flow systems, Ultra-Violet treatment, Ultrasonic treatment, solar hot water systems, using cold water where appropriate, and continuous circulation.
- Reducing energy use for pumping water in irrigation by using the leading irrigation techniques outlined in Chapter 4, including using natural rainwater harvesting methods and other ways to assist rain to flow naturally through the landscape, such as natural sequence farming.

Further to the traditional activities undertaken on dairy farms a number of processing steps can be undertaken in dairies that can significantly reduce energy consumption both onsite and throughout the supply chain. Combining dairy processing on the farm can also provide opportunities for additional revenue raising activities such as producing milk solids - dewatering milk onsite to be used in milk products such as cheese, yoghurt, and ice cream, will reduce both the energy needed onsite to store milk and the energy needed to transport the milk solids to processing plants, as milk contains 98 per cent water. Dairy farms can also reduce their indirect energy use from artificial fertilizers and pesticides by proactive steps to improve resilience of landscapes and the soil fertility to improve the production of biomass for onsite organic composting and energy generation. The range of options to improve indirect energy usage include:

- Collecting waste biomass for energy production and returning the resulting waste to the soil for nutrient replacement.
- Using the water removed from milk onsite on the farm.
- Selecting and cultivating deep rooted pastures, preferably renewable perennials with selective annuals, to create productive sources of biomass for energy and organic composting. This also helps to minimise soil disturbance and enhance soil fertility which is critical for sequestering soil carbon.
- Avoiding importing artificial fertilisers, which have high levels of embodied energy, and excessive artificial nutrients onto the farm.

- Minimising the use of energy intensive herbicides.

Through this combination of energy efficiency, onsite renewable energy generation, landscape management, water management, and reducing energy intensive farm imports, dairy farms can achieve Factor 5 improvements in resource productivity. To-date, there is no dairy farm that has done all of the items outlined above, however, some have implemented a number of the options with successful results.

Whole System Approach to Achieving Factor 5 in Dairies

IPCC Strategy One: Energy Efficiency Opportunities

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, and can deliver up to 40 per cent improvements on current practices. It is advised that dairies use well-designed single lamp fittings with high efficiency, long life, tri-phosphor lamps. These will reduce the power required to achieve the 240 Lux lighting level recommended in dairy sheds. Emerging LED technologies will enable energy use to be reduced further by allowing particular parts of the dairy that require higher levels of light than others to be illuminated without lighting the entire building to these levels.

Reducing Electricity Needed for Ventilation Systems

Natural ventilation should be encouraged through good design of building facilities on a dairy farm. Natural ventilation is enhanced by ensuring high-sided facilities which are oriented to maximise air flow from the most regular wind direction. If there is capacity to open windows or doors on each side of the facility this enables wind to be utilised irrespective of its direction. If the facility has a peaked roof, it can also be designed to enable warm air to exit the top of the building. In cases of high or low weather conditions HVAC systems with improvements such as those outlined in Chapter 2 can be used.

Milk Cooling and Refrigeration

The cost of operating a refrigeration system can be up to 20-25 per cent of the total energy costs for a dairy farm.[11] The efficiency of a refrigeration system is measured by the 'Coefficient of System Performance', referred to as the 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 and 98 per cent 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 refrigeration systems suited to the refrigeration load are selected and that the COSP is high. The 'Nar Nar Goon' Dairy Farm in Australia uses a novel approach to pre-cooling water which is used to cool the milk via a refrigerator running on off-peak electricity. They store water in a deep bore which keeps the water at 6-10 degrees compared to dam water which is normally 16-20 degrees. The cold water is then used to pre-cool the milk coming from the cows before having to be further cooled to 4°C.[12]

Avoid the Need to Heat Water

Heated water is used to clean out pipes in a dairy after milking. These are the pipes through which milk is collected during the milking process. Normally cleaned with hot water the pipes can be cleaned instead with cold water with a cleaning agent, or through other ways of maintaining clean piping, including using ultrasound/IR or UV to remove bacteria and maintain health and safety standards. The reason that hot water is used rather than cold water with a cleaning agent is due to

[11] Environmental Technology Best Practice Programme (1999) *Reducing waste for profit in the dairy industry*, *Good Practice Guide (GG242)*, Environmental Technology Best Practice Programme, UK.

[12] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009.

tradition rather than science.[13] The Konwak Dairy in Victoria, Australia, has reduced hot water needs by using lower temp water and appropriate cleaning detergents.[14]

IPCC Strategy Two – Fuel Switching

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 (see strategy three below).[15] 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 allows for more precise control of water temperature. Therefore, LPG can be a cost-competitive method of heating water in dairies, providing that the price is right. Such instantaneous LPG water heaters heat water as it is required for use, keeping the heat losses to a minimum and so compensate for LPG's higher cost. LPG-fired water heating will also emit 83 per cent less CO_2 than electric water heating.[16]

IPCC Strategy Three – Heat and Power Recovery

Recovering Heat from Milk

When milk is farmed from cows it is typically at 38°C and needs to be cooled to 4°C, hence this heat can be recovered using a heat-exchanger for use in the dairy. The heat removed from the milk from 200 cows in one day is about 163 kWh.[17] As Geoff Andrews from Genesis Now explains,[18] '*An AU$500 heat exchanger, which can be fitted to refrigeration equipment, could heat 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 other heat exchangers. An energy efficient water heating system combined with a heat exchanger, tanks and controls, costs about AU$4,000 compared with about AU$2,000 for a standard system of similar capacity.*

IPCC Strategy Four - Renewable Energy

Solar Water Heating

One obvious way dairy farms could save energy is by using solar water heating. Trials at a cheese manufacturing factory in Italy show that, on clear days solar energy can replace up to 70-80 per cent of the conventional heating energy demand for a 500 litre copper cheese vat. The process in this particular vat requires 45-90 kWh of heat energy per ton of processed milk. In the trials, water is initially heated to up to 82°C by a solar water heater with 21.6 m^2 collectors. The hot water then passes through the vat's jacket at 1,500 litres per hour and warms milk to 45°C in about 25 minutes.[19] Other trials on various cooling processes show that solar energy can partly or completely power the absorption refrigeration process.

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[13] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009.
[14] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009.
[15] Genesis Now (undated) 'Dairy Energy', www.genesisnow.com.au/html/dairy.htm, accessed 16 February 2009.
[16] Genesis Now (undated) 'Dairy Energy', www.genesisnow.com.au/html/dairy.htm, accessed 16 February 2009.
[17] Genesis Now (undated) 'Dairy Energy', www.genesisnow.com.au/html/dairy.htm, accessed 16 February 2009.
[18] Genesis Now (undated) 'Dairy Energy', www.genesisnow.com.au/html/dairy.htm, accessed 16 February 2009.
[19] Tuszyński, W.B., Diakowska, E. and Hall, N.S. (1983) *Solar energy in small-scale milk collection and processing*, FAO Animal Production and Health Paper 39, www.fao.org/docrep/003/X6541E/X6541E00.HTM, accessed 9 April 2009.

Anaerobic Digesters

The main renewable energy that dairy farms are likely to shift to, however, is anaerobic digesters coupled with heat recovery. A good example of the value of this technology is the use of it at Norswiss Dairy Farms,[20] a 1,100-cow dairy farm in the USA. In 2006, Norswiss installed an 848 kW combined heat and power system. The system uses anaerobic digester gas (about 65 per cent methane) from cow manure to fuel a Jenbacher biogas engine. Heat is recovered from the engine's jacket water and intercoolers, and is used to heat the water that maintains the digester tank's temperature. The system then exports to the grid all unused generated electricity – over 6,500,000 kWh or enough energy for over 600 homes. Installation costs were US$2.7 million and Norswiss Farms is expecting to save at least US$70,000 per year in reduced energy costs, with additional savings due to increased cow comfort, decreased animal mortality, and a better manure management plan.[21] Norswiss Farms will also gain revenue earnings from the sale of electricity to the grid, which means overall the system will pay itself back in less than 10 years.[22] US electricity prices are very cheap by global comparison, and therefore in Europe such a system would pay itself back even sooner, i.e. under 6 years. Norswiss is not alone in realising the benefits of utilising cow manure in this way. Microgy Inc, a developer of renewable energy production facilities, has partnered with Pacific Gas and Electric and the US Dairy Association to explore the potential to create renewable energy from biogas using their state-of-the art digester systems in California. One 2007 installation, a grid-connected 60 kW biogas generator that runs on cow manure, was developed in partnership with international award winning farmer Mike Gallo of Joseph Gallo Farms.[23] The three parties are also partnering with other digester companies in a program that will provide both electricity to PG&E's grid and biogas to PG&E's pipelines for delivery to power generators.[24]

Biomass Systems for Energy – Enabling a Complete Whole System Approach[25]

Under the umbrella of biomass energy systems dairy farms are not restricted to only converting effluent from cows into methane for electricity and heating,[26] as it is also possible to use other biomass sources available from the farm, such as waste woody biomass from vegetation, or cellulose from pastures and grasses. The waste biomass is gasified and used to produce electricity and hot water,[27] and the by-product from the gasifier is charcoal (referred to in this case as 'Biochar') which can be used to improve soil productivity. Thus by combining manure and woody biomass together, significant energy production levels are achieved, providing well above the needs of the individual farm. The Biochar produced from biomass gas generation further helps improve soil productivity which enables more biomass to be produced, and the cycle positively

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[20] MidWest CHP Application Centre (2007) 'Norswiss Farms: 848 kW CHP Application – Project Profile', US MidWest CHP Application Centre in partnership with US Department of Energy, USA, www.chpcentermw.org/pdfs/Project_Profile_Norswiss_Farms_Final.pdf, accessed 9 April 2009.
[21] MidWest CHP Application Centre (2007) 'Norswiss Farms: 848 kW CHP Application – Project Profile', US MidWest CHP Application Centre in partnership with US Department of Energy, USA, www.chpcentermw.org/pdfs/Project_Profile_Norswiss_Farms_Final.pdf, accessed 9 April 2009.
[22] MidWest CHP Application Centre (2007) 'Norswiss Farms: 848 kW CHP Application – Project Profile', US MidWest CHP Application Centre in partnership with US Department of Energy, USA, www.chpcentermw.org/pdfs/Project_Profile_Norswiss_Farms_Final.pdf, accessed 9 April 2009.
[23] Pacific Gas and Electric (2007) "Pacific Gas and Electric Company Energizes Governor's 2007 Inaugural 'Green Dream' Celebration With Cow, Soy And Sun Power Carbon Neutral Event powered by PG&E, with help from Microgy, Inc. and Joseph Gallo Farms' Biogas', PG&E Media Release, PG&E, USA, www.pge.com/about/news/mediarelations/newsreleases/q1_2007/070104.shtml, accessed 20 February 2009.
[24] Pacific Gas and Electric (2007) "Pacific Gas and Electric Company Energizes Governor's 2007 Inaugural 'Green Dream' Celebration With Cow, Soy And Sun Power Carbon Neutral Event powered by PG&E, with help from Microgy, Inc. and Joseph Gallo Farms' Biogas', PG&E Media Release, PG&E, USA, www.pge.com/about/news/mediarelations/newsreleases/q1_2007/070104.shtml, accessed 20 February 2009.
[25] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009
[26] Gasification Australia (undated) website, www.gasificationaustralia.com/, accessed 31 march 2009.
[27] Gasification Australia (undated) website, www.gasificationaustralia.com/, accessed 31 march 2009.

feedbacks on itself. As Glenn MacMillan from Genesis Now states, "*Climatic changes we are faced with going into a carbon/energy/natural resource constrained world will influence how we farm our land into the future. Humans need natural resources to survive, just like the natural systems we extract our produce from also need natural resources to survive. It is a cycle, a whole system cycle. Dairy farming can be the stepping stone to recovery, by committing to increasing production, increased profits and reduced inputs the natural systems can return… but there is one condition… we need to repair, restore, protect and regenerate the 'engine' room, our soils which produces the biomass which can make dairies net renewable energy producers.*"[28]

IPCC Strategy Seven: Materials Efficiency (Water)

Irrigation of pastures and drinking water for cows uses the vast majority of the total water usage on dairy farms.[29] Hence the focus here is on ways to both improve water irrigation efficiency and recycle water on dairy farms to reduce dependence on irrigated water.

Efficient Use of Water in Dairy Sheds

The other main area of water usage on dairy farms is the use of and cleaning of dairy sheds. A 2000 survey by Dairy Australia found that, '*the most efficient dairy sheds used under 2,000 litres of water per cow each year. At the other end of the scale, the most water used (by dairy sheds) was 38,000 litres per cow each year – almost 20 times more than the best performers. The average was 9,600 litres per cow each year'.*[30] Dairy Australia and the UK Milk Development Council[31] found that the cleaning of dairy sheds contributes to approximately 7-10 per cent of an average dairy farm's water usage and have outlined their findings and potential Factor 5 water saving solutions in a freely available online resource.[32]

Water Efficient Irrigation

As the Agriculture Sector Study showed, there are several different types of irrigation systems. From the viewpoint of water productivity, flood irrigation, is the most inefficient system. However, it is still used on the majority of dairy farms in, for instance, Australia.[33] As a first step dairy farms should consider ways to improve irrigation efficiency through shifting to the best sprinkler systems that improve water efficiency by 30-40 per cent.[34] Further dairy farmers can shift to using sub-surface drip irrigation as it has several advantages, including: reducing evaporation loss, lower operating pressure/energy requirements, and more flexibility of design than sprinkler systems.[35] Research is underway to assess the scale of water savings possible through using sub-surface drip irrigation on dairy farms.[36]

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[28] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009
[29] Save Water (undated) 'Water Use on Dairy Farms', www.savewater.com.au/about-us/using-savewater-com-au/index.php?sectionid=99&linkid=99, accessed 30 April 2009.
[30] Dairy Australia (2009) 'Saving Water in Dairies', www.dairyaustralia.com.au/Farm/Milking-Cows/Saving-Water-in-Dairies.aspx, accessed 30 April 2009.
[31] Milk Development Council (2009) *Farm Management: Effective Use Of Water on Dairy Farms*, Milk Development Council, www.dairyco.org.uk/adx/aspx/adxGetMedia.aspx?DocID=888,10,6,1,Documents&MediaID=1511&Filename=MDC+Effective+use+of+water+for+web.pdf, accessed 4 May 2009.
[32] Dairy Australia (2009) 'Saving Water in Dairies', www.dairyaustralia.com.au/Farm/Milking-Cows/Saving-Water-in-Dairies.aspx, accessed 30 April 2009.
[33] Save Water (undated) 'Save irrigation water', www.savewater.com.au/about-us/using-savewater-com-au/index.php?sectionid=104&linkid=104, accessed 20 April 2009.
[34] Land and Water Australia (2009) *National Program for Sustainable Irrigation – Irrigation Stories*, National Program for Sustainable Irrigation, Land and Water Australia, www.npsi.gov.au/national-program-sustainable-irrigation/irrigation-stories, accessed 30 April 2009.
[35] Finger, L. (2009) *Feasibility and Sustainability of Subsurface Drip Irrigation in Pasture Production*, Victorian Department of Primary Industries, www.dpi.vic.gov.au/DPI/nrenfa.nsf/LinkView/63C9B6BFF3C7C226CA2574FD000C06F073F4ECDB559620FBCA2574FD0011EE69/$file/Subsurfacedripirrigation.pdf, accessed 4 May 2009.
[36] Finger, L. (2009) *Feasibility and Sustainability of Subsurface Drip Irrigation in Pasture Production*, Victorian Department of Primary Industries,

Reduce the Need to Cool Milk and Return Water from Milk to the Farm (Energy/Water Nexus)

A novel approach to enable water to be recycled back onto the farm arises from the fact that milk from cows is made of up of 95 per cent water and most of the milk produced is not used for milk but rather for producing milk solid products, such as butter, cheese, powdered milk etc. Hence there is potential to dewater milk on the dairy farm to produce milk solid products rather than outsourcing and transporting the milk (and water) to a dairy processor, and return the water back onto the farm.[37] This provides dairy farms with a regular and reliable source of water that is independent of the weather. Dewatering also helps farms to significantly reduce energy usage as dairy farms have to keep their milk cool to 4 degrees by law until it is transferred to a dairy processor. So there is potential to reduce by 95 per cent the energy currently used for cooling milk[38] by dewatering the milk onsite and thus leaving only 5 per of the original volume of milk needing to be cooled and then transported.

Dewatering also has benefits further up the supply chain as it saves the dairy processing plants from having to dewater the milk themselves, significantly reducing the volume to be handled, in order to make cheese, butter, yogurt and other value added milk solid products.[39] This applies to a significant percentage of the dairy industry, with only 20 per cent of the milk ending up on the shelves of supermarkets in Australia as milk.[40]

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www.dpi.vic.gov.au/DPI/nrenfa.nsf/LinkView/63C9B6BFF3C7C226CA2574FD000C06F073F4ECDB559620FBCA2574FD0011EE69/$file/Subsurfacedripirrigation.pdf, accessed 4 May 2009.

[37] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009.

[38] Dairy Australia (2007) *Dairy 2007 Situation and Outlook*, Dairy Australia, www.australiandairyfarmers.com.au/adffv2/downv2.nsf/(Contentbykey)/PublicationsDairy2007SituationOutlook/$file/Dairy%202007%20Situation%20&%20Outlook.pdf?open, accessed 9 April 2009.

[39] MacMillan, G. (2009) Personal Communication with Glenn MacMillan, Genesis Now engineer, 20 March 2009.

[40] Dairy Australia (2007) *Dairy 2007 Situation and Outlook*, Dairy Australia, www.australiandairyfarmers.com.au/adffv2/downv2.nsf/(Contentbykey)/PublicationsDairy2007SituationOutlook/$file/Dairy%202007%20Situation%20&%20Outlook.pdf?open, accessed 9 April 2009.

2) Industry Sector Study – Food Industry (Bakeries)

The Potential for Factor 5 Improvements in Bakery Resource Productivity

Baking bread is one of the oldest industries on Earth, dating as far back to the start of civilization in the Neolithic era. Given this length of experience in bread making it would be easy to assume that today bakeries are extremely efficient, and any energy and water saving opportunities would have already been found. However, most bakeries today are highly inefficient (in terms of their energy and water consumption) and significant potential exists to achieve Factor 5 improvements in the consumption of both electricity and natural gas - with electricity used for the building services, refrigeration and in electric ovens, and natural gas used for gas-fired ovens. However, as energy and water costs only make up approximately 3 per cent of the total costs for most bakeries the potential for energy savings has not been a high priority. In the near future, as the need to reduce energy and water consumption is becoming more acute, all sectors will need to identify such opportunities, and take cost effective measures. Furthermore, there are significant benefits to pursuing Factor 5 improvements in energy productivity. For example, heat generated in a bakery that is not harnessed, and thus wasted, due to little or no insulation or heat recovery, leads to uncomfortable ambient temperatures for staff. In fact, many bakeries are actually paying to overheat their staff as well as baking their bread, with the uncomfortable working conditions being a key factor in the industry's ability to attract and retain staff. In this sector study we focus mainly on Factor 5 energy productivity opportunities with Factor 5 opportunities for water also covered briefly.

The opportunity for such multiple benefits from an energy efficiency program in the bakery sector has motivated a number of governments to work with the sector to help them identify and trial a range of options. An example is the '*Energy Efficiency Best Practice Program*' by the Australian Government Department of Industry, Tourism and Resources, from 1998-2003.[41] This program worked with energy experts Alan Pears and Geoff Andrews and the large bakery chain in Australia, Bakers Delight, to explore energy efficiency opportunities. As part of this process Bakers Delight created a 'Showcase Bakery' where they trialled and measured a number of energy efficiency initiatives and provided a detailed analysis of the energy productivity improvements that could be made across many of the elements of a standard bakery. Applying some of these energy efficiency solutions enabled Bakers Delight in their showcase bakery to cost effectively achieve an overall 40 per cent energy productivity improvement, and a resulting net 48 per cent reduction in greenhouse gas emissions, from energy efficiency improvements in the electric ovens (see Figure 1.2). Due to time constraints, some of the improvements made to the prototype electric oven could not be included in the gas ovens. Hence, even further improvements in energy productivity are still possible in the showcase bakery simply by applying the same techniques used on the electric ovens to the gas ovens.

[41] Department of Industry, Tourism and Resources (DITR) (2003) *Case study: Achieving results in the bread baking sector,* DITR, www.ret.gov.au/energy/Documents/best%20practice%20guides/energy_case_studies_bakersdelight.pdf, accessed 3 March 2009.

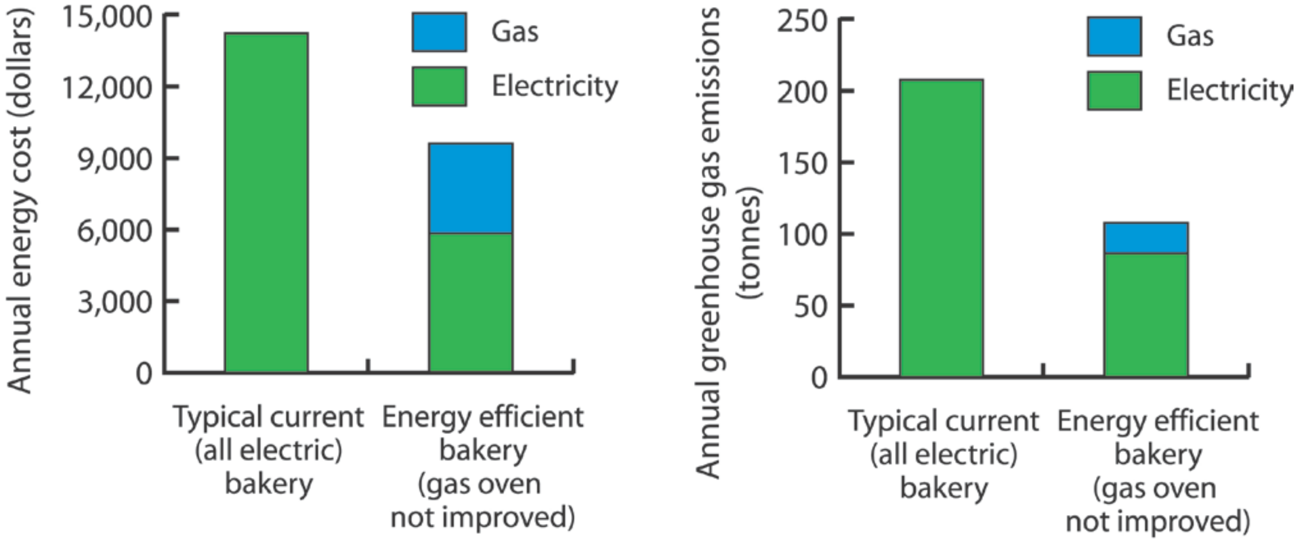

Figure 1.2: (a) Annual Energy Cost, and (b) Annual Greenhouse Gas Emission Reductions, in the Bakers Delight Showcase Bakery

Source: Based on the findings of DITR (2003)[42]

In addition, the research by Pears and Andrews also showed that over time further improvements in energy productivity could be achieved through improved design of ovens, the design and layout of bakeries, and utilising the latest energy efficient lighting, glass and insulation technologies. It is clear from this research, and the results of the Bakers Delight showcase, that a combination of strategies can lead to improvements in energy productivity in the typical bakery of as much as 70-80 per cent. In the following part we outline some of the results from this analysis, having received peer review from Mr Pears and Mr Andrews. These opportunities, plus concerns about climate change, are encouraging bakeries to identify options to minimise their energy consumption and offset their greenhouse gas emissions by improving energy productivity, purchasing renewable energy, purchasing carbon offsets, and reducing emissions from transportation. Stonemill Bakehouse in Canada is one such bakery that has committed to becoming climate neutral, as is Ferguson Plarre Bakehouses in Melbourne, Australia. Both are seeking to become the first climate neutral bakery in the world. We consider their stories next. Of the two, Ferguson Plarre Bakehouses have focused far more on energy productivity gains in an effort to move towards becoming climate neutral, hence their case study is considered in more detail.

Best Practice Case Studies

Stonemill Bakehouse, Canada

The Stonemill Bakehouse is a family business, founded over a hundred years ago, and in 2007 committed to becoming climate neutral (meaning no net direct or indirect greenhouse gas emissions).[43] To achieve this Stonemill have focused on reducing electricity demand and purchasing the remaining electricity from renewable sources, the first bakery in the world to do so. In 2008 they achieved a 12 per cent decrease in demand, with a strategy to achieve further reductions in the future. Stonemill Bakehouse also reduces its transport ‘food miles’ by sourcing organic ingredients locally where possible, and preferring suppliers that can provide products manufactured and produced from recycled materials for packaging and other consumables where

[42] Department of Industry, Tourism and Resources (DITR) (2003) *Case study: Achieving results in the bread baking sector,* DITR, www.ret.gov.au/energy/Documents/best%20practice%20guides/energy_case_studies_bakersdelight.pdf, accessed 3 March 2009.
[43] Stonemill Bakehouse (undated) ‘Environmental Stewardship’, www.stonemillbakehouse.com/English/080~healthy_planet/010~environmental_stewardship/, accessed 17 April 2009.

possible. Stonemill are also reducing water usage through further retrofits to machinery and low-flow restroom fixtures.[44] By using locally grown organic ingredients, they are also contributing to reducing the run-off of fertilisers and pesticides into local rivers and streams.[45]

Ferguson Plarre Bakehouses, Australia

Like Stonemill Bakehouse, Melbourne based Ferguson Plarre Bakehouses is a family business, also founded over a hundred years ago, that operates as a central bake house with over 50 franchise shop fronts. Ferguson Plarre Bakehouse's stated environmental goal is to, *'Minimise our environmental footprint by targeting zero impact across our operations and our value chain. Over time we declare our intent to be a net contributor to environmental enhancement'.*[46] As with Stonemill Bakehouse, they have invested in energy efficiency improvements, achieving over 70 per cent energy productivity (electricity and gas) improvements through a range of measures. For example, having invested in energy efficient lighting, they found that the bulbs were so much brighter than the older lighting system, they only needed half the number of lights. Thus throughout their building every second lighting socket is empty. Ferguson Plarre Bakehouses also use a fully programmable and automated lighting system to ensure lights are switched off when not in use, and sensor lighting is used in all toilets and designated offices.

With savings from these energy efficiency initiatives, over time they plan to lift the percentage of accredited green power renewable energy purchased to 15-20 per cent renewable energy by 2015-2020. In the meanwhile they have replaced some of their electric ovens with gas-fired ovens, which produce 70 per cent less emissions than those using fossil fuel based electricity, and are then offsetting the emissions through accredited offsetting schemes, which also includes their transport related emissions. Ferguson Plarre Bakehouses have achieved such large energy efficiency improvements by:

- Investing in the most energy efficient, state-of-the-art ovens and cooking equipment sourced from Europe.
- Co-locating ovens side by side in an insulated room in order to concentrate the heat, as well as using radiant heat from one oven to heat others.
- Separating the bank of ovens from the rest of the bakery with appropriate room insulation (not just insulation) and air tight doors, minimising the heat loss into adjoining spaces.
- Recovering heat from cooling baked products with exhaust fans to provide heat for the main production area in winter.
- Pre-heating water entering hot water systems with energy recovered from equipment, such as compressors in refrigerators.
- Using solar hot water systems for the staff and the office (as the majority of the hot water used in the bakery is provided using a heat exchanger).
- Rain water toilet flushing for office and staff facilities.
- Installing over 100,000 litres of rainwater tanks.

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[44] Stonemill Bakehouse (undated) 'Baked with Green Power', www.stonemillbakehouse.com/English/080~healthy_planet/030~green_power/, accessed 17 April 2009.
[45] Stonemill Bakehouse (undated) 'Baked with Green Power', http://www.stonemillbakehouse.com/English/080~healthy_planet/030~green_power/, accessed 17 April 2009.
[46] Ferguson Plarre Bakehouses (undated) 'Environmental Achievements', www.fergusonplarre.com.au/Cakes-Savouries/Greenhouse-Challenge.html, accessed 19 February 2009.

- Currently working on a project to enlarge the roof's water catchment area by 300 per cent and double the water storage capacity to 240,000 litres.
- Currently in the process of installing a water filtration process that will convert rainwater into potable water to use in the production process. This would save 2.2 million litres per year (50 per cent of their total water usage) based on the long term average rainfall recorded in the area.
- Using a Diesel Hybrid truck to deliver baked goods from the central bakehouse to the shop fronts, improving fuel efficiency by 25-30 per cent, while actively reducing the number of trips by half.
- Using a fully integrated SCADA (Supervisory Control and Data Acquisition) energy and water monitoring system to enable 'real time' monitoring of all water and energy consumption (electricity and gas) and greenhouse gas emissions. All staff can see this information displayed on a screen in a high-traffic corridor - which has helped to encourage behaviour change and reduce emissions by a further 7-10 per cent.

A Whole System Approach to Factor 5 in Bakeries

IPCC Strategy One: Energy Efficiency

Improving Oven Energy Efficiency (by at least 20 per cent)

As can be seen from Figure 1.3 below, electric ovens used in bakeries are the major energy user, consuming over 50 per cent of the energy used by a bakery. Heat generated by ovens also adds significant load to the building's requirement for air-conditioning. Hence efforts to reduce energy consumption should start here, especially as commercial ovens tend not to be optimised for energy consumption or heat loss.

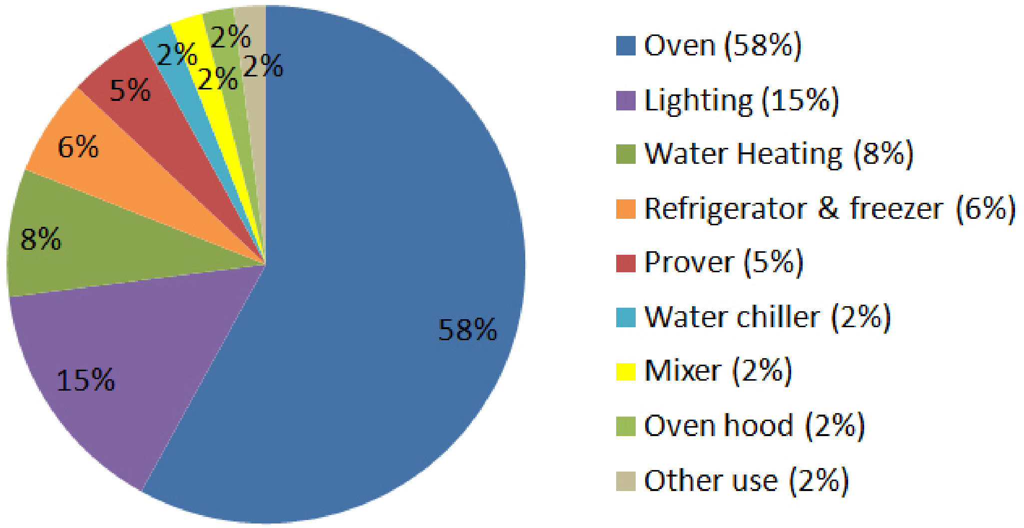

Figure 1.3: Components of energy consumption in typical bakery equipment (not including space heating and cooling)

Source: Based on the findings of DITR (2003)[47]

Commercial ovens are usually made by smaller scale manufacturers, and, due to the low volume of ovens manufactured, tend not to go through the same rigorous design processes as, for instance, domestic appliances. Few countries have minimum energy standards for oven manufacturing. Thus there is significant room to improve the design and energy efficiency of ovens. For instance, many ovens are either poorly insulated or have no insulation at all. Energy experts Pears and Andrews calculated that the ovens in Bakers Delight had an average thermal resistance of only R = 0.22.[48] This compares poorly with typical insulation values in a house ceiling of R = 3. If Bakers Delight used insulation to R = 2.5 around their ovens this would reduce radiated heat by as much as a 75 per cent. This is very important because such a reduction in radiation dramatically reduces the air-conditioning load required in a bakery, and improves the comfort of staff. Insulation is available which provides higher than R = 2.5, enabling a Factor 5 reduction in radiated heat from ovens. With this data Bakers Delight immediately improved the insulation of their ovens in their showcase store. Bakers Delight were also able to further improve the energy efficiency of their ovens by 20 per cent by:[49]

[47] Department of Industry, Tourism and Resources (DITR) (2003) *Case study: Achieving results in the bread baking sector,* DITR, www.ret.gov.au/energy/Documents/best%20practice%20guides/energy_case_studies_bakersdelight.pdf, accessed 3 March 2009.

[48] Pears, A (2004) Energy Efficiency – Its Potential: Some Perspectives And Experiences. Background paper for International Energy Agency Energy Efficiency Workshop, Paris April 2004 http://www.naturaledgeproject.net/Documents/IEAENEFFICbackgroundpaperPearsFinal.pdf

[49] Department of Industry, Tourism and Resources (DITR) (2003) *Case study: Achieving results in the bread baking sector,* DITR, www.ret.gov.au/energy/Documents/best%20practice%20guides/energy_case_studies_bakersdelight.pdf, accessed 3 March 2009.

- Ensuring the oven has fully insulated solid doors and no glass;
- Attaching seals to all four sides of each oven's doors to reduce heat loss;
- Using an energy efficient light that switches on when the door is opened; and
- Installing an individual programmable temperature and time control for each oven, as every hour that an empty oven is operating, approximately 10 kWh of energy is consumed.

Further improvements to oven design can deliver at least 30 - 40 per cent savings, as most bakery ovens have metal joints that provide a thermal bridge from the inside to the outside, allowing heat loss. Thus even if the oven is insulated, heat will still be lost through these thermal metal bridges. For comparison, addressing this issue and eliminating metal bridges in domestic fridges improved energy efficiency by over 30 per cent.

Oven Hood Insulation (74 per cent)

Oven exhaust hoods can be designed and operated to reduce electricity consumption and increase the amount of heat recovered by the system, as in the Bakers Delight case, where improvements where made, '*to the design of the oven hood, and adjustable variable speed drives were fitted on supply and exhaust fan motors. Motors now run on low speed until a light beam detector indicates that one of the oven doors is opened* [and hence releasing hot air into the room]*, when the motors switch to high speed. Back draft dampers have been installed in the ceiling space to prevent the infiltration or loss of conditioned air when the fans are switched off* [minimising the amount of heat that is able to leave the room other than through the exhaust system and into the heat exchanger].'[50] This reduced energy loss from oven hoods by 74 per cent.

Lighting Energy Efficiency (55-90 per cent)

Lighting uses roughly 15 per cent of the energy used by bakeries. Bakers Delight found that '*Improvements to lighting innovations reduced the lighting power from 3.4 to 1.5 kW while maintaining the lighting levels similar to those found in a standard Bakers Delight bakery. The lighting system, which includes both high-efficiency T5 fluorescent lamps and 35W metal halide lamps, is split into two circuits - one being small enough to provide safe access when the bakery is not operational*.'[51] This represents a 55 per cent energy efficiency saving. Considering that the Bakers Delight trial was undertaken six years ago, greater savings are possible (between 60-95 per cent) today with the latest lighting technologies, including WLEDs.

Prover Energy Efficiency (35 per cent)

A 'Prover' is a piece of equipment used in bakeries to store bread in controlled conditions to allow the yeast to ferment the sugars in the dough. A Prover in a standard Bakers Delight bakery holds up to five racks in a single compartment with one door and one heating and humidifying system. The prototype system installed at the Showcase Bakery includes two Prover cabinets, one with two sealed doors, each holding one rack, and the other with three sealed doors, each holding one rack. Each of the cabinets has an independent heating and humidifying system. This innovative design reduces heat and energy loss as bakers only remove single racks. This saved 35 per cent of energy previously used.

Location and Design of Cool Rooms (20-40 per cent)

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[51] Department of Industry, Tourism and Resources (DITR) (2003) *Case study: Achieving results in the bread baking sector,* DITR, www.ret.gov.au/energy/Documents/best%20practice%20guides/energy_case_studies_bakersdelight.pdf, accessed 2 March 2009.

Another major area of inefficiency arises because the cool rooms for bakeries tend to be located close to rooms containing the ovens, and heat is transferred through the walls, the roof and the floor slab from the ovens into the freezer, requiring greater levels of refrigeration to compensate. Hence many bakeries are using electricity to overcome this heat transfer and to keep their cool rooms 'cool', rather than taking steps to reduce the heat transfer. As explained above, Ferguson Plarre Bakehouses have addressed this and are achieving significant energy savings. This strategy improves energy productivity because fridge compressors run more efficiently if there is a small temperature difference between the internal cool air of the fridge and external air temperatures. Bakeries which do not have adequate insulation on or around their ovens and other cooking equipment, tend to achieve ambient indoor temperatures of 30 degrees. Thus locating the fridge and freezers in separate insulated rooms will help the fridge to run more efficiently. Finally, it is possible for new fridge design to be at least 50 per cent better than commercial and domestic fridges on the market today.

Using Glass to Keep the Hot Food Hot (20-30 per cent)

Bakeries usually sell hot food and bread at the front of their store displayed under glass, but virtually none of them use double glazed glass or the new modern low-e glass that is the equivalent of triple glazing. If they did, it would help to keep the hot food hot, while reducing the cooling load needed to cool the customer area of the bakery, and reducing the discomfort if customers touch the hot glass.

Behaviour change of Staff (7 per cent)

Ferguson Plarre Bakehouses[52] has enhanced its efforts to bring about behaviour change by installing a fully integrated SCADA (Supervisory Control And Data Acquisition) energy monitoring system which all staff can see, finding that behaviour change can achieve another 7 per cent energy reduction in bakeries.[53] For the same production value, energy consumption at a bakery in Mascot (excluding air-conditioning) was found to vary from 127 to 162 kWh per day, a difference of 35 kWh. This is through staff:

- Switching off unused decks in the oven with the thermostat,
- Switching off the oven and the prover when finished,
- Not using air-conditioning on cool days,
- Loading mixers to maximum capacity (i.e. not mixing half batches if avoidable),
- Reducing compressed air usage for skinning dough,
- Reducing loaf depanner compressed air usage,
- Reducing compressed air usage for clean-up,
- Monitoring oven and griddle flame characteristics to reduce inefficiency,
- Maintaining compressed air hoses,
- Monitoring power factor correction, and
- Switching off lights when not needed.

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[52] Ferguson Plarre Bakehouses (undated) 'Environmental Achievements', www.fergusonplarre.com.au/Cakes-Savouries/Greenhouse-Challenge.html, accessed 19 February 2009.
[53] Department of Industry, Tourism and Resources (DITR) (2003) *Case study: Achieving results in the bread baking sector,* DITR, www.ret.gov.au/energy/Documents/best%20practice%20guides/energy_case_studies_bakersdelight.pdf, accessed 2 March 2009.

IPCC Strategy Two: Fuel Switching

The main opportunity for fuel switching in a bakery is with the fuel used in the ovens. Either electricity or gas can be used, each with its own method for reducing the environmental impact. With an electric system the electricity can be sourced from renewable sources, however it is not always possible to source 100 per cent green energy from the local energy providers. If gas ovens are used instead of electric, the greenhouse gas emissions are reduced by up to 70 per cent, assuming that the electricity is produced from a fossil fuel source, and the remaining 30 per cent can be offset. Hence the preferable option is to have electric ovens powered by green power, generated on or off site, however using gas with offsets until such green power is a viable transition option, as in the case of Ferguson Plarre Bakehouses.

IPCC Strategy Three: Heat Recovery

Ferguson Plarre Bakehouses recover the heat generated from their refrigeration processes and use it to heat the water required for cake production, saving 100 tons of carbon dioxide per annum. Utilising exhaust fans the bakehouses recover heat from freshly baked products to heat the main production area in winter, saving a further 2,600 tons of carbon dioxide per year. This has contributed significantly to their overall energy demand reduction of 62 per cent.[54]

IPCC Strategy Four: Use of Renewable Energy

Since energy makes up about 2 per cent of bakery costs, transitioning to purchasing 100 per cent accredited renewable energy, if available, is affordable, and even more so when combined with the energy efficiency savings strategies outlined above that show how a bakery can at least halve energy usage and costs. As we explained above, Stonemill Bakehouse in Ontario, Canada already purchases 100 per cent renewable energy.

IPCC Strategy Five: Feedstock Changes

Many bakeries are seeking to source ingredients from nearby farmers to reduce the food miles and the embodied energy of the key ingredients they use. Many bakeries are also choosing to use organic ingredients which, as shown in the agricultural case study, helps to further reduce the energy demand of food production because organic agriculture does not use energy intensive artificial fertilisers and chemicals. Stonemill Bakehouses, featured above in the case study section, is implementing both of these strategies.[55]

IPCC Strategy Seven: Materials Efficiency (Water and Materials)

Water Productivity Improvements

Bakeries can significantly reduce water consumption and the production of wastewater, through first reducing their water usage, then secondly sourcing more of their water from rainwater harvesting and storage with appropriate onsite water treatment. In 2004, the Baking Industry Association of Victoria (BIAV), Australia and Monash University's Department of Management investigated ways of reducing water use practices in bakeries.[56] It was found that the water was used in the following categories: a) within the product, b) by the equipment, c) as part of cleaning

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[54] Ferguson Plarre Bakehouses (undated) 'Environmental Achievements', www.fergusonplarre.com.au/Cakes-Savouries/Greenhouse-Challenge.html, accessed 19 February 2009.
[55] Stonemill Bakehouse (undated) 'Environmental Stewardship', www.stonemillbakehouse.com/English/080~healthy_planet/010~environmental_stewardship/, accessed 17 April 2009.
[56] Baking Industry Association of Victoria (2004) *Victorian Baking Industry Water Wise Project Final Report,* Baking Industry Association of Victoria, www.smartwater.com.au/projectDocs/doc24.pdf, accessed 30 April 2009.

practices, and d) in the amenities (internal and external), with the majority of water used in cleaning and amenities, rather than the actual product. While wastage of water was variable between bakeries, most of the water used was wasted through inefficient cleaning procedures, with the review finding that significant savings of 72,000 litres of water per annum could be achieved. [57] This may seem a lot but there are a number of inefficient cleaning methods used in bakeries, for instance, hoses used without control devices waste a significant percentage of water. This can be addressed through:

- Collecting solids from the floor and equipment by sweeping and shovelling into containers before wetting equipment or floors.
- Installing simple flow control devices onto the hose, that can reduce water flow by up to 50 per cent.
- Using pressure cleaners which can use up to 80 per cent less water than a normal hose for many cleaning tasks.

Other opportunities to reduce water usage come from re-examining traditional practices such as washing in a commercial sink. Commercial sinks require about 40 litres to fill, while a water efficient dish washer uses as little as 15 litres, and also saves time. Furthermore the BIAV report found that:

- '*The culture of the bakery significantly impacts on water usage, where traditional practices (particularly hosing down floors) adversely impacts upon the adoption of water conservation practices, and*
- *There was a lack of awareness of the available water saving devices that exist, such as dual-flush toilet systems, trigger nozzles, flow control devices, circulating pumps (with timers), and [dish] washing machines.*'[58]

Thus with cultural changes and upgrading to more water efficient equipment, bakeries can achieve significant reductions in water usage. If bakeries implement these water saving procedures then they can satisfy much of their water demand through rainwater harvesting, water tank storage, and appropriate onsite water treatment, as demonstrated previously in the Ferguson Plarre Bakehouse's case study. These innovations in water demand management and supply provide a roadmap for bakeries to achieve net 80 per cent reductions in water demand from the mains water supply.

Materials Productivity

As explained in the introduction to the industry section, improvements to materials efficiency and recycling rates help to significantly reduce energy usage. Ferguson Plarre Bakehouses has reduced waste to landfill by 50 per cent through recycling. Their latest bulk raw material handling equipment eliminates approx 450 bags/wk, which halves their requirements for land fill, and they have also reduced their co-mingled waste by 50 per cent. Ferguson Plarre Bakehouses are further reducing energy used throughout the overall supply chain, by recycling all printer cartridges and materials used onsite. They have also shifted to email delivery of all hard-copy journals and mail that is possible, and they have reviewed all administrative procedures with the goal of creating a

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[57] Baking Industry Association of Victoria (2004) *Victorian Baking Industry Water Wise Project Final Report,* Baking Industry Association of Victoria, www.smartwater.com.au/projectDocs/doc24.pdf, accessed 30 April 2009.
[58] Baking Industry Association of Victoria (2004) *Victorian Baking Industry Water Wise Project Final Report,* Baking Industry Association of Victoria, www.smartwater.com.au/projectDocs/doc24.pdf, accessed 30 April 2009.

paperless office in order to reduce the associated embodied energy of office supplies, particularly paper.

In the USA, customers are demanding more environmentally friendly approaches to packaging for bakeries. So USA packaging manufacturers are switching from oriented polystyrene (OPS) to polyethylene terephtalate (PET) for plastic packaging because PET is easier to recycle.[59] Recycling PET packaging saves roughly half the energy compared to that of plastic packaging processed from virgin materials. Bakeries can also further improve materials efficiency and recycling by promoting the use of calico and reusable plastic bags, and recycling all materials used from plastic, paper, and other materials.

IPCC Strategy Eight: Reducing Non-CO2 Emissions

Greenhouse gas reduction options for bakeries also include ensuring refrigerants with high global warming potentials do not leak, and are even replaced with low carbon alternatives. For instance, a significant percentage of emissions from supermarkets comes from the use of HFC refrigerants in large quantities, often in leaky systems. Using low carbon alternative refrigerants can also reduce energy requirements. According to the IPCC's *Fourth Assessment Report,* '*It was found that up to 60% lower greenhouse gas emissions values can be obtained by using alternative refrigerants'.*[60]

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[59] Martin, K. (2008) 'Bakery packaging goes green', *Modern Baking,* 1 November, 2008*,* http://modern-baking.com/bakery_management/bakery_packaging_goes_1108/, accessed 17 March 2009.

[60] IPCC (2007) *Climate Change 2007: Mitigation of Climate Change*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, see 'Residential and Commercial Buildings'.

3) Industry Sector Study – Food Retail Industry (Supermarkets)

The Potential for Factor 5 Improvements in Supermarket Resource Productivity

Significant potential exists to improve efficiency in supermarkets because currently most supermarkets are incredibly wasteful with their energy and water usage. George Monbiot in his 2006 book *Heat* sums it up well, and shows that per square metre, supermarkets use six times more electricity than factories, explaining that,

> *As you come through the door of a supermarket, a unit above your head 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 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.*[61]

Figure 1.4 shows the wide range of areas where supermarkets consume electricity and hence where it can be used more efficiently. The obvious suspects are refrigeration, lighting and spaced heating and cooling, as with residential and commercial buildings, however, supermarkets have a number of unique sets of equipment that warrant particular attention.

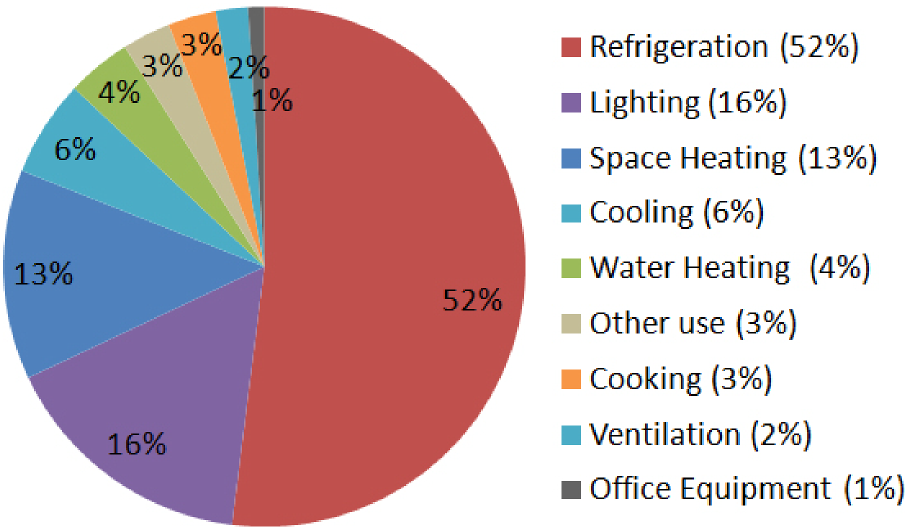

Figure 1.4: Components of electricity consumption in the average Australian supermarket, 1999

Source: Based on the findings of the Australian Grocery and Food Council (2003)[62]

Supermarkets also use significant amounts of water. They have all the water uses of typical retail outlets, such as sanitary fixtures, amenities and landscape irrigation, but they also use large quantities of water to cool the condenser units for the supermarket's extensive refrigeration systems.[63] Large supermarkets tend to use cooling towers and thus water as part of their HVAC

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[61] Monbiot, G. (2006) *Heat: How to Stop the Planet Burning*, Allen Lane, Penguin Press UK.

[62] Australia Food and Grocery Council (2003) *Environment Report 2003*, Produced by the Australian Food and Grocery Council as part of its Eco-Efficiency Agreement with Environment Australia (now the Department of Environment and Water), www.afgc.org.au/cmsdocuments/AFGC%20Enviro%20Rpt%202003_Final.pdf, accessed 13 November 2008.

[63] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.

systems to cool the building, and water is also used in the cleaning and preparation of the fresh food and produce before being put onto display shelves.[64]

In this case study we show that through the application of a range of activities at least 75 – 80 per cent energy and water efficiency savings can be achieved. These activities include: effective building design; efficient lighting; enhancements to appliances and equipment, such as using glass doors and improved insulation to reduce refrigeration loads; improved internal heat flow management, such as using aluminium foil in the ceiling to reduce re-radiated heat back into fridges; alternative refrigerants; heat recovery and co-generation systems; and effective design of in-house operations such as bakeries. We also show that virtual grocery shopping can achieve roughly Factor 5 greenhouse gas reductions depending on the mode of transport the supermarket delivery vans choose to use.

Best Practice Case Studies

Whole Foods Markets, USA

Whole Foods Market Inc. owns and operates a chain of natural and organic foods supermarkets, with operations in the United States, Canada, and the United Kingdom. As of October 2008, they had 275 stores with approximately 53,000 employees. Whole Foods has achieved significant reductions in energy consumption - as much as up to 50 per cent in its stores - by adopting a range of energy efficiency measures, including:[65]

- Installing more efficient lighting.[66]
- Using more efficient equipment, like motors in fridges and other equipment.
- Covering and using doors to contain refrigerated areas.
- Upgrading automatic controls to switch appliances, equipment and lights off when not in use.
- Using better insulation to reduce heating and air-conditioning needs.
- Using low embodied energy materials where possible.[67]

Kathy Loftus, global leader for sustainable engineering maintenance and energy management for Whole Food Markets stated that '*two of their stores have already received LEED Silver certification, in Florida and Texas with another 20 LEED projects underway*.'[68] In 2006, Whole Foods became the first retail chain in the USA to source 100 per cent of its energy from renewable sources - a total of 1.2 million MWhs (1200 million kWh) per year – through both installing solar panels at some of their stores, and purchasing renewable energy credits through the market.[69] This made them the first US Fortune 500 company to source all their energy from renewable sources.[70] They have also converted their fleet of trucks to run on biodiesel fuel and have a comprehensive reduce, reuse and

[64] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.
[65] Whole Story (2009) 'Energy Reduction - Super-Sized', *The Green Journal California*, 28 February 2009, www.thegreenjournal.ca/2009/02/28/energy-reduction-super-sized/, accessed 17 March 2009.
[66] Environmental Stewardship Awards (2009) 'Whole Foods Market receives Orion award for energy reduction', www.oriones.com/esa.php?e=41, accessed 17 March 2009.
[67] Green Bean Chicago (2006) 'LEED-CI Certified: Whole Foods Market in South Loop', *Green Bean Chicago.com*, 20 November 2006, www.greenbeanchicago.com/southgate-market-whole-foods-market-south-loop/, accessed 17 March 2008.
[68] Minor, C. (2008) 'Southeast Portland Fred Meyer store hopes to take a LEED', *Oregan Business News*, 4 November 2008, www.oregonlive.com/business/index.ssf/2008/11/southeast_portland_fred_meyer.html, accessed 20 March 2009.
[69] Whole Foods Market (2008) *Whole Foods Market 2008 Annual Report,* Whole Foods Market, www.wholefoodsmarket.com/company/pdfs/ar08.pdf, accessed 17 March 2008.
[70] Maxfield, J. (2006) 'Whole Foods Market Becomes First Fortune 500 Company to Offset 100% of Its Energy Usage', *The Inspired Economist*, 7 September 2006, http://inspiredeconomist.com/2006/09/07/whole-foods-market-becomes-first-fortune-500-company-to-offset-100-of-its-energy-usage/, accessed 17 March 2008.

recycle program.[71] More recently Whole Foods have begun to work on water conservation initiatives, and some stores have converted to flush-less urinals.

Tesco Supermarkets, UK

Tesco, based in the United Kingdom, is the third-largest grocer in the world operating approximately 2,100 stores in the UK, and 1,600 stores in the US, Asia, Ireland, and Central Europe. Tesco.com is also Britain's largest online grocery delivery service. Tesco is showing what is possible through their new eco-stores which use up to 50 per cent less energy than a similar structure built just three years earlier.[72] Tesco's stated commitment is to further reduce by half the energy consumption of all their new and existing stores and distribution centres by 2020,[73] and they have already built several of these highly energy-efficient stores in the UK to test the new equipment and ideas they intend to roll out across the business.

In a 2007 speech Tesco CEO Sir Leahy listed the strategies that Tesco are using to achieve these improvements in energy productivity, namely:[74]

- Designing better buildings to reduce the heating and cooling required,
- Making their roofs and ceilings lower to reduce the space they need to heat and cool,
- Using more efficient lighting with timers and motion detectors to reduce unnecessary use,
- Using and designing more south-facing windows to maximise the amount of natural light,
- Using more efficient fridges and re-designing fridges to keep more of the cold air in,
- Installing equipment that recycles cold air from their chiller cabinets to use as an alternative to air-conditioning on the sales floor,
- Reducing embodied energy by using timber instead of steel where possible in their new stores, and
- Installing photo-voltaic panels on some of their stores around the world.

> *Tesco's Rama 1 store in Thailand, which opened over three years ago, has solar panelling over its whole roof. Our environment store in Turkey will have an earth and grass roof, and will use geothermal power. Our new business in California is also placing a big emphasis on saving energy and carbon emissions: we have announced today that its distribution centre will include California's largest roof installation of photovoltaic solar power.*

Sir Leahy, Tesco CEO, 2007[75]

Tesco is investing £100 million in a Sustainable Technology Fund to find more practical ways to use renewable energy sources like solar and wind power, and to help deliver these green technologies of the future. Tesco is also building wind turbines on land that was previous car-parking space to contribute to the energy of 20 of its stores,[76] as well as looking at ways to

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[71] Whole Foods Market Inc (undated) 'Green Action', www.wholefoodsmarket.com/values/green-action.php, accessed 17 March 2008.
[72] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review,* Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[73] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review*, Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[74] Leahy, T. (2007) 'Tesco, Carbon and the Consumer', speech transcript, 18th January 2007, www.tesco.com/climatechange/speech.asp, accessed 17 March 2008.
[75] Leahy, T. (2007) 'Tesco, Carbon and the Consumer', speech transcript, 18th January 2007, www.tesco.com/climatechange/speech.asp, accessed 17 March 2008.
[76] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review*, Tesco Inc.,

positively influence consumer purchases by reducing the price of its low-carbon and energy efficient products. For example, one of their goals was to sell 10 million energy efficient light bulbs within a one year period. By cutting the cost of these efficient light bulbs by 50 per cent, sales quadrupled and they were able to achieve their objective.[77] Tesco has also created a Green Clubcard Points system that gives customers reward points for their environmental activities such as using calico bags, recycling their mobiles and printer cartridges at Tesco stores.[78]

Tesco has built a number of environmentally friendly stores all over the world, and in 2008 Tesco claimed to have new environmentally friendly stores in Korea, Malaysia, Thailand, China, Japan, Czech Republic, Poland, Hungary and Turkey. Tesco has also committed to halving the transport emissions associated with distributing their goods worldwide by 2012, compared to 2006 levels.[79] But to achieve their climate change mitigation goals, it is also vital that they retrofit existing stores. According to their CEO Sir Leahy, '*much of the technology first trialled in our environmental stores is now becoming standard in all our stores.'*[80] .

Tesco's work on water efficiency, like energy efficiency, is impressive at some of their stores and begs the question of why it is not being rolled out to all their stores globally. In 2005, Tesco claimed that, '*We have spent £740,000 on water saving programmes, including leakage reduction, push taps, urinal controllers, rainwater recovery and water data loggers. This year we hope to install rainwater recovery units at 33 stores. Our calculations show that at our Chichester store 1,733 m^3 of rainwater could be collected from the roof. Once filtered, this water will be used by toilets and urinals, thus reducing water use from the mains supply by 30-40%.'*[81] But then in April 2009, Tesco announced that, *'Yorkshire Water conservation experts will be carrying out detailed water audits at hundreds of stores, identifying areas where potential savings could be made. Yorkshire Water technicians have already visited 71 Tesco stores across the country and first estimates suggest the project could reduce Tesco's water consumption by 155 million litres a year – enough to fill 64 Olympic swimming pools*.'[82] The second announcement suggests that Tesco's water efficiency initiatives are in the early stages. This is a start but much more could be done to cost effectively reduce water consumption by as much as 80 per cent as we will outline below in IPCC Strategy 7 – Materials Efficiency.

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www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[77] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review*, Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[78] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review,* Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[79] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review,* Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[80] Leahy, T. (2007) 'Tesco, Carbon and the Consumer', speech transcript, 18th January 2007, www.tesco.com/climatechange/speech.asp accessed 17 March 2008.
[81] Tesco (2005) *Tesco Corporate Social Responsibility Report- Energy and Water Tesco*, Tesco Inc., www.tesco.com/csr/g/g1.html accessed 6 May 2009.
[82] The Star (2009) 'Tesco aiming to reduce water consumption', *The Star*, 16 April 2009, www.thestar.co.uk/business/Tesco-aiming-to-reduce-water.5176262.jp, accessed 6 May 2009.

A Whole System Approach to Factor 5 in Supermarkets

IPCC Strategy One: Energy Efficiency

Lighting (60-90 per cent)

Fifteen to twenty per cent of the average supermarket's energy is used just for lighting, both to light the space for customers, and to provide feature lighting for products, such as refrigerators and fruit bins. Innovations in Compact Florescent Lamps (CFLs) and Light Emitting Diodes (LEDs) allow an appropriate combination of both to achieve savings of 70-90 per cent in lighting energy and are now being widely used. Painting the undersides of shelves white (instead of black, as done in many supermarkets) also makes the most of the light generated by increasing reflection back onto the products. It should also be noted that fluorescent lamps operating in cold environments have been found to produce less light, so replacing them with LEDs or externally sourced light (e.g. via fibre optic cables) can achieve larger than expected savings. LEDs can also direct their light more accurately, improving overall efficiency of delivered light to food, where fluorescents lose efficiency through losses in bouncing light around the shelving.

Installing Glass Screens on Vertical Cold Food Display Cabinets and Open Freezers (Approximately 70 per cent)

As Figure 1.4 shows, roughly half of energy usage in a supermarket is for refrigeration. Display cases commonly carry large refrigeration loads, especially vertical open display cabinets, and in an attempt to provide easy access for customers, supermarkets often use open vertical food cabinets, or large open freezers (see Figure 1.5).

Figure 1.5: An example of open vertical display cabinets

Source: Taken by Michael Smith

These vertical cold-food display cabinets contribute significantly to the refrigeration load for two main reasons: firstly because a large amount of this refrigerated air is lost from open freezers and food display cabinets; and secondly, the large open surface area enables, '*heat and moisture* [to be] *exchanged between the products in the cabinet and the store environment* [to] *affect the* *refrigeration load, defrost and environment...and condensation on walls and products.'*[83] Infiltration of moist warm air from outside the cabinets causes about 60-70 per cent of the cooling load for a typical open vertical display cabinet.[84] The reason why this percentage is so large is because this warm air carries water vapour which then requires the refrigerator to go through a number of energy intensive processes trying to maintain the temperature at which it is set. In particular, it is the phase changes from water vapour (2.4 MJ/L), to the liquid phase to ice (0.22 MJ/L) then back to the liquid phase via an inefficient defrost system that adds heat to the refrigerator ~ up to 0.9 kWh/litre flowing into the case. Thus isolating refrigerated cabinets from the surrounding warm moist air and extra water vapour and installing glass doors will limit the amount of warm water vapour that the refrigeration unit will have to additionally cool and heat, and therefore reduces the energy consumption of the cabinets.

Results from a laboratory test that evaluated glass doors on an open five-deck display case show a reduction of the total cooling load of the case by 68 per cent[85] (see Figure 1.6).

Figure 1.6: An example of glass doors on food display cabinets

Source: Taken by Michael Smith

Hence, in most supermarkets a large amount of this refrigerated air is lost from open freezers and food display cabinets, wasting significant amounts of electricity. In an attempt to provide easy access for customers, refrigeration equipment is often comprised of open vertical cabinets, or open large freezers. Modelling and empirical testing by US engineer[86] has shown that if open refrigerators and freezers had glass doors, or sliding covers, they would require 70 per cent less energy, and also preserve food more effectively. Glass doors also provide other benefits, such as ensuring even temperatures are maintained more easily throughout the food cabinets to meet Food

[83] Arias, J. (2005) *Energy Usage in Supermarkets - Modelling and Field Measurements*, Doctoral Thesis, Division of Applied Thermodynamics and Refrigeration Department of Energy Technology Royal Institute of Technology, www.diva-portal.org/diva/getDocument?urn_nbn_se_kth_diva-217-1__fulltext.pdf, accessed 20 March 2009.
[84] Axell, M. (2002) *Vertical Display Cabinets in Supermarkets – Energy Efficiency and the Influence of Air Flows*, Doctoral thesis, Chalmers University of Technology.
[85] Walker, D.H., Faramarzi, R.T. and Baxter, V.D. (2003) 'Investigation of Energy-Efficient Supermarkets Display Cases', 21st International Congress of Refrigeration, Washington DC, USA.
[86] Faramarzi, R. et al (2001) 'Anti-Sweat Heaters in Refrigerated Display Cases', *ASHRAE Journal*: Faramarzi, R. et al (1998) 'The Cool Case of the Cool Case Engineered Systems', *ASHRAE Journal*, May 1998; Faramarzi, R. et al (2002) 'Performance and Energy Impact of Installing Glass Doors on an Open Vertical Deli/Dairy Display Case', *ASHRAE Transactions: Symposia*; Faramarzi, R. et al (1999) 'Effects of Low E-Shields on the Performance and Power Use of a Refrigerated Display Case', *ASHRAE Transactions: Symposia*; Faramarzi, R. et al (1998) 'Comparing Older and Newer Refrigerated Display Cases', *ASHRAE Transactions: Symposia.*

and Health regulations and ensure food does not go off.[87] The normal commercial refrigeration case without a glass door leads to extreme air leakage, cooling the store and thus contributing to the requirement for space heating.

Supermarket space heating, which contributes roughly 13 per cent of total energy use, is largely needed to mitigate this cooling effect of open freezers and food cabinets. Furthermore it is often supplied by air vents under open refrigerated equipment, further adding to energy waste as this warm air is added to the refrigeration cabinet and thus then goes through the process of being cooled.

Selection of Efficient Refrigeration Equipment (50 per cent)

There is scope to halve energy consumption from refrigeration in many supermarkets over time by replacing old freezers and refrigeration equipment with the latest more efficient models. An investigation of the Whole Foods market in St. Louis, USA found that sophisticated new systems for its refrigerated and frozen food cases had achieved significant energy cuts.

> *Whole Foods* [installed a] *refrigeration system to lower energy use and reduce the possibility of refrigerant leaks…* [also using] *LED lights (using 51% less energy than fluorescent lamps and providing improved illumination); integrated night curtains on open multi-deck cases to save energy when the store is closed; 'Innovator' doors with advanced insulation and anti-sweat heat features to provide 20% energy savings; and energy-efficient fan motors and E-plus coils in refrigerated and frozen food cases.*[88]

Whole Foods Market claims that 85 per cent of its equipment purchased is US EPA Energy Star certified as very efficient.[89]

Radiant Heat Barrier Below the Ceiling

A downward facing radiant barrier below the ceiling (or replacing the ceiling) cuts radiant heat compared with the usual white tiled ceilings in supermarkets. White tiles are very effective emitters of heat in the IR spectrum. Thus, with no radiant barrier, they can re-radiate heat back downwards and into the often open freezers. The radiated heat from the ceiling can have a marked effect where supermarkets have open frozen food sections as more energy is needed to keep these areas at the required temperature.

Radiant barriers, once installed can block up to 95 per cent of the heat radiated down by the roof so it can't reach the insulation. Radiant barriers usually consist of a sheet of aluminium foil reinforced by fibreglass and fire-resistant materials. Aluminium foil is used as it reflects thermal radiation very well and because it emits very little heat also. Aluminium foil is also a poor emitter of radiated heat compared to the usual white tiles found on supermarket ceilings, which is why aluminium foil has been used as radiant barriers in indoor ice rinks for years. Ice rinks use low-emissivity ceilings constructed of aluminium foil, fibreglass and fire-resistant materials installed close to the existing ceiling so that it reduces, by 90-95 per cent, the amount of heat radiating from the warm ceiling

[87] Faramarzi, R., Coburn, B. and Sarhadian, R. (2002) *Performance and Energy Impact of Installing Glass Doors on an open Vertical Deli/Dairy Display Case*, Associate Member ASHRAE.
[88] Thaye, W. (2009) 'Got Sustainability?', *Refrigerated and Frozen Foods Retailer*, 21 October 2008, www.rffretailer.com/Articles/Cover_Story/BNP_GUID_9-5-2006_A_10000000000000450006?from=email, accessed 18 March 2009.
[89] Green Bean Chicago (2006) 'LEED®-CI Certified: Whole Foods Market in South Loop', www.greenbeanchicago.com/southgate-market-whole-foods-market-south-loop/, accessed 17 March 2008.

back down to the cold ice, resulting in a smaller annual refrigeration load.[90] Low emissivity ceilings also reduce condensation problems and improve lighting.

IPCC Strategy Three: Power and Heat Recovery

In March, 2008, Whole Foods Inc. opened the first supermarket to generate most of its power onsite through a heat recovery process using fuel cells. The fuel cells convert heat exhaust into electricity and heat for heating and cooling, turning potential waste into usable energy with an energy conversation rate of 90 per cent. Whole Foods Market Inc. claims that with its use of heat recovery technologies they will be able to generate electricity, heat, and almost all the hot water needed to operate the supermarket. In collaboration with the UK Carbon Trust and Brunel University, Tesco is also investigating more traditional methods of heat recovery, looking at both tri and co-generation combined heat and power technology (which captures and reuses heat). They estimate there is potential to save over 10,000 tons of CO_2 per year using this technology.[91]

IPCC Strategy Four: Renewable Energy

As mentioned above, Tesco is investing in green power for its new eco-stores and also installing solar panels on new stores around the world, as the large roof surface of supermarkets lends itself to large solar arrays. Supermarket car parks tend to similarly be very large and could have some form of a micro wind generator incorporated into them with minimal disruption to parking availability, of which Tesco is currently in the process of installing to contribute to powering 20 of its stores. Whole Foods Market Ltd are also using fuel cells in one of its new stores to generate electricity from heat recovery. They claim that this new Whole Foods Market store will be virtually self sufficient in terms of energy. Thus, through a combination energy efficiency initiatives, fuel cells, solar panels and wind turbines it is possible for supermarkets to at least get close to being able to power themselves with onsite renewable energy sources.

IPCC Strategy Six: New Process/Product Design

George Monbiot in his bestselling publication *Heat*[92] outlined a simple alternative that would reduce greenhouse gas emissions by as much as a Factor of 5 - Virtual Shopping. As Monbiot explains, large amounts of energy is saved here because the food does not need to be stored and presented in a supermarket but rather it can be stored in warehouses, ordered online and delivered to the customers' home. A UK Royal Commission on Environmental Pollution[93] found that on average warehouses (per square metre) use about 35 per cent heating and 29 per cent electricity compared to supermarkets. These savings are achieved because warehouses can store more food per square metre and because warehouses do not need to run heating systems to keep customers warm to counteract the cooling effect of open freezers and open cooled food display cabinets. Monbiot states that a contact working for a supermarket chain claimed that the electricity used in warehouses made up only 5 per cent of total supermarket electricity usage. Thus the potential energy savings for supermarkets from shifting more of their sales to online sales, could be as high as Factor 20 – that is 95 per cent reductions, compared to the current wastefully designed supermarkets.[94] Critics of virtual shopping argue that there are still emissions from increased

[90] CADDET (1999) *Potential Energy Efficiency Savings in Ice Rinks*, IEA, OECD, http://oee.nrcan.gc.ca/Publications/infosource/Pub/ici/caddet/english/pdf/R339.pdf, accessed 24 February 2009.
[91] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review*, Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[92] Monbiot, G (2006) *Heat: How to Stop the Planet Burning*, Allen Lane, Penguin Press UK.
[93] Monbiot, G (2006) *Heat: How to Stop the Planet Burning*, Allen Lane, Penguin Press UK, p191
[94] Monbiot, G (2006) *Heat: How to Stop the Planet Burning*, Allen Lane, Penguin Press UK, p196.

transportation. It is true that with virtual shopping, supermarket chains now need to deliver food to customers' homes. However, the UK Department of Transport has found that if supermarkets deliver their produce via vehicles to people's homes this would take the equivalent of three cars off the road. Most of us drive to our supermarkets which can be often miles away from our homes. As Monbiot shows, car journeys account for 62 per cent of visits to shops, almost all outside town centres that require dedicated trips.[95] Thus shifting to online shopping and delivery by vans could save as much as 70 per cent greenhouse gas emissions. Tesco supermarkets are also in the process of shifting their online shopping deliveries to using battery-powered vans, saving around 330 tons of CO_2 each year.

IPCC Strategy Seven: Materials Efficiency (Water and Materials)

Water Productivity Improvements

Supermarkets use 50 per cent of their total water usage to cool the condenser units for the supermarket's extensive refrigeration systems.[96] Large supermarkets also tend to use water in cooling towers as part of their HVAC systems. Hence again there is a strong energy/water efficiency nexus for this sector. All the strategies outlined in IPCC Strategy One, which enable a reduction of refrigeration and cooling loads, also significantly reduce the amount of water needed. The other main areas of water usage are in amenities, cleaning of food and food preparation areas, and irrigation of landscaping. The energy/water nexus is not so strong in these areas. We consider next each of these areas of major water usage for supermarkets and show how significant water savings can be achieved.

- *Evaporative Condensers*: As explained in the introduction to this section, evaporative condensers are used with supermarket refrigeration systems to cool refrigerated display cases, frozen food sections, and freezers. On average, half of the water used by a supermarket is used in the evaporative condensers.[97] There are, broadly, three strategies to reduce water usage in evaporative condensers:

  1. *<u>Reduce Refrigerated Cooling Loads to Save Energy and Water</u>* - As shown above, the refrigeration loads of most supermarkets can be reduced significantly, over 60 per cent, through using glass doors on open display cases, and other strategies outlined above in IPCC Strategy One. This reduces the number of evaporative condensers and the amount of water used by over 60 per cent.[98]

  2. *<u>Reduce the Amount of Water in Evaporative Condensers</u>* - Experts have found that it is possible to improve the water efficiency of the evaporative condensers by between 10 and 60 per cent.[99] Combining these two steps enables up to an 80 per cent reduction in the amount of water used in evaporative condensers for supermarkets.

  3. *<u>Using Low Water Alternatives to Evaporative Condensers</u>* - Hybrid alternatives to evaporative condensers can be used to provide the same service while using at least 80 per cent less water. This technology was recently developed by Muller Industries and is known

[95] Monbiot, G (2006) *Heat: How to Stop the Planet Burning*, Allen Lane, Penguin Press UK, p195.
[96] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.
[97] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.
[98] Alan Pears (2009) Private Communication with Alan Pears, Adjunct Professor, RMIT, and Director, Sustainable Solutions, 6 May 2009.
[99] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.

as the Muller 3C Cooler[100] - which enables 80 per cent reductions in cooling systems for commercial buildings. Muller Industries Dricon units provide a number of advantages, including: 75-80 per cent lower water consumption; it eliminates the risk of Legionella and hence the need for chemical treatment;[101] uses significantly less energy compared to equivalent air-cooled systems (30 per cent); and uses just 5-10 per cent more energy than evaporative condensers (see the Commercial Building Sector Study).

- Cooling Towers: Most large supermarkets use cooling towers as part of their HVAC systems.[102] Cooling towers use the cooling effect of evaporating water to remove heat from water circulating through the HVAC chillers. Reducing the cooling load on the supermarket by at least 50 per cent by the measures outlined above in IPCC Strategy One enables 50 per cent reductions in the amount of water used. In addition, as shown in the Commercial Building Sector study, it is possible to significantly reduce the water used in cooling towers. Finally, water cooling systems with cooling towers can be completely replaced and retrofitted with hybrid air/water cooling systems which do not need any cooling towers.[103] This was shown in the Commercial Building Sector Study to reduce water usage for cooling by over 80 per cent.[104] Rainwater can meet much of the reduced water needs of hybrid air/water systems to further reduce water usage from mains water by up to 90 per cent.[105]

- Amenities: As outlined in the Residential and Commercial Building Sector Study, numerous innovations exist - dual flush toilets, waterless urinals, and reduce flow taps - to enable significant reductions in water usage within supermarkets.[106]

- Reducing Water Usage in Cleaning: While using a broom to clean surfaces uses much less water, health and sanitation regulations often require the food to be rinsed off hard surfaces with water. [107] The traditional hose and nozzle uses more than two times more water than water efficient varieties.[108]

- Irrigation: As outlined in the Residential and Commercial Building Sector Study much can be done through water sensitive landscape design, including planting drought tolerant plants and using sub-surface drip irrigation to reduce water usage in the supermarket's surrounding landscape.

- Alternative Water Sources Collection and Use: Supermarkets usually have roof space and require enormous parking lots, hence rainwater and storm water run off is significant. It is possible to use treated rainwater and stormwater for evaporative condensers, cooling towers, toilets and landscape irrigation, thus enabling significant reduction in mains water usage.

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[100] Australian Institute of Refrigeration, Air-Conditioning and Heating (AIRAH) (2003) 'Case Study: Award winner makes its mark', *EcoLibrium*, August 2003, AIRAH, www.airah.org.au/downloads/2003-08-f01.pdf, accessed 8 May 2009.
[101] Australian Institute of Refrigeration, Air-Conditioning and Heating (AIRAH) (2005) 'Last Days of the Cooling Tower?', *EcoLibrium*, March 2005, www.airah.org.au/downloads/2005-03-F01.pdf, accessed 8 May 2009.
[102] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.
[103] Save Water (2007) 'Product Innovations: Winner – Muller Industries', www.savewater.com.au/programs-and-events/savewater-awards/past-winners-finalists/200607-winners/product-innovations, accessed 8 May 2009.
[104] Australian Institute of Refrigeration, Air-Conditioning and Heating (AIRAH) (2003) 'Case Study: Award winner makes its mark', *EcoLibrium*, August 2003, AIRAH, www.airah.org.au/downloads/2003-08-f01.pdf, accessed 8 May 2009.
[105] Muller Industries (2009) '5 Stars for Melbourne University', www.mullerindustries.com.au/home/newsApr2009_2.shtml, accessed 8 May 2009.
[106] Stasinopoulos, P., Smith, M., Hargroves, K. and Desha, C. (2008) *Whole System Design: An Integrated Approach to Sustainable Engineering*, Earthscan, London, and The Natural Edge Project, Australia.
[107] Alliance for Water Efficiency (2009) 'Supermarket Introduction', www.allianceforwaterefficiency.org/Supermarket_Introduction.aspx, accessed 6 May 2009.
[108] Sydney Water (undated) 'Factsheet: Spray Nozzels', www.sydneywater.com.au/Publications/FactSheets/SprayNozzles.pdf#Page=1, accessed 17 September 2008; Sydney Water (undated) 'Factsheet: Spray Guns', www.sydneywater.com.au/Publications/FactSheets/SprayGuns.pdf#Page=1, accessed 17 September 2008.

Materials Productivity

There are numerous opportunities to reduce material use, waste and improve recycling rates for supermarket chains. For instance, in just over a year, from 2006 to 2007, Tesco was able to save over 132,000 tons of cardboard boxes and other packaging by replacing their disposable transport and display products with reusable plastic 'green trays'. Also, in 2006, instead of throwing out excess food, they started donating it from 35 stores to the charity 'Fare Share', which distributes it to needy people. Tesco achieves diversion of 71 per cent of waste from landfill and are seeking to achieve 80 per cent, or Factor 5, recycling levels in 2009. They are also making it easier for their customers to recycle by providing recycling facilities at most of their larger stores. Across the UK, to improve upon this, Tesco is investing in new technologies to make recycling easier, such as introducing automated recycling machines that sort plastic, metal, and glass so customers don't have to. The containers are then shredded so more material can be stored in each container before it fills up, reducing the number of collection trips required. On average, the automated recycling machines are collecting over 1 million items each week, with the ultimate aim of recycling these materials into their packaging, thereby closing the recycling loop.

Whole Foods Market Ltd has also initiated a wide range of in-store measures to reduce material usage and waste, and to encourage high levels of recycling. This has led to a reduction of landfill waste of up to 75 per cent in some regions. These measures include: banning plastic bags in all stores; only selling rechargeable batteries instead of disposable batteries; providing recycling bins for glass and plastic; and providing collection boxes for cell phones and ink jet cartridges. They have also tried to engage the community by hosting recycling drives for old electronics.

IPCC Strategy Eight: Non-CO2 Reductions

Greenhouse gas reduction options for supermarkets also include ensuring refrigerants with high global warming potentials do not leak, and are even replaced with low carbon alternatives. A significant percentage of emissions from supermarkets comes from the use of HFC refrigerants (in large quantities) in often leaky systems.

> *In all, emissions of the refrigerant can be greater than the emissions due to the system energy use. Refrigerant leakage rates are estimated to be around 30%. Leakage rates can be reduced by system design for tightness, maintenance procedures for early detection and repairs of leakage, personnel training, system leakage record keeping and end-of-life recovery of refrigerant. Alternative system design involves for example, applying direct systems using alternative refrigerants, better containment, distributed systems, indirect systems or cascade systems. It was found that up to 60% lower greenhouse gas emissions values can be obtained by using alternative refrigerants.*

IPCC, *Fourth Assessment Report*, 2007[109]

Many supermarket chains in Europe have replaced HFC refrigerants with alternative refrigerants that are more energy efficient and which have lower global warming potentials.[110] In 2007, the US EPA initiated the GreenChill programme[111] to reduce ozone-depleting and high global warming refrigerants through the use of advanced refrigeration technology with a range of commercial

[109] IPCC (2007) *Climate Change 2007: Mitigation of Climate Change*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, see 'Residential and Commercial Buildings'.
[110] Tesco (2008) *Sustainability Report: More than the weekly shop: Corporate Responsibility Review*, Tesco Inc., www.tescoreports.com/downloads/tesco_crr.pdf, accessed 17 March 2008.
[111] US EPA (undated) 'Green Chill Programme', www.epa.gov/greenchill/, accessed 18 March 2009.

supermarket partners. This is starting a cost effective shift in commercial refrigeration in the supermarket industry in the USA.[112]

[112] US EPA (undated) 'Green Chill Partners', www.epa.gov/greenchill/gcpartners.html, accessed 18 March 2009.

4) Industry Sector Study – The Hospitality Industry (Restaurants)

The Potential for Factor 5 improvements in Restaurant Resource Productivity

The environmental impacts of restaurants are often ignored in books on sustainability, however, the direct and indirect environmental impacts are significant. For instance, the choice of what type of cooking equipment can lead to dramatic energy and water savings, for instance the option to provide customers with appropriately filtered water from the tap, rather than bottled water, results in 2000 times less energy being used per litre.[113] Also, few appreciate that globally there are now over 8 million restaurants and 300,000 hotels, many of which have restaurants.[114] According to a Canadian study, people's expenditure in restaurants is one of the largest indirect ways that we cause greenhouse gas emissions outside our home.[115] In the USA almost one in four meals are bought in a restaurant.[116] US citizens spend roughly half their food budget at restaurants,[117] and most restaurants directly use at least 15 times the energy of a typical household.[118] In the USA, restaurants spend approximately US$5 billion on energy annually, which is the equivalent of about US$161 per restaurant seat per year.[119] Restaurant operators' top five energy end-uses are; cooking (32 per cent), space heating, cooling and ventilation (28 per cent), lighting (15 per cent), refrigeration (13 per cent), and water heating (12 per cent). These five together contribute to over 90 per cent of restaurants' energy usage.[120]

Thus, restaurants can directly improve their energy productivity and reduce greenhouse gas emissions through, building design, using energy efficient cooking equipment, energy efficient lighting, using less hot water, and using solar hot water systems. Using water more efficiently in restaurants not only reduces water bills but also reduces the energy consumption used to provide water to the restaurant, as well as the resulting greenhouse gas emissions by the water utility. Because profit margins are tight in this industry, any energy and water related savings, even seemingly small ones, can have a significant impact on the bottom line. For example, TGI Friday's, a US restaurant chain, is achieving annual savings of US$6,000 per restaurant from recent lighting retrofits.[121] Furthermore, a US EPA study shows that an average restaurant can save over US$10,000 per annum using more energy efficient cooking equipment.[122]

This is especially important as many see the price of electricity as set to rise due to global concerns about climate change leading to energy taxes and carbon trading schemes that will add to the cost of fossil fuel based electricity (see Part 2).

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113 Gleick, P. and Cooley, H. (2009) 'Energy implications of bottled water', *Environmental Research Letters*, vol 4, www.pacinst.org/reports/bottled_water/index.htm, accessed 22 April 2009.
114 The International Hotel and Restaurant Association (undated) 'Leadership: IH&RA Board of Directors 2009', www.ih-ra.com/about/leadership/, accessed 22 April 2009.
115 Statistics Canada (2008) 'Greenhouse gas emissions – a focus on Canadian households', www.statcan.gc.ca/pub/16-002-x/2008004/article/10749-eng.htm, accessed 22 April 2009.
116 Business Wire (2006) 'Americans Eat out Nearly One out of Every Four Meals and Snacks, Spending Almost Half Their Food', *Business Wire*, 14 June 2006, www.allbusiness.com/medicine-health/diet-nutrition-fitness-dieting/5411015-1.html, accessed 22 April 2009.
117 Business Wire (2006) 'Americans Eat out Nearly One out of Every Four Meals and Snacks, Spending Almost Half Their Food', *Business Wire*, 14 June 2006, www.allbusiness.com/medicine-health/diet-nutrition-fitness-dieting/5411015-1.html, accessed 22 April 2009.
118 ESource (1999) 'Prospectus: Multi-Client Study - Delivering Energy and Energy Services to the Restaurant Sector', *ESource*, www.esource.com/esource/getpub/public/pdf/Restaurants.pdf, accessed 17 March 2009.
119 ESource (1999) 'Prospectus: Multi-Client Study - Delivering Energy and Energy Services to the Restaurant Sector', *ESource*, www.esource.com/esource/getpub/public/pdf/Restaurants.pdf, accessed 17 March 2009.
120 ESource (1999) 'Prospectus: Multi-Client Study - Delivering Energy and Energy Services to the Restaurant Sector', *ESource*, www.esource.com/esource/getpub/public/pdf/Restaurants.pdf, accessed 17 March 2009.
121 ESource (1999) 'Prospectus: Multi-Client Study - Delivering Energy and Energy Services to the Restaurant Sector', *ESource*, www.esource.com/esource/getpub/public/pdf/Restaurants.pdf, accessed 17 March 2009.
122 US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.

In addition, recycling, buying organic fresh local food ingredients in season and composting organic waste all helps to reduce energy and water used through the supply chain. The US National Restaurant Association estimates that 20 per cent of all food prepared commercially in the United States goes to waste.[123] Restaurants can help to pass this food onto the poor who need it and thereby make a significant contribution to the community while reducing waste and greenhouse gas emissions. North Carolina, USA, has a specific 'Good Samaritan' law that protects restaurants from liability associated with food donations.[124]

There are a number of leading restaurants that are showing that it is possible to profitably improve resource productivity and reduce greenhouse emissions, as we will now show.

Best Practice Case Studies

Bordeaux Quay (UK),

Bordeaux Quay in Bristol, UK, was retrofitted, under the direction of Barry Haughton, one of the UK's most respected organic chefs, into a 'low-carbon' restaurant, bar, bistro, shop, bakery and cookery school. The building, for which most construction waste was recycled, includes features such as:[125] locally-sourced low carbon materials; state-of-the-art insulation; low energy lighting with motion sensors; skylights; large operable windows to allow passive ventilation; a solar hot water system; and an onsite rain water harvesting system. Bordeaux Quay's daily operations also reduce resource and energy use through several initiatives, including:

- Ovens with the optimal energy conversion efficiency that include a triple fan system that ensures rapid heat recovery when the ovens are opened and reduces the cooking time.
- The kitchen management system includes steps to reduce the use of equipment when not needed, relative to demand.[126]
- A comprehensive recycling and composting scheme that is managed by the Sustainable Development manager.
- Sourcing only local, seasonal, organic and ethically-sourced ingredients in order to reduce embodied energy in food miles and agrichemicals.[127]
- Serving specially filtered tap water in reusable glass bottles rather than transporting bottled mineral water from offsite.[128]
- Most staff commuting to and from work on foot, by bike or by public transport.[129]

Foodorama, Germany

Foodorama in Berlin, Germany, is the country's first carbon-neutral restaurant. The restaurant

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[123] North Carolina Department of Environment and Natural Resources (1999) 'A Factsheet for Restaurant Waste Reduction', North Carolina Department of Environment and Natural Resources, www.p2pays.org/ref/03/02790.pdf, accessed 4 May 2009.
[124] North Carolina Department of Environment and Natural Resources (1999) 'A Factsheet for Restaurant Waste Reduction', North Carolina Department of Environment and Natural Resources, www.p2pays.org/ref/03/02790.pdf, accessed 4 May 2009.
[125] Bordeaux Quay (undated) 'Eco Pages: Saving Energy', www.bordeaux-quay.co.uk/ecopages/eco_saving_energy.php, accessed 25 February 2009.
[126] Whitehall, B. (2006) 'Eco-gastronomic venture sets new goal-posts for sustainability', *The Consultant*, Fourth Quarter 2006, www.fcsi.org/pdfs/WW_Publications/4th_qtr_06/Eco-gastronomic%20Venture.pdf, accessed 25 April 2009.
[127] Bordeaux Quay (undated) 'Eco Pages: Sourcing our Food', www.bordeaux-quay.co.uk/ecopages/eco_sourcing_our_food.php, accessed 25 February 2009.
[128] Bordeaux Quay (undated) 'Eco Pages: Saving Water', www.bordeaux-quay.co.uk/ecopages/eco_saving_water.php, accessed 25 February 2009.
[129] Bordeaux Quay (undated) 'Eco Pages: Saving Water', www.bordeaux-quay.co.uk/ecopages/eco_saving_water.php, accessed 25 February 2009.

reduced its carbon emissions through low carbon initiatives, such as:[130]

- sourcing bio-gas, derived from agricultural waste, from gas plants outside Berlin;
- sourcing green electricity, generated from renewable energy sources;
- investing in state-of-the-art insulation; and
- most staff commuting to and from work by bike or public transport.

The Acorn House and The Water House (UK)

The Acorn House in London, UK, is a low carbon training restaurant which is in a unique position - through its commitment to improving energy performance, The Acorn House is able to influence chefs and cooking staff who in turn then go out and influence the practices of the other restaurants in which they work, both nationally and internationally. The Acorn House has also implemented the following, in an effort to increase energy productivity and reduce its carbon footprint:

- Several energy efficiency measures - including maximising natural light and using energy efficient lighting.
- Using hydrocarbon refrigerants - which both reduce the energy consumption of the refrigerator and have significantly lower global warming potentials than HFC refrigerants.[131]
- Purchasing 100 per cent renewable energy.
- Using low carbon materials - such as organic, recycled and sustainably-sourced materials. For example, the tables are made of wood rather than metal, the chair tops made of recycled plastic, and even the wall paint is organic.
- Onsite water purification and reuse system - to reduce the need for transporting bottled water.
- Recycling over 80 per cent of waste - through a closed-loop system wherein organic waste is composted in a wormery and the compost is used with the restaurant's grey water to grow vegetables and herbs in a rooftop garden. The rooftop garden is part of a green roof, which provides the building with additional insulation.
- Sourcing local, organic and sustainably-grown ingredients - in order to reduce food miles.
- If needed, importing fair trade ingredients from overseas by ship - rather than air freight, as well as using wooden crates, which are returned to the supplier for reuse.

'We've always recycled, conserved energy at home, and tried to be ethical', says restaurant manager Jamie Grainger-Smith. *'We've wanted our work to reflect our values and the way we live our lives at home to spill into our careers'*.[132] The Acorn House is an example of a growing green restaurant movement globally. In the USA, for instance, there is a Green Restaurant association promoting these sorts of strategies.[133] The team from The Acorn House have now designed and started construction on a second restaurant, The Water House, that is reportedly even more energy efficient and environmentally sustainable.

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[130] Sonnenberg, B. (2009) 'Berlin's Carbon-Neutral Eatery', *The Herald-Mail*, 21 January 2009, www.herald-mail.com/?cmd=displaystory&story_id=214878&format=html, accessed 25 February 2009.
[131] Airedale Group (2007) 'Acorn House Restaurant Ceda Grand Prix Awards 2007 Hotel/Restaurant Entry', Presentation, Airedale Group, CEDA, www.airedale-group.co.uk/ceda_winning_entry.pdf, accessed 21 March 2009.
[132] Barclay, E. (2008) 'Five Outstanding Green Restaurants', Food & Health, Treehugger, available at http://www.treehugger.com/files/2008/10/five-outstanding-green-restaurants.php, accessed 16 May 2009.
[133] Green Restaurant Association (undated) website, www.dinegreen.com, accessed 24 February 2009.

The Water House, is located on the bank of Regent's Canal in Shoreditch, east London.[134] Arthur Potts Dawson and Jamie Grainger-Smith, in partnership with the charitable regeneration agency, Shoreditch Trust, have sought to go even further than The Acorn House in the design of this new restaurant, including features such as:

- The kitchen has been designed to be as energy and water efficient as possible – for instance using the latest induction cooking technology from the Garland Ultra series by Enodis that incorporates four 5kW induction hobs with touch controls, which uses energy only when a pan is on the induction plate. According to the US Department of Energy, '*the efficiency of energy transfer for an induction cooktop is 84 per cent, versus 71 per cent for a smooth-top non-induction electrical unit.'*[135]
- The kitchen does not use gas - instead it uses electricity generated from an array of 50 solar panels on the building's roof, hence eliminating the energy demand and greenhouse emissions (other than that from the manufacture of the solar panels). The absence of gas also means less exhaust gases are produced and this reduces the required capacity of the ventilation equipment. Any requirement to top up the solar electricity is sourced from hydro-electric power through the local energy provider.
- The kitchen uses hydrocarbon refrigeration cabinets that reduce energy consumption by up to 15 per cent.
- Space cooling for the building is delivered by a state-of-the-art heat pump - drawing on the ambient temperature of the water in the adjacent canal, under licence from British Waterways.
- A solar hot water system is used.
- The restaurant also makes its own premium filtered bottled water onsite, using a state-of-the-art filtration system, eliminating the energy used and greenhouse emissions required to transport mineral water from around the world, reducing energy usage per bottle of water by 2000 times.[136]

[134] Water House Restaurant (undated) website, www.waterhouserestaurant.co.uk, accessed 24 February 2009.
[135] Lawrence Berkeley National Laboratory (1993) *Technical Support Document for Residential Cooking Products: Volume 2: Potential Impact of Alternative Efficiency Levels for Residential Cooking Products*, Lawrence Berkeley National Laboratory, US Department of Energy,,www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/cookgtsd.pdf, accessed 21 March 2009.
[136] Gleick, P. and Cooley, H. (2009) 'Energy implications of bottled water', *Environmental Research Letters,* vol 4, www.pacinst.org/reports/bottled_water/index.htm, accessed 22 April 2009.

Whole System Approach to Factor 5 in Restaurants

IPCC Strategy One: Energy Efficiency

Energy Efficient Cooking Equipment and Behaviour Change (60-70 per cent)

As the case studies above show, like residential and commercial buildings, there is significant opportunity to reduce energy consumption through design and operation of buildings, selection of lighting, the use of renewable energy, and personal transportation choices. However, further to this, the restaurant sector has the potential to reduce the consumption of a range of kitchen equipment by up to an average of just under 50 per cent, as shown in Table 1.1, and it is the combination of both sets of opportunities that can deliver Factor 5 improvements. As Figure 1.8 further below shows, cooking uses over 30 per cent of the day-to-day energy usage in a restaurant. The USA EPA shows that purchasing more energy efficient equipment achieves energy efficiency improvements of 19-87 per cent across all the main pieces of cooking equipment as shown in Table 1.1.[137] According to the EPA, on average, shifting from standard cooking equipment to energy efficient cooking equipment will achieve approximately 50 per cent energy savings which can achieve, on average, financial savings in the order of US$10,817 per annum, as shown below.[138]

Table 1.1: Energy and Financial Savings Potential from Shifting to Energy Efficient Cooking Equipment

Technology	Standard Equipment and Use (US$/yr)	Energy Efficient Equipment and Use (US$/yr)	Savings (US$/yr)	Energy Savings (%)
Solid Reach-in Refrigerator	210	97	113	54
Solid Reach-in Freezer	432	281	151	35
Walk-in Freezer/Cooler	118	39	80	67
Hot-Food Holding Cabinet	767	438	329	43
Fryer	1,169	502	667	55
Steamer	2,700	508	2,191	73
Glass Reach-in Refrigerator	325	163	162	50
Convection Oven	1,051	731	320	30
Prep Table	406	182	223	55
Toaster	964	128	936	87
Broiler	3,539	2,882	657	19
Combination Oven	4,163	2,596	1,567	29
Pre-rinse sprayer	1,973	1,052	921	47
Demand Control Exhaust Hood	7,500	5,000	2,500	33
Total	**$25,317**	**$14,599**	**$10,817**	**48%**

[137] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.
[138] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.

Source: Based on the findings of US EPA (2007)[139]

Behaviour change can further reduce energy usage in the kitchen. Often equipment is left on when idle. For instance US EPA has found that kitchen fryers are left idling up to 75 per cent of the time. The EPA has found that, '*Cutting out four hours of idle time each day could save around US$250 annually for a gas fryer and about US$350 for an electric fryer'.*[140] More efficiency gains can be made if full loads are used in ovens rather than partial loads that use similar amounts of energy, which can also enable more time where ovens can be switched off between large full loads.

> *Restaurants are* [currently] *massively unsympathetic to the environment. In almost all restaurants in the developed world, chefs cook vegetables until they are almost done and then stop them cooking using running water or ice. Then they refresh them with boiling water when they're ready to serve. But there's no awareness at all that this wastes lots of energy and water - commodities that are becoming increasingly precious. For years, I've taken my veg out of the pan about 50 seconds before they're done - they carry on cooking and are ready when they get to the table. It's really simple.*
>
> **Barry Haughton, Bordeaux Quay, 2006**[141]

This provides a sense of the potential for kitchens in restaurants to achieve energy productivity improvements through behaviour change. Simple behaviour changes like this in the kitchen can further reduce energy usage by at least another 10-20 per cent. To cover all the opportunities for behaviour change is beyond the scope of this book, however, the US EPA's report on this sector outlines other areas of potential behaviour change that can save energy.[142]

Energy Efficient Lighting (60-90 per cent)

As we showed in the Commercial Building section, through a range of strategies to reduce lighting usage plus using more efficient types of lighting, lighting energy efficiency can be improved by a significant amount.

Energy Efficient Refrigeration (50-60 per cent)

The US EPA's study of the restaurant industry found that energy efficient fridges can now save 50 per cent of energy usage.[143] They also recommend a range of strategies that can further improve the energy efficiency of fridges, including:

- *Allow for air circulation*: *Refrigerators remove heat from inside the box and reject that heat out through the coils on the top or bottom of the unit. Don't push your reach-ins into tight spaces where that heat will build up or the unit will end up working harder and using more energy.*
- *Check and set defrost cycles: Defrosting is an energy-intensive process that can vary dramatically from restaurant to restaurant, so it's important to take some time to figure out which defrost settings are right for you. The key is to only defrost for as long as you need, which in most cases is no more than 15 minutes, four times daily. One restaurant*

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[139] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.
[140] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.
[141] Oppenheim, L. (2006) 'Bordeaux Quay - Britain's First Carbon Neutral Restaurant', *TreeHugger*, 26 May 2006, London, UK, www.treehugger.com/files/2006/05/bordeaux_quay_carbon_neutral.php, accessed 17 March 2008.
[142] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.
[143] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.

> *owner saved more than $800 annually by shortening the length of each defrost cycle from 70 minutes to 15 minutes.*[144]

Building Design (70-90 per cent)

As previously presented, effective building design can significantly reduce the need for space heating and cooling, as well as lighting. As we showed in the Commercial Building section it is possible to achieve Factor 5 through a whole system approach to building design.

Available Resources

For those interested in other eco-efficiency opportunities for restaurants which can save energy, there is a great deal of free online eco-efficiency information to help traditional restaurants, and hotel restaurants significantly improve their energy efficiency. These manuals provide detail on how to achieve Factor 5 reductions, several of which are published by the UK Carbon Trust,[145] US EPA,[146] and the UNEP Cleaner Production Program.[147] Also leading restaurant magazines like *Star Chefs* in the USA are publishing guides on how to create a green and environmentally sustainable restaurant, outlining many energy productivity strategies.[148] We recommend these resources to help guide efforts to achieve Factor 5 in the restaurant industry.

IPCC Strategy Three: Heat Recovery

Heat recovery is a cost-effective technology for restaurants to recover heat from refrigerators, ovens and other equipment to heat the restaurant's water.

IPCC Strategy Four: Renewable Energy

With Strategy One and Three we have shown that Factor 5 improvements to energy productivity are possible for the main areas of energy usage in restaurants - cooking (32 per cent), space heating, cooling and ventilation (28 per cent), lighting (15 per cent), refrigeration (13 per cent) and water heating (12 per cent). As mentioned in the opening, these five together contribute to over 90 per cent of restaurants energy usage. Combining these two strategies with purchasing renewable energy enables restaurants to get very close to climate neutral. As shown above, all three featured restaurant case studies are purchasing all their energy from renewable sources and some are using solar hot water systems to heat their water.

IPCC Strategy Seven: Material Efficiency (Water)

About half of the water used in restaurants is used in kitchen areas with another 35 per cent used in the toilets/rest-rooms. Hence we focus on potential water savings in these two areas.

- *Kitchen:* A significant percentage of water can be saved in the kitchen by purchasing water efficient cooking equipment and appliances, reducing water flow rates, and not running water unnecessarily. Water flow rates can be reduced by replacing automatic shut-off spray nozzles, which can use as much as 4.5 gallons of water each minute, with low-volume nozzles using 2 gallons per minute, or by turning off the continuous flow used to wash the

[144] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.
[145] UK Carbon Trust (2007) *Hospitality: Saving Energy Without Compromising Service – Sector Overview,* UK Carbon Trust.
[146] US EPA (2007) *Putting Energy into Profits: Energy Star Guide to Restaurants*, US EPA, www.energystar.gov/ia/business/small_business/restaurants_guide.pdf, accessed 17 March 2009.
[147] Pagan, R., Prasad, P. and Price, N. (2001) *Eco-efficient Food, Restaurant and Catering Queensland and Queensland Hotels Association,* UNEP Cleaner Production Centre, www.gpem.uq.edu.au/CleanProd/retail_food_guide/Retail%20Food%20Manual.pdf, accessed 24 February 2009.
[148] Start Chef (2008) '30 Sustainability Tips', http://starchefs.com/features/trends/30_sustainability_tips/index.shtml, accessed 24 February 2009.

drain trays of the coffee/milk/soda beverage area.[149] As Barry Haughton, head chef and founder of the Bordeaux Quay restaurant points out, there is significant potential to save water in the kitchen as until recently few chefs have often been simply unaware that their practices are wasting water and energy, '*In almost all restaurants in the developed world, chefs cook vegetables until they are almost done and then stop them cooking using running water or ice. Then they refresh them with boiling water when they're ready to serve. But there's no awareness at all that this wastes lots of energy and water - commodities that are becoming increasingly precious. For years, I've taken my veg out of the pan about 50 seconds before they're done - they carry on cooking and are ready when they get to the table. It's really simple'*.[150]

– *Restrooms:* Water can be used more efficiently through installing dual flush toilets, low flow aerator taps, and waterless urinals as discussed in the residential and commercial buildings sector studies.

[149] City of Tampa Florida (undated) 'Efficiency Checklists - Water Efficiency Checklist for Restaurants', www.tampagov.net/dept_WATER/information_resources/Efficiency_checklists/restaurant_water_efficiency_checklist.asp, accessed 4 May 2009.

[150] Cookson, R. (2006) 'The Eco-Eatery', *The Independent*, 18 May 2006, www.independent.co.uk/environment/green-living/the-eco-eatery-478687.html, accessed 4 May 2009.

5) Industry Sector Study – The Hospitality Industry (Fast Food Restaurants)

The Potential for Factor 5 Improvements in Fast Food Restaurant Resource Productivity[151]

Despite numerous studies and resources being available to help improve energy productivity in traditional restaurants, there is little to no such information targeted at 'quick service' or 'fast food' restaurants. To clarify, a fast food restaurant is typically a business that provides food with quick preparation times to cater for the drive-through, short stay, or take-out customer, including burger and fries outlets, sandwich and juice bars, and sushi trains and noodle bars. Since the 1950's this sector of the industry has grown rapidly. In the early 1970s US citizens spent three-quarters of their food related expenditure on home cooked meals, however, by 2000 nearly half the money spent on food was being spent at fast food restaurants.[152] This equates to roughly US$110 billion per annum.[153]

This trend towards faster, cheaper, and now increasingly healthier, food is being seen across the world, evident in the 25 per cent per year growth rate of fast food restaurants in China.[154] Such growth rates mean that this sector will see increasing levels of energy consumption in the coming decades and steps will need to be taken to curb this growth in demand. The good news is that taking a whole system approach to existing fast food restaurants can cost-effectively deliver up to 70 per cent energy and water productivity improvements, with up to 80 per cent, a Factor 5 improvement, achievable in new stores. Australia's leading energy efficiency experts Alan Pears and Geoff Andrews showed in 1997 that Australian fast food restaurants undertaking such an approach could save, on average, an estimated AUD$20,000 per store per annum, as summarised in Table 1.2 below.[155]

Table 1.2: Summary of potential energy efficiency measures

Activity	Action	**Potential Savings** Per Store Per Annum – in AUD$(1997)
Lighting	- Specify maximum installed lighting power (W/sqm) for indoor and outdoor lighting, as well as illumination levels to ensure this is not inadvertently exceeded. - Use lighting controls to minimise unnecessary or over use. - Ensure display lighting is minimised and efficient lighting options are used, such as light emitting diodes (LEDs).	$3,000
Fryers	- Install high efficiency gas fryers, rather than electric, to minimise electricity consumption and reduce the resulting greenhouse gas emissions. - Fit shrouds to fryers, with the required air supply entering at the appropriate place to reduce heat gain into the room. - Install multi-speed exhaust fans with the speed linked to	$5,000

[151] This Sector Study has been co-authored with Alan Pears, Adjunct Professor, RMIT.
[152] Schlosser, E. (2002) *Fast Food Nation*, Penguin Books.
[153] Schlosser, E. (2002) *Fast Food Nation*, Penguin Books.
[154] RNCOS (2008) 'China Fast Food Analysis', *Market Research.Com*, 1 October 2008, www.marketresearch.com/product/display.asp?productid=1913629&g=1, accessed 25 March 2009.
[155] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

	that of the air supply fan that delivers the make-up air required by the gas burners in the fryer. - Ensure fryers incorporate adequate insulation and appropriately sealing lids.	
Chip holding bins	- Ensure adequate insulation, low wattage heat lamps and elements, and hinged access doors and flaps for chip holding bins to reduce heat loss.	$1,000
Horizontal toasters	- Incorporate rapid reheat elements, reflectors, and an auto switch-off function when not in use.	$1,500
Food warmers	- Ensure adequate insulation and sealed lids.	$800
Grillers/Broilers	- Provide options for microwave or a sandwich-type pre-heat module. - Use shorter grilling sections and reduce the heat setting. - Incorporate integrated make-up air supply, a multi-speed fan, and adequate insulation, as per 'fryers' above. - Toasters - see 'Horizontal toasters' above.	$2,000
Refrigeration equipment	- Specified to meet energy targets, especially equipment that is used to cool post-mix soft-drink dispersers.	$1,000
Coffee makers	- Ensure adequately insulated containers and machines. - Select equipment to meet energy efficiency specification.	$700
Cash registers	- Select equipment to meet energy efficiency specification.	$90
Air-conditioning	- Ensure adequate ceiling and duct insulation, and effective duct layout, installation and maintenance. - Ensure adequate shading on windows exposed to sun. - Ensure building envelop is properly designed to minimise heat entering or escaping (depending on climatic conditions). - Ensure new equipment meets energy efficiency specifications.	$4,000
Hot water systems	- Install a solar hot water system, or at least gas fired system with electronic ignition. - Consider options to capture waste heat to generate electricity or to harness heat for other uses. - Use water-efficient fittings and practices to reduce the volume of water that needs to be heated.	Not Included
Total	**Over 80 per cent (Factor 5) energy efficiency savings**	**$ 19,090**

Source: Pears, A. (1997)[156]

The Pears and Andrews 1997 study is timely information now because there is growing interest among global fast food chains and franchise store owners in how they can reduce their energy and water consumption and greenhouse gas emissions cost effectively. For example, McDonald's is trialling new restaurant designs that incorporate more natural light and improved energy-efficiency

[156] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

equipment and in 2005, McDonald's built the first restaurant in the USA to be certified by the Leadership in Energy and Environmental Design (LEED) rating system. US fast food restaurant chain Arby's has also built its first green restaurant,[157] which includes a thermoplastic membrane roof, solar glass and thermally broken aluminium storefront materials, Energy Star certified kitchen equipment, LED lighting and motion sensors, an energy efficient HVAC system, and tankless water heaters. The restaurant will also source at least 35 per cent of its energy from renewable sources and gives preference in its car park for customers that drive fuel-efficient vehicles.[158]

As shown previously, these initiatives are highly cost effective. For instance, a recent article in the Nation's Restaurant News explains that, Don Feinstein, the chairman of Emerald Foods Inc. and Diamond Foods LLC, two Wendy's franchise companies had, '*converted seven of his restaurants in Texas into energy-efficient establishments, and he is planning to do the same with the rest of his units*'. Feinstein is quoted as saying, '*Obviously, energy costs are huge in our industry, and in Texas, where we operate, energy is deregulated, so costs are just terrible. We were paying between $3,000 and $5,000 per restaurant per month* [in energy costs]*; that's a big number. If you multiply 44 restaurants by $4,000, that's $2,112,000. We're talking a lot of money here, so if you can save, say, 20 percent - which is what we're doing - that's a big number*'.[159]

Savings in energy can also be achieved by improving materials efficiency, and this can be done by reducing the generation of waste, and increasing the rates of recycling. Such efforts reduce the bulk amount of material used, and hence it's embodied energy, as well as reducing energy consumption, as recycling uses significantly less energy than creating materials from raw virgin materials. In 1991 McDonalds partnered with the US Environment Defence Fund to investigate opportunities for reducing and recycling waste, and identified a number of cost effective options, such as using paper packaging for burgers instead of polystyrene foam.[160] Since 1991, the company has shifted to recycling up to 80 per cent of its organic waste from its kitchen, including eggshells, coffee grounds, food scraps and discarded napkins.[161] In Europe, McDonald's restaurants claim to be recycling more than 80 per cent of their used cooking oil into biodiesel. In addition, about 30 per cent of the fuel used by the trucks that serve the restaurants is biodiesel, with about 16 per cent made from the company's used cooking oil. By 2008, in the UK, McDonalds publicly promised to be recycling 100 per cent of its used cooking oil into biodiesel for use in its delivery trucks, replacing nearly six million litres of diesel fuel per year.[162] In Germany, McDonald's restaurants recycle over 90 per cent of waste generated by stores - packaging and food wastes are collected from the dining area with a tray cart to be sorted.[163]

There is also significant potential for this industry sector to reduce embodied energy and food miles in their products by providing healthy organic food products based on locally sourced ingredients. There is also potential to change energy intensity by the choice of food products offered. The Subway fast food chain is now one of the largest globally. It simply offers a great variety of fresh

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[157] Environmental Leader (2008) "Arby's To Open 'Green' Restaurant Mid-April, 2009", *Environmental Leader*, 18 February 2009, www.environmentalleader.com/2009/02/18/arbys-to-open-green-restaurant-mid-april/, accessed 12 march 2009.
[158] QSRWeb (2009) "Arby's to build 'green' restaurant in Texas, QSRWeb Ideas and Trends for the Quick Service Restaurant", *Quick Service Restaurant Web*, 12 Feb 2009.
[159] Elan, E. (2009) 'Wendy's franchisee expects cost savings at energy-efficient units', *Nation's Restaurant News*, 9 March 2009.
[160] Environment Defense Fund (2009) 'Better Packaging with McDonald's, Case Study: Paper & Packaging', *Environment Defense Fund*, 30 October 2008, www.edf.org/page.cfm?tagID=30747, accessed 21 February 2009.
[161] Environment Defense Fund (2009) 'Better Packaging with McDonald's, Case Study: Paper & Packaging', *Environment Defense Fund*, 30 October 2008, www.edf.org/page.cfm?tagID=30747, accessed 21 February 2009.
[162] Environment Defense Fund (2009) 'Better Packaging with McDonald's, Case Study: Paper & Packaging', *Environment Defense Fund*, 30 October 2008, www.edf.org/page.cfm?tagID=30747, accessed 21 February 2009.
[163] McDonald's (2008) *2008 Corporate Responsibility Report*, McDonald's, see 'Innovations', www.crmcdonalds.com/publish/csr/home/report/environmental_responsibility/energy_and_climate_change/innovation.html, accessed 21 March 2009.

food options in a variety of sizes and types of bread rolls. Thus Subway restaurants do not have fryers, grillers, and a host of other energy hogging cooking equipment that is commonly used in other fast food restaurants. The global business success of the Subway approach and changing customer demand has led fast food restaurants like McDonalds to now offer healthier and relatively low embodied energy food options like salads and salad wraps.

Best Practice Case Studies

Subway (As Big as McDonalds!)

Subway is recognised as one of the most successful fast food chains in the world, with 30,865 restaurants in 89 countries as of March 2009,[164] which is about the same number of outlets as McDonalds (reported as having 31,000 outlets worldwide).[165] Subway's fast food products are already significantly less energy intensive than most fast food outlets because they offer fresh food options that don't require cooking. Hence, Subway restaurants eliminate the need for fryers, grillers, and a host of other energy consuming cooking equipment that is commonly used in other fast food outlets. As this saves not only energy, but also space, they are able thus to operate using smaller premises than the typical outlet, reducing operating costs significantly through lower commercial rents. Subway claims to be the fastest growing fast food chain in the world, and some argue that their success has been a driving force prompting other major chains, such as McDonalds, to also offer customers menu options such as salads and salad wraps, which are healthier and often have a lower embodied energy.

Subway is now seeking to reduce their environmental impact through applying green design principles to their new stores in the US. The first of these, a Florida Subway 'eco-store', was designed in close collaboration with the US Green Building Council. The store incorporated many effective energy saving principles, and as a result was given a silver rating under the LEED rating system. The success of this store has encouraged Subway to build four more such eco-stores, and to consider efficiency measures across many aspects of their operations, including:

a. High efficiency HVAC systems.

b. The use of remote condensing units for the refrigerators and ice making equipment.

c. Incorporating day lighting and installing controls for high efficiency lighting (*LED lights for interior lighting and exterior signs*), and low flow water fixtures (*to reduce hot water consumption*) - early estimates place savings to the electricity bill of these stores at around 20 per cent.[166]

There is still significant room for further improvement, as the 'Commercial Buildings Sector Study' in this book showed, with the potential of many new commercial buildings to achieve up to 80 per cent energy and water savings, much of which is relevant to fast food outlets.

Subway is attempting to achieve greater material efficiency through increasing their emphasis on recycling in customer areas, while themselves using recycled, or more sustainable, materials in the construction of the buildings and furnishings of their stores. The re-engineering of many of their products, such as packing boxes and cup carriers, has reduced the materials needed for their manufacture, and also reduced transportation costs in distributing them. For example, the redesign of their shipping packaging alone uses up to 97,000 pounds less of plastic each year.[167] Further, Subway napkins are now made from 100 per cent recycled materials – of which 60 per cent is post consumer recyclable. They claim that using 100 per cent recycled fibre for their napkins saves approximately 60,500,000 gallons of water and an additional 147,000 trees.[168]

[164] Subway (undated) website, www.subway.com/subwayroot/index.aspx, accessed 21 March 2009.
[165] McDonald's (undated) 'Getting to know us', www.aboutmcdonalds.com/mcd/our_company.html, accessed 21 March 2009.
[166] QSR Web (2008) 'Fla. Subway store receives LEED certification', *Quick Service Restaurant Web,* 4 December 2008, www.qsrweb.com/article.php?id=12639, accessed 25 March 2009.
[167] National Restaurant Association (undated) 'Subway Focuses Sustainability on Distribution, Packaging, Construction', http://conserve.restaurant.org/conservenow/success_subway.cfm, accessed 25 March 2009.
[168] Subway (undated) 'Going Green: Helping Society', www.subway.com/subwayroot/AboutSubway/HelpingSociety/GoingGreen/index.aspx, accessed 25 March 2009.

The company has also started manufacturing its own cutlery and plastic drinking cups to facilitate a switch from polystyrene to polypropylene – providing savings of both 310,000 pounds of resin, and the equivalent of 13,000 barrels of oil each year.[169] Subway recognises that they are still a long way from being truly energy efficient - retrofitting existing stores to enhance their energy performance will be needed, and there are still many tools suggested by the IPCC Fourth Assessment Mitigation report for commercial buildings of which they are yet to take advantage. As Bill Schettini, Chief Marketing Officer for the Subway chain, remarked, '*We are proud of the efforts we have made, but we also recognize that there is much more to do*'.[170]

[169] McDonald's (2008) *2008 Corporate Responsibility Report*, McDonald's, see 'Innovations', www.crmcdonalds.com/publish/csr/home/report/environmental_responsibility/energy_and_climate_change/innovation.html, accessed 21 March 2009.
[170] Subway (undated) 'Going Green: Helping society', www.subway.com/subwayroot/AboutSubway/HelpingSociety/GoingGreen/, accessed 25 March 2009.

Whole System Approach to Factor 5 in Fast Food Restaurants

The following is summary of a range of options for improving the energy productivity of fast food restaurants organised as per the recommended structure from the IPCC Mitigation Working Group. Further detail can be accessed from Lecture 6.3 of The Natural Edge Project's, '*Energy Transformed: Sustainable Energy Solutions for Mitigating Climate Change*' online package.[171]

IPCC Strategy One: Energy Efficiency

A standard fast food restaurant is estimated to use up to 6.5 GJ (equivalent to 1,800 kWh) of energy per square metre, mostly in the form of electricity, with some gas for cooking and hot water.[172] There are a number of options that when combined can deliver significant reductions in this demand, without loss of productivity, reducing significantly the amount of energy that needs to be sourced from renewable sources. In fact, improvements can be made across each of the main areas of energy consumption in a fast food restaurant, namely air-conditioning and lighting (see Figure 1.8, showing a/c and lighting to be responsible for around 30 per cent), and cooking equipment and refrigeration (around 70 per cent). Also as much of the requirement for air-conditioning is due to the heat generated by cooking and refrigeration equipment, better design and operation of such equipment can lead to not only direct energy productivity improvements but also to reductions in cooling loads.

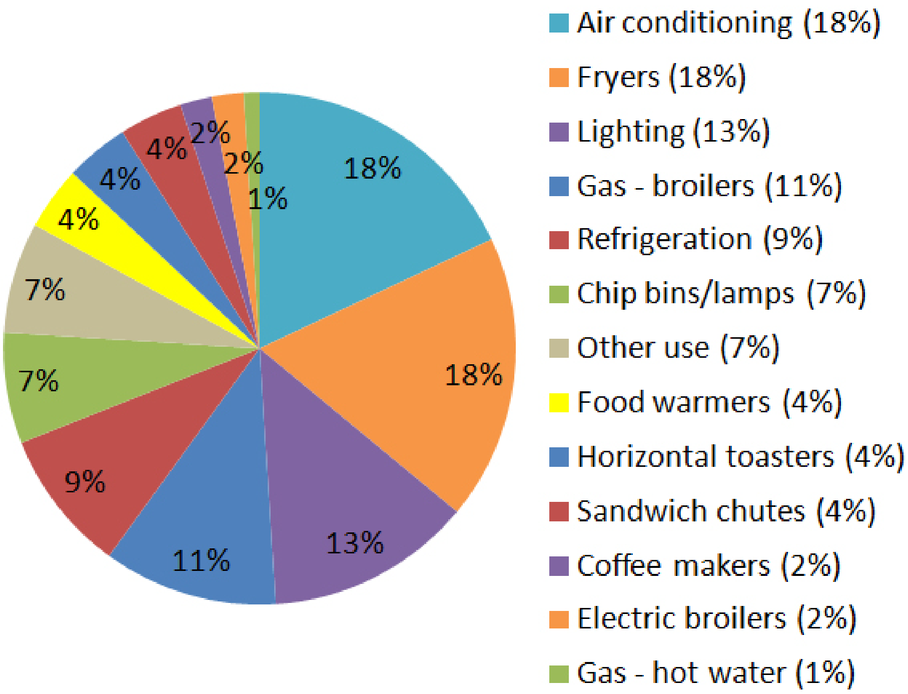

Figure 1.8: Greenhouse gas emissions by activity (*assuming that electricity consumed is sourced from coal fired power stations, as is the case for the majority of fast food restaurants around the world*)

Source: Courtesy of Alan Pears (Based on Pears, A. (1997)[173])

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[171] Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia.
[172] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.
[173] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

Air-Conditioning (70 per cent improvements available)

As outlined in the residential and commercial buildings case studies there are significant opportunities to reduce the consumption of electricity from air-conditioning. These opportunities are mostly related to the form, orientation, and envelope of a building,[174] and include passive solar design, improved insulation, double glazed windows, and minimised air leaks, particularly through the roof and around doors.[175] However air-conditioning requirements in fast food kitchens differ from that of residential and commercial buildings in two main ways. Firstly there is a significant amount of heat generated by cooking and refrigeration equipment that needs to be minimised, as the following will address. And secondly the typical kitchen exhaust fan not only removes the hot air and cooking fumes, but also removes cooled air from the room if not properly installed and operated, such as using air flow dampeners.

Fryers (75 per cent)

The nature of fast food restaurants means that they require at least some of the fryers to be heated at all times during business hours to cope with potential sudden influxes of customers. Maintaining the temperature in the frying liquid is often done by continual heating, and this demand can be reduced by reducing the amount of heat lost from the fryer. Fryers that minimise the loss of heat can be turned off and maintain greater temperatures, allowing quick reheating to operating temperature when needed. By highly insulating fryers and ensuring that they are covered when not in use, and assuming a reliable thermostat is installed to ensure overheating does not occur,[176] the energy demand of fryers can be reduced by up to 75 per cent.[177] Covering the fryers also reduces the safety hazard to staff, and slows the oxidation rate of fat or oil, extending its life. Even though shifting from an electric to a gas fryer will eliminate the demand for mains electricity, the combustion of gas in the kitchen will still produce the equivalent of 25 per cent of the associated mains electricity greenhouse gas emissions. Such emissions can only be offset, however, in the case of a highly efficient electric fryer, renewable electricity can be sourced.

Lighting (50 per cent)

Energy used to light a standard fast food restaurant can be reduced on average by at least 50 per cent, without loss of aesthetic and comfort, by implementing a number of steps that can lead to both reduced energy and maintenance costs. The main step is replacing incandescent lamps with newer technology, such as compact fluorescent lamps (CFLs), often using 50-75 per cent less electricity, or light emitting diodes (LEDs) which using 80-90 per cent less. Such a shift can reduce maintenance costs, related to changing bulbs, that may actually exceed the electricity cost saving, as typically an incandescent globe lasts in the order of 600 to 2,000 hours, compared with a CFL that lasts in the order of 6,000 to 15,000 hours, or a LED that lasts in the order of 25,000 to 100,000 hours, under certain temperature conditions. LED lights are particularly useful for outdoor lighting, decorative lights and security lights and can deliver up to 80 per cent improvements.[178] Additional steps include: switching off lights that are not needed, potentially through control systems;

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[174] Burke, W. (1996) 'Building Envelope', in Public Technology Inc. and US Green Building Council (1996) *Sustainable Building Technical Manual*, Public Technology Inc., ppiv.21-iv.26.

[175] For further detail refer to: Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 9.1.

[176] Pears, A. (2007) Personal communication by Alan Pears (RMIT and Sustainable Solutions) with staff from the Food Science Department of the William Angliss School of TAFE in Melbourne.

[177] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

[178] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

removing excess lamps where light levels are higher than required; and install electronic ballasts to limit the amount of current to the lights.

Refrigerators and freezers (50 per cent)

By selecting an energy efficient refrigerator the energy consumption from refrigeration in many fast food restaurants can be reduced by 50 per cent. For example, an energy-efficient domestic 500 litre frost-free refrigerator/freezer consumes around 2 kWh/day – compared to the 6 kWh/day required for a typical under-bench refrigerator, or the 8 kWh/day required for under-bench freezers, both often used in fast food outlets.[179] This reflects the fact that while governments have ensured that domestic fridges have to comply with rigorous minimum energy performance standards in many OECD countries, energy efficiency standards for commercial refrigeration have not been so rigorously applied. The improvements in domestic refrigerators suggest that similar improvements could be made in the design of commercial under-bench refrigerators and freezers. Most refrigerators' energy efficiency can be improved through ensuring that they have minimal thermal bridging through frames, by using door-operated LED light switches, switching off circulation fans when doors are open, and fitting plastic door strips to reduce heat transfer.[180] In addition, energy consumption of refrigerated rooms can be reduced by ensuring they are well-insulated (including the floor) to ensure no heat leakage from the hot food cooking areas.

Chip Storage Bins (30 per cent)

Once chips are cooked in the fryer they are stored prior to sale in open chip bins that use heating lamps to keep the chips hot; lamps that are often on the whole time the store is open. A range of options exist to reduce the consumption of the storage bins by 30 per cent, including enclosing the bin as much as possible, improving insulation under the trays, insulating the top of the cabinet, and ensuring that all surfaces are appropriately shaped and highly reflective, so that radiant energy is directed to the chips instead of being lost to surroundings.

Horizontal Toasters (50 per cent)

A horizontal toaster typically consists of a continuous belt platform that moves bread between two heat sources, such as electric elements. The energy productivity of horizontal toasters can be increased, from what is often a quite inefficient unit, using a range of design considerations, including insulation, high internal reflectivity, and control systems to switch heat off when not being used. In addition, there are alternatives to electric elements, such as using low wattage quartz elements or halogen lamps with polished reflectors. The quick response of the quartz elements or halogen lamps means the toaster could be easily switched off, or turned down, when not required and also quickly brought back to operating temperatures.

Sandwich/Burger Chutes (~50 per cent)

Typically a sandwich/burger chute/slide is heated by a series of 800-1200 watt elements clamped to the underside of the metal surface. However, due to inadequate insulation and the effect of thermal bridges much of the heat is wasted, not to mention the creation of dangerously hot surfaces around it. Plastic strips or other devices made from heat resistive material could be fitted to the opening at the high end of the chute to limit convective heat loss and reduce energy consumption

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[179] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

[180] Pears, A. (1997) *Report on Energy Efficiency and Greenhouse Gas Emissions from Fast Food Restaurants*, Sustainable Solutions. Summarised in Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C. and Hargroves, S. (2007) *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (TNEP), Australia, Lecture 6.3.

while still allowing easy access to the chute. Finishing off surfaces with a lower emissivity surface would also reduce heat transfer, although stainless steel has a relatively low emissivity, improvement is certainly possible.

IPCC Strategy Three: Heat and Power Recovery

As explained in the introduction to this chapter significant opportunities exist across industry to recover heat generated by plant and equipment to be used as an energy source. Heat can be recovered from a range of equipment in fast food restaurants, such as cooking equipment, refrigerators, and HVAC, to be concentrated as a heat source, say to pre-heat water as McDonalds is starting to do,[181] or to generate electricity, both reducing the consumption of energy.

IPCC Strategy Four: Renewable Energy

Overall, current use of renewable energy by this sector is very poor, both in onsite generation and in sourcing green energy from utilities. The opportunities to reduce energy consumption outlined above provides the fast food sector with the opportunity to reduce demand to levels that are much more cost effective to source from onsite generation, particularly solar hot water, and through purchasing offsets or accredited renewable energy. In North Carolina, USA, for instance Arby's have switched from using natural gas hot water heaters to using solar hot water heaters in 33 restaurants and, in doing so, expect to reduce the cost of natural gas by approximately US$12,000 per year.[182] A McDonald's restaurant, in the USA, has also installed a Ground Source Heat Pump (GSHP), which can increase the HVAC system's efficiency by up to 50 per cent and hence reduce the restaurant's total energy use by up to 20 per cent.[183]

IPCC Strategy Five: Feedstock Change

The fast food sector generates on average more than 1.8 million tons of fast food packaging in the US alone each year.[184] By reducing the demand for such energy intensive packaging the sector can send a strong signal to the market for the supply of alternatives, and hence impact the energy consumption of its supply chain. One of the major ways to reduce the energy consumption of packaging is to utilise recycled content. Paper fibres can be recycled up to 5 times and when recycled uses up to 62 per cent less energy.[185] Subway is showing leadership in this area, using napkins with 100 per cent recycled materials – of which 60 per cent is post consumer recyclable, saving an estimated 147,000 trees annually. Subway has also switched the materials used for the manufacturing of its cutlery and 32 ounce plastic drinking cups from polystyrene to polypropylene. The change resulted in annual resin savings of more than 610,000 pounds. MacDonald's has also made some improvements with its paper and cardboard packaging material to contain 30 per cent recycled fibre, and in Australia, their cold beverage and dessert cups contain 35 per cent post-consumer recycled PET plastic.[186]

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[181] EECA (2004) 'Case Study 04/05: McDonald's combo recycles heat for hot water', *Energy Wise News*, June 2004, www.eecabusiness.govt.nz/emprove/emprove-library/case-study/mcdonalds-recycles-heat-for-hot-water-04.pdf, accessed 12 March 2009.
[182] Environmental Leader (2007) 'Arbys to Install Solar Water Heaters at 33 Locations', *Environmental Leader,* 10 December 2007, www.environmentalleader.com/2007/12/10/arbys-to-installs-solar-water-heaters-at-33-locations/, accessed 12 March 2008.
[183] McDonald's (2008) *2008 Corporate Responsibility Report*, McDonald's, see 'Innovations', www.crmcdonalds.com/publish/csr/home/report/environmental_responsibility/energy_and_climate_change/innovation.html, accessed 21 March 2009.
[184] No Free Refills (2008) *2008 Fast Food Industry Packaging Report*, No Free Refills, Dogwood Alliance, USA, http://nofreerefills.org/files/NoFreeRefillsReport.pdf, accessed 25 March 2009.
[185] International Bureau of Recycling (undated) 'About Recycling', www.bir.org/aboutrecycling/index.asp, accessed 18 March 2009.
[186] McDonald's (2008) *2008 Corporate Responsibility Report*, McDonald's, see 'Innovations', www.crmcdonalds.com/publish/csr/home/report/environmental_responsibility/energy_and_climate_change/innovation.html, accessed 21 March 2009.

IPCC Strategy Seven: Materials Efficiency (Water and Materials Efficiency)

Public information about water usage and efforts to improve water efficiency in the fast food restaurant sector is scarce. In the different fast food chains corporate social responsibility reports, efforts to reduce water usage receive a relatively small amount of coverage compared to their efforts to reduce energy usage and improve recycling. Due to the long term drought in Australia, fast food chains have begun to make water saving investments and now some information related to those efforts is publicly available. For instance, McDonalds Australia has undertaken water audits - which identified that the main areas of water usage were: 37 per cent in the amenities (toilets, taps); 26 per cent on irrigation; 24 per cent in the kitchens (mainly hot water for cleaning); and roughly 13 per cent for cooling.[187] Experience, to-date, while not extensive, already demonstrates that large water savings are possible in all of these areas

Amenities (50-60 per cent)

Since 1999, all new Australian McDonald's restaurants have been fitted with water efficient devices. Specifically this involves installing water efficient taps, dual flush toilets, and waterless urinals or low flush urinals with sensors.[188] In the USA, Subway claims that it is incorporating these features in its new eco-stores.

Irrigation (75 per cent)

Landscaping design for the McDonalds Australia chain is utilising more native species to reduce reliance on irrigation. In mid-2005 McDonalds Australia commenced a trial at the Delahey restaurant in north-west Melbourne, Australia,[189] which they claim has resulted in the reduction of mains water usage by 75 per cent.[190]

> *The design incorporates swales (grass lined drains that catch and convey water) to direct water into planted areas, and the car park surface was engineered to harvest stormwater. Stormwater run-off is directed towards the gardens where the flow is broken up and held using large rocks and mulch, reducing the need for irrigation. The design incorporates drought tolerant plants and features a sub-surface drip irrigation system with low evaporation levels.*[191]

Kitchens (50 per cent)

As with Restaurants, a significant percentage of water can be saved in the kitchen by purchasing water efficient cooking equipment and appliances, reducing water flow rates, and not running water unnecessarily. 'AquaClic' is a simple water saving device that is simply attached to taps and allows only 6 litres of water to flow from the tap per minute instead of the usual 10-17 litres. Low flow spray nozzles (6 L/min) should be used in fast food restaurants on hoses used for washing up as these use one third of the water of traditional hoses while producing the same pressure.[192]

Water Used in Cooling Systems (80 per cent)

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[187] Sydney Water (2006) 'Water cuts are on the menu at McDonald's', *Business Bulletin*, September 2006, www.sydneywater.com.au/Publications/CaseStudies/ConserverSep06.pdf, accessed 9 May 2008.
[188] Sydney Water (2006) 'Water cuts are on the menu at McDonald's', *Business Bulletin*, September 2006, www.sydneywater.com.au/Publications/CaseStudies/ConserverSep06.pdf, accessed 9 May 2008.
[189] Sustainability Matters (2009) 'New Look McDonald's Uses Less Water', *Sustainability Matters*, 3 February 2009, www.sustainabilitymatters.net.au/articles/461-New-look-McDonald-s-uses-less-water, accessed 9 March 2009.
[190] Sydney Water (2006) 'Water cuts are on the menu at McDonald's', *Business Bulletin*, September 2006, www.sydneywater.com.au/Publications/CaseStudies/ConserverSep06.pdf, accessed 9 May 2008.
[191] Sydney Water (2006) 'Water cuts are on the menu at McDonald's', *Business Bulletin*, September 2006, www.sydneywater.com.au/Publications/CaseStudies/ConserverSep06.pdf, accessed 9 May 2008.
[192] Sydney Water (2006) 'Water cuts are on the menu at McDonald's', *Business Bulletin*, September 2006, www.sydneywater.com.au/Publications/CaseStudies/ConserverSep06.pdf, accessed 9 May 2008.

Air-conditioning loads can be significantly reduced in fast food restaurants through a range of strategies to reduce the amount of heat being radiated from different areas of the kitchen. By reducing the air-conditioning load, fast food restaurants can reduce the amount of evaporative cooling required and thus the amount of water used in evaporative coolers. As the Commercial Building Sector Study showed, water usage in either cooling systems or systems to create refrigerated air can be reduced by 80 per cent, and the strategies outlined in the sector study can be applied readily to large fast food restaurants.[193]

Rainwater Harvesting

Rainwater tanks are being installed in a growing number of new McDonald's restaurants in Australia to use in irrigation and toilet flushing and thus reduce the demand on mains water supplies.[194] In France, a new 'greener' McDonalds restaurant at Plaisance du Touch, near Toulouse, has incorporated rainwater harvesting into its design.[195] McDonalds first LEED certified restaurant in Chicago, USA has also incorporated rainwater harvesting into its design and is using the water in its HVAC system first before the water is then used for irrigation. They hope these design changes alone will reduce their water usage by 50 per cent.[196]

[193] Australian Institute of Refrigeration, Air-Conditioning and Heating (AIRAH) (2003) 'Case Study: Award winner makes its mark', *EcoLibrium*, August 2003, www.airah.org.au/downloads/2003-08-f01.pdf, accessed 8 May 2009.

[194] Sydney Water (2006) 'Water cuts are on the menu at McDonald's', *Business Bulletin*, September 2006, www.sydneywater.com.au/Publications/CaseStudies/ConserverSep06.pdf, accessed 9 May 2008.

[195] McDonald's (2008) *2008 Corporate Responsibility Report*, McDonald's, www.crmcdonalds.com/publish/csr/home/report.html, accessed 21 March 2009.

[196] Shapiro, W. (2008) 'The Golden Arches Go Green: McDonald's First LEED® Certified Restaurant', *Green Bean Chicago*, 11 December 2008, www.greenbeanchicago.com/leed-certified-permeable-pavers-led-lighting-recyclinggolden-arches-green-mcdonalds-leed-certified-restaurant/, accessed 9 March 2009.