Fact Sheet

AUSTRALIAN MEAT INDUSTRY COUNCIL

AMIC Australian Meat Industry Council

amic.org.au / www.amic.com.au

No. 17

THE BUSINESS CASE FOR HEAT PUMP WATER HEATERS

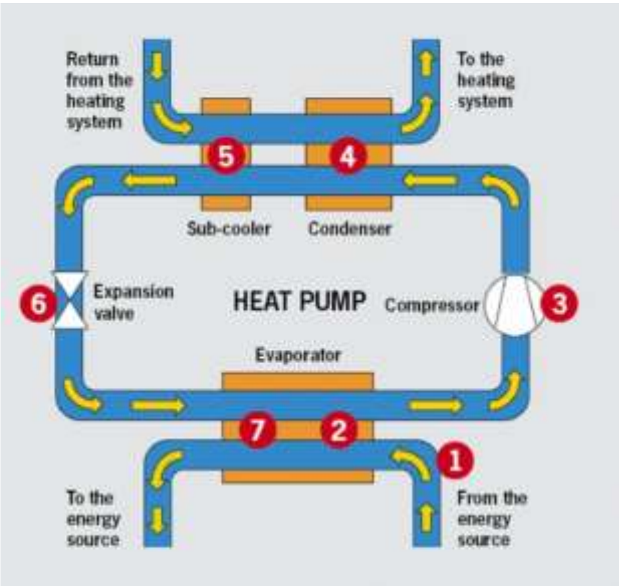

Figure 1 Schematic of a typical heat pump system[1]

TECHNOLOGY OVERVIEW

Heat pumps use electricity to move heat between two places. The most common of these use the vapour-compression cycle, or refrigeration cycle, and is commonly applied in domestic refrigerators and air conditioners and more recently modern reverse-cycle air conditioners which can both heat and cool.

Heat pump performance can be compared using the Coefficient of Performance (COP) which is a measure of the heat moved per unit electricity consumed. So a heat pump which moves four MJ of heat per MJ of electricity has a COP of 4. Higher COPs indicate more efficient units.

Heat pumps have improved markedly in recent years, driven by the widespread use of electrically-commutated motors, often described as "inverter technology", "DC" or "brushless motors". These motors are as much as 70% more efficient than the motors previously used in air conditioners. As each heat pump system typically has three motors which use 70% or greater of the system energy use, improving the motor efficiency makes a significant change to overall system performance. Where older, and poor performing heat pumps have COPs around 3 and even less, modern heat pumps achieve COPs as high as 6. The energyrating.gov.au website, run by the Federal Government, rates the efficiency of heat pumps available on the Australian market, providing values for both heating and cooling, and for operation in cold climates.

AIR SOURCE OR GROUND SOURCE?

The performance of a heat pump is driven by the temperature of both the 'hot place' and the 'cold place'. In a heating application the hot place is that being heated, and the cold place is the source of heat, typically the ambient air or the ground. As the ambient temperature changes, the amount of energy available per cycle of

[1] Taken from here https://www.zenrenewables.com/technology/heatpumps/heat-pump-system/

Australian Government Department of Industry

*This Activity received funding from the **Department of Industry** as part of the Energy Efficiency Information Grants Program.*

The views expressed herein are not necessarily the views of the Commonwealth of Australia, and the Commonwealth does not accept responsibility for any information or advice contained herein.

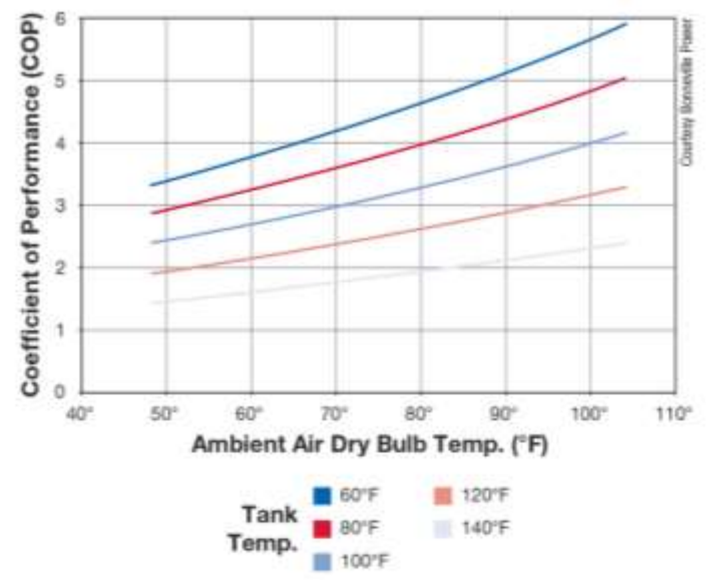

Figure 2: An example COP vs ambient air temperature for a heat

working fluid changes and so does the system performance. Consider Figure 2[2], which shows the performance curve of a heat pump hot water heater. This illustrates how both the ambient and tank temperature alter system performance, with the most efficient arrangement being a combination of low tank temperature and high ambient temperature.

This relationship means that when a heat pump is most needed, during extreme heat or cold, the ambient conditions are sub-optimal. One way to address this is by using the ground as the external heat source/sink. The ground temperature fluctuates far less than ambient temperature, and is generally cooler in hot climates and warmer in cold climates.

Figure 3 shows a plot of soil and air temperature for a cold northern hemisphere site, so winter is December to February. In this scenario the heat pump would be used during winter for heating. The green bars represent the difference between air and soil temperature, with positive results indicating the soil is warmer. So in this situation any time where the green bar is positive a ground source system would be more efficient. This can become even more acute where time of day is considered; typically ground temperatures are fairly stable overnight, while air temperatures are lowest in the morning before the sun starts heating the air.

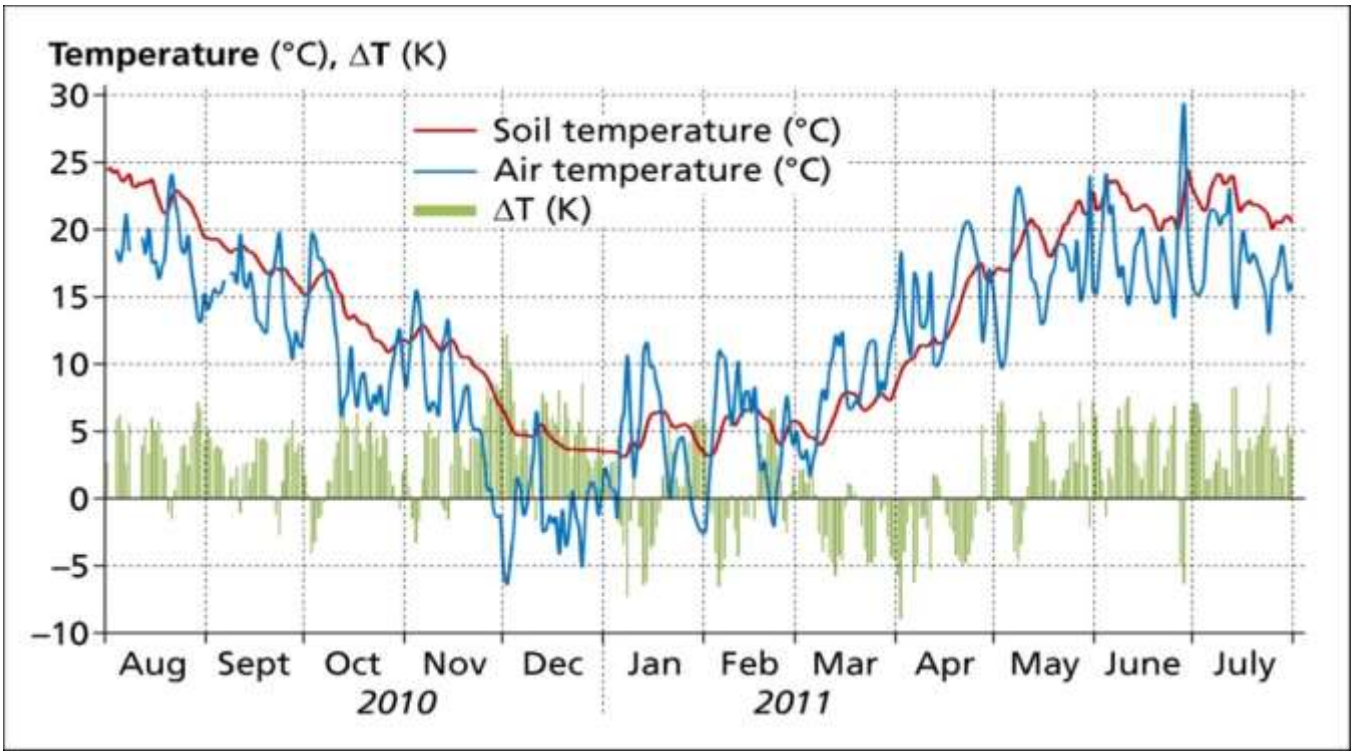

Figure 3: Daily mean values of air temperature (2 m above ground) and subterranean (2 m below ground) temperatures in Oberhausen, Germany, and their difference for the period 08/2010 – 07/2011 (source: H. Püllen, pers. comm.)[3]

[2] Taken from http://www.homepower.com/sites/default/files/articles/ajax/docs/3_HP156_pg58_Gocze-2.jpg

[3] Wilhelm Kuttler (2012). Climate Change on the Urban Scale – Effects and Counter-Measures in Central Europe, Human and Social Dimensions of Climate Change, Prof. Netra Chhetri (Ed.), ISBN: 978-953-51-0847-4, InTech, DOI: 10.5772/50867. Available from: http://www.intechopen.com/books/human-and-social-dimensions-of-climate-change/climate-change-on-the-urban-scale-effects-and-counter-measures-in-central-europe

IS IT SUITABLE FOR YOUR MEAT PROCESSING FACILITY?

Heat pumps are beneficial in cooler climates for heating water, particularly in the absence of natural gas. When use in space heating applications, they are most suitable in hotter climates in order to maintain worker comfort, although they may be replaced by water chillers in larger facilities.

HOW TO DEVELOP YOUR BUSINESS CASE

The business case requires a relatively simple comparison of improved efficiency against capital costs. Websites like www.energyrating.gov.au offer a good starting point to consider the efficiency and capital cost of different heat pumps. This site has the energy efficiency rating, purchase cost and coefficient of performance for each system and includes a calculator to determine your energy costs. Once this desktop analysis has been performed you can then approach the market for quotes, or seek a more detailed feasibility study.

When seeking quotes be sure to ask about the installation cost and any limitations on the system. The Green Building Council of Australia also have an excellent guide on calculating savings from heat pumps.[4]

FUNDING SOURCES

The cost to install a heat pump hot water system can be reduced by utilising Government incentive schemes (if available). You could be eligible to receive Small-scale Technology Certificates (STCs). An STC is a measure of renewable energy which can be traded for money or a discount on the purchase price.

A new heat pump hot water system is eligible if:

- it is a new system and is listed on the register of solar water heaters on the website of the Clean Energy Regulator (http://ret.cleanenergyregulator.gov.au/Hot-Water-Systems/eligible-swhs)
- small-scale technology certificates are created within 12 months of installation. If you choose to go through an agent they will create the certificates on your behalf.

Agents registered with the Clean Energy Regulator will offer you a financial benefit for your small-scale technology certificates, such as a discount off the invoice, in exchange for the right to create and sell certificates.

You can determine the number of certificates your system is eligible for by using the solar water heater calculator on the website of the Clean Energy Regulator (https://www.rec-registry.gov.au/swhCalculatorInit.shtml).

Alternatively, you can ask your registered agent about the number of certificates your system is eligible for, and the price they are offering for each small-scale technology certificate. The financial benefit is usually based on the small-scale technology certificate price at the time of the offer, as this fluctuates depending on supply or demand. The Clean Energy Council publishes the small-scale technology spot price on its website; however different traders may offer different prices depending on the buyer. You may wish to conduct an internet search for 'STC price' or 'REC price' to find other traders and prices.

EXAMPLE COST-BENEFIT ANALYSES

A rural abattoir has to replace an electric resistance hot water heater. A 5m^2 array of solar evacuated tubes was installed the year before and until now boosting had been provided by the electric hot water heater. The electric unit consumed 75,000MJ per year, or 20,833kWh of electricity.

Site engineers are considering replacing the electric unit with either a gas boosted or heat pump boosted system. The efficiencies, annual energy requirements and costs, and capital costs of these two systems are shown in the tables below.

[4] The full methodology is available here in pdf http://www.gbca.org.au/uploads/221/1757/Green%20Star%20-%20Solat%20Hot%20Water%20and%20Heat%20Pump%20Booster%20Energy%20Calculation%20Methodology.pdf

Instant Gas

Efficiency	Gas required to deliver 75GJ of heat (MJ)	Annual gas cost (at $9/GJ)	Capital cost ($)	Total for five-years
85%	88,235	$794	$700	$4,670

Heat Pump

COP	Electricity required to deliver 20.8MWh of heat (kWh)	Annual electricity cost (at 25c/kWh)	Capital cost ($)	Total for five-years
5.2	4,006	$1,002	$1,000	$6,010

As can be seen, the instant gas unit has both a lower up-front capital cost and lower annual energy cost. Therefore in this scenario the instant gas hot water heater represents a better investment. However, this comparison is highly dependent on the input fuel cost. At gas prices of about $12 and above the heat pump becomes more attractive.

The heat pump is eligible for Small-scale Technology Certificates (STCs), tradable certificates that offer an incentive for heat pumps and solar hot water heaters. Many retailers will deem STCs at the time of sale, reducing the sale price or they can be claimed after purchase. In this case the system is eligible for 26 STCs[5], which are trading at $20. This lowers the price of the heat pump system by $520, thus making it a more attractive investment compared to the instant gas heater.

GROUND SOURCE COOLING

A northern Australia abattoir finds that their air conditioner struggles during hot days, causing discomfort in the workplace. Site engineers plan to replace the existing system and are considering a ground source heat pump. The outgoing air conditioner was metered separately and delivered 60,000kWh of cooling each year. The new system will be sized to deliver 80,000kWh each year.

The site engineers find a local installer who can supply a heat pump system with either ground source or air source. Ground source comes with additional capital expenditure, but improved system performance.
The supplier has a data set comparing ambient and underground temperatures for the last 12-months, measured daily at midday. They also supply the performance curve for the heat pump system, showing COP against condenser temperature.

The following table provides a simplified comparison of the two systems using these data. This comparison assumes that maintenance costs are the same and that the installation of the ground source system costs an extra $5,000.

Month	Cool delivery (kWh)	Air temp (°C)	Air source COP	Air source electricity use	Ground temp at 5m (°C)	Group source COP	Ground source electricity use (kWh)	Energy saving from ground source (kWh)	Energy cost saving (at 25c/kWh)
January	10,000	35	2.8	3,571	17	4	2,500	1,071	$268
February	10,000	34	3	3,333	17	4	2,500	833	$208
March	6,800	27	3.2	2,125	16	4.2	1,619	506	$126

[5] STC allocations around Australia are available here http://ret.cleanenergyregulator.gov.au/Hot-Water-Systems/Incentives-for-your-Solar-Water-Heater/Heat-Pump/incentives-hot-water-heat-pump

Month	Cool delivery (kWh)	Air temp (°C)	Air source COP	Air source electricity use	Ground temp at 5m (°C)	Group source COP	Ground source electricity use (kWh)	Energy saving from ground source (kWh)	Energy cost saving (at 25c/kWh)
April	6,800	25	3.4	2,000	16	4.2	1,619	381	$95
May	6,800	24	3.45	1,971	16	4.2	1,619	352	$88
June	3,000	22	3.6	833	15	4.3	697	136	$34
July	3,000	21	3.8	790	14.5	4.4	681	108	$27
August	3,000	22	3.6	833	14	4.5	666	167	$42
September	6,800	24	3.45	1,971	15	4.3	1,581	390	$97
October	6,800	25	3.4	2,000	16	4.2	1,619	381	$95
November	6,800	27	3.2	2,125	16.5	4.1	1,658	467	$117
December	10,000	32	3.25	3,077	17	4	2,500	577	$144

The annual savings of installing the ground source heat pump rather than the air source heat pump is $1,342. Considering the ground source heat pump would cost an extra $5,000 to install, this results in a simple payback period of 3.7 years.

As both of these systems are heat pumps they are eligible for the same number of STCs. This will lower the price of each by the same amount and thus does not impact the comparison.