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HEAT PUMPS IN AQUATIC CENTRES

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HEAT PUMPS IN AQUATIC FACILITIES
General Review of Concept and Performance for locations in Australia

Introduction

This review has been performed by ISECO engineering services at the request of Smartconsult to provide a big picture confirmation that the proposed concepts are sound, performance predictions are valid and operational and safety aspects have been adequately addressed.

ISECO is recognised as Australia's leading specialist consultancy in industrial refrigeration. We are completely independent and do not do installation works which means we provide high quality impartial advice to our clients. The company was established in 1990, and has a wealth of experience within the skillsets of our senior staff. From the very beginning, the company has built expertise in the use of natural refrigerants such as ammonia and more recently carbon dioxide.

We typically take refrigeration projects from concept to design and provide onsite installation reviews and performance monitoring right through to operational and maintenance reviews. Our engineers regularly attend national and international refrigeration forums and trade shows as well as private factory visits at the major compressor manufactures facilities. Obtaining firsthand experience from compressor and heat pump designers.

Because we understand the fundamentals behind refrigeration compressor plants and the big picture in relation to energy efficiency and common-sense applications, we can give reliable advice in relation to use of ammonia in heat pumps and the associated operational and safety aspects.

Water to Water Ammonia Heat Pumps

Water to water heat pumps have been used extensively overseas for more than 20 years in commercial and industrial applications. As utility prices, in particularly gas prices escalate in Australia, these technologies are now gaining traction in Australia and New Zealand.

Iseco has in the last two years completed two design applications using this technology in industrial applications and have knowledge of another recent application in a municipal facility in New Zealand.

The packaged nature of the modern water to water heat pumps as offered by suppliers such as Sabroe and GEA make these very simple to use. They can effectively use low grade heat to provide useful high value heat (and cooling) and are ideally suited for applications such as Aquatic centres, which typically waste much of their low-grade heat resources.

Sources for low grade heat can include:

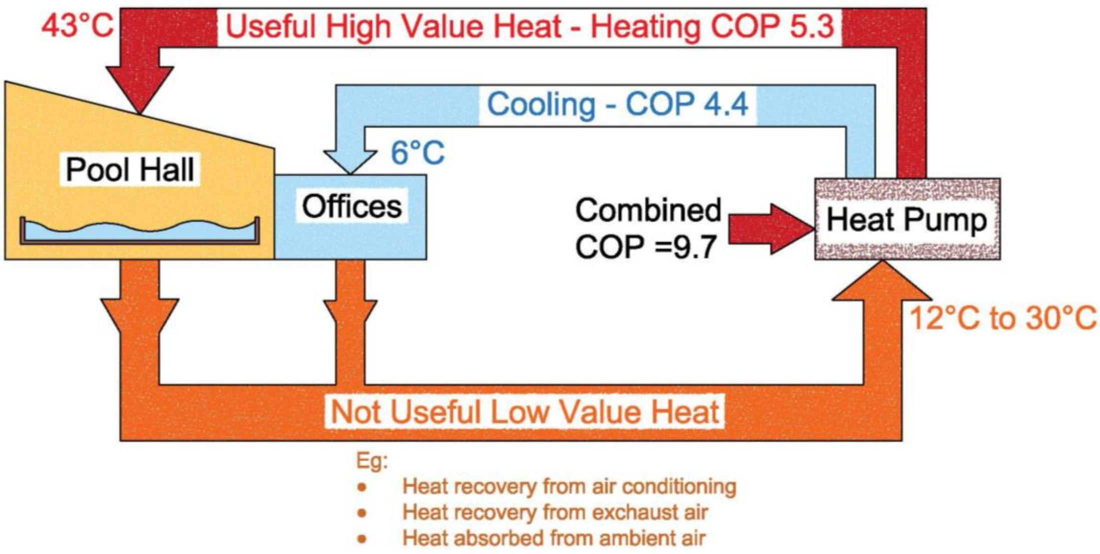
- Airconditioning heat recovery from return water
- Exhaust air streams from pool halls and amenities
- Ground sources
- Heat absorbed from ambient air

A heat pump works by using the compression cycle and relatively small input power to boost the low-grade heat to a higher temperature which can then be usefully used in a range of heat exchange applications. For Aquatic centre applications this is an ideal application since the required heating temperatures are not high, pool water temperatures of 30 ºC and pool hall air heating can be achieved with a heat exchange against say 45ºC leaving the heat pump.

Instead of wasting rejected heat, this can be boosted and used. During summer months the added benefit is possible to provide a cooling source for chilled water-based air conditioning by using the cooled water leaving the Evaporating side of the heat pump.

This is the way sustainable energy systems will work in the future and can work now, utilising the rejected energy instead of wasting it.

Refer to Figure 1 Below:



The proposed type of heat pumps use robust industrial components for their compressors, heat exchangers and controls. Because the concept uses water to provide the evaporator input heat and to absorb the condenser discharge heat, these systems have small refrigerant charges which is completely self-contained.

Ammonia is a sound choice of refrigerant as it is future proof since it has a global warming potential (GWP) of zero, very high efficiency and is low cost in the rare event a top up or replacement is required.

GWP is measure of how much ‘greenhouse gas effect’ a release of a particular refrigerant into the atmosphere will have. Therefore, its contribution to global warming and associated climate change effects. Because Ammonia has a GWP rating of zero it is not a greenhouse gas.

Common synthetic refrigerants used in commercial HVAC and heat pumps, for example R410a has a GWP of 2088, which means that 1kg of **direct** refrigerant emission into the atmosphere is roughly equivalent to 2088kg of CO_2 emissions (CO_2 is the reference with GWP=1).

Furthermore, the higher efficiency of ammonia heat pumps means that the **indirect** CO_2 emissions, associated with electricity generation are also reduced. The nett effect is an overall reduction in emissions compared to alternative systems.

Performance

The parameter used to measure the efficiency of refrigeration compressors and heat pumps is the Coefficient of Performance or COP. This is simply the total useful heating and cooling kW divided by the total electrical power into the heat pump or compressor.

ISECO have modelled three typical scenarios that could apply to the heat pump application at an aquatic centre:

Case 1: Summer Time with air conditioning loads and pool water heating requirements
Case 2: Average Winter conditions approximately 10ºC outside air (Geelong June, July, August average temperature) and no air conditioning load

Case 3: Winters morning approximately 3ºC (Less than 2% of the year in Geelong) outside air and no air conditioning loads

Table 1 Performance per Heat pump unit various scenarios

Cooling capacity kW 12ºC/6ºC	**Heating Capacity Pool Water 28ºC/43ºC**	**Heat Pump input Power kWe**	**Cooling COP**	**Heating COP**	**Combined COP**
Case 1: *Summer*					
700	**845**	**160**	**4.4**	**5.3**	**9.7**
Case 2: *Average Winter Conditions*					
N/A	**860**	**176.2**	N/A	**4.9**	**4.9**
Case 3: *Cold Winter Conditions*					
N/A	**906**	**225.5**	N/A	**4.0**	**4.0**

Note: Evaluations exclude pump power

This brief review shows that high COP values of the order of 10 or so are indeed achievable when combined cooling and heating loads are present. Even with heating on cooler days when it has been assumed that the heat is absorbed from the ambient air, COP values of 4 or greater are possible. It may be possible to further improve these COP values with careful heat exchanger selections to optimise the evaporating and condensing temperatures.

This will require more detailed modelling to confirm final annual energy costs and plant paybacks, but looks to be worth taking the next step to consider in more detail.

ISECO Heat Pump Experience to Date

Case No.1 - New Meat Processing Facility Queensland

This is a 1200 kW heating, 1050 kW cooling Sabroe HeatPac water to water unit with an 8-cylinder reciprocating compressor using ammonia refrigerant.

The application was designed by ISECO and Installed by Scantec.
The system absorbs heat from the main refrigeration plant heat rejection condenser and provides 66ºC water for the facility washdown and amenities usage. It has a nominal COP of 6.3 and an estimated payback of less than 3 years and a predicted gas saving of 17,000 GJ per year.

The System was installed in late 2018 and has been commissioned but not yet run in production mode. Commissioning reports indicate that the unit with its built-in controls and protections was very easy to commission.

Case No.2 - New Meat Production Facility Auckland New Zealand

This is a 700-kW heating, 590 kW cooling Sabroe HeatPac water to water unit with a 6-cylinder reciprocating compressor using ammonia refrigerant. Approximately 30 kg of ammonia charge.

The application was designed by ISECO and is yet to be installed.
The system absorbs heat from the main refrigeration plant heat rejection condenser and provides 65ºC water for the facility washdown and amenities usage. It has a nominal COP of 6.4 and an estimated payback of less than 3 years.

The System will be installed in late 2019.

Ammonia Safety

Because the heat pump systems are pre-packaged and self-contained the ammonia refrigerant charge is small and is contained within piping systems that are all factory fabricated. This significantly reduces the risk accidental leakage.

The risks associated with an accidental leakage can be managed by normal risk management techniques (AS/NZS 4360) and adherence to the current Refrigeration Safety Standard (AS/NZS 5149) requirements.

These would include:

- Locating the equipment in a dedicated plant room not accessible to the public
- Provision of automatic detection, alarm and ventilation systems & Emergency stop buttons
- Automatic system shut down and power isolation in the plant room

- Review of prevailing wind directions and safe locations for ventilation system discharge and or water scrubbing systems if required.
- Fire rated construction materials for plant room and doors
- Routine maintenance by qualified contractors
- Eyewash and safety shower facilities
- Staff training on emergency response procedures

Our experience with larger industrial applications is that providing the above are in place that the risk for these types of plants is very low and can be managed with little extra input to normal operational procedures.

Conclusions

Water to water heat pumps can provide a long-term solution to improving Aquatic centre energy efficiency and reducing heating and cooling costs. COPS in the range of 4.0 to just less than 10 can be expected in typical Melbourne and Geelong ambient conditions. Our experience to date has shown that the pre-packaged nature of these units makes them easy to install.

Whilst each aquatic centre will need to review its particular application potentials as part of the detailed engineering and final payback calculations, the heat pump technology should in our view form the way ahead.