# HEAT RECOVERY FROM REFRIGERATION SYSTEMS

## WHAT IS HEAT RECOVERY?

Heat recovery involves collecting waste heat rejected by the plant and equipment (such as refrigeration plant) and using it for other heating applications such as domestic hot water, wash down water, boiler feed water and even sterilisation.

## WHICH REFRIGERATION SYSTEMS ENABLE HEAT RECOVERY?

Heat recovery can be implemented in a variety of refrigeration systems, including:

- Two-stage and single stage ammonia systems;
- Single stage/economised single stage Freon systems; and
- Cascade $CO_2$ systems with either Ammonia or Freon refrigerants at the high stage.

The viability of heat recovery also depends strongly on the heating energy source available to a site and the cost of this energy source. As an indication, sites with high heating costs (generally using LPG) achieve more significant financial savings from the implementation of heat recovery, than a site with relatively low heating costs (generally using coal or natural gas).

Figure 1 - Heat exchanger

## INSTALLATION OPTIONS

The heat rejected by a refrigeration plant originates almost exclusively at the plant's compressors, before it is then redirected to the condensers and released from the system as waste heat. It is possible to capture this heat at the compressors before it is redirected, either at the compressor's discharge gas lines, or during the oil cooling process of a plant's high stage compressor. The captured heat can be used to heat water which can be stored in large storage tanks until required. There are multiple installation options that may be considered in order to maximise the amount of heat recovered and therefore possible energy savings. The key considerations when deciding upon which heat recovery option to employ in your refrigeration system include; the plant type, plant layout, heating energy source, and heating energy cost. Some of the main options are outlined in Table 1 and shown in Figure 1.

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*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.*

*Please note that where commercial services providers are referred in this report, this is for industry guidance only and should not be considered an exhaustive list of available service providers.*

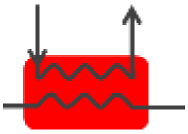
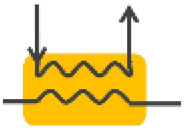
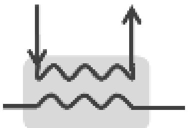
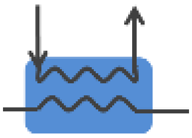
| Option | Schematic | Applicability |
|---|---|---|
| **1) Heat exchanger on the low stage compressors.** |  | All two-stage systems and cascade systems (typically $CO_2$), in particular for sites with high electrical costs, where a reduction in electricity use would be of the greatest benefit.<br>Since a two-stage refrigeration plant is designed such that the heat from the low stage compressors is fed into the high stage compressors, installing a heat exchanger into the low stage compressor discharge gas line would redirect this heat, thereby reducing the amount of heat the high stage compressors are required to deal with. This provides the additional advantage that these compressors are then required to do less work and electrical savings are achieved. |
| **2) Heat exchanger on the high stage compressors.** |  | Sites with high heating costs and/or a high heating demand. Such a project is relevant for compressors of all sizes – however for smaller sites, applicability will depend on total project costs.<br>Installing a heat exchanger onto the high stage compressors would not result in any electrical savings, but since these compressors run at higher temperatures, larger amounts of heat can be recovered. When reciprocating compressors are present in the high stage, even larger amounts of heat can be recovered due to the nature of the compressors. |
| **3) Oil coolers on the high stage compressors.** |  | Systems with screw compressors in the high stage. Recovering heat through oil coolers in the high stage can only be done if screw compressors are used, since reciprocating compressors do not rely on the use of oil to absorb heat as is done by screw compressors. |
| **4) Integrated heat pump on the high stage compressors.** |  | Situations where recoverable heat is insufficient for the site's heat demands, not suitable for sites with high electrical tariffs.<br>This option would be implemented in scenarios where there is either more heat required on site than is able to be recovered from the refrigeration plant, or the heat is required to be at a higher temperature. The heat pump achieves this by increasing the refrigerant pressure, and a much higher portion of the discharge heat can then be recovered (100%, rather than <20%).<br>The pump requires additional electric power to run, and hence such an implementation would only be suitable at sites with very low electrical tariffs, or relatively very high heating costs (LPG, electric heating). |

Table 1 - Main heat recovery options

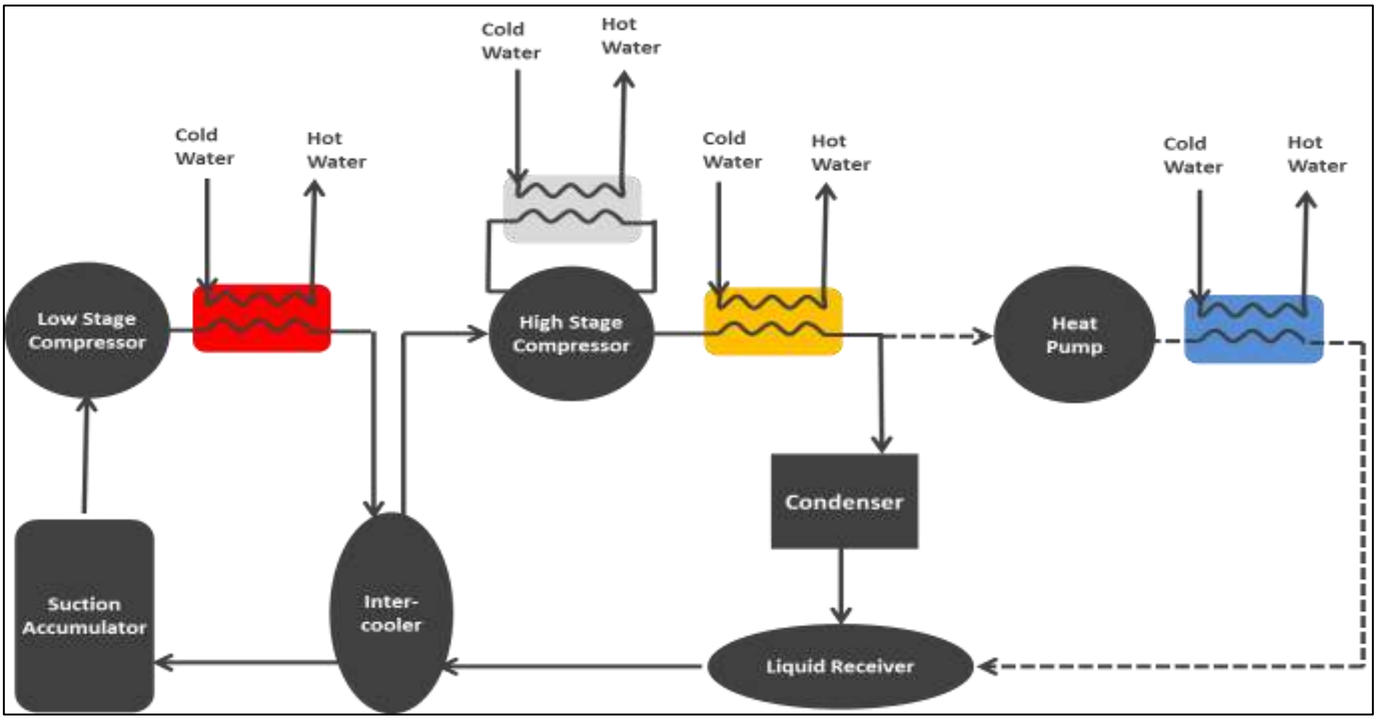



Figure 2 – Schematic depicting the main heat recovery options shown in Table 1.

## HEAD PRESSURE & HEAT RECOVERY

When a heat exchanger is installed onto the discharge line of a high stage compressor, the amount of recoverable heat becomes dependent upon ambient temperatures. The reason being that the higher the ambient temperature, the higher the cooling load and condensing pressure of the plant and the greater the amount of heat that can be recovered from the heat exchangers. Since the condensing pressure increases with temperature, this generally means that more heat can be recovered in summer than winter.

Coupled with the need to maintain high condensing pressures owing to large and relatively constant cooling/freezing loads at red meat processing facilities, there is significant opportunity for heat recovery from refrigeration systems at abattoirs all year round.

An alternative energy saving option to heat recovery from constant condenser pressure systems is the adoption of Variable Head Pressure Control (VHPC) technology. VHPC technology improves the energy efficiency of a plant by optimizing the condensing pressure rather than maintaining it at unnecessarily high levels during periods of reduced cooling requirement. However, while the extent of heat recovery is less for plants with optimised condensing pressures, the overall energy costs are typically less as a result of the energy saved by the optimisation process. An example of how VHPC combined with heat recovery can provide greater combined heating energy cost savings is shown in Figures 3 and 4 and Table 2.

**EXAMPLE**

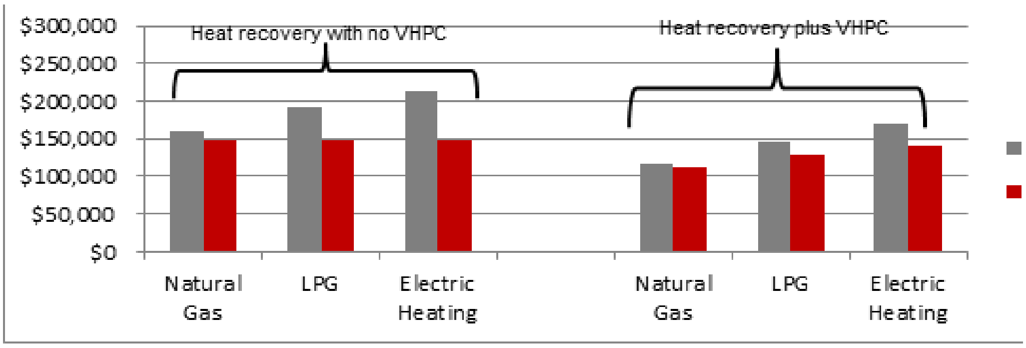



Figure 3 – Modelled heating costs before and after the installation of a low stage heat exchanger in NSW, for a site with high

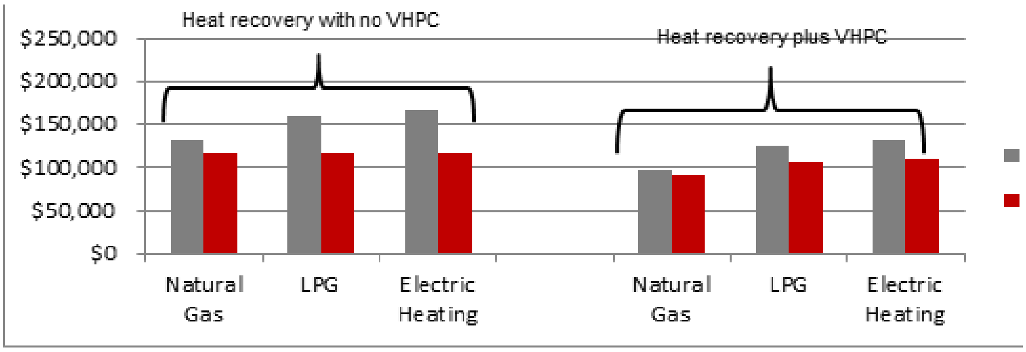



Figure 4 – Modelled heating costs before and after the installation of a low stage heat exchanger in NSW, for site with low electrical costs, but high heating costs.

A site in NSW which has implemented both heat recovery (by installing two heat exchangers onto the high stage compressors) and a VHPC logic onto the evaporative condensers achieved the savings shown in Table 2.

| Implemented technique | Capital cost ($) | Achieved savings ($) | Payback (Yrs) |
|---|---|---|---|
| **Heat Recovery** | 295,578 | 107,817 | 2.7 |
| **VHPC** | 29,216 | 43,575 | 0.6 |
| **Total Savings** | **$151,396 (7.6% of total annual energy costs)** | | |
| **Simple Payback** | **2.15 yrs** | | |

Table 2 - Specific example of energy savings resulting from the implementation of both VHPC and heat recovery.