REFRIGERATION CASE STUDIES 10

Dairygold Co-op Society, Mitchelstown, Co. Cork

Refrigeration is used for a variety of applications in industry but primarily for cooling and freezing of products, condensing vapours, maintaining environmental conditions and cold storage. It is a major consumer of electricity and in some sectors, particularly food, drink and chemicals, it represents a significant proportion of overall site energy costs – up to 90% in the case of some cold storage facilities. There are many opportunities to improve efficiencies and save money. Generally a cost reduction of 20% may be achievable with a good return on any investment made.

The Annual Self Audit and Statement of Energy Accounts Scheme is operated by the Irish Energy Centre for the largest energy consumers in the industrial sector in Ireland. Participation in the scheme is voluntary with member companies committing to annual energy savings targets, regular audits of their energy consumption and the publication of an annual statement of their achievements. The Irish Energy Centre provides support to the membership by helping in the preparation of annual statements and also through workshops, seminars, news-letters and site visits, and by providing information on specific approaches to energy efficiency.

As part of this scheme, the Irish Energy Centre contracted Enviros March, Manchester, U.K., to conduct comprehensive energy audits of the refrigeration facilities at Dairygold Co-op Society, Mitchelstown, Co. Cork, and at Glanbia Ingredients, Virginia, Co. Cavan.

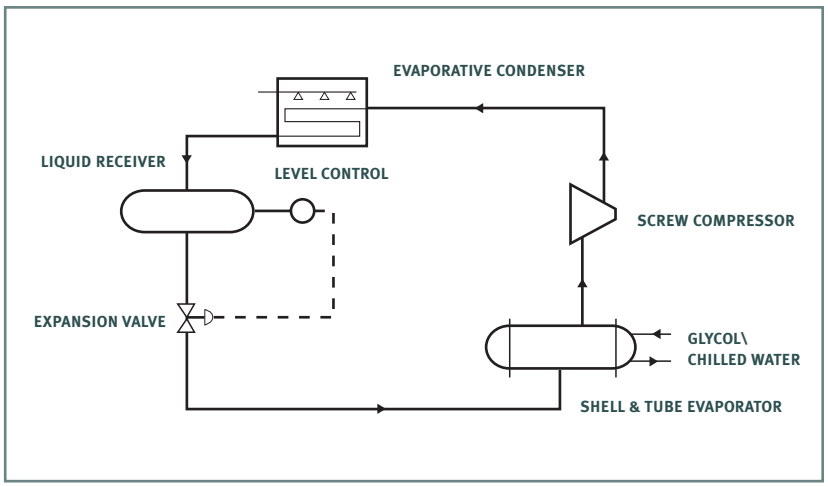


Figure 1: Schematic diagram of typical refrigeration system

TABLE 1. SUMMARY OF AUDIT COSTS AND SAVINGS IDENTIFIED

SITE	ANNUAL REFRIGERATION COST (€)	COST OF AUDIT (€)	POSSIBLE ANNUAL ANNUAL SAVINGS IDENTIFIED (€)	SAVINGS AS A PERCENTAGE OF TOTAL COSTS
DAIRYGOLD	190,450	15,500	87,500	46%
GLANBIA INGREDIENTS	44,500	13,600	17,400	39%

THE AUDIT

The terms of reference of the audits in both instances was to:

1) **Examine the complete system loading including cooling, product, insulation and auxiliary loads.**

2) **Review whole system and component design.**

3) **Audit metered electricity data and relate to factory production and weather conditions.**

4) **Propose energy efficiency opportunities in the above areas and in general operation / maintenance procedures.**

4) **Provide advice and suggestions regarding energy savings, possible investment costs and pay back periods.**

Dairygold Co-op Society, Mitchelstown

DAIRYGOLD CO-OP SOCIETY, MITCHELSTOWN

The Dairygold food processing plant at Mitchelstown, Co. Cork, is one of the largest milk processors and ingredient manufacturers in Ireland. Its products include milk powders, spreads, casein, and whey powder. Refrigeration is an essential part of production at the plant, and it is used for a wide range of cooling processes. The refrigeration system costs €190,450 per annum to operate, accounting for roughly 13% of the plant's total electrical energy consumption. The plant has a comprehensive metering system that monitors the system coefficients of performance (COPs) of the refrigeration system. The COPs typically ranges from 4-5 in summer time during peak production periods to 1-2 in winter time when very little milk is processed. System COP is defined as the ratio of cooling achieved to the total power to the system.

Dairygold Refrigeration System – Description

The Dairygold refrigeration system is an ammonia system serving several evaporators with individually controlled evaporating temperatures. High-pressure ammonia gas is generated in a central compressor house that contains 13 compressors. The high-pressure, high-temperature discharge gas is condensed in 3 evaporative condensers mounted on the roof of the compressor house.

The condensed liquid refrigerant is stored in a liquid receiver, which supplies 4 evaporator circuits, namely, the Baudelot coolers, the Buco ice makers, the plate heat exchanger and the glycol system. A back-pressure valve is located on the inlet to the condenser to ensure that sufficient pressure / temperature is available to remove ice from the Buco when it is operating in the ice building mode.

The glycol cooling circuit supplies 3 milk pasteurisers and a few low temperature cooling loads. The other 3 evaporator circuits all form part of the chilled water system. Chilled water is stored in a large storage tank near the compressor house. Returning chilled water from the site is cooled in a separate, plate-type evaporator before being remixed and discharged to an inner tank in the main chilled water system. The water is pumped over a series of Baudelot chillers and then over a series of Buco ice-

Dairygold Co-op Society, Mitchelstown

builder/chillers and finally returned to the main tank. The main tank supplies a distribution header in the compressor house, which supplies chilled water to 65 heat exchangers throughout the plant.

Potential Savings

The potential to reduce the operating cost of the refrigeration system was evaluated under the headings of cooling load reduction, distribution system, refrigeration system design and plant operation.

The audit revealed that cooling load could be reduced by using softened water rather than chilled water to carry out cooling of the refrigeration compressor cylinder head. This had been in operation on a temporary basis but the soft water had been run to drain after use. Savings of about €4,400 per year could be achieved if this soft water was returned to the evaporative condenser sump and if the

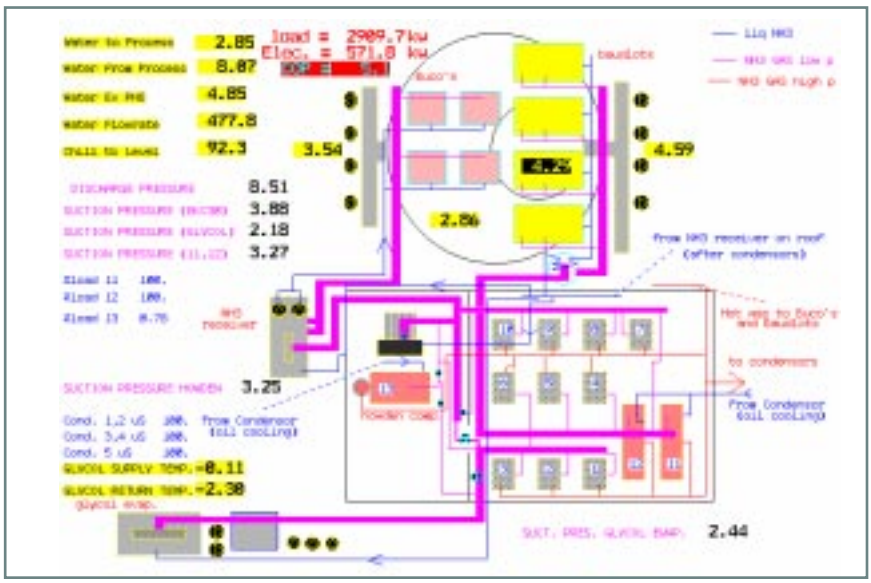


Figure 2. Line Diagram of Dairygold System

water flow was controlled through a solenoid/needle valve arrangement that would only permit flow when the compressors were operating.

The distribution pumps at the plant operate at full load much of the time. To reduce the auxiliary loading during times of low demand, six circuits were identified for control by either installing variable speed drives or by improved load scheduling. The proposed measures would achieve a saving of €38,100 with a 1-year payback period.

The present ammonia system is rather complex and is not reliably meeting its demand. The audit confirmed that the previous practice of ice building in the Buco system was not cost effective and should be permanently discontinued. Apart from the savings that this would achieve in its own right, the decision to discontinue ice making would also make it possible to remove a number of valves from the Buco refrigeration distribution system. This would result in savings of €8,900 per annum by simplifying the operation of the plant and reducing pressure drops.

During the peak operating period, the chilled water temperature often fails to drop to its target of 2°C. The theoretical maximum demand of the plant is currently 8.8 MW, but the temperature of the chilled water begins to rise once the load exceeds 2.3 MW. The control system was investigated to determine the reason for the increase in chilled water temperature, and ways of operating the plant were examined to ensure that the theoretical output is achieved. System observation showed that the plate heat exchanger is operating effectively but that the operating temperatures of both the Buco and the Baudelot evaporators are too high, and as such, their performance was inhibited. It was therefore suggested that the pilot valves on the Buco and Baudelot be adjusted to a setting of -3°C and -4°C respectively to allow the evaporators to perform at their design capacity.

A number of other areas of plant operation that could be improved upon were identified. It was observed that it would be better to operate a compressor dedicated to the plate heat exchanger whenever there is sufficient load. This would save €1.90 per hour and would increase system capacity. It was also seen that the operation of all of the chilled water systems as a common unit would provide better control and some energy savings. Improved control of condensing temperature could save between €8,900 and €26,700 per annum, and improved scheduling of the plant during winter time could save between €5,100 and €9,500 per annum.

Dairygold Co-op Society, Mitchelstown

GLANBIA INGREDIENTS, VIRGINIA, CO. CAVAN

Glanbia Ingredients, Virginia is a subsidiary of Glanbia plc, which is an Irish-based international food company, servicing a worldwide market. The company was formed in 1997 through the merger of Avonmore Foods plc and Waterford Foods plc and it has manufacturing operations in Europe and North America. It is the largest dairy processor in Ireland and the U.K. combined. The Virginia plant produces cream base and cream for Baileys Original Irish Cream Liqueur and milk powders.

Energy consumption at the site is very well monitored. The refrigeration plant costs €44,500 per annum to operate, which accounts for approximately 13% of the plant's total electrical energy costs. The audit revealed that there is potential for energy cost savings through improved control of the refrigeration plant.

Glanbia Ingredients Refrigeration System – Description

The main chilled water system at the Glanbia site consists of a single stage circuit, with a Buco ice builder as evaporator, a bank of 7 reciprocating compressors and 3 evaporative condensers.

The Buco ice builder only works as an ice builder during the night-rate hours. During the day it works as a Baudelot tank, pre-chilling return water that is cooled by the ice stored in the tank below.

The 7 reciprocating compressors are controlled by a Programmable Logic Controller (PLC). The PLC maintains an appropriate suction set point pressure and prevents additional compressors operating if the temperature of the water leaving the ice tank is below 0.25°C. This saves energy, as, when the tank is below 0.25°C, the return temperature is also low, and ice tends to build on the plates to no useful purpose. Three compressors make ice at night under manual control.

The 3 condensers are manually controlled according to observed conditions, but it seems that automatic control of the condensers could save energy.

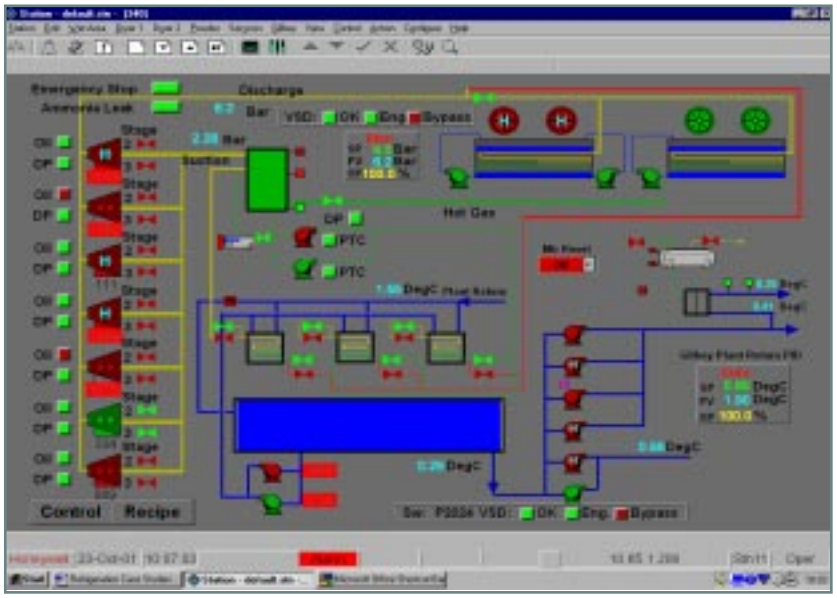
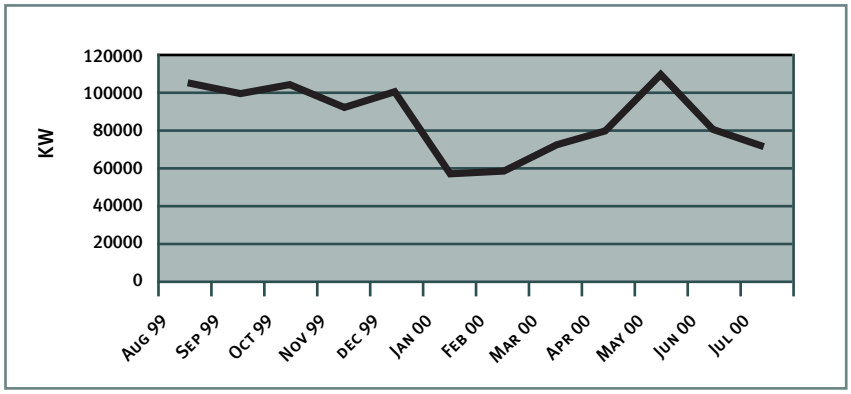


Figure 3. Line Diagram of Glanbia System



Graph 1. Refrigeration Energy Consumption at Glanbia Ingredients, Virgina

Potential Savings

The potential to reduce the operating cost of the refrigeration system was evaluated under the headings of cooling load reduction, refrigeration system design and plant operation. The main cooling loads on the plant are 4 pasteurisers in the cream plant, the Gilbey plant pasteuriser and chilled water Contherms. The main findings of the audit were as follows:

- **The load on the refrigeration system could be significantly reduced if the 4 milk and cream pasteurisers were modified to a more optimal design – such as using lake water for cooling plates and utilising additional heat recovery. This would result in a saving of €7,600 per annum, however the additional costs associated with retrofitting may prove to be uneconomic.**
- **If the proposed flat-rate electricity rate is accepted, there would be no advantage to building ice at night. The cost of building ice would increase to the point where it ceases to be economical. If the plant is to operate without building ice, another evaporator would therefore be required. This would cost €51,000, but would reduce the annual operating cost of the plant from a projected €61,000 to €33,000.**
- **A new control system for the plant is proposed. It is estimated that this system would save roughly 15% of annual energy usage. The control system should be capable of monitoring the system to enable alteration of temperature and pressure set points to maintain system efficiency and ensure optimum utilisation and sequencing of system compressors.**
- **The system would improve the plant's ability to provide process cooling when the ice begins to disappear towards the end of the day.**

CONCLUSION

The energy audits at Dairygold and Glanbia identified ways in which the operating costs of the refrigeration plants could be significantly reduced and plant performance improved. Although the recommendations made in these two case studies are site specific, the principles could be broadly applied to other refrigeration plants. For example, both audits revealed the significant savings potential of;

- **The use of Variable Speed Drives.**
- **Optimising control systems to ensure that the overall system operates at the most appropriate temperature and pressure set points for the system load.**
- **Reducing unnecessary cooling loads.**

Modifications may be required to achieve these savings and may result in some investment, but the simple payback on such investments would be generally good.

Various electricity tariffs may affect the way a plant is operated and this can be seen especially in the process of ice building at night time. Although not resulting in energy savings, cost savings may be achieved by appropriate tariff structures.

In these case studies, the practice of ice-building was found to be uneconomical and the consultants recommended that it be discontinued.

The case studies show that, not only can an audit identify significant energy cost savings, it can also identify measures that will improve the capacity of the system and simplify operation of the plant.

Glanbia Ingredients, Virginia, Co. Cavan

For further information on energy saving technologies and initiatives, contact:
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NDP NATIONAL DEVELOPMENT PLAN

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