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Report

on the

Ecolife Ltd.

heating installation at

Gowran Abbey Nursing Home

eco LIFE IRELAND

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Executive Summary

Ecolife is a company based in Knocktopher, Co. Kilkenny, Ireland, directed by Eddie Devereux and Eamon Marnell. It specialises in intelligent heating design, heat pumps, solar hot water and under floor heating. This report examines an Ecolife installation in the Gowran Abbey Nursing Home (pictured).

Figure 1 Gowran Abbey Nursing Home

The Gowran Abbey nursing is a modern development, housing a maximum of 49 clients under the Health (Nursing Homes) Act, 1990 and the Nursing Homes (Care and Welfare) Regulations, 1993 [1]. The heating source (space and water), prior to the Ecolife installation was a liquid petroleum gas (LPG) supplied boiler. The space heating was through underfloor heating with rudimentary zone control.

The Ecolife installation took over the main load for both space and hot water heating using two units of Ochsner Golf Maxi Air to Water GMLW Plus heat pump. Liquid petroleum gas (LPG) is still used, to reach the hot water design supply temperature, but Ecolife installed Atag modulating gas boiler to achieve this design temperature. When the heat pumps achieve this target temperature on their own, then the LPG boilers do not fire.

Economic performance: The system economic performance was considered for the early months of the year, a period in which the outside air temperatures were unusually low, both day and night. The figures were compared for the same months in 2009, under the previous heating regime and when the home had a lower occupancy. In spite of these low outside air temperatures and lower occupancy, the cost of heating has dropped by the considerable amount of 65% in the period of February to August, when compared with the same period in 2009. The heat energy demand was similar in both periods and the external temperatures were slightly worse in 2010 compared with 2009.

The reasons for the improved economic performance are the efficiency of the air sourced heat pump, its use by night, when the Coefficient of Performance (efficiency) is still sufficiently high to allow the exploitation of the lower cost of electrical units at night-time. Also, Ecolife improved the efficiency of the heat supplied to the building by installing a heat management system, which interfaces with all devices.

Comfort performance: The staff and clients of the Gowran Abbey Nursing Home described the new installation an improvement on the previous system, especially in

terms of controlled temperature, with better zoned control, no system failure and more comfortable living and working environment.

The reasons for the improved comfort performance are due to better zoned-control (monitoring and actuation) of the building, intelligent use of the buffered water and correctly dimensioned heat source.

The overall reduction in energy bills (heat, as well as lighting, sockets, etc.) is 35%. This figure is also interesting in light of the government policy *Maximising Ireland's Energy Efficiency*, published in 2009. This policy sets a target for Ireland of delivering 20% energy efficiency savings in 2020, but for the public sector the government have set a higher target of 33%. If a public building could replicate the savings reported here, then it may be possible to reach the government target for building energy usage, by changing the heating system.

Table of Contents

List of Figures

1. Introduction

This report consists of an early evaluation of a new air to water heat pump used as heating system in the Gowran Abbey nursing home. The system was in place just in time to coincide with an unusually cold winter/spring. The performance comparison puts the new system up against the previous gas boiler, with the small increase in the heat load not considered. The colder outside temperature is also reported.

While there is no published reliable data in the public domain to analyse whether air source heat pumps are suitable for an Irish climate, a considerable amount of recent work has focussed on their performance [2]-[4] and performance in a similar climate [6]. Reported efficiencies, referred henceforth as the Coefficient of Performance (COP), especially in central and northern Europe are quite high and should be replicable in Ireland. The single major caveat lies in the relatively high air humidity values that can occur in Ireland, which, at low winter temperatures, can lead to ice formation in the system. While this can be automatically remedied with a defrost cycle, it compromises the overall efficiency [6]. Because of this, the performance of the heatpump can only be gauged on the total amount of energy delivered in an annual heating period, in relation to the total electrical power consumption in the same period. This is referred to as the Seasonal Performance Factor or SPF. In the case of Gowran Abbey, the Ochsner heatpumps do not have any electrical immersion backup to help with defrosting. Instead they use energy stored in the buffer tank to help in defrost mode.

Firstly outlined in this report is the technical explanation of the heat pump which discusses its design features. The following section is on System Design, which will outline the performance and highlight the source of potential savings. The System Performance will follow and is a 6-month analysis of the system, covering late Winter to end of Summer. The Conclusions sum up the overall performance and also gives an indication of likely future directions.

2. System Design

Air source heat pumps are likely to form a significant part of the heat to buildings. Future buildings must have a percentage of renewable energy systems installed to comply with the European Parliament Buildings Directive (EPBD) 2002/91/EC. The Irish Building Regulations TGD Part L 2008 also requires a renewable energy technology either for space or water heating in new dwellings. The minimum energy input for these systems is 10kWh/m^2/annum. Moreover, heat pumps are considered as renewable technologies, only when the CoP is over 2.5 [8]. A typical air sourced heat pump would have an average CoP of 3.5 [18]. This means that for every 1kWhr of electrical energy used it produces 3.5kWhr of useful heat energy. This would imply a 350% superior performance where electricity is used as the heat source (rarely the case).

Air source heat pumps are usually installed with an underfloor heating distribution system. The temperatures from air source heat pumps are typically 35-45°C, which is lower than the conventional radiator circulating temperature of 60-65°C. While the current generation Ochsner heatpumps can, offer flow temperatures of up to 65°C, without electrical immersion backup, thereby allowing them to compete with conventional radiator heat sources, such higher temperatures reduce the heat pump CoP.

Air source heat pumps offer a reduced CoP and heat output as the ambient external air temperature falls. Moreover, after a sustained period of operation (and especially if the humidity is high) frost can build up on the evaporator surface, this typically occurs when the ambient external air temperature falls below 5 C [6]. The system must run a defrost cycle to remain frost free, this has an impact on the overall efficiency of the unit. As Ireland has a maritime climate it often has high humidity in winter. However, it is important to note that Ochsner heatpumps do not use an electrical immersion, to help with defrosting. Instead they use energy stored in the buffer tank to help in defrost mode.

An air to water heating system has several advantages over its close relation the ground or geothermal source heat pump. The system can have minimal installation impact in terms of time to install and also the external space required. This means that the system could equally be suitable for installation in apartment block developments and large housing schemes. There are also several limiting factors to such a system, one being that it is most suitable for use with underfloor heating systems as the unboosted flow temperature is below the recommended temperature for radiator systems. Another drawback is the relatively high capital cost of the system to supply and install. However, the return on investment can be much faster than other renewable technologies and the lower maintenance costs and longer life make a compelling case for consideration.

The Irish market has been slow to react to the possibilities of the air source heat pumps. A review of the literature has revealed only two studies reporting data on the use of heat pumps in the UK domestic sector. The majority of the heat pump installations are in new builds rather than existing housing and only a few have been subjected to monitoring to establish their effectiveness and running costs. There has

been little or no research into the views of those landlords and end users who have had heat pumps installed [21].

Heat pumps use the sun's energy which is stored in the ground, in water or in the air. From the diagram below we can see that the energy extracted by the heat pump can come directly from the sun (or as output waste heat from household activity). The heat pump extracts the warmth from the surroundings and converts this into useable energy for heating. The majority of the energy needed comes directly from the environment but with a percentage of electricity being used to power the heat pump itself. This ratio is known as the Coefficient of Performance (COP) and is a crucial figure in estimating the efficiency of the system. It is common practise to reduce the running costs by operating heat pumps during the lower electricity tariff period.

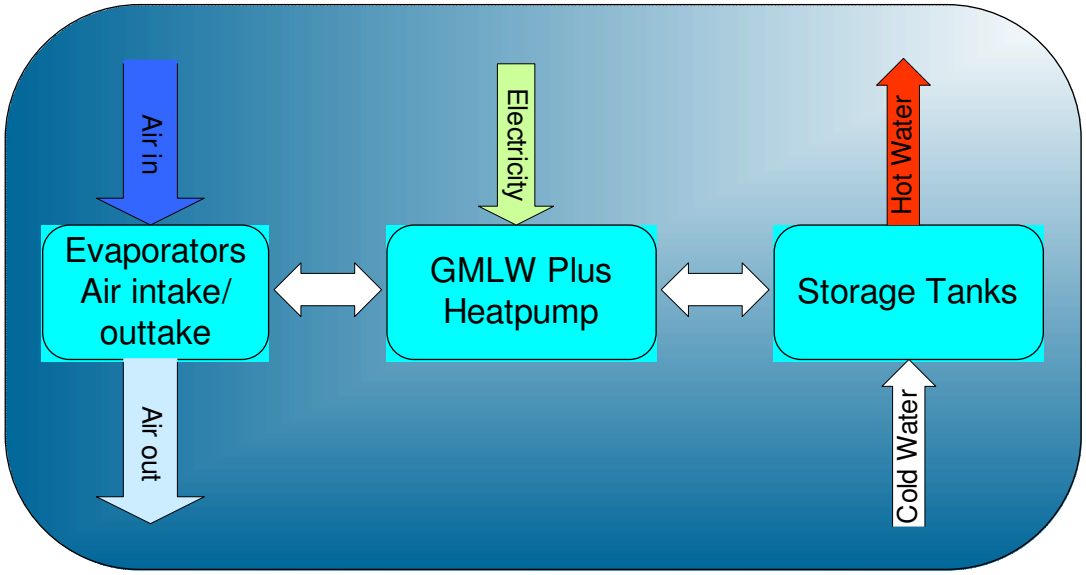

Figure 2 Ecolife system block diagram for Gowran Abbey

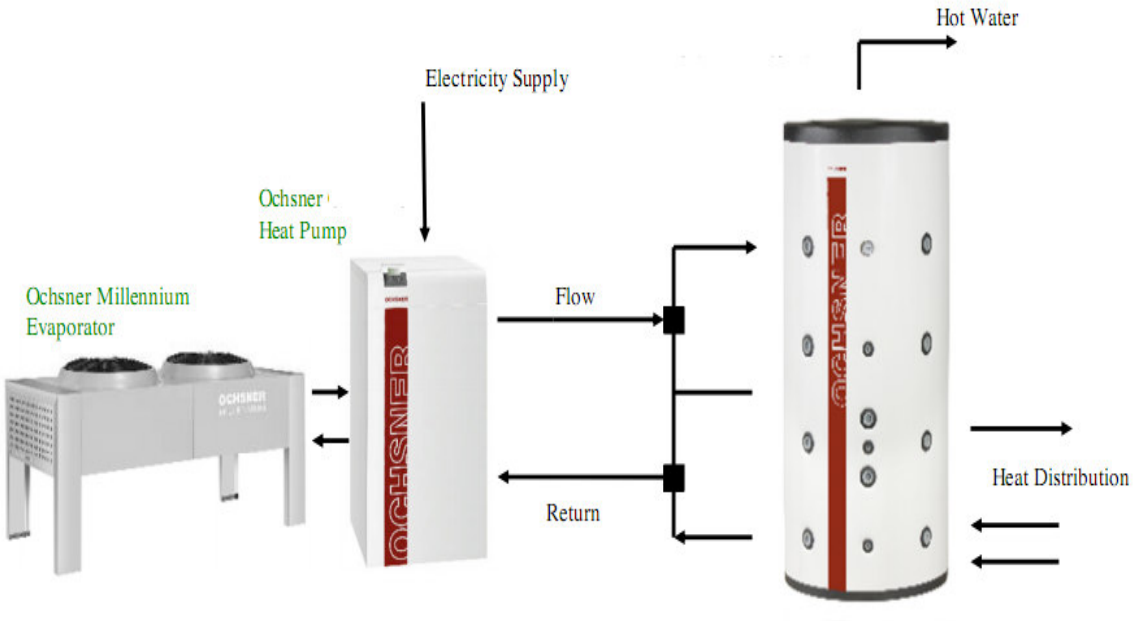

Figure 3 Typical deployment in Ecolife system

The Ecolife installation took over the main load for both space and hot water heating using two units of Ochsner Golf Maxi Air to Water GMLW Plus heat pump to feed two tanks, one to supply heat to the building and one for the hot tap water. Liquid petroleum gas (LPG) is still used (albeit to a much less extent, as seen in the dramatic reduction in the gas bill year-on-year, in Section 3 System Performance) to reach the hot water design supply temperature. Ecolife installed an Atag condensing gas boiler to reach the hot water design supply temperatures. When the heat pumps achieve this target temperature on their own, then the Atag boiler does not fire. Both storage tanks are independently and comprehensively insulated and housed in an insulated custom-built shed. Access to the shed is from one side only, but is complete, as that entire side of the shed consists of removable, insulated panels (pictured).

Figure 4 The two Ochsner evaporators (left) and the two storage tanks (right)

Excess heat is also generated on site 6 mornings of the week in the laundry room. The laundry room heat is now to be vented through a separate heat exchanger and used to help heat the hot tap water.

Figure 5 Extra heat pump for excess laundry room heat (left)

Figure 6 Various space types to be heated at Gowran Abbey

The building is maintained at a comfortably warmth, with thermostats typically set at 22-24 degrees. Each room has a separate thermostat and a separate motorised control valve on the manifold.

3. System Performance

Overview

The system performance is evaluated here for the months February to August of 2010. The staff and management opinion on performance in terms of comfort was solicited. Energy bills for the same months in 2009 were examined and the outside average temperature compared over both periods. Results of readings from the heat pump meter, the LPG tank and various temperature readings are also considered in this section.

Environmental Conditions

The temperature was monitored on site and compared, for reference purposes, throughout the period under examination, with the Met Éireann measurements at the nearest recording station, Oak Park in Carlow. The Oak Park measurements presented here are an average of the two readings given, for night and day. The Gowran readings were taken at various, random times in the day. There is a strong correlation between the two readings, with differences likely being due to the variability in the time of day of the Gowran readings.

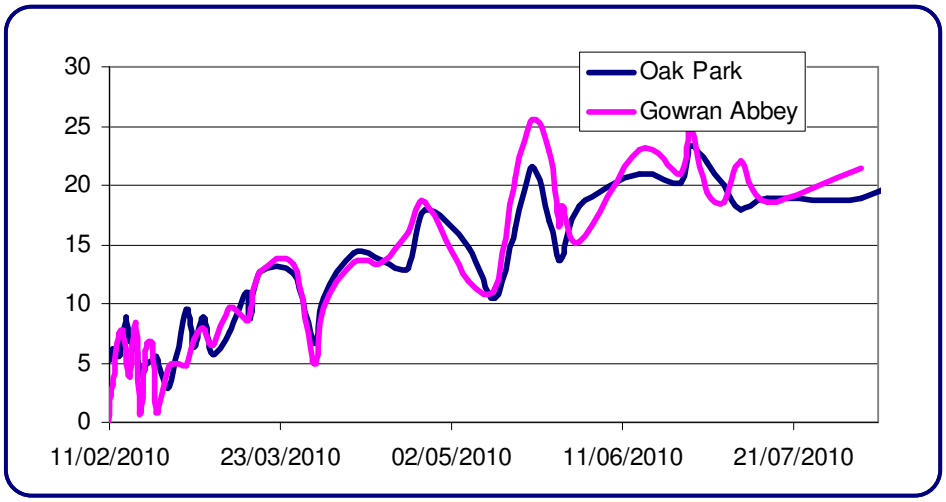

Figure 7 Local temperature readings compared with Oak Park

The months February to August of 2010 have been considerably colder (first three of the months, at least) than the previous year, as can be seen from readings taken from the Met Éireann measurements at the nearest recording station, Oak Park in Carlow. This means that any performance improvement year-on-year could be regarded as a conservative estimate of the long-term improvement.

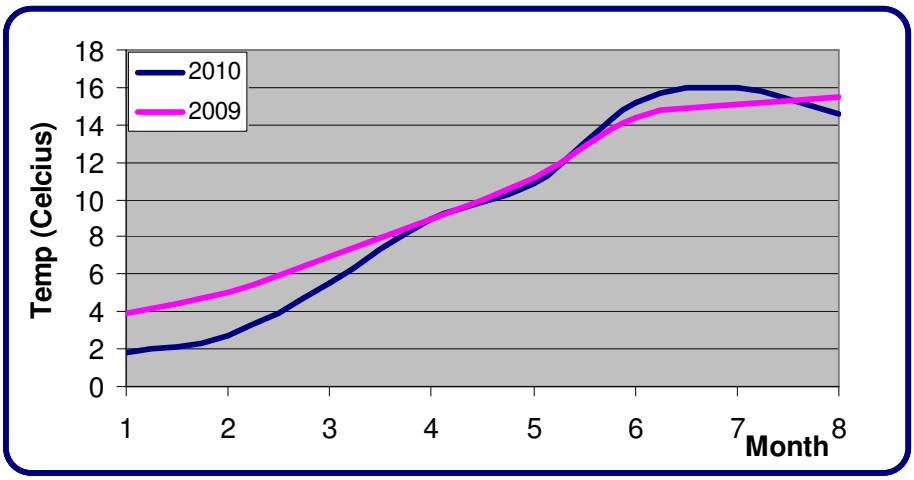

Figure 8 Average external Oak Park air temperature Jan-August 2010 and 2009

It is clear that the 2010 air temperature is relatively low and is indeed below average. This latter point can be seen by comparing with the Met Éireann recordings over a 30-year period for Birr, Co. Offaly.

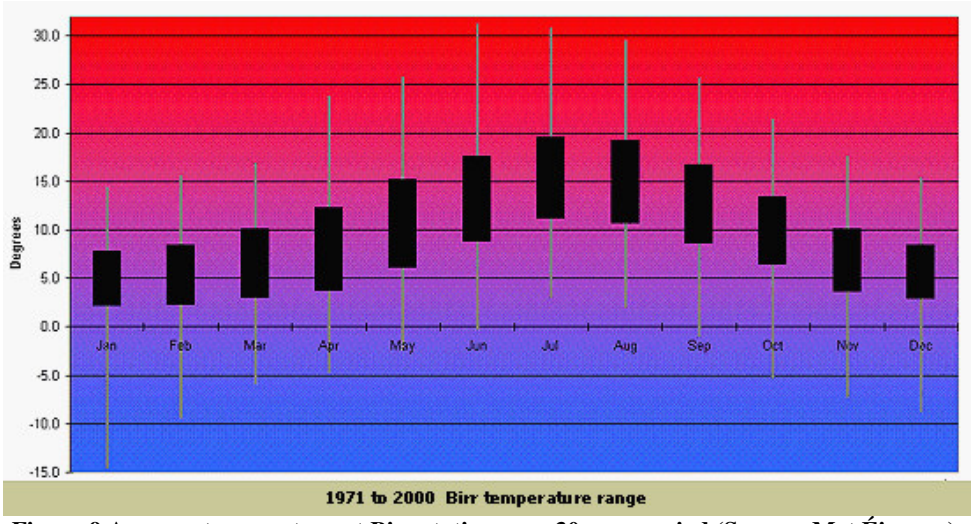

Figure 9 Average temperature at Birr station over 30 year period (Source: Met Éireann).

Even allowing for the Gowran Birr separation, the first three months, the coldest, are clearly below average in the boxplot.

System performance

The Ecolife system statistics were recorded over that interval and the electrical usage and local air temperature readings are presented as trendlines (3rd order polynomial trendlines).

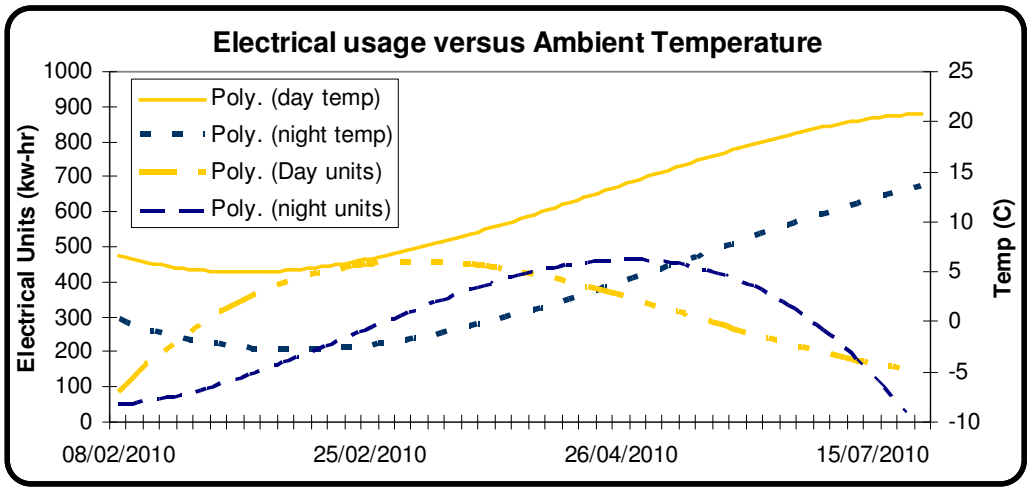

Figure 10 Day and Night electricity and temperature trends

The increase in night electricity usage may be attributed to the air source heat pump firing at night in order to bring the buffer tanks up to the maximum in order to serve the space heat and water requirements of the next day(s). As the days and nights got warmer, the heating system drew less and less electricity, both by day and by night.

In terms of efficiency reduction and defrosting requirements, Ecolife reported finding that when the temperature is around 2 degrees Celsius outside and there is a high humidity in the air i.e. a foggy night, this can cause a lot of ice to build up on the evaporators. This in turn forces the heatpump into defrost mode which in turn reduces the time the heatpumps are heating the building. On the other hand they also found that when the temperatures are below freezing and the cold is drier the defrost time is less.

Economic performance

Apart from the environmental and comfort benefits of installing this heating system, the nursing home was particularly interested in seeing an economic benefit. To verify any improvement, electricity and gas bills were compared for the 6 months of February to August n both 2009 and 2010. The actual amounts will not be revealed in this report, but the figures and underlying trends are clear to see. The reduction in heat energy costs from 2009 to 2010, with a similar load (occupancy, comfort choice, etc) has been 65% in 2010 compared to 2009.
This reduction has also been individually recorded in the following two graphs of cumulative energy bills.

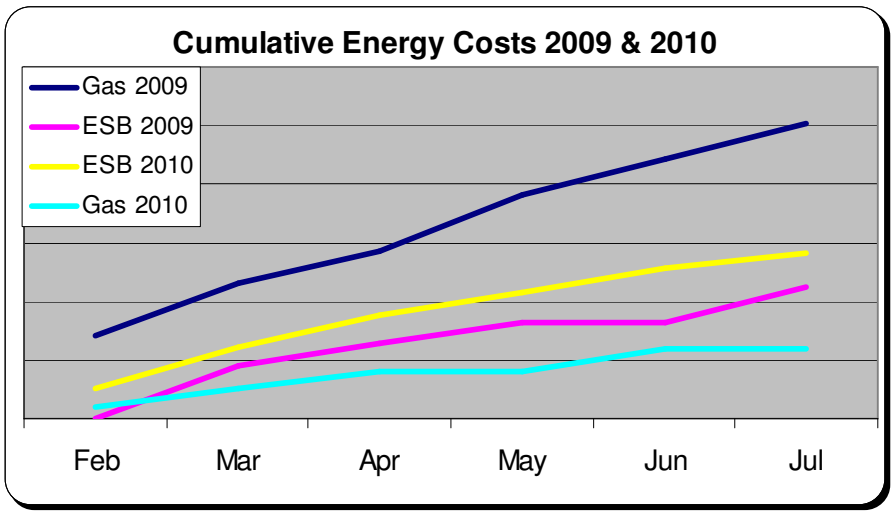

Figure 11 Cumulative gas and electricity costs for both 2009 & 2010

Equally the costs may be compared on a month-by-month basis. In particular for the early three months, it is clear that the gas usage is dramatically lower in 2010, the electricity costs are not comparably higher.

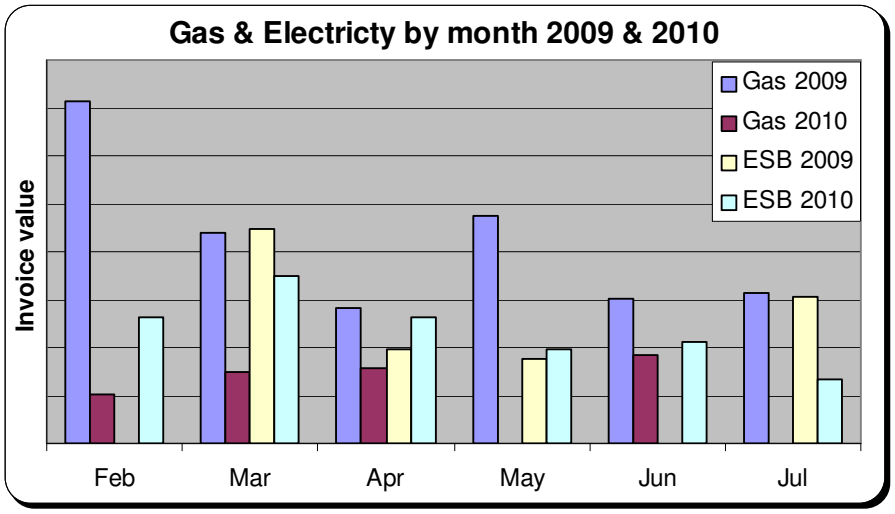

Figure 12 Energy cost comparison by month for both 2009 and 2010

The gas consumed in 2010 is used by the new, more efficient Atag boiler.

The electricity bills increased 26% and the gas bills fell 77% year-on-year because of the heat pump. When the heat element is considered alone, by attributing the increase in electricity costs in 2010 to heat alone and assuming no electricity was used in 2009 for heating purposes, the overall heat energy costs fell by 65% over the six-month period.

Finally, a member of staff and a member of management were each quizzed regarding comfort, ease of use and reliability. So far, given the system is relatively new, there have only been positive experiences to report by both people, under each of these categories.

4. Conclusion and recommendations

In conclusion, the following points can be made:

- Savings of 65% were achieved over a 6-month period, where the outside temperature was actually lower than the year in which the higher costs occurred.
- Based on the 6 months results, air sourced heatpumps can be used in Ireland, as long as the design, sizing, and installation of plant are carried out correctly .
- Related to the previous point, the importance of smart controls must be underlined, to interface with all components of the system.
- This particular system is capable of replication in both new builds and retrofit applications.
- Commercial heat pumps can be regarded as viable competitors to more established products, because of the security of the primary energy source of electricity.
- Typically, there are low maintenance costs associated with heat pumps, thus reducing annual running costs of plant and costly overheads.
- The Carbon footprint of a building can be reduced and, consequently, the Building Energy Rating (BER) can be potentially brought to an A standard.
- Based on this single case study, it appears likely that retrofit installations can be carried out without any major disruption to the day to day running of the building.