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## An Investigation into Energy Consumption and Existing Energy Management Practices in a Dublin Sports Centre

Colin J. Conway

*Technological University Dublin, colin.conway@tudublin.ie*

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# **Brunel**

**University**

**West London**

*School of Engineering and Design*

*An Investigation into Energy Consumption and Existing Energy Management*

*Practices in a Dublin Sports Centre*

*by*

**Mr. Colin Conway**

Student Number: 0826740

A Thesis submitted for the award of MSc in Building Services Engineering

September 2013

Dissertation Tutor: Dr. Peter Warren

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## Abstract

Rising energy costs are a concern to all businesses but especially to those who have a large energy demand. Sports centres with swimming pools have large requirements for heat and electricity in order to maintain thermal comfort within the pool and surrounding areas.

Sports centres which were built in the 1970s were designed at a time when energy was cheap and many of today's control strategies and energy efficiency measures were unavailable.

This project is an investigation into the electrical and thermal consumption of the Tallaght Sports Complex. The Tallaght Sports Complex was built in the 1970s and is lacking in modern energy saving technologies. A detailed examination of the energy flows within the building is carried out and consumption patterns for all large energy users are identified. Methods of reducing energy consumption for the large energy users are discussed, calculated and in some cases, implemented. Results from the implemented energy saving strategies are analysed.

The results of the project show that there is a large potential to reduce the energy demand of the Tallaght Sports Complex, mainly through the installation of a cross flow heat exchanger, but also through the use of variable speed drives and a building management system.

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## Glossary of Terms

AHU	Air Handling Unit
BMS	Building Management System
BSI	British Standards Institute
CER	Commission for Energy Regulation
CHP	Combined Heat and Power
CIBSE	Chartered Institute of Building Services Engineers
CIRIA	Construction Industry Research & Information Association
CO <sub>2</sub>	Carbon Dioxide
DCENR	Department of Communications, Energy and Natural Resources
DEHLG	Department of Environment, Heritage and Local Government
ECG	Energy Consumption Guide
EED	Energy Efficiency Directive
EMS	Energy Management System
EPA	Environmental Protection Agency
EPBD	Energy Performance of Buildings Directive
ETCI	Electro-Technical Council of Ireland
ETS	Emissions Trading Scheme
EU	European Union
ISO	International Organisation for Standardisation
LCCA	Life Cycle Cost Analysis
LIEN	Large Industry Energy Network
MCB	Miniature Circuit Breaker
Mtoe	Million tonnes of oil equivalent
NEEAP	National Energy Efficiency Action Plan
SEAI	Sustainable Energy Authority of Ireland
SME	Small to Medium Enterprise
UNEP	United Nations Environment Programme
VSD	Variable Speed Drive

# 1 Introduction

## 1.1 Introduction

The environmentalist and the businessman may not agree on everything, but they agree that energy efficiency is something to strive for. For the environmentalist, green house gas emissions can be reduced, while for the businessman, costs can be reduced. Whether the environment or money is the primary reason for trying to reduce consumption is irrelevant.

“In no sector is the case for energy efficiency more compelling than in business, where scale, intensity and competitiveness pressures combine to drive energy savings and awareness of environmental impacts. Indeed, many businesses, especially the larger energy users, have been addressing issues of efficiency in recent years and demonstrating the gains that are possible. In 2007, some 1,753GWh were avoided by large energy users through participation in the Large Industry Energy Network (LIEN). Existing actions are anticipated to provide approximately 8,200GWh PEE of energy savings in 2020.” (DCENR, 2009)

As part of the EU’s 2020 Energy Saving Target strategy all Member states must reduce energy consumption by 20% through energy efficiency, decrease CO<sub>2</sub> by 20% and increase the use of renewable energy by 20% from the 1990 baseline levels. According to UNEP’s report on Buildings and Climate Change: Status, Challenges and Opportunities (UNEP, 2007) 30% to 40% of worldwide energy consumption occurs in buildings, and this figure is increasing.

The Energy Efficiency Directive (2012) advises that, to access the potential energy savings, Member States should develop programmes to encourage SMEs to undergo energy audits. The Energy Efficiency Directive goes on to suggest that energy audits should be mandatory, performed regularly for large enterprises and should take into account relevant European or

International Standards, such as EN ISO 50001 (Energy Management Systems), or EN 16247-1 Energy Audits.

## **1.2 Main Aim & Objections of Research**

The primary aim of the research is to assess a 1970s sports centre with swimming pool with regard to its energy consumption, energy costs and energy efficiency. Once a clear understanding of the energy flows within the building is determined, an investigating into possible energy efficiency improvement measures can be undertaken.

The findings from this research may be used by other similar sport centres as a reference point when assessing their own buildings.

## **1.3 Outline of Chapters**

Chapter 1 introduces the main aims and objectives of the dissertation, the rationale behind the chosen topic, the scope and limitations of the dissertation.

Chapter 2 is a literature review which looks at relevant legislation and good practice guides.

Chapter 3 gives a detailed insight into the Tallaght Sports Complex including a brief history, a description of the building's services and benchmarking analysis.

Chapter 4 outlines the results of the audit.

Chapter 5 is a detailed breakdown of the associated energy costs.

Chapter 6 investigates possible energy efficiency strategies and outlines the results of implemented measures.

## **1.4 Rationale behind Chosen Topic**

Ever increasing energy costs are reducing margins for businesses and buildings with heavy consumption have to take a proportionally larger hit. Sports centres with swimming pools are large users of energy due to their large heating load and services requirements. Older sports centres lack the modern technology and controls which newer centres use to minimise costs.

An 1970s sports centre with a swimming pool was indentified in the Dublin suburb of Tallaght and selected to be researched. It was hoped that inefficiencies would be identified and solutions proposed.

## **1.5 Scope and Limitations of Dissertation**

This thesis focuses on gas and electrical consumption in the Tallaght Sports Complex, Dublin 24, Republic of Ireland. Consumption units and costs are analysed and a study of all large users within the building is carried out.

Smaller electrical loads, such as computers, small fridges, general lighting etc. are not studied as the focus was aimed at the larger services specific to swimming pools.

Information was gathered from a number of sources such as billing information, contacting the energy supplier, data loggers, energy meters, thermometers, humidity sensors, interviewing the building manager/ maintenance engineer/ staff and many hours spent on site.

## 2. Literature Review

### 2.1 European Commission's Action Plan on Energy Efficiency

The European Commission published the Action Plan for Energy Efficiency in 2006. It states that “Europe continues to waste at least 20% of its energy due to inefficiency” (EC, 2006). Following from this, the energy efficiency action plan sets out to assist the European Union in achieving its 20% energy saving target by 2020. There are ten priority actions in the document, two of which are relevant here;

#### **Priority Action 5**

##### **Facilitating appropriate financing of energy efficiency investments for small and medium enterprises and Energy Service Companies**

Through a number of specific initiatives in 2007 and 2008 the Commission will call upon the banking sector to offer finance packages specifically aimed at small and medium enterprises and Energy Service Companies to adopt energy efficiency savings identified in energy audits. Access to Community financing, such as Green Investment Funds, co-financed by CIP36, will be made available for promoting eco-innovations. (EC, 2006)

#### **Priority Action 8**

##### **Raising energy efficiency awareness**

Priority areas, besides improved labelling, will include education and training plans and programmes for energy managers in industry and utilities. Included will also be teaching aids for primary, secondary and vocational educational curricula. These will be developed as of 2007 through Community programmes, by recommendations to Member States and through co-operation with Member State and Community educational agencies. (EC, 2006)

The 20% energy saving target relates to three main aims, also known as the 20-20-20 targets; The European Union has committed by legislation to these targets and proposes the following be achieved by 2020;

- Reduction of 20% for greenhouse gas emissions when compared to the level of greenhouse gas emissions of 1990.
- Increasing to 20% the amount of energy consumption in the EU produced by renewable sources.
- Improvement of the EU's energy efficiency by 20%.

Long term investments in energy efficiency are often avoided due to a lack of information on life cycle analysis. As stated in the Green Paper (DCENR, 2006), the most important barrier to increasing energy efficiency is a lack of information on costs and availability of new technology; lack of information on costs of own energy consumption; lack of training of technicians on proper maintenance and the fact that these aspects are not properly taken into account by market participants.

The Green Paper (2006) states a number of tools for project assessment such as; computer programmes lifecycle analysis handbooks and investment grade energy audits.

The paper gives measures to identify options for how any barriers to the targets can be overcome. Some of the main actions proposed within the Green paper (2006) are summarised as follows;

- Implementation of energy-efficiency action plans for all member states that might identify measures to be taken at all national levels. The action also states that the action plans would



need to be monitored to assess their success both in terms of improving energy efficiency and their cost effectiveness.

- The need for all EU citizens to be provided better information, through better targeted publicity campaigns and improved product labelling.
- Identification of the best potential for state resources to provide an incentive to the efficient use of energy.
- Targeting of public procurement to push forward new energy efficient technologies, such as more energy efficient transport and electrical equipment.
- Review of the Energy Performance of Buildings Directive in all member states.

(McCarthy, 2013)

## **2.2 Energy Efficiency Directive**

Shifting to a more energy-efficient economy should also accelerate the spread of innovative technological solutions and improve the competitiveness of industry in the Union, boosting economic growth and creating high quality jobs in several sectors related to energy efficiency. (EC, 2012)

The European Council developed the Energy Efficiency Directive (EED) firstly to ensure the 2020 energy saving targets are achieved, and secondly to stimulate the growth of employment in the energy efficiency sector. The directive was published in 2012 and aims to increase energy efficiency in the public and private sectors of all member states and to provide the necessary legal measures for the 2020 targets to be achieved (EC, 2012).

Energy audits are referred to frequently in the directive. It states that SMEs should be encouraged to undergo energy audits while for large enterprises, energy audits should be mandatory.

To tap the energy savings potential in certain market segments where energy audits are generally not offered commercially (such as small and medium-sized enterprises (SMEs)), Member States should develop programmes to encourage SMEs to undergo energy audits. Energy audits should be mandatory and regular for large enterprises, as energy savings can be significant. Energy audits should take into account relevant European or International Standards, such as EN ISO 50001 (Energy Management Systems), or EN 16247-1 (Energy Audits)  
(EC, 2012)

Annex VI of the directive sets out the minimum criteria for energy audits including those carried out as part of energy management systems, and states that they are to be based on the following guidelines:

- (a) be based on up-to-date, measured, traceable operational data on energy consumption and (for electricity) load profiles;
- (b) comprise a detailed review of the energy consumption profile of buildings or groups of buildings, industrial operations or installations, including transportation;
- (c) build, whenever possible, on life-cycle cost analysis (LCCA) instead of Simple Payback Periods (SPP) in order to take account of long-term savings, residual values of long-term investments and discount rates;

(d) be proportionate, and sufficiently representative to permit the drawing of a reliable picture of overall energy performance and the reliable identification of the most significant opportunities for improvement.

Energy audits shall allow detailed and validated calculations for the proposed measures so as to provide clear information on potential savings.

The data used in energy audits shall be storable for historical analysis and tracking performance. (EC, 2012)

Europe is currently on track to miss its energy saving target by more than half. The Coalition for Energy Savings suggests that the directive proposed by the European Commission is likely only to close 2/3 of the current gap towards the 20% energy saving target for 2020. (CES, 2013)

### **2.3 Energy Performance of Buildings Directive**

The Energy Performance of Buildings Directive was published in 2002. The objective of this Directive is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. (EC, 2002)

Article 1 of the directive, lists the following areas which the directive lays down requirements to:

- (a) The general framework for a methodology of calculation of the integrated energy performance of buildings;
- (b) the application of minimum requirements on the energy performance of new buildings;
- (c) the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- (d) energy certification of buildings; and

(e) regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old. (EC, 2002)

There is not a single reference to energy audits in the entire directive. The directive was revised in 2010, the aim of this revision was to clarify and simplify certain provisions, extend the scope, make some more effective, and provide for the leading role of the public sector. The revised directive contains one reference to energy audits.

The energy performance certificate shall provide an indication as to where the owner or tenant can receive more detailed information, including as regards the cost-effectiveness of the recommendations made in the energy performance certificate. The evaluation of cost effectiveness shall be based on a set of standard conditions, such as the assessment of energy savings and underlying energy prices and a preliminary cost forecast. In addition, it shall contain information on the steps to be taken to implement the recommendations. Other information on related topics, such as energy audits or incentives of a financial or other nature and financing possibilities may also be provided to the owner or tenant.(EC, 2010)

## **2.4 National Energy Efficiency Action Plan**

In order to achieve the 20% energy savings set out in the EU's Energy Efficiency Action Plan, the Irish government developed its National Energy Efficiency Action Plan (NEEAP) in 2007. With regards to the role of energy audits, the first NEEAP; Maximising Ireland's Energy Efficiency (2007) only refers to Article 8 of the Energy Services Directive (ESD) that requires Member States to ensure the availability of energy audits and energy efficiency improvement measures. (McCarthy, 2013).

The second NEEAP (2012) mentions audits a number of times with regard to public buildings.

“We have introduced several pieces of legislation to promote energy efficiency in the public sector – The European Communities (Energy End-Use Efficiency and Energy Services) Regulations 2009 (S.I. No. 542 of 2009) transpose Directive 2006/32/EC into Irish law. The regulations set out several obligations on public bodies with respect to their exemplary role in energy efficiency, putting in place obligations and standards for energy-efficient procurement, energy management practices, energy audits, the use of energy-efficient buildings and annual reporting on the actions being taken to improve energy efficiency” (DCENR, 2012)

With respect to private buildings, the second NEEAP (2012) only makes one reference to audits. On page 76 it describes a free service offered to SMEs which includes “an initial energy audit” It is unclear how detailed this audit is or what exactly is audited.

In the executive summary of the second NEEAP, it states that “final consumption peaked in 2008 and has fallen 9.6% since” (DCENR, 2012), it goes on to attribute this fall to energy efficiency measures driven by government policy. It fails to mention that Ireland’s economy went into recession in 2008 and that this a large factor in the reduced national consumption.

## **2.5 EU Emissions Trading Scheme**

In 2005, the EU launched the Emissions Trading Scheme (ETS) as their main strategy to reducing green-house gas emissions across Europe. The scheme has created an international carbon market by implementing a price on each tonne of carbon emitted. Companies are issued allowances and any emissions emitted above their allowance will result in the company having to buy carbon credits or invest in low carbon technologies to reduce their carbon output. Up to 38% of the total CO<sub>2</sub> emissions released from installations in Ireland are legally obliged to the scheme, with an average of 50% across Europe. There are three phases to the scheme; the first

phase was for the 2005-2008 period, followed by the second phase from 2008-2013, and finally the last phase from 2013 – 2020.

As noted under the agreement of the ETS (2009) each member state is required to draw up national allocation plans for each trading period setting out how many allowances each installation will receive each year. (McCarthy, 2013)

## **2.6 Voluntary Agreement in Energy Efficiency**

*“The Government has committed to reaching energy efficiency savings of 20% by 2020, and energy suppliers will play a key role in meeting this goal.”* (DCENR, 2012).

Nine energy suppliers (including Energia) agreed with the Sustainable Energy Authority of Ireland (SEAI) to help their respective customers in reducing consumption. The voluntary agreement was reached in 2012 and a main advantage to consumers is assistance in performing energy audits.

The agreement sets out annual kWh reduction targets for energy suppliers to achieve by helping organisations improve their overall energy efficiency. In their report “Voluntary Agreements in the Field of Energy Efficiency and Emission Reduction Review and Analysis of the Experience in Member States of the European Union” (2012), Bertoldi & Rezessy explain that, voluntary agreements that rely on taxation usually target energy-intensive industry, and where by mandating energy management systems (EMS) and energy audits, an extremely high impact can be achieved but may be difficult to quantify in advance in order to establish realistic targets. (McCarthy, 2013)

The review by Bertoldi & Rezessy (2010) goes on to note that in Ireland it is assumed that the proper design of an EMS, along with the right level of commitment with regards to managerial,

human and financial resources, the EMS will deliver results without necessarily committing to targets.(Bertoldi, et al., 2010)(McCarthy, 2013)

## **2.7 Good Practice Guide 219 and Good Practice Case Study 360**

The Good Practice Guide 219 and the Good Practice Case Study 360 take a different approach to reducing energy consumption in swimming pools and sports centres. The Good Practice Case Study 360 follows the concept of treating energy management as a management issue, where all building occupants have a role to play, as opposed to the Good Practice Guide 219 which focuses more on the “engineering problem with an engineering solution” model. Although both these texts are dated, they are still relevant today as all the same issues prevail. One area which has changed since these texts were first published is the availability of Variable Speed Drives (VSDs).

### **2.7.1 Good Practice Case Study 360**

The Good Practice Case Study 360 focuses on a number of sports centres in the metropolitan borough of Kirklees (UK). One advantage of being part of a large group of facilities is the ability to form a purchasing consortium. This means that, as a larger overall consumer, suppliers will be eager to get the contract and may be willing to lower unit costs.

The Kirklees council provide support to the sports centres by way of its energy management unit. The unit will undertake building surveys to identify investment opportunities, assess building performance, monitor energy consumption and provide building managers with information and guidance.

These are two valuable assets in the drive to reduce costs for sports centres in Kirklees, the Tallaght sports complex has neither of these options available to it.

“Energy is the second highest expenditure within the budgets of most sports centres, although it is often overlooked until the management contract is in crisis, or people are complaining about being uncomfortable” (The Department of the Environment, 1997).

The Kirklees approach has three main themes

- Communication raises staff awareness and increases their understanding of energy costs and consumption.
- Energy is not “someone else’s problem”; staff must accept that they are responsible for how much energy and water they use.
- Staff often need advice and training to help them understand what they must do individually to save energy.

It is quite obvious that the Kirklees approach has a large emphasis on the personal responsibility of all building occupants as opposed to solely placing the task of reducing energy consumption on the energy manager.

Energy awareness is discussed in job interviews; job descriptions for centre managers include energy appreciation; there are quarterly training sessions for all staff on energy management and the theme of “energy as a controllable resource” is emphasised in staff induction and training. Pool supervisors and managers also attend energy efficiency seminars.

Keeping staff motivated can be an issue and the Kirklees approach is to inform all staff about energy usage and costs. “Initially staff are surprised to learn just how much it costs for the energy needed to keep each centre operating”(The Department of the Environment, 1997). Making staff fully aware of the costs involved and keeping them updated as to any savings made is a motivational tool used by many organisations. Kirklees also try to promote a pioneering



culture by running a monthly competition for the best idea which leads to improvements in quality or energy efficiency.

Another staff led approach is a repairs and faults sheet where staff have the responsibility to highlight any problems which they encounter. This is useful as the staff members are moving around the entire building everyday and if they are “energy aware” they may observe a problem before the energy manager does. Duty managers also carry out visual inspections daily to check items such as: doors, windows, pool covers, and pool water and air temperatures.

The operations manager, Ian Kendall uses the following checklist for swimming pools

- Use swimming pool covers
  - This reduces evaporation and enables savings to be made in pool heating. Equipment running time, ventilation requirements and condensation damage are all reduced. Switch off the pool hall ventilation system when the cover is applied and switch it on only after the cover is removed.
- Turn electrical appliances on in stages
  - Equipment should be switched on when required rather than everything being switched on all at once.
- Link the main ventilation system to the energy management system for automatic start up and shut down times (and for priority switching)
  - Ensures the main ventilation system operates only when it is needed. If you do not have an energy management system, use automatic time switches instead.
- Check that controls such as thermostats are functioning correctly, and that areas in which they are situated are appropriately zoned

- Ensures heating is only provided where and to the extent that it is needed. Remember to have external frost stats calibrated, as these may override other controls and bring on the heating before it is really needed to prevent frost damage.
- Check that time switches are set correctly, and that they are reset for summertime and wintertime operation
  - Ensures that heating, hot water and ventilation systems operate only when they are actually required.
- Use heat recovery wherever possible by recirculating air and using run around coils.
  - Examples include venting sauna heat into the pool hall, using waste heat from refrigeration wherever it will be useful, and run-around coils on heater flues.
- Install door closers and draught excluders and check whether building insulation and/or glazing can be improved.
  - Reduces draughts and improves comfort for visitors and staff. Cuts heat lost through ventilation and losses through the building fabric, and may enable lower temperature settings.
- Ensure there is a programme of planned preventive maintenance.
  - Use schedules or checklists of items to be inspected during weekly, monthly, quarterly, half-yearly and annual checks. The centre engineer should complete boiler room log sheets weekly.
- Rely on daylight wherever possible and install energy saving lights with appropriate controls.

- Use high-efficiency lamps and other diffusers in all areas, with time switches for remote area lighting, infrared detectors for lights in sports areas, and photo-electric control where daylight is available.
- Check water meter weekly – last thing at night and first thing in the morning – to identify leaks.
  - Detect and rectify leaks as soon as possible. Use auto-flush urinals, tap restrictors, and showers on 15-second timers.

(The Department of the Environment, 1997)

Kirklees began installing an energy management system (EMS) almost 30 years ago in all of its council buildings. The system's central station is housed in the main council office. The EMS allows plant operation, in 280 separate buildings, to be monitored from one location. It is also possible to log in to the system remotely. This system allows operators to monitor plant performance compared with historical data and compared to other buildings. With so much data available, there are many possible advantages, for example, the building manager in one swimming pool can compare the gas consumption in his building to that of similar buildings on a daily basis, and so as weather changes, he can benchmark his performance.

As part of their energy management strategy, Kirklees initiated two ideas. Firstly they began their Reduce Energy Directive (RED) and secondly, they came up with the concept of energy link officers. RED is an information and awareness campaign with two main strands;

- Informing sports centre managers about their energy consumption/trends/patterns to assist them in developing an appreciation of their energy use.

- Providing publicity and promotional material to enable centre managers to run staff awareness campaigns.

The *energy link officer* is an onsite employee who is tasked with certain responsibilities and works closely with the centre manager to run awareness campaigns with the RED initiative.

The *energy link officer* is different from a traditional energy manager in that they are not working behind the scenes, but instead are tasked with spreading information and raising awareness and motivation. Their specific responsibilities include;

- monitoring energy consumption monthly;
- collating and presenting quarterly energy consumption figures at the centres' monthly management team meetings;
- publicising consumption figures among staff;
- raising staff awareness and motivation;
- seeking ideas and suggestions from staff and presenting them to the building's management team for discussion;
- providing feedback to staff on the responses to their suggestions;
- meeting the energy link officers from the other sports and leisure centres to identify examples of best practice and exchange operating experiences and
- meeting representatives from the property services consultancy and two area engineers quarterly to discuss progress and to plan future initiatives.

(The Department of the Environment, 1997)

Under the RED initiative, energy link officers record any reason why consumption might be affected on a particular day. For example, if a pump (say to the heat exchanger for pool water) was being replaced, there might be lower electricity consumption that day. At first glance it may seem that the daily performance was better than normal. However, the pool's water temperature will drop during the day until the pump is back on line. This day's data should not be allowed to skew the records as it would not be possible to maintain thermal comfort without the pump. For this reason, the energy link officer fills in a comments log with any relevant instances.

Kirklees send an engineer to each building annually to test every major energy system. The annual visits alternate between summer and winter. This is viewed as a pro-active approach which helps to identify potential problems before system performance is adversely affected energy efficiency.

The Kirklees council installed combined heat and power (CHP) plant in a number of its centres including Huddersfield, Spenborough and Dewsbury. Although using CHP does not reduce consumption, it shifts the building's fuel source away from grid electricity to natural gas. This has the result of reducing the building's CO<sub>2</sub> footprint. But, more importantly from the manager's point of view, a unit of natural gas is approximately one third of the cost of a unit of electricity, hence financial savings can be significant if the CHP is correctly sized. All of the buildings in Kirklees which installed CHP had a reduction in their kg/CO<sub>2</sub>/m<sup>2</sup>. As the Tallaght sports complex does not have a CHP installed but does have a gas supply, it is worth investigating this possibility.

## 2.7.2 Good Practice Guide 219

### 2.7.2.1 Introduction

Good Practice Guide 219 focuses on a few key technical solutions to improving energy efficiency in swimming pools. These are

- heating
  - CHP
  - condensing boilers
- ventilation
  - variable ventilation rates
  - ventilation heat recovery
- electrical services
  - lighting and controls
  - fans and pumps
- pool water treatment
  - pool water heat recovery
- domestic water supply
  - controls and storage

	Space heating	Water heating	Fans & Pumps	Lighting	General power
Proportion of energy used	53%	25%	10%	6.5%	5.5%
Cost of energy used	28%	13%	27%	16%	16%

**Table 1: Proportion of energy used and cost of energy used in an indoor pool. (The Department of the Environment, 2000)**

Table 1 shows a typical breakdown of energy used and energy costs for an indoor pool. The space and water heating use gas, so their percentage cost is lower than their consumption

percentage, where-as the fans, pumps, lighting and general power use electricity, so their percentage cost is higher than their consumption percentage.

Lighting and general power have consumption percentages of 6.5% and 5.5% respectively, while their cost percentages are both 16%. To explain this, it should also be noted that some electrical loads are on mainly during daytime hours (indoor lighting) while others (filter pumps) are on 24 hours per day. Electricity is cheaper at night, so the 24 hour loads have a cheaper average unit price.

Looking at Figure 1, gives an indication of how well a swimming pool is performing. Assuming that all plant is working correctly and all operational procedures and housekeeping are in order, the next step in the drive for energy efficiency is an investment measure. If old plant needs to be replaced or there is other refurbishment planned, it can be a perfect opportunity for an energy efficiency upgrade.

Typical annual energy use (kWh/m <sup>2</sup> )		
Sports centre with pool:		
Good	Fair	Poor
<510	510-745	>745
Dry sports centre:		
Good	Fair	Poor
<290	290-410	>410

Figure 1: Typical energy use for a sports centre (The Department of the Environment, 2000)

Possible projects would be:

- combined heat and power (CHP)
- condensing boilers
- ventilation heat recovery
- variable ventilation rates
- pool water heat recovery

(The Department of the Environment, 2000)

All of these are relevant to the Tallaght Sports Complex as none of them are installed. When calculating the savings and payback periods for each, care should be taken not to overestimate. The individual savings do not always add up when two or more projects are combined. For example, heat recovery from the pool air could be calculated at current flow rates, while installing a variable speed drive to reduce flow rates could be a second project. If both projects go ahead, the heat recovered will be less than calculated due to the reduced air flow.

The Good Practice Guide 219 recommends a two stage approach. In the first stage, the individual savings and payback period of each project are calculated and the best option is selected. Each remaining project is now recalculated taking into account any changes to parameters made by the first project. The next best project is now selected. This process continues until the budget is used or when further projects offer little savings.

#### **2.7.2.2 Fuel**

Fuel selection depends on availability, efficiency and price. As an existing gas supply is present at the Tallaght Sports Complex, there will be no need to investigate a change of fuel.



### ***2.7.2.3 Heat Production***

The possible methods for converting fuel to heat are:

- CHP units
- condensing boilers
- modern standard boilers
- standard boilers
- heat pumps

(The Department of the Environment, 2000)

CHP units can offer very high seasonal efficiencies but certain conditions must exist such as, long running hours, sufficient electrical load, and year round thermal load. Swimming pools are often good candidates for CHP.

If CHP is not suitable, condensing boilers are another option. “Condensing boilers can be particularly effective in pool installations and payback on the extra cost can be achieved in 2-3 years when compared with conventional non-condensing boilers.” (The Department of the Environment, 2000)

A combination of CHP for the base load and a condensing boiler for peak loads is also possible.

Heat pumps would not be an option for the main source of heat for such a large load. They may however be effective as part of a heat recovery strategy.

### ***2.7.2.4 Heat Supply***

Getting the heat from its source to where it is needed involves pumps, pipe work, heat exchangers, valves, hot water storage, heat emitters and control gear. It is of the upmost

importance that the system works as efficiently as possible and any waste be identified. With regard to the pool water, “Even a 0.5°C rise will result in a substantial waste of energy, because of the high thermal capacity of water. There will also be a significant increase in the rate of evaporation, which will, in turn, lead to a need for increased ventilation in order to protect the building fabric and maintain a comfortable air temperature.” (The Department of the Environment, 2000)

#### *2.7.2.5 Ventilation and Air Quality*

The pool air is typically kept at 30°C and relative humidity should be kept in the region of 50-70%. With this air temperature and the warm temperature of the water (29-30°C), there will be a lot of evaporation from the pool. Humidity can rise quickly and chemicals from the pool water become airborne. Adequate ventilation is essential to maintain comfortable conditions. Ventilation rates can be reduced if there are fewer bathers as there will be less splashing which would reduce evaporation.

#### *2.7.2.6 Heat Recovery*

As mentioned in the previous paragraph, high ventilation rates are required in the pool area. The air which is expelled is in the region of 30°C and 60% humidity. This air has an enthalpy of approximately 71 kJ/kg. There is considerable scope here for the use of a heat recovery technology.

Three possibilities are: a cross flow heat exchanger, run-around coils and a thermal wheel.

- Cross flow heat exchanger
  - Capable of recovering 75% of the sensible heat (the most efficient of the three types).

It is made from a series of parallel plates between the supply and extract ducts which

- allow heat exchange from the warm extract air to the cooler inlet air. Supply and extract routes must be immediately adjacent, if not, extra duct work can be installed.
- Latent heat is also recovered as the air is cooled past its dew point and condensation occurs.
  - Run around coils
    - Capable of recovering 60% of the sensible heat. They offer flexibility as pipe work can be used between the extract and supply points. Air to water heat exchangers are used at the extract and supply ducts. A fluid is pumped between the two exchangers, taking heat from the extract air and transferring it to the supply.
  - Thermal wheel
    - Heat recovery varies but can be as high as 75% under optimum conditions. Air passes through a honey comb disc; this disc slowly circulates between the supply and extract ducts transferring heat. As there are moving parts, this device requires more maintenance than the other types.

Heat recovery is also possible from the pool water. The potential for savings is limited though as water is slowly released as fresh water is introduced. During filter backwashing, water is released quickly but this is only for a couple of minutes and only happens once a week.

## **2.8 Benchmarking**

In order to assess the performance of any building, benchmarking is carried out. There are a number of sources of benchmarking values depending on the building type. Benchmarking is carried out in section 3.2 *Benchmarking* using: CIBSE Guide F, Good Practice Guide 219, TM 46, Carbon Trust's CTV006 and Energy Consumption Guide 78.

## 2.9 ISO 50001

ISO 50001:2011 is an energy management standard providing certification for a building or organisation. It is based on the common elements of continuous improvement found in similar international management system standards. There are no maximum or minimum values (kWh/m<sup>2</sup> etc.) required to achieve certification, however, the standard provides a framework of requirements which must be adhered to.

The requirements have a strong emphasis on record keeping. There must be metering and sub-metering in place which is recorded at set intervals, the person responsible for this job is clearly identified. This is just one example which shows how the framework sets out a list of responsibilities so there is no excuse for complacency with regard to energy management.

Seeking certification to ISO 50001 is voluntary and is sought by organisations for a number of reasons. The most obvious reason is the potential financial savings available if a successful energy management strategy is implemented. Some companies like to use the certification as a badge of honour to show customers and shareholders their commitment to environmental issues.

The Tallaght Sports Complex does not have ISO 50001 certification nor has it ever applied for it. There are advantages to be gained from certification, but there is nothing stopping any organisation from implementing their own energy management policy and achieving the same results. A question that arises is “Is ISO 50001 worth the hassle?”

A survey of fourteen organisations in Ireland with ISO 50001 certification, carried out in April 2013 (Gibbons, 2013) asked several interesting questions. The following is a select of questions from the survey with the number of responses.

“Does your organisation agree that the certification process provides value for money?”

Strongly agree	3
Agree	10
Neutral	1
Disagree	0
Strongly disagree	0
Don't know	0

“Overall, how would your organisation rate the certification process?”

Highly Complex	0
Fairly Complex	8
Average	5
Fairly Simple	1
Very Simple	0
Don't know	0

“Does your organisation agree that certification added value to their business?”

Strongly agree	5
Agree	9
Neutral	0
Disagree	0
Strongly disagree	0
Don't know	0

“Has certification led to an increase in your organisation's profits?”

Significant increase	4
Minor increase	8
No change	1
Minor decline	0
Significant decline	0
Don't know	1

“Does your organisation agree that ISO 50001 certification has been important to their customers?”

Strongly agree	2
Agree	7
Neutral	5
Disagree	0
Strongly disagree	0
Don't know	0

Although the sample of only fourteen organisations is small, a general pattern emerges from the statistics. It seems that, although the certification process is considered complex, organisations are satisfied with the outcomes and most experienced financial benefits.

### 3. Tallaght Sports Complex

#### 3.1 Introduction

The Tallaght Sports Complex is a privately run sports centre with swimming pool in the suburb of Tallaght in south-west Dublin. It has a gym with weight lifting facilities, a sauna, a wellness centre, a 30 m x 20 m sports hall, a 25 m x 9 m swimming pool, an aerobic room, a crèche and various offices, changing rooms and staff rooms. The building is single storey with a total area of 2252 m<sup>2</sup>. The building is over 40 years old and has had no major refurbishment in that time. Financial difficulties have been a major concern in recent years and management were forced to reduce the number of staff from 42 to 15. Automatic controls have failed and not been replaced or upgraded and increasing energy costs are mounting pressure on the complex.

In the last twelve months (July 2012-June 2013), the cost for energy has been €104,174. This is split between natural gas and electricity. Electricity accounted for 15.16% of the consumed units but 37.9% of the energy costs. Gas is used by two boilers for heating the pool water, pool air, radiators, and domestic hot water. Electricity is used for everything else: fans, pumps, all appliances, lighting, general services and the sauna. Bills for the last twenty-two months are used in the following sections.

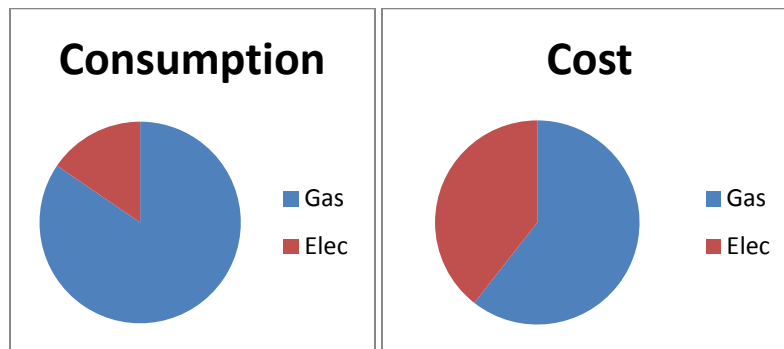
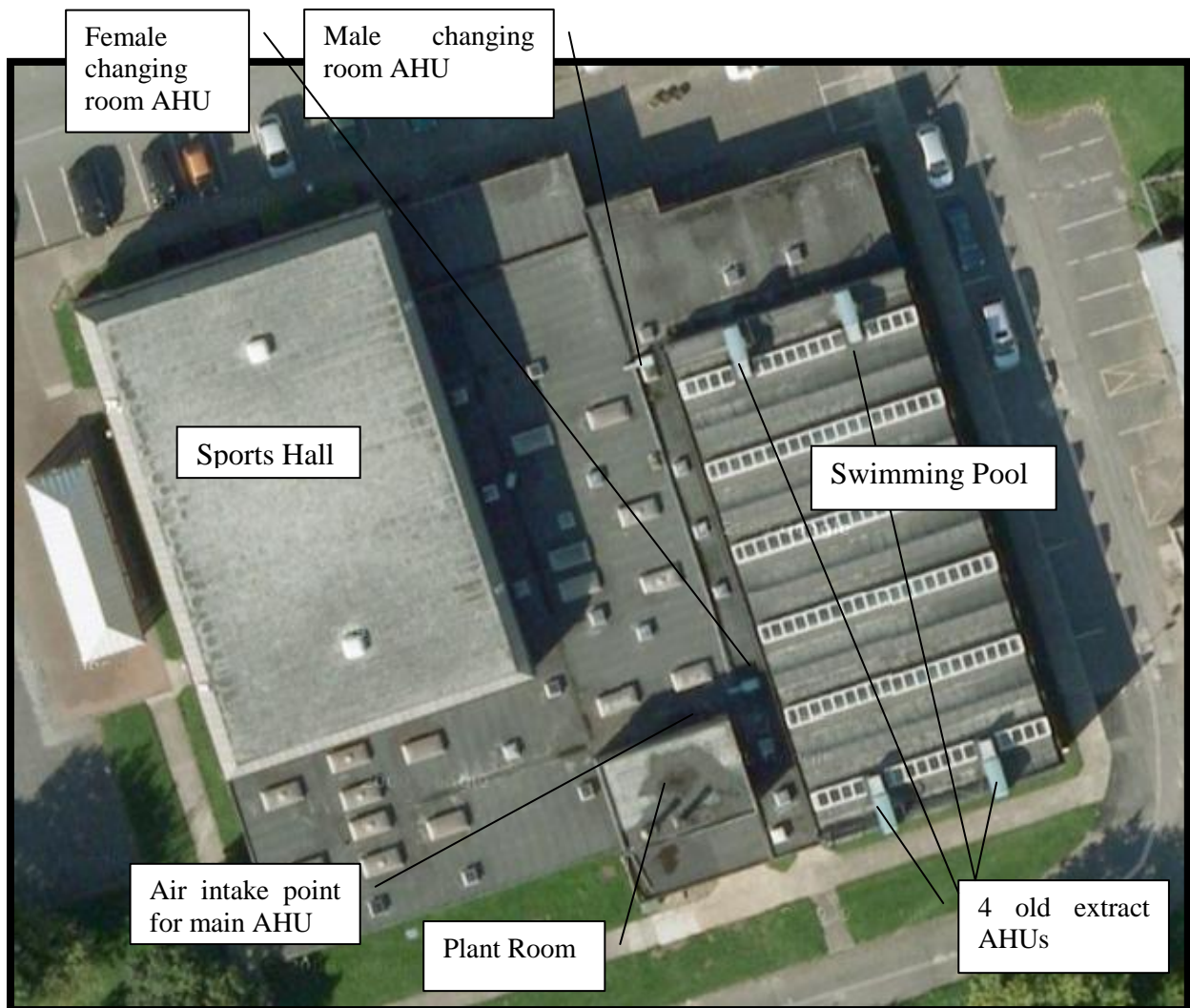


Figure 2: Electricity and Gas - Consumption and Cost Split

### 3.1.1 Arial Photo



**Figure 3: Arial photo of Tallaght Sports Complex**

Figure 3 shows the entire building from above. The sports hall, swimming pool and the plant room are the three prominent sections of the building, all other areas are offices, changing rooms, corridors etc.



## 3.2 Benchmarking

### 3.2.1 Good Practice Guide 219

In the twelve months from July 2012 to June 2013, the total units of gas and electricity were 1,271,948 kWh and 227,300 kWh respectively. The value of energy per unit area is therefore:

$$\frac{1,271,948+227,300}{2252} = 666 \text{ kWh/m}^2/\text{annum}$$

The Good Practice Guide 219 gives the following table for benchmarking. As the Tallaght Sports Complex has a pool, it falls into the “fair” category, in fact it falls 66% of the way through the “fair” category, closer to “poor” than “good”.

Typical annual energy use (kWh/m <sup>2</sup> )		
Sports centre with pool:		
Good	Fair	Poor
<510	510-745	>745
Dry sports centre:		
Good	Fair	Poor
<290	290-410	>410

Figure 4: Good Practice Guide 219 - Benchmarking

### 3.2.2 TM 46

CIBSE’s TM46 gives separate benchmarks for electrical and thermal consumption for 29 different types of buildings. The Tallaght Sports Complex used 101 kWh/m<sup>2</sup> of electricity and 565 kWh/m<sup>2</sup> of gas from July 2012 to June 2013. In Table 2 the Tallaght Sports Complex is compared with three separate building types.

	Tallaght Sports Complex	Swimming pool centre	Fitness & health centre	Dry sports & leisure facility
Electrical	101	245	160	95
Fossil Thermal	565	1130	440	330

Table 2: TM 46 Energy Benchmarks (kWh/m<sup>2</sup>/year)

Although the Tallaght Sports Complex has a swimming pool, the building could be described as being split 50/50 between pool/pool facilities/changing rooms etc and sports hall/changing rooms etc. In fact, in TM 46 when referring to a “swimming pool centre”, under column J, it states “swimming pool centre without further sports facilities”. This helps to explain why the Tallaght Sports Complex scored so well on the benchmark, the total area of the building cannot be described as a swimming pool centre. A more accurate benchmark may be found by averaging the benchmarks of the *swimming pool centre* and the *dry sports and leisure facility*. The averaged values are 170 kWh/m<sup>2</sup> for electrical and 730 kWh/m<sup>2</sup> for fossil thermal. Even after averaging the benchmarks, the Tallaght Sports Complex scores very well. The Tallaght Sports Complex has no CHP, heat recovery, VSDs or automatic controls. This highlights the difficulties in benchmarking; it is very difficult to compare many buildings to available benchmarks as they do not fit into existing categories.

### 3.2.3 Energy Consumption Guide 78

The Energy Consumption Guide 78 (ECG78) deals specifically with sports and recreational buildings. In it, seven reference types are given ranging from a local dry sports centre to a regional centre. “Type 4 – combined centre” is the closest match to the Tallaght Sports Complex.

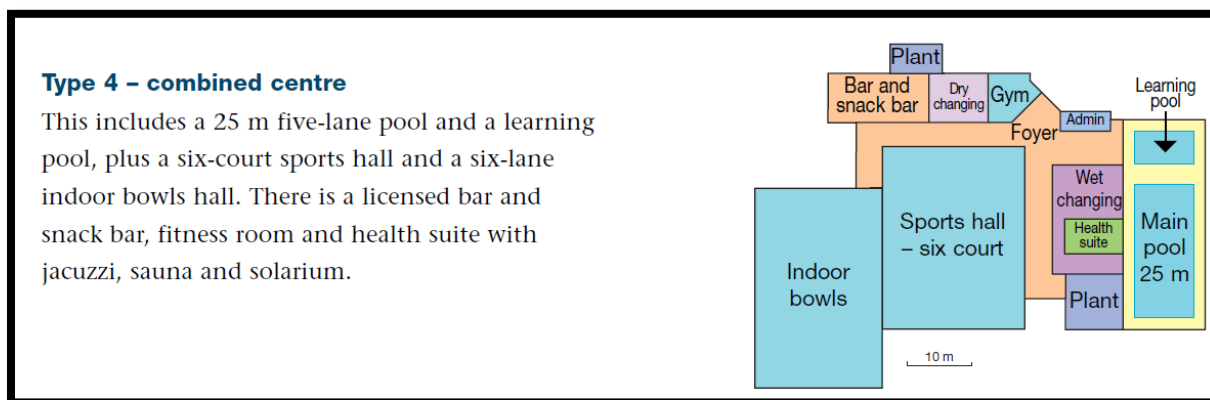


Figure 5: Energy Consumption Guide 78

In the ECG78, initial values are given for each type of sports centre for both “*Typical*” and “*Good Practice*”. The *typical* value can then change depending on factors specific to the building being benchmarked. The *typical* electricity value starts at 152 kWh/m<sup>2</sup>. As ventilation is turned off at night, 12 is subtracted off this value. The use of a pool cover reduces the value by another 3, however, as the building is pre-1980, 36 is added. This gives a final value of 173 kWh/m<sup>2</sup>. The same process for heating fuel give a final typical Value of 462 kWh.

	Tallaght	ECG78 Typical	ECG78 Good Practice
Electricity (kWh/m <sup>2</sup> )	101	173	96
Heating Fuel (kWh/m <sup>2</sup> )	565	462	264

**Table 3: Energy Consumption Guide 78 – Benchmarks**

This places the Tallaght Sports Complex very close to good practice for electrical consumption but well below even the typical rating for gas consumption. This seems like a reasonable assessment due to the lack of controls and the overall poor operating conditions of the heating system.

	Electricity use (kWh/m <sup>2</sup> )	Heating fuel use (kWh/m <sup>2</sup> )
<b>Benchmarks</b>		
<i>Typical</i>	152	598
<i>Good practice</i> (includes items marked in red below)	96	264
Effect on benchmarks of changes relative to <i>typical</i>	Add to or subtract	
<b>Building and services changes</b>		
<b>Building fabric</b> improved with high insulation levels and detailing to avoid air leakage	0	-39
<b>Ventilation</b> systems improved – pool hall with reduced ventilation out of hours, heat recovery or desiccant dehumidification. Sports hall radiant gas tube heating or minimal ducting, and appropriate hall ventilation rate	-12	-193
<b>Pool water pumps and treatment</b> improved energy efficiency with minimised pump rates and multi-speed demand-controlled pumps	-14	0
<b>Pool cover</b> installed and used regularly	-3	-46
<b>Lighting</b> improved standards – metal halide lighting in pool hall with daylight and presence detection. Sports hall high-frequency compact fluorescent or high-pressure sodium with stepped lighting levels and presence detection	-15	0
<b>Operation and scheduling</b> improved with separate schedules for pool hall, sports hall, bowls and fitness facilities, and optimal use of ventilation and lighting controls	-12	-56
<b>Features</b>		
<b>Combined heat and power</b> installed, sized for summer heat load	-42	+36
<b>Pool temperature</b> increased by 2°C to 32°C	0	+41
<b>Older centre</b> (usually pre-1980) with poor standards of insulation and airtightness or extensive single glazing, and older-style lighting	+36	+103
<b>Location and level of use</b>		
<b>High usage</b> – more than 150 customers per m <sup>2</sup> per year (525 000 customers per year for the 3500 m <sup>2</sup> combined centre)	+19	+52
<b>Light use</b> – less than 50 customers per m <sup>2</sup> per year (175 000 customers per year for the 3500 m <sup>2</sup> combined centre)	-15	-34
<b>Location in Scotland</b>	+10	+86
<b>Southern location</b> – Thames valley, Avon valley or further south	0	-65
<b>Exposed location</b> – unprotected hillside or seafront site	+12	+43

Figure 6: ECG78 Benchmarking

### 3.2.4 CTV006

The Carbon Trust's guide CTV006 gives a much more straight forward benchmarking guide. Figure 7 is taken from the benchmarking section and gives typical and good practice values. Using the "Centre with 25m Swimming pool" row, the Tallaght Sports Complex comes in better than good practice for both fossil fuel and electricity.

Type	Good practice – fossil fuel (kWh/m <sup>2</sup> /yr)	Good practice – electricity (kWh/m <sup>2</sup> /yr)	Typical – fossil fuel (kWh/m <sup>2</sup> /yr)	Typical – electricity (kWh/m <sup>2</sup> /yr)
Centre with 25m Swimming pool	573	152	1336	237
Centre with leisure pool	573	164	1321	258
Combined centre (with more than one type of facility)	264	96	598	152

Figure 7: CTV006 - Benchmarking

### 3.2.5 Conclusion

Using four different sources as benchmarking guides has given very different results. This shows the difficulty in accurately benchmarking. Grouping buildings can be difficult and like for like comparisons are quite often impractical.

## 3.3 Description of Services, Operation and Control

### 3.3.1 Automatic Control System

Originally the heating and ventilation for the building was automated and consisted of various thermostats, contactors, two and three port valves and a central computer located in the plant room sub-board. This whole system has not been operational for a number of years and controls are now operated manually. Obviously this creates inefficiencies in the systems and over-heating can occur if staff are slow to operate heating valves.

### **3.3.2 Water Services**

The building's water services consist of hot and cold systems. Hot water is used mainly by the showers in the changing areas but also hot taps. Cold water storage is provided by a sectional tank located overhead in the plant room. The tank includes a divider to allow cleaning of the tank without isolating the water supply.

A hot water calorifier (approximately 3500 litres) serves the hot water supply requirements of the building. It appeared in good condition but is not lagged. The calorifier is heated by a hot water circuit from the main hot water header.

On the cold water supply pipe-work adjacent to the calorifier there is a pump which pressurises both the hot and cold water systems. This pump uses 1.35 kW and is single speed with manual on/off control. It is sometimes turned off at night but not always as was observed during inspections. The pump is in poor condition and is noticeably noisy.

### **3.3.3 Pool Water System**

The pool water is treated on a continuous closed loop purification system. The turnover period should not be greater than four hours. Two electrically driven end suction pumps connecting in parallel draw water from the pool, force it through a sand filter, then through a shell and tube heat exchanger (this is where the pool water is heated) and finally back to the pool. These pumps use a combined load of 10 kW and run 24 hours/day.

During the course of the study, one of the pumps failed and had to be replaced. During the five day period when only one pump was running, the water temperature in the pool dropped to the point where customers were complaining. This was an interesting development as it clearly showed the need for the two pumps.

While discussing ideas with the building manager, he said that they previously experimented with turning the filter pumps off at night. However, after a few days there was a noticeable smell from the water and this practice was immediately discontinued.

The inlet and draw-off system is designed to have uniform circulation to all parts of the pool. There are two bottom drainage outlets provided at a minimum of three metres apart at the lowest point of the pool. The pool dimensions are 25 m by 9 m by 1 m (average) which gives 225 m<sup>3</sup>. For a four hour turnover the flow rate must be 56.25 m<sup>3</sup>/hour.

### **3.3.4 Heating System**

The building's heating is generated by two parallel connected 550 kW low-pressure, hot-water boilers which are sized to meet 70% of the peak load. The boilers were formally oil-fired type. These boilers were manufactured by Hogfors Ltd and run at a maximum efficiency of approximately 80%. Both boilers have been converted to natural gas. The old oil fuel system was decommissioned but is still visible.

The boilers serve a primary header which provides the building's six hot water circuits with flow and return temperatures of 82°C and 71°C.

There were two main pumps on the heating header but one of these failed a few years ago and was not replaced. The remaining pump (heating pump 1) is three-phase and takes 1.2 kW and is on 24 hours/day with no speed control.

The heating circuits serve the building's air handling units, radiator circuit, calorifier circuit, sports hall fan heaters and pool heat exchanger circuit. The heating system is a closed loop pressurised system. The circuits are detailed in Table 4.

Circuit	Type	Notes
No. 1	Sports Hall Fan Heaters	
No. 2	Calorifier	
No. 3	AHU-01	
No. 4	Pool Heat Exchanger	
No. 5	AHU-02 & AHU-03	Circuit not in use
No. 6	Radiators	
Total Facility Load		

**Table 4: Hot water circuits**

The circuits serving the main AHU and the swimming pool heat exchanger have three-port valves fitted, however, these are no longer in use. The calorifier circuit has a two-port valve which is not in use either.

The boilers are left on constantly and cycle on/off depending on the return water temperature. Control of the various heating circuits is manual. The building manager regularly checks thermometers for the pool air and pool water temperatures. If he feels that either/both temperature is sufficient and no more heat is required, he walks to the plant room and closes the valve to the relevant circuit. Likewise, when the temperature drops, he opens the valve. When the hot water circuit to the AHU is closed, the AHU fan remains running at full speed. This ensures that humidity does not rise in the pool area but also means that the air temperature will drop quickly.



The radiator circuit is turned on manually when the staff feel that heating is required. The warm air from the pool area escapes into adjacent rooms and provides reduces the requirements of the radiators. The radiators do not have thermostatic radiator valves (TRVs) fitted and are controlled individually by turning their valves manually.

There are four fans in the sports hall served by hot water circuit number 1. Again, manual operation is used here. When heat is required in the hall, the fans are turned on from the plant room sub-board and the valve is opened to circuit 1.

### **3.3.5 Ventilation**

The building is served by three AHUs. All three are 100% fresh air, once through type. The first air handling unit (AHU-01), supplies air to the swimming pool area through six linear bar supply grilles around the perimeter of the pool area.

AHU-01 is responsible for maintaining the temperature and humidity of the air in the pool and is supplied by heating circuit number three.

The second and third AHUs serve the male and female changing areas. These AHUs are smaller than AHU-01 and are located externally on the lower roof. They supply fresh air directly into the two separate changing areas via short runs of ductwork. Both have heat exchangers fed from heating circuit number five. These AHUs no longer heat the air as the pipe-work supplying them has corroded and thus, circuit number five is never turned on. The following table shows the air flow rates for the facility.

AHU	Serving	Volume (m <sup>3</sup> )	Ventilation	Flow Rate (m <sup>3</sup> /sec)
AHU-01	Swimming Pool	2400	10 ac/hr	6.5
		Occupancy		
AHU-02	Male Changing	50	10 litres/person	0.5
AHU-03	Female Changing	50	10 litres/person	0.5

**Figure 8: Air flow rates**

There are four large extract fans on the roof of the pool area. These no longer work and have not been in use for a number of years. Air is still able to escape through these and on inspection, by placing a hand close to the fans, the warm air leaving is obvious. There was a heat recovery system in place in the past. The four extract fans have heat exchangers and pipe-work connects back to a pre-heat coil in AHU-01. The pipe-work for the old run around coil system has rusted badly and would need to be replaced if the heat recovery system was to be used again. The pump for the heat recovery system is still in place but has been isolated.

There are a number of small extract fans located in the changing rooms and toilets, however their flow rates do not come close to the supply flow rates. As a result, the building is under positive pressure. Upon opening doors to the pool area, air is forced outward quite dramatically. This outward pressure is also felt at external doors.

### 3.3.5.1 Photos



**Figure 9: Old extract AHU**

Figure 9 shows one of the four old extract units above the pool. These form part of the disused heat recovery system. The panel shown open in the photograph is always open and warm air can be easily felt escaping through it. The pressure from the main AHU's fan easily forces air out through all four of the old extract points. The fans in the extract AHUs have been disconnected.



**Figure 10: AHU-01 air intake point**

Figure 10 shows the air intake point for the main AHU. This is where a cross flow heat exchanger could be located.



**Figure 11: Changing room AHU**

The two smaller supply AHUs can no longer have hot water supplied to them as their pipe work has rusted away. The fans still work and supply fresh air to the pool changing rooms.

## **4. Energy Audit**

### **4.1 Introduction**

The audit of the Tallaght Sports Complex was conducted over the course of a one year period. It consisted of many site visits, collection of billing information and the use of data loggers, temperature and humidity sensors. The audit took a lot more work than was initially expected for various reasons but the main cause of delay was due to the lack of labelling on the sub-boards. The plant room sub-board has MCBs and contactors for fans, pumps, boilers and various other loads, none of which were labelled. A number of site visits over the course of a few weeks were spent identifying each circuit. This was necessary to gain a full understanding of the loads and how they are controlled.

The data logger used was a Hawk 5000. This is a specialised piece of equipment and can measure true power (kW) and apparent power (kVA) along with many other parameters. Some cheaper loggers measure current alone and multiply it by a set voltage to produce a spurious kW load. This is fine for resistive loads where the power factor is unity or where accuracy is not essential. In fact, the second logger used, the *Efergy e2*, operates by measuring current alone. This puts limitations on the applications for the *Efergy e2*. The sauna, for example, is a purely resistive load, so the *Efergy e2* worked perfectly there.

### **4.2 Relevant Standards and Regulations**

The following standards, regulations and resource guides were revised and taken into consideration when providing the consumption analysis and proposed recommendations;

- Commission for Energy Regulation (CER) - Distribution Use of System Charges (DUoS): 1<sup>st</sup> October 2012 – 1<sup>st</sup> September 2013.
- Chartered Institute of Building Services Engineers (CIBSE) TM46 Energy Benchmarks
- CIBSE – Energy Efficiency Guide F
- CIBSE – TM 46
- Energy Consumption Guide 78
- CTV006
- EN 12464-1:2002 Lux levels
- EU Proposed Energy Audit Standard En 16247-1 – General Requirements
- Energy Management Standard ISO 50001
- International Performance Measurement and Verification Protocol (IPMVP)
- National Rules for Electrical Installation in Ireland (ETCI)
- SEAI - Building Energy Manager's Resource Guide
- SEAI – Energy Map

## **4.3 Electrical Billing Information**

### **4.3.1 Introduction**

Electricity is supplied by Energia on a Low Voltage - Maximum Demand tariff. The bill consists into the following sections:

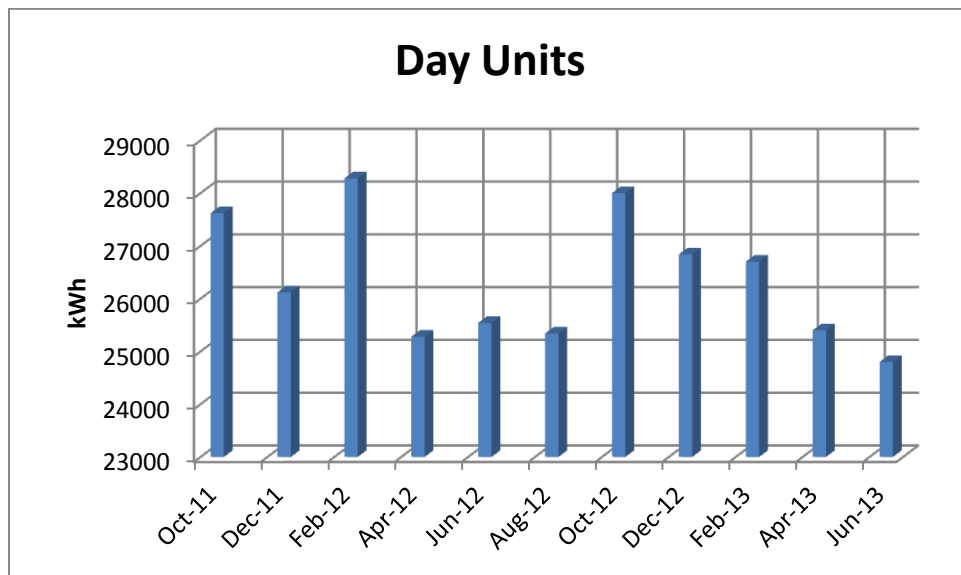
- Day units (kWh)
- Night units (kWh)

- Service capacity charge (kVA)
- Low power factor surcharge (kVArh)
- Electricity tax (kWh)
- Maximum demand (kW)
- VAT

Every second bill is estimated, so accurate information is provided on a two-monthly basis.

### 4.3.2 Day Units

Day units are measured in kWhs which are consumed between the hours of 8 am and 11 pm. Day units are the largest portion of the electrical bill at 68.8% of the total.



**Figure 12: Day Unit Consumption**

In *Figure 12: Day Unit Consumption*, the number of day units for each two month period is shown. It can be seen that they vary considerably from a minimum of 24,800 kWh (May and June 2013) to a maximum of 28,280 kWh (January and February 2012). Although there is some

correlation with the seasons visible in the graph, the day unit consumption seems somewhat erratic.

### 4.3.3 Night Units

Night units are measured in kWhs which are consumed between the hours of 11 pm and 8 am.

Night units are the second largest portion of the electrical bill at 15.6% of the total.

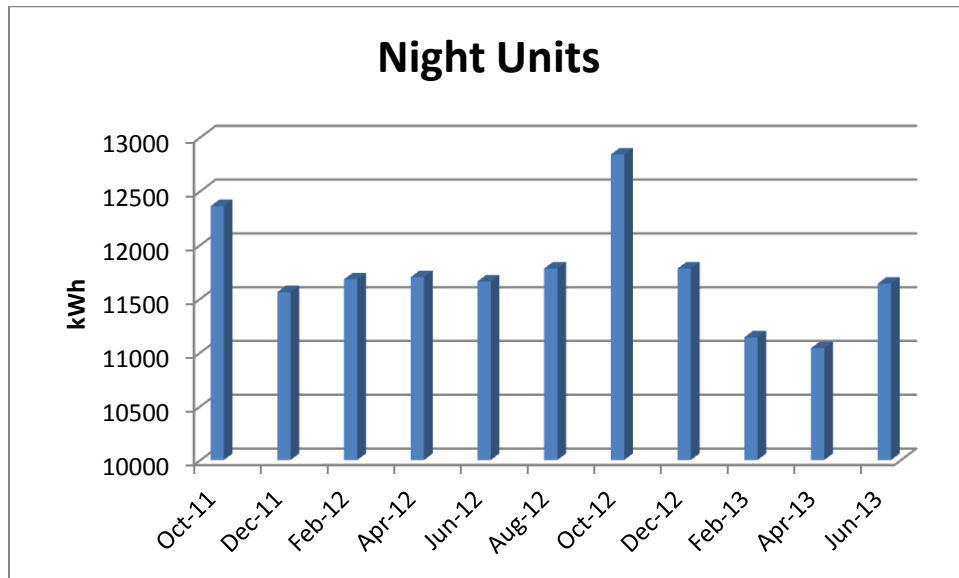


Figure 13: Night Units Consumption

In *Figure 13: Night Units Consumption*, it can be seen that the night time consumption is relatively consistent, this is to be expected, as apart from external lighting, there are no night-time loads which should vary on a daily or monthly basis. The bills with the higher loads may be explained by the sauna, which is manually controlled and sometimes left on overnight accidentally.

### 4.3.4 Service Capacity Charge and Public Service Organisation Levy (PSO Levy)

The service capacity charge (also known as the Maximum Import Capacity (MIC)) is a charge based on the agreed maximum value of load which the building will use at any time. Currently



the agreed MIC is set at 60 kVA. If the maximum demand of the building was to exceed 60 kVA, then penalties would apply, this however has never happened, so the MIC is not too low. There may be scope to reduce to MIC, though this needs to be considered carefully, because if that transformer capacity is sold to another customer, it may not be available again if needed.

The PSO levy is a government charge to cover the higher costs of peat and renewable energy. It is similar to the MIC charge in that it is calculated based on the agreed MIC.

If the MIC can be reduced, a saving will be made on both the MIC and PSO levy. Together they represent 6.8% of the electrical bill.

#### **4.3.5 Standing Charge**

The standing charge represents 5.9% of the total bill. It is not based on consumption, but it is relevant when checking other provider's tariffs.

#### **4.3.6 Maximum Demand Charge**

The maximum demand refers to the largest electrical consumption, measured in kW, over any fifteen minute period. The value given in the bill is the average kW consumption for that fifteen minute period. The purpose of this charge is to create an incentive to discourage large variations in consumption during the day.

On the current tariff, the maximum demand charge only applies for two of the six annual bills; these are the winter bills of November/December and January/February. As can be seen in *Figure 14: Recorded Max Demand*, the recorded maximum demand was 44, 45, 46 and 44 kW respectively. Overall, the maximum demand charge only represents 1.6% of the total electricity bill, and therefore, peak reduction techniques will not offer large savings. It should be noted that the maximum demand values are measured in kW, while the MIC is measured in kVA. If, for

example, a value of 46 kW was measured while the power factor was 0.9 lag, then the kVA load would be  $\frac{46 \text{ kW}}{0.9} = 51.1 \text{ kVA}$

This concept should not be over looked when making decisions on reducing the MIC. Alternatively, the supplier can issue maximum demand in kVA on request.

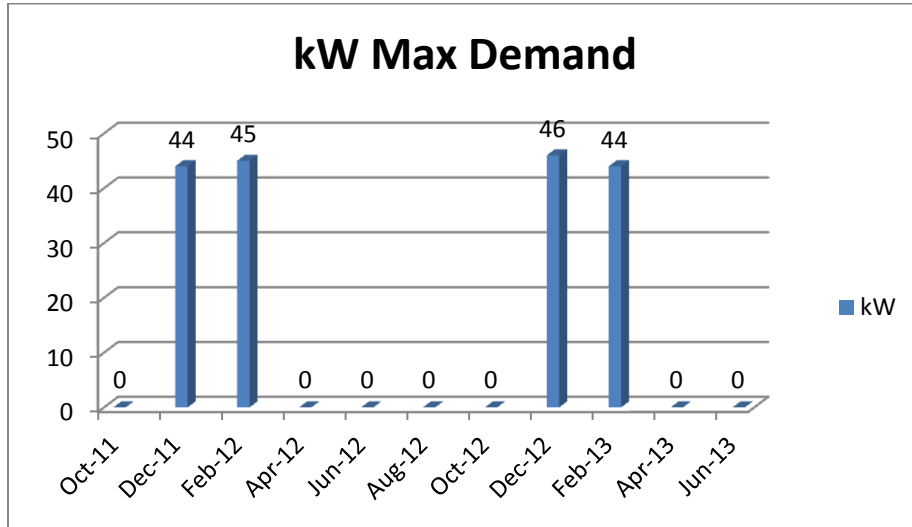


Figure 14: Recorded Max Demand

#### 4.3.7 Low Power Factor Surcharge

The low power factor surcharge represents 0.9% of the total electricity bill. Although this is a relatively small value, it is one which can be eliminated with the use of capacitors. The supplier allows one kVArh for every three kWh purchased. The number of kVArh above the allowed value for each bill is shown below in *Figure 15: kVArh*. A few points should be noted about this graph

- The large drop in kVArh from the December bill onwards is due to the installation of capacitors as part of the author's project. This is discussed in detail section

- 6.5 Power Factor Correction.
- The April bill had zero kVARh and the June bill had 2433 kVARh. This may have been a mistake on the supplier's part. If the 2433 kVARh is averaged out over the two bills, 1216 kVARh per bill is calculated. This value is more in line with the February bill of 1347 kVARh.
- The capacitors were installed one quarter of the way into the December's billing period, which explains why that bill is not in line with the following bills.

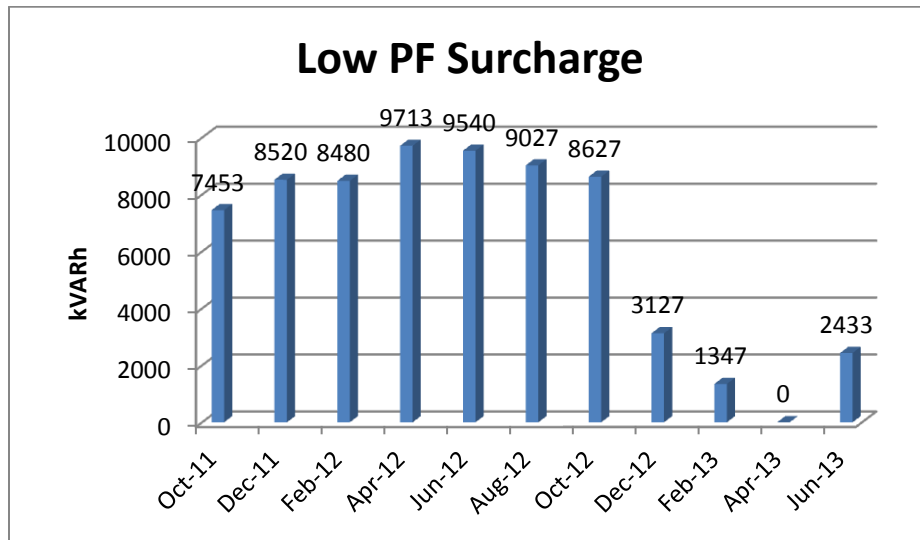


Figure 15: kVARh

### 4.3.8 Electricity Tax

The electricity tax is the smallest of the component parts of the electricity bill at 0.3%. The electricity tax is a set charge for every kWh consumed regardless of whether they are day or night units. If general consumption is reduced, the electricity tax will reduce also.

### 4.3.9 VAT

VAT is added at a rate of 13.5% to the total.

## 4.4 Data Logger

### 4.4.1 Introduction

The data logger was installed on the main board and each of the two sub-boards for one week to record: kW, kVA, kVAr, power-factor and current. kW, kVA, kVAr and power-factor were recorded for each phase and total, while current is only recorded for each phase. The data logger was also used to gain information about various individual loads throughout the building. The data logger's software was used to generate some graphs, where the desired graph was not available, Microsoft Excel was used.

### 4.4.2 Main Board

The data logger was installed on the main board on Saturday 6<sup>th</sup> October 2012 for one week. It was set to log every four minutes. *Figure 16: Daily kW profile* shows the total kW consumption on each of the seven days.

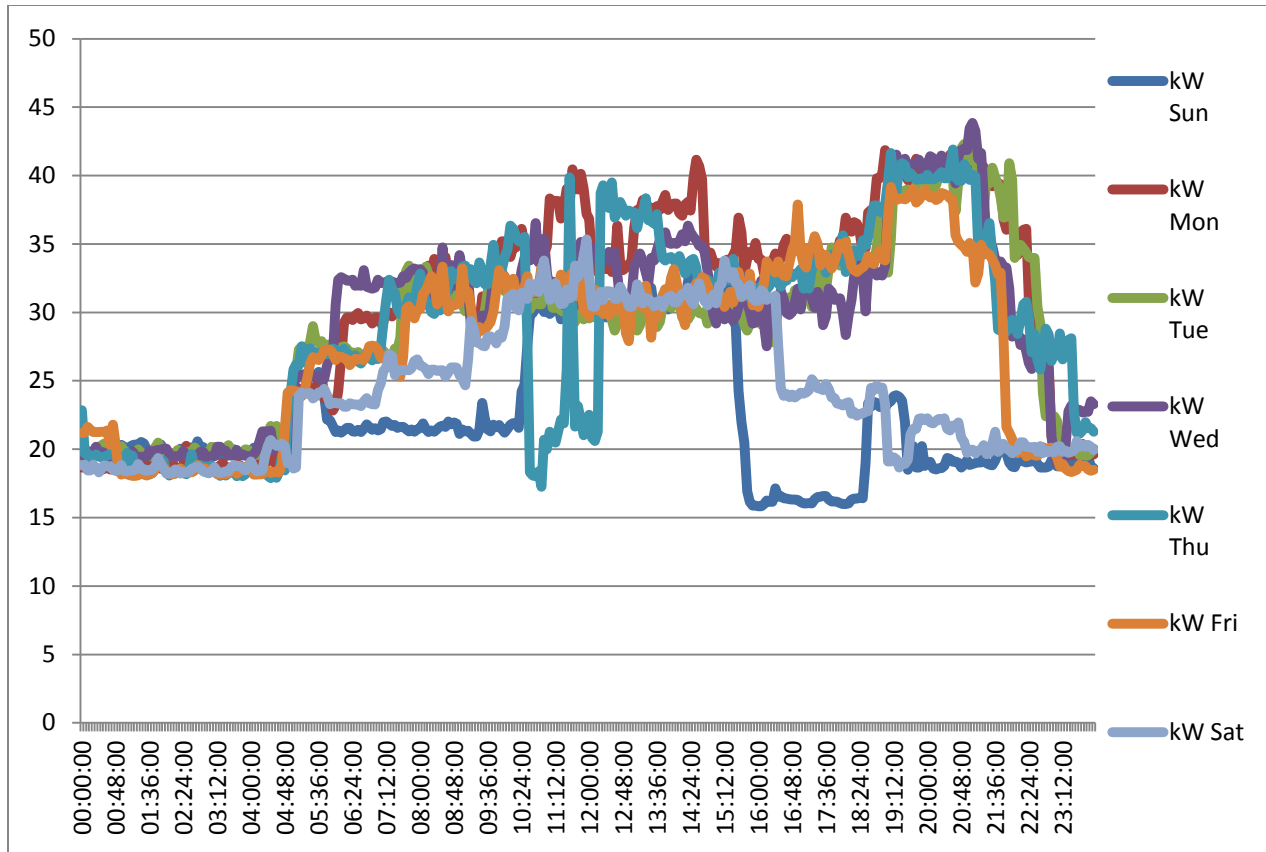


Figure 16: Daily kW profile

The week-days all follow a similar pattern;

- 20 kW night time load
- at 5 am, the load rises to 25 kW
- at some time between 6-7 am, the load rises to 34 kW
- from then until 7 pm, the load varies between 30-40 kW
- for the hour and a half between 7-9:30 pm, the load peaks at 40-44 kW
- after 9:30 pm, the load drops back to its 20 kW night load.

Saturday and Sunday

- Both have the same night load and 5 am spike as the weekdays

- Weekend loads remain lower than weekdays
- The evening peaks are not present and the load drops back to its night load a lot earlier.
- On Saturday, the load reduces to 24 kW at 4:30 pm and gradually drops to the 20 kW night load.
- On Sunday, the load drops below 20 kW as early as 3:30 pm.

### Observations

- The 5-am spike is caused by the manual turning on of the Air Handling Unit (AHU). The electrical load in the AHU is a single three-phase fan using 5.5 kW. Hot water is pumped through the AHU's heat exchanger continuously, regardless of whether it is on or not. The AHU is turned on to begin heating the air in the pool area. The night security personnel carry out this task by walking into the plant room and turning an isolator on the plant room sub-board. This 5 am start is regardless of external weather conditions or internal air temperature.
- The next spike, which happens between 6 am (Wednesday) and 7:40 am (Friday), is the sauna turning on. This is also manual. A member of staff walks to the sauna, reaches up and unlocks a padlock and turns an isolator. The sauna has a load of 5 kW and is left on all day. It is turned off manually before staff leave at night but the time varies depending on how busy they are and what time they remember to do it. In fact, sometimes in error, it isn't turned off at all, this was proved during the time which the data logger was connected to the sub-board and can be seen later in section *4.4.4 Sub-Board 1*. It was also noted that the sauna was empty on most of the author's site visits.
- On the five weekdays, the drop to 20 kW night load varies by an hour and forty minutes. This is again due to the manual operation of large loads such as the sauna and the AHU.

- On the Thursday, there is an erratic drop in load of approximately 17 kW at 10:36 am. The load goes back up at 11:30 am briefly and drops again, before returning to normal at 12:16 pm. This was caused by a long running fault present in the electrical installation. Occasionally when there was rain, an MCB in the plant room sub-board would trip. This MCB fed the control wiring for some of the contactors including the two boilers, the main pump for the hot water and the AHU. The same fault occurs on Wednesday 17<sup>th</sup> of October while the data logger is monitoring the plant room sub-board. The author identified the source of the fault to be a disused belden cable which was connected to the circuit. The cable was connected to a thermostat on the roof but was no longer in use. Disconnection of this cable has since rectified the fault.

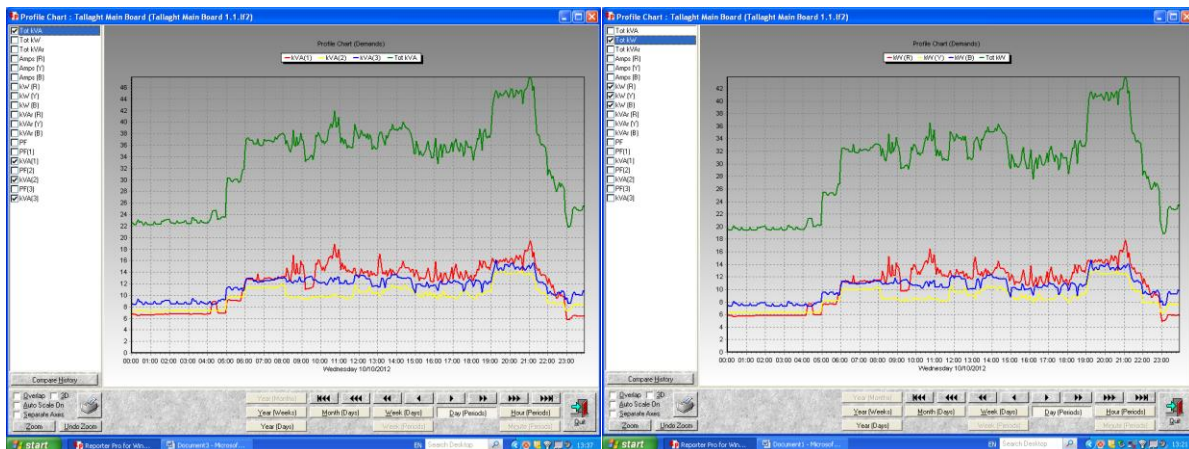


Figure 17: Main board – kVA/kW – Wednesday

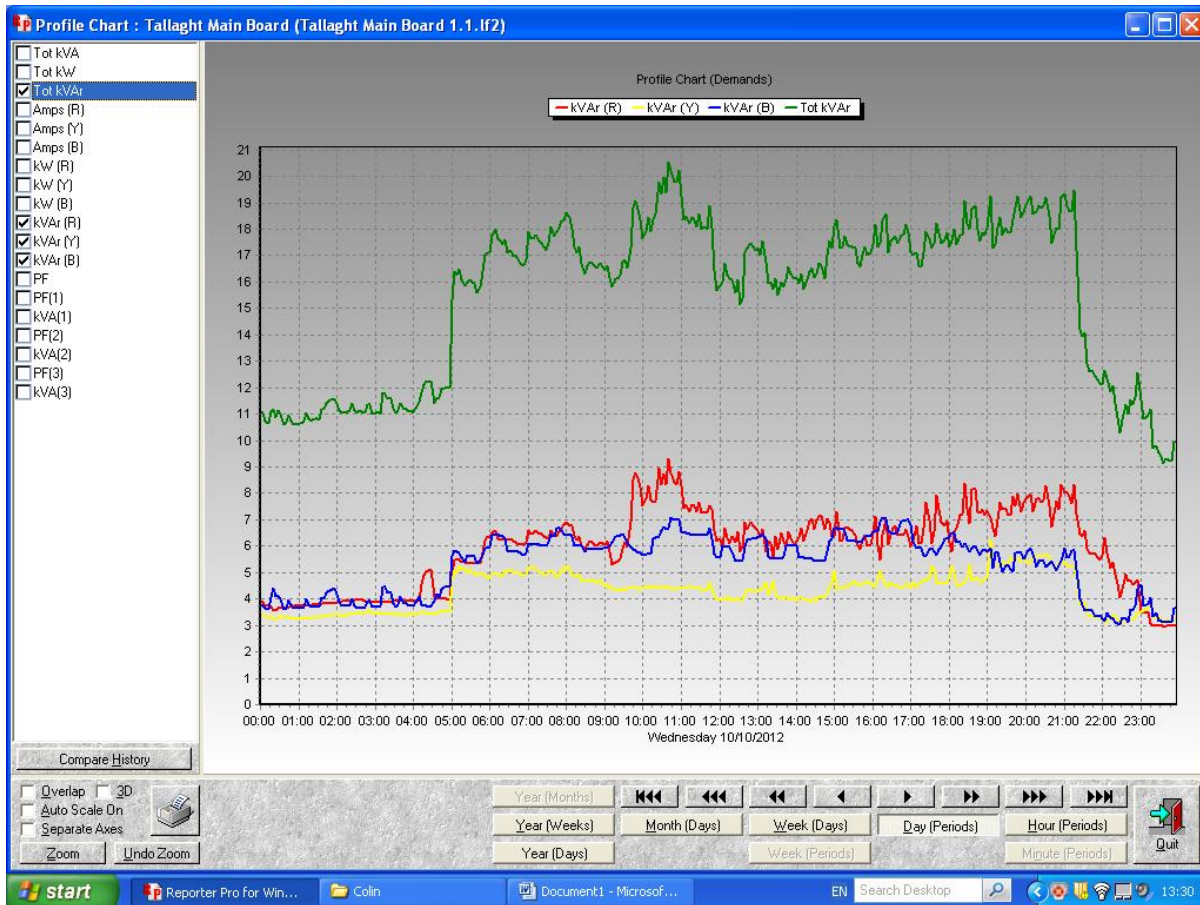
Figure 17: Main board – kVA/kW – Wednesday shows two screen shots displaying the data logger’s software. On the left hand side, total kVA and each individual kVA are selected, while on the right, total kW and each individual kW are. The graphs shown are generated and any given day or hour can be selected. The value of kVA is always greater than the value of kW due

to the power factor of the circuit. The power factor and kVAr shall be discussed later. Just one day is shown here for clarity and Wednesday was selected at random.

Observations -

- The 5 am (AHU) spike and the 6 am (sauna) spike are clearly visible.
- The three phases are reasonably well balanced
- Peak consumption occurs between 7 – 9:30 pm
- kW and kVA follow a very similar pattern but kVA is always larger.
  - During the night time, there is 22.5 kVA and 20 kW.
    - This gives a power factor of  $\cos \vartheta = \frac{kW}{kVA} = \frac{20}{22.5} = 0.889$  *lagging*
  - At the peak (9 pm), there is 47 kVA and 43 kW
    - This gives a power factor of  $\cos \vartheta = \frac{kW}{kVA} = \frac{43}{47} = 0.915$  *lagging*
  - When the power factor falls below 0.95 lag, the building is using excess kVAr and if this happens for a prolonged period, penalties will occur.

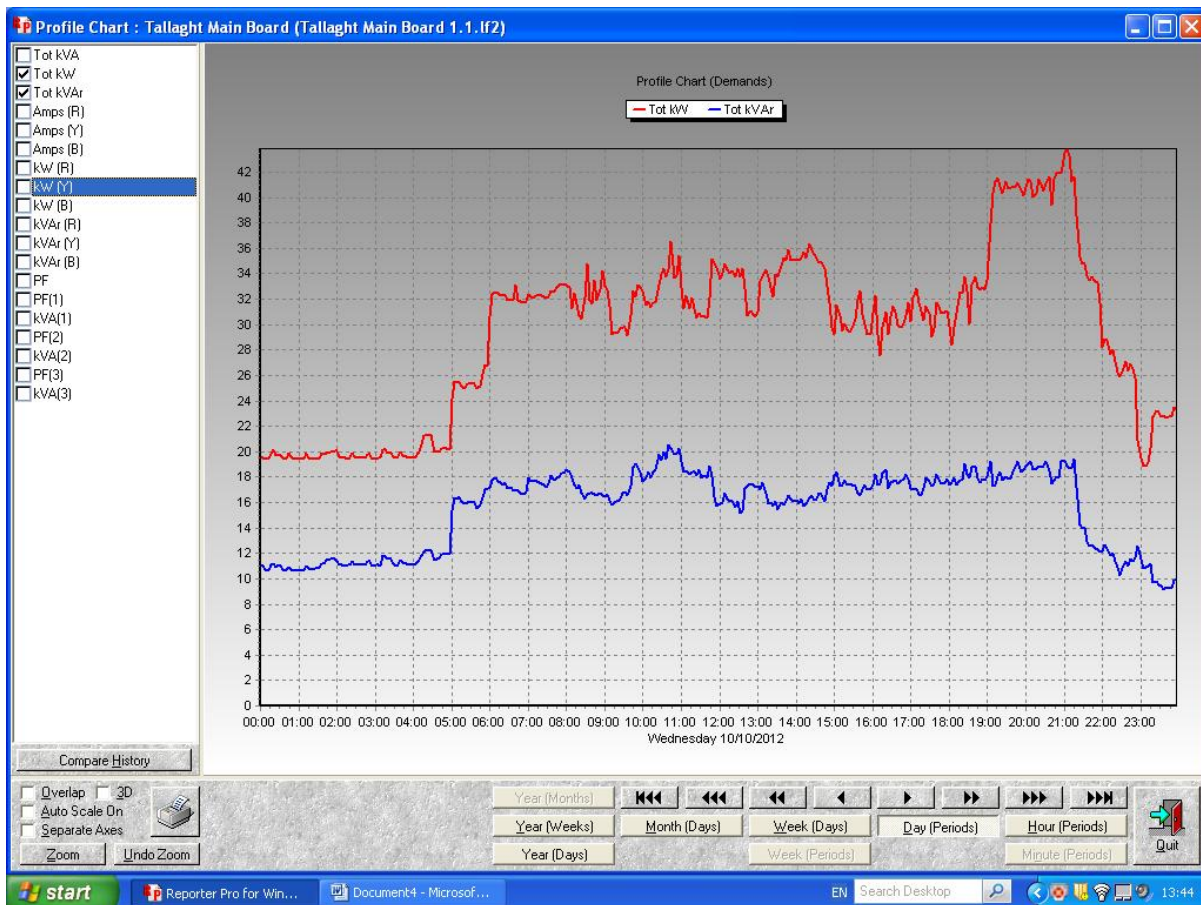




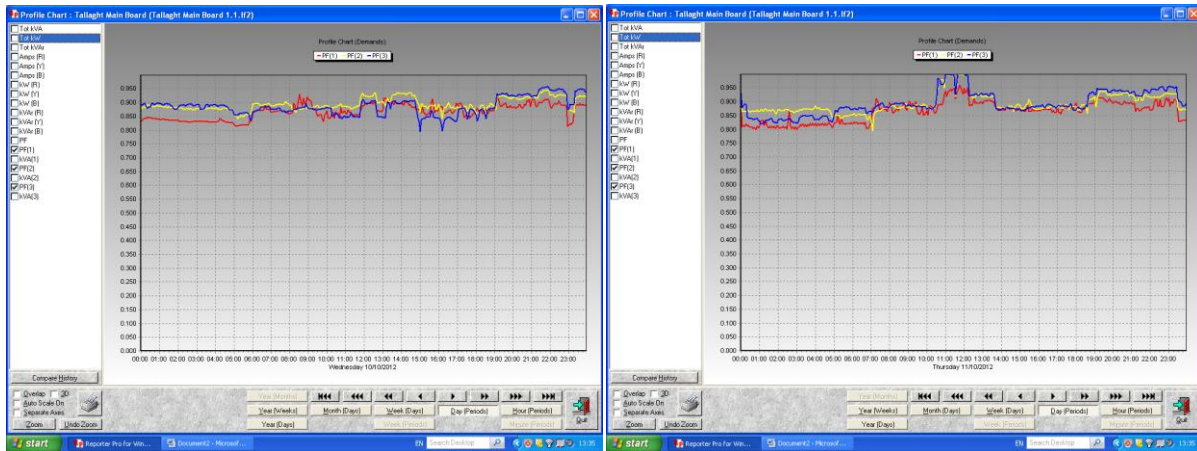
**Figure 18: Main Board - kVAr – Wednesday**

Figure 18: *Main Board - kVAr – Wednesday* shows the kVAr for the same day as above. kVAr is wattless energy and is undesirable. During the night time, there is a constant value of 11 kVAr. This jumps to 16 kVAr at 5 am when the AHU is switched on. There is no increase at 6 am when the sauna turns on as the sauna is a purely resistive load which will increase kW and kVA but not kVAr. The large value of kVAr at night time can be attributed to two motors which run 24 hours per day. These motors turn pumps which suck water from the pool, through filters, through a shell and tube heat exchanger and finally, back to the pool.

When kW is plotted against kVAr, as in *Figure 19: Main Board - kW vs kVAr – Wednesday*, an interesting graph is produced in which it is possible to separate certain loads. The inductive load of the AHU increases both kW and kVAr so can be seen turning on at 5 am and off at 9:30 pm, while the resistive load of the sauna which increases kW but not kVAr, can be seen turning on at 6 am and off at 11 pm. There are many other loads within the building, but these two are easy to identify using the kW vs kVAr graph.



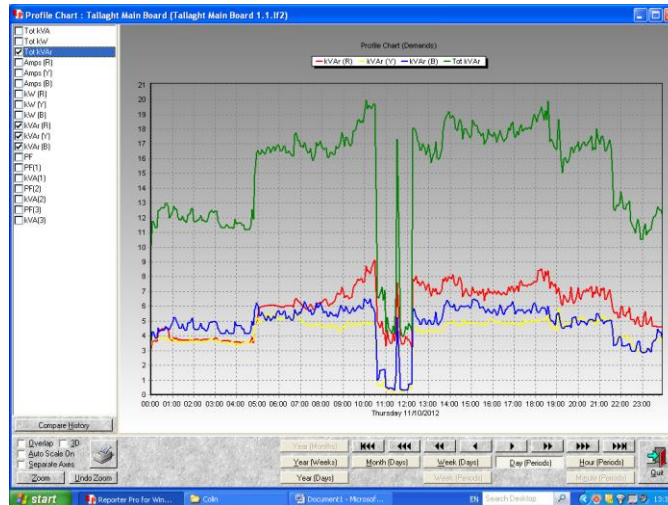
**Figure 19: Main Board - kW vs kVAr – Wednesday**



**Figure 20: Main Board - Power Factor**

In *Figure 20: Main Board - Power Factor* two graphs are shown. On the left is the power factor for each of the three phases on the Wednesday and on the right is the Thursday. On the Wednesday, the power factor never gets up to the 0.95 value required to eliminate penalties. What can also be seen is that the power factor drops at 5 am (AHU) and improves at 6 am (sauna).

On the Thursday, there is an interesting feature in the graph. As mentioned previously, there was a fault that day at 11:36 am which resulted in the two boilers, the main heating pump, the two filter pumps and the AHU shutting down. The power factor goes to almost unity during the fault. This is useful information as it shows which loads are causing the poor power factor.



**Figure 21: kVAr Thursday**

Figure 21 shows total kVAr and the kVAr on each phase for the Thursday. This graph also proves that the loads which tripped under the fault are responsible for the large kVAr consumption.

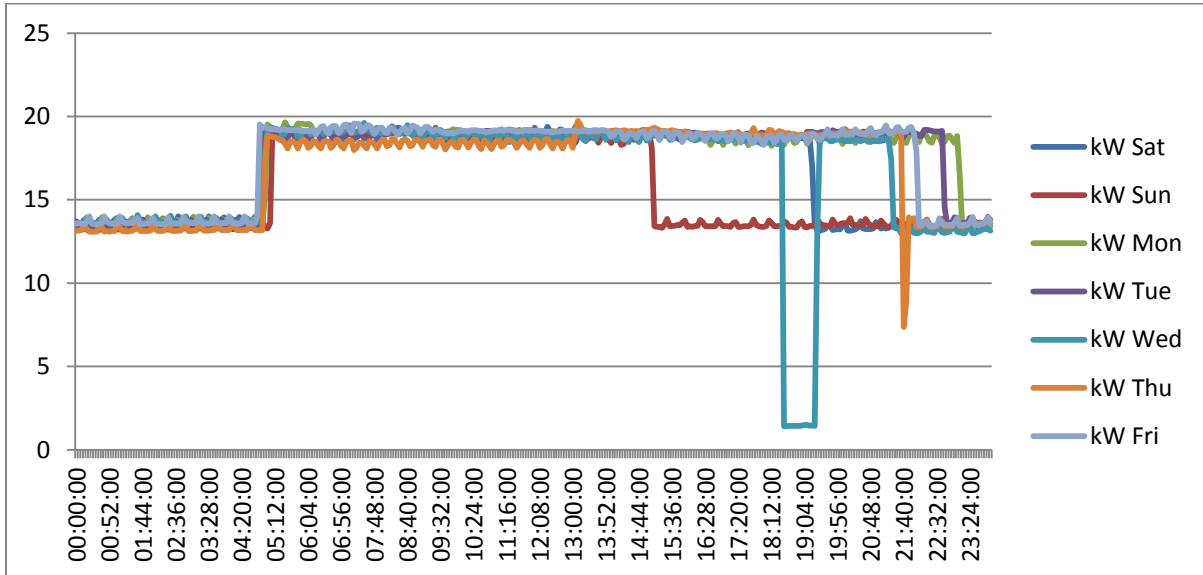
#### **4.4.3 Plant Room Sub-Board**

The data logger was connected to the plant room sub-board from Saturday 13<sup>th</sup> October 2012 for one week. When the plant room board is monitored in isolation, there is a very steady state condition observed. At night, there is a steady load of 13.5 kW, this rises to 19 kW at 5 am when the AHU is turned on. The load remains constant until the AHU is turned off.

Observations -

- The AHU is turned on every day at a consistent time (5 am).
- The AHU was turned off at the following times
  - Sunday – 3pm
  - Saturday – 7:15 pm
  - Monday – 11:12 pm

- Tuesday – 10:44 pm
- Wednesday – 9:24 pm
- Thursday – 9.40 pm
- Friday – 10:04 pm
- These times are similar to the turn off times from the previous week when the data logger was connected to the main board.
- On Wednesday at 6:32 pm, the contactor circuit fault occurs again which is visible by the large drop in load until 7:24 pm.
- 10 kW of the night load is attributed to the two pool filter pumps which run 24 hours per day.



**Figure 22: Daily kW profile - Plant Room**

The kVAr consumption on the plant room sub-board is also very steady. It has a total value of 10.5 kVAr at night and 15 kVAr once the 5 am switch on has occurred. This proves that a

considerable portion of the total kVAr is caused by the two 24 hour filter pumps. The AHU adds to the instantaneous kVAr, but as it is not on for as many hours, it not responsible for a proportionally large monthly kVAr consumption.

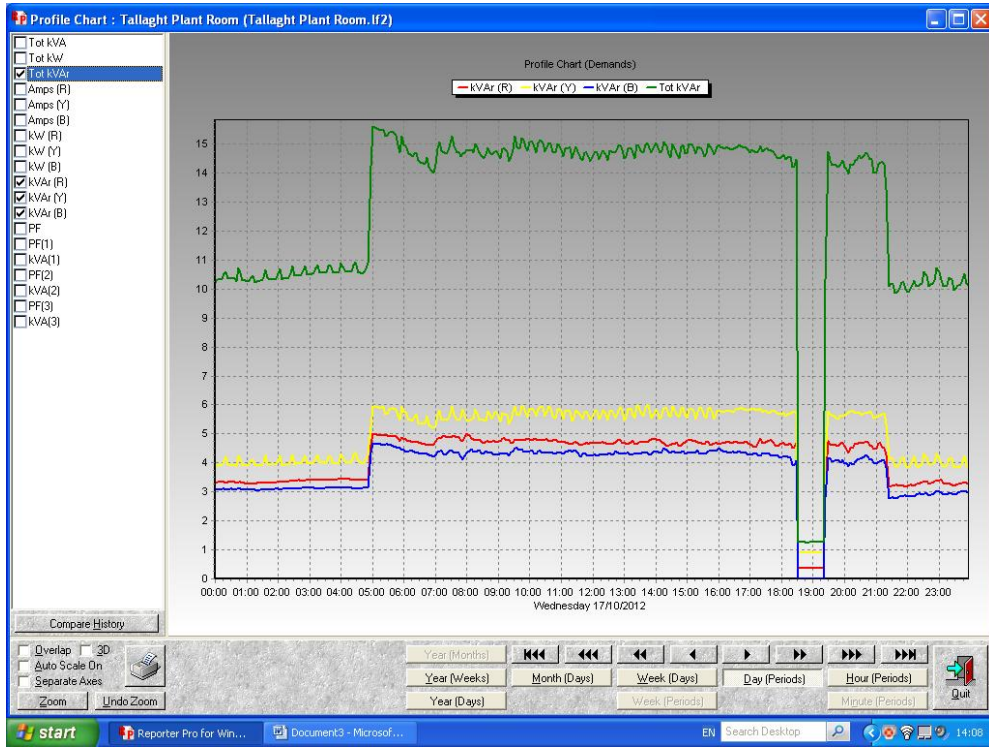


Figure 23: Plant Room kVAr - Wednesday

#### 4.4.4 Sub-Board 1

Sub-board 1 supplies all circuits in the building other than those in the plant room. The data logger was connected to this board for one week from Saturday 20<sup>th</sup> October. The sub-board supplies many loads which switch on and off repeatedly throughout the day and as such the consumption profile varies considerably during the day. The sauna is supplied from this board and can be seen turning on and off by a sudden 5 kW change in kW consumption. It is interesting to note the varying times which this happens, as early as 5:44 am on Thursday compared to 7:32 am on Tuesday. The weekend switch-on times are later again but there is a different occupancy

pattern those days. Switching off on the weekdays varies between 9:40 pm and 10:22 pm. On the Sunday, the sauna was accidentally left on all night. This can clearly be seen in the large Monday night load in *Figure 24: Daily kW profile - Sub-Board 1*. This happened during the week that the sub-board had the data logger attached but there is no way of knowing how often this happened. It was shown earlier in *Figure 13: Night Units Consumption* that some months have higher night time consumption than others and this may be the cause. The manual switching of the sauna clearly creates inefficiencies in the system and is addressed in section *6.3 Sauna*.

#### Observations

- The night load is mainly external security lighting
- The peaks and troughs seen on the main-board are caused by sub-board 1
- Weekend consumption is lower than weekday and evening peaks are not present
- Night load of 5 – 6 kW is normal, peak is approximately 25 kW
- The time at which night load conditions are reached varies between the days.

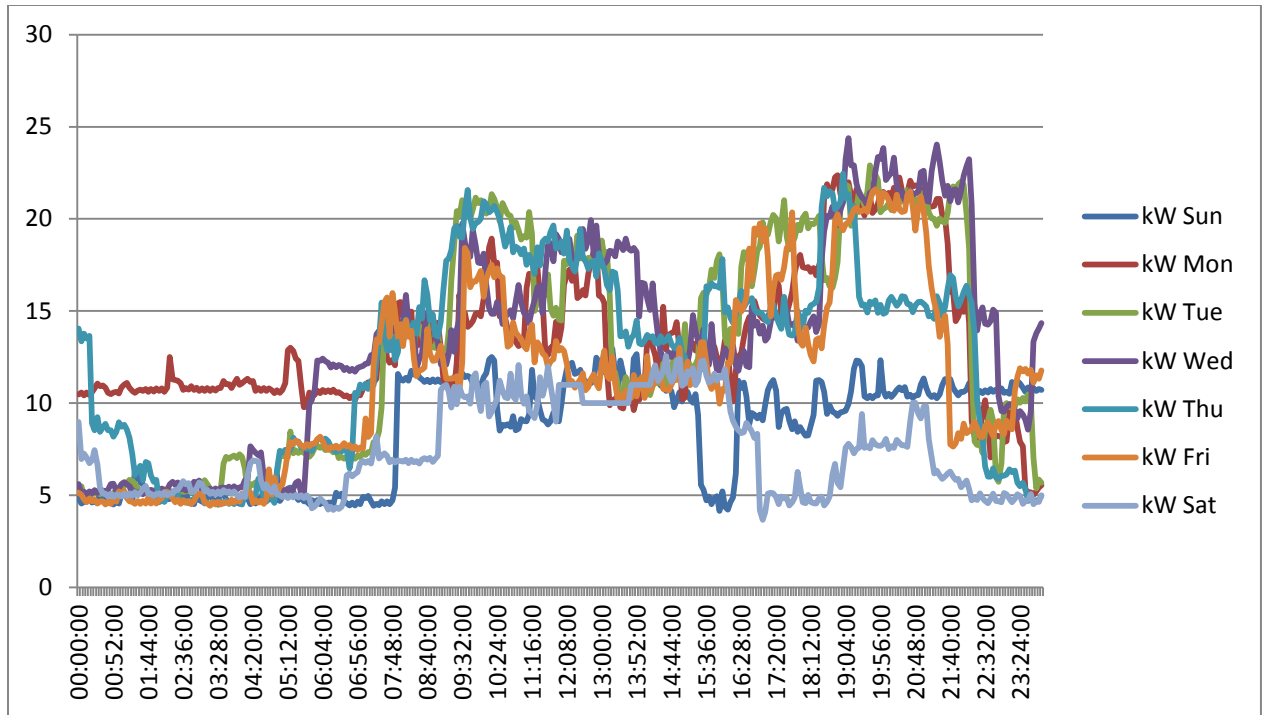


Figure 24: Daily kW profile - Sub-Board 1

The kVAr consumption on sub-board 1 is far smaller than that of the plant room sub-board. The total varies between 1 and 6 kVAr. This board does therefore not warrant any further investigation with regard to power factor correction.



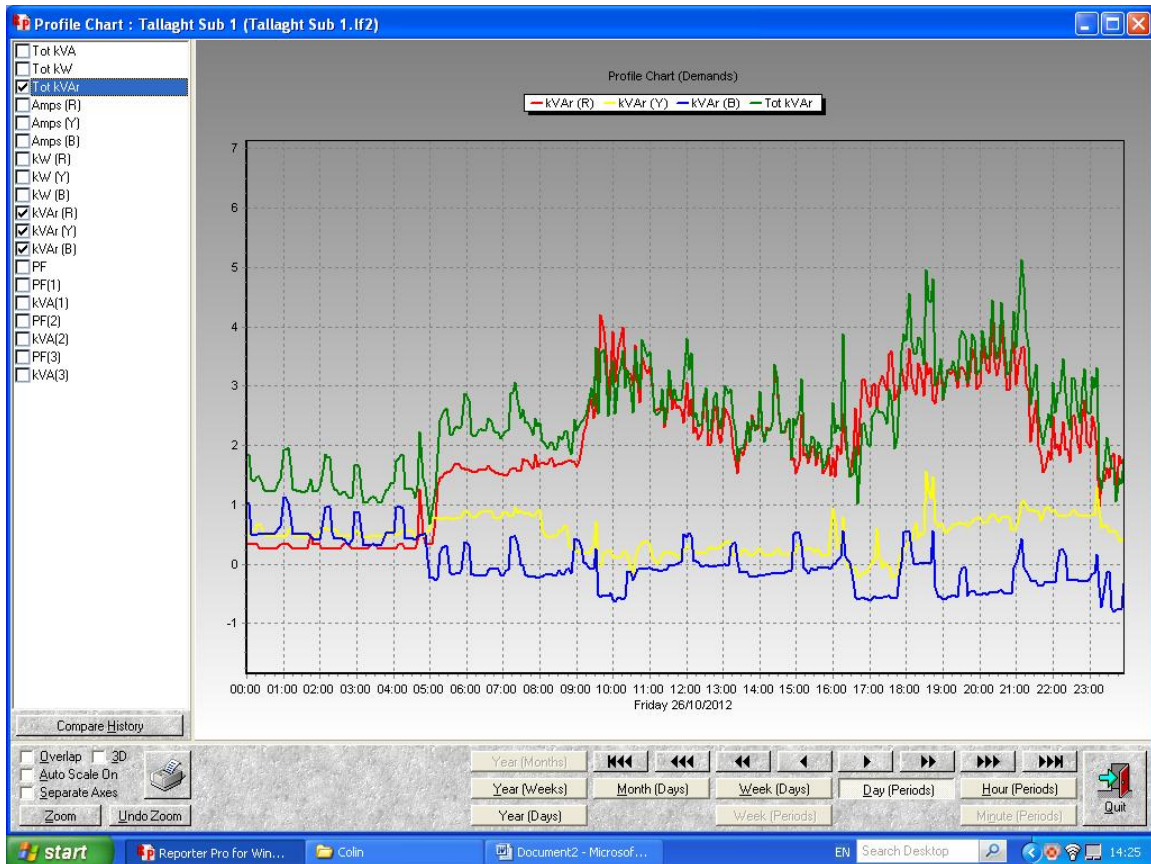


Figure 25: Sub-board 1 - kVAr – Friday

## 4.5 Significant Electrical Users

### 4.5.1 Filter Pumps

The two filter pumps which are on 24 hours per day have been identified as significant users of electricity. The data logger was attached to each to gain data. As these are constant loads, only a snap shot reading was required to gain sufficient information. The following information was obtained from filter pump 1: 6 kVA, 5 kW, 3.4 kVA.

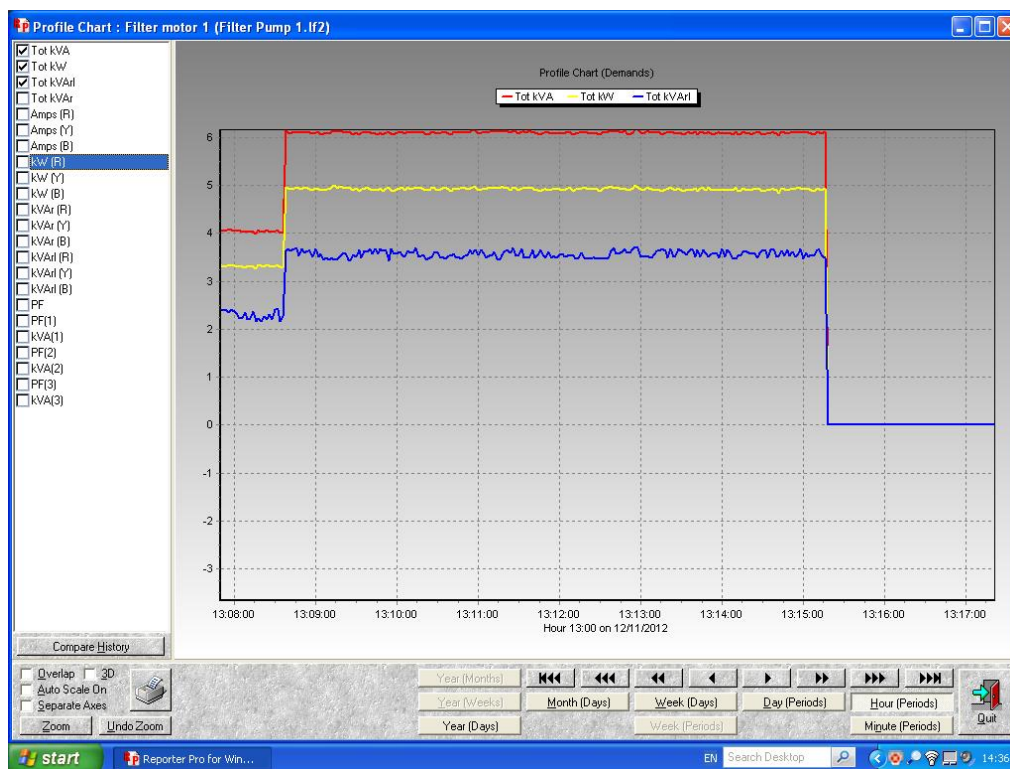


Figure 26: Filter pump 1

Filter pump 2 gave identical results. Between the two pumps, the annual consumption is  $(5 \times 2)$  kW x 24 hrs x 365 days = 87,600 kWh

This represents 38.5% of the total 227,300 kWh of electrical consumption for the previous twelve months. As the filter pumps run 24 hours a day, a large portion of their consumption is on

the night rate and therefore their cost percentage will be lower than their consumption percentage. Day units =  $87,600 \times \frac{15}{24} = 54,750 \text{ kWh}$ , night units =  $87,600 \times \frac{9}{24} = 32,850 \text{ kWh}$ .

The two pumps therefore represent 34.85% of the total 157,080 kWh day units and 46.78% of the total 70,220 night units.

The annual kVAr consumption between the two motors is  $(3.4 \times 2) \text{ kVAr} \times 24 \text{ hrs} \times 365 \text{ days} = 59,568 \text{ kVArh}$ . There was an average of 53,000 kVArh annually in penalties. The building consumes a higher value of kVArh than this, but it is allowed a quota dictated by its kWh consumption. The value of 53,000 is the amount of kVArh consumption above the quota. If the motor's power factor was improved to unity, the low power factor penalty should be eliminated.

#### **4.5.2 Main Air Handling Unit (AHU-01)**

The electrical load in the AHU is a single three-phase fan which draws in fresh outside air, passes it over a heat exchanger and down into ductwork which supplies the fresh/heated air to the swimming pool hall and some adjacent rooms. Below is a screen grab of the *real-time monitoring* option available with the data logger. The phase values can be seen on the red, yellow and blue columns and the totals are across the bottom of the screen. A total value of 5.5 kW was measured.

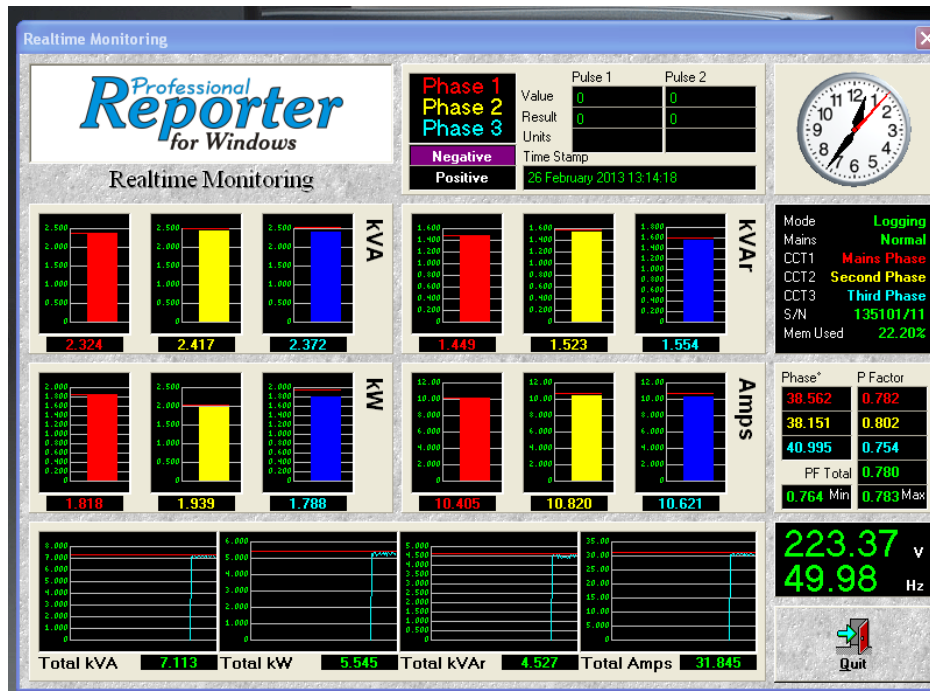


Figure 27: AHU-01 - Data Logger

The AHU is manually operated and turned on at 5 am. The turning-off times vary and were discussed in the 4.4.3 *Plant Room Sub-Board* section. During the week in which the AHU was monitored, it was on for 110 hours. That gives an annual consumption of, 5.5 kW x 110 hours x 52 weeks = 31,460 kWh (13.8% of the 227,300 kWh total)

#### 4.5.3 Sauna

The sauna is a purely resistive load which is used seven days per week. It is manually controlled by operating an isolator which is locked in a box with a pad lock. The circuit is three-phase, but as it is a balanced load, only one phase was monitored using a single phase energy meter. As such, consumption has to be multiplied by three to get total values. The energy meter was attached from Thursday 1<sup>st</sup> November to Thursday 8<sup>th</sup> November.

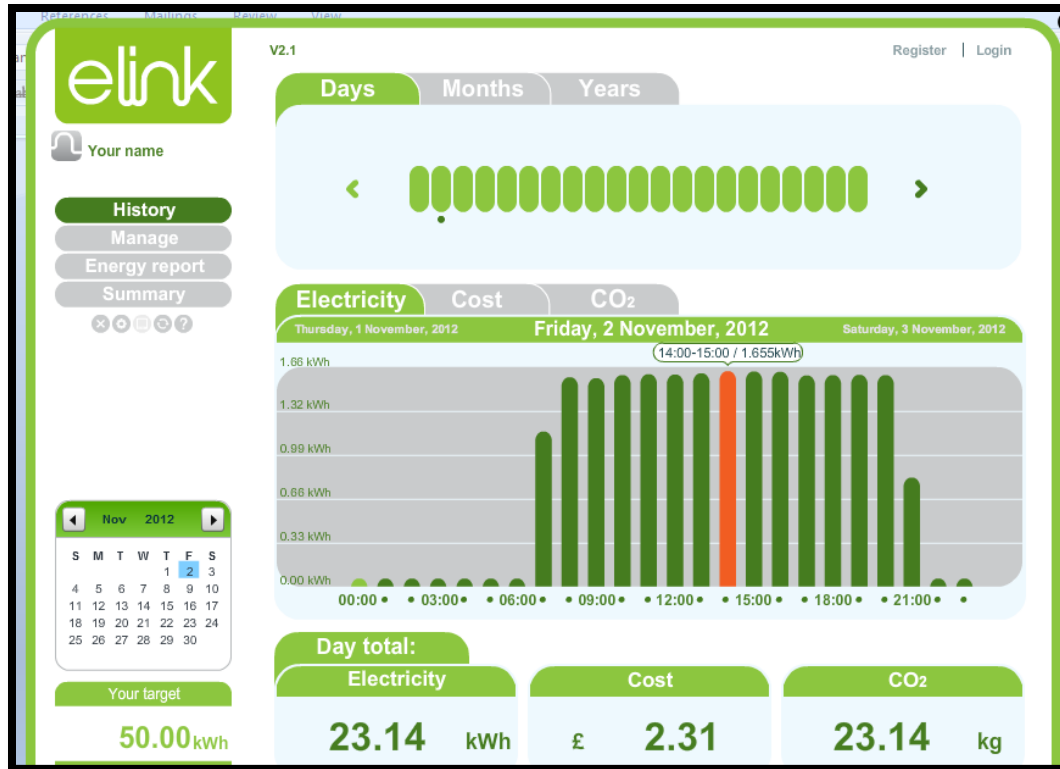


Figure 28: Sauna - Friday 2nd November

The readings given in the columns above are the kWh consumption for each hour. As these values are for one hour, the instantaneous kW consumption is the same value. Therefore, one phase of the sauna uses 1.655 kW and the total load is  $1.655 \times 3 = 5$  kW. The consumption for this day is given in the bottom left of the screenshot as 23.14 kWh. The total consumption is therefore  $23.14 \times 3 = 69.42$  kWh. The total consumption for the week was 441 kWh. This gives an annual consumption of 22,935 kWh (10% of the total 227,300 kWh).

On the week which the sauna was monitored in isolation (November 1<sup>st</sup> to 8<sup>th</sup>), the switch on and off times varied on the weekdays by over an hour. This is due to the manual nature of the switching and is addressed in section 6.3 *Sauna*.

#### 4.5.4 AHU-02 & AHU-03

AHU-02 and AHU-03 supply fresh air to the male and female changing rooms. Both AHUs use a single-phase fan which was measured at 0.375 kW each. Currently these fans are left on 24 hours/day. Annual consumption therefore is  $0.375 \times 2 \times 24 \times 365 = 6570 \text{ kWh}$  (2.9% of total).

#### 4.5.5 Pool Lighting

The circuit for the swimming pool lights was monitored for one week from November 8<sup>th</sup> to 15<sup>th</sup> using the Efergy energy monitor. The lights consume 1.45 kW when they are on and they are manually controlled. There is considerable roof glazing in the pool area and daylight is sufficient for lighting a lot of the time. From the data gathered, it is clear that the lights are turned off when not in use. It is also worth noting that the week in which the circuit was monitored was quite dull and therefore the information cannot be extrapolated out accurately for an annual load. 114 kWh were consumed over the week which gives 5,928 kWh annually (2.6% of total).

There does seem to be some erratic night consumption, for example, on Thursday 15<sup>th</sup>, the lights were not turned off until after 1 am and were back on at just after 3 am.

#### 4.5.6 Wellness Centre

The wellness centre is a single room with six electrical exercise machines. These machines are aimed at elderly customers and those who are not very fit. Customers sit or lie on each machine and resist the movement of the machine. All of the machines are plugged into a single socket circuit. This circuit was monitored for one week. Weekly consumption was 26 kWh. The wellness centre attracts a lot of customers and easily pays for itself.

#### **4.5.6 Conclusion**

The filter pumps, AHU and sauna account for 58.65% of all the electricity consumed by the building. These are the loads which should be focused on initially in the quest for energy savings.

### **4.6 Gas Billing Information**

#### **4.6.1 Introduction**

Gas is purchased from Energia and bills are issued on a monthly basis. Bills were available for the period from June 2012 to June 2013 (13 months). For all annual values given, June 2012 shall be omitted and June 2013 used as it is more up to date. In the past twelve months, gas has cost €64,688 which is 62.1% of the €104,174 total (gas & electricity). Consumption does vary with the seasons but not as much as might be expected. As the pool requires heating all year round, even the summer months have a demand in the order of 2,500 kWh/day, or 105 kW, 24 hours per day.

#### **4.6.2 Monthly Data**

Figure 29 shows the monthly kWh units consumed. Monthly consumption varies between 63,000 and almost 146,000 kWh.

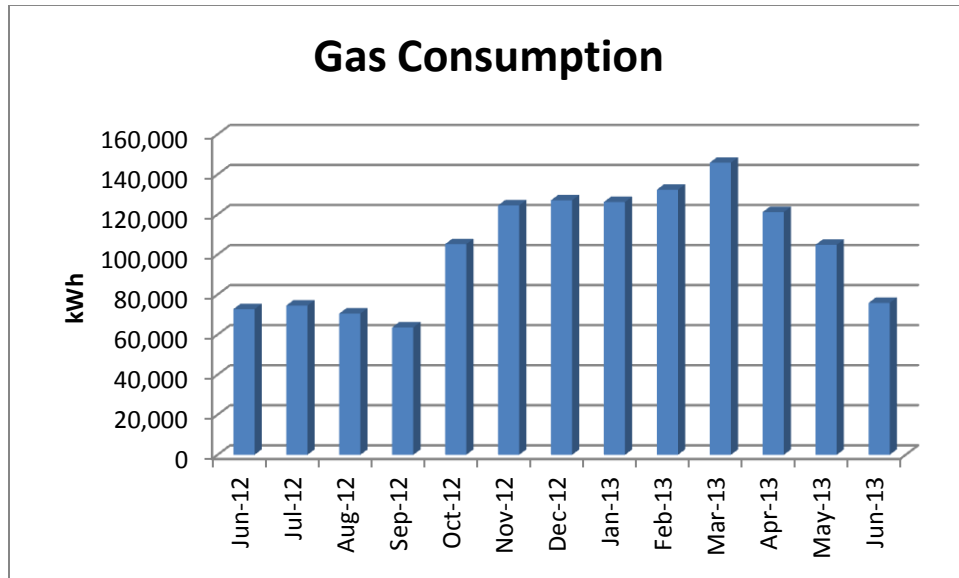


Figure 29: Gas consumption

The gas bill is broken down into five parts.

- Gas rate – the charge per kWh of gas consumed.
- Carbon tax – government levy per kWh of gas consumed – introduced on May 1<sup>st</sup> 2010
- Transportation rate – charged per kWh of gas consumed
- Shrinkage rate - charged per kWh of gas consumed
- Site capacity charge – Bord Gais Networks calculate a site capacity value annually, based on the previous year’s consumption and weather data. The energy year starts in October so this value changes each year starting from October. A rate is multiplied by the site capacity value on each bill. As a rule of thumb, the annual fee (in euro) is close to double the site capacity (in kWh).



As the gas rate, carbon tax, transportation charge and shrinkage charge are all based on kWh of gas used; a reduction in consumption will reduce all four charges in proportion. If there is a sustained reduction year round, the site capacity charge will reduce on the following October.

#### 4.7 Monthly Regression Analysis

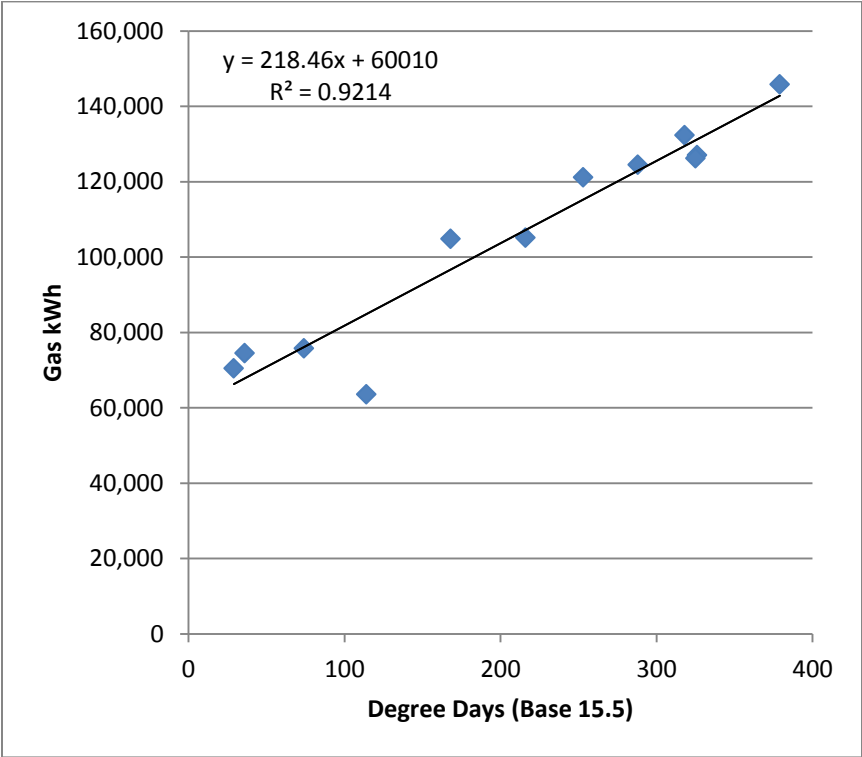
Although the consumption of gas on a monthly basis offers an insight into monthly variations, it does not give accurate feedback as to the performance of the heating system with respect to the weather. Regression analysis shall be used to set up a performance indicator for the heating system using degree days as the driver for gas consumption.

The closest weather station with the available data is Naas. Naas is approximately 20 km from Tallaght with a similar inland weather climate so the degree day data should be very similar to that in Tallaght. The degree days were obtained from [www.degreedays.net](http://www.degreedays.net) using 15.5°C as the base temperature. Table 5 shows the heating degree days obtained cross referenced with the actual gas consumption for the corresponding month.

	HDD	Gas (kWh)
Jul-12	36	74,554
Aug-12	29	70,523
Sep-12	114	63,632
Oct-12	216	105,192
Nov-12	288	124,538
Dec-12	326	127,094
Jan-13	325	126,252
Feb-13	318	132,379
Mar-13	379	145,865
Apr-13	253	121,202
May-13	168	104,889
Jun-13	74	75,828

**Table 5: Monthly heating degree days and gas consumption**

Using the values in Table 5, an XY scatter diagram was generated with the degree days on the x axis and gas consumption on the y axis as shown in Figure 30. By adding a trendline, it can be seen that when the monthly values are plotted, they fit close to the line. This indicates that degree days are a direct driver of gas consumption. As a result, the equation of the line ( $y=218.4x+60010$ ) can be used to assess both historical monthly performance and future performance. This equation gives the base load of the building as 60,010 kWh/month and states that there will be another 218.4 kWh consumed for every degree day. These numbers should not be considered as 100% accurate be are good indicators of performance.



**Figure 30: Gas - degree day XY scatter diagram**

Table 5 can now be expanded to include the predicted gas consumption based on the formula from Figure 30. The next column is the difference between the predicted consumption and the

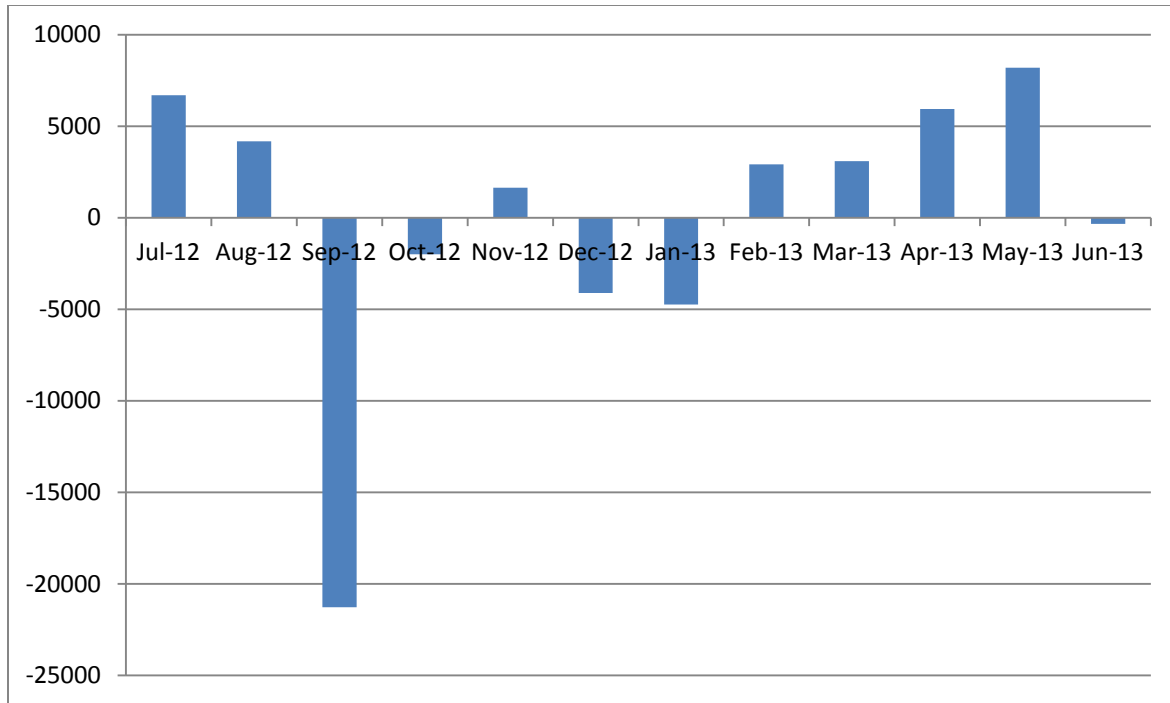
actual consumption, a positive number indicates that more gas was consumed than the formula predicted and visa versa.

	HDD	Gas (kWh)	Predicted	Difference
Jul-12	36	74,554	67872	6682
Aug-12	29	70,523	66344	4179
Sep-12	114	63,632	84908	-21276
Oct-12	216	105,192	107184	-1992
Nov-12	288	124,538	122909	1629
Dec-12	326	127,094	131208	-4114
Jan-13	325	126,252	130990	-4738
Feb-13	318	132,379	129461	2918
Mar-13	379	145,865	142784	3081
Apr-13	253	121,202	115265	5937
May-13	168	104,889	96701	8188
Jun-13	74	75,828	76172	-344

**Table 6: Monthly Performance**

A more user-friendly way to view this information is to plot the *difference* column against the months on a column chart as shown in Figure 31. When the column points upwards, that month's consumption was above what should have been used based on the month's weather and visa versa. It can be seen that most months fall within a plus/minus value of 5,000 kWh. The one month of interest is September 2012 which has an under consumption of 21,276 kWh. Unfortunately, as no maintenance records are kept it is impossible to say why this month performed so well. It should be pointed out that it is possible that the building didn't perform well at all, perhaps a pump failed and hot water couldn't be pumped to where it was required, resulting in thermal comfort being compromised and a loss of customers.

This performance indicator can easily be updated on a monthly basis to check for under or over performance.



**Figure 31: Gas Performance Indicator**

Simply updating this performance indicator is pointless unless the information is used constructively. This is discussed later in section 6.6 *Energy Management Policy*.

#### **4.8 Daily Gas Profile**

To obtain a daily load profile, the gas meter was read every hour over a 24 hour period on Thursday 13<sup>th</sup> June. The information obtained is shown in Figure 32. The consumption increases as soon as the AHU is turned on at 5 am and averages around 130 kW. Consumption drops at night when the AHU is turned off and the pool is covered.

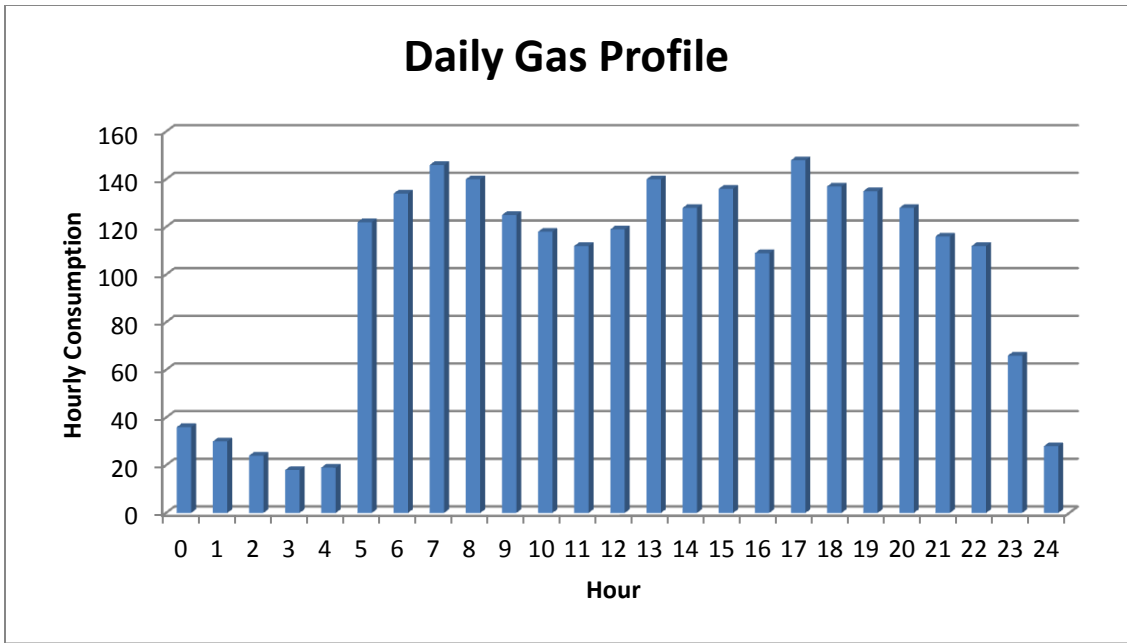


Figure 32: Daily gas profile

## 5. Energy Costs

### 5.1 Introduction

Electricity and gas are currently supplied by Energia. All bills are available in appendices B & C.

### 5.2 Electricity

#### 5.2.1 Day Units

In Figure 33, the changing price of a day unit of electricity over the twenty-two month period can be seen. The price increases over the winter months of November to February, and drops again between March and October. This pattern is not guaranteed however and could change at any time. The price varied between €0.1354 and €0.1669 per kWh (excluding VAT).

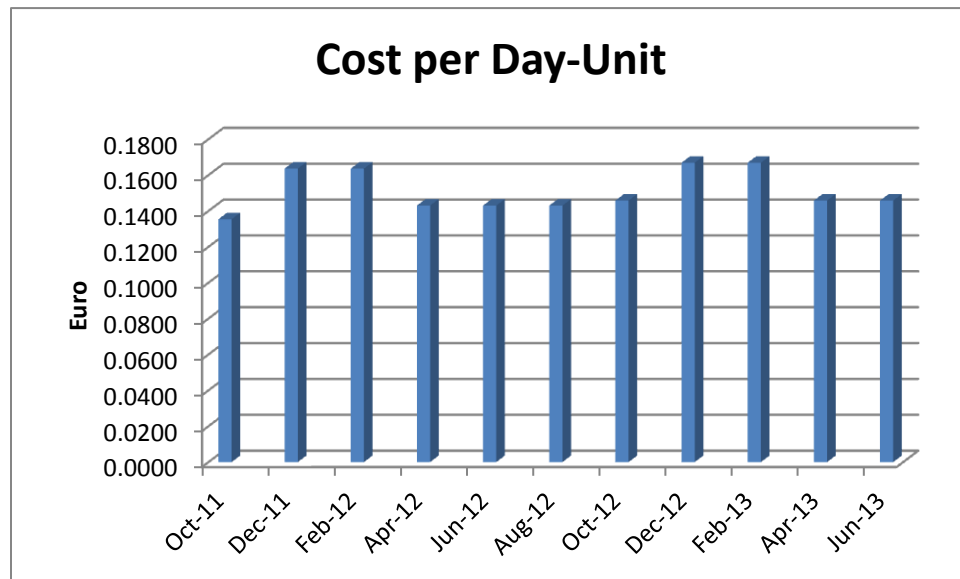


Figure 33: Cost per Day-Unit

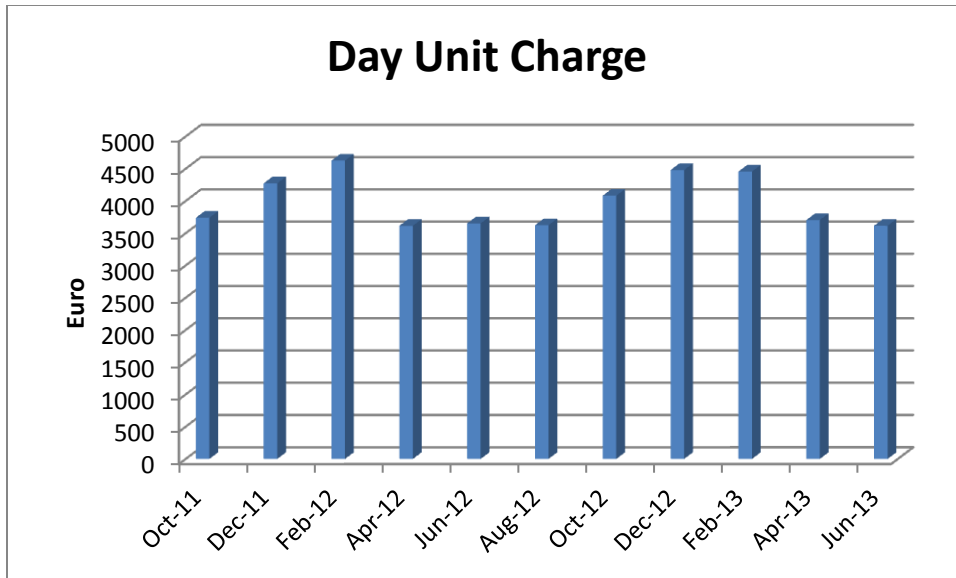


Figure 34: Day Unit Charge

In Figure 34, the actual cost of the day units for each two month period is graphed. It can be seen that the charge does not directly follow the consumption due to the unit price fluctuation. This is illustrated below in Figure 35, the column on the left is the percentage of day unit consumption which that bill is responsible for (out of the eleven previous bills), while the column on the right is the percentage of day unit cost which that bill is responsible for.

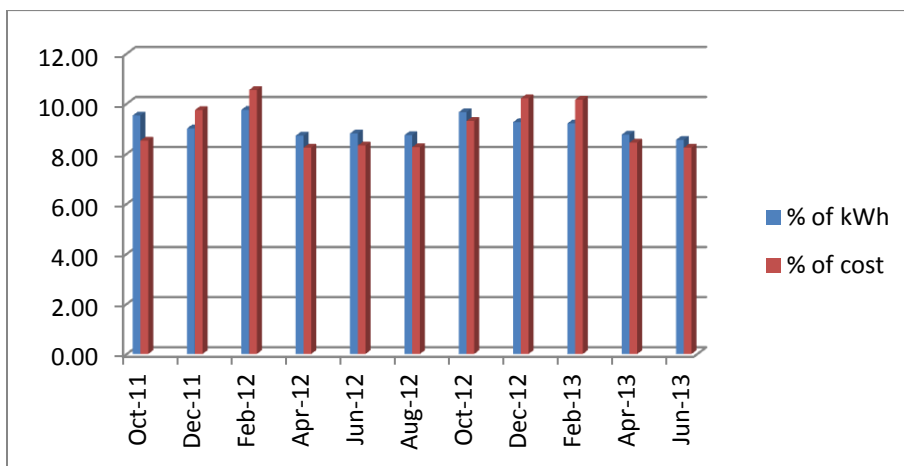
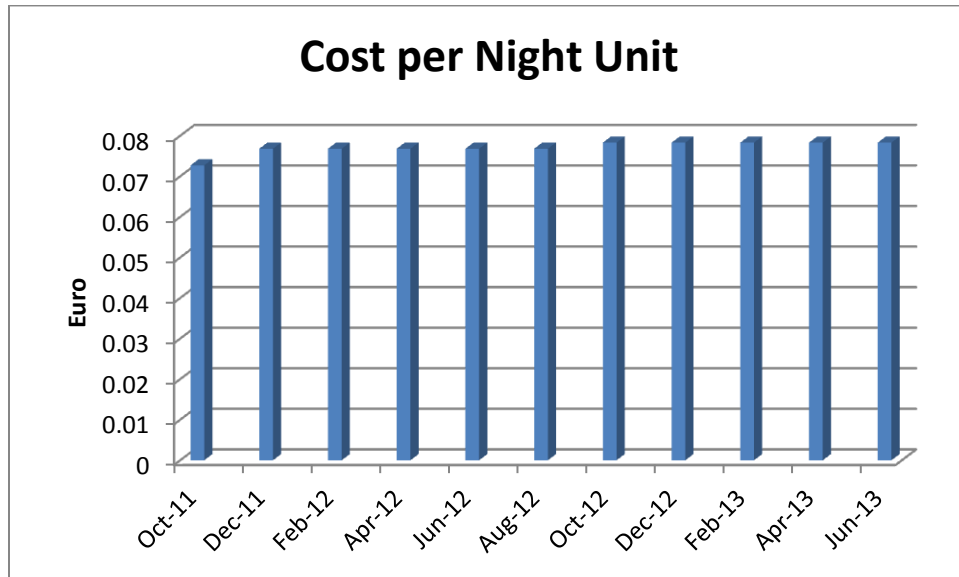


Figure 35: Percentage of consumption and cost

## 5.2.2 Night Units

In *Figure 36: Cost of Night Units*, it can be seen that the cost of night units did not change a lot in the twenty-two month period, from 7.27c to 7.83c/kWh (a 7.7% increase).



**Figure 36: Cost of Night Units**

*Figure 37: Charge for Night Units* shows that the night unit charge is usually fairly consistent varying between €864 and €1005.



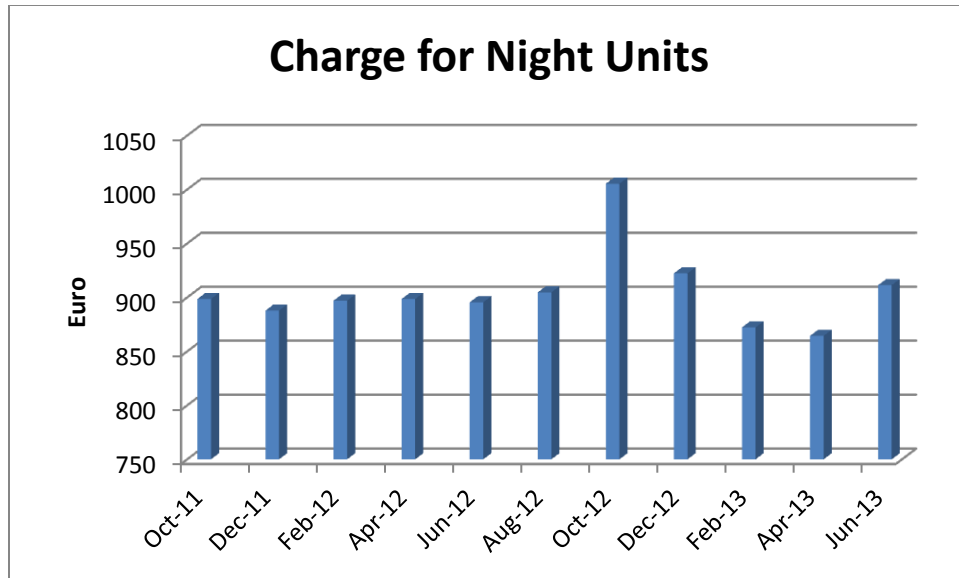


Figure 37: Charge for Night Units

### 5.2.3 Service Capacity Charge and Public Service Organisation Levy (PSO Levy)

Figure 38: MIC and PSO Levy cost per unit shows the changing cost per unit for both MIC and PSO charges. Both values are multiplied by the agreed 60 kVA to calculate the charge. Any reduction in MIC would reduce both charges.

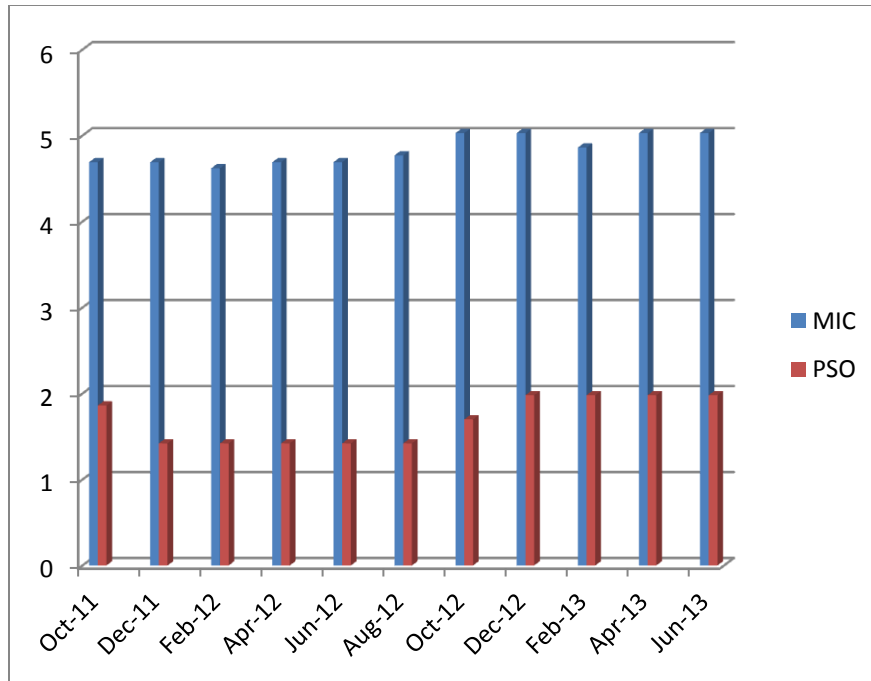


Figure 38: MIC and PSO Levy cost per unit

### 5.2.4 Standing Charge

The standing charge represents 5.9% of the total bill. It is not based on consumption, but it is relevant when checking other provider’s tariffs. It has remained fairly consistent vary between €332 and €343 per two-month bill.

### 5.2.5 Maximum Demand Charge

On the current tariff, the maximum demand charge only applies for two of the six annual bills; these are the winter bills of November/December and January/February.

As can be seen in *Figure 39: Max demand cost per kW* and *Figure 14: Recorded Max Demand* below, the cost per kW varies between €5.55 and €5.73 and the recorded maximum demand was 44, 45, 46 and 44 kW respectively. Overall, the maximum demand charge only represents 1.6%

of the total electricity bill (€1,013 over twenty-two months) and therefore, peak reduction techniques won't offer large savings.

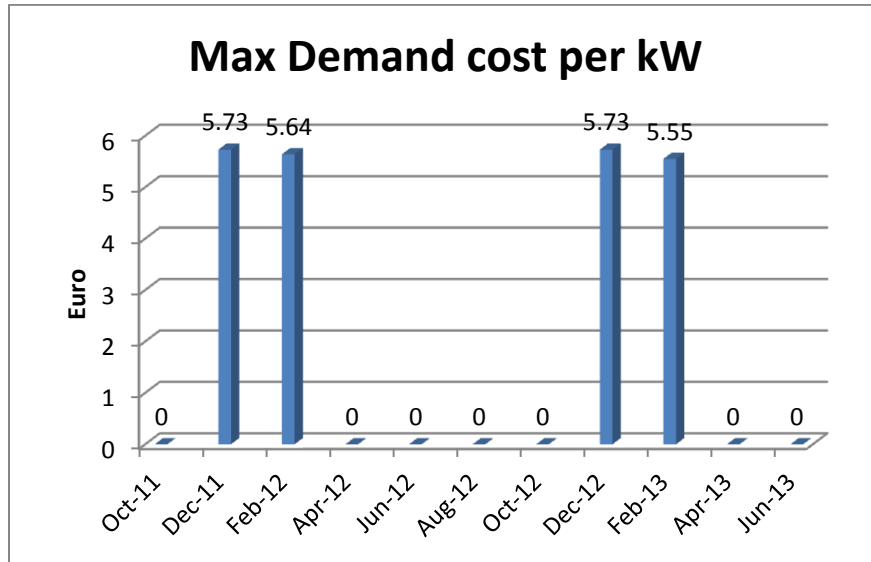


Figure 39: Max demand cost per kW

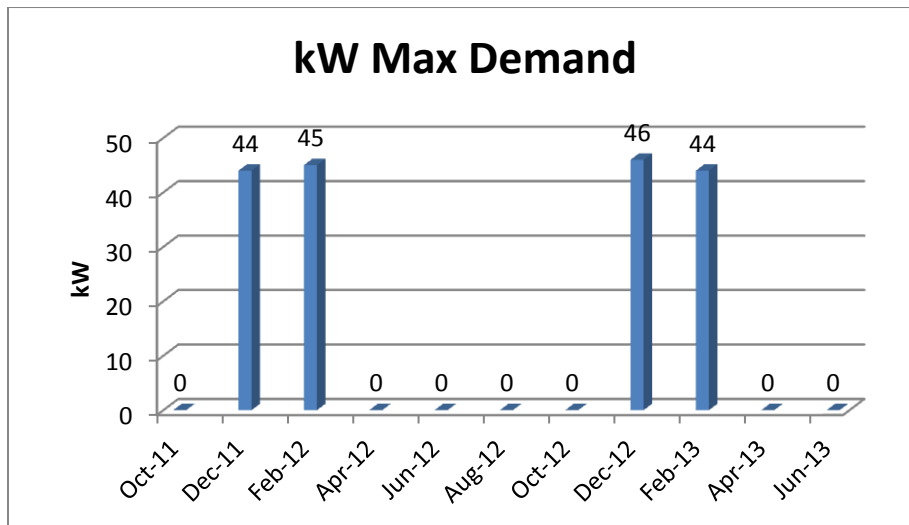


Figure 40: Recorded Max Demand

### 5.2.6 Low Power Factor Surcharge

The low power factor surcharge over the twenty-two month period totalled €569 (0.9% of the total). Capacitors were installed one quarter of the way into the December's billing period as part of the project. Figure 41 shows the kVArh from each billing period.

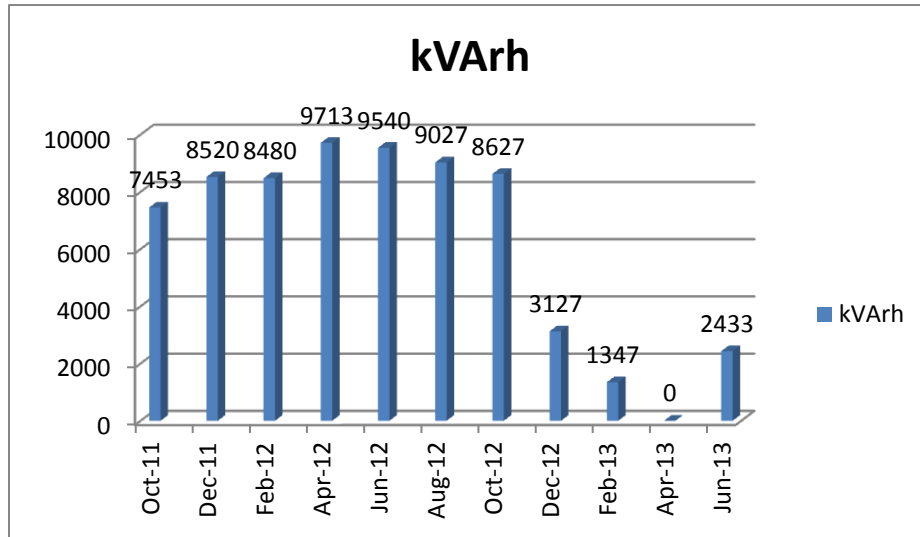


Figure 41: kVArh

From October 2012, the cost per kVArh has increased from 0.8c to 1c per kVArh (a 25% increase). The installation of capacitors has reduced the low power factor surcharge at a time when its unit price has increased. Costs and payback period are discussed in section

## 6.5 Power Factor Correction.

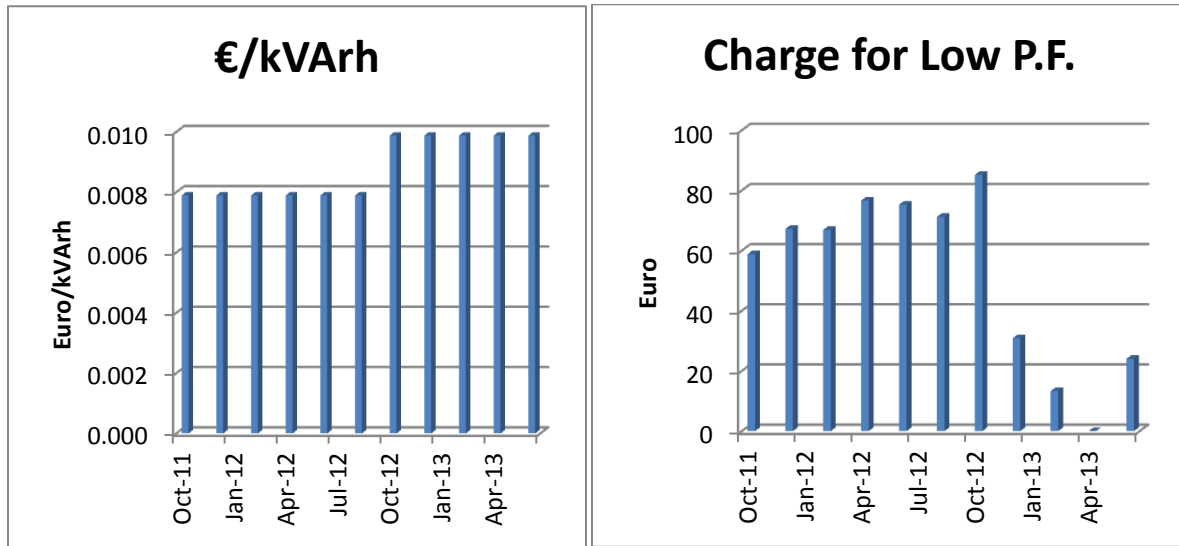


Figure 42: Low Power Factor Costs

### 5.2.7 Electricity Tax

The electricity tax is the smallest of the component parts of the electricity bill at 0.3% (€209 over the twenty-two month period). The electricity tax is a charge of 0.05c/kWh regardless of whether they are day or night units. If general consumption is reduced, the electricity tax will reduce also.

### 5.2.8 Summary

Day units are by far the largest cost on the electrical bill at 68.9% of the total. Figure 43 gives a breakdown of each component of the electrical bill.

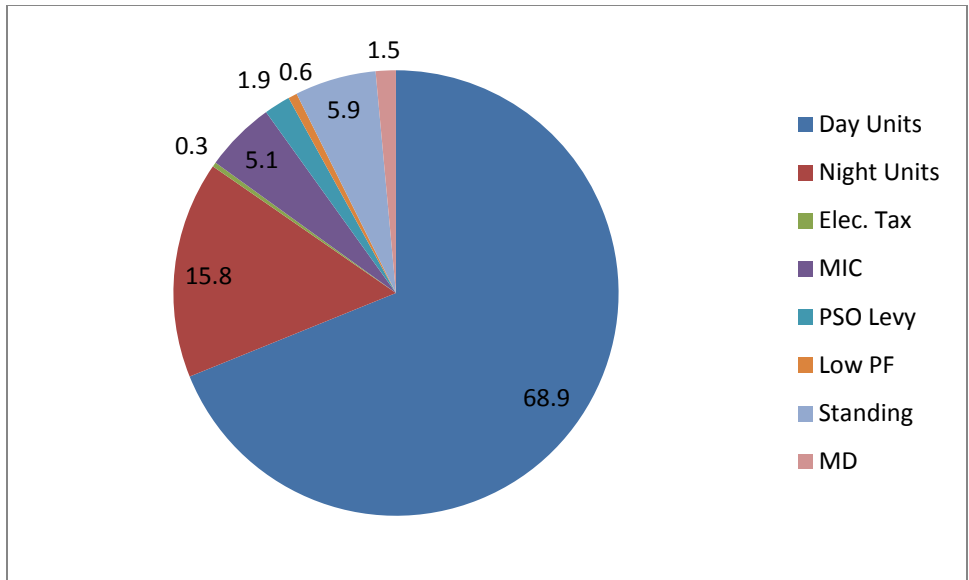


Figure 43: Electrical bill - 12 month breakdown

### 5.3 Gas

A breakdown of the five sections of the bill is shown below *Figure 44*. All values are excluding VAT.

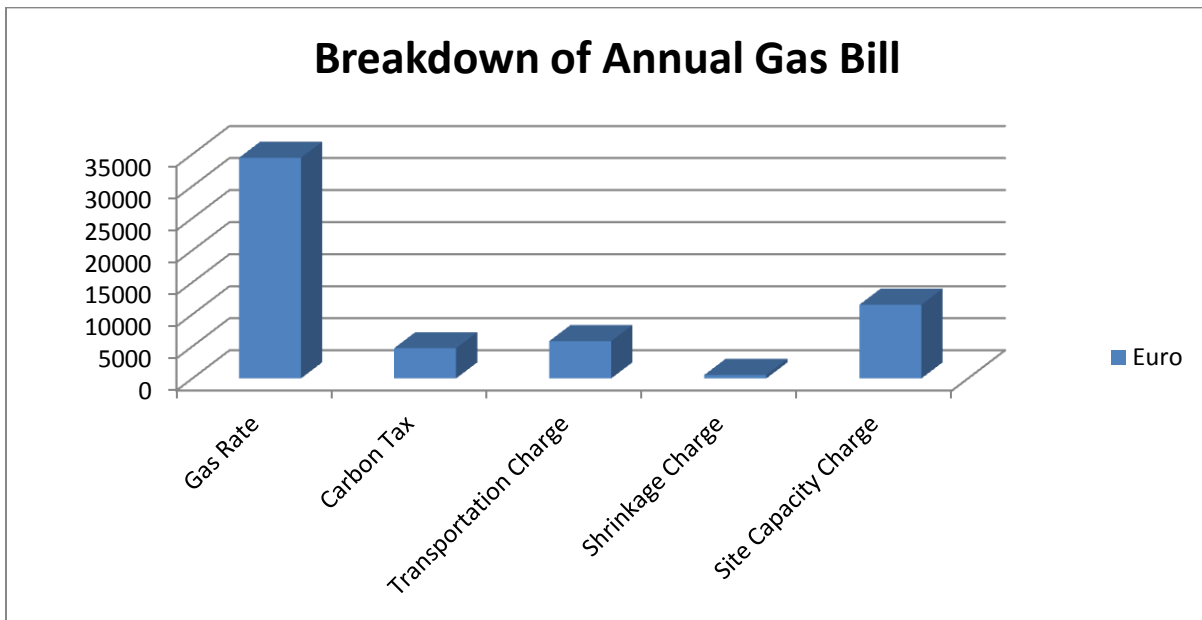


Figure 44: Breakdown of annual gas bill

As the gas rate, carbon tax, transportation charge and shrinkage charge are all based on kWh of gas used, a reduction in consumption will reduce all four charges in proportion. If there is a sustained reduction year round, the site capacity charge will reduce on the following October.

## 6. Discussion of methods to reduce energy use and costs

### 6.1 Heat Recovery

With over €65k annually used to heat the building and pool, and no heat recovery being used, this is the largest area for potential savings. There are a few methods for heat recovery but the two best options will be considered here: run around coils and cross flow heat exchanger. The following calculation shows the financial savings based on a one degree rise in air temperature, regardless of heat recovery method.

#### Information for calculation:

- Main AHU volume flow =  $6.5 \text{ m}^3/\text{sec}$
- Density of air =  $1.2 \text{ kg}/\text{m}^3$
- Average weekly AHU operation = 110 hours
- Gas unit cost (total for gas charge, transportation, shrinkage, carbon tax and VAT) = 3.5 c/kWh
- Specific heat capacity of air =  $1.02 \text{ kJ}/\text{kg.K}$
- Boiler efficiency = 80%

#### Annual financial saving for every one degree increase in air temperature

- Mass flow of air =  $6.5 \frac{\text{m}^3}{\text{sec}} \times 1.2 \frac{\text{kg}}{\text{m}^3} = 7.8 \text{ kg}/\text{sec}$
- Load reduction =  $7.8 \frac{\text{kg}}{\text{sec}} \times 1.02 \frac{\text{kJ}}{\text{kg.K}} \times 1^\circ\text{C} = 7.96 \text{ kW}$
- Load reduction (input to boiler) =  $\frac{7.96}{0.8} = 9.95 \text{ kW}$
- Annual load reduction =  $9.95 \text{ kW} \times 110 \text{ hours} \times 52 \text{ weeks} = 56,914 \text{ kWh}$
- Financial saving =  $56,914 \text{ kWh} \times \text{€}0.035 = \text{€}1,992$

It can be seen above that for every one degree increase in air temperature from heat recovery, an annual saving of €1,992 is possible.



There are a few points worth noting here:

1. As the hot water flow to the main AHU (circuit no.3) is controlled manually, using a heat recovery method will only realise savings if the circuit is regulated appropriately. Ideally, as part of any heat recovery strategy, there should be a thermostat and humidity sensor installed in the pool area which controls the hot water flow in circuit no.3. As a 3-port bypass valve exists on this circuit, re-commissioning this would not only get the most from heat recovery but would increase efficiency in its own right, as the current manual method allows for frequent overheating.
2. This calculation is based on current gas prices and flow rates. If a VSD is installed on the AHU fan, the values will change.
3. There are other factors to consider such as extra costs to run pumps/fans etc.
4. Air currently escapes through many openings in the building. This should be reduced as much as possible to capitalise on savings.

In order to calculate the potential savings from both heat recovery methods, actual performance data was used as opposed to theoretical values. RPS Engineering Services provided performance certificates for an installed run-around coil system and an installed cross-flow (plate) heat exchanger. The performance certificates can be seen in Appendix D.

### 6.1.1 Cross flow heat exchanger

This type of system has never been used in this building. It would require the installation of ductwork from an extract point(s) to the main AHU intake point. The four existing disused extracts would be the obvious choice.

Air temperatures from the performance certificates are given for two outdoor air temperatures, -5°C and 0°C.

		Sample 1	Sample 2
Exhaust air	(°C)	23	23
Supply air (into unit)	(°C)	-5	0
Supply air (leaving unit)	(°C)	12.6	14
Supply air temp. Increase	(°C)	17.6	14
Max. Possible temp. Increase	(°C)	28	23
Efficiency	(%)	62.9	60.9

**Table 7: Plate heat exchanger- performance data**

Efficiency decreases as external air temperature increases. In this case, efficiency has decreased by 2% with a 5°C increase in external air temperature. That averages out at 0.4% decrease per °C. This value shall be used to estimate efficiency at other external temperatures, although this method is not exact, it should yield reasonably accurate results.

The following example explains the calculations in Table 8

If the external temperature is 5°C, then the heat exchanger's efficiency has dropped to 58.9%. The internal temperature is always kept at 30°C. Therefore, the maximum temperature rise possible is 25°C. The actual temperature increase is (25°C \* 0.589) 14.7°C. This brings the air temperature to (5°C + 14.7°C) 19.7°C before it enters the AHU heating coil.

External temperature	Percentage efficiency	Internal temperature	Maximum temp increase	Supply air temp. increase	Air temp. to heating coil
(°C)	(%)	(°C)	(°C)	(°C)	(°C)
<b>-5</b>	<b>62.9</b>	<b>30</b>	<b>35</b>	<b>22.0</b>	<b>17.0</b>
-4	62.5	30	34	21.3	17.3
-3	62.1	30	33	20.5	17.5
-2	61.7	30	32	19.7	17.7
-1	61.3	30	31	19.0	18.0
<b>0</b>	<b>60.9</b>	<b>30</b>	<b>30</b>	<b><u>18.3</u></b>	<b>18.3</b>
1	60.5	30	29	<u>17.5</u>	18.5
2	60.1	30	28	<u>16.8</u>	18.8
3	59.7	30	27	<u>16.1</u>	19.1
4	59.3	30	26	<u>15.4</u>	19.4
5	58.9	30	25	<u>14.7</u>	19.7
6	58.5	30	24	<u>14.0</u>	20.0
7	58.1	30	23	<u>13.4</u>	20.4
8	57.7	30	22	<u>12.7</u>	20.7
9	57.3	30	21	<u>12.0</u>	21.0
10	56.9	30	20	<u>11.4</u>	21.4
11	56.5	30	19	<u>10.7</u>	21.7
12	56.1	30	18	<u>10.1</u>	22.1
13	55.7	30	17	<u>9.5</u>	22.5
14	55.3	30	16	<u>8.8</u>	22.8
15	54.9	30	15	<u>8.2</u>	23.2
16	54.5	30	14	<u>7.6</u>	23.6
17	54.1	30	13	<u>7.0</u>	24.0
18	53.7	30	12	<u>6.4</u>	24.4
19	53.3	30	11	<u>5.9</u>	24.9
20	52.9	30	10	<u>5.3</u>	25.3

**Table 8: Plate heat exchanger- calculated performance**

To try to put a financial value on the savings is difficult as the weather fluctuates, however, a rough estimate can be found if it assumed that the external temperature varies between 0°C and 20°C throughout the year. The average supply air temperature increase for these external temperatures is 11.52°C. (The average of the underlined values)

It was shown in the previous section that an annual financial saving of €1,992 could be expected for every one degree increase in supply air temperature to the AHU. The annual saving therefore is  $(11.52^{\circ}\text{C} * \text{€}1,992) \text{€}22,948$

Another issue to be considered is the pressure drop created by the plate heat exchanger and additional duct work. A new fan may be required to help draw the air out of the new extract duct.

### 6.1.2 Run around Coils

Run around coils were used previously in this building. There are four extract points above the pool where the air passed through air to water heat exchangers. The water was pumped through pipe-work to a pre-heat coil in the main AHU. This raised the air temperature before it reached the heating coil and therefore reducing the heating load. The old pipe-work, pump and heat exchangers are still in place but in poor condition and would need to be replaced.

Data on air temperatures from the run-around coil performance certificate are summarised below.

		Sample 1	Sample 2
Exhaust air	(°C)	23	23
Supply air (into unit)	(°C)	-5	0
Supply air (leaving unit)	(°C)	7.1	9.9
Supply air temp. Increase	(°C)	12.1	9.9
Max. Possible temp. Increase	(°C)	28	23
Efficiency	(%)	43.2	43.0

**Table 9: Run-around coils- performance data**

The performance of the run around coils is far inferior to the plate heat exchanger. The run around coil system also requires a pump to circulate the heat transfer fluid while will have a reasonably large electrical load.

### **6.1.3 Conclusion**

Cross flow (plate) heat exchangers offer the best solution for heat recovery in this building. Installation will require new duct-work from the old extract points above the swimming pool, to the air intake point for the main AHU. There is ample space to locate the heat exchanger on the flat roof. For optimum performance, the recommissioning of the 3-port valve for the AHU heating circuit is recommended. The 3-port valve should be controlled automatically using temperature and humidity sensors in the pool area.

#### **6.1.3.1 Payback Period**

An estimate of costs for supply and fit of all duct work, heat exchanger and control gear was given by RPS Engineering Services as €50,000. This is only a rough estimate as the proposed system was described during a phone conversation and RPS Engineering Services did not conduct a site visit.

An annual saving of €22,948 was calculated, however, this shall be reduced to €20,000 to allow for heat losses in ducts and other inefficiencies.

A simple payback period of 2.5 years is expected.

#### **6.1.3.2 CO<sub>2</sub> Reduction**

$$\text{Reduction in kWh gas consumption} = \frac{€22,948}{€0.035} = 655,657 \text{ kWh}$$

$$\text{CO}_2 \text{ reduction} = 655,657 \text{ kWh} * 0.2047 \text{ kgCO}_2/\text{kWh} = 134,213 \text{ kgCO}_2 \text{ per annum}$$

CO<sub>2</sub> Emission factors for gas and grid electricity are taken from SEAI. (SEAI, 2011)

[http://www.seai.ie/Publications/Statistics\\_Publications/Emission\\_Factors/](http://www.seai.ie/Publications/Statistics_Publications/Emission_Factors/)

## 6.2 Heat Generation

### 6.2.1 High Efficiency Boilers

The existing boilers are in the region of 80% efficient. Replacing the existing boilers with two new high-efficiency natural gas fired modulating condensing boilers selected to operate at 80/60°C flow/return temperatures would give an annual efficiency of approximately 95%.

The previous twelve month's gas consumption was 1,271,948 kWh. That gives an output of  $1,271,948 \times 0.8 = 1,017,558 \text{ kWh}$ . If the boiler's efficiency was 95%, the consumption would

have been  $= \frac{1,017,558}{0.95} = 1,071,114 \text{ kWh}$

A reduction of 200,834 kWh, at a value of €7,029

#### 6.2.1.1 Payback Period

Replacing the boilers is an expensive solution. A quote of €40,000 was supplied by RPS Engineering Services. This gives a simple payback period of 5.7 years. A better option would be to leave the current boilers in place, but replace with high efficiency boilers when they need to be replaced.

#### 6.2.1.2 CO<sub>2</sub> Reduction

CO<sub>2</sub> reduction = 200,834 kWh \* 0.2047 kgCO<sub>2</sub>/kWh = 41,111 kgCO<sub>2</sub> per annum

## 6.2.2 CHP

### 6.2.2.1 Introduction

In section 4.8 *Daily Gas Profile*, it was shown that in June, the gas consumption averaged 135 kW from 5 am to 11 pm. Assuming the boilers are 80% efficient, this gives a heat output of 108 kW. As this is a summertime load, it can be considered the base heating load. A common method used to size CHP plant is to select the CHP to match the base load, therefore it can be used on full load year round and the existing boilers can be brought in when the required load exceeds the CHP's maximum output.

The running hours of the CHP will be 8 am to 11 pm Monday-Friday, 8 am – 6 pm Saturday and 8 am to 4 pm Sunday. These times were selected to match the measured loads in the building, the 8 am start is to coincide with the start of day-time electricity units.

The CHP plant selected for the feasibility study is the ENER-G 70 which has a heat output of 109 kW, an electrical output of 70 kW and a fuel input (HHV) of 226 kW. The CHP data sheet can be seen in Appendix E.

- Annual hours of operation =  $[(15*5) + 10 + 8]*52 = 4,836$  hours
- Cost per unit of gas (gas rate + carbon tax + shrinkage + transportation) = €0.0355
- Average annual electricity day unit = €0.1524
- Average annual electricity night unit = €0.078

### 6.2.2.2 Electrical Savings

#### Day Units

During operation, the CHP will supply the entire electrical load. On Saturday and Sunday, after the early shutdown, the electrical load is 20 kW (see *Figure 16: Daily kW profile*). The only day units purchased from the grid will be at the weekend with an annual value of (5 hours + 7 hours) × 52 weeks × 20 kW = 12,480 kWh

$$12,480 \text{ kWh} \times \text{€}0.1524 = \text{€}1,901$$

#### Night Units

There will be no change to night units as the CHP will not be on during night time hours. The last twelve months saw 70,220 kWh consumed at night at a cost of €5,481.

#### Electricity Tax

The electricity tax will reduce as fewer units are purchased. Day units purchased = 12,480 kWh, night units = 70,220 kWh, therefore the total units = 82,700 kWh.

$$\text{Electricity tax} = 82,700 \text{ kWh} * \text{€}0.0005 = \text{€}41.35$$

#### MIC & PSO Levy

The maximum demand should reduce to 20 kW. The MIC could be reduced to 25 kW.

$$\text{The annual MIC charge} = 25 \text{ kW} * \text{€}5.03 * 6 \text{ bills} = \text{€}754.50$$

$$\text{The annual PSO Levy} = 25 \text{ kW} * \text{€}1.98 * 6 \text{ bills} = \text{€}297$$

#### Low Power Factor & Standing Charge



No change

### Maximum Demand

$$\text{Annual MD Charge} = 20 \text{ kW} * €5.55 * 2 \text{ bills} = €222$$

Table 10 shows the breakdown of the electrical bill with and without the CHP installed. The values on the “without CHP” column are taken from the previous 12 months bills.

	Charge Without CHP	Charge With CHP
	€	€
Day units	23961	1901
Night Units	5481	5481
Electricity Tax	114	41.35
MIC	1785	754.5
PSO Levy	662	297
Low PF	225	225
Standing charge	2054	2054
Max Demand	508	222
Total ex. VAT	34790	10975.85
Total inc. VAT	39487	12458
	Annual Saving =	27029

**Table 10: CHP - Annual electrical savings**

### **6.2.2.3 Thermal Savings**

The CHP plant has a heat output of 109 kW. For the boilers to produce this heat, they would have to consume  $\frac{109 \text{ kW}}{0.8} = 136.25 \text{ kW}$  of gas (taking the efficiency of the boilers as 80%).

The CHP plant therefore will offset the gas consumed by the boilers by (4,836 hours \* 136.25 hours) 658,905 kWh. The value of the offset gas is 658,905 kWh \* €0.0355 = €23,391

When VAT is added, the total is €26,549

#### **6.2.2.4 CHP Gas Cost**

The CHP plant consumes 226 kW of gas. Annual consumption is therefore  $226 \text{ kW} * 4,836 \text{ hours} = 1,092,936 \text{ kWh}$ .

Gas for the CHP costs  $1,092,936 \text{ kWh} * €0.0355 = €38,799$

When VAT is added, the total is €44,037

#### **6.2.2.5 Maintenance Cost**

A maintenance charge is levied per kWh of electricity generated. This covers all maintenance and also provides a service where the CHP plant is monitored remotely by an onboard computer which helps predict breakdowns. The charge is €0.013/kWh.

Although the CHP is capable of generating 70 kW, the data logger shows that 50 kW is a more realistic value. Maintenance charge =  $50 \text{ kW} * 4,836 \text{ hours} * €0.013 = €3,143$

#### **6.2.2.6 Financial Summary**

- Electrical savings      €27,029
- Thermal savings        €26,549
- CHP gas cost            €44,037
- Maintenance            €3,143

This gives an annual saving of €6,398

#### **6.2.2.7 Payback Period**

CHP unit	€100,000
Installation	€30,000
Annual Saving	€6,398

Simple Payback Period  $\frac{130,000}{6398} = 20.3 \text{ years}$

With such a long payback period, a discounted cash flow would have to be used which will push the increase the payback period. This project is deemed unfeasible.

#### **6.2.2.8 CO<sub>2</sub> Reduction**

Using the CHP, electrical day-units reduce from 158,180 kWh to 12,480 kWh. A reduction of 145,700 kWh. Gas consumption will increase by (1,092,936 kWh - 658,905 kWh) 434,031 kWh.

$$\text{CO}_2 \text{ reduction} = (145,700 \text{ kWh} * 0.4886 \text{ kgCO}_2/\text{kWh}) - (434,031 \text{ kWh} * 0.2047 \text{ kgCO}_2/\text{kWh}) = -17,657 \text{ kgCO}_2 \text{ per annum}$$

This value suggests that the CO<sub>2</sub> emissions will actually increase.

#### **6.2.2.9 Conclusion**

The annual saving is disappointing and would take over twenty years to payback as installation alone costs approximately €30,000. One reason for the poor payback is because, if the electrical output is lower than maximum electrical output, then the CHP will consume less than the stated 226 kW of gas. This lower value of gas consumption is not known and cannot be worked into the equation, leaving the cost of the gas consumed by the CHP in the equation, higher than the actual cost. This may also explain the calculated increase in carbon emissions.

For the installation of a CHP to be financially successful, there must be a large shift from electrical consumption to gas. As the electrical consumption of the building is relatively low, this shift is limited and the financial savings are therefore limited too.

### 6.3 Sauna

The sauna is rated at 5 kW and has an annual consumption of 22,935 kWh (see section 4.5.3 *Sauna*). 5% of its consumption is night units while 95% are the more expensive day units.

The average cost over the last twelve months for day and night unit is 15.24c/kWh and 7.8c/kWh respectively. The annual running cost of the sauna is calculated below as €3,870.

	Units	Cost/Unit	Cost
	kWh	€	€
Day units	21788.25	0.1524	3320.53
Night Units	1146.75	0.078	89.45
			3409.98
<b>Total Including VAT</b>			<b>€3870.32</b>

**Table 11: Sauna running costs**

The manual nature of the switching results in the sauna being left on while not in use and needs to be addressed. If there was a building management system (BMS), linking the sauna to a timer would be an ideal solution. As there is no BMS, it was decided to replicate the automatic switching using a contactor and a domestic heating timer. The three-phase cable supplying the sauna was connected through the contactor and the contactor is controlled by the timer. Following a discussion with the building manager, the following switching times were agreed to coincide with usage.

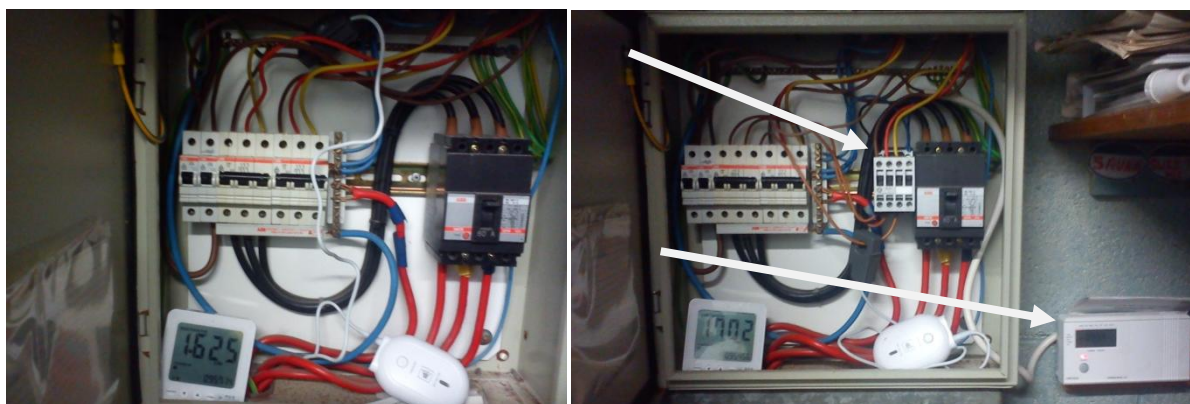
Sauna Times			
Mon	07:00-15:30	17:30-21:00	
Tue	07:00-11:30	16:00-20:00	
Wed	07:00-11:30	13:00-15:30	18:30-21:00
Thu	07:00-11:30	16:00-20:00	
Fri	07:00-11:30	13:00-15:30	17:30-21:00
Sat	09:00-14:30		
Sun	10:00-14:30		

**Table 12: Sauna switching times**

This time-table has 5 hours on the night rate and 54 hours on the day rate. With this time table, the annual running costs are reduced to €2,544. The contactor and timer cost a total of €70. That gives a payback period of less than one month and an annual saving of €1,327.

	Hours	Rating kW	Units kWh	Cost/Unit €	Cost €
Day Units	54	5	270	0.1524	41.148
Night Units	5	5	25	0.078	1.95
					43.10
		Total Weekly Cost Including VAT			48.92
		Total Annual Cost Including VAT			2543.64

**Table 13: Sauna - New running costs**



**Figure 45: Sauna timer circuit**

The sauna is supplied from a three-phase MCB in a small board attached to sub-board 1. Figure 45 shows the board before and after the contactor and timer were fitted (shown with arrows).

Also visible is the energy monitor used to monitor the circuit. Figure 46 shows two screen shots from the energy monitor’s software. On the left is the consumption for Monday 5<sup>th</sup> November and on the right is Monday 10<sup>th</sup> December. It can be seen that the consumption for one phase has dropped from 26.8 kWh to 19.45 kWh. This equates to a 22 kWh reduction for the sauna for one day.

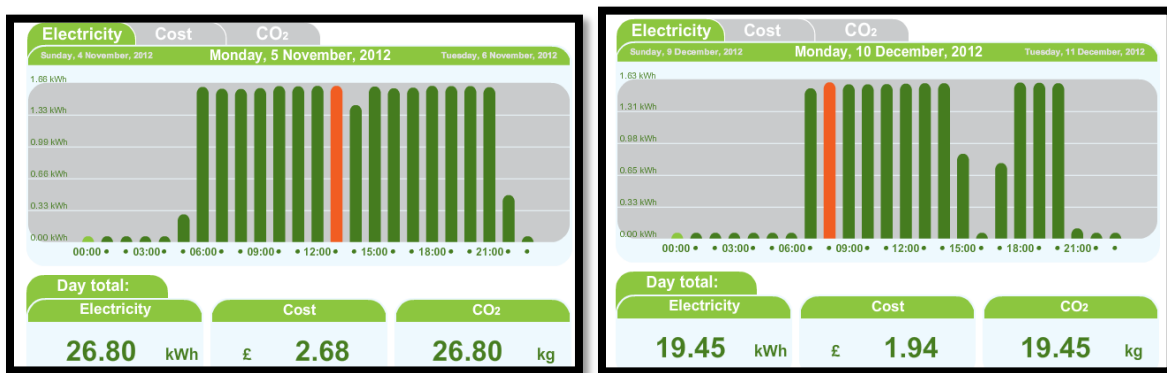


Figure 46: Sauna – before and after timer

Although this simple control method was considered a success, there were some problems encountered. Occasionally staff wanted the sauna turned on at a time outside of the agreed hours. This was possible by either pressing the boost button or by switching to 24 hour on mode. Problems arose because too many different people were interfering with the controls and sometimes leaving it on all night. As the concept of the timer was an experiment to replicate a BMS, this problem would be solved with the use of a BMS as the controls are not available to all staff.

### 6.3.1 CO<sub>2</sub> Reduction

Day units have dropped from 419 kWh/week to 270 kWh/week. This equates to a reduction of 7,748 kWh per annum.

$$\text{CO}_2 \text{ reduction} = 7,748 \text{ kWh} * 0.4886 \text{ kgCO}_2/\text{kWh} = 3,785 \text{ kgCO}_2/\text{annum}$$

## 6.4 AHU

The main AHU's fan is fixed speed and has an annual consumption of 31,460 kWh. It is manually turned off at night and back on at 5 am. The fan runs at a constant speed regardless of the pool air temperature or humidity. It is proposed that the fan motor should be fitted with a variable speed drive (VSD) linked to a temperature/humidity sensor in the pool area. This arrangement will slow the fan down when pre-set conditions have been met and speed the fan up when more air is required. As part of the project, an old ABB VSD was borrowed and the supply cables for the AHU were wired through it.



**Figure 47: VSD installation**

Figure 47 shows the VSD fixed to the wall to the left of the plant room sub-board. The data logger can be seen sitting on top of the sub-board with its three leads going into the board to monitor the AHU's consumption. Sitting on top of the VSD is a single phase energy meter which is monitoring one phase of the AHU.

For the experiment, the speed of the fan was reduced by 0.5 Hz (1%) each day and the pool air temperature and humidity were monitored. It was found that the frequency could go as low as 26 Hz and thermal comfort conditions were met.

However, on certain days when the external temperature was dropped, the fan would have to be turned up to maintain internal conditions. The outside air temperature was in the region of 6-10°C for most of the time during the experiment (February).

Using the data logger, the power consumption at every frequency from 50 Hz to 25 Hz was determined. Figure 48 shows how the fan's load decreases as its speed decreases. The largest decrease in load per 1 Hz frequency reduction happens when the frequency changes from 50 Hz to 49 Hz. Each further 1 Hz frequency reduction reduces the load slightly less each time.

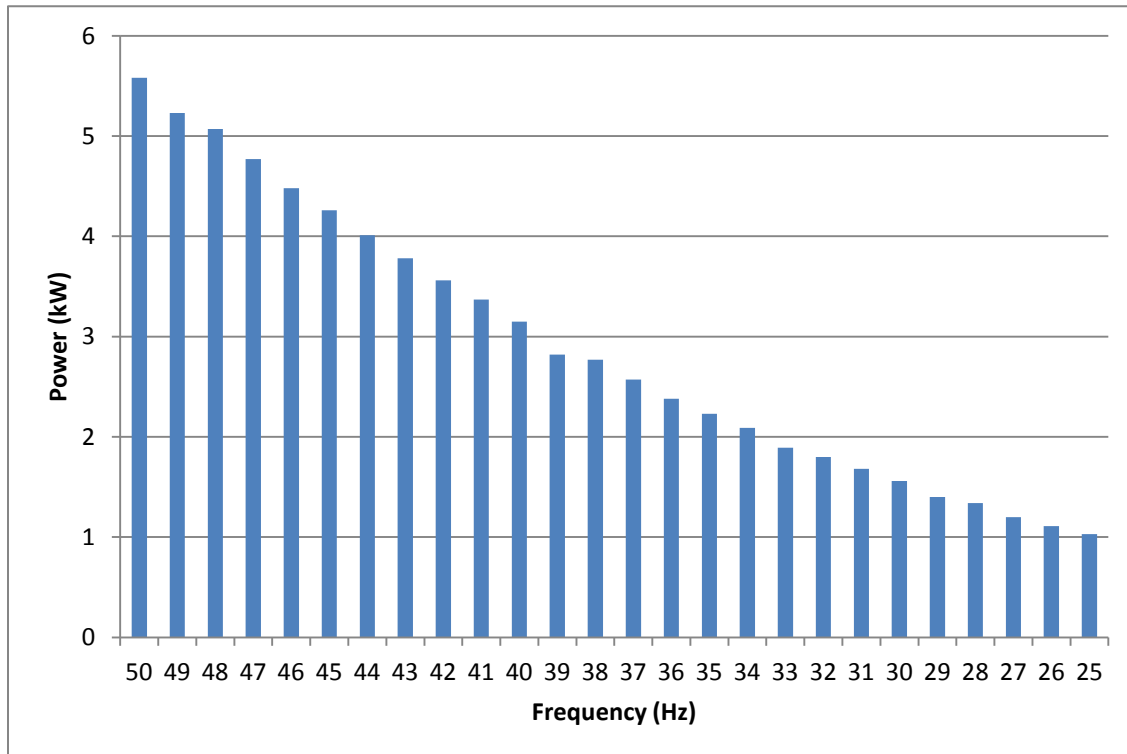


Figure 48: AHU power vs. Frequency



The formula for calculating the power at any given frequency is;

$$P2 = \frac{P1}{\left(\frac{F1}{F2}\right)^2}$$

- Where,
- P1 = power consumed at full speed (kW)
  - P2 = power consumed at reduced speed (kW)
  - F1 = frequency at full speed (Hz)
  - F2 = frequency at reduced speed (Hz)

Using the above formula, the theoretical power consumption for each frequency from 50 Hz to 25 Hz was calculated and compared to the actual measured values. The result is shown in Figure 49. It can be seen that the actual consumption is lower than that calculated in the formula. The difference however is small and both follow the same slope.

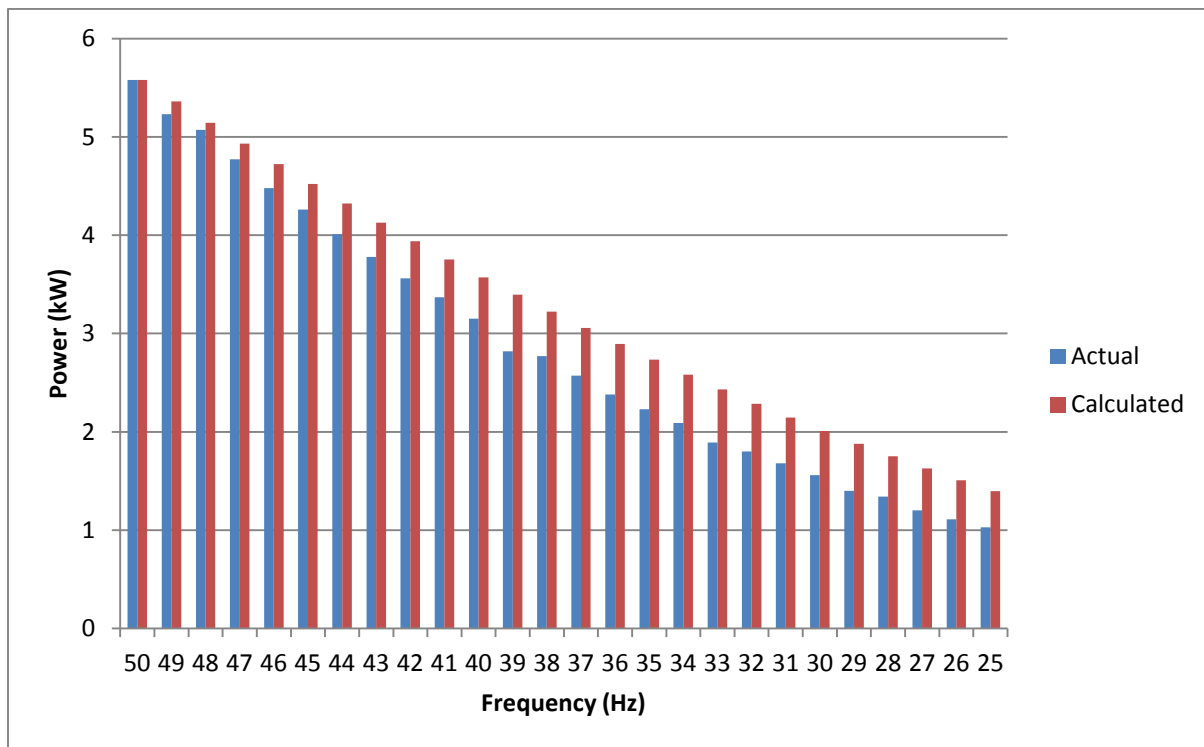


Figure 49: Actual vs. calculated consumption

The AHU is on for 110 hours per week, split between 21 night-time hours and 89 day-time hours. Average unit costs are 15.24 c/kWh and 7.8 c/kWh for day and night units respectively.

Annual day units cost  $5.58 \text{ kW} \times 89 \text{ hours} \times 52 \text{ weeks} \times \text{€}0.1524 = \text{€}3935.61$ , and annual night units cost  $5.58 \text{ kW} \times 21 \text{ hours} \times 52 \text{ weeks} \times \text{€}0.078 = \text{€}475.28$ .

The total running cost including 13.5% VAT is  $(\text{€}3,935.61 + \text{€}475.28) \times 1.135 = \text{€}5,006.36$ .

The same calculation was carried out for the reduced power consumption for every frequency from 50 Hz to 25 Hz. For example, at 40 Hz, the AHU load is 3.15 kW which gives an annual running cost of €2,826 (a saving of €2,180).

Simple payback periods were then calculated against a capital cost of €1,250 for a new correctly sized VSD. For a one year payback, 45 Hz is required, for a six month payback, 40 Hz is required.

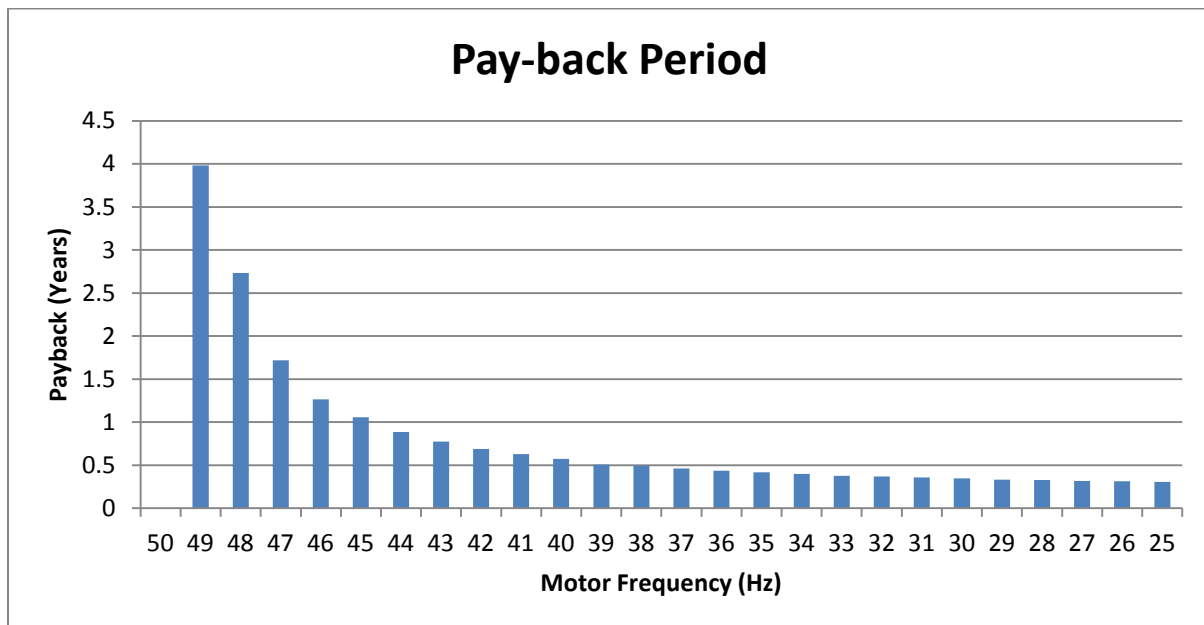


Figure 50: AHU payback period

### 6.4.1 CO<sub>2</sub> Reduction

At 40 Hz, the power reduces from 5.58 kW to 3.15 kW, a reduction of 2.43 kW. This gives an annual reduction of  $(2.43 \text{ kW} \times 110 \text{ hours} \times 52 \text{ weeks})$  13,899.6 kWh.

CO<sub>2</sub> reduction = 13,899 kWh \* 0.4886 kgCO<sub>2</sub>/kWh = 6,791 kgCO<sub>2</sub>/annum

### 6.4.2 Conclusion

The installation of a VSD proves to be a very attractive option. At 40 Hz, a six month payback is possible, and it was shown during experiments that no thermal discomfort is experienced at this speed. It should also be noted that if the air speed in the AHU is reduced, then the rate of heat extraction from the hot water circuit will reduce, which will have a thermal saving.

## 6.5 Power Factor Correction

There are two main ways in which capacitors can be used for power factor correction. The first is to connect all the capacitance required at the main board. This requires a unit with an on board computer to constantly monitor the power factor and to switch capacitors in/out of circuit to match the given load. Although this is the easier of the two methods, the units are very expensive and the payback can run into years. The second method involves identifying the individual loads which are causing the problem and connecting correctly sized capacitors to each. Although this method takes more time, it is far cheaper and was performed as part this project. Figure 51 shows the data logger connected to one of the two filter motor pumps.



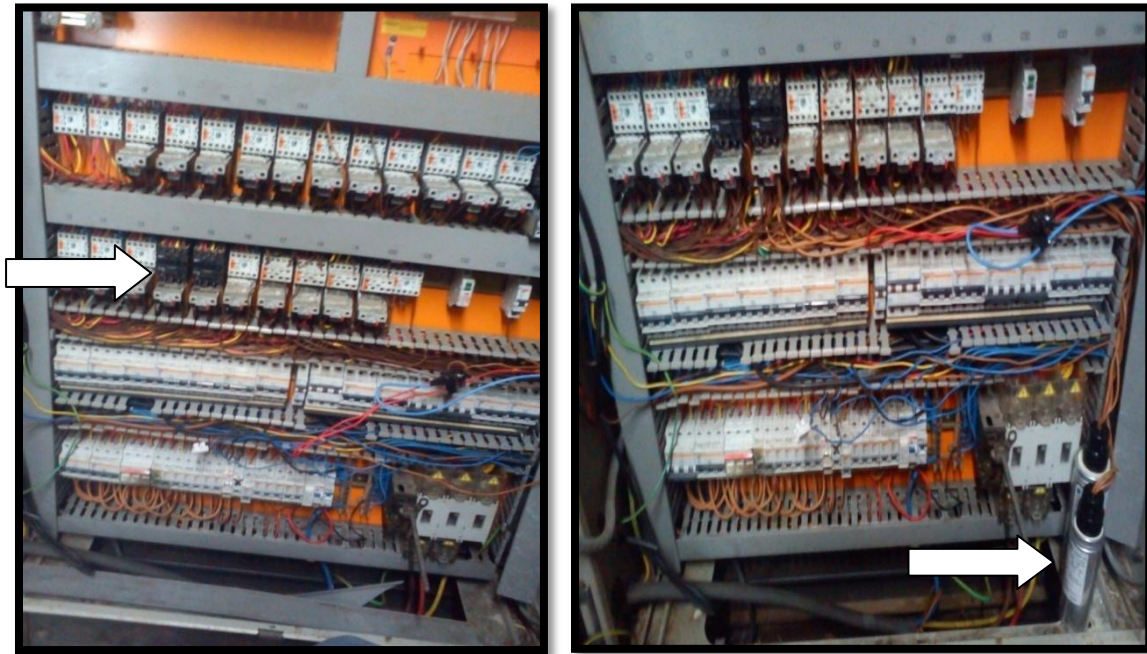
**Figure 51: Monitoring the filter motor pumps**

As discussed in section 4.5.1 *Filter Pumps*, each filter pump motor

consumes 3.5 kVAr and is on 24 hours/day, and if the two motors had their power factor corrected to unity, the low power factor surcharge should be eliminated.

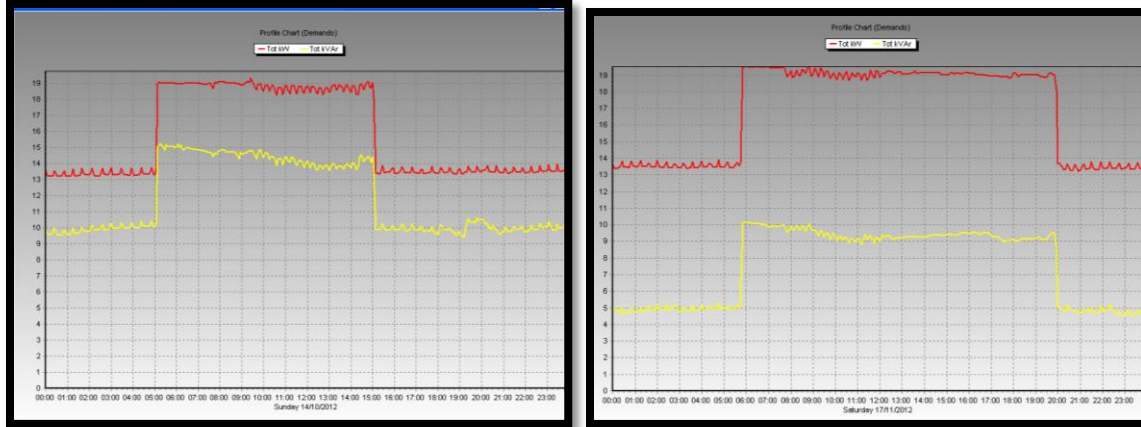
Three-phase delta connected capacitors can be purchased rated by their kVAr. As 3.5 kVAr capacitors are not available, it was decided to use a 5 kVAr and a 2.5 kVAr to give a total of 7.5 kVAr.

The capacitors were wired with three 2.5mm<sup>2</sup> cables and connected in parallel with the motors on the load side of the relevant contactors. By doing this, the capacitors are only connected when the motor on which prevents over correction.



**Figure 52: Capacitor connection**

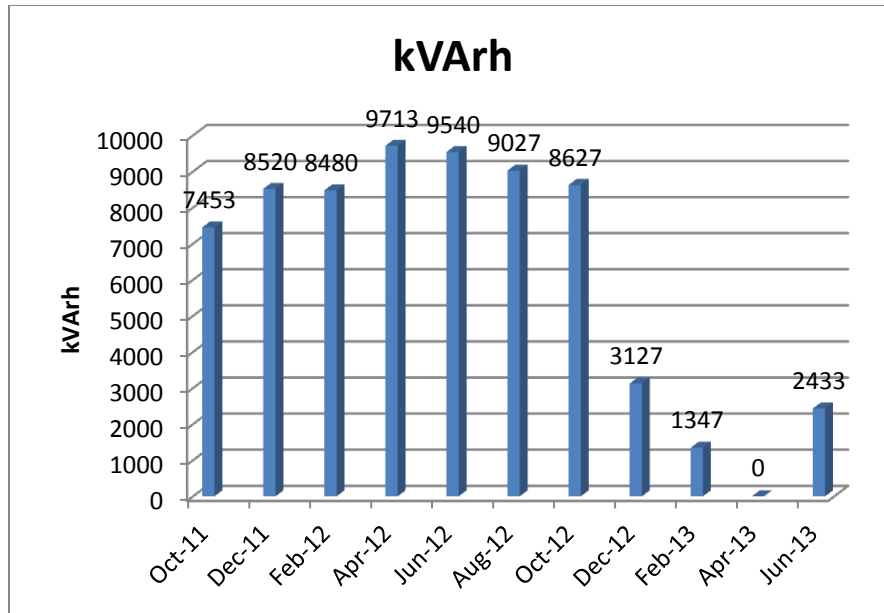
Figure 52: *Capacitor connection* shows two photographs. On the left is the plant room sub-board before the capacitors were connected. The arrow points to the two contactors which control the filter pump motors. The arrow in the photograph on the right shows the two capacitors.



**Figure 53: Before and after power factor correction**

Figure 53 shows the kW (red) and kVAr (yellow) readings on the plant room sub-board for 24 hour periods before (left) and after (right) the capacitors were installed. The on/off times are irrelevant; the values while on and off are important. The kW values haven't changed; 13.5 kW at night and 19 kW during the day in both cases. The kVAr value however has dropped from 15 kVAr to 10 kVAr (daytime) and from 10 kVAr to 5 kVAr (night-time).

The 5 kVAr drop is less than the 7.5 kVAr installed so the low power factor surcharge will not be eliminated; only reduced. Figure 54 shows the number of kVArh units above the allowed quota on each two-month bill.



**Figure 54: kVAr penalties**

The capacitors were installed one quarter of the way into the December billing period. The average value of the seven bills before the capacitors were installed is 8766 kVArh. That gives

an average instantaneous value of  $\frac{8766 \text{ kVArh}}{24 \text{ hours} \times 60 \text{ days}} = 6.09 \text{ kVAr}$ .

The 5 kVAr reduction is 24hours/day; therefore, the new average instantaneous value should be 1.09 kVAr. This gives a bi-monthly value of  $1.09 \text{ kVAr} \times 24 \text{ hours} \times 60 \text{ days} = 1566 \text{ kVArh}$ .

This calculation does correspond to the values appearing on bills since installation. It is believed that the value of zero kVArh on the April bill was an error and that the value of 2433 kVArh on the June bill covers to two billing periods.

Comparing the previous average value (this is used as the value had the capacitors not been installed) to the billed values, the financial savings generated since installation can be calculated.

	Billed units	Avg.	Reduction	Charge	Saving
	kVArh	kVArh	kVArh	€/kVArh	€
Dec-12	3127	8765	5638	0.009875	55.68
Feb-13	1347	8765	7418	0.009875	73.25
Apr-13	0	8765	8765	0.009875	86.55
Jun-13	2433	8765	6332	0.009875	62.53

278.01

Total Saving Inc. VAT €315.54

The capacitors cost €50 and have generated a saving of €315.54 in the 7.5 months since installation. This gives a payback period of just over one month and an annual saving of over approximately €500.



## 6.6 Energy Management Policy

There is currently no specific energy management policy in the Tallaght Sports Complex. A clearly defined policy which involves and informs all staff of energy consumption and costs will generate savings. The value of the possible savings can't be calculated but anywhere from 5-10% could be possible. The final details of the energy management policy would have to be determined by the building manager as he knows his staff and their work culture best, but the main aspects of the policy should include the following recommendations.

- Appoint an Energy Manager
  - The current maintenance engineer should have the role of energy manager added to his title. This could involve one hour of every working day dedicated to energy management.
  - Responsibilities would include
    - setting up, updating and monitoring energy performance indicators for all large energy consuming plant. An energy performance indicator for gas consumption was constructed in section 4.7 *Monthly Regression Analysis*. Maximum and minimum limits should be agreed. If the consumption falls above or below these limits, then the Energy Manager is required to investigate as to why this happened.
    - monitoring energy consumption monthly and collating and presenting figures
    - publicising consumption figures among staff
    - raising staff awareness and motivation
    - seeking ideas and suggestions from staff and presenting them to the building's management team for discussion
    - providing feedback to staff on the responses to their suggestions
    - spearheading energy saving initiatives

- Annually checking rates with other suppliers
- Make staff energy awareness and motivation a priority
  - Communicate with staff the costs of energy on site
  - Have quarterly meetings showing any progress and any on-going projects
  - Explain how each staff member can make a difference and seek suggestions
  - Explain that energy efficiency is everyone's responsibility
- Set up Sub-metering
  - Sub-metering on each of the two sub-boards can help to identify when consumption rises above normal which helps to rectify any problems quickly.

## 6.7 Supplier and Tariff

Several suppliers (Vayu, Bord Gais, Electric Ireland and Energia) were contacted to see if a cheaper tariff was available. Using the previous twelve month's consumption as a template, all tariffs were compared. The cheapest was the current supplier, however, a saving can be made by switching to a 12 or 24 month contract. By doing so, the day units are cheaper but the night units are more expensive. All other charges remain constant. The results are summarised below.

Energia Quote			
variable	kWh	c/kWh	cost
Summer day units	103540	0.1458	15096
Winter day units	53540	0.1696	9080
night units	70220	0.0783	5498
		total plus VAT	33681
		saving	0
<b>12 Month</b>	kWh	c/kWh	cost
Summer day units	103540	0.1428	14786
Winter day units	53540	0.1486	7956
night units	70220	0.0855	6004
		total plus VAT	32626
		saving	1055
<b>24 Month</b>	kWh	c/kWh	cost
Summer day units	103540	0.1425	14754
Winter day units	53540	0.1482	7935
night units	70220	0.0851	5976
		total plus VAT	32535
		saving	1146

Table 14: Energia quote

Vayu's quote can be seen in Appendix F.

## 6.8 Summary of Results

Table 15 shows a summary of results from chapter 6. It should be noted that these values are not cumulative, for example, if a cross flow heat exchanger *and* new high efficiency boilers were installed, the total savings would not be equal to the two individual savings combined.

	Annual Saving	Simple Payback Period	Energy Source	Reduction	CO <sub>2</sub> /kWh	CO <sub>2</sub> Reduction
	€	Years	Type	kWh	kg	kg
Cross flow heat exchanger	20,000	2.5	Gas	655,657	0.2047	134,213
High efficiency boilers	7,029	5.7	Gas	200,834	0.2047	41,111
CHP	6,398	20.3	See section 6.2			-17,657
Sauna automatic switching	1,327	0.05	Elec.	7,748	0.4886	3785
VSD on AHU's fan (40 Hz)	2,180	0.5	Elec.	13,899	0.4886	6,791
Power factor correction	500	0.1	N/A	N/A	N/A	N/A
Change to 12 month contract	1,055	N/A	N/A	N/A	N/A	N/A
Change to 24 month contract	1,146	N/A	N/A	N/A	N/A	N/A

**Table 15: Summary of results**

## 7. Conclusion

The investigation into the consumption of energy at the Tallaght Sports Complex has revealed that the electrical consumption is in line with that expected from this type and size of building. The gas consumption, however, is well above that expected for good practice. (See section 3.2 Benchmarking).

The main cause of inefficiency is that there is no heat recovery system in place which means that a large volume of air at 30°C and 60% humidity is being expelled from the building for 110 hours per week. This problem is compounded by the main AHU's fan which has been shown to supply air at a rate well above that required. Furthermore, air can easily escape from above the pool area through the four disused extract AHUs.

The proposed remedy for this situation is to install duct-work from the old extract AHUs to bring the air to the supply point of the main AHU. At this point, a cross flow heat exchanger should be installed to preheat the supply air. A VSD should also be fitted to the AHU's fan along with automated controls which respond to pool air temperature and humidity. These two features alone should pay back in under three years and reduce energy costs by approx 20%.

No action needs to be taken with the current boilers, but when they fail, they should be replaced with high-efficiency condensing boilers. At that point, the flow and return temperatures should be reduced to maximise efficiency.

A BMS would be advantageous. It can provide automatic switching to many various loads. It was shown in section 6.3 *Sauna*, that automatic switching is far more efficient than manual.

Lastly, an energy management policy should be put in place. This would give responsibility for various energy management tasks to specific people. A good energy management policy, when implemented with commitment, has been proven to keep consumption from creeping back up after initial gains.

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# Appendices

## Appendix A – Management of the Project

### Appendix A1 – Original Project Proposal

#### Introduction

The subject of the project and thesis is the Tallaght Sports Complex, located in Tallaght, a suburb in South/West Dublin, Ireland. This building has an annual spend of over €90,000 between natural gas and electricity. The building is over 40 years old and has had no major refurbishment in that time. Financial difficulties have been a major concern in recent years and management were forced to reduce the number of staff from 42 to 15, automatic controls have failed and not been replaced or upgraded and increasing energy costs are mounting pressure on the complex.

The sports complex has a swimming pool, sauna, weights room/gym, aerobic room, wellness centre, large multipurpose hall and a number of changing rooms and offices.

#### Background to the Project

The author selected this building as it is over 40 years old and as it has a swimming pool; it is likely to have large energy consumption. Being old, the building is more likely to be operating inefficiently, improving the potential to find areas for improvement. The author approached the manager of the Tallaght Sports Complex asking for unrestricted access to the building, in return, the author would present all findings to the manager for consideration. After a meeting, the manager gave his approval and said he hoped that some real savings would



materialise from the research. He also indicated that funds to carry out any proposed projects were at a minimum and therefore no-cost and low-cost options were the most viable.

### **Aims and Broad Objectives**

The main aim of the project is to perform an in-depth energy audit of the premises to identify where, when and why energy is being used, how it is controlled and to identify possible improvements to reduce consumption/costs.

#### Objectives

- Gather all relevant data for energy audit
- Carry out a literature survey to support background knowledge in this area.
- Carry out some of the recommendations to check how the theory compares to reality.
- Access the current energy management strategy and energy awareness amongst staff.
- Set up a new energy management strategy

### **Methods to be Adopted**

Consumption on main electrical boards will be monitored using a Hawk 5000 data logger.

Consumption of individual circuits will be monitored using Efergy energy monitors.

Temperature/humidity sensors will be used to access thermal comfort within the various spaces.

A lux meter will be used to determine artificial and natural lighting levels.

Past utility bills will be used for historical data.

A questionnaire shall be used to assess awareness/motivation levels of staff in relation to energy.

**Time-Plan with specific dates for submission of future forms**

A Gantt chart outlining the estimated time to completion with critical submission dates is attached.

**Deliverables or Specific Outcomes**

- Identification of trends in energy consumption
- Identification of significant energy users
- Identification of control systems
- Identify areas of waste
- Propose list of recommendations ranging from no-cost to high-cost
- Carry out some of the recommendations and compare before and after energy consumption and monitor other relevant parameters
- Presentation of analysed data in a concise manner

**Appendix A2 – Original and Final Gantt chart**

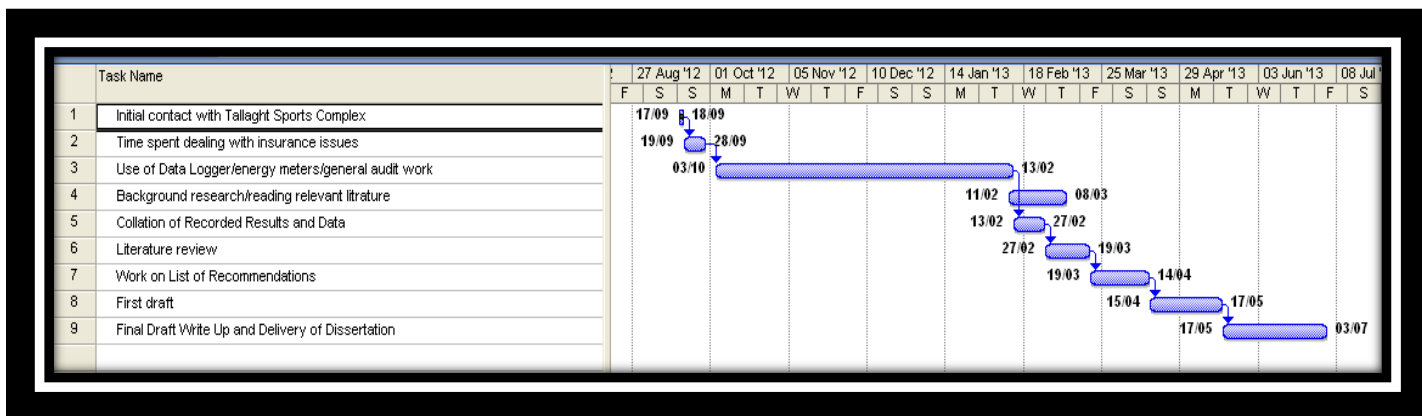


Figure 55: Original Gantt chart

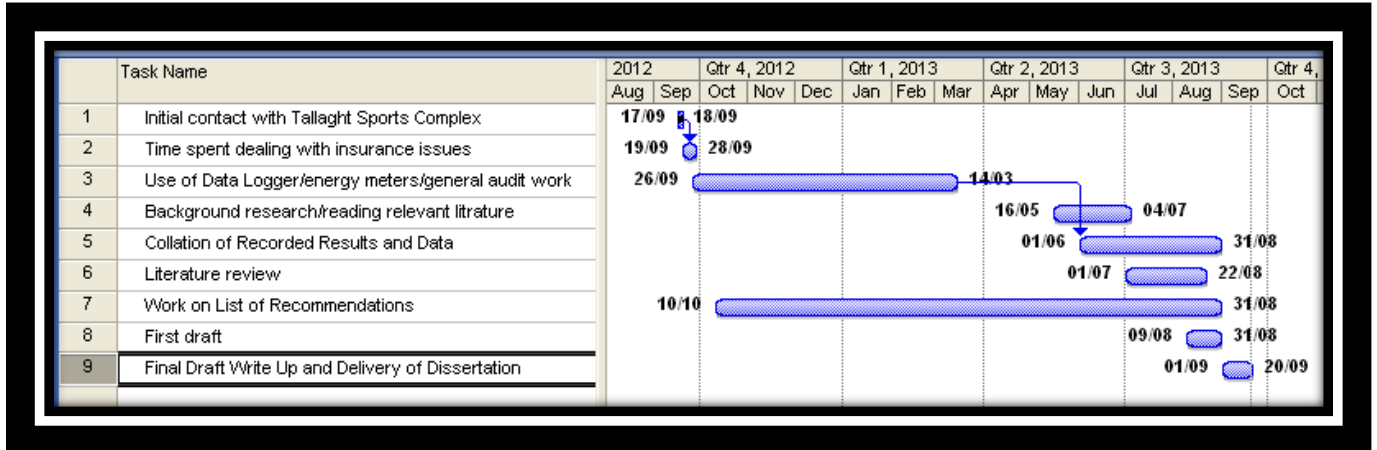


Figure 56: Final Gantt chart

### Appendix A3 – Review of Project Management

When comparing the two Gantt charts, it is obvious that I was over ambitious with respect to the finish date for the project. I got started in early September 2012 by making contact with the sports centre’s manager and convincing him to agree to allow me access to the building. There were some initial delays as I had no insurance, either through Brunel or my employer. In the end I signed a disclaimer and I was able to begin.

I borrowed a 3-phase data logger from a technician in Dublin Institute of Technology. I had some difficulty in using it as there is a number of settings required when configuring the data logger before connecting it. On my first connection, after one week, I downloaded the recorded data but all values were zero. I figured out that I should have set the current amplification factor

to 1000 and set the voltage factor to 1. Although a week was wasted, I learned how to use the equipment correctly eventually and I used it on the three main boards and on various loads.

Physically connecting the data logger's clips proved difficult at points as the clips are quite large. On the main board, I had to open trunking and pull the main cables out slightly. Another problem was the sheer volume of data generated by the logger. Although it was tempting to use every graph available, I had to limit the use of data to that which was relevant to the project's objectives.

Historical data from bills proved very useful. In order to access these, I contacted the supplier, and after they verified that I had permission from the building manager, I had access to an on-line account with a limited number of previous bills.

When I focused my attention on the plant room sub-board, I ran into a problem. None of the MCBs or contactors were labelled and no one knew which was which. Not only that, but as the board is over forty years old, there was spurious connections, disused circuits and the board was in general disarray. I needed to monitor the power going to each load so I had no choice but to start working on the board. This took a few visits and many hours work. The manager had also informed me of an electrical fault where an MCB would trip when it rained and asked if I could fix it. I felt obliged as they had granted me access to their building. This took more time but they were delighted when the fault was fixed after being there for a few years and the board is now clearly labelled.

One interesting aspect of the project developed when I realised that there was an issue with low power factor. I knew the theory of connecting capacitors but I had never actually done it and no one that I spoke to had either. Sourcing the capacitors was an endeavour in itself but after many

phone calls I managed to locate them. I calculated the micro-farad rating required of each capacitor from the kVAr value which I measured on the data logger, as that is what I had been thought in class years ago. However, the sales man gave me a funny look and just asked for the kVAr rating.

It was a little disappointing that the installed 7.5 kVAr only reduced the load by 5 kVAr. I checked both capacitors and they are both working. If I was to do it again I would over-size the capacitance connected. It was very satisfying however, to see the low power factor charge reducing on subsequent bills.

Gathering data on the gas consumption was a lot more difficult as I had no access to any logging equipment. The building's gas meter and the gas bills were the only sources and in order to get a daily profile, I had to check the meter every hour over a 24 hour period. I completed this task with the help of the night security man and some other staff members. Ideally I would have liked to do this on a number of days throughout the year but it would have been too much to ask the staff.

I had to determine a cut off point with regard to gathering data on the many connected loads in the building. There are many loads not considered in the thesis as they were deemed too small and not specific to sports centres/swimming pools. For example, there are five vending machines near the front door. I had considered experimenting with these but ultimately decided to leave them out. There are also small fridges, computers, printers, general lighting, outdoor lighting, general power etc. which all fell into the "too small/not specific to sports centres" category. By cutting these items out, it allowed me to focus more on the larger, more relevant loads.

From my first visit to the pool area, I guessed that the supply air was excessive. As soon as a door onto the pool area was opened slightly, air was forced out at a high speed. I believed that the main AHU's fan could be slowed down without a drop in thermal comfort. I wasn't content with calculating this, I wanted to prove it. I had considered buying a VSD, but the cost for one with the correct kW rating was €1,250. Through pure luck, I mentioned this to a friend who said he could get a loan of an old one for me. Connection of the VSD proved that the fan could be slowed considerably. The building manager is now considering purchasing their own one.

The technical aspects of the project went without too many problems and good progress was made up to Easter 2013. For a few months after that, other aspects of my life brought the project to a halt. I proceeded again in late June. Although I would have loved to continue gathering data, at that point I decided to begin writing. As the document progressed, certain questions arose and I needed to return for more site visits. This resulted in some parallel work between writing and data gathering but it was unavoidable.

The writing of the thesis was not easy for me. I could connect meters, take readings, generate graphs, perform calculations and install equipment all day, but I need to force myself to sit down and type. I was also under pressure during this time as my wife gained employment and I couldn't concentrate with my two young children constantly attacking me. My parents came to the rescue by offering to take them for three hours each weekday. So I had to make the most of that time.

The original objectives set out in the proposal were largely met.

- Gather all relevant data for energy audit
  - This was achieved through bill data, data loggers, meters etc (Section 4)
- Carry out a literature survey to support background knowledge in this area.
  - This was achieved and focuses mainly on Good Practice Guides. I also read a number of papers on solar-thermal collectors for swimming pools but I decided to stay away from this and focus on the existing installation. (Section 2)
- Carry out some of the recommendations to check how the theory compares to reality.
  - This was achieved in the case of the sauna (section 6.3), the power factor correction capacitors (section 6.5) and the installation of the VSD on the main AHU (section 6.4).
  - The theory vs. reality was interesting in the cases of the capacitors and the VSD. For the capacitors, 7.5 kVAr was installed, but only a 5 kVAr drop resulted. For the VSD, *Figure 49: Actual vs. calculated consumption*, showed the difference actual consumption and calculated consumption for each frequency from 50 Hz to 25 Hz.
- Access the current energy management strategy and energy awareness amongst staff.
  - As for the current energy management strategy, there isn't one.
  - With regard to energy awareness among staff, I spoke to staff members in an informal way but I didn't carry out a proper survey. This was an omission on my part. However, from our conversations, I can tell that the staff have a reasonable understanding of energy matters.

- Set up a new energy management strategy
  - Section 6.6 *Energy Management Policy*, lays out some specific points for an energy management policy for the Tallaght Sports Complex. I will continue working with the complex in the near future to help setting this up as requested.

The "*Deliverables or Specific Outcomes*" section of the proposal had the following points.

- Identification of trends in energy consumption
- Identification of significant energy users
- Identification of control systems
- Identify areas of waste
- Propose list of recommendations ranging from no-cost to high-cost
- Carry out some of the recommendations and compare before and after energy consumption and monitor other relevant parameters
- Presentation of analysed data in a concise manner

I believe all points have been achieved.

## Conclusion

In retrospect I am reasonably happy with how I managed the project. I got started early and did most of my data gathering in the first half of the academic year. The months from March to June was probably the busiest of my life because of too many commitments and the project had to be put on hold. I got working on it again in late June and stayed consistent from then on. My



original time frame was idealistic and did not take the *real world* into account. If I was to do a similar project again, I would start as early as possible and try to from a broad view of the end document; chapter headings etc.

As I type the last few words of my document, I can feel a huge weight beginning to lift and I look forward to spending more time with my children again. Thank you for taking the time to read.

Slán agus beannacht,

Colin Conway.

**Appendix B – Gas Bills**



**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 383 744  
 Bord Gais Call Centre: 1850 200 694

TALLAGHT COMMUNITY SCHOOL  
 BALROTHERY  
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<b>ACCOUNT INFORMATION</b>		Bill No:	2299396
Account Number	6582092676		
Accounting Period	1 Jun 2012 to 30 Jun 2012		
GPRN Number	0587327		
Annual Quantity	1,252,824	Consumption	Z
Conversion Factor	10.8889		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	11 Jul 2012
Account balance after previous bill	€4,745.03		
Payment 1	27 Jun 2012	€4,745.03 CR	
Current Bill	€3,590.89		

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

**NEW BALANCE DUE BY 25 Jul 2012** €3,590.89



**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Jun to 30 Jun**

Connected at:	Distribution Level
Capacity:	5,973 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	72,752 kWh	@ €0.022666	€1,672.03
Carbon Tax	72,752 kWh	@ €0.0037	€269.18
<b>- TRANSPORTATION -</b>			
Transport Rate	72,752 kWh	@ €0.003617	€279.88
Shrinkage Rate	72,752 kWh	@ €0.00036	€26.19
Site Capacity Charge	30 Days	@ €30,5100	€915.60
<b>Total Excluding VAT</b>			€3,193.78
<b>Standard Rate VAT @ 13.5%</b>			€427.11
<b>Total Gas Charges For This Period</b>			<b>€3,590.89</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 25 Jul 2012** €3,590.89  
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**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gais Call Centre: 1850 200 694

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<b>ACCOUNT INFORMATION</b>	
Bill No:	2330754
Account Number	6582092676
Accounting Period	1 Jul 2012 to 31 Jul 2012
GPRN Number	0587327
Annual Quantity	1,252,924 Consumption Z
Conversion Factor	10.8889
Environmental impact information is on the back of the bill	

<b>ACCOUNT SUMMARY</b>	
Date	09 Aug 2012
Account balance after previous bill	€3,590.09
Payment 1 25 Jul 2012	€3,590.09 CR
Current Bill	€3,730.20

**NEW BALANCE DUE BY 23 Aug 2012 €3,730.20**

Keep your bills accurate and submit your meter readings every month.

Use the NEW Energia Meter Reading Mobile App - available from the Apple and Android App stores. Download it NOW and submit a meter reading - you will be in with a chance to win 1 of 10 Owl Monitors. For more details see the insert with this bill.

You can also submit a meter reading on line at [www.energia.ie/meter](http://www.energia.ie/meter) or via email at [customer.service@energia.ie](mailto:customer.service@energia.ie).

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Jul to 31 Jul**

Connected at:	Distribution Level
Capacity:	5,973 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	74,554 kWh	@ €0.023485	€1,750.90
Carbon Tax	74,554 kWh	@ €0.0037	€275.85
<b>- TRANSPORTATION -</b>			
Transport Rate	74,554 kWh	@ €0.003447	€256.81
Shrinkage Rate	74,554 kWh	@ €0.00030	€22.84
Site Capacity Charge	31 Days	@ €30.6199	€949.12
Total Excluding VAT			€3,286.52
Standard Rate VAT @ 13.5%			€443.68
<b>Total Gas Charges For This Period</b>			<b>€3,730.20</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 23 Aug 2012 €3,730.20**

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**ACCOUNT INFORMATION**

Bill No:	2371893
Account Number	6582092676
Accounting Period	1 Aug 2012 to 31 Aug 2012
GPRN Number	0587327
Annual Quantity	1,252,924 Consumption Z
Conversion Factor	10.8889
Environmental impact information is on the back of the bill	

**ACCOUNT SUMMARY**

Date	12 Sep 2012
Account balance after previous bill	€3,700.20
Payment 1 23 Aug 2012	€3,700.20 CR
Current Bill	€3,599.87

**NEW BALANCE DUE BY 26 Sep 2012 €3,599.87**

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Aug to 31 Aug**

Connected at:	Distribution Level
Capacity:	5,973 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	70,523 kWh	@ €0.023651	€1,667.64
Carbon Tax	70,523 kWh	@ €0.0037	€260.97
<b>- TRANSPORTATION -</b>			
Transport Rate	70,523 kWh	@ €0.003617	€257.13
Shrinkage Rate	70,523 kWh	@ €0.000368	€25.39
Site Capacity Charge	31 Days	@ €30.5100	€946.12
Total Excluding VAT			€3,710.00
Standard Rate VAT @ 13.5%			€428.10
<b>Total Gas Charges For This Period</b>			<b>€3,599.87</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 26 Sep 2012 €3,599.87**

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<b>ACCOUNT INFORMATION</b>		Bill No:	2408890
Account Number	6582092676		
Accounting Period	1 Sep 2012 to 30 Sep 2012		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	11.0000		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	10 Oct 2012
Account balance after previous bill	€3,599.07		
Payment 1	26 Sep 2012	€3,599.07 CR	
Current Bill	€3,414.67		

**NEW BALANCE DUE BY 24 Oct 2012** €3,414.67

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Sep to 30 Sep**

Connected at:	Distribution Level
Capacity:	5,973 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	63,632 kWh	@ €0.024664	€1,567.87
Carbon Tax	63,632 kWh	@ €0.0037	€235.77
<b>- TRANSPORTATION -</b>			
Transport Rate	63,632 kWh	@ €0.003617	€231.79
Shrinkage Rate	63,632 kWh	@ €0.00039	€24.82
Site Capacity Charge	30 Days	@ €0.5100	€15.60
Total Excluding VAT			€3,008.62
Standard Rate VAT @ 13.5%			€406.15
<b>Total Gas Charges For This Period</b>			<b>€3,414.67</b>

Effective 1st October 2012. Your gas charges will be amended to reflect an increase in regulatory approved 3rd party pass through costs. This equates to an average increase of 5%-6% of your total bill depending on your usage pattern. Energia remains committed to providing the most competitive business energy prices in Ireland and regret having to pass on these costs increases.

If you have any queries in relation to this matter please contact our Customer Service team on 1850 36 37 44 selecting Option 2

Important notice. Revised general terms and conditions for supply of energy are available to view on [www.energia.ie](http://www.energia.ie) or by request.

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 24 Oct 2012** €3,414.67

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**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

<b>ACCOUNT INFORMATION</b>		Bill No:	2446386
Account Number	6582092676		
Accounting Period	1 Oct 2012 to 31 Oct 2012		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	11.1944		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	12 Nov 2012
Account balance after previous bill	€3,414.67		
Payment 1	24 Oct 2012	€3,414.67 CR	
Current Bill	€5,241.23		

**NEW BALANCE DUE BY 26 Nov 2012** €5,241.23

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Oct to 31 Oct**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	105,192 kWh	@ €0.025769	€2,716.74
Carbon Tax	105,192 kWh	@ €0.0007	€699.21
<b>- TRANSPORTATION -</b>			
Transport Rate	105,192 kWh	@ €0.00171	€1807.9
Shrinkage Rate	105,192 kWh	@ €0.00009	€41.02
Site Capacity Charge	31 Days	@ €31.5613	€978.40
Total Excluding VAT			€4,917.82
Standard Rate VAT @ 13.5%			€623.41
<b>Total Gas Charges For This Period</b>			<b>€5,241.23</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 26 Nov 2012** €5,241.23

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BALROTHERY, TALLAGHT, DUBLIN 24

<b>ACCOUNT INFORMATION</b>		Bill No:	2488335
Account Number	6582092676		
Accounting Period	1 Nov 2012 to 30 Nov 2012		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	11.0833		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	11 Dec 2012
Account balance after previous bill	€5,241.23		
Payment 1	26 Nov 2012	€5,241.23 CR	
Current Bill	€6,411.22		

**NEW BALANCE DUE BY 27 Dec 2012** €6,411.22



Wishing you a very Happy Christmas and a prosperous New Year. Be kind to the environment in 2013 and sign up to paperless billing by logging on to [www.energia.ie/paperless](http://www.energia.ie/paperless)

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Nov to 30 Nov**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	124,538 kWh	@ €0.026924	€3,358.14
Carbon Tax	124,538 kWh	@ €0.0037	€460.79
<b>- TRANSPORTATION -</b>			
Transport Rate	124,538 kWh	@ €0.00471	€586.57
Shrinkage Rate	124,538 kWh	@ €0.00042	€52.31
Site Capacity Charge	30 Days	@ €31.5613	€946.84
Total Excluding VAT			€5,948.65
Standard Rate VAT @ 13.5%			€762.57
<b>Total Gas Charges For This Period</b>			<b>€6,411.22</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 27 Dec 2012** €6,411.22

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**ACCOUNT INFORMATION**

Bill No: 2511279  
 Account Number: 6582092676  
 Accounting Period: 1 Dec 2012 to 31 Dec 2012  
 GPRN Number: 0587327  
 Annual Quantity: 1,192,101 Consumption: Z  
 Conversion Factor: 11.0000  
 Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date: 07 Jan 2013  
 Account balance after previous bill: €6,411.22  
 Payment 1: 27 Dec 2012 €6,411.22 CR  
 Current Bill: €6,526.56

**NEW BALANCE DUE BY 21 Jan 2013 €6,526.56**



Happy New Year. Be kind to the environment in 2013 and sign up to paperless billing on [www.energia.ie/paperless](http://www.energia.ie/paperless). You will be in with a chance to win tickets to the six nations Ireland/England rugby match at the Aviva Stadium in February!

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Dec to 31 Dec**

Connected at: Distribution Level  
 Capacity: 5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	127,094 kWh	@ €0.026006	€3,647.00
Carbon Tax	127,094 kWh	@ €0.0037	€470.20
<b>- TRANSPORTATION -</b>			
Transport Rate	127,094 kWh	@ €0.00471	€606.01
Shrinkage Rate	127,094 kWh	@ €0.00044	€55.92
Site Capacity Charge	31 Days	@ €31.5613	€976.40
Total Excluding VAT			€5,750.27
Standard Rate VAT @ 13.5%			€776.20
<b>Total Gas Charges For This Period</b>			<b>€6,526.56</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 21 Jan 2013 €6,526.56**

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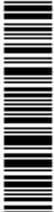


**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gais Call Centre: 1850 200 694

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<b>ACCOUNT INFORMATION</b>		Bill No:	2559440
Account Number	6582092676		
Accounting Period	1 Jan 2013 to 31 Jan 2013		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	10.9723		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	08 Feb 2013
Account balance after previous bill	€6,326.58		
Payment 1	21 Jan 2013	€6,326.56 CR	
Current Bill	€6,340.99		

**NEW BALANCE DUE BY 22 Feb 2013** €6,340.99

Join Energia Extra today and save even more with superb offers for you and your business. Full details on the enclosed leaflet or on [www.energia.ie/extra](http://www.energia.ie/extra)

For further information on your fuel mix, please contact us.

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Jan to 31 Jan**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	126,252 kWh	@ €0.027791	€3,506.67
Carbon Tax	126,252 kWh	@ €0.0067	€847.13
<b>- TRANSPORTATION -</b>			
Transport Rate	126,252 kWh	@ €0.00471	€594.65
Shrinkage Rate	126,252 kWh	@ €0.00044	€55.55
Site Capacity Charge	31 Days	@ €3.15613	€976.40
Total Excluding VAT			€5,604.40
Standard Rate VAT @ 13.5%			€756.59
<b>Total Gas Charges For This Period</b>			<b>€6,340.99</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 22 Feb 2013** €6,340.99  
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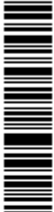


**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gáis Call Centre: 1850 200 694

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**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24



<b>ACCOUNT INFORMATION</b>		Bill No:	2602849
Account Number	6582092676		
Accounting Period	1 Feb 2013 to 28 Feb 2013		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	10.9723		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	08 Mar 2013
Account balance after previous bill	€6,300.00		
Payment 1	22 Feb 2013	€6,300.00 CR	
Current Bill	€6,377.03		

**NEW BALANCE DUE BY 22 Mar 2013** €6,377.03

Effective 1st April 2013. Your gas charges will be amended to reflect increases in Bord Gáis Networks pass-through charges.

Energia remains committed to providing the most competitive business energy prices in Ireland and regret having to pass on these costs increases.

If you have any queries in relation to this matter please contact our customer service team on 1850 36 37 44 or your Key Account Manager.

For further information on your fuel mix, please contact us.

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Feb to 28 Feb**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	132,379 kWh	@ €0.009917	€3,563.25
Carbon Tax	132,379 kWh	@ €0.0037	€489.80
<b>- TRANSPORTATION -</b>			
Transport Rate	132,379 kWh	@ €0.00471	€623.51
Shrinkage Rate	132,379 kWh	@ €0.00044	€56.25
Site Capacity Charge	28 Days	@ €31.6013	€885.72
Total Excluding VAT			€5,614.53
Standard Rate VAT @ 13.5%			€758.50
<b>Total Gas Charges For This Period</b>			<b>€6,377.03</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 22 Mar 2013** €6,377.03

Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gais Call Centre: 1850 200 694

TALLAGHT COMMUNITY SCHOOL  
 BALROTHERY  
 TALLAGHT  
 DUBLIN 24  
 Co. DUBLIN

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

<b>ACCOUNT INFORMATION</b>		Bill No:	2621829
Account Number	6582092676		
Accounting Period	1 Mar 2013 to 31 Mar 2013		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	11.0277		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	08 Apr 2013
Account balance after previous bill	€6,077.03		
Payment 1	22 Mar 2013	€6,077.03 CR	
Current Bill	€7,076.97		

**NEW BALANCE DUE BY 22 Apr 2013** €7,076.97



Great NEW offers for you and your business on Energia Extra this month. Log on to [www.energia.ie/extra](http://www.energia.ie/extra) now and check out how you can save a little extra for you and your business. More details on the enclosed leaflet.

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Mar to 31 Mar**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	145,865 kWh	@ €0.027169	€3,965.92
Carbon Tax	145,865 kWh	@ €0.0037	€539.70
<b>- TRANSPORTATION -</b>			
Transport Rate	145,865 kWh	@ €0.00171	€248.70
Shrinkage Rate	145,865 kWh	@ €0.00044	€64.18
Site Capacity Charge	31 Days	@ €31.5613	€976.40
Total Excluding VAT			€6,205.22
Standard Rate VAT @ 13.5%			€541.75
<b>Total Gas Charges For This Period</b>			<b>€7,076.97</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 22 Apr 2013** €7,076.97

Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gais Call Centre: 1850 200 694

TALLAGHT COMMUNITY SCHOOL  
 BALROTHERY  
 TALLAGHT  
 DUBLIN 24  
 Co. DUBLIN

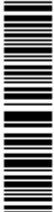
**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

<b>ACCOUNT INFORMATION</b>		Bill No:	2664172
Account Number	6582092676		
Accounting Period	1 Apr 2013 to 30 Apr 2013		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	11.0000		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	08 May 2013
Account balance after previous bill	€7,076.07		
Payment 1	22 Apr 2013	€7,076.07 CR	
Current Bill	€6,412.82		

**NEW BALANCE DUE BY 22 May 2013** €6,412.82



Great special offer this month on [www.energia.ie/shop](http://www.energia.ie/shop) - 25% off another superb energy saving product. More details on the enclosed leaflet.

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Apr to 30 Apr**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	121,202 kWh	@ €0.029706	€3,604.00
Carbon Tax	121,202 kWh	@ €0.0037	€448.75
<b>- TRANSPORTATION -</b>			
Transport Rate	121,202 kWh	@ €0.00471	€570.86
Shrinkage Rate	121,202 kWh	@ €0.00044	€53.33
Site Capacity Charge	30 Days	@ €32,4454	€973.36
<b>Total Excluding VAT</b>			<b>€5,630.00</b>
<b>Standard Rate VAT @ 13.5%</b>			<b>€762.78</b>
<b>Total Gas Charges For This Period</b>			<b>€6,412.82</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 22 May 2013** €6,412.82

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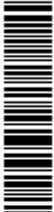


**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gais Call Centre: 1850 200 694

TALLAGHT COMMUNITY SCHOOL  
 BALROTHERY  
 TALLAGHT  
 DUBLIN 24  
 Co. DUBLIN

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24



<b>ACCOUNT INFORMATION</b>		Bill No:	2701583
Account Number	8582092876		
Accounting Period	1 May 2013 to 31 May 2013		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	10.8889		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	07 Jun 2013
Account balance after previous bill	€6,412.02		
Payment 1	22 May 2013	€6,412.02 CR	
Current Bill	€5,376.53		

**NEW BALANCE DUE BY 21 Jun 2013** €5,376.53

Why not get your business energy in good shape during the summer months and lose that excess energy consumption? Our team are here to help and you can email them right now for advice and expertise at [energy.encyency@energia.ie](mailto:energy.encyency@energia.ie).

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 May to 31 May**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	104,889 kWh	@ €0.028743	€2,805.05
Carbon Tax	104,889 kWh	@ €0.0037	€386.09
<b>- TRANSPORTATION -</b>			
Transport Rate	104,889 kWh	@ €0.00471	€494.03
Shrinkage Rate	104,889 kWh	@ €0.00042	€44.05
Site Capacity Charge	31 Days	@ €32,4454	€1,005.01
Total Excluding VAT			€4,737.03
Standard Rate VAT @ 13.5%			€639.50
<b>Total Gas Charges For This Period</b>			<b>€5,376.53</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 21 Jun 2013** €5,376.53

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**CUSTOMER SERVICE**  
 Emergency Faults: 1850 20 50 50  
 Account Enquiries: 1850 363 744  
 Bord Gais Call Centre: 1850 200 694

TALLAGHT COMMUNITY SCHOOL  
 BALROTHERY  
 TALLAGHT  
 DUBLIN 24  
 Co. DUBLIN

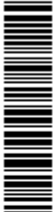
**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

<b>ACCOUNT INFORMATION</b>		Bill No:	2738184
Account Number	8582092876		
Accounting Period	1 Jun 2013 to 30 Jun 2013		
GPRN Number	0587327		
Annual Quantity	1,192,101	Consumption	Z
Conversion Factor	10.9167		
Environmental impact information is on the back of the bill			

<b>ACCOUNT SUMMARY</b>		Date	05 Jul 2013
Account balance after previous bill	€5,076.53		
Payment 1	21 Jun 2013	€5,076.53 CR	
Current Bill	€4,160.32		

**NEW BALANCE DUE BY 19 Jul 2013** €4,160.32



Share the great deals on Energia Extra with your colleagues by using the enclosed poster. Loads of superb discounts available for everyone that works in your business. Please put your Energia account number on the poster to make it easy to register.

**DETAILS OF GAS CHARGES**

**TARIFF: Fuel Variation Tariff**  
**Billing Period: 1 Jun to 30 Jun**

Connected at:	Distribution Level
Capacity:	5,380 kWh

<b>- GAS CHARGES -</b>			
Gas Rate	75,828 kWh	@ €0.028653	€2,016.53
Carbon Tax	75,828 kWh	@ €0.0037	€280.00
<b>- TRANSPORTATION -</b>			
Transport Rate	75,828 kWh	@ €0.00471	€357.15
Shrinkage Rate	75,828 kWh	@ €0.00048	€34.88
Site Capacity Charge	30 Days	@ €32,4454	€973.36
Total Excluding VAT			€3,993.48
Standard Rate VAT @ 13.5%			€494.04
<b>Total Gas Charges For This Period</b>			<b>€4,160.32</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 19 Jul 2013** €4,160.32  
 Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2

**Appendix C – Electrical Bills**



**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
 Account Enquiries: 1850 363 744

TALLAGHT COMMUNITY SCHOOL SPOR  
 BALROTHERY  
 TALLAGHT  
 DUBLIN 24  
 Co. DUBLIN

**ACCOUNT INFORMATION**

Bill No: 2282109

Account Number 2106438013  
 Accounting Period 1 Jun 2012 to 30 Jun 2012  
 MPRN Number 10000037467  
 DUoS/TUoS Cat Code DGB Meter Conf Code M0008 Profile 09

Maximum Import Capacity 80 kVA

Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 08 Jul 2012

Account balance after previous bill €3,079.29  
 Payment 1 21 Jun 2012 €3,079.29 CR  
 Current Bill €3,055.58

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

**NEW BALANCE DUE BY 20 Jul 2012 €3,055.58****DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**  
**Billing Period: 1 Jun to 30 Jun**

Standing Charge		€343.20
Day units	25,540 KWH @ €0.140	€3,575.60
Night units	11,660 KWH @ €0.0768	€895.79
Service Capacity Charge (KVA)	80 kVA @ €4.00	€281.40
Low Power Factor Surcharge	9,540 kVAh @ €0.00788	€75.27
D50 Levy 00 kVA @ €1.12		€89.20
Credit for estimated charges		€2,608.29 CR
VAT credit @ 13.5% on Estimated account		€356.00 CR
Electricity Tax	37,200 kWh @ €0.0006	€16.60
VAT @ 13.5% on €3,351.48		€722.44
<b>Total Charges For This Period</b>		<b>€3,055.58</b>

Keep your bills accurate and submit your meter readings every month. Use the brand NEW Energia Meter Reading Mobile App - available from the Apple and Android App stores. Download it NOW and use this bill to register your details.

You can also submit your meter reading on line at [www.energia.ie/meter](http://www.energia.ie/meter) or via email at [customer.service@energia.ie](mailto:customer.service@energia.ie). Keep this bill with you as you will need the details.

Download the NEW Meter Reading Mobile APP. Submit a meter reading and be in with a chance to win 1 of 10 Owl Monitors. For more details see the insert with this bill.

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 20 Jul 2012****€3,055.58**

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**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

**ACCOUNT INFORMATION**

Bill No: 2334251

Account Number 2106438013  
Accounting Period 1 Jul 2012 to 31 Jul 2012  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09

TALLAGHT COMMUNITY SCHOOL SPOR  
BALROTHERY  
TALLAGHT  
DUBLIN 24  
Co. DUBLIN

Maximum Import Capacity 80 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 11 Aug 2012

Account balance after previous bill €3,055.50  
Payment 1 20 Jul 2012 €3,055.50 CR  
Current Bill €3,036.93

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

**NEW BALANCE DUE BY 27 Aug 2012 €3,036.93**



Keep your bills accurate and submit your meter readings every month.

Use the NEW Energia Meter Reading Mobile App - available from the Apple and Android App stores. Download it NOW and submit a meter reading - you will be in with a chance to win 1 of 10 Owl Monitors. For more details see the insert with this bill.

You can also submit a meter reading on line at [www.energia.ie/meter](http://www.energia.ie/meter) or via email at [customer.service@energia.ie](mailto:customer.service@energia.ie). Actual meter readings supplied by ESB have been used on this bill where available. If you have any queries please contact our customers services team on 1850 363 744.

**DETAILS OF CHARGES**

TARIFF: Low Voltage Max Demand

Billing Period: 1 Jul to 31 Jul

Estimated Account	€2,675.71
VAT @ 13.5% on €2,675.71	€361.22
<b>Total Charges For This Period</b>	<b>€3,036.93</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 27 Aug 2012 €3,036.93**

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**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

**ACCOUNT INFORMATION**

Bill No: 2363002

Account Number 2106438013  
Accounting Period 1 Aug 2012 to 31 Aug 2012  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09

TALLAGHT COMMUNITY SCHOOL SPOR  
BALROTHERY  
TALLAGHT  
DUBLIN 24  
Co. DUBLIN

Maximum Import Capacity 80 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

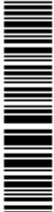
Date 11 Sep 2012

Account balance after previous bill €3,026.03  
Payment 1 27 Aug 2012 €3,036.03 CR  
Current Bill €3,022.12

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

**NEW BALANCE DUE BY 25 Sep 2012 €3,022.12**



**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**  
**Billing Period: 1 Aug to 31 Aug**

Standing Charge		€346.87
Day units	25,340 KWH @ €0.140	€3,547.60
Night units	11,780 KWH @ €0.0768	€904.70
Service Capacity Charge (KVA)	80 kVA @ €4.77	€382.20
Low Power Factor Surcharge	9,027 kVAh @ €0.00788	€71.22
D50 Levy 00 kVA @ €1.12		€89.20
Credit for estimated charges		€2,676.71 CR
VAT credit @ 13.5% on Estimated account		€361.22 CR
Electricity Tax	37,120 kWh @ €0.0006	€22.27
VAT @ 13.5% on €5,338.37		€720.68
<b>Total Charges For This Period</b>		<b>€3,022.12</b>

**Advance Notice:** Effective 1st Oct 2012, your electricity charges will be amended to reflect an increase in fuel commodity costs and regulatory approved third party electricity pass through costs.

Energia remains committed to providing the most competitive business energy prices in Ireland and regret having to pass on these costs increases.

Full details will be provided in your next bill. However, if you have a query in relation to this matter please contact our customer care team on 1850 36 37 44.

**Important notice.** Revised general terms and conditions for supply of energy are available to view on [www.energia.ie](http://www.energia.ie) or by request.

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 25 Sep 2012 €3,022.12**  
 Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

**ACCOUNT INFORMATION**

Bill No: 2412442

Account Number 2106438013  
Accounting Period 1 Sep 2012 to 30 Sep 2012  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code M0006 Profile 09

TALLAGHT COMMUNITY SCHOOL SPOR  
BALROTHERY  
TALLAGHT  
DUBLIN 24  
Co. DUBLIN

Maximum Import Capacity 80 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

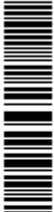
Date 12 Oct 2012

Account balance after previous bill €3,022.12  
Payment 1 25 Sep 2012 €3,022.12 CR  
Current Bill €3,029.52

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

**NEW BALANCE DUE BY 26 Oct 2012 €3,029.52**



Actual meter readings supplied by ESB have been used on this bill where available. If you have any queries please contact our customers services team on 1850 363 744.

For further information on your fuel mix, please contact your electricity supplier.

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**

**Billing Period: 1 Sep to 30 Sep**

Estimated Account €2,669.16

VAT @ 13.5% on €2,669.16 €700.34

**Total Charges For This Period €3,029.52**

Effective 1st September 2012. Your electricity charges will be amended to reflect an increase in commodity & regulatory approved 3rd party pass through costs. This equates to an average increase of 3.5% of your total bill depending on your usage pattern.

Energia remains committed to providing the most competitive business energy prices in Ireland and regret having to pass on these costs increases.

If you have any queries in relation to this matter please contact our Customer Service team on 1850 36 37 44 selecting Option 2

Important notice. Revised general terms and conditions for supply of energy are available to view on [www.energia.ie](http://www.energia.ie) or by request.

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 26 Oct 2012 €3,029.52**

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**CUSTOMER SERVICE**  
 Emergency Faults: 1850 372 999  
 Account Enquiries: 1850 363 744

<b>ACCOUNT INFORMATION</b>		Bill No:	2449434
Account Number		2106438013	
Accounting Period		1 Oct 2012 to 31 Oct 2012	
MPRN Number		10000037467	
DUs/TUs Cat Code	DGB	Meter Conf Code	MCC06 Profile 09

TALLAGHT COMMUNITY SCHOOL SPOR  
 BALROTHERY  
 TALLAGHT  
 DUBLIN 24  
 Co. DUBLIN

Maximum Import Capacity 80 kVA  
 Environmental impact information is on the back of the bill

**PREMISES SUPPLIED**

BALROTHERY, TALLAGHT, DUBLIN 24

<b>ACCOUNT SUMMARY</b>		Date	13 Nov 2012
Account balance after previous bill		€3,029.52	
Payment 1	26 Oct 2012	€3,029.52 CR	
Current Bill		€3,712.87	

**NEW BALANCE DUE BY 27 Nov 2012** €3,712.87



For further information on your fuel mix, please contact your electricity supplier.

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**  
**Billing Period: 1 Oct to 31 Oct**

Standing Charge		€343.25
Day units	28,000 KWH @ €0.1450	€4,062.40
Night units	12,840 KWH @ €0.0763	€979.37
Service Capacity Charge (KVA)	60 kVA @ €5.09	€301.80
Low Power Factor Surcharge	8,627 kVAh @ €0.000875	€7.55
PSC Levy 60 kVA @ €1.70		€102.00
Credit for estimated charges		€2,668.18 CR
VAT credit @ 13.5% on Estimated account		€360.34 CR
Electricity Tax	40,840 kWh @ €0.0005	€20.42
VAT @ 13.5% on €5,940.43		€801.96
<b>Total Charges For This Period</b>		<b>€3,712.87</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 27 Nov 2012** €3,712.87  
 Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

Tallaght Community School Spor  
Balrothery  
Tallaght  
Dublin 24  
Co. DUBLIN

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24



**ACCOUNT INFORMATION**

Bill No: 2489280

Account Number 2106438013  
Accounting Period 1 Nov 2012 to 30 Nov 2012  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09  
Maximum Import Capacity 60 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 11 Dec 2012

Account balance after previous bill €3,712.07  
Payment 1 27 Nov 2012 €3,712.07 CR  
Current Bill €3,371.19

**NEW BALANCE DUE BY 27 Dec 2012 €3,371.19**

Wishing you a very Happy Christmas and a prosperous New Year. Be kind to the environment in 2013 and sign up to paperless billing by logging on to [www.energia.ie/paperless](http://www.energia.ie/paperless)

Actual meter readings supplied by ESB have been used on this bill where available. If you have any queries please contact our customers services team on 1850 363 744.

For further information on your fuel mix, please contact your electricity supplier.

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**

**Billing Period: 1 Nov to 30 Nov**

Estimated Account	€2,570.21
VAT @ 13.5% on €2,970.21	€400.98
<b>Total Charges For This Period</b>	<b>€3,371.19</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 27 Dec 2012 €3,371.19**

Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
 Account Enquiries: 1850 363 744

Tallaght Community School Spor  
 Balrothery  
 Tallaght  
 Dublin 24  
 Co. DUBLIN

**ACCOUNT INFORMATION**

Bill No: 2532436

Account Number	2106438013
Accounting Period	1 Dec 2012 to 31 Dec 2012
MPRN Number	10000037467
DUs/TUs Cat Code	DGB
Meter Conf Code	MCC06
Profile	09
Maximum Import Capacity	60 kVA
Environmental impact information is on the back of the bill	

**ACCOUNT SUMMARY**

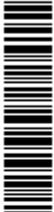
Date: 12 Jan 2013

Account balance after previous bill	€3,071.19
Payment 1 27 Dec 2012	€3,071.19 CR
Current Bill	€3,983.14

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24

**NEW BALANCE DUE BY 28 Jan 2013 €3,983.14**



Happy New Year. Be kind to the environment in 2013 and sign up to paperless billing on [www.energia.ie/paperless](http://www.energia.ie/paperless). You will be in with a chance to win tickets to the six nations Ireland/England rugby match at the Aviva Stadium in February!

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**

Billing Period: 1 Dec to 31 Dec

Standing Charge		€343.20
Day units	26,840 KWH @ €0.1000	€4,479.00
Night units	11,780 KWH @ €0.0763	€902.37
LVMD Maximum Demand Charge Summary	46 kW @ €5.79	€265.58
Service Capacity Charge (KVA)	60 kVA @ €5.03	€301.80
Low Power Factor Surcharge	3,127 kVAh @ €0.009875	€30.88
P&O Levy 00 kVA @ €1.88		€116.80
Credit for estimated charges		€2,870.21 CR
VAT credit @ 13.5% on Estimated account		€400.98 CR
Electricity Tax	38,620 kWh @ €0.0005	€19.31
VAT @ 13.5% on €6,779.56		€917.17
<b>Total Charges For This Period</b>		<b>€3,983.14</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 28 Jan 2013 €3,983.14**

Issued By Energia, Mill House, Ashdowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



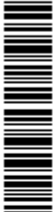
**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

Tallaght Community School Spor  
Balrothery  
Tallaght  
Dublin 24  
Co. DUBLIN

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24



**ACCOUNT INFORMATION**

Bill No: 2567830

Account Number 2106438013  
Accounting Period 1 Jan 2013 to 31 Jan 2013  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09  
Maximum Import Capacity 60 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 09 Feb 2013

Account balance after previous bill €3,900.14  
Payment 1 28 Jan 2013 €3,900.14 CR  
Current Bill €3,677.16

**NEW BALANCE DUE BY 25 Feb 2013 €3,677.16**

Join Energia Extra today and save even more with superb offers for you and your business. Full details on the enclosed leaflet or on [www.energia.ie/extra](http://www.energia.ie/extra)

For further information on your fuel mix, please contact us.

Actual meter readings supplied by ESB have been used on this bill where available. If you have any queries please contact our customers services team on 1850 363 744.

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**

**Billing Period: 1 Jan to 31 Jan**

Estimated Account	€3,239.79
VAT @ 13.5% on €3,239.79	€437.37
<b>Total Charges For This Period</b>	<b>€3,677.16</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 25 Feb 2013 €3,677.16**

Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



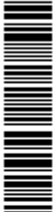


**CUSTOMER SERVICE**  
 Emergency Faults: 1850 372 999  
 Account Enquiries: 1850 363 744

Tallaght Community School Spor  
 Balrothery  
 Tallaght  
 Dublin 24  
 Co. DUBLIN

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24



**ACCOUNT INFORMATION**

Bill No: 2597295

Account Number 2106438013  
 Accounting Period 1 Feb 2013 to 28 Feb 2013  
 MPRN Number 10000037467  
 DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09  
 Maximum Import Capacity 60 kVA  
 Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 07 Mar 2013

Account balance after previous bill €3,677.18  
 Payment 1 25 Feb 2013 €3,677.16 CR  
 Current Bill €3,527.03

**NEW BALANCE DUE BY 21 Mar 2013 €3,527.03**

Superb offers now available on our NEW online shop that is packed full of great energy efficiency products. Check it out now on [www.energia.ie/shop](http://www.energia.ie/shop).

For further information on your fuel mix, please contact us.

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**  
**Billing Period: 1 Feb to 28 Feb**

Standing Charge			€331.00
Day units	28,700 KWH @	€0.1669	€4,786.23
Night units	11,140 KWH @	€0.0763	€852.20
LVMD Maximum Demand Charge Summary	44 kW @	€5.55	€244.20
Service Capacity Charge (KVA)	60 kVA @	€4.00	€240.00
Low Power Factor Surcharge	1,347 kVAh @	€0.009875	€13.30
F&C Levy 60 kVA @		€1.98	€118.80
Credit for estimated charges			€3,209.79 CR
VAT credit @ 13.5% on Estimated account			€437.37 CR
Electricity Tax	37,840 kWh @	€0.0005	€18.92
VAT @ 13.5% on €2,347.30			€316.89
<b>Total Charges For This Period</b>			<b>€3,527.03</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 21 Mar 2013 €3,527.03**

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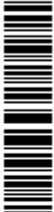
**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

Tallaght Community School Spor  
Balrothery  
Tallaght  
Dublin 24  
Co. DUBLIN

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24



**ACCOUNT INFORMATION**

Bill No: 2640901

Account Number 2106438013  
Accounting Period 1 Mar 2013 to 31 Mar 2013  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09  
Maximum Import Capacity 60 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 12 Apr 2013

Account balance after previous bill €3,527.03  
Payment 1 21 Mar 2013 €3,527.03 CR  
Current Bill €3,602.09

**NEW BALANCE DUE BY 26 Apr 2013 €3,602.09**

Great NEW offers for you and your business on Energia Extra this month. Log on to [www.energia.ie/extra](http://www.energia.ie/extra) now and check out how you can save a little extra for you and your business. More details on the enclosed leaflet.

For further information on your fuel mix, please contact us.

Actual meter readings supplied by ESB have been used on this bill where available. If you have any queries please contact our customers services team on 1850 363 744.

**DETAILS OF CHARGES**

TARIFF: Low Voltage Max Demand

Billing Period: 1 Mar to 31 Mar

Estimated Account €3,173.65  
VAT @ 13.5% on €3,173.65 €426.44  
Total Charges For This Period €3,602.09

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 26 Apr 2013 €3,602.09**

Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**  
 Emergency Faults: 1850 372 999  
 Account Enquiries: 1850 363 744

<b>ACCOUNT INFORMATION</b>		Bill No:	2679502
Account Number		2106438013	
Accounting Period		1 Apr 2013 to 30 Apr 2013	
MPRN Number		10000037467	
DUs/TUs Cat Code	DGB	Meter Conf Code	MCC06
Profile		09	
Maximum Import Capacity 60 kVA			
Environmental impact information is on the back of the bill			

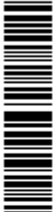
Tallaght Community School Spor  
 Balrothery  
 Tallaght  
 Dublin 24  
 Co. DUBLIN

<b>ACCOUNT SUMMARY</b>		Date	13 May 2013
Account balance after previous bill		€3,822.09	
Payment 1	26 Apr 2013	€3,822.09 CR	
Current Bill		€2,469.96	

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24

<b>NEW BALANCE DUE BY 27 May 2013</b>	<b>€2,469.96</b>
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Great special offer this month on [www.energia.ie/shop](http://www.energia.ie/shop) - 25% off another superb energy saving product. More details on the enclosed leaflet.

For further information on your fuel mix, please contact us.

**DETAILS OF CHARGES**

**TARIFF: Low Voltage Max Demand**  
**Billing Period: 1 Apr to 30 Apr**

Standing Charge			€343.25
Day units	25,400 KWH @	€0.1458	€3,703.32
Night units	11,040 KWH @	€0.0763	€841.73
Service Capacity Charge (KVA)	60 kVA @	€5.00	€300.00
P90 Levy 60 kVA @	€1.90		€115.00
Credit for estimated charges			€5,773.05 CR
VAT credit @ 13.5% on Estimated account			€428.44 CR
Electricity Tax	36,440 kWh @	€0.0005	€18.22
VAT @ 13.5% on €5,949.52			€722.29
<b>Total Charges For This Period</b>			<b>€2,469.96</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 27 May 2013** €2,469.96

Issued By Energia, Mill House, Ashdowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2



**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
Account Enquiries: 1850 363 744

Tallaght Community School Spor  
Balrothery  
Tallaght  
Dublin 24  
Co. DUBLIN

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24

**ACCOUNT INFORMATION**

Bill No: 2718066

Account Number 2106438013  
Accounting Period 1 May 2013 to 31 May 2013  
MPRN Number 10000037467  
DUoS/TUoS Cat Code DGB Meter Conf Code MCCC6 Profile 09  
Maximum Import Capacity 60 kVA  
Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 13 Jun 2013

Account balance after previous bill €2,469.06  
Payment 1 27 May 2013 €2,469.06 CR  
Current Bill €3,036.02

**NEW BALANCE DUE BY 27 Jun 2013 €3,036.02**



Why not get your business energy in good shape during the summer months and lose that excess energy consumption? Our team are here to help and you can email them right now for advice and expertise at [energy.encyency@energia.ie](mailto:energy.encyency@energia.ie).

For further information on your fuel mix, please contact us.

Actual meter readings supplied by ESB have been used on this bill where available. If you have any queries please contact our customers services team on 1850 363 744.

**DETAILS OF CHARGES**

TARIFF: Low Voltage Max Demand

Billing Period: 1 May to 31 May

Estimated Account	€2,674.01
VAT @ 13.5% on €2,674.01	€361.11
<b>Total Charges For This Period</b>	<b>€3,036.02</b>

**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 27 Jun 2013 €3,036.02**

Issued By Energia, Mill House, Ashtowngate, Navan Road, Dublin 15 Our VAT Registration Number IE 632 6035 0 Page 1 of 2

**CUSTOMER SERVICE**

Emergency Faults: 1850 372 999  
 Account Enquiries: 1850 363 744

Tallaght Community School Spor  
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 Tallaght  
 Dublin 24  
 Co. DUBLIN

**PREMISES SUPPLIED**

Balrothery, Tallaght, Dublin 24

**ACCOUNT INFORMATION**

Bill No: 2754435

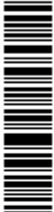
Account Number 2106438013  
 Accounting Period 1 Jun 2013 to 30 Jun 2013  
 MPRN Number 10000037467  
 DUoS/TUoS Cat Code DGB Meter Conf Code M0006 Profile 09  
 Maximum Import Capacity 60 kVA  
 Environmental impact information is on the back of the bill

**ACCOUNT SUMMARY**

Date 12 Jul 2013

Account balance after previous bill €3,036.02  
 Payment 1 27 Jun 2013 €3,036.02 CR  
 Current Bill €3,017.33

**NEW BALANCE DUE BY 26 Jul 2013 €3,017.33**



Share the great deals on Energia Extra with your colleagues by using the enclosed poster. Loads of superb discounts available for everyone that works in your business. Please put your Energia account number on the poster to make it easy to register.

For further information on your fuel mix, please contact us.

**DETAILS OF CHARGES****TARIFF: Low Voltage Max Demand**

Billing Period: 1 Jun to 30 Jun

Standing Charge		€343.25
Day units	24,800 KWH @ €0.1458	€3,615.84
Night units	11,840 KWH @ €0.0789	€931.11
Service Capacity Charge (KVA)	60 kVA @ €5.00	€300.00
Low Power Factor Surcharge	2,433 kVAh @ €0.009875	€24.03
PSC Levy 60 kVA @ €1.98		€118.80
Credit for estimated charges		€2,674.01 CR
VAT credit @ 13.5% on Estimated account		€361.11 CR
Electricity Tax	36,440 kWh @ €0.0005	€18.22
VAT @ 13.5% on €5,393.35		€720.00
<b>Total Charges For This Period</b>		<b>€3,017.33</b>

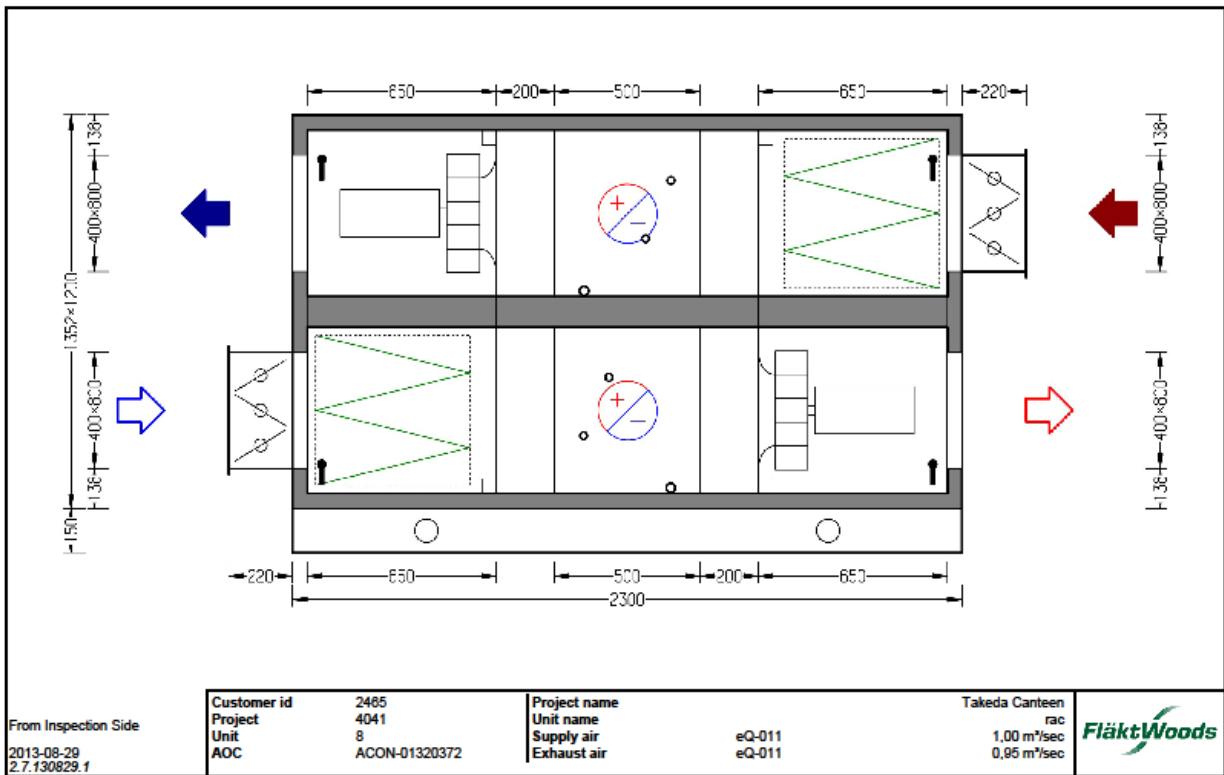
**THIS AMOUNT IS DUE FOR PAYMENT by Direct Debit on 26 Jul 2013**

**€3,017.33**

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**Appendix D – Performance Certificates**

# Run Around Coils





**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320372	
Unit	8 () / rac	2013-08-29
Size	011	Page 2

**TECHNICAL SPECIFICATION**  
(components listed in direction of air flow)

**SUPPLY AIR**

**End connection frame**

Pressure drop, dimensioning 5 Pa

**Casing end wall**

**Damper**

- Width cm : 080
- Height in cm : 040
- Tightness class : CEN 3
- Connection: slip joint (PG)
- Function : Outdoor air
- Location: externally end wall
- Damper type: 200 mm blade
- Material : galvanized sheet steel

**Filter**

Unit size : 011	
Filter class : F7	
Filter type : glass fibre, standard	
Filter length : Long bag (vertical pockets only)	
Filter frame : plastic	
Connection side : inlet in end wall	
Location: negative pressure	
Material: galvanized sheet steel	
Inspection side : right	
Number of filters	2x492x492
Pressure drop, start	58 Pa
Pressure drop, dimensioning	108 Pa
Pressure drop, end	158 Pa
Face area	0,5 m <sup>2</sup>
Face velocity	2,1 m/s





**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320372	
Unit	8 () / rac	2013-08-29
Size	011	Page 3

**ECOTERM liquid-coupled heat exchangers**

Unit size : 011				
Function: air heater				
Output variant : 1				
Design: normal face area				
Fin pitch: 2 mm				
Fluid circuits : 16				
Material, coil : Cu/Al				
Material, frame : galvanized sheet steel				
Connection side : right				
Liquid volume				9,0 l
Nom. pipe size				25
Pressure drop, dimensioning				73 Pa
Air temperature				-5 / 7,1 °C
Relative humidity				90 / 36 %
Liquid temperature				13,7 / 6,1 °C
Pressure drop water				35,4 kPa
Flow				0,52 l/s
Face velocity				1,8 m/s
Efficiency				43,1 %
Ethylene glycol				30 %
<b>Performance, unregulated</b>				
Air temperature in	-5	-5	0	5 °C
Air temperature out	7,1	7,1	9,9	12,5 °C
Efficiency	43,1	43,3	42,9	41,7 %
Output	14,6	14,7	11,9	9,09 kW

**Empty section**

Unit size : 011  
 Length: 020  
 Inspection side : right



#### AIR HANDLING UNIT eQ

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320372	
Unit	8 () / rac	2013-08-29
Size	011	Page 4

### Plenum fan Centriflow Plus

Unit size : 011  
Fan size : 2  
Equipment: normal + pressure tapping for air flow measurement  
Anti-vibration mountings : rubber  
Position inside the casing : supply air  
Outlet direction : forward, to duct (rectangular)  
Material : galvanized sheet steel  
Inspection side: right

#### Dimensioning data

Speed	2075 Rpm
Fan efficiency	71,1 %
Total efficiency	54,7 %
Pressure rise, dimensioning	405 Pa
Fan shaft power at dim. data	0,584 kW
Grid Power	0,759 kW
Temperature rise	0,6 °C

#### SFP Calculation

Grid power according to SFP	0,655 kW
Pressure rise	351 Pa
Speed	1970 Rpm

#### Centriflow Plus Fan Unit + Motor

Wheel diameter: 035  
Number of poles: 4  
Rated output: 00110  
Motor type: Fläkt Woods Asynchronous  
Voltage: 220 – 240 VD / 380 – 420 VY  
Brand: Fläkt Woods  
Version: 2011

#### Single-speed motor

Voltage: 220-240 V delta, 380-420 V star, 220 V delta, 380 V star	
Temperature sensors in stator winding: with thermistor	
Design variant: FläktWoods IE2	
Efficiency	81,4 %
Speed	1435 Rpm
Motor output	1,1 kW
Electric current	2,5 A
Number of Poles	4
Output margin, minimum	10 %

#### Frequency converter

Efficiency	94,5 %
Operating frequency	72 Hz
Max frequency at frequency control	86,7 Hz
Max speed at frequency control	2488 Rpm

#### Motor accessories

Motor: 1-Speed  
Motor control: Mounted frequency converter  
Type: Standard  
Length: 100  
Power supply: 3x400 VAC

#### Protective screen door (for EQL(R,K) internal mounted motor)

Unit size : 011  
Fan type: Plenum fan (EQLK)  
Material: galvanized sheet steel  
Version number: version 2



**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320372	
Unit	8 () / rac	2013-08-29
Size	011	Page 5

**End connection frame**

Pressure drop, dimensioning 4 Pa  
**Casing end wall**

**Damper**

Width cm : 080  
Height in cm : 040  
Tightness class : CEN 3  
Connection: slip joint (PG)  
Function : exhaust air  
Location: externally end wall  
Damper type: 200 mm blade  
Material : galvanized sheet steel

**Filter**

Unit size : 011  
Filter class : F7  
Filter type : glass fibre, standard  
Filter length : Long bag (vertical pockets only)  
Filter frame : plastic  
Connection side : inlet in end wall  
Location: negative pressure  
Material: galvanized sheet steel  
Inspection side : left  
Number of filters 2x492x492  
Pressure drop, start 53 Pa  
Pressure drop, dimensioning 103 Pa  
Pressure drop, end 153 Pa  
Face area 0,5 m<sup>2</sup>  
Face velocity 1,9 m/s

**ECOTERM liquid-coupled heat exchangers**

Unit size : 011  
Function: air cooler  
Output variant : 1  
Design: normal face area  
Fin pitch: 2 mm  
Fluid circuits : 16  
Material, coil : Cu/Al  
Material, frame : galvanized sheet steel  
Connection side : left  
Liquid volume 9,0 l  
Nom. pipe size 25  
Pressure drop, dimensioning 66 Pa  
Air temperature 23 / 12,5 °C  
Relative humidity 50 / 87,6 %  
Liquid temperature 6,1 / 13,6 °C  
Pressure drop water 35,4 kPa  
Flow 0,52 l/s  
Face velocity 1,9 m/s

**Empty section**

Unit size : 011  
Length: 020  
Inspection side : left



**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320372	
Unit	8 () / rac	2013-08-29
Size	011	Page 6

**Plenum fan Centriflow Plus**

Unit size : 011

Fan size : 2

Equipment: normal + pressure tapping for air flow measurement

Anti-vibration mountings : rubber

Position inside the casing : exhaust air

Outlet direction : forward, to duct (rectangular)

Material : galvanized sheet steel

Inspection side: left

**Dimensioning data**

Speed	2002 Rpm
Fan efficiency	71,6 %
Total efficiency	54,9 %
Pressure rise, dimensioning	390 Pa
Fan shaft power at dim. data	0,529 kW
Grid Power	0,69 kW
Temperature rise	0,6 °C

**SFP Calculation**

Grid power according to SFP	0,598 kW
Pressure rise	338 Pa
Speed	1902 Rpm

**Centriflow Plus Fan Unit + Motor**

Wheel diameter: 035

Number of poles: 4

Rated output: 00110

Motor type: Fläkt Woods Asynchronous

Voltage: 220 – 240 VD / 380 – 420 VY

Brand: Fläkt Woods

Version: 2011

**Single-speed motor**

Voltage: 220-240 V delta, 380-420 V star, 220 V delta, 380 V star

Temperature sensors in stator winding: with thermistor

Design variant: FläktWoods IE2

Efficiency	81,4 %
Speed	1435 Rpm
Motor output	1,1 kW
Electric current	2,5 A
Number of Poles	4
Output margin, minimum	10 %

**Frequency converter**

Efficiency	94,2 %
Operating frequency	70 Hz
Max frequency at frequency control	86,6 Hz
Max speed at frequency control	2486 Rpm

**Motor accessories**

Motor: 1-Speed

Motor control: Mounted frequency converter

Type: Standard

Length: 100

Power supply: 3x400 VAC

**Protective screen door (for EQL(R,K) internal mounted motor)**

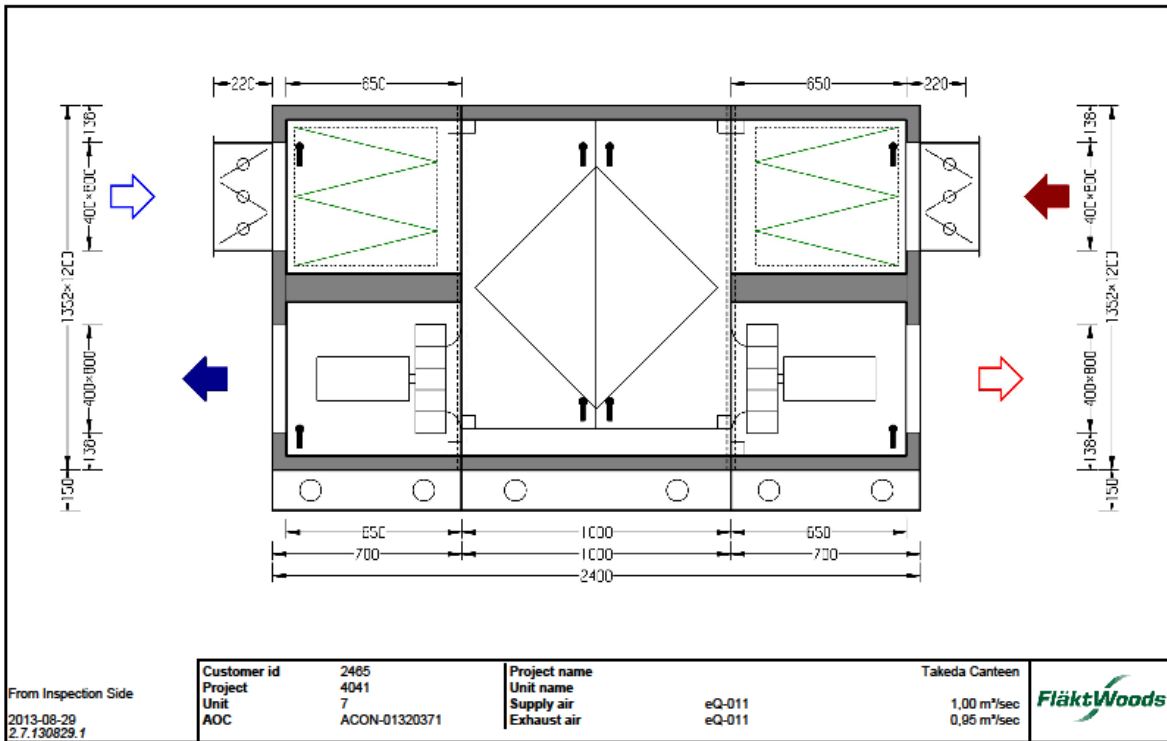
Unit size : 011

Fan type: Plenum fan (EQLK)

Material: galvanized sheet steel

Version number: version 2

# Cross Flow Plate Heat Exchanger





**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320371	
Unit	7 () /	2013-08-29
Size	011	Page 2

**TECHNICAL SPECIFICATION**  
(components listed in direction of air flow)

**SUPPLY AIR**

**End connection frame**

Pressure drop, dimensioning 5 Pa

**Casing end wall**

**Damper**

- Width cm : 080
- Height in cm : 040
- Tightness class : CEN 3
- Connection: slip joint (PG)
- Function : Outdoor air
- Location: externally end wall
- Damper type: 200 mm blade
- Material : galvanized sheet steel

**Filter**

- Unit size : 011
- Filter class : F7
- Filter type : glass fibre, standard
- Filter length : Long bag (vertical pockets only)
- Filter frame : plastic
- Connection side : inlet in end wall
- Location: negative pressure
- Material: galvanized sheet steel
- Inspection side : right
- Number of filters 2x492x492
- Pressure drop, start 58 Pa
- Pressure drop, dimensioning 108 Pa
- Pressure drop, end 158 Pa
- Face area 0,5 m<sup>2</sup>
- Face velocity 2,1 m/s

**Plate heat exchanger, RECUTERM**

- Unit size : 011
- Installation alternative, right-hand/left-hand : 1
- Exhaust air direction: downwards
- Fin material : aluminium
- Design : sectionalized defrosting
- Material : galvanized sheet steel
- Inspection side: right
- Version number: version 1

**Performance, unregulated**

Air temperature in	-5	0 °C
Air temperature out	12,6	14 °C
Efficiency	62,9	60,9 %

**Supply air**

Pressure drop, dimensioning	129 Pa
Air temperature	-5 / 12,6 °C
Relative humidity	90 / 24,8 %

**Exhaust air**

Pressure drop, dimensioning	107 Pa
Air temperature	23 / 9,4 °C
Relative humidity	50 / 92,9 %



**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320371	
Unit	7 () /	2013-08-29
Size	011	Page 3

**Plenum fan Centriflow Plus**

Unit size : 011  
 Fan size : 2  
 Equipment: normal + pressure tapping for air flow measurement  
 Anti-vibration mountings : rubber  
 Position inside the casing : supply air  
 Outlet direction : forward, to duct (rectangular)  
 Material : galvanized sheet steel  
 Inspection side: right

**Dimensioning data**

Speed	2154 Rpm
Fan efficiency	71,9 %
Total efficiency	55,3 %
Pressure rise, dimensioning	461 Pa
Fan shaft power at dim. data	0,662 kW
Grid Power	0,86 kW
Temperature rise	0,7 °C

**SFP Calculation**

Grid power according to SFP	0,739 kW
Pressure rise	405 Pa
Speed	2037 Rpm

**Centriflow Plus Fan Unit + Motor**

Wheel diameter: 035  
 Number of poles: 4  
 Rated output: 00110  
 Motor type: Fläkt Woods Asynchronous  
 Voltage: 220 – 240 VD / 380 – 420 VY  
 Brand: Fläkt Woods  
 Version: 2011

**Single-speed motor**

Voltage: 220-240 V delta, 380-420 V star, 220 V delta, 380 V star  
 Temperature sensors in stator winding: with thermistor  
 Design variant: FläktWoods IE2

Efficiency	81,4 %
Speed	1435 Rpm
Motor output	1,1 kW
Electric current	2,5 A
Number of Poles	4
Output margin, minimum	10 %

**Frequency converter**

Efficiency	94,5 %
Operating frequency	75 Hz
Max frequency at frequency control	86,9 Hz
Max speed at frequency control	2493 Rpm

**Motor accessories**

Motor: 1-Speed  
 Motor control: Mounted frequency converter  
 Type: Standard  
 Length: 100  
 Power supply: 3x400 VAC

**Protective screen door (for EQL(R,K) internal mounted motor)**

Unit size : 011  
 Fan type: Plenum fan (EQLK)  
 Material: galvanized sheet steel  
 Version number: version 2



**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320371	
Unit	7 () /	2013-08-29
Size	011	Page 4

**EXHAUST AIR**

**End connection frame**

Pressure drop, dimensioning 4 Pa

**Casing end wall**

**Damper**

Width cm : 080  
Height in cm : 040  
Tightness class : CEN 3  
Connection: slip joint (PG)  
Function : exhaust air  
Location: externally end wall  
Damper type: 200 mm blade  
Material : galvanized sheet steel

**Filter**

Unit size : 011  
Filter class : F7  
Filter type : glass fibre, standard  
Filter length : Long bag (vertical pockets only)  
Filter frame : plastic  
Connection side : inlet in end wall  
Location: negative pressure  
Material: galvanized sheet steel  
Inspection side : left  
Number of filters 2x492x492  
Pressure drop, start 53 Pa  
Pressure drop, dimensioning 103 Pa  
Pressure drop, end 153 Pa  
Face area 0,5 m<sup>2</sup>  
Face velocity 1,9 m/s





**AIR HANDLING UNIT eQ**

Project	4041 () / Takeda Canteen	2.7.130829.1
AOC	ACON-01320371	
Unit	7 () /	2013-08-29
Size	011	Page 5

**Plenum fan Centriflow Plus**

Unit size : 011  
 Fan size : 2  
 Equipment: normal + pressure tapping for air flow measurement  
 Anti-vibration mountings : rubber  
 Position inside the casing : exhaust air  
 Outlet direction : forward, to duct (rectangular)  
 Material : galvanized sheet steel  
 Inspection side: left

**Dimensioning data**

Speed	2046 Rpm
Fan efficiency	72,2 %
Total efficiency	55,5 %
Pressure rise, dimensioning	431 Pa
Fan shaft power at dim. data	0,577 kW
Grid Power	0,751 kW
Temperature rise	0,6 °C

**SFP Calculation**

Grid power according to SFP	0,657 kW
Pressure rise	379 Pa
Speed	1956 Rpm

**Centriflow Plus Fan Unit + Motor**

Wheel diameter: 035  
 Number of poles: 4  
 Rated output: 00110  
 Motor type: Fläkt Woods Asynchronous  
 Voltage: 220 – 240 VD / 380 – 420 VY  
 Brand: Fläkt Woods  
 Version: 2011

**Single-speed motor**

Voltage: 220-240 V delta, 380-420 V star, 220 V delta, 380 V star  
 Temperature sensors in stator winding: with thermistor  
 Design variant: FläktWoods IE2  
 Efficiency 81,4 %  
 Speed 1435 Rpm  
 Motor output 1,1 kW  
 Electric current 2,5 A  
 Number of Poles 4  
 Output margin, minimum 10 %

**Frequency converter**

Efficiency	94,5 %
Operating frequency	71 Hz
Max frequency at frequency control	86,5 Hz
Max speed at frequency control	2481 Rpm

**Motor accessories**

Motor: 1-Speed  
 Motor control: Mounted frequency converter  
 Type: Standard  
 Length: 100  
 Power supply: 3x400 VAC

**Protective screen door (for EQL(R,K) internal mounted motor)**

Unit size : 011  
 Fan type: Plenum fan (EQLK)  
 Material: galvanized sheet steel  
 Version number: version 2

**Appendix E – CHP Data Sheet**

**NATURAL GAS CHP RANGE**

Product Reference	Electrical Output kW <sub>e</sub>	Engine Manufacturer	Engine Type	Aspiration Type	Output Brake kW <sub>b</sub>	Output Jacket Coolant kW <sub>th</sub>	Output Exhaust kW <sub>th</sub>	Total Heat Output kW <sub>th</sub>	Fuel Input (LHV) kW	Fuel Input (HHV) kW	Max Return Operating Temp °C	Generator Type	Generator Efficiency %	Overall Unit Efficiency (LHV) %	
ENER-G 4	4	Yanmar	-	Natural	-	-	-	8	15	16	55	-	TBC	84.8	
ENER-G 10	10	Yanmar	3GPF88-C	Natural	-	-	-	17	32	36	68	-	TBC	84.5	
ENER-G 25	25	Yanmar	4GPF98-C1	Natural	-	-	-	38	75	82	75	-	TBC	85.2	
ENER-G 35	35	MAN	E0834 E302	Natural	38	38	23	61	111	123	80	UCI224G	92.8	87.2	
ENER-G 50	50	MAN	E0834 E302	Natural	54	46	33	79	148	164	80	UCI224G	92.6	87.4	
ENER-G 70	70	MAN	E0836 E302	Natural	74	63	46	109	204	226	80	UCI274E	94.1	87.7	
ENER-G 90	90	ENER-G	EGE-06L	Natural	95	110	51	161	278	308	80	UCI274H	94.9	90.2	
ENER-G 100	100	ENER-G	EGE-06L	Natural	105	116	56	172	303	335	80	UCI274H	95.0	90.0	
ENER-G 110	110	ENER-G	EGE-06L	Natural	116	122	62	184	327	362	80	UCI274H	95.0	90.0	
ENER-G 125	124	ENER-G	EGE-06L	Natural	130	131	69	200	361	399	80	UCI274H	95.0	89.7	
ENER-G 135	135	MWB	EGE-08V	Natural	143	146	71	217	392	434	80	UCDI274K	94.6	90.1	
ENER-G 150	152	MWB	EGE-08V	Natural	160	156	80	236	432	478	80	UCDI274K	94.7	89.8	
ENER-G 165	165	ENER-G	EGE-12V	Natural	173	197	88	286	497	550	80	HCI444E	95.4	90.8	
ENER-G 185	185	ENER-G	EGE-12V	Natural	194	210	99	309	545	603	80	HCI444E	95.5	90.8	
ENER-G 210	210	ENER-G	EGE-12V	Natural	220	226	111	337	604	669	80	HCI444E	95.5	90.7	
ENER-G 230	229	ENER-G	EGE-12V	Natural	240	237	121	358	649	718	80	HCI444E	95.4	90.6	
ENER-G 310	310	Perkins	4006-23 TRS1	Turbocharged	322	152	205	357	820	907	80	HCI544E	96.2	81.4	
ENER-G 375	378	Perkins	4006-23 TRS2	Turbocharged	393	162	239	401	978	1082	80	HCI544E	96.3	79.8	
ENER-G 425	430	Perkins	4008-30 TRS1	Turbocharged	447	189	279	468	1119	1238	80	HCI544E	96.2	80.4	
ENER-G 500	505	Perkins	4008-30 TRS2	Turbocharged	526	211	316	527	1298	1436	80	HCI634G	96.1	79.6	
ENER-G 770	770	MTU	AoE 8V4000L62	Turbocharged	800	434	438	872	1883	2083	78	TBC	96.2	87.3	
ENER-G 850	847	MTU	AoE 8V4000L63	Turbocharged	880	483	465	948	2054	2272	78	TBC	96.2	87.5	
ENER-G 1060	1060	Jenbacher	JMS 320 GS-N.L.	Turbocharged	1095	666	542	1208	2605	2881	70	TBC	96.8	87.2	
ENER-G 1150	1150	Caterpillar	G3516B LE	Turbocharged	1208	586	842	1428	2956	3280	80	TBC	95.2	87.0	
ENER-G 1160	1163	MTU	AoE 12V4000L62	Turbocharged	1200	660	643	1303	2822	3121	78	TBC	96.9	87.5	
ENER-G 1190	1190	Jenbacher	JMS 416 GS-N.L.	Turbocharged	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC
ENER-G 1560	1557	MTU	AoE 16V4000L62	Turbocharged	1600	872	847	1719	3765	4164	78	TBC	97.3	87.1	
ENER-G 1600	1600	Caterpillar	G3516E	Turbocharged	TBC	TBC	TBC	TBC	TBC	TBC	80	TBC	TBC	TBC	TBC
ENER-G 1710	1707	MTU	AoE 16V4000L63	Turbocharged	1760	979	900	1879	4121	4558	78	TBC	97.0	87.2	
ENER-G 1950	1942	MTU	AoE 20V4000L62	Turbocharged	2000	1078	1078	2156	4685	5182	78	TBC	97.1	87.6	
ENER-G 2000L	2000	Jenbacher	JMS 612 GS-N.L.	Turbocharged	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC
ENER-G 2000C	2000	Caterpillar	G3520E	Turbocharged	2070	1017	TBC	TBC	TBC	4761	80	TBC	TBC	TBC	TBC
ENER-G 2150	2138	MTU	AoE 20V4000L63	Turbocharged	2200	1210	1150	2360	5139	5684	78	TBC	97.2	87.7	
ENER-G 2680	2680	Jenbacher	JMS 616 GS-N.L.	Turbocharged	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC

# Appendix F - Vayu Quote

## Indicative Pricing Schedule for:

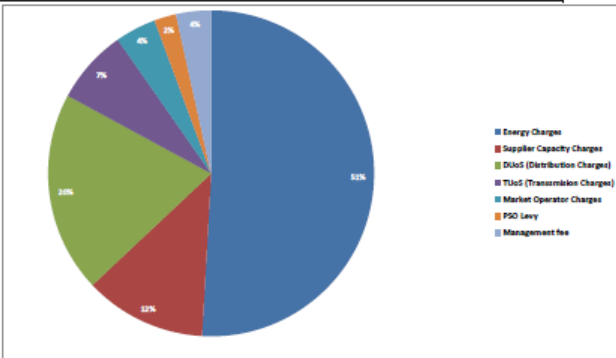
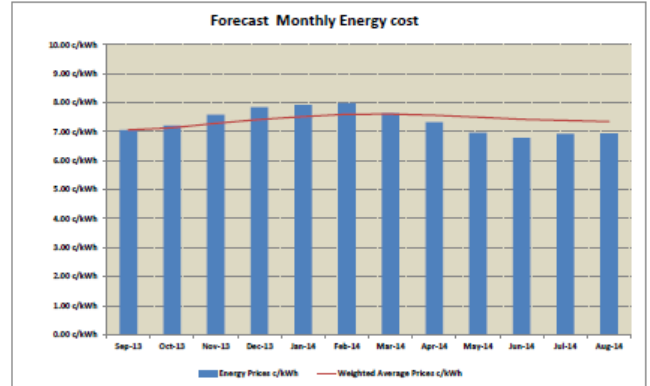
Sports Complex Tallaght Community

### 1. Summary of Charges

Charges	Total €	Unit Price c/kWh
Energy Charges	€18,700	7.35 c/kWh
Supplier Capacity Charges	€3,870	1.76 c/kWh
DUoS (Distribution Charges)	€5,636	2.88 c/kWh
TUoS (Transmission Charges)	€2,427	1.07 c/kWh
Market Operator Charges	€1,533	0.69 c/kWh
PSO Levy	€713	0.31 c/kWh
Management fee	€1,137	0.60 c/kWh
<b>Total</b>	<b>€32,816</b>	<b>14.44 c/kWh</b>

#### GENERAL INFORMATION

DUoS CATEGORY	DOB
MIC	60 KVA
CONNECTION VOLTAGE	LV
NETWORK CHARGING CAPACITY 80% MIC	0.048 MWh
VAYU MANAGEMENT FEE	0.60 c/kWh
CUSTOMER NAME	Sports Complex Tallaght Community
MPRN	10000037487



PRIVATE AND CONFIDENTIAL CUSTOMER USE ONLY

### 2. Detail of Charges

INDICATIVE PRICING SCHEDULE	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Total
<b>DUoS (Distribution Charges)</b>	<b>€535</b>	<b>€601</b>	<b>€551</b>	<b>€554</b>	<b>€567</b>	<b>€533</b>	<b>€564</b>	<b>€505</b>	<b>€545</b>	<b>€511</b>	<b>€547</b>	<b>€523</b>	<b>€6,535</b>
(a) Standing Charge	€07	€07	€07	€07	€07	€07	€07	€07	€07	€07	€07	€07	€800
(b) Capacity Charge	€150	€150	€150	€150	€150	€150	€150	€150	€150	€150	€150	€150	€1,800
(c) Unit Rates	€317	€383	€334	€336	€349	€315	€346	€287	€327	€294	€329	€305	€3,924
Day	€301	€363	€317	€320	€332	€302	€320	€274	€311	€278	€313	€289	€3,728
Night	€16	€20	€17	€16	€18	€14	€17	€13	€16	€16	€17	€16	€197
<b>TUoS (Transmission Charges)</b>	<b>€196</b>	<b>€239</b>	<b>€207</b>	<b>€207</b>	<b>€216</b>	<b>€191</b>	<b>€214</b>	<b>€176</b>	<b>€202</b>	<b>€185</b>	<b>€204</b>	<b>€191</b>	<b>€2,427</b>
(a) Network Capacity Charge	€09	€83	€73	€73	€76	€09	€75	€03	€71	€64	€72	€66	€853
(b) Network Transfer Charge	€47	€58	€50	€49	€52	€45	€52	€42	€49	€45	€49	€46	€584
(c) System Services Charge	€77	€94	€81	€80	€85	€73	€84	€68	€79	€73	€80	€75	€948
(d) DSM Charge	€3	€4	€4	€4	€4	€3	€4	€3	€4	€3	€4	€3	€42
<b>Market Operator Charges</b>	<b>€108</b>	<b>€132</b>	<b>€114</b>	<b>€113</b>	<b>€119</b>	<b>€103</b>	<b>€118</b>	<b>€96</b>	<b>€111</b>	<b>€103</b>	<b>€112</b>	<b>€106</b>	<b>€1,333</b>
(a) Variable Market Operator Charges	€14	€17	€15	€15	€15	€13	€15	€14	€14	€13	€14	€14	€172
(b) Imperfections Charges	€94	€115	€99	€98	€103	€90	€103	€83	€97	€90	€98	€92	€1,161
<b>Energy Charges</b>	<b>€1,296</b>	<b>€1,617</b>	<b>€1,468</b>	<b>€1,509</b>	<b>€1,603</b>	<b>€1,402</b>	<b>€1,535</b>	<b>€1,195</b>	<b>€1,318</b>	<b>€1,186</b>	<b>€1,321</b>	<b>€1,250</b>	<b>€16,700</b>
(a) Day Energy	€1,003	€1,272	€1,165	€1,209	€1,272	€1,123	€1,186	€940	€1,021	€896	€1,021	€951	€13,000
(b) Night Energy	€293	€345	€303	€300	€331	€280	€348	€255	€297	€290	€299	€299	€3,640
<b>Supplier Capacity Charges</b>	<b>€321</b>	<b>€392</b>	<b>€338</b>	<b>€336</b>	<b>€354</b>	<b>€307</b>	<b>€351</b>	<b>€285</b>	<b>€331</b>	<b>€306</b>	<b>€334</b>	<b>€315</b>	<b>€3,970</b>
<b>Management fee</b>	<b>€92</b>	<b>€112</b>	<b>€97</b>	<b>€96</b>	<b>€101</b>	<b>€88</b>	<b>€101</b>	<b>€82</b>	<b>€95</b>	<b>€88</b>	<b>€96</b>	<b>€90</b>	<b>€1,137</b>
<b>PSO Levy</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€59</b>	<b>€713</b>
<b>TOTAL</b>	<b>€2,607</b>	<b>€3,152</b>	<b>€2,834</b>	<b>€2,875</b>	<b>€3,020</b>	<b>€2,684</b>	<b>€2,942</b>	<b>€2,398</b>	<b>€2,661</b>	<b>€2,437</b>	<b>€2,672</b>	<b>€2,533</b>	<b>€32,815</b>
kWh (Day) 08:00-23:00	12,700 kWh	15,300 kWh	13,360 kWh	13,480 kWh	13,980 kWh	12,720 kWh	13,860 kWh	11,540 kWh	13,100 kWh	11,700 kWh	13,180 kWh	12,160 kWh	157,080 kWh
kWh (Night) 23:00-08:00	5,680 kWh	7,160 kWh	6,000 kWh	5,780 kWh	6,280 kWh	4,860 kWh	6,240 kWh	4,800 kWh	5,840 kWh	5,800 kWh	5,920 kWh	5,860 kWh	70,220 kWh
DAY UNIT RATE c/kWh	7.25 c/kWh	7.63 c/kWh	8.00 c/kWh	8.23 c/kWh	8.35 c/kWh	8.10 c/kWh	7.85 c/kWh	7.47 c/kWh	7.15 c/kWh	7.03 c/kWh	7.11 c/kWh	7.16 c/kWh	7.6 c/kWh
NIGHT UNIT RATE c/kWh	4.81 c/kWh	4.49 c/kWh	4.71 c/kWh	4.85 c/kWh	4.92 c/kWh	5.37 c/kWh	5.21 c/kWh	4.95 c/kWh	4.74 c/kWh	4.66 c/kWh	4.72 c/kWh	4.76 c/kWh	4.8 c/kWh

INDICATIVE PRICING SCHEDULE	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Total
<b>DUoS (Distribution Charges)</b>	<b>2.91 c/kWh</b>	<b>2.67 c/kWh</b>	<b>2.85 c/kWh</b>	<b>2.87 c/kWh</b>	<b>2.80 c/kWh</b>	<b>3.03 c/kWh</b>	<b>2.81 c/kWh</b>	<b>3.09 c/kWh</b>	<b>2.88 c/kWh</b>	<b>2.92 c/kWh</b>	<b>2.86 c/kWh</b>	<b>2.90 c/kWh</b>	<b>2.88 c/kWh</b>
(a) Standing Charge	0.37 c/kWh	0.30 c/kWh	0.35 c/kWh	0.35 c/kWh	0.33 c/kWh	0.38 c/kWh	0.33 c/kWh	0.41 c/kWh	0.35 c/kWh	0.38 c/kWh	0.35 c/kWh	0.37 c/kWh	0.35 c/kWh
(b) Capacity Charge	0.82 c/kWh	0.87 c/kWh	0.78 c/kWh	0.78 c/kWh	0.74 c/kWh	0.86 c/kWh	0.75 c/kWh	0.92 c/kWh	0.79 c/kWh	0.86 c/kWh	0.79 c/kWh	0.83 c/kWh	0.79 c/kWh
(c) Unit Rates	1.73 c/kWh	1.71 c/kWh	1.72 c/kWh	1.74 c/kWh	1.72 c/kWh	1.79 c/kWh	1.72 c/kWh	1.76 c/kWh	1.73 c/kWh	1.88 c/kWh	1.72 c/kWh	1.66 c/kWh	1.73 c/kWh
Day	1.64 c/kWh	1.62 c/kWh	1.64 c/kWh	1.66 c/kWh	1.64 c/kWh	1.72 c/kWh	1.64 c/kWh	1.68 c/kWh	1.64 c/kWh	1.59 c/kWh	1.64 c/kWh	1.60 c/kWh	1.64 c/kWh
Night	0.09 c/kWh	0.09 c/kWh	0.09 c/kWh	0.08 c/kWh	0.09 c/kWh	0.08 c/kWh	0.09 c/kWh	0.08 c/kWh	0.09 c/kWh	0.09 c/kWh	0.09 c/kWh	0.09 c/kWh	0.09 c/kWh
<b>TUoS (Transmission Charges)</b>	<b>1.07 c/kWh</b>	<b>1.06 c/kWh</b>	<b>1.07 c/kWh</b>	<b>1.07 c/kWh</b>	<b>1.07 c/kWh</b>	<b>1.09 c/kWh</b>	<b>1.07 c/kWh</b>	<b>1.08 c/kWh</b>	<b>1.07 c/kWh</b>	<b>1.05 c/kWh</b>	<b>1.07 c/kWh</b>	<b>1.06 c/kWh</b>	<b>1.07 c/kWh</b>
(a) Network Capacity Charge	0.38 c/kWh	0.37 c/kWh	0.37 c/kWh	0.38 c/kWh	0.37 c/kWh	0.39 c/kWh	0.37 c/kWh	0.38 c/kWh	0.38 c/kWh	0.36 c/kWh	0.37 c/kWh	0.37 c/kWh	0.38 c/kWh
(b) Network Transfer Charge	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh	0.26 c/kWh
(c) System Services Charge	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh	0.42 c/kWh
(d) DSM Charge	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh	0.02 c/kWh
<b>Market Operator Charges</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>	<b>0.59 c/kWh</b>
(a) Variable Market Operator Charges	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh	0.08 c/kWh
(b) Imperfections Charges	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh	0.51 c/kWh
<b>Energy Charges</b>	<b>7.05 c/kWh</b>	<b>7.20 c/kWh</b>	<b>7.58 c/kWh</b>	<b>7.84 c/kWh</b>	<b>7.91 c/kWh</b>	<b>7.98 c/kWh</b>	<b>7.63 c/kWh</b>	<b>7.31 c/kWh</b>	<b>6.96 c/kWh</b>	<b>6.78 c/kWh</b>	<b>6.91 c/kWh</b>	<b>6.94 c/kWh</b>	<b>7.35 c/kWh</b>
(a) Day Energy	7.90 c/kWh	8.31 c/kWh	8.72 c/kWh	8.97 c/kWh	9.10 c/kWh	8.83 c/kWh	8.66 c/kWh	8.14 c/kWh	7.79 c/kWh	7.66 c/kWh	7.75 c/kWh	7.82 c/kWh	8.31 c/kWh
(b) Night Energy	5.15 c/kWh	4.82 c/kWh	5.05 c/kWh	5.20 c/kWh	5.27 c/kWh	5.76 c/kWh	5.58 c/kWh	5.31 c/kWh	5.08 c/kWh	5.00 c/kWh	5.06 c/kWh	5.10 c/kWh	5.18 c/kWh
<b>Supplier Capacity Charges</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>	<b>1.75 c/kWh</b>
Management fee	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh	0.50 c/kWh
PSO Levy	0.32 c/kWh	0.26 c/kWh	0.31 c/kWh	0.31 c/kWh	0.29 c/kWh	0.34 c/kWh	0.30 c/kWh	0.36 c/kWh	0.31 c/kWh	0.34 c/kWh	0.31 c/kWh	0.33 c/kWh	0.31 c/kWh
<b>TOTAL</b>	<b>14.19 c/kWh</b>	<b>14.03 c/kWh</b>	<b>14.64 c/kWh</b>	<b>14.52 c/kWh</b>	<b>14.90 c/kWh</b>	<b>15.27 c/kWh</b>	<b>14.64 c/kWh</b>	<b>14.68 c/kWh</b>	<b>14.05 c/kWh</b>	<b>13.93 c/kWh</b>	<b>13.99 c/kWh</b>	<b>14.06 c/kWh</b>	<b>14.44 c/kWh</b>