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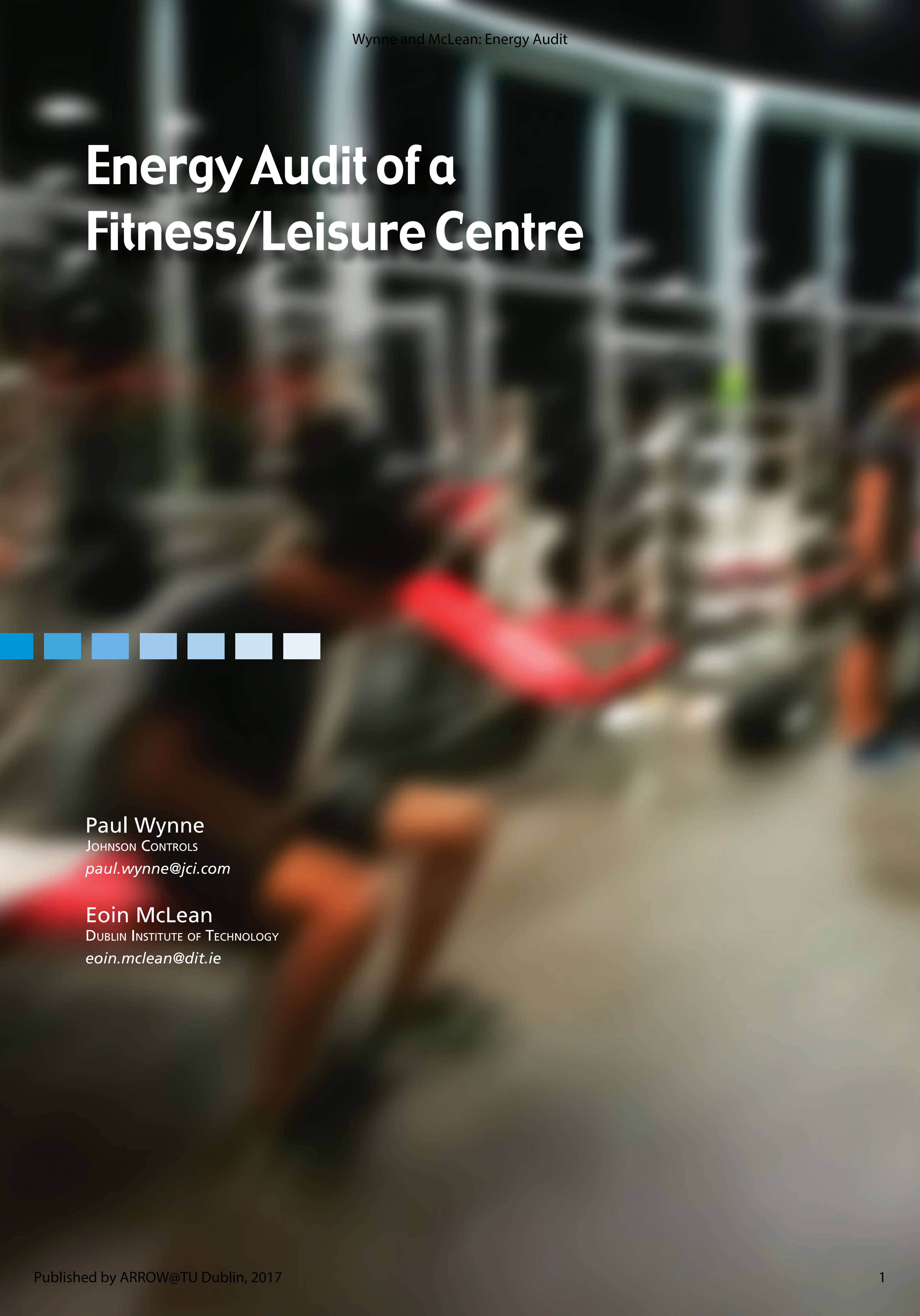

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Abstract

This paper aims to investigate the energy performance of a fitness/leisure centre. A detailed energy audit has been conducted to determine the energy consumption of the building. Through the collection and analysis of data, the energy performance and Energy Performance Indicators (EnPIs) have been identified. This research indicates that an energy audit can lead to identifying significant energy savings potential in a building. Energy saving opportunities have been identified with a potential to save 158,906kWh of electricity, 81,201kg of CO_2 and potentially saving up to €51,230 per annum. A combined heat and power (CHP) plant could yield savings of up to €28,522 annually. A lighting upgrade offers potential savings of 122,976kWh of electricity and €19,373 annually. Due to their high energy demand, commercial buildings have the potential for significant energy savings. The fitness centre was built in 2004 to a high standard and is a well maintained building. Nevertheless, this paper demonstrates the significant potential for energy reduction in buildings such as fitness centres.

Keywords

Energy audit, energy monitoring system, significant energy user.

Glossary

EMS *Energy Monitoring System*
EnPIs *Energy Performance Indicators*
HVAC *Heating Ventilation and Air Conditioning*
IEA *International Energy Agency*
kWh *Kilowatt hour*
SEAI *Sustainable Energy Authority Ireland*
SEU *Significant Energy User*

1. Introduction

Buildings represent the largest energy-consuming sector in the economy, accounting for over one-third of all final energy and half of global electricity consumed (IEA, 2013). As a result, buildings are also responsible for approximately one-third of global carbon emissions. With an expected population increase of 2.5 billion people by 2050, and given improvements in economic development and living standards, energy use in the buildings sector is set to rise sharply, placing additional pressure on energy availability (IEA, 2016).

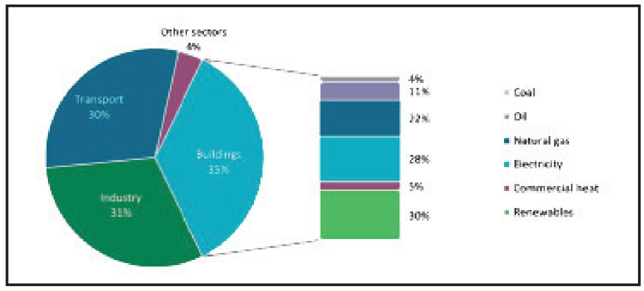

Figure 1. Final energy consumption by sector and buildings energy mix, 2010 *(IEA, 2013)*

Figure 1 indicates that buildings consumed 35% of final energy consumption in 2010 and electricity consumption made up 30% of this. Due to high losses in the generation and transmission of electricity, any savings in the building sector will translate into greater savings in primary energy use in the power sector, and a greater reduction in CO_2 emissions.

This research demonstrates that energy efficiency and low-carbon technologies can play a vital role in the energy revolution needed to bring about a reduction in our dependence on fossil fuels and reduce carbon emissions.

This paper will outline a structured approach to conducting an energy audit to the international standard ISO 50002. The key objectives of this paper are to:

- Identify and document all energy-consuming equipment in the building;
- Collect data from existing metering, utility bills and data loggers;
- Analyse data and breakdown consumption by use and source;
- Identify a historical pattern of energy performance;
- Identify Significant Energy Users (SEUs) and Energy Performance Indicators (EnPIs);
- Identify energy improvement opportunities;
- Evaluate and rank energy performance opportunities (ISO 50002, 2014).

2. Background

The fitness centre considered here was built in 2004 and has a total floor area of 2787m^2. The building is a lightweight, steel-framed structure with metal decking roof and side walls.

The ground floor includes the double height main swimming pool, reception, offices and changing areas. A cardio fitness theatre, aerobics studio, weights area and spinning studio are located on the first floor. The second floor has a performance lifting area, strength training area and weights area. The building also includes a basement underground carpark. The main facilities and areas are as follows:

- 25m stainless steel swimming pool;
- Jacuuzi;
- Male and female steam room and sauna;
- Fully equipped gymnasium;
- Cardio fitness theatre;
- Large aerobics studio;
- Spinning studio.

The international standard ISO 50002 specifies the principles governing carrying out of energy audits, the requirements for the common processes during energy audits, and the deliverables for energy audits. It includes a series of annexes that address different types of audits for industry, buildings, transportation and services. Audits include essential information on current energy use and performance and recommendations for improvements in a wide range of areas, including operational controls, maintenance controls, modifications and capital projects.

The energy audit process consists of the following stages, as illustrated in Figure 2:

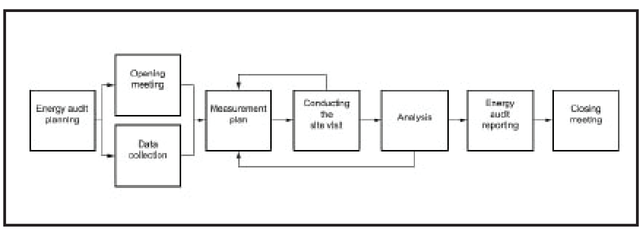

Figure 2. Figure 2: Energy audit process flow diagram. *(ISO 50002, 2014)*

The standard states that the content of the report shall be appropriate to the defined energy audit scope, boundaries and objectives of the energy audit.

3. Methodology

3.1 Scope of the audit

This report details the electrical and thermal energy-consuming equipment throughout the building. The report is aligned with the requirements and methods detailed in the Energy Efficiency Directive, EN-16247-2 Energy Audits-Buildings. The report also details the energy baseline and Energy Performance Indicators (EnPIs) to facilitate the measurement and verification.

3.2 Data collection

Energy data use has been obtained from the electricity bills and from the gas bills (daily data). A data logger was installed on the sauna/steam room distribution board. Sub-metering data was available on site through an energy monitoring system (EMS) and provided a breakdown of the electricity consumption into the following areas:

- MCC2 – air handling units;
- MCC3 – pool plant;
- Ground floor distribution board
- Air conditioning – Condenser No:1 and condenser No: 2, first floor;
- Main gas meter;
- Main water meter;
- DHW water meter.

3.3 Conducting the site visit

The author conducted site visits initially to document all energy-consuming systems and equipment in the building. The equipment was categorised into the following areas:

- HVAC equipment;
- Lighting;
- Other energy-using equipment.

Access to the as-built drawings and operation and maintenance manuals was provided by the manager which facilitated the equipment lists. Subsequent site visits were conducted to detail historical and current energy performance data. Access was provided to gas and electricity bills for 2014 – 2015 and to the EMS.

4. Energy Consumption

4.1 Energy use

Gas and electricity are the primary energy sources in the building with monthly bills generated from the gas and electricity meters on site. Table 1 summarises the gas and electricity usage for 2014 and 2015.

Table 1: Energy use

Leisure Centre – Energy Use				
	2014kWh/yr	2014k€/yr	2015kWh/yr	2015k€/yr
Gas	1,085,932	€48,359.39	1,170,274	€44,260.61
Electricity	662,538	€108,568.27	690,759	€111,067.88
Gas	**1,748,470**	**€156,927.66**	**1,861,033**	**€155,328.49**

The gas usage has remained relatively stable with an increase in 2015 of 7.8% compared to 2014. It can be seen from Table 1 that even though the gas consumption slightly increased, the annual cost reduced slightly. This was due to the manager moving to a new supplier and obtaining a better tariff near the end of 2014.

Figure 3 shows the total energy consumed in the building in 2015 was 1,861,033kWh and is made up of 63% gas consumption and 37% electricity.

Figure 4 indicates that electricity represents 72% of the annual energy cost but only consumes 37% of the energy.

Monthly electricity usage for 2014 and 2015, shown in Figure 5, displays consistent consumption with a slight increase over the summer months, indicating an increase in air conditioning (AC) use.

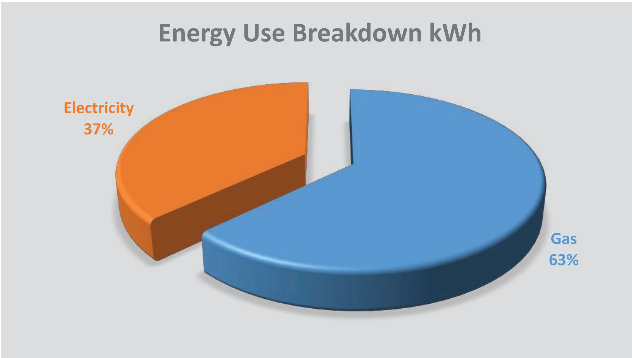

Figure 3. Energy use breakdown

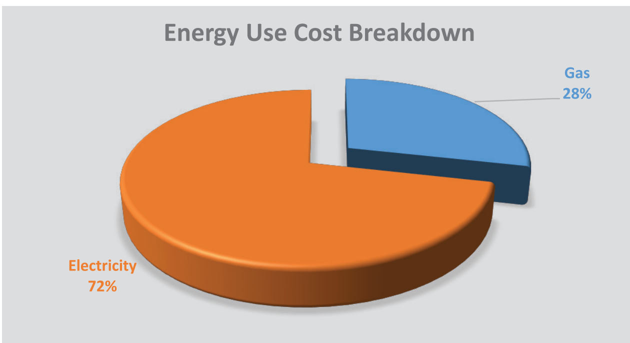

Figure 4. Energy use cost breakdown

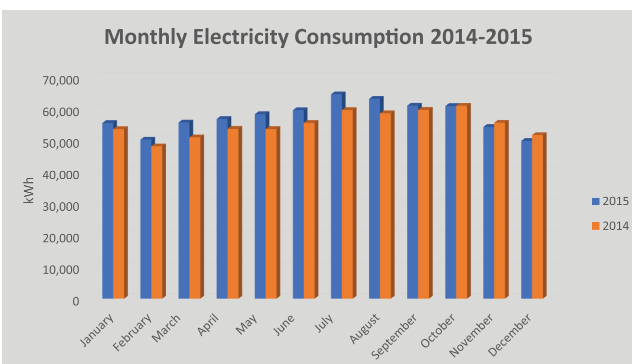

Figure 5. Monthly electricity consumption 2014 and 2015

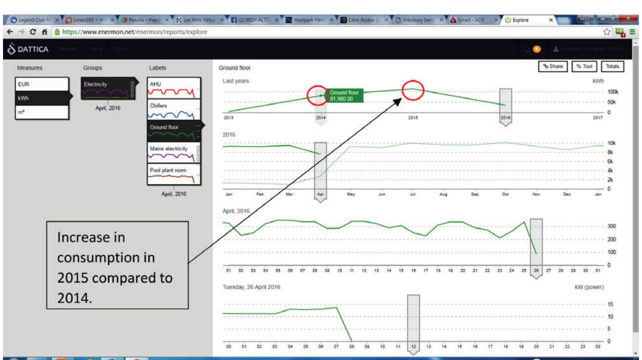

Figure 6. Increase in consumption on the ground floor distribution board

Through the data analysis it was found that the increase in electricity consumption was due to a marked increase in consumption on the ground floor distribution board in 2014. The average daily consumption up to 24/04/2014 was 38kWh. From 25/04/2014 to 31/12/2015 the average daily consumption was 308kWh.

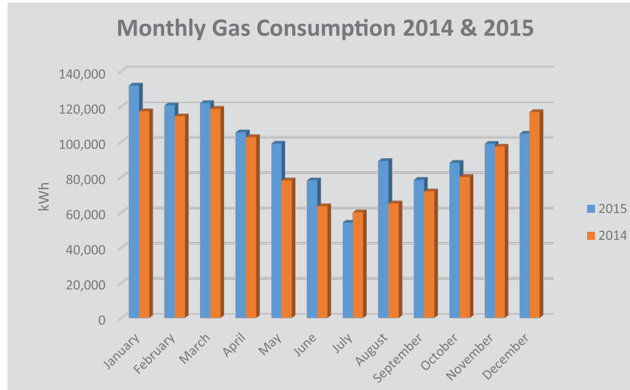

Figure 7. Monthly gas consumption 2014 and 2015

Figure 6 is a screenshot from the EMS which shows the increase in consumption on the distribution board from 2014 to 2015. This was discussed with the building manager but he was not aware of any reason to explain this sudden increase. It is possible during an AC maintenance visit a previously not working piece of equipment was repaired. This situation highlights the importance of continuous energy monitoring.

Monthly gas consumption for 2014 and 2015 in Figure 7 displays reasonable consistent consumption with the exception of August 2015. There is no obvious explanation for the increase in consumption in August. It could be expected that there might have been an increase in visitor numbers, which in turn would increase hot water consumption, but this is not the case as visitor numbers were lower than in July.

4.2 Data collection and sources

The gas and electricity consumption data was collected from the supplier's bills for 2014 and 2015 and was obtained from the fitness/leisure centre manager. A breakdown of electricity consumption was obtained from the EMS. The weather data (degree days) was obtained from the website degreesdays.net. Data relating to visitor numbers, opening hours and operating times were obtained from the manager. A datalogger was installed on the sauna/steamroom and an ammeter was used to estimate the loads of all other unmetered loads at the main distribution board.

4.3 Metering arrangements

The building contains an EMS, which measures the following areas:

- Ground floor distribution board;
- Air conditioning;
- MCC-02 Air handling units;
- Pool plant room control panel;
- Main electricity incomer;
- Main gas meter;
- Main water meter;
- DHW water meter.

The system is viewed on the manager's PC and allows access to live and historical consumption data. The system allows the manager to monitor the electricity and gas consumption and to compare each month.

Table 2: Main Distribution Board			
MCCB No.	Description	Metered kWh	Estimated kWh
1	AC Condenser No.2 First FLoor	49,345	
2	Lettable Unit 2: Lads Lounge		34,538
3	Sauna and Steam Rooms		70,237
4	PFC		No Load
5	AC Condenser No.1 First FLoor	Incl in No.1	
6	Fire Alarm		No Load
7	Spare		
8	Basement DIstribution Board		70,605
9	MCC-01 Boilerhouse		34,538
10	MCC-02 AHUs	58,836	
11	MCC-03 Pool Plantroom	57,830	
12	First Floor DIstribution Board		96,706
13	Ground Floor DIstribution Board	114,725	
14	Second Floor DIstribution Board		34,538
15	Lift		13,815
16	Lettable Unit 1: Cafe		55,260
Total	**Actual Electricty Consumption 690,759kWh**	**280,535**	**410,237**

4.4 Breakdown of energy use

Using the data available from the EMS for 2015, it can be seen that the total electricity consumption from the four sub-metered areas – ground floor distribution board, MCC-02 air handling units, MCC-03 pool plantroom and the air conditioning – totalled 280,535kWh out of a total of 690,759kWh. This figure only accounts for 41.0% of electricity consumption in 2015. The building manager was not aware of this and was surprised to discover the extent of the energy consumption missing. The main distribution board is located in the basement switch room. Table 2 details the circuits and the metered totals and the estimated totals for 2015. An ammeter was used to estimate the loads on all the unmetered circuits.

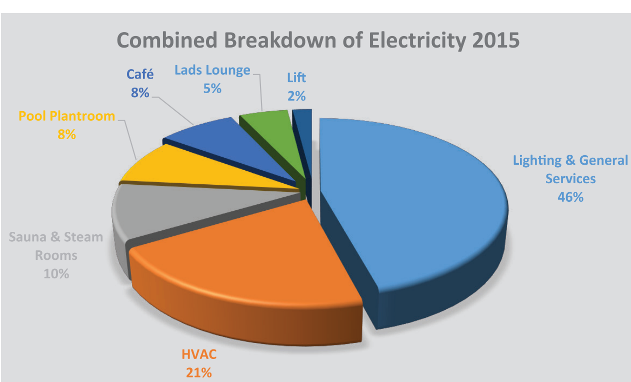

Figure 8. Categorised breakdown of electricity 2015

Figure 8 groups together the circuits from Table 2 into appropriate categories, i.e. AC, AHUs and MCC-01 into HVAC, and the distribution boards into lighting and general services.Figure 8 indicates that one of the significant energy users is the sauna/steam room, consuming an estimated 10% of the annual total. The combined HVAC total consumes 21% and the pool plantroom consumes 8%. The lighting and general services for the building accounts for 46% of the total.

There are AC condenser units fitted in the basement car park which, in all probability, are connected to the basement distribution board.

Table 3: Sauna and steam room daily consumption				
Sauna and Steam Room	kWh (L1)	kWh (L2)	kWh (L3)	Total kWh
06/03/2016	30	74	50	154
07/03/2016	39	107	72	218
08/03/2016	35	110	69	214
09/03/2016	37	108	67	212
10/03/2016	36	108	69	212
11/03/2016	34	102	63	198
12/03/2016	24	74	46	144

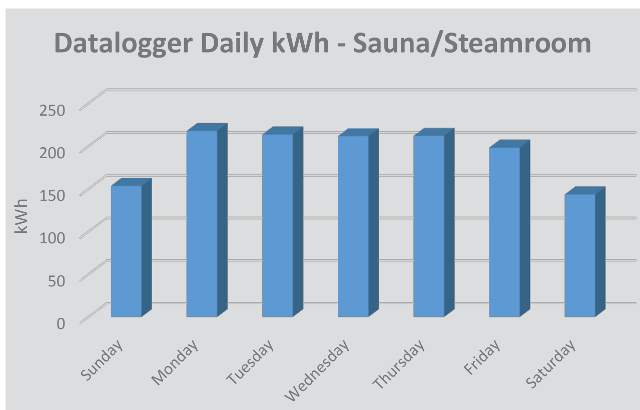

Figure 9. Datalogger daily kWh for the sauna/steam room

This is leading to a misrepresentation of the energy readings on the EMS as it is not accounting for a sizeable AC load.

4.5 Significant energy user

The data obtained from the data logger installed on site to measure the electricity consumption of the sauna/steam room distribution board is detailed in Table 3. The total consumption recorded for the week beginning the 06/03/2015 was 1,351kWh, and the annual consumption is estimated to be 70,237kWh, (1,351 x 52weeks).

Figure 9 shows the daily electricity consumption obtained from the data logger. The load is consistent during the week and drops off at the weekend due to shorter opening hours. The sauna and steam room distribution board consumes an estimated 10% of the total annual energy.

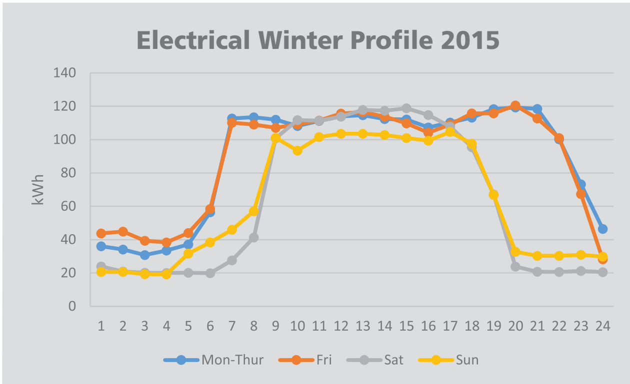

Figure 10. Winter weekly profile 2015.

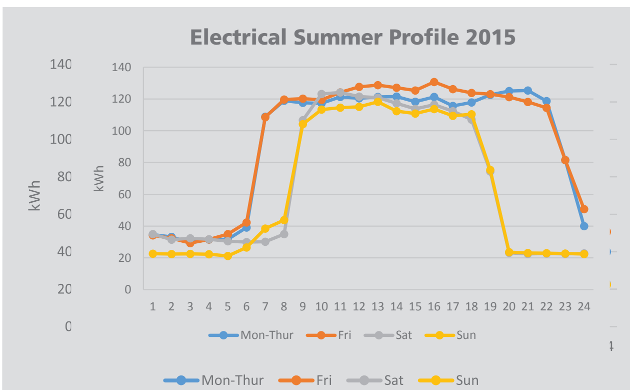

Figure 11. Summer weekly profile 2015.

4.6 Profile of energy consumption

Figure 10 shows the main incoming load profile for the week beginning 02/11/2015 for different opening hours. It can be seen that the overall load ramps up steeply when the main plant is switched on at 05.30 and plateaus during the day at a consistent 120kWh. The longer opening hours from Monday to Friday are easily identified on the graph. Figure 11 shows the summer profile for the week beginning 06/04/2015 and follows a similar pattern to the winter.

5. Analysis and baseline

There is a large thermal demand for the swimming pool, space heating and hot water. The parameter "degree days" will affect the energy use, as a lower outside temperature will increase heat loss and requires more energy to warm up the building and the swimming pool. The indicator "opening hours" will also affect the energy use.

The following independent variables are used to analyse the variation of the energy use for 2014 and 2015 and to derive Energy Performance Indicators (EnPIs):

- Degree days base 15.5°C;
- Opening hours;
- Number of visitors.

5.1 Analysis of gas consumption

The gas consumption is compared to degree days (base 15.5°C) for 2014 and 2015. An XY scatter diagram was gen-erated with the degree days on the x axis and the gas con-sumption on the y axis, as shown in Figure 12 and Figure 13. By adding a trendline, it can

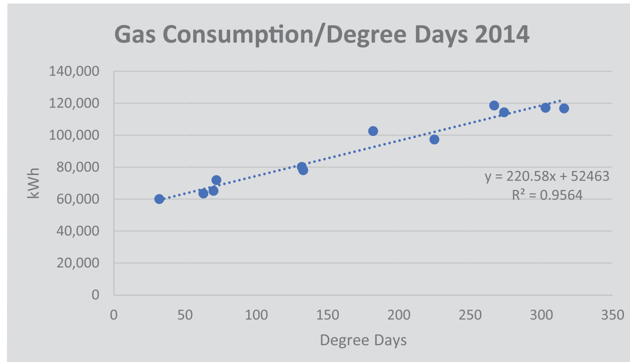

Figure 12. Gas consumption/degree days 2014.

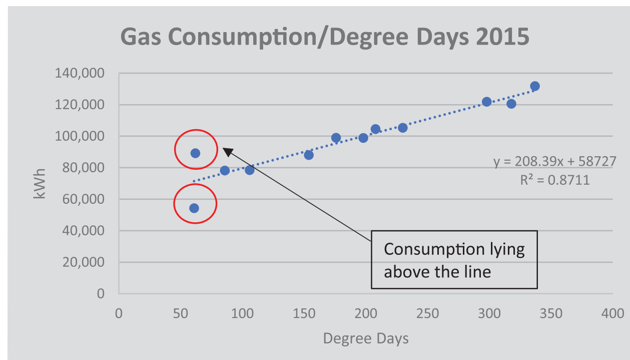

Figure 13. Gas consumption/degree days 2015.

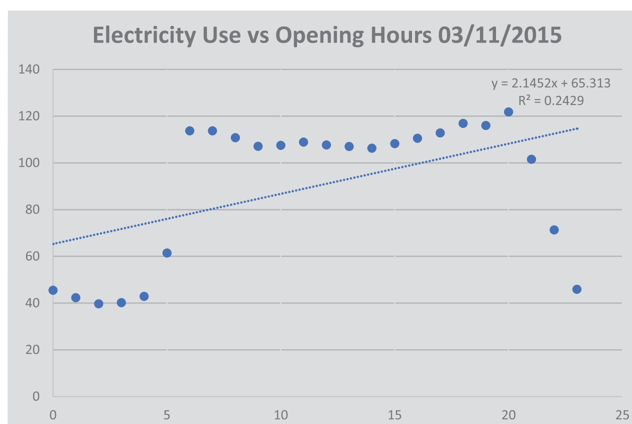

Figure 14. Electricity use vs opening hours.

be seen that when the monthly values are plotted, they fit close to the line. There is very good correlation for both years, with a better correlation in 2014 with an R2 value of 0.9564 compared to 0.8711 for 2015.

In 2014, the equation of the line: $y = 220.58x + 54263$ gives the base load of the building as 52,463kWh month and states that for every increase of one degree day that another 220.58kWh of gas will be consumed.

In 2015, the equation of the line: $y = 2208.39x + 58727$ gives the base load of the building as 52,463kWh month and states that for every increase of one degree day that another 220.58kWh of gas will be consumed. As can be seen from Figure 14, two months fall outside the line. Less gas than expected was used in July while in August more gas than expected was used. This issue was discussed with the building manager but there

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Table 4: Proposed energy efficiency measures

	Measure	Potential Electricity Saved kWh/Yr	Potential Carbon Saved kg Co_2/kWh	Approx. Installed Cost €	Potential Cost Savings €/Yr	Approx. Payback Period	Comments
LCM 1	Install VSDs on pool AHU	8,102	4,140	€1,200	€1,328	1.0	
LCM 2	Preheat water to steamroom	2,512	1,284	€450	€412	1.2	Based on 414 litres per week of water usage per generator
LCM 3	Upgrade pool heating pump-set	25,316	12,936	€2,200	€1,5952	2.0	Based on upgrade and pressure sensor installation
HCM 1	CHP option 1 GG70 CHP option 2 GG50	– –	– –	€125,000 €116,000	€41,958 €28,522	2.6 3.6	Based on 5,200 hours pa Based on 5,200 hours pa
HCM 2	LED lighting upgrade	122,976	62,841	€42,864	€19,373	2.2	

was no obvious reason he knew of for the unexpected gas usage. The manager has had ongoing issues with two of the four boilers and is in the process of installing two new condensing boilers.

5.2 Analysis of electricity consumption

There is no clear correlation between electricity consumption and the three independent variables.

Figure 14 shows the relationship between the electricity use and the opening hours based on daily usage recorded on the 03/11/2015. The figure indicates poor correlation between electricity use and opening hours.

6. Opportunities for improving energy performance

The following is a discussion of the main opportunities for energy efficiency improvement, together with estimated costs, savings and payback periods. The opportunities in Table 4 are divided into two categories:

I. Low Cost Measures (LCM)
II. High Cost Measures (HCM)

6.1 Accelerated capital allowance (ACA)

The ACA is a corporate tax reduction incentive. It works as follows:

- A company purchases a product;
- In the accounting year of the product purchase, that product is listed as eligible for the ACA;
- When filing the corporation tax return for the year of product purchase, taxable income is reduced by the full amount of the product purchase.

The project can avail of the ACA on proposed energy efficient measures totaling €162,714.

6.2 Combined heat and power (CHP)

CHP is a highly efficient energy solution that is suitable for buildings with a high thermal load. CHP is the simultaneous generation of usable heat and electricity in a single process. It can reach efficiencies in excess of 85% due to utilisation of heat from electricity generation and the avoidance of transmission losses because electricity is generated onsite.

Bills analysis – gas

The gas consumption and unit costs for 2015 were calculated and the average hourly gas consumption over 24 hours was 133kWh, and the average unit rate was 3.83c/kWh. Assuming that the efficiency of the boilers is 80%, then the average annual heat load is calculated at 107kWth. Therefore, a CHP of approximately 90/110kWth output is appropriately sized for this installation.

Bills analysis – electricity

The daytime base loads and unit costs were calculated for 2015. The average cost per daytime unit, including all transmission and service charges, was €0.164. For the basis of the CHP selection, a unit of 90kWe would be suitable.

CHP selection

The optimal electrical CHP size is 90kW and a thermal demand of approximately 90/110 kWh. Based on the available Sokatherm CHP units, the best fit is the GG70. This provides 71kWe and 114 kWth, with an overall efficiency of 90.7%.

Additionally, this would comply with the SEAI definition of high efficiency CHP (i.e. >75%) and would allow the fitness centre to claim back an annual carbon rebate of €3,278.

Economic Analysis 1 – CHP based on existing data

The CHP unit specified is a Sokatherm GG70. If the unit was owned outright, then the figures obtained from Tables 5a and 5b are as follows:

- Capital cost €125,000
- Annual saving €41,958
- Carbon Tax Rebate €3,278
- ACA Capital Write-off €15,625
- Payback time 2.6 years
- Net benefit after 5 years €100,417 (includes initial capital cost incurred)

Economic Analysis 2 – CHP based on estimated data after the lighting upgrade

This economic analysis is based on the assumption that the lighting upgrade is installed before the purchase of the CHP. The lighting is estimated to save 122,976kWh annually. The CHP figures are average values of kWh in each month for day time units, which equates to 5,475 hours in a year. Therefore, the average saving with the lighting upgrade is (122,976/5,475) = 22.46kWh saving per month. This would reduce the lowest figure in February of 87.83kWh to (87.83 – 22.46) 65.37kWh. A CHP sized <65.37kWh would be suitable.

Based on the available Sokatherm CHP units, the best fit is the GG50. This provides 50kWe and 82 kWth, with an overall efficiency of 90.4%. If the unit was owned outright, then the figures are as follows:

Table 5a: CHP financial analysis 1

CHP Financial Analysis: GG70.			
	kWh	Cost €/kWh	Total €/kWh
Electricity displaced	71	0.164	€11.64
Boiler fuel displaced	114	0.038	
Boiler efficiency -80%		0.048	€5.46
		Savings sub-total	**€17.10**
CHP fuel cost	204	0.038	€7.81
Maintenance costs per hour run			€1.85
		Sub-total CHP costs	**€9.96**
Net benefit	Savings Sub-total	Sub-total CHP costs	Sub-total Savings
	€17.10	€9.66	€7.44
	Annual hours	Sub-total savings	
Annual savings	**5,200**	**€7.44**	**€38,680.46**

Table 6a: CHP Financial Analysis 2

CHP Financial Analysis: GG50.			
	kWh	Cost €/kWh	Total €/kWh
Electricity displaced	50	0.164	€8.20
Boiler fuel displaced	82	0.038	
Boiler efficiency -80%		0.048	€3.93
		Savings sub-total	**€12.13**
CHP fuel cost	146	0.038	€5.59
Maintenance costs per hour run			€1.50
		Sub-total CHP costs	**€7.09**
Net benefit	Savings Sub-total	Sub-total CHP costs	Sub-total Savings
	€12.13	€7.09	€5.03
	Annual hours	Sub-total savings	
Annual savings	**5,200**	**€503**	**€26,176.54**

Table 5b: CHP installation financial appraisal 1

CHP installation financial appraisal:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Expenditure						
CHP supply and commission	€97,000					
Integration cost estimate	€28,000					
Total expenditure	€125,000					
Savings		€38,680	€38,680	€38,680	€38,680	€38,680
Carbon rebate €0.00309/kWh gas	€0.00309	€3,278	€3,278	€3,278	€3,278	€3,278
Write-off	€15,625.00					
Total savings		€41,958	€41,958	€41,958	€41,958	€41,958
Net cash flow		€41,958	€41,958	€41,958	€41,958	€41,958
Cumulative cash flow	-€125,000	-€67,417	-€25,458	€16,500	€58,458	€100,417

Table 6b: CHP installation financial appraisal 2

CHP installation financial appraisal:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Expenditure						
CHP supply and commission	€88,000					
Integration cost estimate	€28,000					
Total expenditure	€116,000					
Savings		€26,177	€26,177	€26,177	€26,177	€26,177
Carbon rebate €0.00309/kWh gas	€0.00309	€2,346	€2,346	€2,346	€2,346	€2,346
ACA capital write-off	€14,500					
Total savings		€28,522	€28,522	€28,522	€28,522	€28,522
Net cash flow		€28,522	€28,522	€28,522	€28,522	€28,522
Cumulative cash flow	-€116,000	-€72,978	-€44,455	-€15,933	€12,933	€42,112

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- Capital cost €116,000
- Annual saving €28,522
- Carbon Tax Rebate €2,346
- ACA Capital Write-off €14,500
- Payback time 3.6 years
- Net benefit after 5 years €41,112 (includes initial capital cost incurred)

6.3 LED lighting

Lighting is estimated to account for over 20% of the total electricity consumed in the building. There are significant opportunities to realise energy savings through replacement of existing compact fluorescent fittings with new energy efficient LEDs.

Table 7: LED lighting financial appraisal

LED lighting financial appraisal:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Expenditure						
Investment	€42,864					
Annual costs						
Total expenditure	€42,864					
Savings		€19,373	€26,177	€26,177	€26,177	€26,177
ACA capital write-off	€5,358					
Total savings		€19,373	€19,373	€19,373	€19,373	€19,373
Net cash flow		€19,373	€19,373	€19,373	€19,373	€19,373
Cumulative cash flow	-€42.864	-€18,133	-€1,240	€20,613	€39,986	€59,359

The current lighting is estimated to consume 189,925kWh and costs €30,085 per annum. The proposed LED lighting is estimated to consume 66,949kWh and cost €10,712 per annum, resulting in energy savings of 122,976kWh per annum and financial savings of €19,373 per annum. The lighting analysis calculation used the average unit cost of electricity of €0.16.

The LED lighting upgrade estimated costs are as follows:

- LED fittings cost €36,364
- LED lighting installation €6,500
- Total capital cost €42,864
- ACA capital write-off €5,358
- Annual saving €19,373

Table 7 indicates a simple payback of 1.9 years with a cumulative cash flow at the end of year five of €59,359.

7. Summary

The detailed energy audit of the energy consumption has revealed that the electrical and gas consumption is in line with CIBSE benchmarks for similar buildings (CIBSE, 2012).

Figure 15 provides a breakdown of electricity consumption and

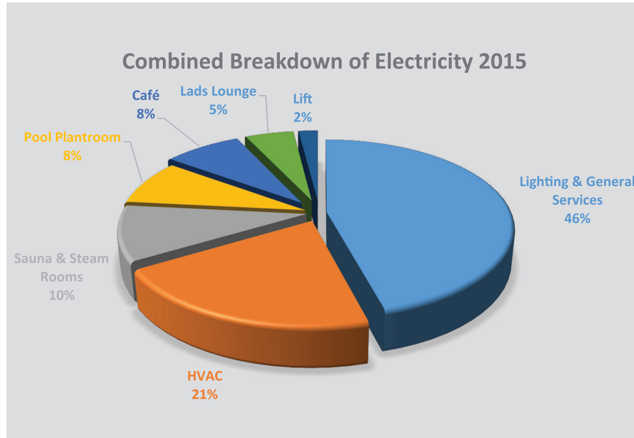

Figure 15. Categorised breakdown of electricity 2015

indicates that the lighting and general services distribution boards consume 46% of the total. HVAC accounts for 21% of the total consumption. The largest single energy user is the sauna and steam room distribution board, consuming 10% of the total.

The detailed energy audit has identified that significant energy saving potential exists. The installation of a CHP plant and a lighting upgrade to LED fittings would significantly reduce energy consumption. Installation of a CHP plant can potentially save between €41,958 and €28,522 annually, based on Option 1 or 2. A lighting upgrade can potentially lead to savings of 122,976kWh of electricity and €19,373 of savings annually.

It should be noted that these values are not cumulative. For example, if the CHP and lighting upgrade were installed, the total savings would not equal the two individual savings combined. The lighting upgrade would lower the annual electrical consumption which in turn would lower the performance of the CHP.

8. Conclusion

The energy saving opportunities identified in this paper identified a potential savings of 104,981kg CO_2 annually.

Buildings are complex and have numerous energy-consuming systems. For the specific building considered in this research, there are air conditioning and air handling units, low-pressure hot water boilers, instantaneous hot water generators, swimming pool plant, and a building management system. This research shows sub-metering and an EMS are critical to the efficient operation of a building. The onsite EMS was a valuable asset allowing access to accurate real data on the building.

9. Discussion and recommendations

This analysis suggests that providing the EMS to cover the sauna/steam room, the basement distribution board, the second-floor distribution board and the café would be beneficial. Expanding the EMS will allow greater capture of the total electricity consumption and will facilitate verification of savings in the future.

During discussions with the building manager, he mentioned that he finds it difficult to find time to review the data on the EMS. This highlights the difficulty in controlling energy usage in buildings when the manager's primary aim is obviously running the core business. It would seem, therefore, that such time constraints on managers/owners of SMEs (at least in the context of a fitness centre) represents an opportunity for energy engineers to provide solutions for cost-effective ways to continuously monitor energy and optimise energy consumption.

References

CIBSE, 2012. *Guide F: Energy Efficiency in Buildings*. [Online].

EPBD Implementation Group, 2012. Action Plan for the Implemenation in Ireland of EPBD Recast. [Online]

Available at: http://www.environ.ie/en/Publications/DevelopmentandHousing/BuildingStandards/FileDownLoad,31057,en.pdf. [Accessed 20 February 2016].

IEA, 2013. Transition to Sustainable Buildings - Strategies and Opportunities to 2050. [Online] Available at:https://www.iea.org/media/training/.../Sustainable_Buildings_2013.pdf [Accessed 6 February 2016].

ISO 50002, 2014. *Energy audits – Requirements with guidance for use,* Geneva: ISO.

ISO, 2015. Evolution of ISO 50001 Certificates in Ireland. [Online]

Available at: http://www.iso.org/iso/home/standards/certification/iso-survey.htm?certificate=ISO%2050001&countrycode=IE#standardpick [Accessed 10 February 2016].

SEAI, 2015. Annual Report 2015 on Public Sector Energy Efficiency Performance. [Online] Available at: http://www.seai.ie/Publications/Your_Business_Publications/Public_Sector/Annual-Report-2014-on-Public-Sector-Energy-Efficiency-Performance-.pdf [Accessed 28 February 2016].

Sokatherm, 2016. Sokatherm. [Online] Available at: http://www.sokratherm.de/htcms/en/our-compact-chp-units-1/50-kw-class-1.html [Accessed 26 April 2016].