Ore Valley Business Centre (Lochgelly)

Phase 2 study
In-use and post-occupancy

This document contains a Building Performance Evaluation report from the £8 million Building Performance Evaluation research programme funded by the Department of Business Innovation and Skills between 2010 and 2015. The report was originally published by InnovateUK and made available for public use via the building data exchange website hosted by InnovateUK until 2019. This website is now hosting the BPE reports as a research archive. Although no support or further information on the reports is available from the host, further information may be available from the original InnovateUK project evaluator using the link below[1].

InnovateUK project number	450088
Project author	ECD Architects for Fife HARCA
Report date	2014
[1]InnovateUK Evaluator	N/A

Building sector	Location	Type	Constructed
Commercial	Lochgelly, Fife	Tenanted offices	2011

Floor area	Storeys	EPC / DEC	BREEAM rating
1450 m^2 (GIA)	Four	N/A	N/A

Background to evaluation

The Ore Valley Business Centre Lochgelly Business Centre (also known as Lochgelly Business Centre) was designed as an energy efficient building which would be economical to run, as the commercial rent to tenants was to include all energy costs. The environmental design used the Termodeck ventilated hollowcore slab technique. The design team researched off-site fabrication and systems for quick assembly on site, with the then-innovative Thermalex system used. This was based on curtain-walling principles to speed on-site construction. The system was claimed to provide an air-tight solution without the need for any sealants.

Design energy assessment	In-use energy assessment	Electrical sub-meter breakdown
No	Yes	Yes

The CIBSE *TM22* analysis and comparison with CIBSE *TM46* and *ECON 19* benchmarks suggested that the building generally performed adequately. Gas use was 76.8 kWh/m^2 per annum. Electricity consumption was 36.5 kWh/m^2 per annum. This was close to the 'good practice' benchmark although the building was not fully occupied (*Pro-rata* estimate: 62.8 kWh/m^2 per annum). A whole building air test produced a result of 19.27 m^3 (m^2.h) with an air change rate of 6.53/h, results indicative of serious failures in the building fabric. A thermal imaging survey revealed both thermally strong and weak areas, at window/door and window/wall junctions, and to floor/wall junctions. Monitoring indicated that the building's heat up time, especially after a weekend, were insufficient to raise the space temperatures to comfortable levels for sedentary workers.

Occupant survey type	Survey sample	Structured interview
BUS	16 of 30 (53% response rate)	No

The BUS occupant satisfaction survey was carried out in October 2012. The summary of the main issues in the BUS survey indicated that the building scored well compared to the benchmarks of other buildings and the BUS scale midpoints. Thermal comfort perceptions were generally positive, although the temperature of the building was too cold for some users in winter. The heating in the reception area was a longstanding defect that had been difficult to resolve. The south-facing front façade gathered a noticeable solar heat gain in comparison to the rear façade. Overall comfort, building design and user needs all scored highly.

Technology Strategy Board
Driving Innovation

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Technology Strategy Board
Driving Innovation

1 Executive Summary

1.1 Concept

The Lochgelly Business Centre (also known as Ore Valley Business Centre) was conceived to encourage start up businesses in the economically deprived town of Lochgelly, Fife, Scotland. The hope was to develop an energy efficient building which would be economical to run, as the commercial rent to tenants was to include all energy costs. The building was competed and occupied in 2011.
It has been very well received by tenants and the local community, both in the way it operates internally and of the visual and economic statement it makes to the town.

1.2 Building Performance

1.2.1 U-values: The in-situ measurements of four wall constructions produced the following results for U-Values: Wall – Thermalex glass cladding (0.23); Rendered elevation (0.3); Tiled Elevation (0.36); and Kalwall cladding (0.56). A large proportion of the external walling therefore meets, or is close to meeting, the maximum allowable U-values of 0.27 W/m^2K for walls in the Scottish 2010 Building Regulations. The Thermalex performed in line with the manufacturer's claims, although the Kalwall did not meet its design U Value. See Section 4.1.1.

Walling U-values;	Design	In situ Test
Kalwall:	0.30 (manufacturer)	0.56 (tested)
Thermalex:	0.276 (manufacturer)	0.23 (tested)
Tiled Wall:	0.20 (calculated)	0.36 (tested)
Rendered Wall:	0.20 (calculated)	0.30 (tested)

1.2.2 Air Permeability: Tests for air permeability and air change rates were conducted for individual rooms, as well as for the entire building. The tests produced results under both negative and positive pressure, which showed that, although the individual rooms tested are well within the regulations, the overall shell failed to meet the regulations requirements. The 2010 building regulations require shell buildings to be designed to achieve a maximum air permeability of $7m^3/m^2.h$@ 50Pa. From 1st May 2011, air tightness testing was required on completion of the shell and again on completion of fit-out works. Windows and other shell fabric joints were well detailed to minimize cold bridging and air infiltration, but the execution and settlement may have produced weak points. A whole building air test produced a result of $19.27m^3/h/m^2$, with an air change rate of 6.53, with indications of serious failures in the building fabric. If air leakage testing had been carried out after completion and after fit-outs, as proposed in the regulations, it is possible the building would have met the requirements and/or minimal remedial works could have been undertaken to help meet the requirements. A serious leak had been detected in the basement and sections of the wall had been opened up for examination. This opening up has prevented an adequate whole building air permeability result, which merit retesting once remedial works are complete. Results from tests to individual rooms gave acceptable results. See section 4.1.2.

1.2.3 Thermal Imaging: In the context of thermal transmittance and air leakage, a thermal imaging survey revealed thermally strong, as well as weak areas, at window/door and window/wall junctions; and to floor/wall junctions. It also revealed thermal profiles/patterns of the TermoDeck and the Kalwall elements. Some of the weak leakage areas in the basement, windows and floor boxes could be remedied in the future for minimal costs. See section 4.1.3

1.2.4 Daylighting: Measurements of illumination and calculation of daylight factors were carried out in the large office in the ground floor (Room 7); a small office in the second floor (Room 15); and a medium office in the second floor (Room 19). The results showed that all the rooms evaluated meet the recommended Average Daylight Factor for general offices = 5%. While the small and medium offices meet the recommended Minimum Daylight Factor = 2%, the large office on the ground floor does not meet the recommendation. The daylight uniformity in the large room is quite poor – owing to the design and distribution of windows. Taller windows would improve the daylight factors at the back of the room, and wider or better distribution of the windows along the southern wall would give a better daylight distribution across the width of a room. Increasing the average reflectance of the interior at the back of the room would improve the daylight at the back and uniformity across the room. Refer to section 4.2

1.2.5 Internal environmental conditions: The external temperature and relative humidity and the internal temperature, relative humidity and CO_2 concentrations were monitored for a series of internal spaces. The winter periods of 2012/2013 and 2013/2014 were mild in comparison to a usual Scottish winter. The data indicated that the building heat up times, especially after a weekend were insufficient to raise the internal space temperatures to comfortable levels for sedentary workers. However, the rooms which were mostly affected by cooler space temperatures were predominately unoccupied rooms, which were not subject to internal heat gains from occupants and equipment. Unfortunately for the BPE study and for the building owner, these unoccupied rooms were never occupied for an extended period during the monitoring; it is therefore unknown how these rooms would perform thermally if they were continually occupied. It was of interest that the coolest occupied room was room 19, where the single occupant frequently complains of feeling cold and supplements space heating using an electric fan heater; this room was also found to be the leakiest room during airtightness testing. Boiler start times, (08:00 Mon.-Fri.) should be reviewed by the building owner, to ensure space temperature has reached comfortable temperatures prior to the building opening, particularly on a Monday morning. Overheating was restricted to the glazed conference room and should be addressed.
Internal relative humidity levels were found to be lower than 40% for more than 50% of the time. Sustained low relative humidity has a health impact to occupants; these include drying of nasal passages, heightened sense of smell, irritation of respiratory tract, irritated skin, dry eyes and can cause static shocks. This building, like most buildings in the UK, is free running for relative humidity. This means the mechanical ventilation system does not treat the moisture content of the air like a full air-conditioned system; so low relative humidity is unavoidable. The building owner should ensure that the building is kept free of dust, which may assist in reducing the symptoms of low relative humidity.
Generally, the internal CO_2 concentrations were found to be acceptable in most rooms. Two rooms were found to have high concentrations for extended periods through the year; these were room 3 and the conference room. Air extract flow measurements in the conference room and supply diffuser elsewhere in the building indicated poor performance, which indicates the systems were not adequately commissioned. Increased ventilation rates would assist in diluting CO_2 concentrations. The recommendation would be for the ventilation systems to be re-commissioned and consideration given to increasing RH. Refer to Section 6.

1.2.6 Occupancy: Since completion, tenant occupation has steadily grown, yet the 3 large offices remain unoccupied. This under occupation has implications on the building performance and economic viability of the operation.
The designed accommodation for each floor is 45 staff. For most of the year, on the ground floor, 3 cellular offices were occupied, and the other spaces were empty. The first and second floors had similar occupancy, namely; 3 cellular offices occupied and the fourth empty; 2 medium offices occupied; and the large open plan office in each remained empty. The two meeting rooms and conference room on the second floor are used intermittently by reservation.

1.2.7 Ventilation: This consists of a mixture of window opening, mechanical ventilation and the Swedish hollow core system TermoDeck, which serves as a means of ducting air through the building. TermoDeck tempers incoming fresh air all year round, by utilizing the thermal capacity of the structure. This permits pre-cooling air during the warm months and pre-heating air during the cold months, if necessary.Overheating in the Conference room was identified and examined in section 9.3. This is partly due to solar gain and to inadequate ventilation. It is recommended that shading be considered as well as a re-commissioning of the extract fans, which are not operating to manufacturer's specification, together with the potential of openable windows to reduce mechanical demand.

1.2.8 Termodeck: It is generally acknowledged that the Termodeck system has operated as designed with minimal maintenance. Minor amendments were required to the settings following Termodeck's monitoring report No 1.
It is also worth noting that the Termodeck system utilises heat gain from equipment and patrons, therefore the building will not be as efficient now as it will be when completely full. The smaller rooms are now fully occupied with only the 3 larger offices remaining empty. It is testament to the system that, despite the items above, the building has continued to operate on a consistent basis.

1.2.9 Energy Analysis: (refer to section 8)
1. Further investigation is required to reconcile the discrepancy between the overall and detailed meter readings. This may limit the ability to observe issues and to make improvements.

2. Lighting use is high. Study of out of hours occupation is recommended to establish that the lighting use reflects usage in evenings and weekends. The building would benefit from more extensive use of controls (user or automatic).
3. The Small Power readings appear small. Further investigation of the 'no sub meter' element is required to address this.
4. The common kitchen is under-utilised. Many tenants use their own kettles, microwaves, etc. This makes monitoring and control difficult. The multiplicity of tenants may encourage this practice.
5. A significant use of localised electrical heaters within tenant spaces has been noted. It appears that the heating controls may not reflect the extended hours of occupation. As a result, these heaters may be utilised out of hours.
6. The heating system seems reasonably successful, if not exceptionally so. However, without monitoring the Termodeck separately, it is difficult to assess this fully outwith any impact of the LTHW heating. It may be preferable to separate the energy requirements of each system in any future monitor regime.
7. The building consumes more energy than was envisioned. In addition to the thermally weak points identified by air-tightness tests and thermographic imaging, this could also be linked with the systems designs versus the current occupancy patterns. The systems for lighting and heating operate most of the time as if they were operating for continuously occupied spaces. In reality, most spaces have experienced intermittent and fluctuating occupancy for most of the past year, and the building has been under-occupied during the course of the study.

The TM22 analysis and comparison with TM46 and ECON 19 benchmarks suggest that the building generally performs adequately, though not exceptionally. The distortions caused by underoccupation and construction issues have impacts which need to be addressed.
Gas use for the building at 76.8 kWh/m^2/yr lies closer to the 'good practice' than 'typical' benchmark figures. This suggests that the choice of heating systems is successful. Addressing air permeability issues in the building will improve this figure.
Electrical consumption is more contentious. Although the metered results of 36.5 kWh/m2/yr are close to the 'good practice' benchmark, the building has significant unoccupied spaces. Taking these into consideration with estimated usage figures (section 8.3.6) seriously distorts the figure to 62.8kWh/m^2/yr, which just exceeds the 'typical' figure. However, this is a worst case assumption. The true figure is likely to be inbetween.

1.2.10 Handover: The building handover was processed as standard with a single handover meeting and demonstration of the building systems. However in the time after handover it has become apparent this was considerably inadequate and the client has struggled to understand the operations of the building and the maintenance required. Much of this is down to the new systems being used and to both the contractors' and designers' unfamiliarity with them, which meant bringing in several specialist sub-contractors during the construction process. This has led to ongoing problems regarding snagging, the preparation of a maintenance programme and proper operation of the both Termodeck and BMS. On a positive note however, this has not significantly affected the running of the building from the users perspective, as the passive nature of the M&E strategy has meant that the building continued to operate well despite these issues, providing good justification for the system used. Refer to the Soft Landings Seminar report.
There was a significant problem with the issue of the mechanical and electrical O&M manuals from the sub-contractor, which has seriously hampered the clients' ability to understand and operate the building. However as a result of this BPE study the client is now in possession of these O&M manuals as supplied by the main contractor. This, together with the training seminar carried out under this project by the original sub-contractor, has given the client a fuller understanding of the controls and given him confidence to resolve some of the more minor matters. The client has now, separately from this project, entered into a maintenance/monitoring agreement with this contractor. Refer to Soft Landings seminar of 01/11/2014 in Appendix.

1.2.11 Appreciation
"However, despite some problems, the centre is now in place, delivering real benefit to the local economy, providing jobs to local residents and supporting numerous new businesses across a diverse range of industry sectors."
Nick Clark, Lochgelly Building Manager, Fife HARCA

"The long term proposal is to develop Lochgelly as a compact urban town with new development in sustainable, well-connected locations and viable and a vibrant town centre. The business centre will shape a town local residents will be proud of…"
Keith Winter, Head of Fife Council Development Services

2 Introduction and Background

Historically, Lochgelly was a thriving mining town in Fife. However, it fell into decline economically, socially and physically following the systematic programme of pit closures throughout Scotland during the latter part of the 20th century. As a result, working people have moved away, leaving a higher proportion of residents over the age of 65, lone parents, high unemployment, and the lowest average house price in the UK.
Due to this decline, Lochgelly was identified in 1999 as one of four priority regeneration areas in Fife and, following a competitive tendering process, Fife Housing Association Regeneration Community Alliance (HARCA) was chosen as the preferred delivery partner for regeneration projects within Lochgelly. Fife HARCA, a subsidiary of Ore Valley Housing Association, has subsequently undertaken a programme of social housing provision as well as developing a range of economic initiatives through funding and the construction of various commercial opportunities aimed at a regeneration of the town of Lochgelly

The Lochgelly Business Centre was conceived by Fife HARCA as a stimulus to economic development in Lochgelly. It was in essence, a speculative development demonstrating Fife HARCA's long commitment to the area and its desire to create further employment opportunities by facilitating new start and developing companies. As a business incubator unit providing low-cost office space to start-up businesses, the client wished to procure a low carbon/energy building which would allow tenants to pay a flat rate for office accommodation, with all ancilliary facilities (reception, etc) and energy bills included.

The building was funded by the Scottish Government's 'Town Centre Regeneration Fund' and allocated the largest sum of all supported projects at £1.75m, which had to be spent during financial year 2010. As such, the design team (procured by the client) researched off-site fabrication and systems for quick assembly on site. As a result of the funding method and timescale restraints, the innovative 'Thermalex' system by SD Systems was utilised, which is based on curtain walling principles to speed on-site construction. In addition, this system claims to provide an air-tight solution without the need for any sealants. The building was completed and occupied in 2011.

Application for TSB funding: Fife HARCA saw a great opportunity with the TSB BPE project to test the buildings actual performance. The business centre was the first new build non-domestic development undertaken by Fife HARCA, as such the opportunity to undertake such a detailed BPE project offered an excellent opportunity to maximise learning across the entire construction cycle through to operation and management, which would greatly support future integration of sustainable design and modern methods of construction and business growth in this sector.
The results would be used to up skill staff and the project team in preparing for, undertaking and interpreting the results from building performance evaluation activities. Results would be fed on to the project supply chain, from design team to contractor as well as product suppliers and installers to enhance their knowledge for future developments with the client. It would also give the opportunity to present the key findings to the building occupants to support their effort to reduce energy expenditure and associated carbon emissions, and encourage engagement and ongoing dialogue with asset manager.

Apart from the TSB mandatory reporting, the other focussed areas of the study as per the original TSB application can be summarised as follows:-

1. Measurement of the efficiency and effectiveness of the 'Termodeck' floor system.
2. Measurement of the 'Kallwall' system.
3. Analysis of the Thermalex wall.
4. The 'Thermalex' system claims to prevent air-leakage without use of sealants.
5. Measure unregulated energy usage in a variety of office types and sizes.
6. The building’s impact in the local environment.
7. Tenant flexibility of building controls.
8. The handover and subsequent operation of the building.

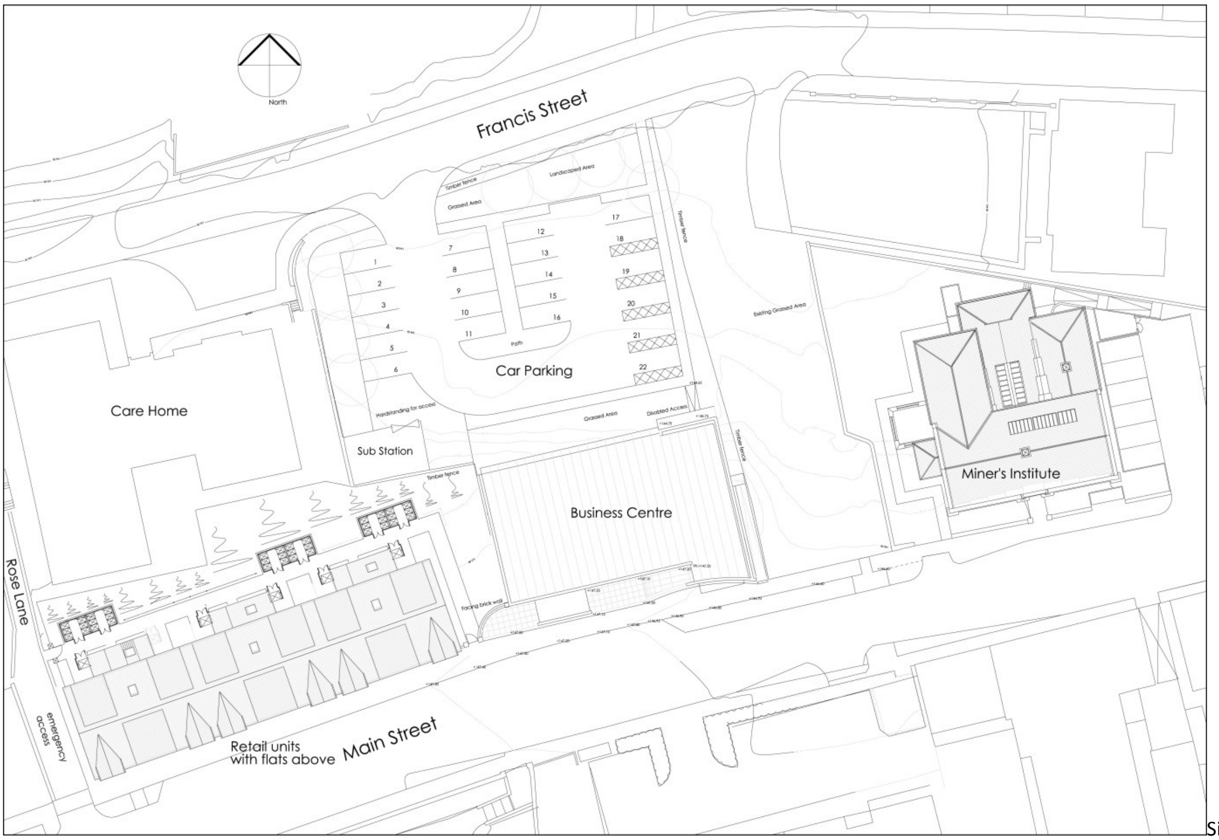
These issues are addressed in Section 10.

3 Building Design Review

3.1 Construction

3.1.1 Building Type/Design: The Lochgelly Business Centre was designed as a 'business incubator unit' to provide low cost office space, meeting room and support facilities, and networking opportunities to start-up businesses to develop the ethos of economic regeneration in Lochgelly. It was to be seen a flagship for growth to assist small companies grow. Fife HARCA wanted to develop a low energy building for environmental as well as commercial reasons, as the rent charged was a fixed rate, to be inclusive of all energy costs.

The location for the proposed business centre was a gap site between the grade B listed miners institute and a recently completed mixed use development of social housing flats above small retail units, both of which were designed by ECD architects. The Business Centre site was located on the towns main street which over the years had suffered significant decay and was now lacking in terms of streetscape and scale.



Site Plan showing The Business Centre in context with the Miners Institute and the commercial/housing Development

Fife HARCA had always been interested in good quality design, and a set of design workshops was organised with them as well as the committed and enthusiastic Lochgelly Community Association. Throughout the design process the public were consulted and regular meetings were held to give the local community a sense of empowerment, as the development was part of the ongoing regeneration of the area.

The buildings to either side of the site set the context in terms of scale, and typographically the site extended the full depth of the block from main street. With a southerly aspect, to North Street to the rear, the site dropped in level by an entire storey. The brief dictated the desired size and budget of the building and the building height of 3 storeys was set by the miners institute to the east, and the mixed use development adjacent to the west. This, along with parking requirements, determined that the building footprint would only take up half of the site area.

The Main Street frontage was identified as being the preferred main orientation due to being more prominent in the road hierarchy, thereby giving more prominence to the new building and assisting in terms of repairing the streetscape and becoming a beacon site for the ongoing regeneration of the town. In addition the building could benefit from the southerly aspect in terms of solar gain and light. To the rear of the building would be the car park which was again the best location in terms of access from a relatively minor Road, and the basement storey, which would house the plant and switch rooms, also provided level access into the building from the parking area.

Elevationally the building had to respond to two very different facades to either side. From this the idea of developing the building in two distinct parts was generated and in plan the building was split into public and private areas with the public areas containing all facilities which visitors to the building would utilise such as reception, kitchen and meeting areas, with the private areas containing offices of a mixture of sizes and informal break out areas to allow casual networking between tenants. This arrangement could then be replicated on the facade to respond to the buildings in either side.

To the West of the business centre was the mixed use development, characterised by a strong horizontal element separating the uses at first floor level with vertical Bay elements above this line to break up the elevation. These elements were brought into the elevation of the private section of the business centre with the ground floor being clad in heavy grey tiles with a false steel beam above to Anchor the building to the ground. Above this the facade changed dramatically with white kalwall used to create a clean, contemporary look with the transoms and mullions carefully located to reflect the verticality of the adjacent building at this level. The choice of kalwall was more than aesthetic. The largest office units were located along this facade but would also be the least private due to passing traffic, therefore kalwall was utilised as it would allow natural light to flood the space. However as it is an opaque material there would be no loss of privacy. In addition kalwall is a highly insulating material therefore it was hoped to minimise solar gain and avoid overheating.

The response to the adjacent grade B listed miners institute on the 'public' side of the building would be critical to its overall success. The intention was to pay homage to it without attempting to mimic. At this point on plan, main street had a gentle bend, therefore the concept of a curved feature was introduced which would instantly create a more modern feel. This curved element would be clad in large scale concrete panels to respond to the miners institute in terms of scale and material colour, but could be arranged in a very different and more modern manner. At the top of this element the main boardroom projects through the concrete as a glass box to act as a landmark and create an unashamedly modern feature. The business centre and miners institute are separated by a landscaped strip which provides breathing space between the two and allows this successful juxtaposition.

3.1.2 Main Structure / Materials: The primary structure of the building was steel frame to enable quick erection, due to the time limitations of the public funding which was being provided.

More flexibility was available in the cladding material and the innovative Thermalex system was utilised, due it being inherently airtight, without the need for relying on mastic at joints. The airtight aspect was also a key requirement for the Termodeck system. In addition the Thermalex system came as a kit of parts (developed from curtain walling construction methods) which could be assembled quickly by the main contractors' joiners on site giving a significant time advantage over traditional build.

A significant portion of the main façade was translucent to allow natural light into the building. To avoid the building overheating in summer or losing too much heat in winter, Kalwall was utilised in the majority of the cladding. This material is translucent but has a much higher U-value than curtain walling (section 3.6).

3.1.3 Form: The building with a GIA of 1450m^2 is formed in two distinct zones. The office accommodation which fronts the Lochgelly Main Street provides 21 office units over 3 floors with office sizes ranging from 21- 83sqm. These were based on an anticipated 2-person office module. This zone has been designed with flexibility in mind and all internal office walls can be removed to allow businesses to expand into adjacent office space. This flexibility allows businesses to grow without expending large capital costs in moving premises. At the heart of each floor is a break-out space, which has been provided to allow the opportunity for informal chance meetings between tenants within the building, creating networking opportunities.

The second zone within the building contains all of the communal facilities including reception, meeting rooms, conference room, kitchen, a larger break-out space and washroom facilities. This core area has been located to the east of the office wing to allow future expansion onto a vacant site also owned by Fife HARCA. Services including Main Gas and Elecric meters,AHU, boilers and BMS are located in the basement to the rear of the building.

External Building Views

First Floor

Second Floor

Basement

Ground Floor

3.2 Ventilation Strategy

There are three separate ventilation strategies within the building;

1. Mechanical supply and extract to office accommodation via Termodeck;
2. Natural ventilation to the circulation areas, reception and entrance foyer; and

3. Dedicated extraction units in other areas.

3.2.1 Mechanical Supply and Extract: The double deck air handing unit (AHU1) is sized to supply 2.2m^3/s to the office accommodation and is located in the building's basement. Fresh air intake is located at low level at the side of the building adjacent to a grassed area and the exhaust point is at the rear of the building, towards the buildings car park. The AHU operates using full fresh air (no recirculation of air during occupied periods) and conveys tempered outside air through the main supply duct, this branches to serve three zones. These are:

- Ground Floor Level
- First Floor Level
- Second Floor level

The zone supply ducts are fitted with a motorised zone damper, after this, the duct branches to supply to each office. The supply air passes through Termodeck hollowcore slabs and is delivered to the room via a number of ceiling mounted diffusers.

The extract air is drawn from each room through linear extract grilles to the adjacent corridor to a bellmouth extract duct located in the ceiling void. Vitiated air is routed to the AHU and finally exhausts air through a louvre to outside.

	
Double deck AHU located in the basement.	**Office with exposed TermoDeck and supply diffusers.**

3.2.2 Natural Ventilation: The reception and foyer are ventilated through natural ventilation by opening windows in the reception area.

3.2.3 Mechanical Extract: Mechanical extracts are provided to ventilate meeting rooms, toilets, shower, comms room, cleaner's stores and the communal kitchen. Two ducted extract systems serve cleaners cupboards and toilets, the ducts rise vertically through the building to discharge at the exhaust point on the roof. These fan units are located externally on the roof of the building. The meeting rooms and conference room are located on the second floor of the building; air is extracted through ceiling mounted grilles and exhausted through the roof mounted fan units. Extract units serving the comms and shower room is by through the wall extract units. In all cases make-up air is provided from adjacent corridor spaces and is drawn in through undercuts in doors of via transfer grilles in the case of the toilets.

3.3 Heating Strategy

The building is heated by a mixed system. The tenanted area is served by a hollow concrete convection system (Termodeck), with a more conventional radiator circuit (LTHW) heating the communal areas to the East of the building. The escape stair to the South-West has a single electric convector heater at its lowest level.

3.3.1 Convection System: The heating/cooling/ventilation of the majority of the building (office units and adjacent corridors) is supported by the 'Termodeck' system, wherein tempered air is passed through the cores of the concrete floor slabs and rooms are kept at optimum temperatures by way of convection from the thermal mass. The Lochgelly

Business Centre is the first building in Scotland to employ this system. As part of the service, Termodeck proposed to monitor the building for 2 years post-occupancy to fine tune the system and increase efficiency.

Due to the type of building and uncertainty during the design process of whether it would have a full-time member of staff, the building services have been designed to be as 'passive' as possible, ie. the Termodeck system adjusts according to the external temperature and therefore seasons. The Termodeck system dictated that the building fabric be as dense as possible to help the building maintain a constant temperature. As a result, concrete floorplates were required as a minimum provision.

The Termodeck AHU provides heating/ ventilation to three zones:-
TD1 Ground Floor Level.
TD2 First Floor Level.
TD3 Second Floor Level.

The main supply duct separates into the three zone ducts. Each individual zone supply duct is fitted with its own dedicated motorised zone damper. Generally, the air passes through each hollowcore slab above each occupied space and delivered to the space via soffit mounted ceiling diffusers.

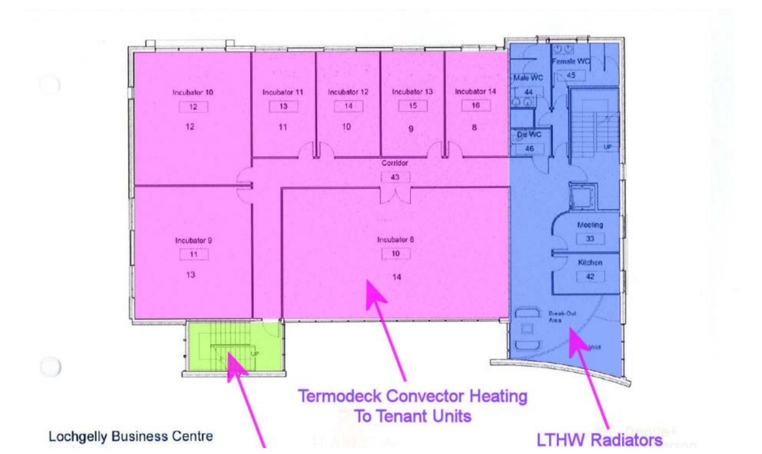
The BMS controls the buildings thermal mass temperature sensors located in the hollowcore concrete floor units. Room air temperature sensors serve each Termodeck space and the BMS is capable of switching control to an agreed alternative array of sensors, if required at in the future.

Two 80kW wall mounted gas fired boilers are located in the basement; these heat the hot water for the AHU, supplying heat to two heating circuits. These are on a constant temperature circuit and a variable temperature circuit. The constant temperature circuit serves an AHU heating coil by which outside air is heated (if needed). The warmed air is delivered to the office accommodation with the ventilation air.

3.3.2 Conduction System: The remainder of the building is heated via a conventional LTHW (low temperature hot water) variable temperature radiator circuit. The circuit is powered by the same gas boilers and BMS controls as the convection system. Hot water is fed to a 500litre storage unit, which primes the circuit on startup. The radiators are fitted with thermostatic valves.

	
80kW boilers serving both systems	Typical radiator in communal zone

3.3.3 Stairway Electrical Heating: The secondary (West) stair is isolated from the LTHW conduction circuit and not suitable for Termodeck. This is served by a single, fanned electric panel heater located beside the exit on the ground floor, rated at 1500W.



(Heating Types Sub-division)

3.4 Cooling Strategy

In the office areas, cooling is provided by absorption of heat gains by the Termodeck; during periods of warm weather the slab is cooled by night time ventilation. Outside air is passed through the AHU to discharge heat stored in the thermal mass of the Termodeck hollowcore slabs. This heat is then recovered as required to balance the heating.

The comms (server) room temperature is maintained by a dedicated direct expansion (DX) air conditioning unit (known as AHU2). This is a conventional standalone ceiling mounted cassette system, rated at 430W.

Meeting rooms and toilets have mechanical extract systems linked to roof or wall extract fans. All other rooms and spaces are naturally ventilated. The spaces are not conditioned.

3.5 Control Strategy

The Termodeck system is controlled via the BMS located in the basement of the building, but will adjust according to the outside air temperature automatically. A single central air handling unit (AHU) provides ventilation to the Termodeck treated areas.

	
BMS controls	

The BMS controls the buildings thermal mass temperature sensors located in the hollowcore concrete floor units. Room air temperature sensors serve each Termodeck space and the BMS is capable of switching control to an agreed alternative array of sensors, if required in the future. The LTHW supply and return circuits are also regulated. The systems are controlled on site by the client.

3.5.2 Occupation and Non-occupation: The minimum supply air temperature to the Termodeck units is 12°C and the maximum supply temperature is 40°C. The Occupied periods are 08.00-21.00hrs Mon-Fri.

Throughout the Occupied period the AHUs run in full fresh air mode. When additional heating or cooling is required, the AHUs make full use of the heat recovery device with supplementary heat from heating coils or cooling from ambient conditions.

During Unoccupied periods the unit runs in full re-circulation mode for heating and in full fresh air mode for cooling. When in full fresh air mode, the system relies upon the lower ambient air temperatures available overnight to purge some of the heat stored in the Termodeck during the day. When a zone setpoint temperature is achieved the motorised zone damper will close; when all zones have achieved setpoint the AHU operation will cease. Termodeck have made an initial monitoring report following the installation of remote access recorders. This report is attached and, while it makes certain further recommendations, it confirms that the system is operating efficiently.

The ‘Service Core’ area of the building (toilets, kitchen, conference rooms) is served by the same boilers which feed the Termodeck coils, controlled locally via radiators and DX units. It operates to the same hours as the Termodeck.

3.6 Daylighting/ Artificial Lighting

3.6.1 Daylighting Strategy / Orientation: The main building façade and entrance is orientated in a southerly aspect. The objective was to provide as much daylight as possible to each office to reduce operating costs for these start-up businesses. The largest offices on each floor were located on the southern façade, with floor to ceiling translucent Kalwall panels utilised as part of the daylighting and solar control system allowing significant natural light to penetrate the floor plate. The lighting circuits in these offices are set up in rows in order that those closest to the windows are on far less frequently that those to the rear of the office. Internal walls and ceilings are of conventional reflectance levels – approximately 0.3 for floors; 0.5 for walls; and 0.7 for ceilings. A few walls have purple/maroon colours with lower reflectance levels.

Windows on the other facades were much reduced due to increased heat-loss in these orientations. The opportunity for improving the proportions of the rooms was limited by the site width and the lettable area requirements.

The East and West sides are bordered by buildings of a similar height. There is shading and reflectance from the building that is adjacent to the west façade with varied reflectances of the materials in front of differing elevations- the rear (North) is bordered by an open car park; the East by paving and plants and the South by paving and road tarmac.

3.6.2 Artificial Lighting: Lighting throughout the building uses a mixture of lamp types. The units within the cellular offices are exclusively T5/T16 luminaires. These are also used within the shared meeting rooms, plant areas and the reception desk area. All other general lighting to circulation and common parts use compact fluorescent lamps. LED feature lights are situated in some localised areas, though not in significant numbers. With the exception of toilet areas, which are controlled by presence detectors and overrun timers, lighting is controlled locally, on a room-by-room basis. There are no other automatic controls, such as presence or photosensitive lighting detectors, or dimmers. Within each incubator unit, lighting is split into two circuits, manually operated. In the smaller units, the circuits are split perpendicular to the windows, rather than parallel.

External areas are lit by HIT lamps, which are controlled by an external photo sensitive detector.

Artificial lighting is reduced by the use of natural light where possible. To achieve this, but avoid overheating due to solar gain, Kalwall was used on the southern elevation. This product allows light to pass through whilst providing a lower U-value than glazing.

	
Kalwall, externally	Kalwall, internally

	
Lighting to larger South Facing Offices	Corridor lighting

3.7 Small Power Use

Non-serviced loads vary significantly as noted above, depending on the activity of each tenant. Non-serviced loads within the ‘core’ area of the building would be limited to the standard kitchen appliances and the reception equipment. The building owner carried out an audit of all small power items throughout the building as part of this study. These can be seen in the TM22 data. In addition to the proliferation of IT equipment, there is a notable presence of electric heaters, kettle and microwaves. However, analysis of the TM22 indicates that equipment use is not high for a building of this type.

3.8 Hot Water

There is very limited hot water demand within this building, which is restricted to the toilets and communal kitchen. This is provided at the point of use, using instantaneous under-sink electric heaters. A shower room in the basement has an independent 9.8kW shower unit.

3.9 Metering

There was no metering of individual offices incorporated into the design. The ethos was that the tenants paid a flat fee which incorporated electrical and gas costs. This was due to all lettable rooms being served by the TermoDeck system for heating and the assumption that all rooms would utilise a similar level of energy. However a number of users have shown high unregulated electrical use, where individual metering of offices would have been beneficial.

Sub meters were initially installed to monitor each floor and the Termodeck, as well as three of the individual offices’ small power. This installation was amended in August 13 to comply with TM22 requirements.

All new tenants are given an 'energy induction' explaining the ethos behind the building and a commitment to attempt to conserve unregulated emissions is included in the lease.
In addition, a quarterly energy group is in place to discuss methods of reducing unregulated emissions in the building.

3.10 Surrounding Environment

The building is located on Main Street, Lochgelly which is the main route through the town, with a high concentration of vehicular and pedestrian traffic to its southern aspect. This aspect is the main entrance into the building providing a partially sheltered, level access to the reception area and would be the access predominantly used by visitors.

The rear of the building is bounded by the staff car park which leads directly onto Francis Street, which is a quiet residential road. There is a staff entrance to the rear of the building providing level access also. Visitors can gain access at this point via a video phone and internal access is provided via the lift to all floors.

To the east of the building there is a moderate landscaped area which is split between hard landscaping to Main Street and soft landscaping elsewhere. There is a stepped access along the gable of the building which provides access to the front of the building for able-bodied patrons.

The western façade is bounded tightly by the neighbouring mixed use residential and commercial property.

The properties to the east and west are both owned by Ore Valley HA.

Main Street View

View East from Conference Room

3.11 Construction Contract

The contract was a standard SBCC contract but run with a strong partnering ethos. Due to public funding the contractor was selected via the OJEU process and was identified very early to allow input into buildability, programming and to enable a familiarisation with the proposed materials and Termodeck system. He was not familiar with the more unusual construction methods used.

The project was run as a traditional contract with a full design team engaged up to completion.

3 Building Fabric Performance

4.1 Building Fabric Components

The building fabric has is made up of different constructions and connection systems, and therefore varying thermal performance and air permeability levels. It also made up of different proportions of transparent, translucent and clear materials resulting in various levels of transmittance, reflectance and absorbance of daylight. This section presents the results of in-situ U-value tests, air pressure tests, thermal imaging and daylight measurements.

4.1.1 U-Values: The building has exposed concrete surfaces to utilise the thermal mass effect. Thermal mass is, however, utilised in floors made of ventilated hollow-core slabs. It has a variety of levels of U-values, air tightness, and glazing ratios. In-situ U-Value measurements of four wall constructions produced the following results: Wall with Glass cladding (0.23); Wall with Render (0.3); Wall with Tile Cladding (0.36); and Kalwall Facade (0.56). The Scottish 2010 Building Regulations maximum allowable U-values (2010 area weighted average) for all elements of the same type is 0.27 W/m^{2}K for walls; and 1.8 W/m^{2}K for windows, doors and roof lights. Therefore, the glass clad walls meet the 2010 building regulations requirements. The Kalwall also does so, if considered as windows.

U-values (W/m²K):	Designed	Actual
Roof;	0.19	
Floors;	0.15/0.17	
Glazing;	1.20	
Walling;		
Kalwall:	0.30 (manufacturer)	0.56 (tested)
Thermalex:	0.276 (manufacturer)	0.23 (tested)
Tiled Wall:	0.20 (calculated)	0.36 (tested)
Rendered Wall:	0.20 (calculated)	0.30 (tested)

4.1.2 Airtightness: Tests for air permeability and air change rates were conducted for individual rooms as well as the entire building. All testing was undertaken on Wednesday 13 March 2013, between 0900 and 1345. This was in accordance with the ATTMA TSL1 – Issue 1 methodology. The tests produced the results shown in the below table under both negative and positive pressure, together with the average air permeability rate and corresponding air changes. Note that in room 19, the return air pathways were found and sealed after inability to pressurise the room. The main reason for the variation between Room 7 & 15, and Room 19 would appear to be gaps around the ducting serving Room 19 where they pass through the wall to the corridor. This area was noted as particularly leaky.

Room	Negative Pressure (m^3/h/m^2)	Positive Pressure (m^3/h/m^2)	Avg Air Permeability (m^3/h/m^2)	Avg Air Change per hour (ACH)
Room 7 (door unsealed)	4.31	3.41	3.86	4.85
Room 7 (door sealed)	4.08	3.09	3.58	4.51
Room 15	4.81	2.51	3.66	6.20
Room 19	6.73	5.47	8.13	8.97
Entire building	It was not possible to reach the required pressure to do the test due to significant leakage at the basement level and the lift/stair shaft at the west of the building			

The air leakage testing for rooms 7, 15 and 19 revealed significant air leakages around columns, floor boxes, doors, windows, wall/floor/ceiling junctions, and ventilation ducts as follows:

Leakage points	Room 7	Room 15	Room 19
Beneath door	√		
Ventilation grille	√		
Loose blanking plates in TermoDeck ceiling	√		
Around window frames	√		
Window seals		√	
Edges of glazing			√
Floor boxes	√	√	√
Base and top of column	√		
Settlement cracks at windows	√		
Between floor/carpet & wall junction at perimeter of room	√	√	√
Gaps between double doors	√		
Around wall mounted temperature sensor		√	
Settlement cracks at wall/ceiling junction		√	
Around ventilation duct			√

On 25th June 2013 a whole building air permeability test was carried out with surprising results. The average result was $19.27m^3/h/m^2$, with an air change rate of 6.53. This is significantly above what should be expected and implies serious failure.

Further investigation showed that, generally, the building performed as it should, as confirmed by the individual room testing carried out previously. However, significant leakage was observed in a few areas;

Around the steelwork at the NW corner of the ladies' toilets in the basement and second floor,
Where the lift shaft meets the external wall,
Under the door to the plant room,
At the basement entrance where plasterboard has been removed to deal with leakage (Section 9.4)

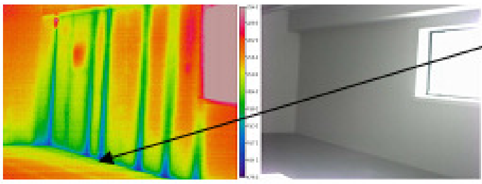
The Scottish 2010 building regulations require Shell buildings to be designed to achieve a maximum air permeability of $7m^3/m^2.h$@ 50Pa. From 1st May 2011, air tightness testing was required on completion of the shell and again on completion of fit-out works. The recommendation for all other buildings is an air permeability of $10m^3/m^2.h$@ 50Pa or less. Although the individual rooms that were tested are well within the regulations, the overall shell failed to meet the regulations requirements. It was not possible to reach the required pressure to do the test due to significant leakage at the above noted areas. The basement plant room also had large unsealed openings around ducting routes and wall/ceiling constructions.

Overall, the windows and other shell fabric joint designs were well detailed to minimize cold bridging and air infiltration, but the execution and possible settlement seem to have produced air leakage points. It is not clear whether the contractor was obliged to meet any airtightness specification. If air leakage testing had been done after completion and after fit-outs, as proposed in the regulations, it is possible the building would have met the requirements and or minimal remedial works would have helped to meet the requirements. It is noted that, while the fabric materials contributed to air tightness, problems arose where differing materials interacted.

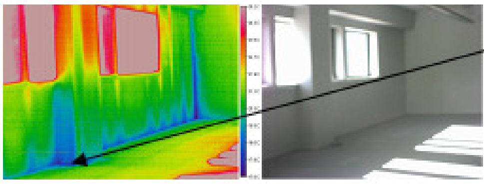
4.1.3 Thermal Imaging: Infra-red thermographic surveys were undertaken in the selected sample rooms, and the exterior of the entire building. The external weather conditions for the external imaging was idea - consisting of low external temperatures combined with dry weather and significant cloud cover. The exterior and interior surveys were carried out during the winter on 08 February.2013 and further interior images on 13 March 2013, between 0900 and 1345. As the night sky has the potential to reflect off the building surfaces and high wind speeds quickly cool the façade (which gives false thermographic readings) it was decided to restrict the surveys to dry, calm daylight hours.

Methodology: The surveys on 08 February 2013 were undertaken in the late afternoon and evening. The surveyors worked systematically around the neighbouring dwellings capturing internal and external images (both infra-red and digital) of areas of potential defects and equipment heat gain. The internal and external conditions at the time of the survey are provided in the below table. The testing on 08.02.2013 was undertaken by Dr. Filbert Musau and Janice

Foster (both non-members of UKTA) and that on 13 March 2013 by Thermal Imaging UK (members of UKTA) in accordance with the requirements of TSB monitoring protocol, BPE IP1/06 and BSRIA 39/2011.



These images highlight the main points of air entry to Room 7, which were around the floor and at the bottom of the centre column. The images may also highlight the ability of cooler air to flow within the wall along the path of the upright framing.



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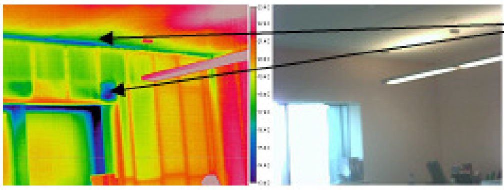
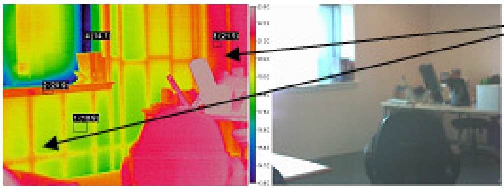
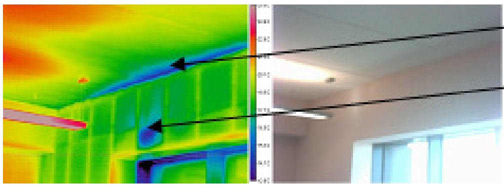


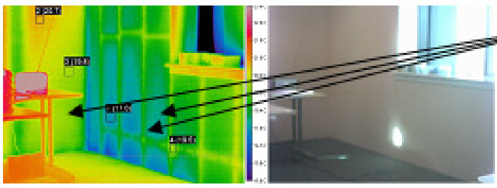
Cold spots may identify source of cool air (from outside) into the warm side of the wall insulation



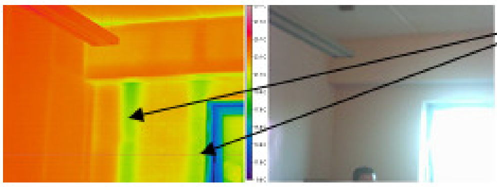
Relative temperatures and thermal pattern of external wall may highlight that cool air is able to cool the plasterboard lining of the external wall from inside the wall. This may be resulting in a thermal bypass negating to some extent the benefits of the wall insulation.



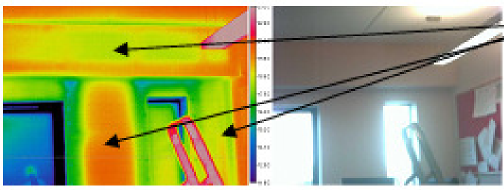
1. Cold spots may identify source of cool air (from outside) into the warm side of the wall insulation
2. Pattern on ceiling may also highlight ability of cool air to flow above Termodeck panel



Relative temperatures and thermal pattern of external wall may highlight that cool air is able to cool the plasterboard lining of the external wall from inside the wall. This may be resulting in a thermal bypass negating to some extent the benefits of the wall insulation.



Cooler regions may be caused by thermal bridging of wall structure



Cooler regions may be caused by thermal bridging of wall structure, accentuated by cool air flow on the warm side of the insulation

Discussion: In the context of thermal transmittance and air leakage, the thermal imaging survey revealed thermally strong, as well as weak areas, at window/door and wall junctions; and floor/wall junctions. It revealed heat loss/cold air ingress at window frames and seals, skirting boards, door thresholds and building services penetrations. It also revealed thermal profiles/patterns of the TermoDeck and the Kalwall elements. Some of the weak leakage areas in the basement, windows and floor boxes could be remedied in future at minimal costs.

4.1.4 Daylighting: Measurements of illumination levels and calculation of daylight factors in selected spaces produced the following results:

Room Measured	Occupancy	Window orientation	Minimum DF (%)	Maximum DF (%)	Average DF (%)	Uniformity
Large office Ground floor Room 7	Unoccupied	South	0.17	122.46	9.39	0.001
Small office Second floor Room 15	Intermittent	North	3.22	59.93	13.48	0.054
Medium office Second floor Room 19	Intermittent	North	2.20	52.70	16.85	0.042

All the rooms evaluated meet the recommended Average Daylight Factor for general offices, which is 5%. While the small and medium offices meet the recommended Minimum Daylight Factor of 2%, the large office on the ground floor does not meet this requirement. The daylight uniformity in the large room is quite poor – owing to the design and distribution of windows. Taller windows would improve the daylight factors at the back of the room, and wider or better distribution of the windows along the southern wall would give better daylight distribution across the width of a room. Higher average reflectance of the interior at the back of the room would improve the daylight at the back and uniformity across the room.

4.2 Acoustic Testing

4.2.1 INTRODUCTION

The purpose of the noise measurements was to evaluate the performance of two different facade constructions impacted by noise from the busy road along which the business centre is situated; and how this affects noise levels in the offices that overlook the road. All rooms adjacent to the road are exposed to traffic noise from it, but those with Kalwalls were thought to be the most exposed. The measurements therefore aimed to compare two similar large open plan offices with two different facades. One of the facades is on the ground floor level and has solid wall constructions with conventional large and small windows. The second one is on the first floor level and has a translucent Kallwall construction with conventional small windows. Details of the characteristics of the two constructions are presented is the U-values section of the report. The other aim was to provide recommendations on possible acoustical upgrades if needed.

Section 2 presents noise criteria and the assessment metric used. Section 3 presents the methodology used for the noise measurement survey. The process is discussed along with the equipment used for the measurements and the specific methodologies used to perform the measurement. Also discussed are the measurement locations with and the conditions around the measurement site. The results of the measurements are presented and discussed in Section 4. Section 5.0.presents the conclusions of the report including a discussion of the noise impact, and measures that could reduce noise levels.

4.2.2 NOISE CRITERIA AND NOISE ASSESSMENT METRICS

Sound is technically described in terms of the loudness (amplitude) of the sound and frequency (pitch) of the sound. The standard unit of measurement of the loudness of sound is the decibel (dB). Decibels are based on the logarithmic scale. The logarithmic scale compresses the wide range in sound pressure levels to a more usable range of numbers. In terms of human response to noise, a sound 10 dB higher than another is judged to be twice as loud; a sound 20 dB higher is perceived to be four times as loud; and so forth. Everyday sounds normally range from 30 dB (very quiet) to 100 dB (very loud). Since the human ear is not equally sensitive to sound at all frequencies, a special frequency dependent rating scale has been devised to relate noise to human sensitivity. The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear. Neighbourhood noise levels are measured in terms of the "A-weighted decibel," abbreviated dBA.

Sound levels decrease as a function of distance from the source as a result of wave divergence, atmospheric absorption and ground attenuation. As the sound wave form travels away from the source, the sound energy is dispersed over a greater area, thereby dispersing the sound power of the wave. Atmospheric absorption also influences the levels that are received by the observer. The greater the distance travelled the greater the influence and the resultant fluctuations. The degree of absorption is a function of the frequency of the sound as well as the humidity and temperature of the air. Turbulence and gradients of wind, temperature and humidity also play a significant role in determining the degree of attenuation. Intervening topography can also have a substantial effect on the effective perceived noise levels. Noise has been defined as unwanted sound and it is known to have several adverse effects on people. From the known effects of noise, criteria have been established to help protect the public health and safety and prevent disruption of certain human activities. These criteria are based on known impacts of noise on people, such as hearing loss, speech interference, sleep interference, physiological responses and annoyance.

Most of the metrics use the A-Weighted noise level to quantify noise impacts on humans. A-Weighting is a frequency weighting that accounts for human sensitivity to different frequencies. Noise metrics can be divided into two categories: single event and cumulative. Single-event metrics describe the noise levels from an individual event such as an aircraft fly-over, a train pass-by, or perhaps a heavy equipment pass-by. Cumulative metrics average the total noise over a specific time period, which is typically 1 or 24-hours for neighbourhood noise problems.

Several rating scales have been developed for measurement of neighbourhood noise. These account for: (1) the parameters of noise that have been shown to contribute to the effects of noise on man, (2) the variety of noises found in the environment, (3) the variations in noise levels that occur as a person moves through the environment, and (4) the variations associated with the time of day. They are designed to account for the known health effects of noise on people described above. Based on these effects, the observation has been made that the potential for a noise to impact people is dependent on the total acoustical energy content of the noise. A number of noise scales have been developed to account for this observation. These include the: Equivalent Noise Level (LEQ), the Community Noise Equivalent Level (CNEL) and the L (%) scale. The L (%) scale is the metric that is used in the analysis in this report.

L (%) is a statistical method of describing noise which accounts for variance in noise levels throughout a given measurement period. L (%) is a way of expressing the noise level exceeded for a percentage of time in a given measurement period. For example since 5 minutes is 25% of 20 minutes, L (25) is the noise level that is equal to or exceeded for five minutes in a twenty-minute measurement period. It is L (%) that is used for many Noise Ordinance standards. For example, most daytime City, State and City Noise Ordinances use an ordinance standard of 55 dBA for 30 minutes per hour or an L(50) level of 55 dBA. In other words the Noise Ordinance states that no noise level should exceed 55 dBA for more than fifty percent of a given period.

4.2.3 Methodology

The following subsections describe the methodology; equipment and the procedures used to perform the measurements.

Noise emanating from the adjacent road was identified by the surveyors as the primary noise source of concern. Noise measurements were therefore performed in the two representative offices facing the road. Regular buses along the road and stopping at a bus stop opposite the building; and a few trucks hauling through the road were particularly identified as a noise source of concern. The intent of the measurement locations was therefore to examine and quantify levels of noise from mainly traffic related sources around the building.

Measurement Equipment
The noise measurements were performed using two Pulsar Analyser Model 30 sound level meters equipped with microphones. The sound level meters satisfy IEC 61672-1:2002 Class 1 and Class 2. Pulsar model 105 acoustic calibrators were used to check calibration before and after each measurement. The sound level meters and acoustic calibrators used are tested and calibrated annually by Pulsar instruments. The capabilities include: real Time 1:1 Octave Band Analysis; Wide Single Measurement Range of 23dB (A) to 137dB (A); Simultaneous measurement of all Parameters, Frequency Weightings; and Time Weightings.

Eltek sensors were used to record ambient and internal temperature and relative humidity. This data was recorded along with observations of cloud cover, wetness/dryness and sun conditions during each measurement.

Procedure

The procedure for sound level meter (SLM) measurement included the following steps:

1. Note the external weather conditions E.g. Dry sunny, fair, cloudy etc.
2. Note external temperature and relative humidity and wind speed if possible
3. Do one test with windows closed and another with windows in the subject rooms closed
4. Calibrate both SLMs to 93.7dB before taking measurement
5. Ensure the sample time t is set to record every 10 seconds
6. Place microphone windscreen on both SLMs
7. Place external SLM 1m close to the building facade, near to the centre of subject room at least 1m from ground level (use tripod)
8. Place internal SLM in the middle of the room at about desk height (use tripod)
9. Start a field log by pressing the button with red circle (bottom, middle). Note reg number
10. Take simultaneous indoor/outdoor measurements for at least 15 minutes – do not take readings if it is raining, foggy, road is wet or wind is greater than 12mph
11. Note time of any loud noise sources, such as a bus, van, motor cycle, siren etc.
12. Stop recording
13. Calibrate SLM after taking a measurement

Figure 1: Two sound level meters ready to take measurements after calibration

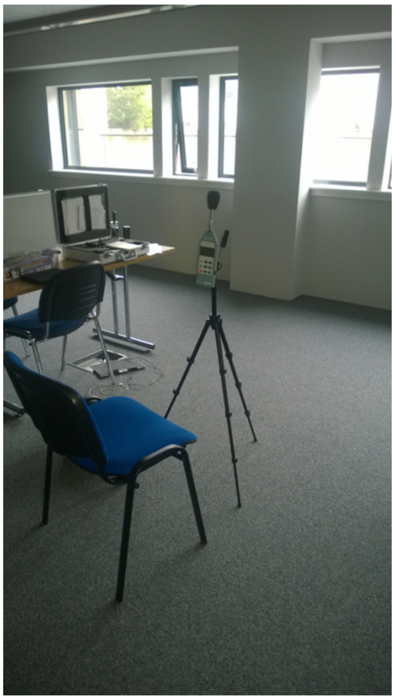


Figure 2: Internal sound level meters in open plan office on the ground level – windows open

Figure 4: External sound level meter in open location one meter from wall and 1m above ground level

Figure 3: Internal sound level meters in open plan office on the ground level – windows closed

	Measurements 1	**Measurements 2**
Ext. meter Calibration	Start=93.7/End =93.7	Start=93.7/End =93.4
Int. meter Calibration	Start=93.8/End =93.7	Start=93.7/End =93.8
Wet/dry	Dry	Dry
Sunny /Cloudy	Cloudy	Cloudy
Int temp	21.3	20.2
Ext. temp	19.6	19.7
Wind direction and speed	NNE 8 kmph	CALM
Internal RH	61.1	66.2
External RH	68.0	70.7

Table 1: Calibration and weather conditions recorded during the measurements

A series of attended noise measurements were performed. Two attended measurements of 15-minute periods each were performed for each of the two open plan offices – one with windows closed, and one with windows open. The measurements were performed during daytime hours (13:50 am to 15:30 pm. The sound level meters were set up to save the measured LAF (Sound pressure level with fast time weighting); L_{At} (Equivalent continuous sound pressure level of the entire measurement) and L_{cpeak} (Sound pressure peak level) noise levels each 10 seconds. An observer was situated with the sound level meter during each measurement period. The observer recorded the sources of noise present at each site along with the times of significant noise events (e.g., a truck or bus pass/stop or motor cycles or people or sound from nearby traffic lights) during the measurement period. Weather conditions including wind speed and direction, temperature, relative humidity, and cloud cover were also recorded during each measurement.

After the measurements, the recorded levels were used to generate charts showing the fluctuation of noise over time – see results figure below. These charts were reviewed along with the observation logs of the measurements to determine the noise levels during the observed noise events. The noise metric for the overall measurement (L%) was calculated using the ten-second data.

Figure 7: Building opposite the lochgelly business centre. This could reflect sound but was not taken into account in the discussion. The bus stop on the right hand side experiences regular stopping of buses.

Figure 7: Wall at the entrance area in front of the ground floor open plan office, forming a sound buffer.

4.2.4 RESULTS

Figures 5 and 6 show the measured sound profiles at 10 second intervals.

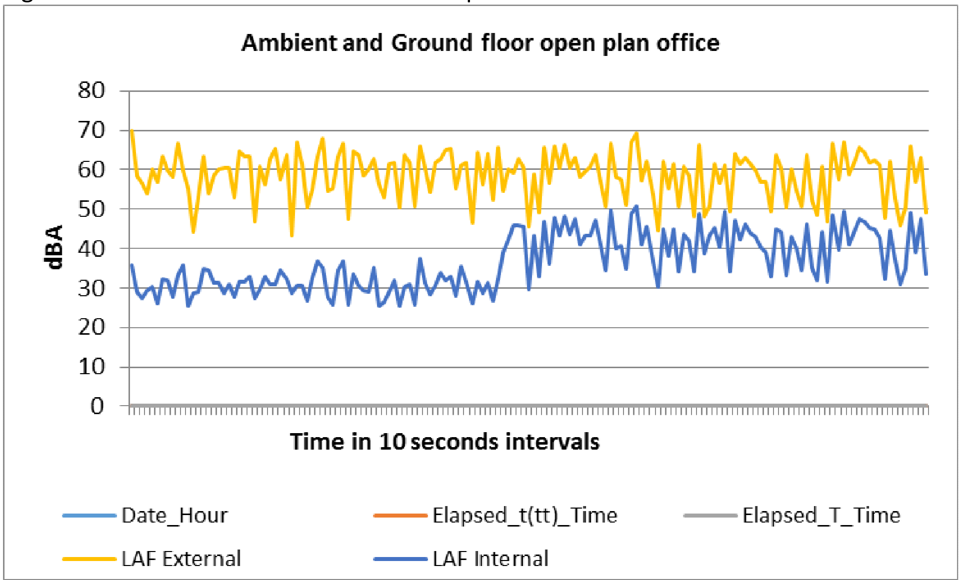


Figure 5: Sound level profile during a 30 min measurement period in open plan large office on the ground floor. Windows were closed for 15min and then opened for the remaining 15min.

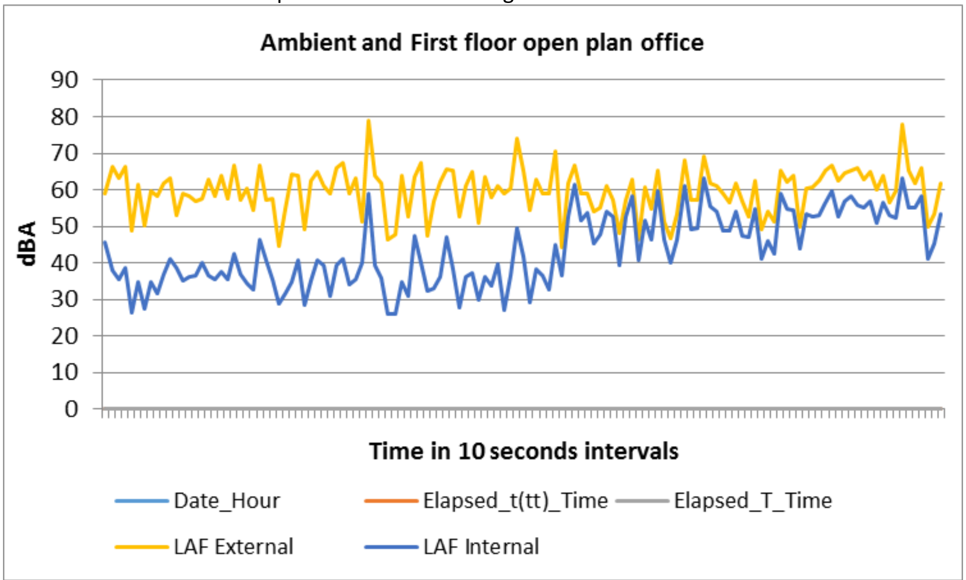


Figure 6: Sound level profile during a 30 min measurement period in open plan large office on the first floor. Windows were closed for 15min and then opened for the remaining 15min.

The key finding is that the ground level room is generally better protected from noise generated from the road when. This is the case whether windows are closed or opened. Noise levels along the road were found to be relatively high but typical of what would be expected for busy roads. The key noise sources observed during the measurements along the road, in order of the number of events counted during the one hour period were as follows: Van (40), bus (16), truck (13), cars with loud engines (11), traffic lights sound (9), people talking (7); kid making noise (4), motor cycles (3), and car horns (2).

Noise levels measured from the external ranged generally between 50 and 65 dBA with a few events exceeding 65 dBA, three exceeding 70 dBA, and two exceeding 75 dBA. Truck, bus, loud car, and motor cycle passes typically caused most of the noise events that exceeded 65 dBA. The maximum noise level during the measurement period was 79 dBA.

The below table analyses the results based on the ordinance standard of 55 dBA for 30 minutes per hour or an L(50) level of 55 dBA that is used by most daytime City, State and City Noise Ordinances. It shows that the external noise exceeded significantly the fifty percent of the one hour measurement period. The ground floor internal measurements did not exceed this, while in the first floor, it did so by a significant percentage when the windows were open.

	Measurement 1	**Measurement 2**
External	73.5%	77.1%
Internal windows closed	0%	1.4%
Internal Windows open	0%	30%
Total external	75%	

Table 2: Percentage of time when noise level exceeded 55 dBA.

4.2.5 CONCLUSIONS

The measurement results presented above show that three sources generate considerable noise to the offices, namely, noise from trucks, buses, and vans based on dBA levels and number of noise events recorded. They also showed that loud cars and motor cycles also cause significant noise. The percentages of time when the noise levels exceeded 55 dBA were: external = 75.2%; internal ground floor = 0% and first floor internal (when windows were open) = 30%. The impact of the buses is compounded by the presence of a bus stop opposite the building. The first floor open plan office with Kallwall is more adversely impacted by road related noise than the ground floor based on the measurement. This could be the case with the other adjacent offices with kalwall, facing the road. The impact is significant when windows are opened and this can have implications on whether or not occupants choose to open windows for ventilation. The buildings opposite the business centre are not close enough to reflect significant noise levels. The solid walls and short wall in front of the ground floor office have a significant impact on reducing noise to this level.

The most effective way to deal with noise in terms of noise reduction is to remove it completely or modify the source of the noise to reduce levels, but this is not feasible in the Lochgelly case. The amount of noise generated by a bus event was noted to greatly increase as it stopped and as it left the bus stop. Removing the bus stop could eliminate the additional noise generated by the buses stopping but this may not be feasible. Treating or modifying the path of the noise between the source and the receptor is the next most efficient noise reduction method. The typical noise reduction method applied to the path is a noise barrier, most often, a wall, berm or combination of the two. The wall at the entrance in Lochgelly is already effective for the ground level but it is not practical to build it higher to reduce noise in higher floor levels. The most feasible noise reduction measure to implement at Lochgelly is to control the ventilation through the Termodeck. This should be controlled such that it always keeps temperatures within the comfort range and supplies adequate fresh air, so that occupants do not have to open windows. Sound insulation by way of curtains could have some noise reduction effect, but would reduce daylight transmission into the offices.

4.3 Ventilation and thermal environment

This consists of a mixture of window opening, mechanical extract ventilation and the Swedish hollowcore system Termodeck, which also serve as a route of ducting ventilation through the building. Termodeck tempers incoming fresh air year round by utilizing the thermal capacity of the structure – pre-cooling air during the warm months, and pre-heating fresh air during the cold months, if necessary. Two mechanical extract fans with local manual controls provide ventilation in the conference room. Air flow tests by MEARU using a test hood revealed that the fans are not providing equal air extraction – one is performing poorly. The control of the ventilation system is not very clear to users. The make-up air drawn into this room is from the lobby, and some of it would be vitiated air from the incubator units along the corridor. This room has a large glazed southern, east and west facing façades which are not shaded, and is very exposed to southern solar radiation – there were complaints by the owner regarding summer overheating in the room in 2013. The eastern glazing has some degree of internal shading by way of a projector screen, which is not effective.

Regarding heating, detailed monitoring of the temperature and relative humidity in various rooms shows that the spaces are maintained within recommended thermal comfort range, both in occupied and unoccupied spaces. This means that there is a significant level of energy wasted heating empty spaces.

4.4 Conclusions and key findings

Unfortunately the heating and ventilation strategy for the building has not worked as well as was anticipated; as the remote connection to the Termodeck system was not installed it was difficult to determine the exact energy use, due to lack of analysis by those with requisite expertise. In addition, the mechanical O&M manual was not issued to the client upon handover, so they were unable to understand and monitor the systems properly. This has subsequently been resolved by the installation of software which allows access. Termodeck's monitoring reports would indicate that the system is operating as designed. The BPE has been instrumental in the client receiving the O&M manuals.

The ventilated air tends to have a low inherent humidity. Perhaps the heating aspect tends to dry it out. This can contribute to an uncomfortable environment.

It is also worth noting that as the Termodeck system utilises heat gain from equipment and patrons the building will not be as efficient now as it would be when completely full. The smaller rooms are now largely occupied with only the 3 larger offices remaining empty.

The Kallwall fails to achieve expectations. It has limited benefit on sound performance. Unfortunately, it is mostly utilised on the southern aspect, which is also the noisiest.

The Thermolex material does perform as promised. It does require careful consideration of detailing at windows, doors and junctions with other materials, perhaps to a greater extent than traditionally carried out.

4 Key findings from occupant survey

5.1 BUS Survey Introduction

The BUS took place on the 11th October 2012 at the Lochgelly Business Centre. Alan Campbell administered the BUS surveys to tenants, assisted by Nick Clark of Fife HARCA

A letter was sent to each tenant one week before the survey took place outlining the nature of the survey and requesting their cooperation in completing the survey.

There were 30 Surveys distributed to the existing tenants and Fife HARCA staff, and 16 were completed and returned. This represents a response rate of 53% which is above the 40% required by Arup. We were satisfied with the response rate and the quality of responses received on the day. The completed forms were collected by Nick Clark and forwarded to ECDA for analysis. Individual responses are confidential and tenants were assured of this prior to the survey.

Copies of the actual ARUP reports can be found in Appendix A and Appendix B.

Client Building User Profile Summary

100% of building users surveyed was over 30.

No respondents were outside contractors.

44% of respondents used the building as their normal work base.

62% were male and 38% were female.

19% had worked at their present desk for more than one year and 81% had worked there for less than 1 year.

25% had worked in the building for more than 1 year and 75% had worked there less than 1 year.

The split between those working at a window seat was 50-50.

93% travelled to work by car with 7% travelling by bus.

5.2 BUS Analysis

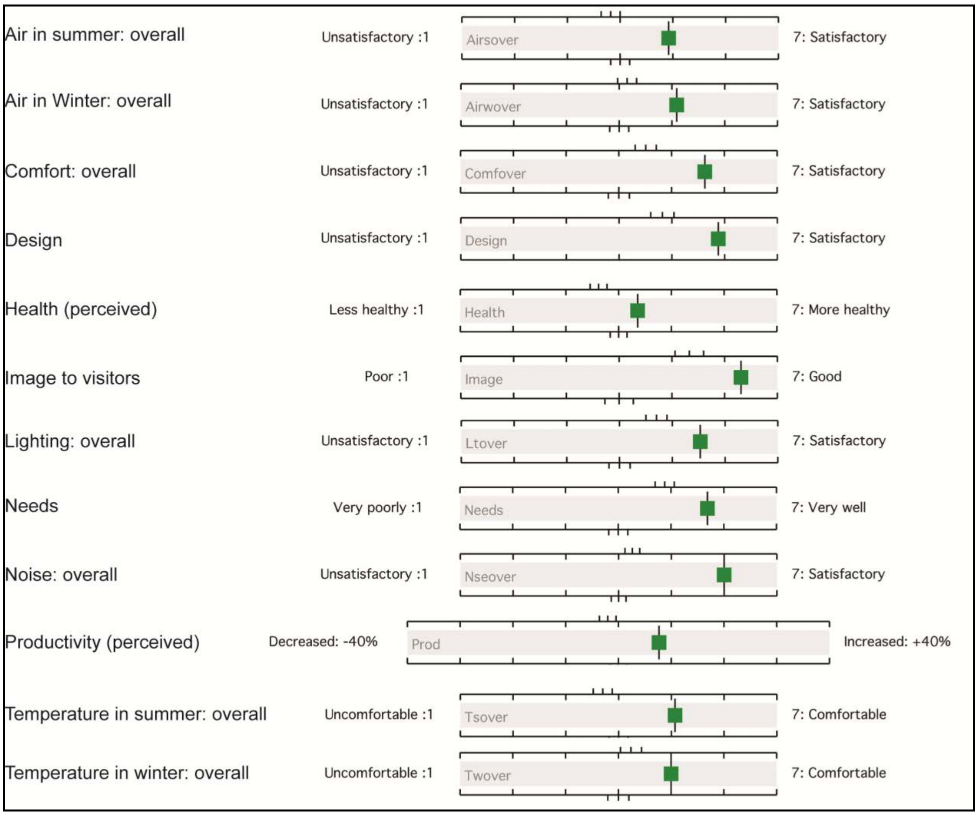
The results have been split into the following categories: -

- Issues scoring better than benchmark and scale midpoint (Green Square)
- Issues scoring between the benchmark and the scale midpoint (Amber Circle)
- Issues scoring poorer than benchmark and scale midpoint (Red Diamond)

The benchmark used by the BUS survey is taken from the last 50 buildings surveyed and held on the Arup database. The midpoint is the optimum answer that can be provided by the respondent for a particular question.

The following is a summary of the results from the BUS survey.

5.2.1 Summary (Overall variables)



BUS Table 1

The overall summary of the main issues in the BUS survey indicate that the building is scoring well when compared to the benchmarks of other buildings and the scale midpoints.

The image to visitors is particularly good which is in keeping with general comments from staff and visitors at the building.

5.2.2 Temperature

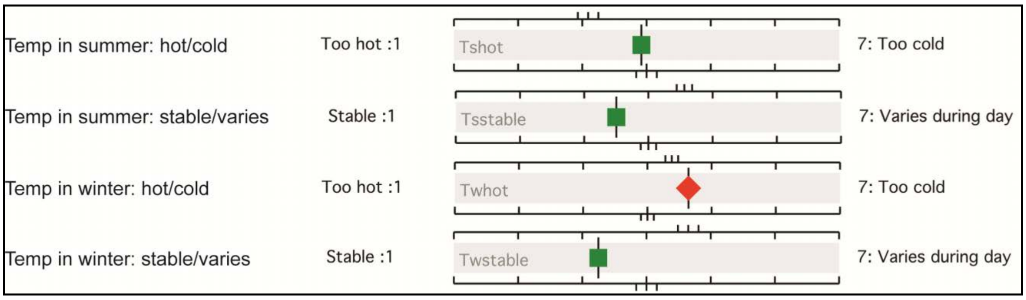
The building generally scores well in this category however there is an issue with the temperature of the building being too cold for some users in winter. Although temperature can be subjective, the lack of user controls in the offices could exacerbate any issues which tenants have as they would be used to having control over heating, etc.

Throughout the questionnaire a number of comments were received regarding the heating, such as: -

Building at back is cooler than front;
Badly designed heating systems;
Too hot in boardroom;
The heating in reception is difficult to control;
I wear extra clothing in winter.

With regards to the above comments the heating in the reception area has been a longstanding defect which has been difficult to resolve and work regarding this is ongoing. It would also appear that the south facing front façade gathers a noticeable solar heat gain in comparison to the rear façade.

This does not appear to be the feedback of the majority of building users; however it could be that these issues are evident in some areas of the building but not in others.



BUS Table 2

5.2.3 Air

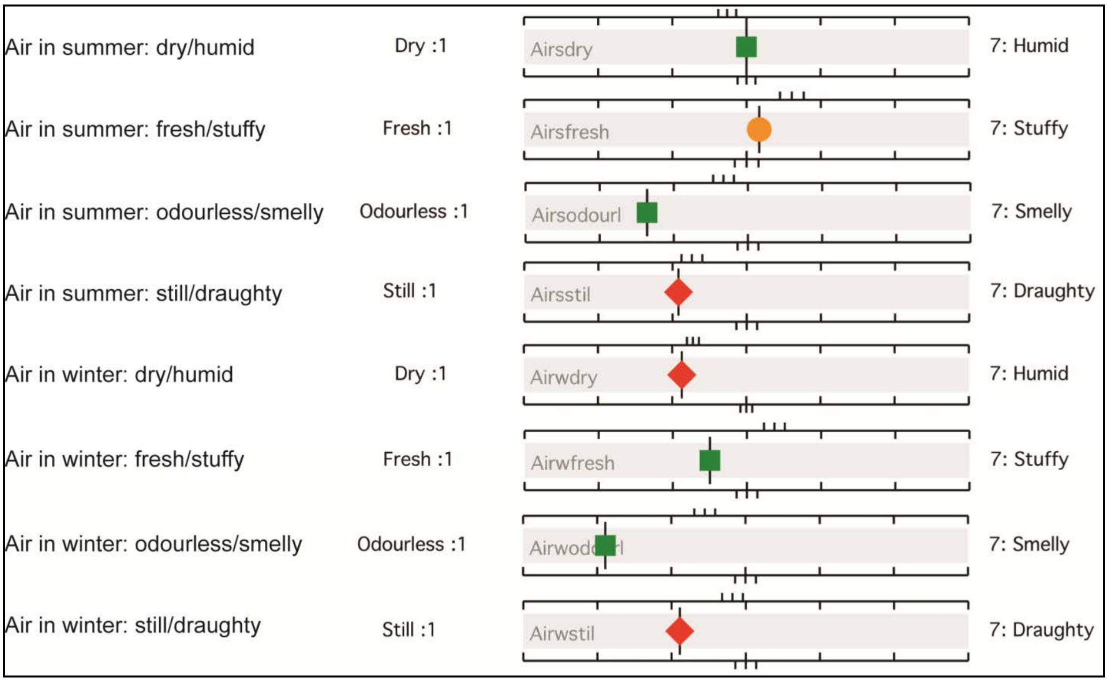
The results in this table display a varied response for several items regarding the air quality in the building.

There appears to be a yearlong issue regarding the stillness of the air in the building. This may be down to the inherent design of the system supplying air from ceiling terminals at a low velocity; however it should be noted that only a single comment regarding lack of air was received within the questionnaire results. This comment is also at odds with the air test results which indicated a problem with gaining pressure in the building, but this may be related to the work concerning water ingress in the basement.

There is an interesting discrepancy regarding dry/humid air between summer and winter as the air quality should be consistent from the system throughout the year.

There are no issues with odours in either winter or summer. This could be due to the canteen being in a separate area closed off from offices. Hot food is discouraged in breakout areas.

Overall users reported being largely satisfied with air related issues as can be seen in BUS Table 1.

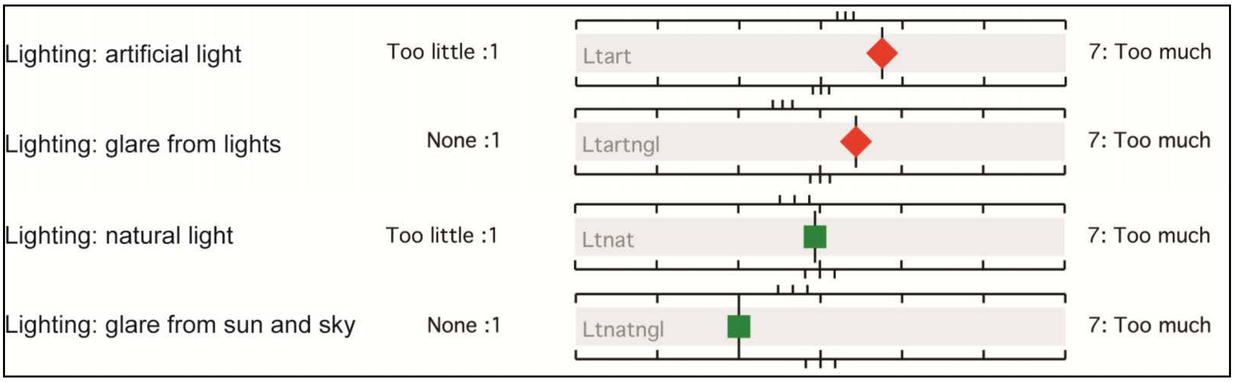


Bus Table 3

5.2.4 Lighting

Although BUS Table 1 indicates that most building users are satisfied with lighting overall, this masks some individual issues users have with lighting. It also indicates a high 'forgiveness' factor which is implied throughout the results. Users have individual issues but overall are satisfied. The main issues with lighting are the artificial lighting and the glare from this. The design of the building allows for high levels of natural daylight and it would appear that this is very popular with a number of tenants, though a similar number of tenants have problems with the artificial lights.

The room layouts vary significantly throughout the building, so it would be of benefit to ascertain which users relate to which rooms to gain a more thorough understanding of the lighting issues.



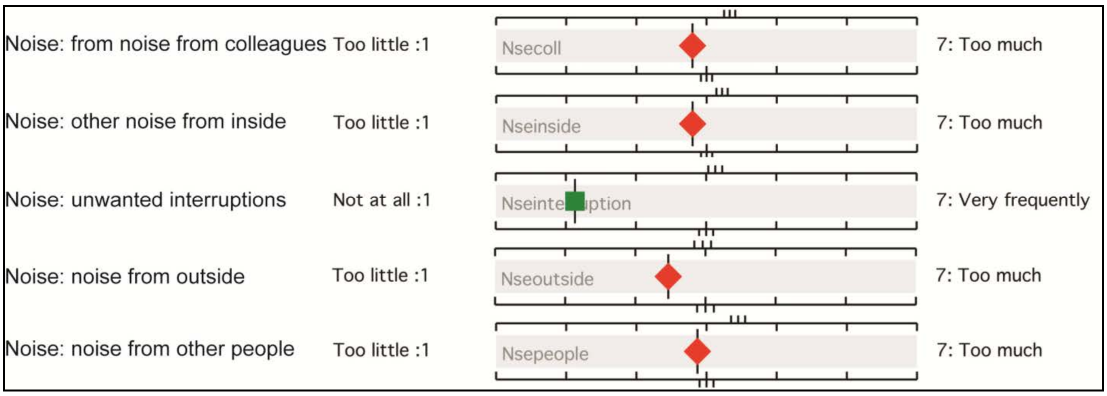
Bus Table 4

5.2.5 Noise

The noise results are somewhat contradictory in that the building scores poorly generally, yet the red indicators are as a result of the building being slightly too quiet and there is a very good score for 'unwanted interruptions', with the summary in BUS Table 5 indicating overall satisfaction with this element. This may be explained by the fact that the poor scores in the table below are very borderline to being acceptable and the unwanted interruptions score is very high.

The low noise from external sources score may reflect that the business centre is not yet full to capacity. However there have been some comments from tenants that they are being disturbed by noise from adjacent rooms.

Due to the nature of the building layout, there are a number of offices which are sandwiched between others, which may cause noise to become more of an issue. It may be of benefit to ascertain which users relate to which rooms in order to gain a more thorough understanding of the noise issues.

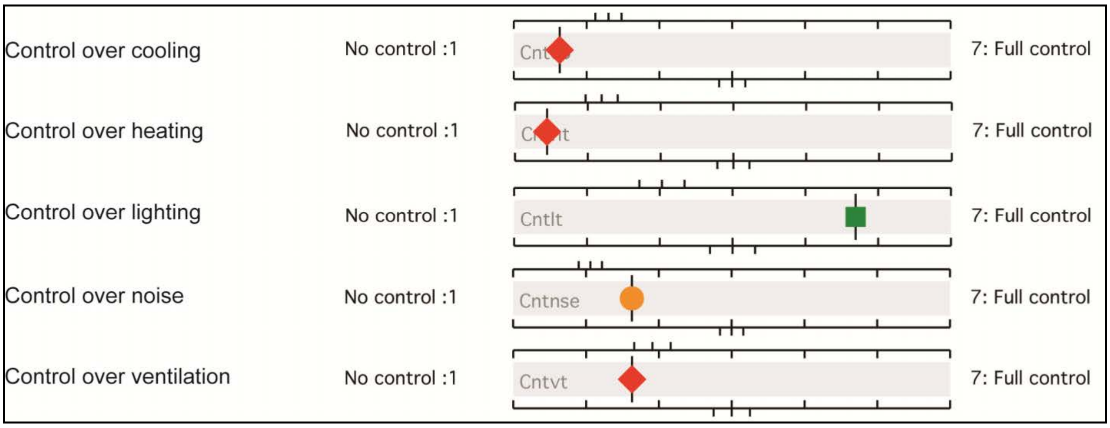


Bus Table 5

5.2.6 Control

This is the poorest scoring section of the BUS survey and it is no surprise, as the building services have not been designed to provide occupants with individual levels of control. There is very little occupant control in the building. Control over cooling is slightly better as mechanical air extract is only present in meeting rooms and it can be locally controlled. There are also some openable windows in the building which might explain why the control over ventilation performs slightly better.

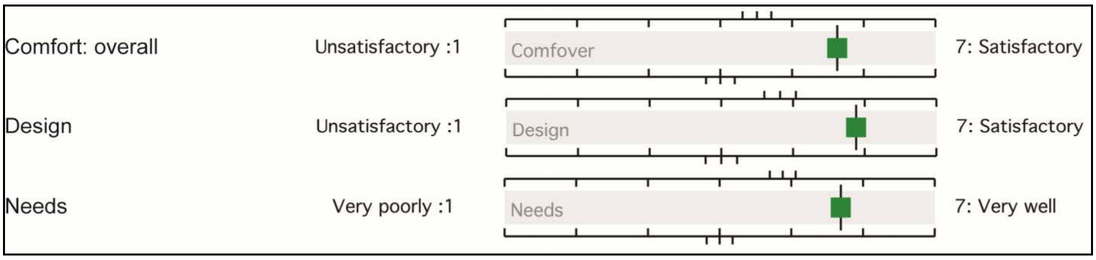
One interesting point to consider is that this lack of control does not seem to be impacting on user comfort as BUS Table 1 and BUS Table 7 report that this scores above the benchmark and midpoint scale. Effectiveness and speed of response of requests to changes scored highly which may also impact on user comfort. This indicates a good level of response from the FM team with regards to changes to building services.



BUS Table 6

5.2.7 Design/Needs Variables

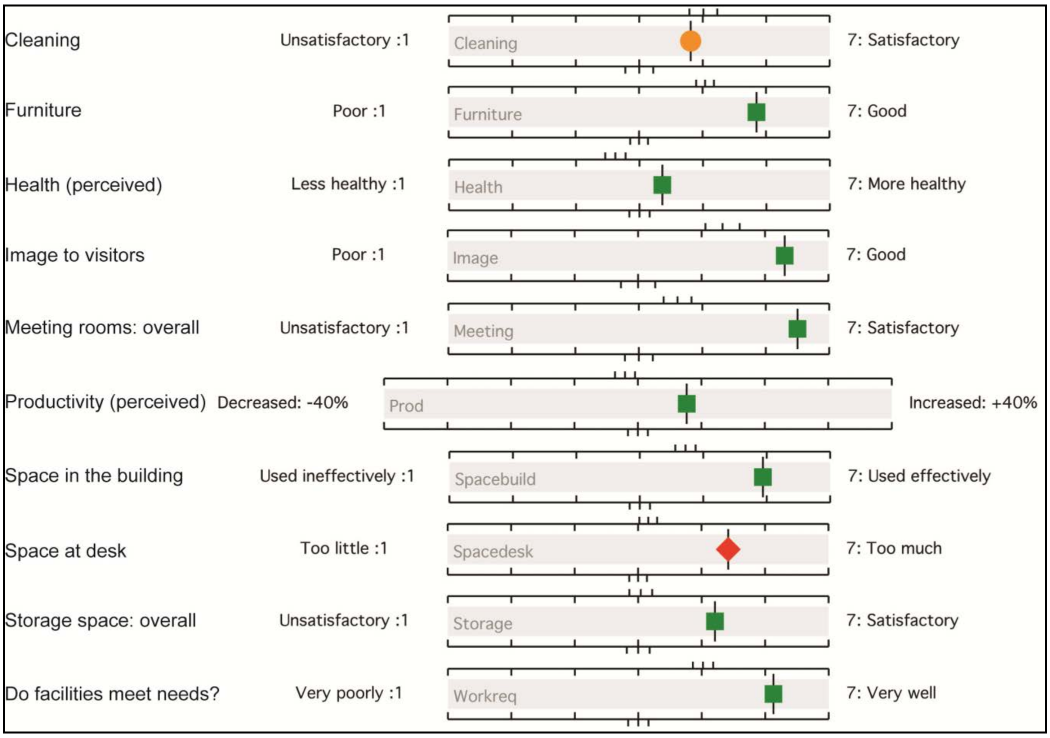
Overall comfort, building design and user needs all score highly with building occupants. This indicates that although there are individual issues in the building overall satisfaction is high and the building is performing well in relation to meeting the needs of staff.



BUS Table 7

5.2.8 FM Variables

All of the FM variables scored highly with meeting rooms, furniture, image to visitors and user needs scoring particularly highly. Interestingly, the occupants seem to have problems with there being too much space at their desks.



BUS Table 8

5.2.9 Summary Table of all results

Green Squares	Amber Circles	Red Diamonds
Issues scoring better than the benchmark and scale midpoint	Issues scoring between the benchmark and the scale midpoint	Issues scoring poorer than benchmark and scale midpoint
Air in summer: odourless/smelly Air in summer: dry/humid Air in summer: overall Air in winter: fresh/stuffy Air in winter: odourless/smelly Air in winter overall Comfort: overall Design Effectiveness of response to requests for changes Furniture Health (perceived) Image to visitors Lighting: natural light Lighting: glare from sun and sky Lighting: overall Meeting rooms: overall Needs Noise: unwanted interruptions Noise: overall Productivity (perceived) Space in the building Speed of response to requests for changes Storage space: overall Temperature in summer: overall Temperature in summer: hot/cold Temperature in summer: stable/varies Temperature in winter: overall Temperature in winter: stable/varies Do facilities meet user needs?	Air in summer: fresh/stuffy Cleaning Control over noise Personal safety in building and its vicinity	Air in winter: still/draughty Air in summer: still/draughty Air in winter: dry/humid Control over heating Control over ventilation Noise: noise from colleagues Noise: noise from outside Noise: other noise from inside Noise: noise from other people Lighting: artificial light Lighting: glare from lights Control over cooling Space at desk Temperature in winter: hot/cold

BUS Table 9: Summary of all issues

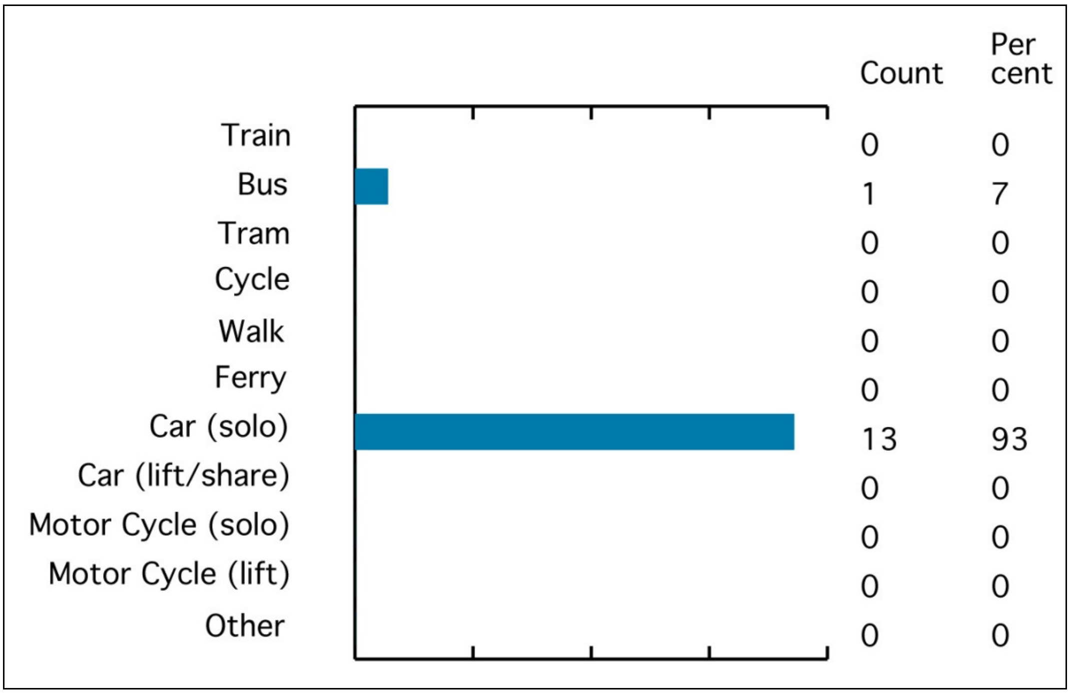
The previous table shows that the main issues of concern highlighted in the Building User Survey are:

- Air in winter: still/draughty
- Control over heating
- Control over ventilation
- Noise: noise from colleagues
- Lighting: artificial light
- Lighting: glare from lights
- Noise: noise from outside
- Noise: other noise from inside
- Noise: noise from other people
- Air in summer: still/draughty
- Air in winter: dry/humid
- Control over cooling
- Space at desk
- Temperature in winter: hot/cold

5.3 Transport

5.3.1 Journey to work

An overwhelming majority of building users at Client make the journey to work by car. 93% of building users travel to work as the sole occupant of the car. 7% of building users arrive by bus. Although public transport links are available within walking distance of the office very few employees are using public transport.



5.4 BUS Individual Feedback Comments

Comments

A large number of individual comments have been made as part of the BUS survey. The full list can be found in Appendix B. The following is a summary of the comments made in the BUS report. This summary is focusing on frequently occurring comments rather than one off individual opinions. It may be beneficial for Client to consider all comments made. Appendix B.

Things that work well

Assistance with problems e.g. IT;

Good car parking;

Quiet work area;

Impressive large meeting rooms;

Shared facilities encourage networking with other tenants

Changed behaviour because of conditions in the building

Front entrance being used due to flooding in basement, causing problems for wheelchair access;

Wearing extra clothes in winter;

Comfort Overall

Number of comments regarding the heating system and temperature;

Pleasant working environment;

Design

A number of positive comments regarding the design of the building;

A number of comments regarding the basement flooding;

Positive comments about accessibility throughout the building.

Health (perceived)

- An enjoyable place to work;
- Sore eyes due to lighting levels and lack of air.

Hinder (things that hinder)

A high proportion of comments regarding current wheelchair access arrangements due to basement flooding;

Some comments regarding internet/wireless connections, although it seemed to have improved recently;

Heating issues;

Reception not always staffed.

Lighting

Glare and lighting levels from the artificial lights is the most reported lighting issue;

Positive feedback on high amount of natural lighting.

Meeting Rooms

Positive comments regarding quality of rooms;

Meeting rooms seem to be available when required, however there are comments regarding a booking system being required.

Needs

Vast majority of comments are regarding the basement leak; it may be worthwhile repeating this question once this issue has been resolved as it may be hiding other issues.

Noise

Comments regarding tenants voices from adjacent offices.

Productivity (perceived)

The environmental conditions are good for productivity.

Requests for changes

Internal response is good, but poor when external contractors are required;
Issues with heating are noted, however this is inherent in the design of the system.

Space at desk

Notes regarding lack of furniture being provided by one respondent.

Storage

A number of respondents commented on the lack of storage space provided within the rooms.

Journey to work

Good connections to the A92.

5.5 Conclusions and key findings for the BUS

Results show that the main issues highlighted in the Building User Survey are: -

Temperature in winter too cold

Lack of User Control

Too little noise from both inside and outside

Too much artificial light and glare.

It is advised that Client investigate the causes of these issues and the feasibility of undertaking remedial works to improve conditions if possible.

Please find the following appendices attached separately to this report: -

Appendix A (Data Tables)
Appendix B (Comments)

6. Environmental Monitoring

6.1 External Conditions

During February 2013, a TinyTag was placed beneath a canopy covering an entrance on the north side of the building to monitor external temperature and relative humidity at the site. Readings were initially set to capture data every five minutes. In December 2013 the measurement interval was increased to every ten minutes. Figure 6.1.1 and 6.1.2 detail the external temperatures by year.

The external temperature in 2013 indicates few occasions where the temperature fell below 0°C, which is unusual for the Scottish climate. There were occasions in June and July where the external temperature was unusually high, peaking at over 30°C. The data for 2014 indicates a very similar temperature pattern with warm temperatures for each season. A review of summer temperatures, indicate large diurnal temperature swings which are favourable for pre-cooling of the Termodeck thermal mass. However the high temperatures were not sustained on a daily basis and cooler daytime temperatures followed high temperatures; at these times there is a high probability that the thermal mass had been overcooled.

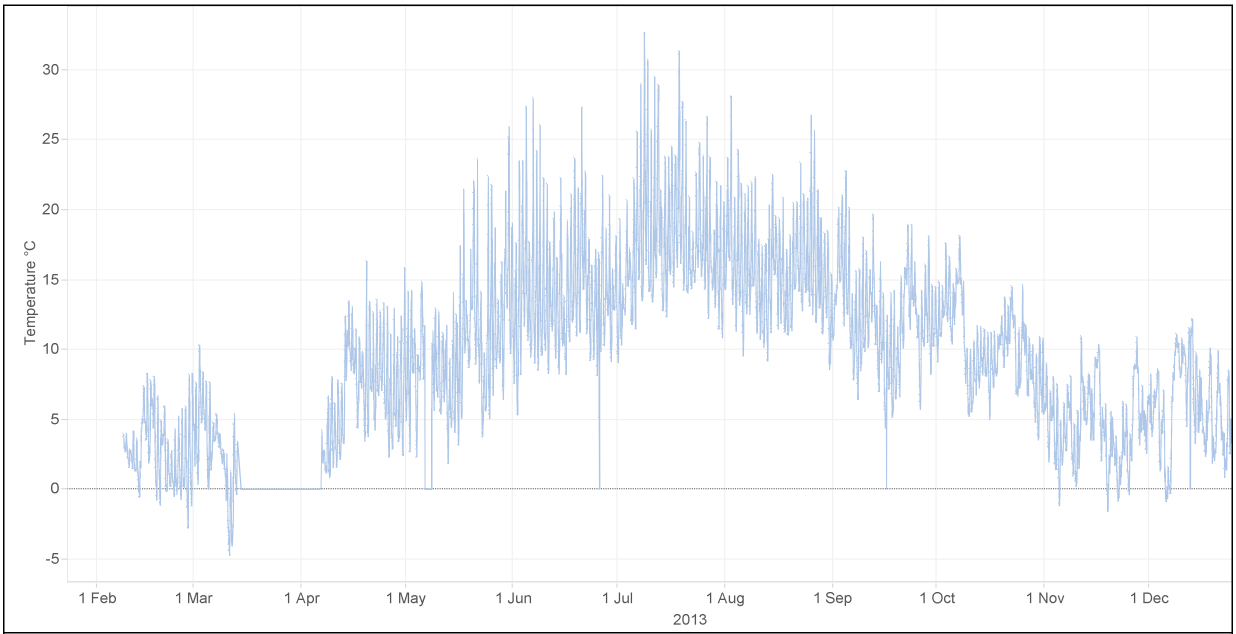


Figure 6.1.1: External temperature condition for Ore Valley Business Centre February – December 2013

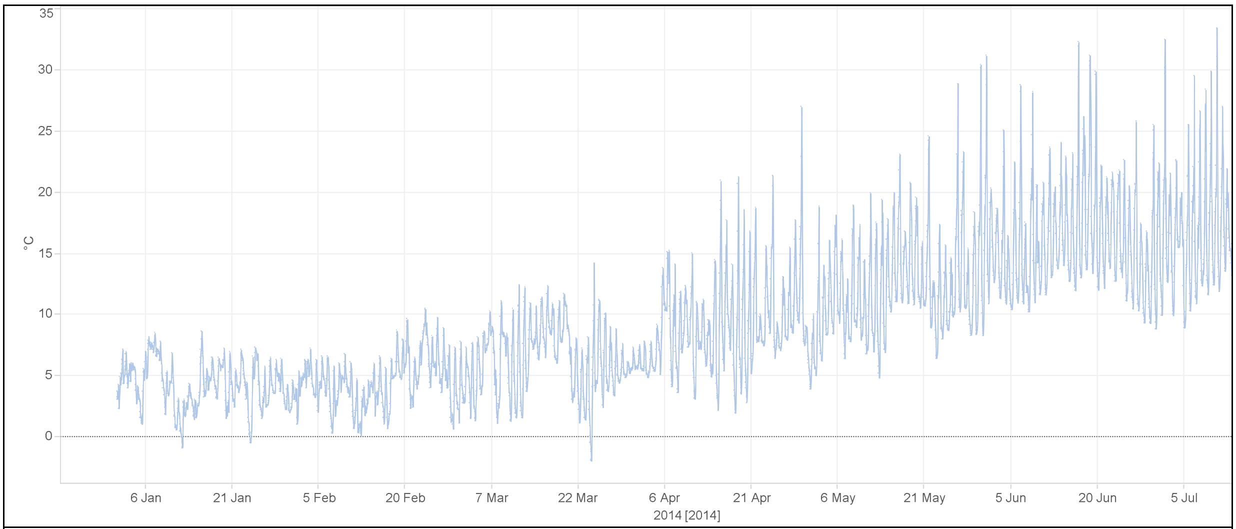


Figure 6.1.2: External temperature condition for Ore Valley Business Centre January – July 2014

6.2 Internal Conditions

Internal conditions of two intermittently occupied offices and one unoccupied office were monitored for temperature, relative humidity and CO_2 concentrations, from 24th January 2013. These were room 7, room 15 and room 19. At the time of installing the apparatus the building owner informed us of an expected tenancy in room 7. The tenancy did not go ahead, however the room was occupied periodically for meetings throughout the project. In July 2013, internal monitoring was extended to include a further five rooms. These were room 3, 8, 13, 21 and conference room. Table 6.2.1 details the floor area and location within the building. An external sensor was also installed beneath a canopy over the rear entrance door to record external temperature and relative humidity, as detailed in section 6.1.

Figure 6.2.1: Eltek Transmitter located in Room 13

Figure 6.2.2: Eltek Transmitter located in Room 7

	Floor Level	Floor Area (m^2)	Orientation
Room 3	Ground	20	North
Room 7	Ground	85	South
Room 8	First	20	North
Room 13	First	48	North
Room 15	Second	20	South & West
Room 19	Second	51	North & West
Room 21	Second	85	South
Conference	Second	32	East, South, West

Table 6.2.1: Environmental monitoring locations within Lochgelly Business Centre.

Table 1.5 in CIBSE (Chartered Institute of Building Services Engineers) Guide A details recommended comfort criteria for office applications; for temperature these are, 21-23°C during winter and 22-24°C during summer. At the time of design their overheating threshold was based on an occupied office to have reached 28°C or above for a period of more than 1% of annual occupied hours, assuming a working day of 08:00-18:00hrs. The reduction of summer overheating would have been considered during the design phase.

The CIBSE guide recommends an air supply rate of around 8 litres per second per person with an internal CO_2 concentration of approximately 1000ppm in workspaces. Low CO_2 concentrations are generally used as a marker for indoor air quality and effectiveness of the ventilation system. Relative humidity should be maintained around 40-60% however, the building is mechanically ventilated (not air-conditioned) which means relative humidity of internal air is not controlled by the building services systems in the building. The moisture content in the air can pose negative health effects on the building occupants, where both too low and too high relative humidity can have an impact. Each of the rooms are analysed to determine whether the rooms fall within CIBSE recommended comfort range for offices, these are plotted in Table 6.2.2.

	Temperature (°C)			Relative Humidity (%)			CO_2 Concentration (ppm)		
	Min	Max	**Mean**	Min	Max	**Mean**	Min	Max	**Mean**
Room 3	13.1	24.2	**20.3**	23	73	**42**	422	1859	**630**
Room 7	13.0	26.0	**19.9**	22	72	**41**	441	1218	**548**
Room 8	10.1	26.3	**21.2**	22	68	**41**	444	1803	**566**
Room 13	13.0	26.7	**21.4**	22	67	**41**	430	1755	**577**
Room 15	11.5	27.0	**19.6**	16	73	**42**	423	2120	**530**
Room 19	11.3	28.6	**20.7**	16	73	**40**	321	1045	**417**
Room 21	14.0	26.0	**20.3**	19	72	**43**	433	3037	**543**
Conference	10.5	55.3	**21.4**	9	72	**38**	355	4325	**708**

Table 6.2.2: Minimum, Maximum and Mean Internal Conditions for occupied hours 08:00-18:00hrs Mon-Fri.

Each room exhibits low minimum temperatures; these occurred in early December 2013 and coincide with a boiler breakdown and a broken motor drive belt on the supply side of the air handling unit. Low temperatures were experienced for a period of around eight days and are below the HSE (Health and Safety Executive) minimum working temperatures. While maximum temperatures reach values higher than the recommended CIBSE comfort conditions, the critical value of 28°C (used at the time of design to benchmark overheating) was exceeded in two of the monitored rooms; these are room 19 and the conference room. Reviewing the overheating for room 19, in 2013 the critical temperature exceeded 28°C for 0.01% (15mins) of the year, this occurred in the spring of 2013. During 2014, room 19 overheated 0.05% (35mins) of the time during April 2014. This room has a large area of inoperable north facing windows. The tenant frequently complains of feeling cold and uses a portable fan heater to supplement the heating supplied through the Termodeck. The average hourly air change rate (ACH) due to infiltration is circa 9ACH and one could infer a sedentary occupant is feeling some discomfort due to drafts.

The temperature of the conference room reached 55°C suggesting the sensor has been influenced by solar radiation. This room has large glazed southern, east and west facing façades which are not shaded and are very exposed to solar radiation throughout the day. A white shield was placed around the temperature sensor; however due to the extensive glazed areas there was difficulty in placing the sensor in a shaded position in the room, even with a shield. Air flow measurements by MEARU, using an automatic volume flow meter, revealed the extract fans are not providing their combined design extraction rate of 210 litres per second (maximum) which will have an effect on comfort temperatures. There were complaints by the owner regarding summer overheating in the room in 2013. The eastern glazing has some degree of internal shading by way of a projector screen, which is not effective as the heat gains have already entered the room. The conference room and the overheating issues are discussed in more detail in Chapter 9 of this report. Figures 6.2.3 and 6.2.4 detail conference room temperature profiles for August and December 2013. During August the conference room temperature rarely fell below 20°C through the month and daily peaks reached up to 45°C. As the recordings were clearly affected by solar radiation, December 2013 has been graphed to provide a comparison of summer and winter temperatures in the room. While there are distinguishable daily peaks during the weekdays when the heating is operational, there were also temperature peaks as a result of solar radiation towards the end of the month, at a time when the building was unoccupied and heating system was switched off.

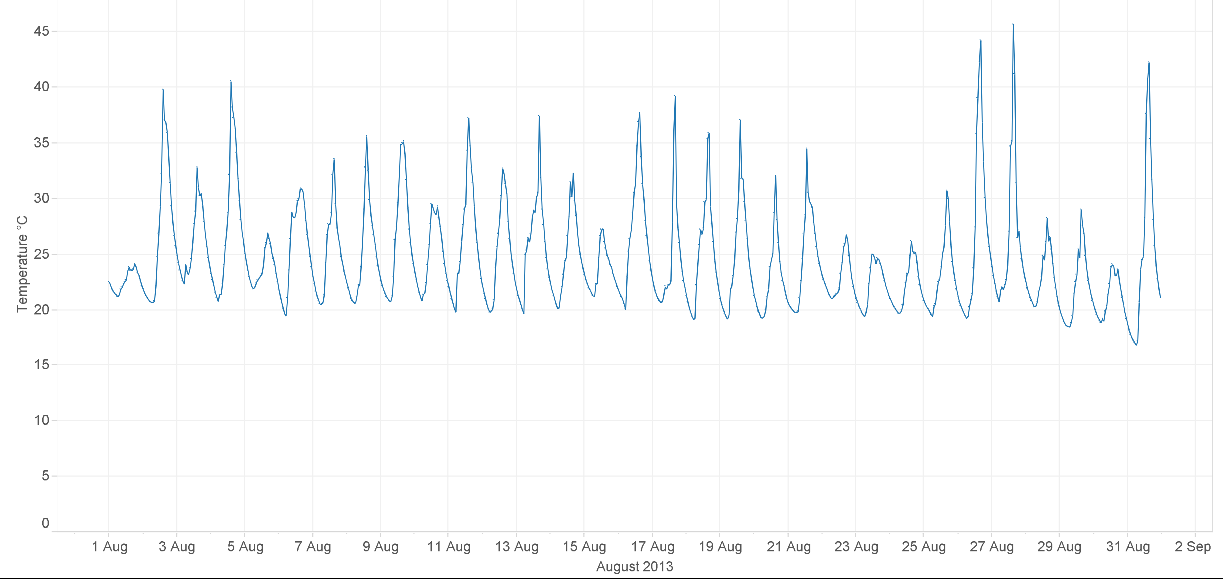


Figure 6.2.3: Recorded Temperature in Conference Room August 2013

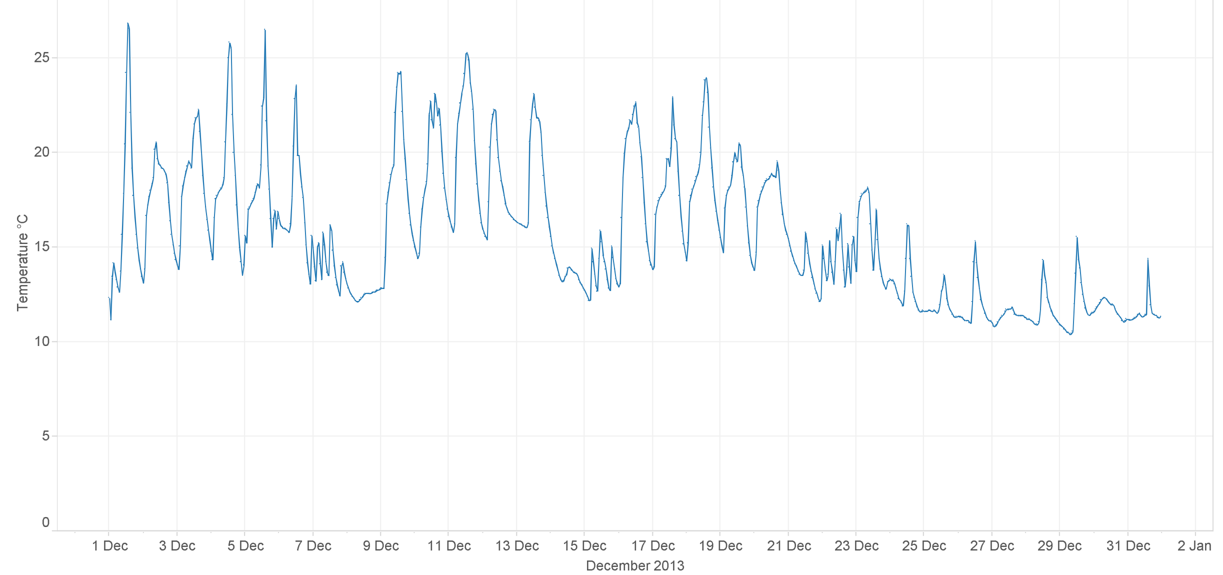


Figure 6.2.4: Recorded Temperature in Conference Room December 2013

The relative humidity (RH) of a room is an important factor to an occupants' feeling of well-being and CIBSE recommend a range between 40-70% to be acceptable, with 65% an optimal value. Low RH was recorded in all rooms and six room exhibited RH in excess of 70%. Table 6.2.3 details the percentage of occupied time above and below the comfort RH band recommended by CIBSE, it is of note that the RH is lower than 40% for around half of the year in each room. As the ventilation system provided is a mechanical ventilation system and does not condition the air for moisture content, low RH is unavoidable during periods of sustained cold weather. This could pose a health risk to the occupants. Low humidity can heighten the sense of smell and increase risk of static shocks, especially on a carpeted floor surface. The landlord should take precautions to limit generation of dust to reduce risk to occupants with allergic rhinitis and asthma.

	Relative Humidity (%)	Relative Humidity (%)
	Less than 40%	Greater than 70%
Room 3	49.59	0.26
Room 7	53.65	0.39
Room 8	55.30	0.00
Room 13	51.40	0.00
Room 15	50.09	1.11
Room 19	51.49	0.24
Room 21	45.12	0.53
Conference	51.76	0.01

Table 6.2.3: Percentage of time RH is outside the recommended comfort band for occupied hours 08:00-18:00hrs Mon-Fri Jan 2013 to May 2014.

Mean values for CO_2 concentrations (Table 6.2.2) indicate all rooms are of acceptable air quality. However values greater than 1000ppm have been recorded in all rooms at some stage during the monitoring period. The two most frequent rooms with high CO_2 concentrations are the conference room and room 3 on the ground floor. The conference room exceeds 1000ppm for 18% of the monitoring period which correlates with the function of the room (more densely occupied) and the poor performance of the extract fans in the room. In room 3, the frequency of CO_2 concentrations over 1000ppm was 5% of the monitoring period. This correlates to the nature of the tenants business; the tenant does not use the incubator unit as a conventional office, where there are frequently a large number of occupants in the room seated around a large table (**Figure** 6.2.5**).** The ventilation system provides a fixed air supply to the rooms, based on an assumed occupancy. This unanticipated use of the room (with high occupant numbers) has an impact on the ability for pollutants to be diluted by the ventilation system. Random air flow measurements were taken at three supply diffusers in room 21, the design air flow rate from each diffuser was 21 litres per second (l/s). The three measurements taken were 13.1 l/s, 10.8 l/s and 13.2 l/s, suggesting the ventilation system may not have initially been commissioned properly. Thus, the air flow delivered into room 3 may not be the design flow rate.

Figure 6.2.5: Internal view of room 3.

Figure 6.2.6: Internal view of conference room, showing pull down projector screen often used for solar shading.

Internal space temperature was reviewed for a Monday and Tuesday during the 2014 heating season, the conditions are plotted in Figure **6.2.7** the recommended CIBSE winter thermal comfort band of 21-23°C is shaded. The heating during the weekend is set to 'off' the space temperature falls to between 16 and 19°C on the morning of Monday 24th February the temperature begins to rise as the boilers are activated. Rooms 7, 15 and 21 did not reach the recommended comfort temperatures over the two days reviewed. Two of the rooms were unoccupied at the time and not subject to internal gains from equipment, occupants and lighting, which would help to raise internal temperatures. This pattern follows throughout the heating period and thus suggests the building operator should review boiler settings and switch heat on earlier than 0800 on a Monday morning.

It was of note that of the occupied office rooms, room 19, which is not occupied on a daily basis, tends to have the lowest temperature. Figure 6.2.8 identifies a period of occupancy on 20th February where a rapid heat up and cool down period between 8:00 – 14:00hrs is recorded; supporting the occupant habits of supplementing space heating with an electric fan heater.

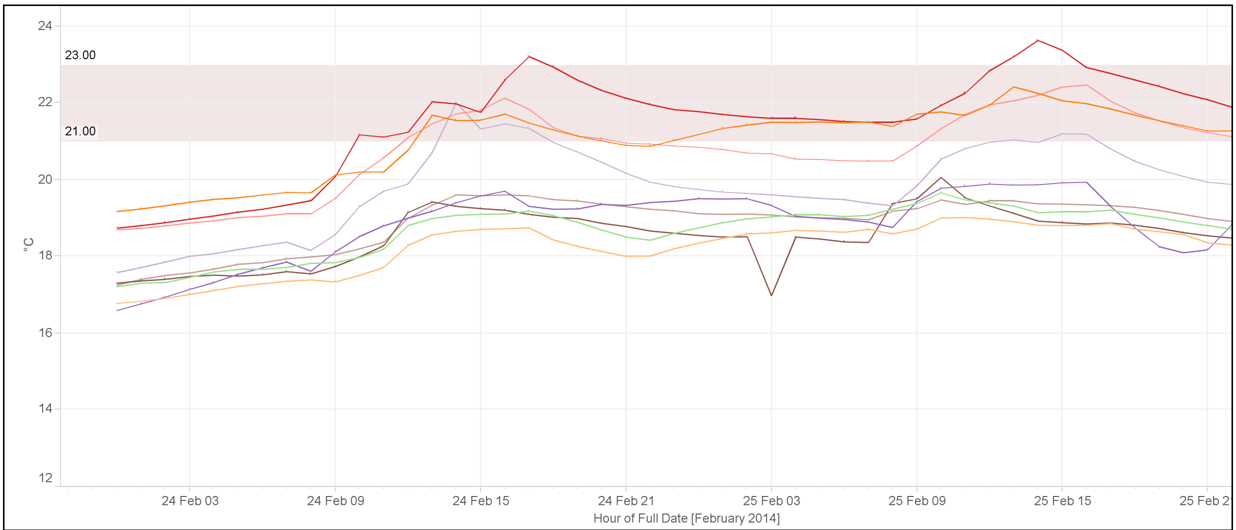


Figure 6.2.7: Internal temperature condition for monitored rooms 24th – 26th February 2014

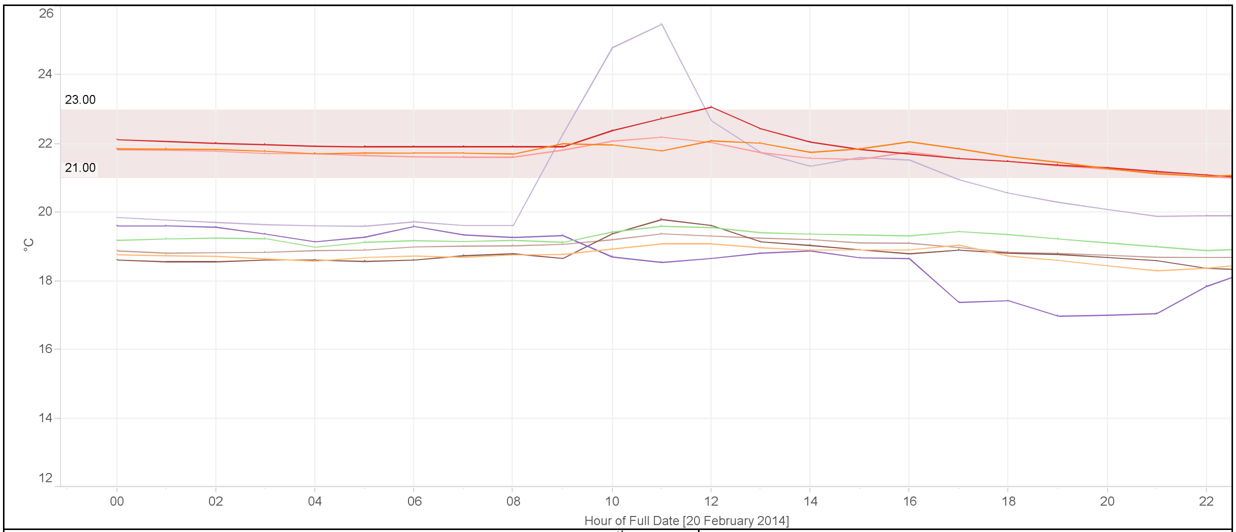


Figure 6.2.8: Internal temperature condition for monitored rooms 20th February 2014

6.3 Conclusions and key findings for this section

The external temperature and relative humidity and internal temperature, relative humidity and CO_2 concentrations were monitored for a series of internal spaces. The winter period 2012/2013 and 2013/2014 were mild in comparison to a usual Scottish winter. The data indicated that the building heat up times, especially after a weekend were insufficient to raise the internal space temperatures to comfortable levels for sedentary workers. Although the rooms which were mostly affected by cooler space temperatures were predominately the unoccupied rooms, which were not subject to internal heat gains from occupants and equipment. Unfortunately for the BPE study and the building owner, the unoccupied rooms were not occupied for an extended period during the monitoring; it is therefore unknown how these rooms would perform thermally if they were continually occupied. It was of interest that the coolest occupied room was room 19, where the single occupant frequently complains of feeling cold and supplements space heating using an electric fan heater, this room was also found to be the leakiest room during airtightness testing. Boiler start times should be reviewed, by the building owner, to ensure space temperature has reached comfortable temperatures prior to the building opening on a Monday morning. Overheating was restricted to the glazed conference room.

Internal relative humidity levels were found to be lower than 40% for more than 50% of the time. Sustained low relative humidity has a health impact to occupants, these include drying of nasal passages, heightens sense of smell, irritation of respiratory tract, irritate skin, dry eyes and cause static shocks. The building, like most buildings in the UK, is free running for relative humidity. This means the mechanical ventilation system does not treat the moisture content of the air, like a full air-conditioned system; therefore low relative humidity is unavoidable. Possibly the heating of the ventilated air dries it out. The building owner should ensure that the building is kept free of dust which may assist in reducing symptoms of low relative humidity. If this is common, the designer may have to consider introduction of humidifier measures.

The internal CO_2 concentrations generally were found to be acceptable in most rooms. Two rooms were found to have high concentrations for extended periods through the year. These were room 3 and the conference room. Air extract flow measurements in the conference room and supply diffuser elsewhere in the building indicated poor performance which indicates the systems were not adequately commissioned. Increased ventilation rates would assist in diluting CO_2 concentrations. The recommendation would be for the ventilation systems to be re-commissioned.

7 Details of aftercare, operation, maintenance & management

7.1 General

The building is run and operated by Fife HARCA (a subsidiary of Ore Valley Housing Association) with staff manning reception and with an office for the administration.
The centre's manager is responsible for maintenance on a reactive basis. He has had no formal training in commercial building management and BMS operation.
Although the maintenance manuals have now been received by the client, experience in this sector remains an issue.
The original building services supplier/installer has since run a series of training workshops relative to energy management and to the BMS system and monitoring arrangements.
HARCA are also looking into the potential to employ an FM agent to assist with the management and maintenance arrangements.

7.2 Operation, maintenance, and management

There has been a difficulty in the operation, maintenance and management of the building since occupation due to several factors as highlighted in the soft landings workshop (refer to appendix):-

7.2.1 Handover: The O&M manuals were passed around the project team, but were never completed. As a consequence the building did not yet have a full set of operation and maintenance manuals. As a direct result of this BPE project the maintenance manuals are now in the client's possession, and allied to the services sub contractors' workshops, the client has now a much better understanding of the buildings operation.

The building's systems were well explained at handover, but this was undermined by a lack of simple instructions for building users. In addition, the lack of appropriate manuals and technical literature at the time of handover restricted the level of detail and understanding available to operational staff and made managing the building and its facilities difficult.

The project team has been attempting to plug gaps in knowledge and resolve issues.

7.2.2 Operational: The iconic building desired by the client was regarded as "lettable" at handover, and was relying on the simple systems to operate efficiently.

Due to a lack of training and building operation literature at handover, there was a limited understanding as to whether the building was performing properly.

The building's remote monitoring system was cut out on cost grounds (approximately £2000), but the implications of this was not appreciated until the building was handed over and the client, with the Termodeck provider, attempted to run the building. A replacement remote monitoring system became operational in late October 2012 resulting in an ability to recognise any maintenance issues by the provider. They are now able to look into imbalances in the system, recommending adjustment as necessary. Although generally a passive operation, expertise is required to get the best from what is a relatively unknown technology.

The M&E consultants experienced significant staff issues during 2010. As a result, they disengaged from the project towards project completion and were generally not around to help the project team understand the building and support the client. Suitable replacements could not be brought in at such a late stage of the project to resolve this.

The bulk of the building operates in the manner that it was intended, delivering a comfortable working environment without issue. However, since completion, the building has had a leakage problem in the basement that is evidenced by significant water ingress during prolonged rainfall. Despite significant effort, this issue remains unresolved. This has proven to be especially frustrating. Ponding in the rear entrance causes difficulties with occupants and particularly with the less abled, who tend to use this route from the car park. Exploratory works (removing wall panels), have impacted on air permeability.

There was an issue with one radiator at reception, which could not be turned off. This radiator was installed adjacent to the entrance to the IT Server cupboard which is actively cooled and therefore was likely to cause air flow and issues in both the heating and cooling balance in this area. Of primary concern was the fact that this radiator seemed to control all of the radiators in the reception and lounge area above. This was subsequently investigated and found not to be the case and the issue has since been addressed by having the radiator disconnected and permanently disabled. This has had no impact on the heating of the local area which is well served by five remaining radiators in this area. We would anticipate that the loss of warm air outside the server cupboard will improve the efficiency of the cooling element within as well.

The front door remains heavy to open but the glass interior door has been re-installed giving it more height clearance above the carpet and making it easier to open.

Section 9 expands on issues which had an impact.

7.2.3 Manageability and maintainability: Very few issues emerged with the building in the initial 6 months of operation with the installed systems working effectively despite little to no building management interaction. The first major problem, one that still persists, was the leak problem in the basement which first was discovered after the initial 6 months of operation.

After several years of investigation involving many elements of the project team and third parties, it has become apparent that the cause for the leak issue was the incorrect installation of damp proof membrane which instead of repelling water ingress acted as a sump in the wall cavities. Particularly evident during periods of heavy rain, water would gather in a trough formed by the membrane in the cavity and pool until it hit a certain height at which point it would spill over the membrane in to the habited area of the basement causing a flood. The resulting damage has been considerable from basic decoration, lifted floor coverings etc. but more concerning has been the impact on the metal work behind the plasterboards and the building's frameworks. The risk to users was and remains the primary concern but a recent push by Fife HARCA has focused attention on resolving the issue once and for all.

Operation and maintenance of the centre lies with the building management team but there is an inherent reliance on sub-contractors for support with major issues such as plant maintenance, cleaning etc. However, on two occasions the centre has lost heating from faults that were not picked up by the BMS and therefore gave no obvious electronic indication to the staff that there was a problem. The only evidence was a loss of heat in the Termodec areas of the building. With limited knowledge of the air handling system, centre staff were able to identify the fault – two fan belts had sheared leading to no circulation of warm air through the Termodec slabs. The fault would not show on the system as both the fans and heat exchanger continued to work without issue; only the lack of airflow was a problem. However, when the same issue arose over a year later, staff were able to quickly identify and resolve the issue as a result of the previous experience.

The client believes that the building has proved to be functional for the tenants. This is considered a success, as the building was effectively a speculative office development.

The Termodeck has proved to be "mercifully bullet-proof" in terms of providing relatively stable occupant comfort conditions. This has restricted the effect of knowledge limitations and monitoring shortcomings. There have been requirements for belt replacements and filter cleansing since installation, which are maintenance issues not realised at the time. Remote monitoring would identify such issues timeously. However, such issues are now understood by the client following the training workshops.

The building's maintenance requirements were not fully appreciated by the client at the project development stage and the project team did not specifically address maintainability in the design.

7.2.4 Occupation levels and income: The extent of maintenance works relied on the clients knowledge of the buildings operation, allied to the rate of occupation and relative income. Finances were stretched at the early stages and any maintenance was purely on a reactive basis. As the building has become more occupied this has eased, although 2 of the 3 large offices remain unlet. The centre is now well used and enjoying a high level of occupancy but marketing the facility to potential tenants has not been without difficulty. The larger room spaces in the building have been difficult to let given the higher rent and rateable values they attract. Few new or start-up businesses (the target audience) could be expected to afford these costs. The client has been successful in filling the smaller spaces but with so much of the potential rental income tied up in the larger rooms, a significant focus has had to be given to promoting these units to ensure that financial projections for the facility remain on track. The client is currently considering a proposal to sub-divide these larger offices into smaller, easier to let spaces although a recent re-certification of the rateable value of the larger offices sees all office spaces in the centre now fall underneath the threshold where they would attract small business rates relief, significantly enhancing the product offering.

Had the difficulties in letting so many spaces been anticipated from the outset, perhaps greater flexibility in space and energy provision been allowed for within the design. However, this is not a simple operation, particularly with regard to lighting and small power provision/control. It implies a degree of post-contract work to suit potential tenants once signed up, which may affect the pricing model (although effectively this is what is now being considered).

7.3 Lessons Learned

The development of the business centre proved to be a challenge throughout. From inception through to operation, numerous difficulties have been encountered that had material impacts on the project that had to be overcome. This put considerable strain on the organisation's resources and personnel.

The importance of information transfer to the client has been highlighted.

Green credentials (specifically Termodeck) were achieved on a very tight budget and construction schedule.

As start-ups fail or succeed, occupants come and go. This building type needs greater flexibility of space provision than originally anticipated. Perhaps, it should be designed from the outset to the smallest unit size. As needs grow, occupants could rent multiple units or combine same. This was perhaps not appreciated from the beginning, where variety of unit size was seen as the answer to flexibility requirements.

However, despite these problems, the centre is now in place, delivering real benefit to the local economy, providing jobs to local residents and supporting numerous new businesses across a diverse range of industry sectors.

8 Energy use by source

8.1 Sub Metering

In April 2013, 4 main Sub-meters were initially installed to cover each of the three floors as well as the Termodeck installation. There were also 3 offices sub metered for small power and lighting.

This installation however did not comply with TM22 requirements, and this arrangement was subsequently amended in August 2013 to monitor the following circuits in compliance with TM22 requirements:-

Lighting
Small Power
Space Heating
Hot Water
Lift
Kitchen
Fans

As result, data suitable for running under TM22 was available for one year only, rather than two.

We will consider the TM22 analysis, then discuss the results of the earliere analysis under section 8.3.

8.2 TM22 Analysis

8.2.1 The Building: The Lochgelly Business Centre is a 4-storey construction, completed in 2010. It consists of cellular business incubator units plus common areas over three floors, with plant in the basement. The Gross Internal Floor Area (as measured from drawings) is 1450m^2, of which 812m^2 is available for let. The building supports various occupiers, who rent space and use of common facilities, including energy provision.

The offices areas and some circulation areas are heated using the Termodeck ventilated concrete slab system, while the other common parts have a more conventional low temperature hot water radiator (LTHW) system. Both are powered by the same gas boiler. It is naturally ventilated throughout.

Although the building has regular core hours (09.00-18.00), in practice much of it is occupied in the evenings and at weekends.

During the period of study a significant number of the incubator units remained unlet. This will distort the results with regard to the overall performance of the building. An estimate of the likely energy use under full occupation was considered and will be referred to in Section 6.2.

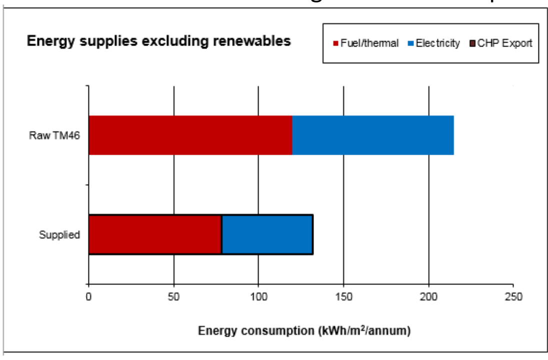
8.2.2 Annual Energy Use: The building utilises gas for space heating and grid supplied electricity for everything else. Energy bills for the purposes of this report were available from 25/02/13-20/05/14 (gas) and 01/03/13-01/06/14 (electricity). Based upon suppliers' metered information, the building used 113.7MWh gas and 77.6MWh electricity, adjusted for a year as appropriate. This equates to 78.4kWh/m^2 for gas and 53.5kWh/m^2 for electricity, as shown below;

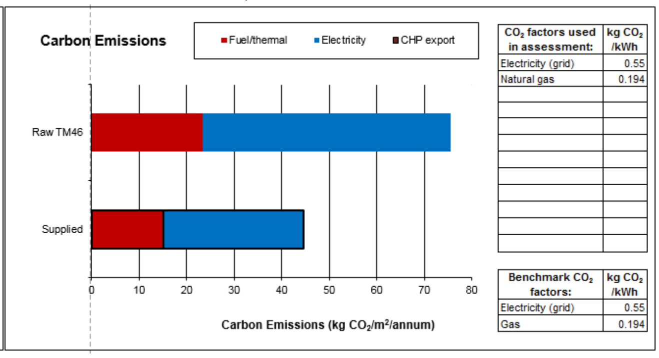
BUILDING ENERGY SUMMARY

Energy, carbon and cost summary	Units	Electricity	Fuels	Thermal
Non renewable fuel or electricity supplied to site	kWh/annum	77,613	113,751	0
Separable energy uses	kWh/annum	0	0	0
Renewable energy used on site	kWh/annum	0	0	0
Renewable energy exported	kWh/annum	0	0	0
Output from CHP used in building	kWh/annum	0		0
Exported CHP	kWh/annum	0		0

Unit values	Energy supplied (kWh/m^2 GIA)		Carbon dioxide emissions ($kg\ CO_2/m^2$ GIA)		
	Fuel/thermal	Electricity	Fuel/thermal	Electricity	TOTAL
Supplied	78.4	53.5	15.2	29.4	44.7
Exported CHP	0.0		0.0		
Raw TM46	120.0	95.0	23.3	52.3	75.5

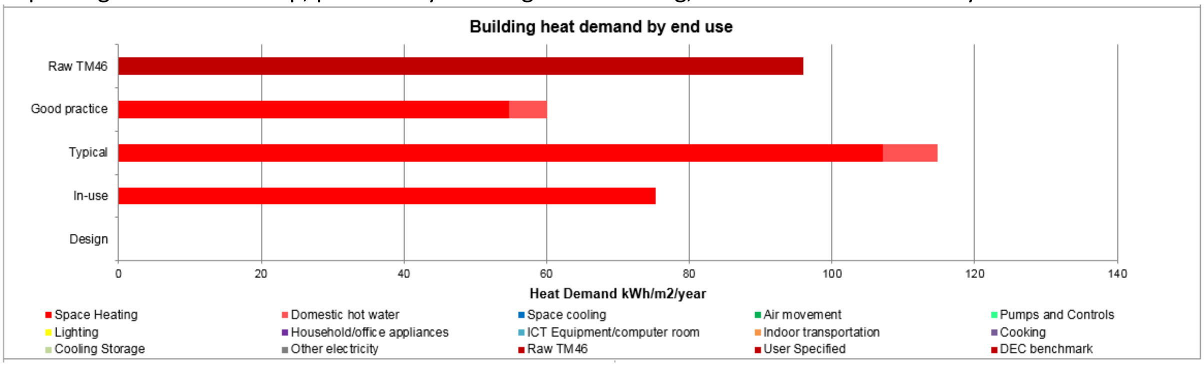
The charts below show the figures when compared to TM46 benchmarks;





As the building is in Scotland DEC figures are not available. It can be seen that on overall performance the building compares favourably with the benchmarks.

8.2.3 Detailed Energy Use: Gas is used for space heating alone, with no hot water or cooling. With regards to the building heat demand, it would be preferable if the two heating formats could be identified separately by meters. However, this has difficulties; both systems share the same boilers and common circulation spaces are split between either. Sensors were installed within the Termodeck construction but were there in order to monitor and confirm that the system was operating properly. The supplier confirmed this in a report, making observations on means of improving the control setup, particularly with regards to zoning, which works on a floor by floor basis.



For assessment of electricity demand the building was broken down to 7 submeters on a half-hourly recording regime for comparison with the overall figures. Results were recorded over a year, from 01/07/13-30/06/14. Where identified, the electrical demand has been categorised in accordance with TM22 guidelines. Some items could not be identified as attached to any submeter, so were recorded as such.

a) *Space Heating*

   Electrical demand is used for controls, for driving the pumps on the LTHW system and for the air handling unit (including heat recovery) driving the air for the Termodeck heating.

b) *Water Heating*

   All hot water deliveries use local electric instantaneous units. These are shared amongst all occupants, with no individual provision. It was noted that kettles proliferate throughout, despite a common use kitchen made available. These are considered under the Small Power section.

c) *Lighting*

   There is a mix of individually controlled lighting (incubator units) and common lighting. Of the latter, only the toilet areas are controlled by presence detectors with overrun timers. Photocells are used for the external lights, which are not included within this submeter. The incubator units' occupancy rates affect the lighting use, so are factored in by the usage factors.

d) *Small Power*

   An audit was carried out throughout the building of all the small power, (including computers, kettles, water coolers, etc. within units). Power ratings were recorded from the items themselves.

e) *Kitchen*

   These items relate only to the communal kitchen facilities, which are only partially used by the occupants.

f) *Lift*

The building has one communal lift installation, which is shared amongst the tenants. One month's results (November 2013) failed to record.

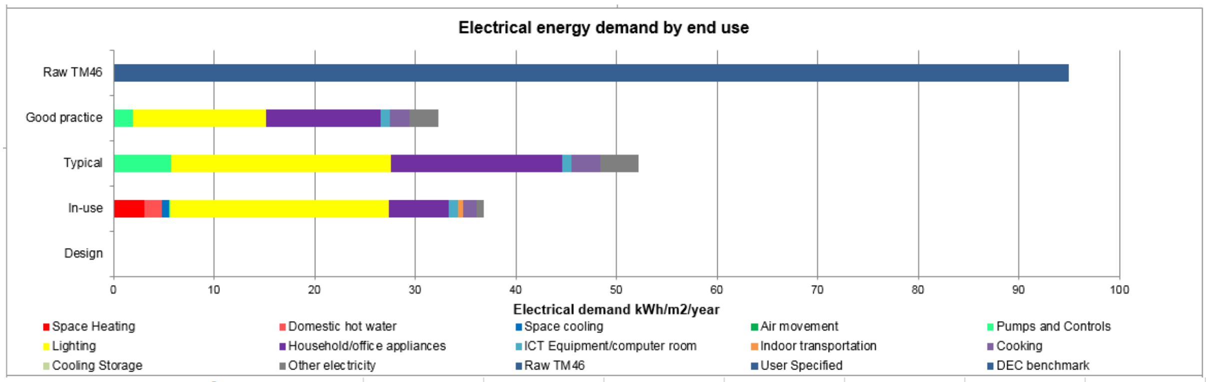
g) Fans

These relate to ventilation fans only, used for toilets and server rooms. Extract fans also serve the common meeting rooms. There is no evidence of the ventilation to the toilets being linked to the lighting.

h) No submeter

Items which are not linked to identifiable submeters, (due to function or location), fall under this category. There is, however, a significant divergence between the submeter and utility meter provision, which is only partially resolved. This requires further investigation to reduce the inevitable distortion of analyses results.

These items are identified in detail under the TM22 'in-use' section. Note should be taken of the large amount of non-core hours activity, which has been identified within the various profiles.
The total electrical energy use is reflected under ISO 12 ECON 19;



ENERGY DEMAND (kWh/m²/year)

System	Heat demand (kWh/m2/year)				Electricity demand (kWh/m2/year)			
		In-Use (kWh/m²/year)	Typical benchmark (kWh/m2/year)	Good practice benchmark (kWh/m2/year)		In-use electricity (kWh/m²/year)	Typical benchmark (kWh/m2/year)	Good practice benchmark (kWh/m2/year)
Space Heating		75.3	107.2	54.7		3.1		
Domestic hot water		0.0	7.6	5.3		1.7		
Space cooling		0.0				0.7	0.0	0.0
Air movement		0.0				0.1	0.0	0.0
Pumps and Controls		0.0				0.0	5.7	1.9
Lighting		0.0				21.8	21.9	13.3
Household/office appliances		0.0				5.9	17.1	11.4
ICT Equipment/computer room		0.0				0.9	0.9	0.9
Indoor transportation		0.0				0.6		
Cooking		0.0	0.0	0.0		1.3	2.9	1.9
Cooling Storage		0.0				0.0		
Other electricity		0.0				0.7	3.8	2.9
Total		75.3	114.8	60.0		36.8	52.2	32.3
Metered building energy use		75.3				53.5		
Variance TM22 versus metered total		0.0				-16.7		
Variance TM22 versus metered total		0%				-31%		

Whole building benchmarks

	Energy demand (kWh/m²GIA)	
	Heat	Electricity
Raw TM46	96.0	95.0

(ECON 19 Breakdown)

8.2.4 Comment: Analysis of the Breakdown reveals some interesting points. The thermal performance of the two heating systems falls between the 'typical' and 'good practice' benchmarks. The electrical load factors approach the 'good practice' figure. Of particular interest, the most significant contributors, lighting and small power, diverge significantly from the benchmarks. Despite choice of efficient lighting (T5, CFL, LED lamps), the figure barely beats the 'typical' figure. This may reflect the extensive out of hours use, (not reflected in the benchmark), and the lack of zoning/photocell/presence controls. On the other hand, the small power element seems to be exceptionally low. Despite an intensive audit, there must be items which have not been identified as covered by the relevant submeter. A major caveat concerning partial occupancy must apply to the electrical section. In particular, the lighting and small power demands will increase notably under full occupancy. As it is a significant issue, this is considered further in section 8.3.5.

8.2.5 Metering Breakdown- Patterns: The monthly meter readings were explored for patterns and anomalies.

General gas use: The usage was roughly consistant to what may be anticipated, reflecting seasonal factors. The readings vary from mothly to quarterly, due to a change in provider during the study. However, one can see the reduction in Summer consumption, particular during April-May 2013.

General Electricity Use: For most of the year, consumption averaged approximately 6.1MWh/month. However, in winter, consumption increased by 20%, even though the heating is mainly provided by gas. There will, of course, be increased demand by pumps, heat exchangers, etc. The dip around August be be explained partly by seasonal factors and by occupant issues, such as holiday absences.

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RESULTS OF METER/SUBMETER READINGS

GENERAL ELECTRICAL USE (kWh)

01/03/2013	01/04/2013	5385
01/04/2013	01/05/2013	6095
01/05/2013	01/06/2013	6491
01/06/2013	01/07/2013	6344
01/07/2013	01/08/2013	5320
01/08/2013	01/09/2013	6014
01/09/2013	01/10/2013	5941
01/10/2013	01/11/2013	6461
01/11/2013	01/12/2013	6766
01/12/2013	01/01/2014	7179
01/01/2014	01/02/2014	8092
01/02/2014	01/03/2014	6992
01/03/2014	01/04/2014	7098
01/04/2014	01/05/2014	6438
01/05/2014	01/06/2014	6560
TOTAL		97176

GENERAL GAS USE (kWh)

From	To	
25/02/2013	28/03/2013	16052
28/03/2013	30/04/2013	11304
30/04/2013	16/05/2013	4581
17/05/2013	13/08/2013	20637
14/08/2013	14/11/2013	8515
15/11/2013	13/02/2014	42658
14/02/2014	20/05/2014	36182
TOTAL		139929

ELECTRIC SUBMETERS (kWh)

	SUBMETERS	Aug'13	Sept'13	Oct'13	Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14	May'14	Jun'14	Jul'14	TOTALS
E1	LIGHTING	1165	2687	2867	1923	2510	3379	2925	3059	2889	2984	2717	2426	31531
E2	SMALL POWER	243	499	626	2880	1055	900	845	1009	867	927	897	909	11657
E3	SPACE HEATING	36	81	82	384	629	778	604	382	195	116	62	234	3583
E4	HOT WATER	62	142	154	258	146	166	152	166	163	152	172	329	2062
E5	LIFT	32	67	75	0	80	92	67	77	78	80	74	76	798
E6	KITCHEN	11	28	48	43	81	88	59	64	49	73	60	22	626
E7	FANS	1	1	9	51	0	13	0	2	4	1	5	56	143
		1550	3505	3861	5539	4501	5416	4652	4759	4245	4333	3987	4052	50400

SUBMETER BREAKDOWN

Mon-Fri Core

	SUBMETERS	Aug'13	Sept'13	Oct'13	Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14	May'14	Jun'14	Jul'14	
E1	LIGHTING	597	1239	1479	770	1317	1843	1624	1683	1582	1578	1432	978	16122
E2	SMALL POWER	93	177	253	1299	443	358	388	472	379	380	359	316	4917
E3	SPACE HEATING	15	35	36	194	168	222	148	77	60	40	24	120	1139
E4	HOT WATER	22	53	62	138	58	71	66	71	76	62	88	173	940
E5	LIFT	11	23	27	0	28	37	25	27	28	28	25	28	287
E6	KITCHEN	6	14	28	29	57	55	40	42	29	41	28	10	379
E7	FANS	1	2	4	35	0	1	0	2	2	1	4	27	79
		745	1543	1889	2465	2071	2587	2291	2374	2156	2130	1960	1652	23863

Mon-Fri non-core (evenings)

	SUBMETERS	Aug'13	Sept'13	Oct'13	Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14	May'14	Jun'14	Jul'14	
E1	LIGHTING	450	1081	976	759	843	1053	942	913	1008	1011	906	756	10698
E2	SMALL POWER	104	220	245	1056	402	342	323	349	325	361	352	368	4447
E3	SPACE HEATING	11	24	26	126	260	323	262	139	84	45	23	85	1408
E4	HOT WATER	25	55	60	79	53	63	54	55	56	55	55	112	722
E5	LIFT	14	30	32	0	29	33	28	30	33	32	31	33	325
E6	KITCHEN	4	11	16	10	16	21	15	18	17	25	20	8	181
E7	FANS	0	0	5	10	0	2	0	0	3	0	1	18	39
		608	1421	1360	2040	1603	1837	1624	1504	1526	1529	1388	1380	17820

Sat-Sun

	SUBMETERS	Aug'13	Sept'13	Oct'13	Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14	May'14	Jun'14	Jul'14	
E1	LIGHTING	118	367	412	393	349	483	359	463	299	395	379	692	4709
E2	SMALL POWER	46	102	128	526	210	200	134	188	163	187	187	225	2296
E3	SPACE HEATING	10	22	21	64	201	233	194	166	52	31	15	29	1038
E4	HOT WATER	15	34	31	41	35	33	33	40	31	34	29	112	468
E5	LIFT	8	14	16	0	22	22	15	20	17	20	18	15	187
E6	KITCHEN	1	3	3	4	8	11	3	5	4	7	12	4	65
E7	FANS	0	0	0	6	0	10	0	0	0	0	0	11	27
		198	542	611	1034	825	992	738	882	566	674	640	1088	8790

If we examine the submeter results:

Lighting:- There are few significant changes over the year, bar August and November 2013. This may suggest that lighting use changes little over the year, although winter evenings have an impact. Weekend consumption seems to be constant. This may reflect earlier comment that lights appear to be left on irrespective of occupancy.

Small Power:- Apart from August 2013, small power use is consistent through most months. There is a spike in November, plus increased usage over winter weekends, perhaps reflecting the use of standalone electrical heaters at these times.

Space Heating:- Tends to reflect increased demand during winter as the general heating. There is an unexplained spike during July 2014 core hours.

Hot Water:- Consistent, apart from a 60% increase during November core hours, which must be anomalous, (perhaps more visitors during that period).

Lift:- Generally consistent, despite a zero return in November 2013. This is patently an erroneous result, although unlikely to cause significant distortion of overall results.

Kitchen:- No real pattern. Increase in November/December, which may be due to demand for hot meals.

Fans:- Figures are generally low. Interesting result during some winter months, when increased ventilation demand is not usually anticipated. However, use of meeting rooms impact on ventilation demand. The July increase may reflect overheating due to solar gain.

8.2.6 Impact of Partial Building Occupancy: As noted, the building did not enjoy full occupancy over the period of study. This inevitably distorts the results. We explored this and have attempted to anticipate the impact of 100% occupancy as a desktop exercise.

Of a total lettable floorspace of 812m^2, 338m^2 remained empty; a ratio of 41% floorspace unused. If occupied, the number of persons in the building would increase by 91%, based upon floorspace. This significantly distorts any comparison with benchmarks, which assume a fully occupied property. Therefore, we ran a dummy version of TM22 with estimated corrections to see the impact under-occupancy has on the results of the study. Our methodology is presented below;

<u>E01 Lighting</u>
The only lighting significantly affected by increased occupancy is luminaire types A1 and A2, prevalent in the cellular units and shared meeting facilities. The current situation was reflected in the usage factors used. If the building was totally let, A1 and A2 lighting use would increase by 96%, (based upon luminaire count). All other lights would not be affected. This would result in lighting demand increasing by ***11763kWh/year***. As most unlet units are South-facing, the estimate may reduce somewhat due to daylight factors. This assumes that the vacant rooms were unlit throughout the year, which may not be the case. Therefore, this estimate is a 'worst case' situation.
<u>E02 Small Power</u>
If occupied, it can be assumed that the vacant units would impose a similar load to the occupied ones. By identifying the current loading from the occupied units (11657-1140= 10517kWh/yr.) we estimate a potential increase of ***9570kWh/year***, based on floor area.
<u>E03 Space Heating</u>
The Termodeck system is designed to heat the whole floor plates, so would be unaffected by occupancy numbers. Similarly, the LTHW only affects common areas. There may, however, be a small increase in the building's ambient heat due to additional persons and equipment. Similarly, the building's gas use would be little affected.
<u>E04 Hot Water</u>
The additional occupancy would increase demand on the instantaneous hot water in the kitchen and toilets by approximately 91%, adding an additional estimated load of ***1937kWh/year***.
<u>E05 Lift</u>
As three of the empty units are on the ground floor, we anticipated use would increase by less than 91%, perhaps 45%. This would add ***359kWh/year***.
<u>E06 Kitchen</u>
The use of communal kitchen facilities is limited due to kettles, microwaves, etc. within the units themselves. Nevertheless, it would seem reasonable to anticipate use would be increased by 91%, i.e. ***567kWh/year***.
<u>E07 Fans</u>
We anticipate little additional impact on these as they are driven by timers rather than by occupancy.
<u>Non-metered</u>
We anticipate little impact.

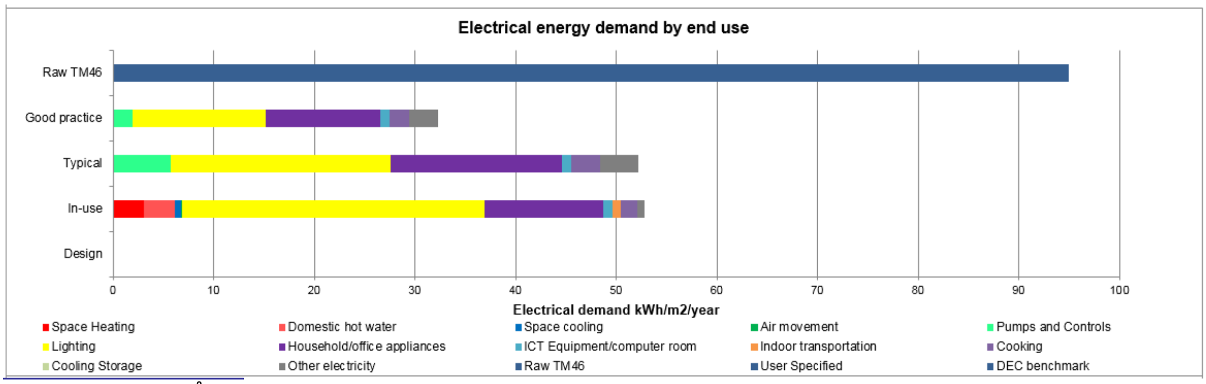
In summary, we would estimate a fully occupied building to have an increased electrical power demand of ***24196kWh/year***.

Impact of Estimated Full Occupancy against Benchmark:

Unit values	Energy supplied (kWh/m^2 GIA)		Carbon dioxide emissions ($kg\ CO_2/m^2$ GIA)		
	Fuel/thermal	Electricity	Fuel/thermal	Electricity	TOTAL
Supplied	78.4	70.9	15.2	39.0	54.2
Exported CHP	0.0		0.0		
Raw TM46	120.0	95.0	23.3	52.3	75.5

One can see that the estimated electricity supply rises to ***70.9kWh/m²***.

Under ISO 12 ECON 19 the results change significantly;



ENERGY DEMAND ($kWh/m^2/year$)

	Heat demand (kWh/m2/year)				Electricity demand (kWh/m2/year)			
System		**In-Use ($kWh/m^2/year$)**	**Typical benchmark (kWh/m2/year)**	**Good practice benchmark (kWh/m2/year)**		**In-use electricity ($kWh/m^2/year$)**	**Typical benchmark (kWh/m2/year)**	**Good practice benchmark (kWh/m2/year)**
Space Heating		75.3	107.2	54.7		3.1		
Domestic hot water		0.0	7.6	5.3		3.0		
Space cooling		0.0				0.7	0.0	0.0
Air movement		0.0				0.1	0.0	0.0
Pumps and Controls		0.0				0.0	5.7	1.9
Lighting		0.0				30.0	21.9	13.3
Household/office appliances		0.0				11.9	17.1	11.4
ICT Equipment/computer room		0.0				0.9	0.9	0.9
Indoor transportation		0.0				0.8		
Cooking		0.0	0.0	0.0		1.7	2.9	1.9
Cooling Storage		0.0				0.0		
Other electricity		0.0				0.7	3.8	2.9
Total		**75.3**	**114.8**	**60.0**		**52.8**	**52.2**	**32.3**
Metered building energy use		75.3				**70.9**		
Variance TM22 versus metered total		**0.0**				**-18.1**		
Variance TM22 versus metered total		0%				-25%		

Note that the TM46 benchmark for a typical Type 1 office building is now exceeded. This is solely due to the lighting performance, which is possibly twice what it need be, so requires further study. Other factors perform satisfactorily.

8.3 Initial Small Power and Lighting Analysis for 3 Offices

8.3.1 At the commencement of the study sub-meters were set up at various distribution boards within the building to monitor electrical energy consumption within the building. The sub-meters collected data at 5 minute intervals for the circuits identified in table 5.1 and 5.2. These were subsequently replaced by the TM22 compliant arrangement. Nevertheless, the results merit consideration.

The distribution of sub-meters were arranged as follows:

Electrical Energy Per Zone	
Basement	Motor Control Panel (MCP)- Plant energy consumption
Ground floor	Total electrical energy consumption
First floor	Total electrical energy consumption
Second floor	Total electrical energy consumption

Table 5.1: *Electrical Energy by Zone in Ore Valley Business Centre, Lochgelly*

Electrical Energy Consumption Per Room			
Room 3	Ground floor	Small Power	Lighting
Room 8	First floor	Small Power	Lighting
Room 20	Second floor	Small Power	Lighting

Table 5.2: *Electrical Energy for small power and lighting by Office in Ore Valley Business Centre, Lochgelly*

As per the TSB application document, the electrical sub-circuits are set up to monitor unregulated energy use in a variety of office types and sizes to determine whether the current model of rent charges is successful and to assist in targeting and identifying reductions in the unregulated electrical energy consumption.

In this section the energy consumption for a three month period from April – June 2013 will be reviewed on for each floor and unregulated energy consumption in individual offices will be discussed.

8.3.2 Electrical Energy Consumption by Floor: Data for three months electrical energy consumption is plotted in figure 5.1, it shows that the energy demand at the MCP in the basement to consume significantly more energy than any other circuit, with the ground floor having a higher base load than the other floor levels. High peaks are shown for both the first and second floors. For clarity this data has been plotted by month and discussed below. Data for each circuit has been averaged over an hour to provide legibility to the data.

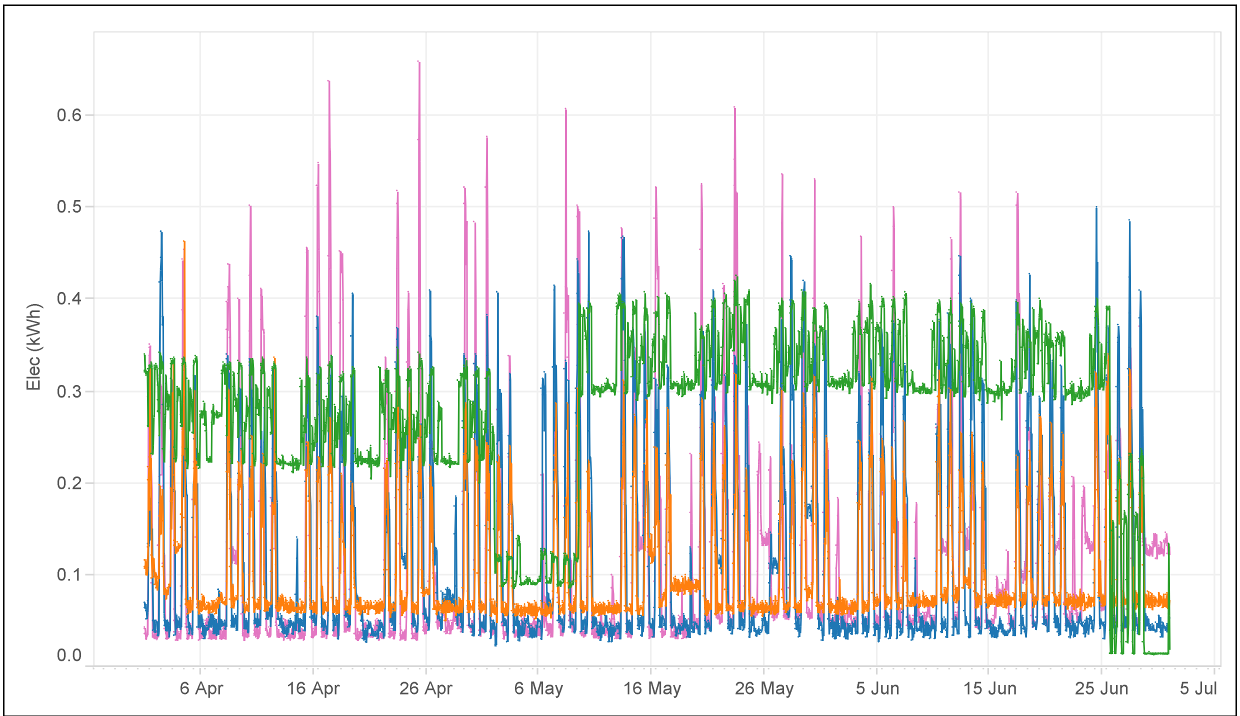


Figure 5.1: *Electrical Energy by Zone in Ore Valley Business Centre, Lochgelly*

Legend
MCP
Ground
First
Second

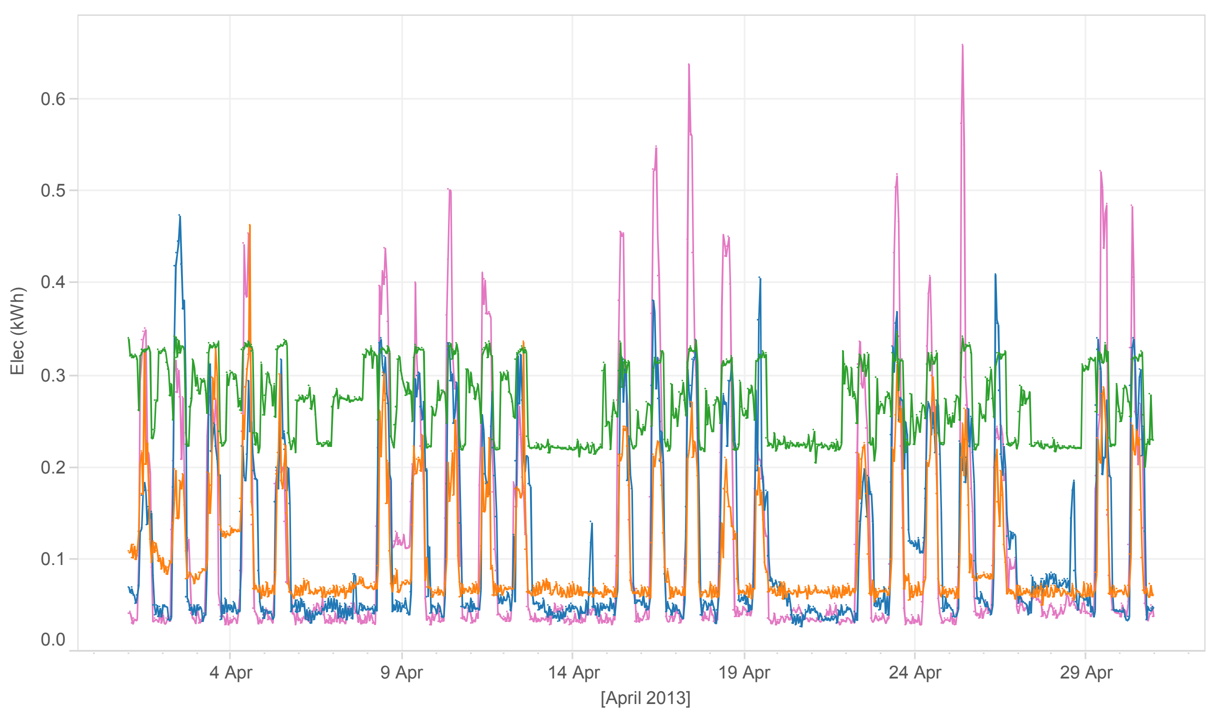


Figure 5.2: *Electrical Energy Consumption by Zone, April 2013 in Ore Valley Business Centre, Lochgelly*

Legend
MCP
Ground
First
Second

The data for April shows the base load consumption for MCP (plant) circuit to be consistently higher than any other sub-circuit, with weekend periods being clearly identifiable. The peaks in the graph identify the consumption to increase per floor during office hours when lighting and small power are being used in each of the offices. Even though occupancy of first and second floor levels are identical the chart exhibits the second floor to consume considerably more electrical energy than the first floor offices, however it appears that the second floor consumption reduced considerably on a Friday. Figure 5.3 details the profile over a typical weekday, 17th April, which clearly shows the peak consumption in the second floor over all other consumption in the building. Figure 5.4 illustrates the typical pattern on a Friday, 19th April 2013.

While the office building is unoccupied during the night and over weekends, it shows the base load of the plant to be higher than all floor levels, however comparing the floor levels, the ground floor has the largest base load, which may be for the server in one of the offices and associated comfort cooling in the ground floor server room.

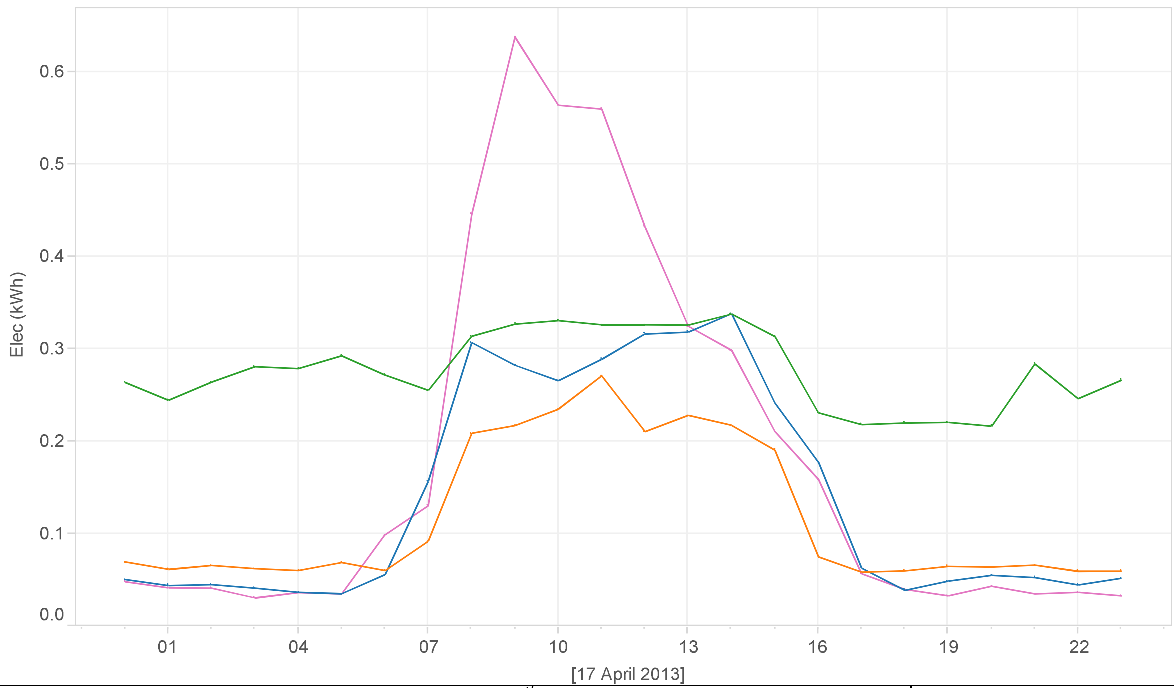


Figure 5.3: *Electrical Energy Consumption by Zone, 17th April 2013 in Ore Valley Business Centre, Lochgelly*

Legend
- MCP
- Ground
- First
- Second

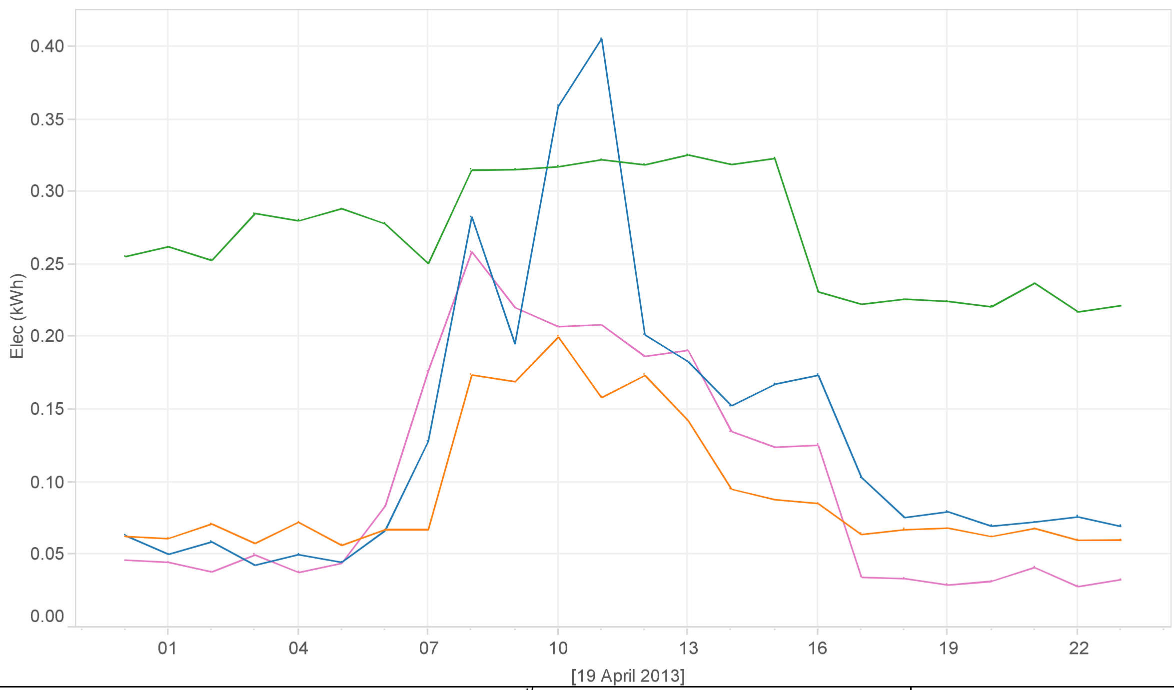


Figure 5.4: *Electrical Energy Consumption by Zone, 19th April 2013 in Ore Valley Business Centre, Lochgelly*

Legend
- MCP
- Ground
- First
- Second

Data for May continues to exhibit the MCP base load as much higher than the other circuits on each floor level. However the valve has increased to between 0.3 and 0.4 kWh throughout the month of May. There is large drop in MCP demand early May for a period of about a week, although this represented a weekend of a public holiday, the load continues to be reduced until the Thursday. It is not clear what caused this drop in consumption.

The base load for the ground floor continues to be higher than the other two floors, but the ground floor exhibits lower peak consumption data. This may be due to the number of vacant offices on the ground floor.

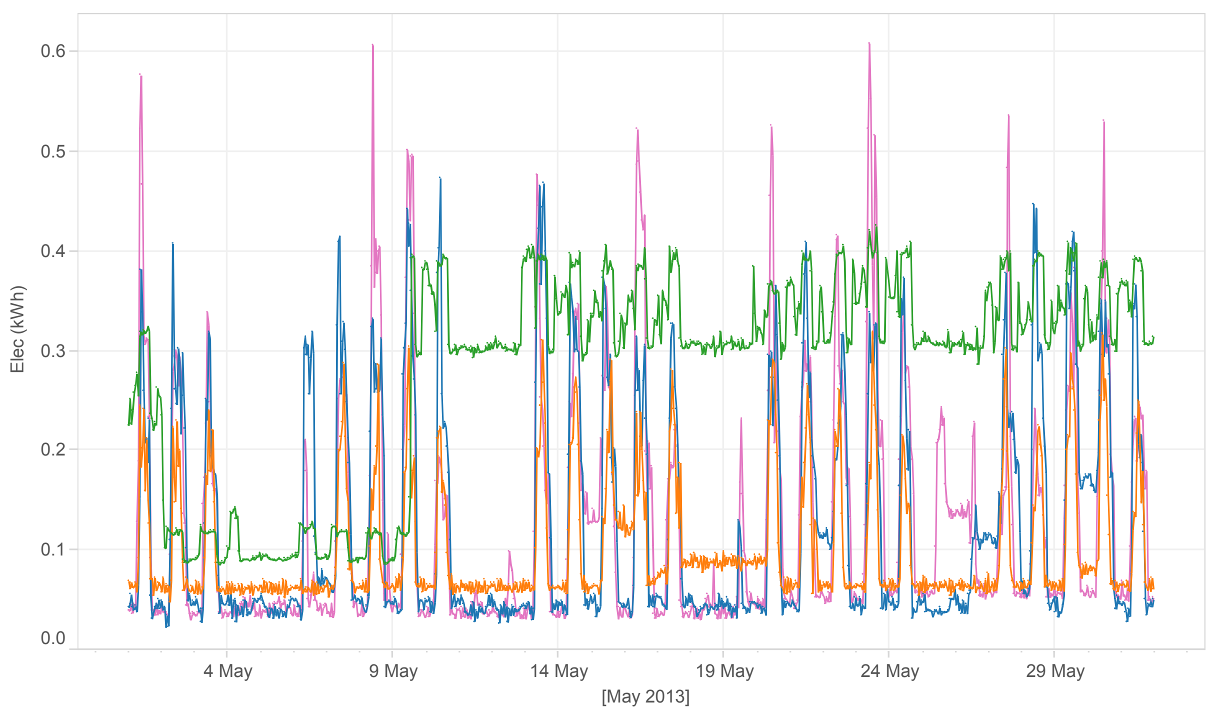


Figure 5.5: *Electrical Energy Consumption by Zone, May 2013 in Ore Valley Business Centre, Lochgelly*

Legend
- MCP
- Ground
- First
- Second

During June, similar trends to May are identified; however the peaks in second floor consumption are less frequent than those seen in April and May. Towards the end of June there is a large drop in MCP consumption which coincides with the second air tightness test, reported earlier. The building operator was unsure of how the plant operated and the time controls for the air handling plant. It appears that not all the plant may be fully operational; while there is a profile that follows the air handling unit operation where it is set to operate to provide heating or cooling of the thermal mass as required, there could well be other plant that has not been set to operate following the air tightness test. The building operator has reported, during a recent visit (11th July 2013) that complaints from occupants have been made in regard to high internal temperatures since the test. However external air temperatures in the local area have been unusually high, like the rest of the UK.

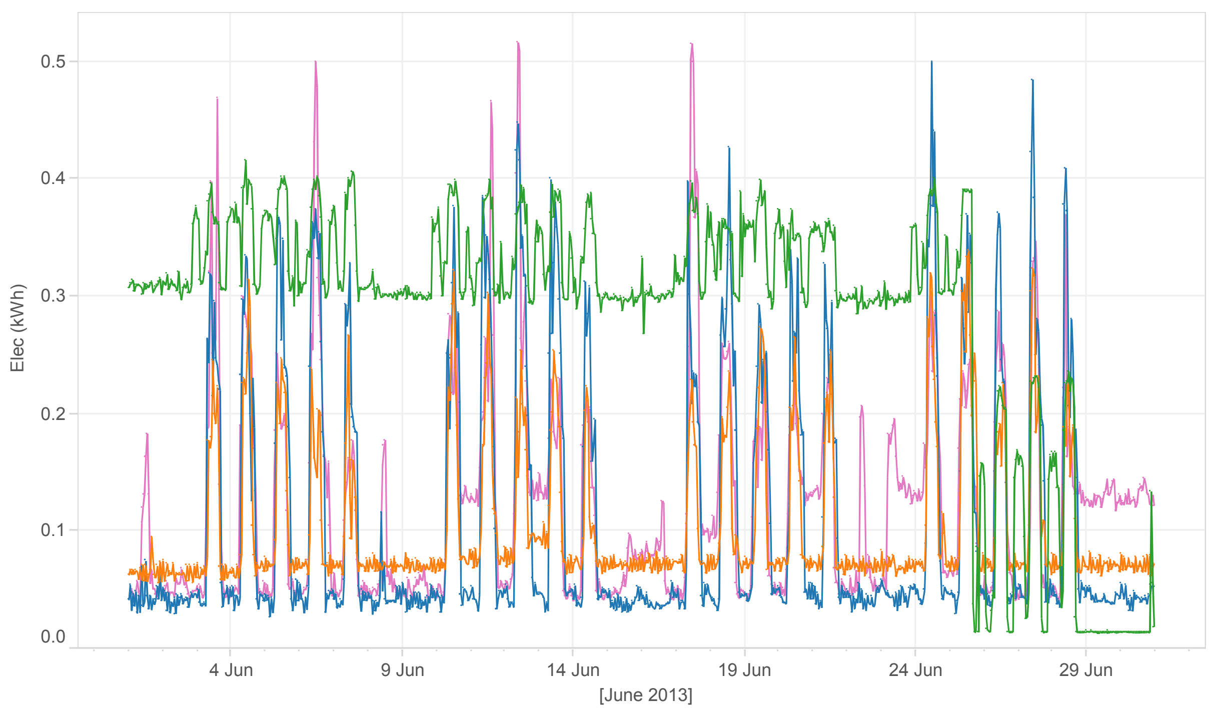


Figure 5.6: *Electrical Energy Consumption by Zone, June 2013 in Ore Valley Business Centre, Lochgelly*

8.3.3 Electrical Energy Consumption by Office

Sub-circuits for lighting and small power in one office on each floor are being monitored. The energy consumption is shown to compare the same circuits for each of the offices. Office 3 ($21m^2$) is located on the ground floor, is occupied by a community group where the office is occupied frequently by support workers and their clients, there is no computer equipment in the office. The window faces north.

Office 8, ($21m^2$) located on the first floor is occupied by a small business with two desks set up. There is computer equipment in this room. The occupancy pattern of this office is currently unknown, as the occupants have not been there on visits to the building. The window faces north.

Office 20, ($48m^2$) located on the second floor, it is a larger is occupied by a small business. There are four desks each with computer work stations. This office has two occupants who appear to be full-time workers and the third occupant is there on occasion. Two windows face west. However, there is a building across a narrow grassed area limiting views out.

8.3.4 Artificial Lighting

A review the lighting pattern in figure 5.5 demonstrates that the artificial lighting in office 20 and office 3 are frequently switched on, the occupants of office 8 use lighting infrequently. Office 20 lighting consistently consumes 0.05kWh and office 3 consumes 0.03kWh. However, there are a greater number of lamps in room 20. The profile indicates that throughout this three month reporting period artificial lighting in room 3 and 20 is continually switched on when occupied. The lighting system is not daylight linked or fitted with presence/absence detection, which would significantly increase energy consumption and is reliant on occupant behaviour to adjust the lighting. As the rental for each office includes all energy bills, there is little motivation for the occupants to conserve energy.

Data for one week in each month from 7th – 13th demonstrates the artificial lighting pattern across each of the offices is plotted in figures 5.7 - 5.9. The pattern demonstrate the occupants of room 3 frequently switch off the lighting in the room, while occupants of room 20 switch on the lighting on entry to the room and the artificial lighting generally remains on throughout the day. Even now daylight hours are longer; a reduction in use of artificial lighting has not been seen in room 20.

Figure 5.11 illustrates the consumption per month for the lighting circuits in each of the offices; it clearly demonstrates the increased use in room 20 over the other two offices.

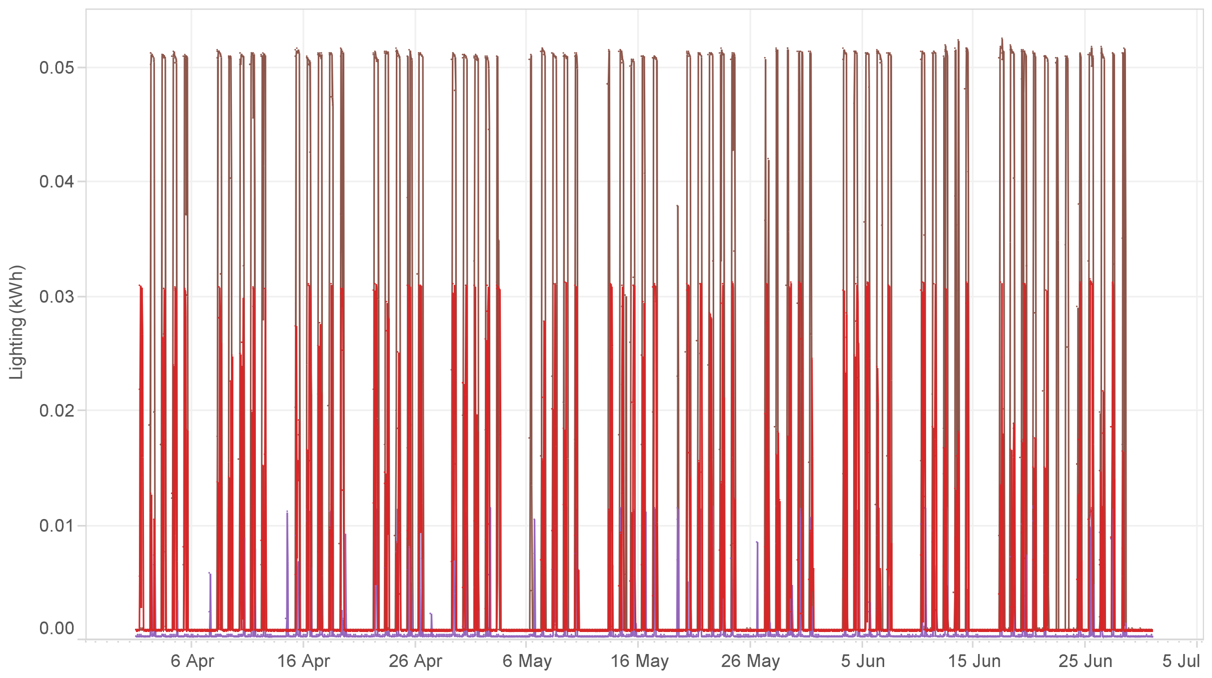


Figure 5.7: *Electrical Energy Consumption for Artificial Lighting, April to June 2013 in Ore Valley Business Centre, Lochgelly*

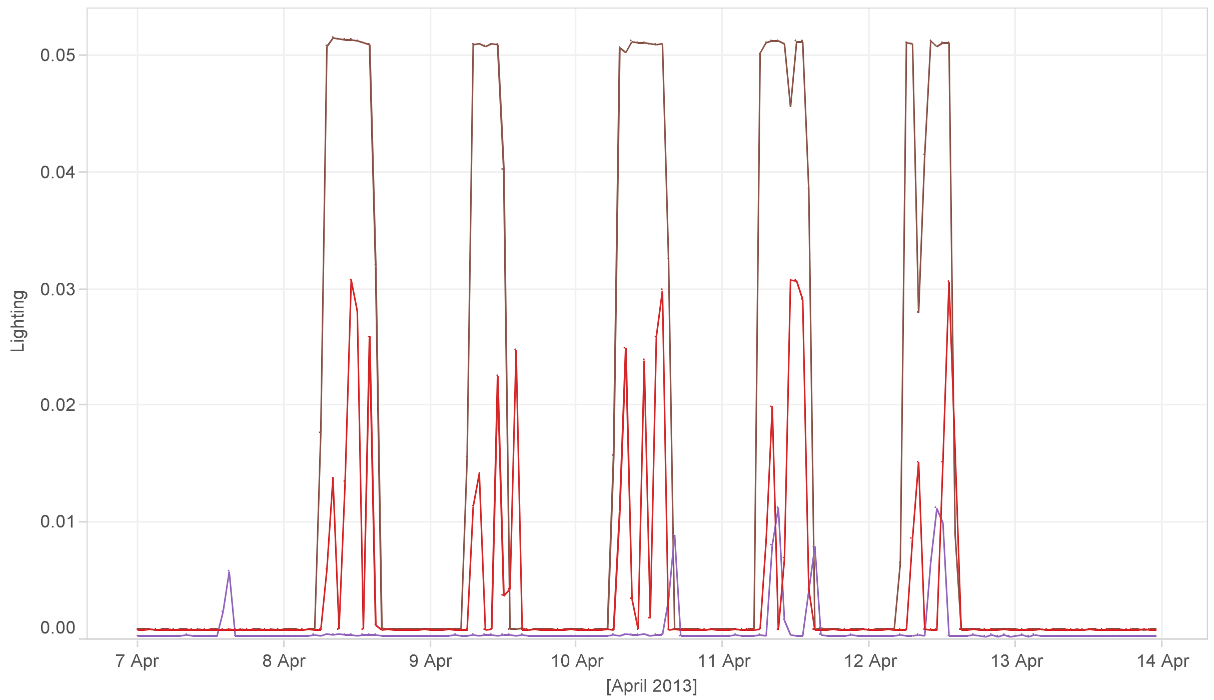


Figure 5.8: *Electrical Energy Consumption for Artificial Lighting, 7th April to 13th April 2013 in Ore Valley Business Centre, Lochgelly*

Legend
Office 3
Office 8
Office 20

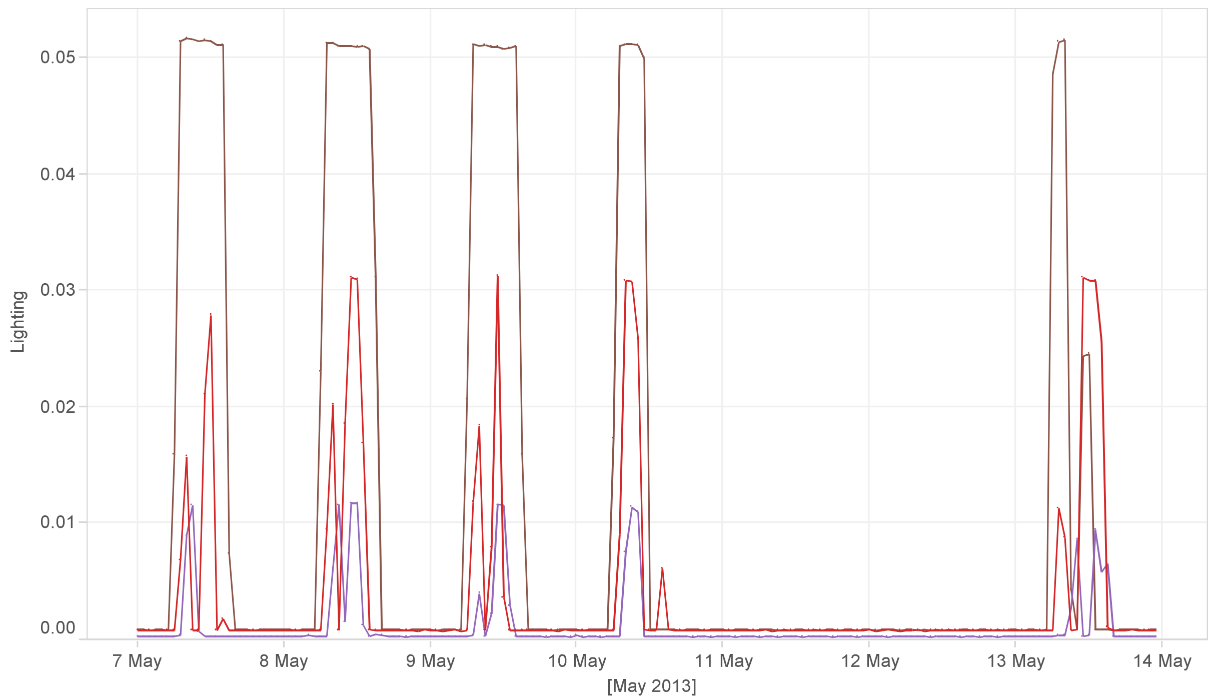


Figure 5.9: *Electrical Energy Consumption for Artificial Lighting, 7th May to 13th May 2013 in Ore Valley Business Centre, Lochgelly*

Legend
Office 3
Office 8
Office 20

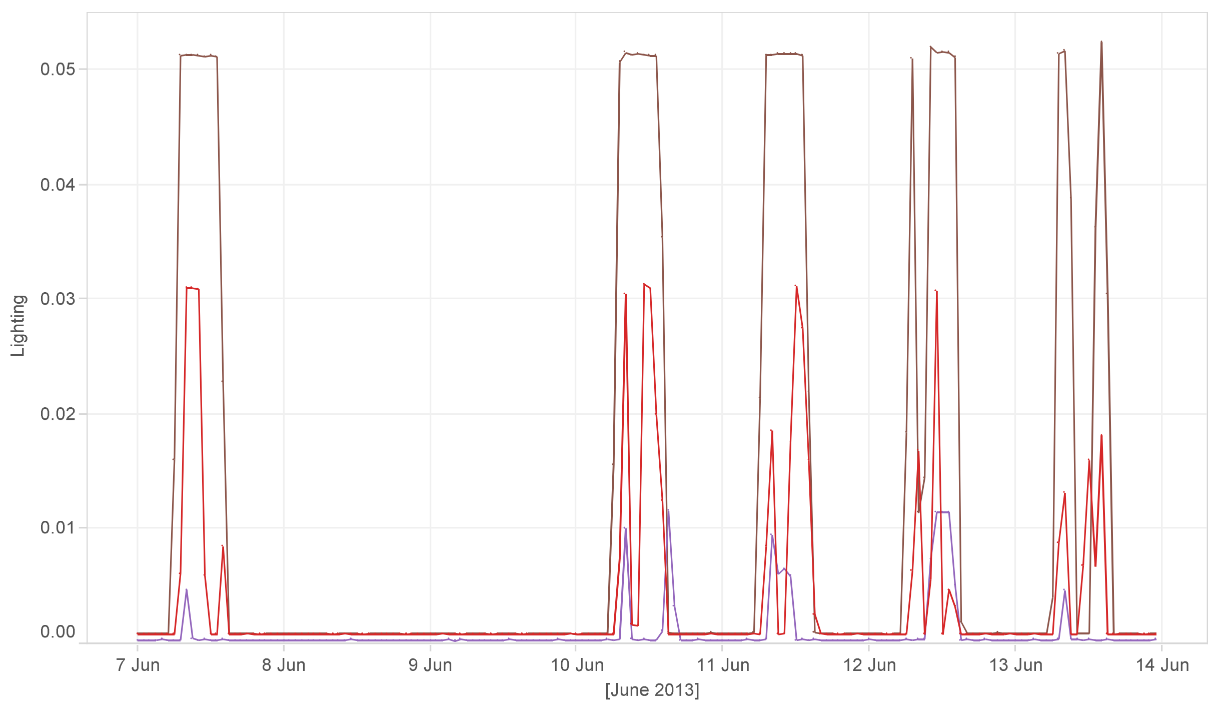


Figure 5.10: *Electrical Energy Consumption for Artificial Lighting, 7th June to 13th June 2013 in Ore Valley Business Centre, Lochgelly*

Legend
Office 3
Office 8
Office 20

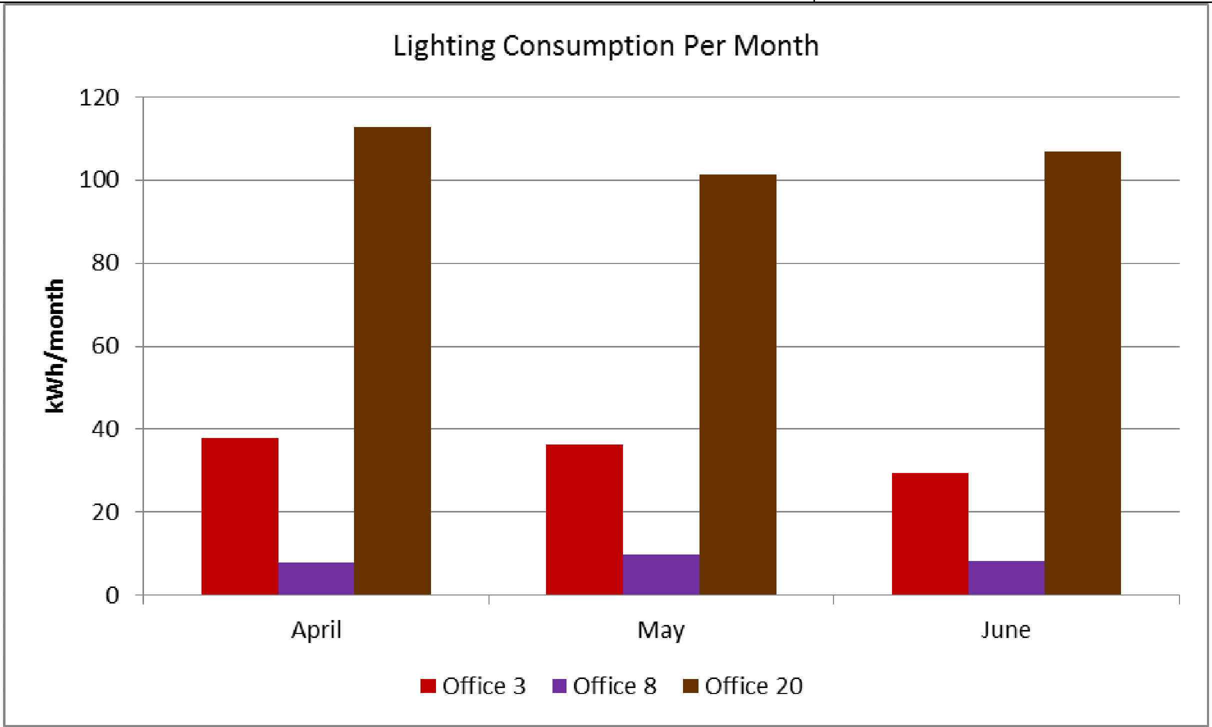


Figure 5.11: *Electrical Energy Consumption for Artificial Lighting, by Month, April – June 2013 in Ore Valley Business Centre, Lochgelly*

8.3.5 Small Power

Referring to figure 5.12, the small power in each of the sub-metered offices shows room 20 to be the largest electrical consumer with some high peaks from time to time. There are small peaks throughout the day in room 3, which as it holds no computer equipment may be from the use of a portable stereo and boiling of kettle for hot drinks.

A week long period is shown for 7th – 13th April, in figure 5.13, during this week it demonstrates that room 20 has a higher base load than the other two offices, and this equipment remains switched on of an evening and over the weekend. Small peaks are identified in room 3 on two of three of the days. However, the load is shown not to be constant. While during this sample week, office 8 has not consumed any power from the sockets at all. This trend follows through the three months. Figure 5.14 shows monthly consumption for comparison. The consumption in office 8, although is occupied with a business is virtually zero, the consumption for office 3 on the ground floor shows a small energy consumption, while office 20 consumes significantly more.

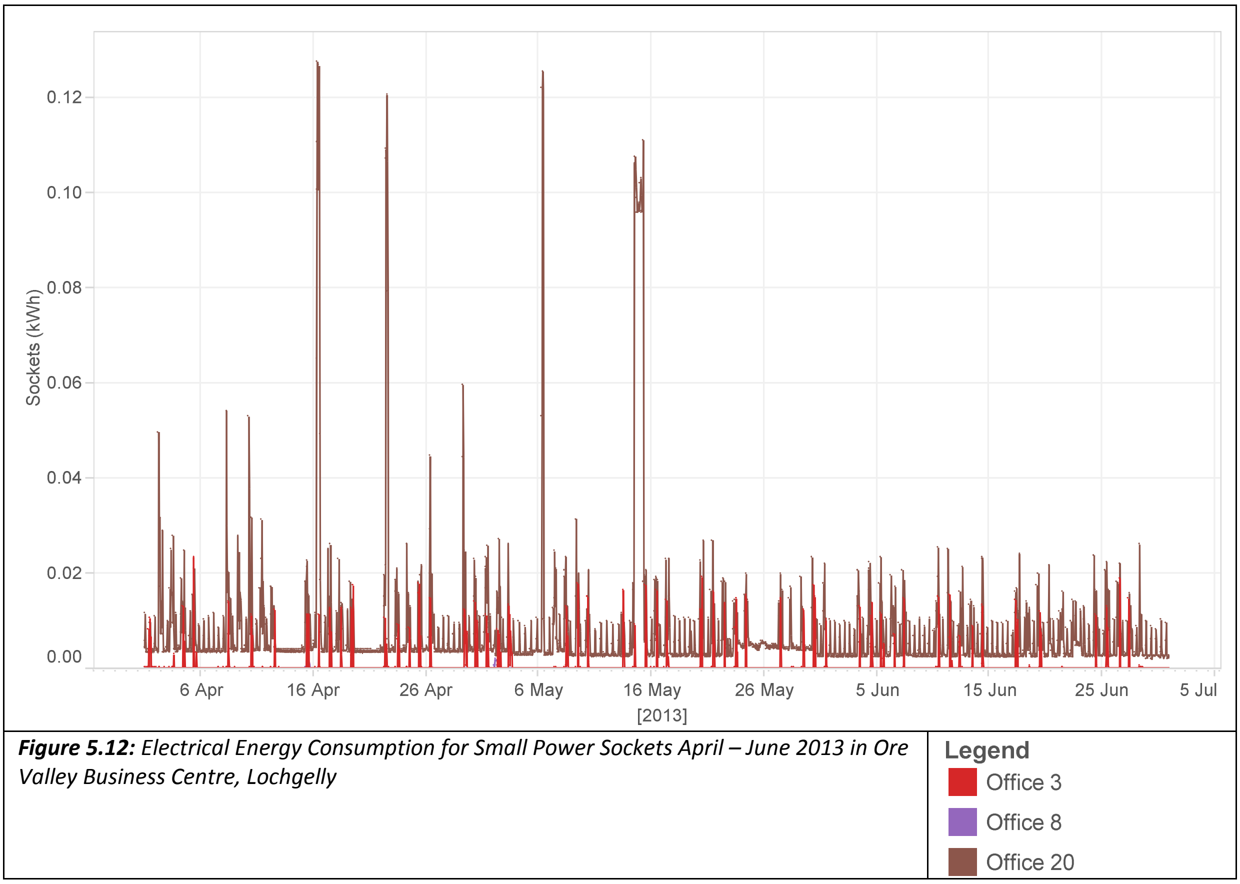


Figure 5.12: *Electrical Energy Consumption for Small Power Sockets April – June 2013 in Ore Valley Business Centre, Lochgelly*

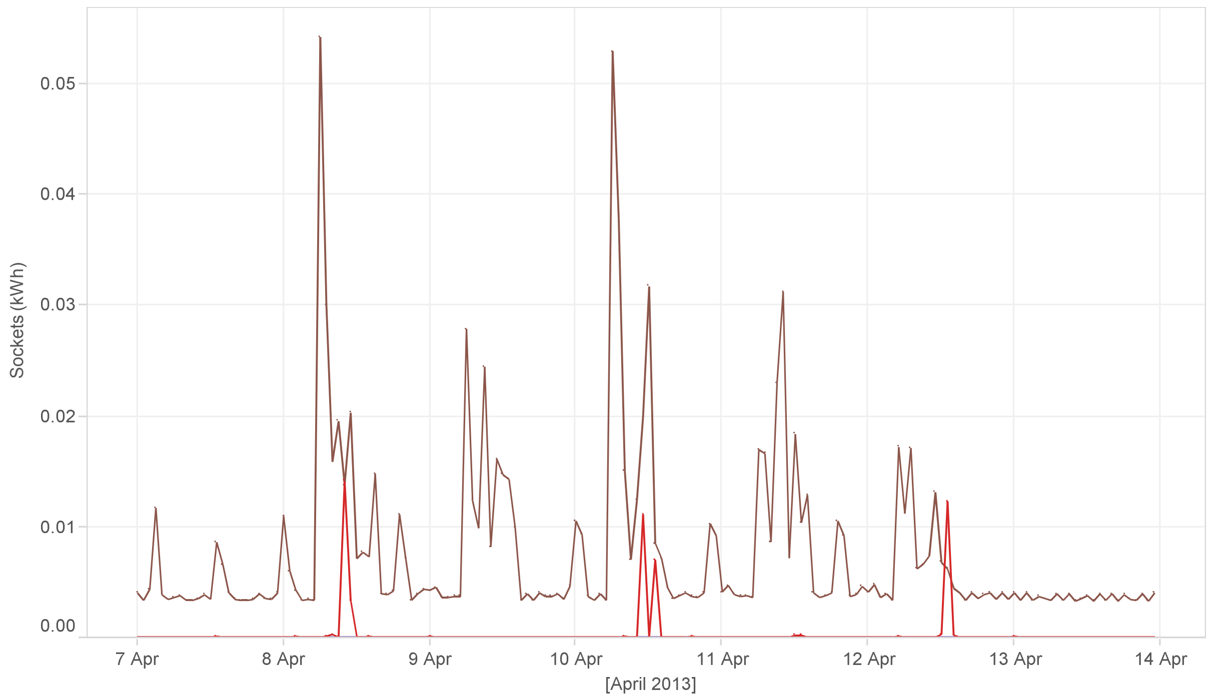
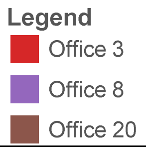


Figure 5.11: *Electrical Energy Consumption for Small Power Sockets 7th – 13th April 2013 in Ore Valley Business Centre, Lochgelly*



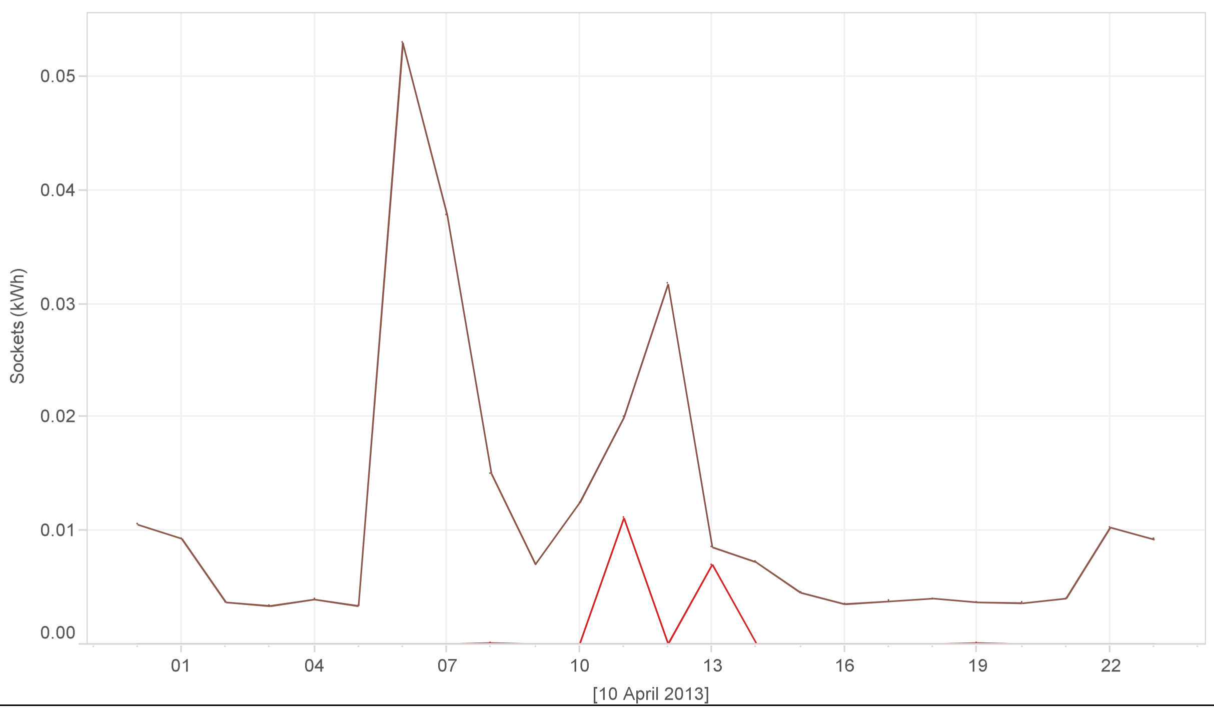


Figure 5.12: *Electrical Energy Consumption for Small Power Sockets 10th April 2013 in Ore Valley Business Centre, Lochgelly*	**Legend** Office 3 Office 8 Office 20

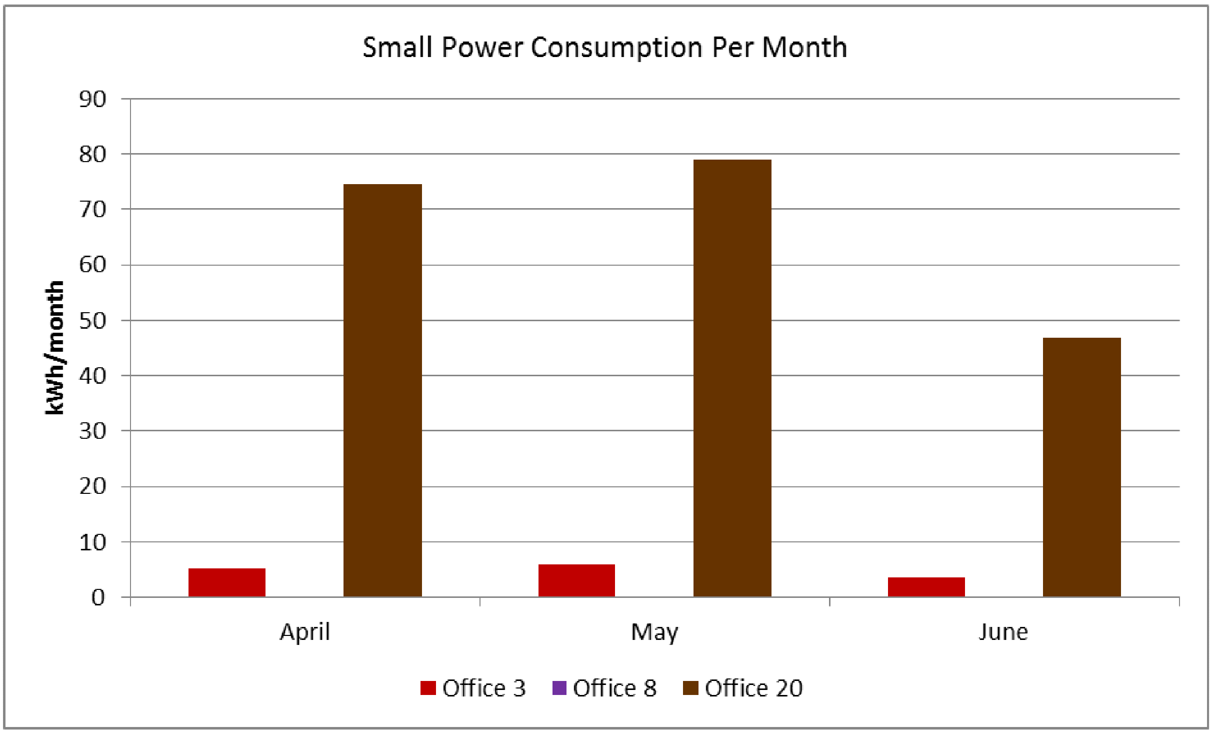


Figure 5.13: *Electrical Energy Consumption for Small Power Sockets by Month. Ore Valley Business Centre, Lochgelly*

Combining the lighting and small power consumption for each office the percentage of consumption per floor is indicated in table 5.3

	April (%)	May (%)	June (%)
Ground Floor Room 3	4	5	4
First Floor Room 8	1	1	1
Second Floor Room 20	19	16	15

Table 5.3: *Percentage of Total Room Electrical Energy Consumption by Month. Ore Valley Business Centre, Lochgelly*

8.4 Conclusions and key findings for this section

8.4.1: There is a significant discrepancy in the overall results and the sum of the sub-meter results. Although not having a great impact on the overall results, it interferes with the detailed analysis. This limits the ability to identify improvement strategies.

8.4.2: Lighting use is very high compared to the benchmarks. This is backed up be the individual rooms analysis. Study of out of hours occupation is recommended to establish that the lighting use reflects usage in evenings and weekends. It is known that the building is used extensively after 6.00pm and at weekends. The various tenants may have differing lighting requirements. The studies of sample rooms (8.3.4) suggest that lights are often left on irrespective of occupancy or conditions. The building would benefit from more extensive use of controls and dimmers within the units, whether by presence detectors or zoned photocells. Unfortunately, the under-occupied units tend to be those on the Southern elevation, making assessment of potential impact difficult. In the smaller rooms, the lighting circuits are not parallel to the window, which would permit the outer circuit to be switched off when daylight was sufficient, as well as allow simple fitting of photosensitive detectors. However, this would interfere with amendment to physical layouts by adjusting wall locations. Confirmation that unoccupied rooms were not lit during the study period is required. The high level of metered use suggests that this may not be the case.

8.4.3: The Small Power readings appear very small. This was assessed by a walk-round survey and was considered comprehensive. Further investigation of the 'no submeter' element is required to address this in case items which should be recorded by the small power sub-meter are not being recorded. It shows that consumption varies significantly with differing occupancies.

8.4.4: The common kitchen is under-utilised. Many tenants use their own kettles, microwaves, etc., which makes monitoring and control difficult. Room 3 on the Ground Floor is used as an 'ad-hoc' kitchen. The multiplicity of tenants may also encourage this practice. It is unlikely that such a situation could be resolved easily.

8.4.5: The heating controls are set to an operating core period of 08.00-21.00 Mon-Fri. This does not reflect the building's actual use, which include occupation out with these periods. A significant number of localised electrical heaters were noted during the Small Power audit. It is possible that these heaters may be utilised out with core hours, particularly at weekends, (comment has previously been made of issues with temperature on Monday mornings). Revision of the control period should be considered, particularly in preventing the building cooling down too much over weekends. One restriction of the Termodeck system is that it is difficult to create heating zones to reflect variety of and lack of occupancy, particularly for a building of this size.

8.4.6: The ventilation in the toilets is controlled automatically, but that in the meeting rooms are user operated. There may be a tendency not to switch this off of exit.

8.4.7: The heating system seems reasonably successful, if not exceptionally so. However, without monitoring the Termodeck system separately, it is difficult to assess this fully without the impact of the LTHW heating. Again, enhanced zoning of the system monitors would be beneficial.

8.4.8: The building was not designed on the basis of variable occupation. This perhaps should be a consideration in the briefing for similar building types. If so, greater consideration may be granted to the zoning issue. However, this highlights a serious restriction in the use of the Termodeck system, which may more suited to general office buildings than those which requires such variance of use. Unoccupied spaces are fully heated, with controls limited to a floor by floor basis.

8.4.9: It was noted that plant consumption increased notably as the issues affecting air permeability came to light. This emphasises the impact air leakage can have on consumption, particularly for heating.

8.4.10: Interpolation has been used to estimate the impact of full occupation. It would be a worthy exercise to re-assess the energy use of the building should it be fully let in the future. This would make an interesting comparison with the estimates, as well as providing definitive results on the building performance.

9 Technical Issues Post-Completion

There have been several technical issues following handover and occupation of the building, which have greater or lesser impact on the environmental performance and comfort of the building . There have also been issues specifically identified during the BPE process.

9.1.1 BMS and systems handover

Perhaps one of the main concerns to both the client and design team was the handover process, particularly as it related to the services and controls for the building. As had been mentioned earlier disputes with sub-contractors and services consultants resulted in what must be considered a poor and rushed handover. This was magnified by having no O&M manuals given to the client, resulting in a lack of knowledge of the operation and rectification of any problems however minor. The client, as outlined in section 7, was not familiar or experienced in running a facility and controls of this nature, and relied on normal operation until such times as a failure occurred. As part of the BPE study we were able to bring back Campbell Controls (the original installation sub-contractor) to present a comprehensive training seminar, outlining and explaining in detail the operation of the BMS and the implications of warning lights and the rectification of minor issues. The client has now a fuller understanding of the systems and operation, and have now entered into a separate agreement with Campbell Controls to remotely monitor and advise on service requirements.

9.2 Termodeck performance

During the course of the works, and due to a savings exercise, the specified monitoring software on the Termodeck was omitted by the services consultant. This was not picked up by the design team or client, resulting in a lack of understanding on whether the system was actually operating efficiently. Again as part of the BPE we were able to have installed the relevant software. Termodeck were able to remotely access the systems operation and submitted their first two reports just prior to the British company being sold, though the new company were unable to continue this monitoring service. The client and design team are able to remotely access the system, and in light of the Campbell Controls seminar are able to better understand and interpret any issues arising from a red flag.

As can be seen from the Monitoring reports the Termodeck system has worked well, with only minor adjustments being required by Campbell Controls. The system has operated with minimal maintenance, with only a belt breakage and filter cleaning being required. All parties now recognise that the system was installed and operated pretty much as it was designed, and that had a more high maintenance solution been installed with the level of handover experienced, many more problems could have ensued. The domestic boilers which service the Termodeck are familiar to the client who felt comfortable with any maintenance requirements.

9.3 Overheating in Conference Room

The building owner had complained of overheating of the Conference Room located on the second floor (figure 1) of the business centre. A standalone electric fan was used as a result. The room projects out from the external façade with three elevations (east, south and west) comprising of floor to ceiling curtain wall glazing, with no opening windows (figure 2).

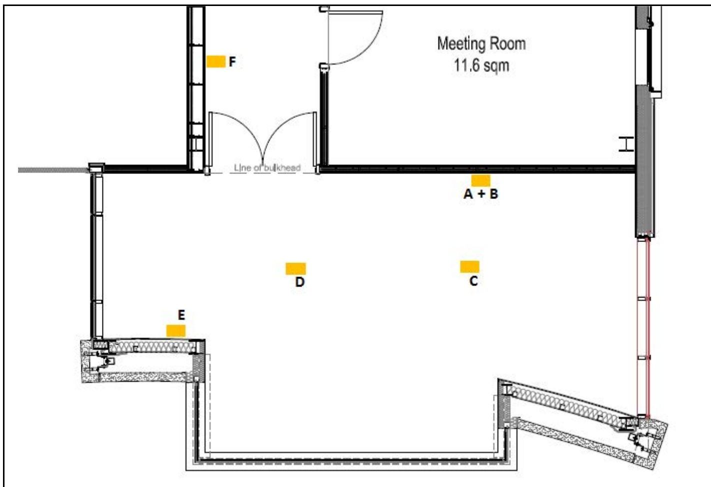
The room is ventilated by two mechanical extract fans each with a design flow rate of $0.105 m^3/s$ (105 litres per second), with local manual control for each fan. Make up air is drawn from the adjacent corridor; refer to figure 3 for floor plan.

Figure 1: *Internal view of conference room, south and east facing glazing in view. (The blind in the background is a retractable projector screen).*

Figure 2: *External view of conference room, south and east facing glazing in view.*

The temperature and relative humidity were measured using five Tinytag data loggers in various locations in the conference room and a further data logger placed in the adjacent corridor. The monitoring period commenced on 11th July 2013 with readings taken at five minute intervals until 22nd October 2013.

Figure 3: *Second floor plan indicating location of conference room.*



Data Logger Location

A - 2.20m AFFL
B - 1.00m AFFL
C - 2.46m AFFL
D - 2.46m AFFL
E - 1.35m AFFL
F - 1.35m AFFL

Figure 4: *Second floor plan indicating location of data loggers.*

Figure 5: *Image of data loggers A (at high level) and B (at low level).*

Figure 6: *Image of data loggers C (far) and D (near).*

Figure 7: *Image of data logger E.*

Figure 8: *Image of data logger F located outside the conference room.*

The mean values of the internal space temperature for the conference room were calculated and plotted against the temperature in the hall and external temperature. It can be seen in figure 9 that while the temperature increases with a rise in external temperature, the temperature in the room also rises to uncomfortable levels when the external temperature is relatively low. This indicates that the room is subjected to solar gain. For example on 21st September 2013 the external temperature is around 19°C while the internal temperature was seen to rise to around 28°C.
To determine the extent that the room is occupied a sensor was placed in the room during August 2013 to monitor temperature, relative humidity and carbon dioxide concentrations (CO_2) (figure 10). A shroud was fitted to the sensor in an attempt to shield the sensors from the sunlight. Figure 11 details the internal temperature against CO_2 concentrations, while the temperature recordings are higher than expected, it is anticipated that the shroud is not shielding the temperature probe sufficiently or the sensor is in direct view of solar gains. However, the CO_2 concentrations are independent and indicate the room is well used, with a maximum CO_2 concentration of over 4000ppm. There are numerous instances where CO_2 concentrations reach over 2000ppm, indicating there may be inadequate ventilation in the room.

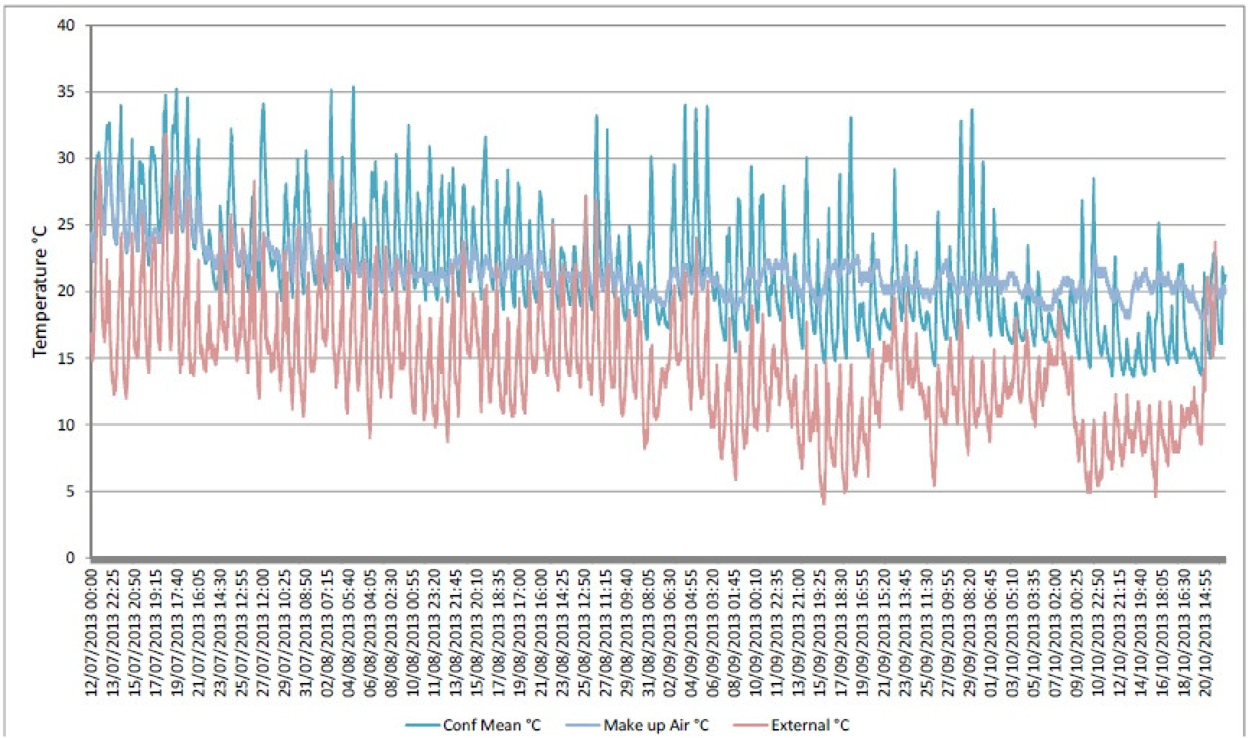


Figure 9: *Graph indicating conference room temperature against adjacent hall and external temperatures.*

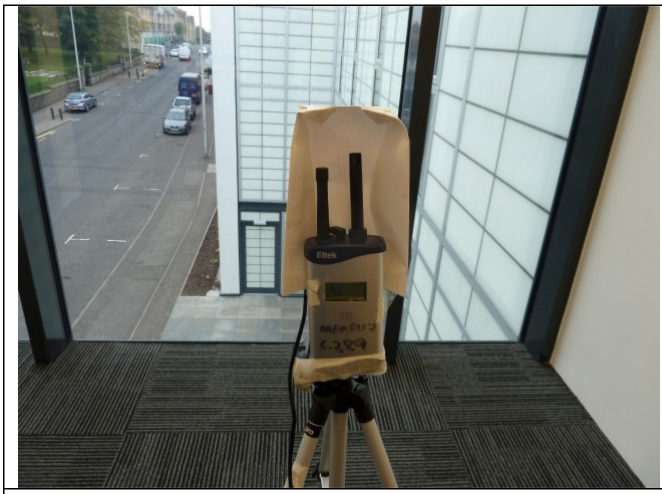


Figure 10: *Combined temperature, relative humidity and carbon dioxide sensor with shroud to protect against solar gain.*

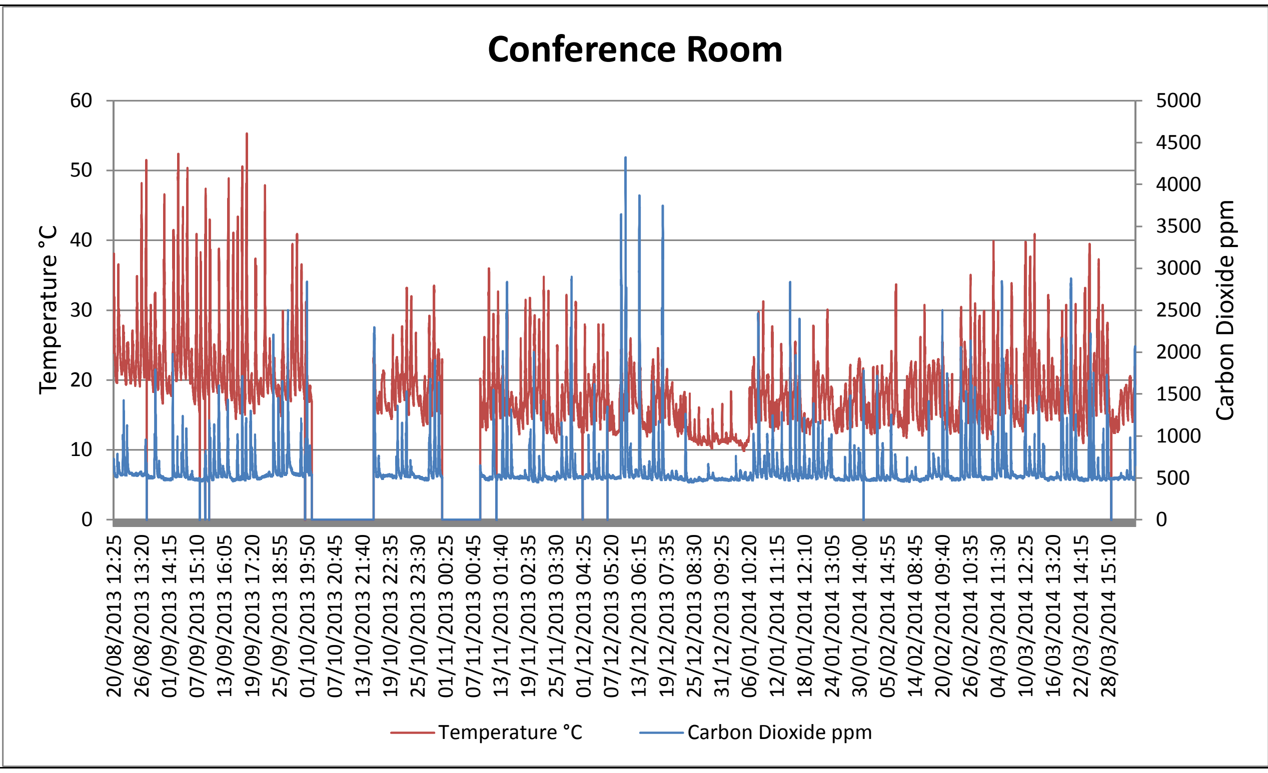


Figure 11: *Temperature plotted against carbon dioxide emissions in conference room.*

The extract ventilation in the room was measured using a power flow hood, this revealed that the two identical fans are operating at different flow rates and fall short of the design value 105 litres per second each. Table 1 provides fan flow rates of each extract fan under each fan speed. A restriction in door opening to adjacent hall was also observed while the fans were operating on medium and high speeds. This indicates an imbalance of pressure between each side of the door and appropriate transfer grilles in the door (or elsewhere) would need to be fitted to ease opening when fans are operating at full design flow rate.

Fan Speed	EG01 (Litres per second)	EG02 (Litres per second)
High	21.4	79.2
Med	6.7	71.0
Low	0.0	22.5

Table 1: *Extract fan flow rate performance at three speed settings – measured in litres per second.*

As temperature and CO_2 builds up in the room it is recommended that each time the room is occupied, even for short periods, the extract fans are operated to provide ventilation to the room. The controls are located beside the light switches and are operated using the sliding controls, figure 13, details the fans both set to speed 3. It is important to remember to check the isolator beside the controllers is in the 'on' position and turn off the extract fans when vacating the room.

Figure 12: *Extract fan controls to right hand side of light switch.*

Figure 13: *Extract fan controls shown operating at high speed.*

9.4 Leak in basement

Following completion of the building a leak and subsequent ponding was discovered in the basement adjacent to the external steps down the eastern side of the building, facing the prevailing wind. Additionally, problems were identified at the base of the liftshaft. Following several reports blaming lapping of DPCs and remedial works these issues have still to be resolved. These are believed to be the source of significant heat loss, confirmed by the thermographic study, and of air leakage, which may distort the energy footprint for the building.

9.4.1 Survey and findings: Towards the end of June 2011 the building experienced a rapid and significant intake of water which was witnessed by the client.
The water route was described as entering through the wall / solumn interface and flowing towards the lower ground internal floor area, within the internal floor area, pooled water was found spread across the floor of the rear entrance corridor.

Following this description two visits were immediately carried out by ECDA personnel. Photographs were taken which detail the extent of the ingress. Indications of issues of DPC overlapping were evident. The walls did not display any signs of water ingress which suggests that the vertical tanking is performing as designed
On inspection the water has forced its way between the column base infill and solumn concrete. Duct tape has been used as jointing between upper insulation board and pieced insultation beneath. It is also clear that the DPM has not been lapped over the wall dpc which would suggest this is the weak point of construction giving way to any hydrostatic pressure.
During the water ingress inspection a white fungal growth was discovered to wall of lift enclosure. We would advise inspection by a rot specialist.

Photo 1 services void behind staircase enclosure and lift

Dampness is evident at base of staircase enclosure. However, the blockwork to lift shaft at junction is not damp, which would suggest that mortar disolouration is due to the mortar mix, confirming that the DPM is not lapped over the DPC.

Photograph 2 Electrical room

Further images of upturned DPM indicating a clear line of water ingress along same gable wall

Photograph 3 Staircase and rear corridor wall junction

From the photograph it seems spare foam as been applied to a gap between the floor slab and wall suggesting the DPM was cut flush with the wall and sitting beneath the depth of the floor.

Photograph 4 rear entrance corridor. Image indicates area of floor where ponding occurred.

The reason for the ponding is unclear as it could have eminated from the area hilighted in Photo 6 and flowed to this point of the corridor, or it may have come from directly beneath the floor at this point. An invasive survey to a small section of floor approximately 600mm long x 300mm wide, excavated to the depth of DPM, would confirm the route of water ingress.

The contractor has removed plasterboard and internal blockwork at this location, causing an unsightly entrance when entering the building from the rear. This has been commented upon during the BUS and tenant workshop as being detrimental to the building image, and a hazard with water sometimes being apparent on the floor following heavy rain. Additionally, this has been identified as a point of serious air leakage (Section 4.1.2), as has the liftshaft junction.

The client has employed an independent third party to report on this issue. His final report is still awaited.

9.5 Reception Issues

Complaints were received about the Reception environment. The radiator could not turn off, due to a defective thermostatic valve to be turned off. Additionally, the high setting of the door closer spring made access difficult, encouraging users to leave the front door open. These have now been addressed and resolved.

10 Key messages for the client, owner and occupier

10.1 Key Messages

10.1.1 Tenant Energy Usage: One of the attractions for tenants is the fact that all energy costs are included in commercial rent. This allows the start-up company to better manage finances effectively by cost certainty in the premises costs. However, it is clear that the offices are being well utilised outwith normal office hours and therefore expending more energy. There is also not the same imperative to switch electrical equipment/lights off when not being used, as no cost is being levied at the individual company. Fife HARCA has to absorb any increased energy costs in their rental income. This may impact on any incentive for energy management by the users.

There are several issues that still need to be clarified:-

- Lighting usage
  The lighting loads seem very high and the client should ensure tenants are encouraged to switch off lights particularly when leaving their office in the evening. PIRs could also be considered for all common areas and not just the toilets.
- Out of Hours Working
  The nature of some of the tenants suggests that sometimes all night working is required. This is certainly increasing the time frame when energy is being expended in the building. Unless access to the building is restricted to certain hours, the client may need to reappraise their rental policy
- Kitchen Usage
  It was noted that various kettles, microwaves were located within the individual offices. This was obviously to save time in accessing the kitchen. This will again be increasing energy use.
- Termodeck
  While the Termodeck is operating well, it was noted that one tenant in particular found it cold in winter. It may be possible to adjust the settings for that floor to accommodate that office. Discussion with the other users of that floor would be required, as no other complaints had been received.
  It may also be worth examining the timings of Temodeck use as the building is certainly being well used during out of hours working. In winter, the system cools down too far over weekends to achieve an adequate heating level by Monday mornings. Consideration should be given to either bringing forward the Monday startup time by an hour or two, or raising the 'unoccupied' default temperature to avoid so much cooling over weekends. If weekend occupation is habitual, as it appears, perhaps the 'occupied' period should include Saturdays.

There is a Tenant Handbook issued on occupancy to all users. The client has acknowledged that this may require review of its information on energy use.

10.1.2 Conference Room:
It is evident that the conference room overheats in summer. This subject is dealt with in detail in section 9.3 and the client should consider:-

  - Blinds to shade solar gains.
  - Calibration of the extract fans to ensure operation in line with manufacturer's specification of extract rates.
  - Consideration of automation of ventilation controls with temperature/CO_2 sensors.
  - Installation of openable vents in windows.

10.1.3 Basement Leak: Heat loss in the basement is higher than it should be due to the water ingress problems, with associated condensation risk. It contributes significantly to air permeability problems. This needs to be addressed as a matter of urgency. At the very least a temporary solution would restrict heat loss until a complete solution can be achieved.

10.1.4 Large Unlet Offices:
A substantial floor area of unlet space resides in the 3 large office spaces located one on each floor. These spaces remain unlet due to the imposition of higher rates. It would seem that this market sector requires smaller offices, and

the client should progress with their plans to sub divide these offices in 2 or even 3 smaller offices. This should make them much more attractive to the small start-up company.

10.1.5 Mechanical Ventilation: The impact of poorly performing ventilation affects overheating, CO2 generation and general discomfort. These should be commissioned and tested with great care.

10.1.6 Handover:
This has been discussed several times throughout this report, and the importance of a proper comprehensive handover procedure cannot be over emphasised. The new plan of work and soft landings should ensure future compliance. Fife HARCA now understands and will certainly ensure full handover instructions, certificates and manuals are received.

11 Wider lessons

The original aims and objectives of the study as noted in the introduction can be summarised as follows:-

11.1.1 Measurement of the efficiency and effectiveness of the 'Termodeck' system
It is generally acknowledged that the Termodeck system has operated as designed with minimal maintenance. Minor amendments were required to the settings following Termodeck's monitoring report No 1.
It is also worth noting that as the Termodeck system utilises heat gain from equipment and patrons, the building cannot not be as efficient now as it will be when completely full. The smaller rooms are now fully occupied, with only the 3 larger offices remaining empty. It is testament to the system that, despite the items above, the building has continued to operate on a consistent basis.

The major issue can be resolved by control, adjusting the operating settings to reflect actual building use.
The delivery of consistantly dry air should be considered. Some form of returning humidity after heating may be required. Perhaps simple measures, such as installation of plants would inprove the environment.

11.1.2 Measurement of the 'Kalwall' system
The design for Kalwall was based on the manufacturers stated U Value of 0.30W/m^2. The actual results from the in situ measurement were 0.56W/m^2. Further investigation as to why this result is higher than the design value is required. Results of in-situ testing from other installations would be useful to ensure that the product does not generally deliver such results, as this would impact on its suitability for future specification.

Measurements of illumination and calculation of daylight factors in the large office ground floor (Room 7); Small office Second floor (Room 15); and Medium office Second floor (Room 19) The results showed that all the rooms evaluated meet the recommended Average Daylight Factor for general offices . While the small and medium offices meet the recommended Minimum Daylight Factor, the large office on the ground floor does not. The daylight uniformity in the large room is quite poor – owing to the design and distribution of windows. Taller windows would improve the daylight factors at the back of the room, and wider or better distribution of the windows along the southern wall would give a better daylight distribution across the width of a room. The average reflectance of the interior at the back of the room would improve the daylight at the back and uniformity across the room. The system itself works in principal , delivering a pleasant visual atmosphere (during the day at least). However, this does not seem to be reflected in a reduction of artificial lighting use. This may be an unfair observation, as many of the principal rooms that use this material were largely unoccupied during the period of study.

In summary, the material performs well on an aesthetic basis, but has serious questions on its physical performance.

11.1.3 Analysis of the Thermalex wall and its claim to prevent air-leakage without use of sealants.
The design for Thermalex was based upon the manufacturer's stated U Value of 0.276W/m^2. The actual result from the in situ measurement of the wall type was 0.23W/m2. This is a successful result, encouraging consideration of its further use.

Tests for air permeability and air change rates were conducted for individual rooms, as well as for the entire building. The tests produced results under both negative and positive pressure, which showed that, although the individual rooms tested are well within the regulations, the overall shell failed to meet the regulations requirements. The 2010 building regulations require Shell buildings to be designed to achieve a maximum air permeability of 7m3/m2.h@ 50Pa. From 1st May 2011, air tightness testing was required on completion of the shell and again on completion of fit-out works. Windows and other shell fabric joints were well detailed to minimize cold bridging and air infiltration, but the execution and settlement may have produced weak points. Additionally, significant leakage was experienced at junctions with other materials, which is a construction issue. It is unclear whether the contractor was contractually obliged to meet any airtightness specification. If air leakage testing had been carried out after completion and after fit-outs, as proposed in the regulations, it is possible the building would have met the requirements and/or minimal remedial works would have helped to meet the requirements.
In the context of thermal transmittance and air leakage, the thermal imaging survey revealed thermally strong, as well as weak areas at window/door and wall junctions; and floor and wall junctions. It also revealed thermal

profiles/patterns of the Termodeck and the Kalwall elements, although the materials on their own seem stable. Some of the weak leakage areas in the basement, windows and floor boxes could be remedied in the future for minimal costs. Investigations are ongoing concerning a leak in the basement, which is considered to prevent the whole building test being concluded satisfactorally.

The product itself performed as promised, being lightweight and easy to erect. However, as shown by the air permeability tests, junctions with other materials are critical areas. The detailing of these points must be carefully considered, particularly from a buildability aspect, in order to ensure integrity of air sealing. This should perhaps be an issue that is emphasised at any technical meeting with the builder.

11.1.4 Measure unregulated energy usage in a variety of office types and sizes.
Refer to section 8.3 for the report on small power and lighting loads to 3 individual offices. It is clear that the lighting loads are in excess of what was envisaged. It is felt that this could relate to the fact that enegy costs are included in the rental. It is also evident that out of hours usage in the evening at at weekends was greater than envisaged. In general, it is difficult to predict energy consumption where a variety of tenants are involved.

The client will be reviewing the energy advice component of the Tenants' Handbook.

11.1.5 The building's impact in the local environment
Lochgelly councillor Ian Chisholm has underlined the difference the new Ore Valley Business Centre has made to the central area of the town. Councillor Chisholm attended the official opening of the new business units by the Cabinet Secretary for Infrastructure and Capital Investment, Alex Neil MSP.

"I was here when Ore Valley Housing Association's visionary project was initiated. I am delighted to have seen this building grow from start to finish. It is a concept driven by Ore Valley Chief Executive Andrew Saunders who has to take credit for floating the idea and successfully bidding for funds from the Scottish Sustainable Communities Initiative (SSCI) run by the Scottish Government. This building will, I hope, be the first home of future successful companies raised here in Lochgelly".

He added, "There are many firsts in this development but one which I personally applaud is the radical heating and ventilation system....a first here in Scotland. I was happy to pass on to the Cabinet Secretary, Alex Neil MSP, the community's appreciation of the boost to the regeneration of Lochgelly that this investment has given."
Ian Chisholm

Delivering for Town Centres
"People in this area know all too well that our high streets have been struggling for years. They are the heart of our communities, so doing what we can to support them is absolutely vital.

"Regeneration projects can make such a difference when it comes to breathing life into struggling town centres, which is why the SNP has been determined to do what it can to invest in towns and villages in Fife.
Natalie McGarry

"The delivery of the business centre in Lochgelly has already brought an important boost to the town"
Derek Mackay MSP

Cabinet Secretary Backs Business Centre development

"It is incredible to imagine that this was once a derelict piece of land that has now been transformed into prime business accommodation.

"The Ore Valley Business Centre is an excellent example of what the Town Centre Regeneration Fund can help achieve.

The new investment we have seen here in Main Street is making a tremendous difference to the look of the town and will play its part in bringing jobs prosperity to Lochgelly."
Alex Neill MSP

Lochgelly – Town of the Future

"The long term proposal is to develop Lochgelly as a compact urban town with new development in sustainable, well-connected locations and viable and a vibrant town centre. The business centre will shape a town local residents will be proud of…"
Keith Winter, Head of Fife Council Development Services

11.1.6 Tenant flexibility of building controls.
From the BUS survey it is evident that the tenants do not feel they have control on systems. Control was the poorest scoring section of the BUS survey and it is no surprise as the building services have not been designed to provide occupants with individual levels of control. There is very little occupant control in the building. Control over cooling is slightly better as air extract is only present in meeting rooms and it can be locally controlled. There are also some openable windows in the building which might explain why the control over ventilation performs slightly better. One interesting point to consider is that this lack of control does not seem to be impacting on user comfort. Perhaps the perception of non-control is a greater factor than actuality.

However, it has been suggested that where users have most control, lighting and perhaps meeting room ventilation, energy may be wasted by omission to turn these off after use.

11.1.7 The handover and subsequent operation of the building.
The building handover was processed as standard, with a single handover meeting and demonstration of the building systems. However, after handover it has become apparent that this was considerably inadequate and that the client has struggled to understand the operations of the building and the maintenance required. Much of this is down to the new systems being used and both the contractor's and designer's unfamiliarity with them, which meant bringing in several specialist sub-contractors during the construction process. This has led to ongoing problems regarding snagging, the preparation of a maintenance programme and proper operation of the Termodeck and BMS. On a positive note, however, this has not significantly affected the running of the building from the users perspective, as the passive nature of the M&E strategy has meant that the building continues to operate well despite this, providing good justification for the system being used. Refer to the Soft Landings Seminar report.

There was a significant problem with the issue of the mechanical and electrical O&M manuals from the sub-contractor which has seriously hampered the clients' ability to understand and operate the building. However as a result of this BPE study the client is now in possession of these O&M manuals as supplied by the main contractor. This, together with the training seminar carried out under this project by the original sub-contractor, has given the client a much better understanding of the controls, as well as given confidence to resolve some of the more minor matters. The client has now, separately from this project, entered into a maintenance/monitoring agreement with this contractor.