HEATING, VENTILATION & INSULATION TECHNICAL REPORT FOR NEUADD DYFI, ABERDYFI

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Date	07 October 2016
Version	V1.0
BSSEC Project No	201622
Client Project No	LVO87 Neuadd Dyfi Aberdyfi – 20-23-00-37
Peer Review	Samantha Borley
Director Approval	Paul Bennett

EXECUTIVE SUMMARY

This report has been commissioned by the Welsh Government's Resource Efficient Wales programme to support Neuadd Dyfi. The purpose of the Resource Efficient Wales programme is to save resources namely energy, waste and water.

This report represents the results of a technical and commercial investigation of heating, ventilation and insulation options at Neuadd Dyfi, Aberdyfi.

The specific areas to be considered are 1) the suitability of the proposals to install a mechanical ventilation system in the studio, 2) the possible improvement to building fabric in the main hall to reduce heat losses, and, 3) the suitability of a ground source heat pump heating and ventilation system in the main hall.

This report is intended to provide recommendations to support Neuadd Dyfi make a funding application for building improvements that improve resource efficiency at the same time as improving the internal environmental conditions for the users of Neuadd Dyfi

The survey work was carried out by Paul Bennett of BSSEC. The survey work identified that there are many issues with the existing environmental conditions within the building. They are summarised as:

- Problems with poor air quality in the studio leading to people feeling tired.
- The studio not having a building control certificate as it does not have a ventilation system.
- The main hall area has many problems with its uncomfortable existing infra-red heating system and noisy/draughty ventilation system.

The above issues affect the user experience in the building as well as its energy performance affecting the operating costs of the site.

BSSEC has identified a number of opportunities which have been included within this report that will reduce operational costs and carbon footprint whilst improving the user experience thermal comfort, air quality and internal environment.

The 3 key recommendations are:

1. **Studio** - It is recommended that the proposed mechanical ventilation system is installed in the annex with some performance and efficiency changes made to the specifications. This will improve air quality, thermal comfort and achieve building control compliance. Funding of at least £35,000 should be sought.

2. **Main Hall Fabric** - It is recommended that the roof of the main hall is provided with at least 185 mm of thermal insulation as part of an over-roofing/cladding project. It is recommended that the floor (stage and tiered areas) are applied with at least 150 mm of thermal insulation to the underside of the floor. The void between the main hall suspended ceiling and stage area should also be sealed to prevent draughts. These improvements will reduce heat losses by 22%. These works should form part of a wider maintenance and improvement project. Funding for these improvements should be identified by an architect for the entire project.

3. **Main Hall Heating and Ventilation** – It is recommended that a natural ventilation and ground source heat pump solution is provided in the main hall. This will resolve many problems in the main hall such as infra-red bodily heating, headaches, draughts, controllability and high energy consumption. Funding of around £260,000 should be applied for.

BSSEC would like to extend our thanks to Mr Desmond George of Neuadd Dyfi for his assistance throughout the survey process.

Table of Contents

1. Introduction

1.1. Objectives

This report has been commissioned by the Welsh Government's Resource Efficient Wales programme to support Neuadd Dyfi. The purpose of the Resource Efficient Wales programme is to save resources namely energy, waste and water.

This report has been prepared by Paul Bennett of BSSEC, a framework consultant, and has been commissioned by Mr Andy Rowland of Ecodyfi for Mr Desmond George of Neuadd Dyfi.

The specific objectives for the report are to provide support to Neuadd Dyfi in 3 key areas:

1. Provide a technical and commercial review of the current proposals to provide ventilation to the recently built studio annex.
2. Review and consider practical options to improve thermal insulation levels in the existing main hall and in particular the floor and roof.
3. Review and consider practical options to heat and ventilate the main hall space using a ground source heat pump.

The principal factors guiding option appraisal will be:

- Consideration to energy conservation and reduced operational costs and carbon footprint.
- Improved thermal comfort and internal environment.
- The studio has not received Building Regulations sign off as it does not have a ventilation system.
- Other benefits.

The option appraisal shall also be guided and informed by:

- General building condition, structural restrictions and upcoming planned maintenance works.
- Safe access to supply and install solutions.
- Fitness for purpose.
- Minimal disruption to building users.

It is intended that this report will be used to support and guide Neuadd Dyfi in their application for grant aid with the Rural Development Programme 2014-2020. The target date for the application being the 31 October 2016.

1.2. Neuadd Dyfi

Neuadd Dyfi is a community owned hall, situated on the western edge of Aberdyfi. The building dates back to the 1920's and underwent extensive refurbishment approximately twenty years ago, followed more recently by an Annexe extension, with its own lobby and entrance, housing a studio and a committee room. The linked main building consists of the large hall, a large stage, toilets and a kitchen.

The hall is run by a volunteer management committee made up from Community Councillors, Representatives of User Groups and interested individuals.

The activities that take place within the hall include:

- Women's Institute.
- Youth Club.
- Aberdyfi mothers and toddlers.
- Performances by amateur and professional groups (using the 400 seat Theatre).
- Wedding receptions.
- Clubs, associations, music groups.
- Private parties.
- Council meetings
- Dance group, Zumba Tai Chi Keep fit.
- Young Farmers rehearsals and competition performances.
- Art & Craft.

Figure 1.2a Neuadd Dyfi Community Hall

Figure 1.2b Neuadd Dyfi Community Hall

The building is located adjacent to the coast and the site is situated between a railway line and the A493 road. To the side of the site is a council owned car park. The building is in a relatively sheltered position owing to the sand dunes, railway embankment to its south and Yr Horan (150m tall hill) to its North.

2. Existing Baselines

2.1. Building Occupancy Baseline

Address	Facility Type	Useful Floor (m^2)	Others (m^2)
1 Aber Villas, Aberdovey, North Wales LL35 0HR	Main Hall and Studio	444 m^2	Kitchen, toilets, corridors
The building is occupied approximately 30 hours per week.			

Table 2.1a Site Details

It is notable that the site use varies owing to its booking and occupancies. Analysis of data supplied by Neuadd Dyfi suggests the following trends:

Space	Floor area	Minimum Occupancy	Maximum Occupancy	Min hours per booking	Max hours per booking	Typical hours range per week
Studio	66 m^2	5	65	1.5	8	9-19
Main Hall	378 m^2	20	460	2	8	4-17

Table 2.1b Site Occupancy

It is concluded that:

- Both spaces are highly transient and have a varied occupancy patterns.
- The spaces need to respond by the hour in terms of bookings.
- For the majority of time the main hall is at low occupancy levels.
- The main hall is only fully occupied around 6-9 times a year (maximum 27 hours a year).
- The studio is the hardest 'worked' space in terms of hours per week and occupancy densities.

The services need to respond to the transient nature of the building with only occasional fully occupancy in the main hall. The studio is used more consistently used and at a higher occupancy so services need to respond more effectively.

2.2. Building Energy Baseline

The following information in Table 2.2 was supplied by the client.

12 months (CY 2014)	Energy Consumption		Cost (Ex VAT)		CO_2 emissions
Utility	KWh/year	%	£/year	%	Tonnes
Electricity	22,736	83%	£2,771.51	94%	12.12
Natural Gas	4,782	17%	£180.00	6%	0.88
Total	27,518	100%	£2,951.51	100%	13.00
Notes: Emissions: The emission factors are based on DEFRA 2015 figures – 0.1846kgCO_2/kWh of Gas & 0.5331kgCO_2/kWh of Electricity. Unit costs: Costs are based on site billing data. Costs exclude CCL and VAT					

Table 2.2a Site Energy Consumption Summary

Notes:

1. The gas consumption has been estimated on the basis of a monthly gas cost of £15 per month. A standing charge of £70 per year and unit charge of 2.3p/kWh has been assumed.
2. The site is provided with a PV array on the studio roof which generated an income in 2015 for Neuadd Dyfi of £2,145. The PV array has generated 4,266 kWh of which 49% was exported and 51% was used on site. The PV energy used on site equates to 10% of the sites electricity use.
3. The site received an energy audit detailing building services and energy saving opportunities. This report was prepared by Ecodyfi and is titled “Communities Opportunity Report” dated 23/09/2015.
4. The average electricity unit charge is taken as 12.2p/kWh.

2.3. Main Hall Building Services Overview

The Main Hall building services include:

- Fresh air inlet louvres over the stage area.
- Extract ductwork linked to 2 main extract fans controlled from the foyer area. These are rated at 0.75 kW peak each i.e. 1.5 kW total load.
- 4 Punka de-stratification fans.
- 12 direct electric infra-red radiant heaters rated at 3kW each i.e. 36kW total load. Switched from the lobby.
- Tungsten lighting (dimmed).
- Stage lighting LED.

The main hall suffers from:

- Original fabric with ‘new’ roof – 19 years old. Most constructions have poor thermal performance.
- Too hot versus too cold poor controllability.
- Noisy mechanical punka and extract ventilation fans when switched on.
- Crosstalk from the fresh air louvres i.e. people speaking in the studio can be heard in the hall.
- Thermal discomfort from people sat near radiant heaters. People talk of their heads being ‘cooked’ and of headaches.

- Draughts from the open fresh air inlet louvres.
- Poor acoustics generally from fabric and services.
- The hall in operation is heated up, becomes stale, then purged using fans leaving the hall cold.

2.4. Studio Building Services Overview

The studio services include:

- Modern construction and good thermal performance.
- Good acoustic ceiling panels.
- No ventilation (hence the proposals for a mechanical ventilation system).
- Ground source heat pump operating at 46°C with 'fan coil' type wall mounted space heat emitters. It is notable that there is reported to be around 15kW spare capacity on this system.
- Low energy lighting.
- Roof mounted PV array

The studio suffers from:

- Lack of ventilation and the room quickly becomes stuffy.
- The studio does not have building regulation approval.

2.5. Other Building Services

Other building services include:

- A gas water heater is provided in the kitchen area for domestic hot water heating.
- The corridors are heated via direct electric wall mounted heaters.
- The building electricity supply is rated at three phase 100 amp (approx 70 KA or 60kW).
- The building gas supply is rated at 6m3/hr (approx 67kW).

2.6. Existing Maintenance Costs

The sites maintenance requirements are quite simple with the following estimated requirements;

Component	Servicing Need	Estimated Annual Cost
Lighting	Change of lamps	£50
Heat pump	Annual service needed	£250
Gas water heater	Annual gas safe service needed	£150
Ventilation fans	NA	£0
Electric infra-red heaters	Change of heaters	£200
Total		£650

Table 2.5a Estimated Site Maintenance Costs

3. Studio Design Review

3.1. Introduction

When constructed the studio annex was not provided with any natural or mechanical ventilation. The construction of the studio does however incorporate for the provision of future mechanical ventilation in that a power supply and builders-work holes for ducts and louvres has been provided.

There are 2 main consequences to the studio not having a ventilation system. Firstly, the studio does not have full Building Regulations approval, and secondly, the studio users complain of a warm and stuffy environment leading to headaches and a loss of concentration.

Neuadd Dyfi had in 2014 instructed a building services engineering consultant to prepare a full design specification and drawings to provide mechanical ventilation to the studio. However, it was reported that the cost of the proposals would be in the order of £37,000. The proposals have not yet been implemented and funding is being considered.

In this section the studio ventilation proposals are reviewed in detail for the purposes of evaluating if the proposals are fit for purpose and offer value for money.

3.2. Performance Requirements

The studio accommodates a wide range of building users and occupancies. The ventilation system should be sized for up to 65 occupants yet be capable of efficiently providing fresh air for as few of 5 occupants. The system should be capable of being efficiently operated for bookings of only 1.5 hours at a time, and be capable of room division. Furthermore the system should be compliant with the Building Regulations and CIBSE heating and ventilation requirements.

The table below provides details of the design requirements as recommended by CIBSE:

Winter External Design Temp °C	Internal Winter Dry Resultant Temp °C	Internal Summer dry resultant temperature °C	Suggested air supply rate l/s/person	Noise Rating NR (NB dBA = NR + 6)	Design Occupants	Minimum air change rates per hour
-3	19-21	21-23	10	25-30	5-65	6-10 (based on use as a changing room)

Table 3.2a: CIBSE Design Criteria CIBSE Guide A

Based on the above a ventilation system should provide fresh air for at least 65 people at 10 litres of air per second being 650 litres per second (or 0.65 m^3/second). This equates to 6 air changes per hour.

To enable compliance with Building Regulations the ventilation system should incorporate controls, ventilation heat recovery and specific fan power of 1.8 for existing buildings.

3.3. Review Documents

The following documents were prepared by Mr Adrian Tester Building Services Engineer tel (01970 624510):

- Drawing : Proposed ventilation installation layout I – Drawing Number 14-821 Dated May 2014
- Drawing : Proposed ventilation installation layout II – Drawing Number 14-822 Dated May 2014
- Specification: Provision of Hall Ventilation Dated May 2014. Comprising 72 pages.
- Air Design (UK) Ltd Quotation Reference SD-12-Q02268 Rev 04 dated 27 September 2016 comprising 10 pages.
- Building Controls Maintenance Ltd Quotation reference j40\006 Dyfi Hall, Aberddyfi dated 15 September 2016 comprising 2 pages.

3.4. Overview of Ventilation Proposals

The key features of the ventilation system as specified in the specification, quotations and drawings are:

- An air handling unit located on the annex flat roof complete with G4 standard filters, thermal wheel heat recovery device, supply and extract fans delivering 0.53m3/s fresh air (NB suitable for only 53 people and not the 65 required).
- Supply fan power rated at 0.75kW and extract fan rated at 1.1kW (1.85 kW total).
- Variable speed fans with invertors.
- Specific fan power = 1.73 overall (compliant with Building Regulations)
- Heater battery off coil temperature 21°C. Rated at 10.28 kW 82/71°C. (NB the heat pump can only deliver hot water at 46C so this is not correct and carries risks).
- Heat recovery at 12kW via the thermal wheel.
- Noise attenuation to meet NR 25 (to be sized by the contractor).
- Steel ductwork (all sized).
- Thermal insulation.
- Louvres and grilles.
- Dampers.
- Control panel located in the plant room with a local controller in the hall controlling the room temperature at 21C +/- 2C. Manual settings of small hall / large hall i.e. 50%/100% air volumes.
- The ventilation is designed with a low level supply air input into the room with a high level extract. This is known as a displacement ventilation system and is a suitable proposal.

Key features of the specification are:

- The specification uniquely specifies controls to be provided by “Building Control Maintenance”.
- The specification uniquely specifies that the air handling unit be provided by “Air Design (UK) Ltd”.
- The specification contains 48 of its 72 pages (66%) attributed to general contract terms. Many of these clauses are not related to the Neuadd Dyfi project.

3.5. Review Findings

3.5.1 Cost

The cost of the proposed ventilation was estimated at £37,000 by Adrian Tester. A breakdown was requested from Adrian Tester but was not reported as available. This cost is thought to include VAT although this needs confirmation.

The cost expressed as metre square rate is £561/m^2.

Comparison projects were sought but an exact match was difficult to find. However, reference projects were found for new build performing arts buildings with ventilation services (http://www.building.co.uk/cost-model-performing-arts-buildings/5050599.article) costing around £321/m^2. This rate is for a new build project and refurbishment projects are more complex and therefore a more reasonable target should be £400-450/m^2 (i.e. £26,400 to £29,700). The proposed cost is therefore 25-40% high as compared with a cost model.

Two local contractors were approached to provide a check price quotation of the ventilation system. They were ACS wade Ltd and A P Mitchell Building Services Limited. A P Mitchel were unable to provide a quotation. A price from ACS Wade is being determined but not as yet submitted.

The uniquely specified air handling unit and controls quotations were obtained and the prices were £6,109 and £15,660 respectively plus VAT. The total of these 2 items being £21,769 plus VAT = £26,123. These 2 items account for 70% of the project cost.

The Adrian Tester cost is thought to be higher than anticipated owing to the following reasons:

- The controls and air handling units are uniquely specified and therefore are not competitive. At £15,660 this seems very high.
- The specification is a 72-page document and a large part of the content is not uniquely relevant to the project and contractors may feel nervous about price certainty owing to many vague clauses.
- The works are relatively small scale and therefore the availability of local contractors may be limited. It may be necessary to invite tenders from South Wales i.e. Cardiff or Swansea.
- NB: The Air Design quotation now has smaller fans than the original specification requirements and therefore a re-quote of the controls and invertors may reduce the price.

3.5.2 Compliance

The proposed ventilation system is mostly compliant with the requirements of standards. The proposals are mostly fit for purpose and the choice of a displacement ventilation strategy is good.

However, there are 2 non conformities:

1. The specification heater battery off coil air temperature is designed at 21°C with heating connections at 82/71°C. Not only is this is lower than the typical 29°C off coil temperature but the actual heating connection from the ground source heat pump is only 46°C. The result is that the air temperature delivered by the air handling unit will be lower than required to mix with room air and air will feel cooler. In summary there is a risk of draughty air being perceived in the winter months. This risk is seen as a medium risk and needs to be considered by Neuadd Dyfi.
2. The air handling unit air flow rate does not comply with CIBSE recommendations to provide 10 litres of fresh air per person. It achieves fresh air for only 53 people and the requirement is for 65 people.

3.5.3 Operational Suitability

The system is mostly suitable for Neuadd Dyfi as the controls can operate at 2 levels i.e a large and small hall at 100% or 50%. However, once the ventilation is switched on there is a risk that it is not switched back off.

It is suggested that the following should be included:

- The room controls include a push button with green and red light labelled “studio ventilation 1.5 hour provision”. This will operate once in the time frame. In addition an over-ride key should also be provided.
- The room controls include 3 settings below on a dial fully labelled as:
    - Position 1 – up to 15 people
    - Position 2 – up to 30 people
    - Position 3 – up to 65 people

3.5.4 Running Costs

The system, as currently proposed, is likely to cost in energy alone around 35p per hour in summer and approaching 70p per hour in winter (Ex VAT). These costs should be factored into room rental charges.

3.6. Alternatives

There is an alternative to mechanical ventilation in the studio and that is Natural ventilation. One such approach could include passive stack ventilation using a roof vent to induce air into the space and allowing air to ventilate out.

In order to test this concept one manufacturer was contacted to assess feasibility. The manufacturer was Monodraught. A quotation was prepared and is referenced E13574 Dated 28th September 2016. The contact was Tim Adams Tel 01494 897 700.

Monodraught proposed to provide 2 Windcatcher X-Air 170 Natural ventilation systems with motorised low leakage volume control dampers, extended egg crate grille, 50mm acoustic lining and attenuating swept upstand insert. Each unit weighing 213.5 kg.

The capital cost estimate including 2 windcatchers, controls, builders work, installation, overhead and profit and VAT is £36,000 being £545/m^2.

The running costs are only during the heating season in terms of lost heat in the space. However, it is anticipated that the heat gain owing to occupants could offset the lost heat. In the worst case it is estimated that the running cost could be around 30 pence per hour in winter time.

The risks and limitations of a natural ventilation alternative are as follows:

- The fresh air entering the space in winter is not pre-heated so draughts may be experienced if fully opened. However, the vents will normally open when the room is fully occupied and a build-up of heat is present.
- Whilst noise attenuation is provided in the form of acoustic treatment and attenuator sections there is a risk of external noise at times of high noise i.e. passing trains.
- There is no heat recovery from the extracted air. However, the vents will normally open when the room is fully occupied and a build-up of heat is present.
- The existing roof will need to be cut and sealed around the roof vents. In addition the acoustic ceiling panels taken down, re-sized and re-installed.

Important note; Whilst Monodraught were approached to provide information and initial proposals they are not recommended. Should the concept of passive stack ventilation using roof vents be of interest a specification should be drawn up and enquires made to at least 4 companies to ensure that competitive prices are obtained.

3.7. Conclusions

The mechanical ventilation system with some specification changes could be tendered and a compliant solution could be provided. This is the most suitable and controllable solution for the studio, but, the risk of draughts would have to be accepted.

The Natural ventilation alternative is feasible comparable cost alternative but does carry with it some limitations and risks. It would require the existing roof to be cut open and re-weathered in 2 locations. It would require the internal acoustic ceiling panels to be cut and grilles fit through them. There is also the risk of noise break in and out owing to the proximity near to the train line.

The best option is therefore the mechanical ventilation proposal with specification changes.

3.8. Recommendations

It is recommended that:

1. Neuadd Dyfi consider the risk of potential draughts associated with the low temperature heating in the air handling unit from the existing ground source heat pump.

2. The specification and drawings are amended with:
    a. Air handling unit air flow rate of 0.65 m^3/s (to suit 65 people).
    b. More project specific and reduced preliminaries are within the specification.
    c. At least 3 suppliers are specified for the air handling units
    d. Updated controls quotation to include studio room controls with a push button and green and red light labelled “studio ventilation 1.5 hour provision”. The room controls to include 3 settings below on a dial fully labelled as; Position 1 – up to 15 people, Position 2 – up to 30 people, Position 3 – up to 65 people. An over-ride key switch is to be provided.
    e. At least 3 suppliers are specified for the controls installation.

3. A cost for ventilation should budgeted for at least £35,000 in future funding bids – allowing a 15% contingency on previously stated figures.

4. The specification and drawings should be tendered to a list of 4/5 contractors ranging from local to National and should include consideration to some Cardiff and Swansea contractors.

5. The selected contractor should be closely managed and all final proposals verified especially in terms of:
    a. Final controls panel drawings
    b. Acoustic performance of the system and attenuators
    c. Air handling unit access and maintenance
    d. Health and Safety

4. Main Hall Thermal Insulation

4.1. Introduction

The main hall was constructed in the 1920's and has been improved incrementally over time. However, the standard of thermal insulation of the main hall principal fabric elements is overall quite poor.

The purpose of this section of the report is to review and consider practical options to improve thermal insulation levels in the existing main hall and in particular the floor and roof.

In addition Neuadd Dyfi has requested that their development aspirations and plans be taken into account particularly:

a) The plans to remove the tiered seating and to provide a new floor within the next 5 years.

b) The plans to replace the metal roof as it is approaching 20 years old and should be replaced in the next 5 years.

The heat loss for the fabric and ventilation losses to the space as per the existing fabric constructions is calculated at 46 kW peak (using IES Virtual Environment software 2016). The annual heating consumption at present is estimated at around 9,000 kWh.pa based on the existing electric heating system. The annual hall heating cost is estimated to be around £1,098 per annum. It is notable that the existing heating system in the hall is sized at 36kW and are therefore under-sized. Any and all improvements in the building fabric will reduce heat loads, annual energy bills and improve thermal comfort to the space.

4.2. Existing Fabric

In this section the existing fabric construction build up and U values are reported.

4.2.1. Existing Floor

The floor in the main hall is constructed in 3 main zones:the stage, flat floor and sloping seated area.

Area	Construction	U Value W/M^{2}K
Stage	25mm Marine ply over a 1.2m void with grid mat covering over sand base	1.5921
Flat Floor	22mm maple on sprung batons on 1mm chipboard with 100mm jablite polystyrene insulation	0.2477
Tiered Seated Area	22mm close boarding over a void with sand base	1.5011

Table 4.2.1a: Existing Floor Constructions

It was observed during the site survey that all floor voids were ventilated to prevent the build-up of moisture and mould. Access was possible below the stage floor via trap-doors and under the flat floor via the stage floor void. Access below the tiered seated area was limited to small access points for visual inspection only / cable pulling.

4.2.2. Existing Wall

Area	Construction	U Value W/M^{2}K
External wall	Main walls are single skin concrete block with a small void and 60mm of compressed straw board	0.7932

Table 4.2.2a: Existing Wall Construction

The internal face of the wall was covered in a fabric material that has good acoustic properties. Owing to the internal space need for circulation there is limited scope to over clad internally.

4.2.3. Existing Roof

Area	Construction	U Value W/M^{2}K
Roof	Metal sheet, 50mm insulation and metal sheet.	0.7020

Table 4.2.3a: Existing Roof Construction

The underside of the roof is accessible in the stage area at a high level via a scaffolding. The roof in the main hall area is located above a suspended ceiling and can only be accessed via the suspended ceiling itself. It is noted that the existing roof suffers from rain impact noise and this is a distraction to those in the stage area.

4.2.4. Existing Windows

Area	Construction	U Value W/M^{2}K
Windows	Metal framed and double glazed	1.6

Table 4.2.4: Existing Window Construction

The windows are limited in the hall space and are quite short in profile. The windows are for the majority of the time located behind blinds to keep the daylight out of the main hall area.

4.2.5. Draught Proofing

In terms of the fabric it is reported by Neuadd Dyfi that the main hall does not really feel draughty. The doors and windows were all new 17 years ago and had acoustic seals installed to reduce break-in of sound.

It was reported that the stage area is draughty as when the hall area heats up the warm air above the suspended ceiling makes a route to the stage area and then drops onto the stage area.

However, in terms of the mechanical ventilation system the main fresh air ventilation inlet ducts allow the natural inflow of air. When these are closed using manual dampers they are reasonably tightly shut, but often they are open and cause cold draughts. The issue of the hall mechanical ventilation will be discussed and addressed in S5 of this report.

4.3. Opportunities

The main opportunities are to provide:

- Additional thermal insulation to the roof when the existing roof is to be re-clad in the next 5 years.
- Additional thermal insulation to the main hall stage and tiered seating floor area when the sloping floor is removed.
- Sealing the air space between the stage and the main hall.

The target standards for fabric improvements are detailed in Building Regulation L2B Conservation of fuel and power in existing buildings other than dwellings (2010 edition with 2016 amendments). The limiting fabric target U values are:

- Roof 0.18 W/m^2
- Floor 0.22 W/m^2

4.3.1. Floor

As the floor comprises 3 different zones the improvement works are proposed as follows;

Zone	Fabric Improvement	Resulting U Value W/m^{2}K
Stage	The stage floor is supported using 150mm deep steel beams at 400mm centres. There is an opportunity to fill the gap between the steelwork with 150mm depth of glasswool. The insulation would be held in place using a suitable fire board. The overall area of this floor is 14m x 7m.	0.2284
Flat Floor	No change. However, it is suggested that the insulation is inspected, if necessary re-fixed in place.	No change
Sloping Seated Area	The proposed flooring system is yet to be designed and specified by an architect for this area. However, it is expected that 150mm of glasswool insulation could be added	0.2264

Table 4.3.1a: Proposed Floor Insulation

It should be noted that the resulting U values are close to the target U value and that discussion should be made with building control about the practicalities in achieving a lower U value.

4.3.2. Roof

2 options were considered for insulating the roof.

The first option was to insulate the underside of the roof using 185mm of UF foam to achieve a U value of 0.18 W/m^{2}K. This would be held in place using a board. However, access to install this in the main hall would require scaffolding and the existing ceiling to be removed in its entirety. This is not a practical solution and has been discounted.

The second and preferred option is to, at the time of replacement, over-clad the existing roof with a new 'refresh' insulated cladding system.

BSSEC approached a roof supplier called Euroclad Elite Systems and a proposal was provided for a suitable over-clad system including 200mm of insulation. See Quotation reference 100328 dated 23/09/2016 for details. It is estimated that the overall U value of the new roof layered on-top of the existing roof will achieve an overall U value of 0.18 W/m^{2}k.

Neuadd Dyfi at the same time contacted their structural engineer, to assess if the existing roof and steelwork can support the additional load for the over-clad system, and it was reported that it could.

4.4. Cost Benefit Analysis

The cost improvements for the roof and floor are outside of the scope of the advice given in this report as they are part of a wider maintenance and building improvement plan that will include many other aspects (e.g. flooring and seating removal, new floors and seats, new lighting, new roofing, guttering etc).

It is suggested that a suitable architect or building surveyor is employed to develop these solutions and to provide cost advice.

The benefits of the insulation is as follows:

Improvement Scenario	Calculated Peak Heat Load in KW	Estimated annual heating demand kWh.pa	Annual Cost Saving £.pa
Existing	46	9,000	0
Roof Only	43 (6.5% reduction)	8,550	£54.90
Floor Only	39 (15% reduction)	7,650	£164.70
Roof and floor together	36 (21.5% reduction)	7,065	£219.60

Table 4.4a: Benefit Analysis

Other benefits would include improved acoustic attenuation and reduced rain noise in the main roof structure which at present is an issue, and, the reduction of cold draughts in the stage area owing to the sealing of roof voids.

4.5. Recommendations

It is recommended that:

1. Improvements to the roof and floor insulation are made in accordance with Section 4.3 above. This should include sealing the roof voids between the main hall area and the stage to prevent draughts.
2. Budget costs to provide insulation to the roof and floor are obtained from an architect or building surveyor.
3. Final fabric designs are also provided by an architect or surveyor.
4. Improvements are implemented at the same time as the new roof and floor projects are rolled out.

5. Main Hall Heating and Ventilation

5.1. Introduction

The main hall is provided with a basic heating and ventilation system which do not suit the needs of the space.

The purpose of this section of the report is to review the existing services, the current and future needs of the hall, and, to suggest options for proposed heating and ventilation services.

Owing to the success of the ground source heating in the studio Neuadd Dyfi would like to consider a ground source heating solution in the main hall. Consultation was recommended to the existing (and local) ground source heat pump installer Eco Friendly Installations.

5.2. Overview of Existing Services

The main hall heating system comprises of 12 direct electric infra -red heaters rated at 3 kW each (36 kw total). These are controlled manually from the foyer area. The heaters are a source of thermal discomfort and complaint as they heat up peoples' heads. They are also not suited to theatre applications in that they colour the hall 'red'. They are a major distraction during productions.

The main hall ventilation system comprises of; fresh air inlet louvres over the stage area and main entrance, extract ductwork linked to 2 main extract fans controlled from the foyer area (rated at 0.75 kW peak each) and 4 Punka de-stratification fans. The ventilation system draws in external air and simply extracts the air from the space (a cold purging effect). The air inlets are not provided with any noise attenuation at all and there are complaints of cross talk i.e. people talking in the studio can be heard in the main hall. The extract fans and punka fans all generate noise. It is notable that the extract fans are provided with noise attenuation.

Overall the hall controllability is poor and suffers from being too warm or too cold. The hall heating and ventilation services are not fit for purpose.

It should be noted that whilst the hall heating and ventilation systems are not fit for purpose they are relatively low cost to operate at present. The current hourly running cost is approximately £4.60 per hour.

5.3. Performance Requirements

The main hall accommodates a wide range of building users and occupancies. The main hall can accommodate small groups of 20, medium sized groups such as weddings and up to 460 people theatre productions. However, it should also be remembered that this is a community building and not a national theatre.

The ventilation system should be sized for up to 460 occupants yet be capable of efficiently providing fresh air for as few of 20 people. The system should be capable of being efficiently operated for bookings of only 2 hours at a time. The system should also be quiet in operation.

Furthermore the system should be compliant with the Building Regulations and CIBSE heating and ventilation requirements.

The table below provides details of the design requirements as recommended by CIBSE:

Winter External Design Temp °C	Internal Winter Dry Resultant Temp °C	Internal Summer dry resultant temperature °C	Suggested air supply rate l/s/person	Noise Rating NR (NB dBA = NR + 6)	Design Occupants	Minimum air change rates per hour
-3	22-23	24-25	10	20-25	20-460	8-15

Table 5.3a: CIBSE Design Criteria CIBSE Guide A

Based on the above a ventilation system should provide fresh air for at least 460 people at 10 litres of air per second being 4,600 litres per second (or 4.6 m^3/second). This equates to 10 air changes per hour.

To enable compliance with Building Regulations the ventilation system should incorporate controls, ventilation heat recovery and specific fan power of 1.8 for existing buildings.

It is notable that the Building Control Officer / Architect / Fire Officer would have an opinion on smoke control and fire alarms in the main hall if a new heating and ventilation system was to be provided. The exact requirements are subject to consultation and design options by the previously mentioned parties. For completeness a budget sum will be allowed in each option for smoke control and an alarm system.

It is notable that the existing building structure is quite old and appears structurally light-weight. Consultation has not been made with a structural engineer in this section and therefore it has not been ascertained if the existing steelwork can support either new heating and ventilation system.

5.4. Overview of Options Available

There are 2 main options available to Neuadd Dyfi. The first is a full mechanical ventilation and heating system and the second is a natural ventilation system with ground source heat pump heating.

Ground source heat pump heating is not recommended to heat air in the main hall mechanical ventilation system as the air temperatures will be too low (refer to section 3 studio design review) and draughts will be problematic. Therefore for the mechanical ventilation option a gas powered heating system would be required.

5.5. Option 1 – Full Mechanical Ventilation System

This option would include a new gas supply, boiler room, air handling unit plant room, air duct distribution and ceiling grilles and louvres.

The existing gas supply would need to be upgraded to support the new heat load of the fabric heat losses and the ventilation air load. A boiler system could be located along with a new air handling unit in the former projection room located above the main foyer area. This would mean that the existing space as used as a store would have to be re-located. Air duct lines would be routed above the existing suspended ceiling. This would mean that the existing system would need to be either partially or fully taken down and re-installed. The supply and extract air terminals would be installed within the ceiling system at high level.

A displacement ventilation system (where supply air is provided below floor via grilles or at a low level using displacement drums) would be ideal for a theatre application. However, at the present time until a new floor is provided this option would not be practically feasible. It should also be noted that the existing circulation spaces follow the external wall routes and ductwork drops or displacement drum terminals would ‘block’ circulation and emergency access. Displacement ventilation at this time is therefore not feasible.

The cost for providing a full mechanical heating and ventilation system is estimated in the following table:

Element	Cost £/m2	Cost £
Smoke extract & Alarm	105.82	40,000
Gas supply	26.46	10,000
LPHW Boiler	150.00	56,700
Plant room modifications	39.68	15,000
Air handling unit	20.00	7,560
Ventilation	110.00	41,580
Power supplies	12.00	4,536
BMS Controls	40.00	15,120
Builders work	39.68	15,000
Removal and re-instatement of ceiling	26.46	10,000
Sub total	570.10	215,496
OH&P at 15%	85.51	32,324
Contingency at 10%	57.01	21,550
Design fees at 10%	57.01	21,550
Sub total	769.63	290,920
VAT at 20%	153.93	58,184
Total	**923.55**	**349,104**

Table 5.5a: Mechanical Heating and Ventilation Cost Estimate

The running cost for a mechanical heating and ventilation system would be in the order of £8 per hour.

This option has a high capital cost of £349,104 and also a high running cost of £8 per hour.

5.6. Option 2 – Natural Ventilation System

The most energy efficient method to heat and ventilate the hall using a renewable resource is to consider a natural ventilation solution with ground source heat pumps.

This option would include roof mounted natural ventilation passive stacks allowing fresh air to enter the space and exhaust air to leave the space. These would be ducted between the suspended ceiling and roof terminals. They would include attenuators and acoustic lining to reduce external noise and cross talk to a minimum. Each passive stack would be controlled in zones from a control panel to include fire alarm, heating interlock, night cooling and carbon monoxide control with a room temperature sensor.

The natural ventilation manufacturer Monodraught were approached and a quotation was provided ref E13574 dated 28 September 2016. The quotation included for:

- 6 Windcatcher X-Air 200 natural ventilation systems with attenuating swept upstand insert, motorised volume control damper, egg crate grille and 50mm acoustic lining.
- Installation
- Cranage
- iNVent control panel with 3 zones within the main hall
- Commissioning
- Weight 272kg each

The ground source heat pump manufacturer Eco-friendly Installations were contacted and budget costs were provided on the following basis (Source email dated 23 September 2016 from Mark Giddens):

- Ground source heat pump array and drilling to extract 31 kW of heat from the adjacent car park ground / rear of the building.
- Heat pump unit located in the existing studio plant room.
- Connections and cascade between the existing heat pump and the new to access a further spare 15 kW of heating capacity
- Wall mounted heat emitters in the main hall
- Pipework
- Control system
- Supply, install and commission service

It is important to note that a firm quotation was not provided.

The cost for providing a naturally ventilated and ground source heat pump solution is estimated in the following table:

Element	Cost £
Smoke extract and alarm (assumes 2 windcatchers can operate as smoke controlled devices)	10,000
GSHP drilling	21,000
GSHP Internal	41,000
X-Air 200 6 off	57,450
Install	4,850
Cranage	2,000
iVent controls	1,977
Commission	475
Builders work & holes	18,000
Ceilings (partial take down and replace) – removal of existing ventilation services	5,000
Total	161,752
OH&P 15%	24,263
Contingency at 10%	16,175
Design Fees at 10%	16,175
Sub total	218,365
VAT at 20%	43,673
Grand Total	**262,038**

Table 5.6a: Natural Ventilation and Ground Source Heat Pump Cost Estimate

It was advised by EcoFriendly Installations that if grant aid funding is used for projects then no benefits can be claimed from the RHI (Renewable Heat Incentive) scheme.

The approximate running cost of the natural ventilation and ground source heat pump system is £1.50 per hour.

It should be noted that the natural ventilation and ground source heat pump system will have limitations as compared with a full mechanical system. The limitations will include air temperature controllability, noise control and potential draughts.

Important note; Whilst Monodraught and EcoFriendly Installations were approached to provide information and initial proposals they are not recommended. Should the concept of passive stack ventilation using roof vents and ground source heating be taken forward then it is recommended that at least 4 companies are approached to ensure that competitive prices are obtained.

5.7. Option Appraisal

The following table compares the options:

Comparison	As Existing	Mechanical Ventilation & Heating	Natural Ventilation and Ground Source Heat Pump
Running Cost £ per Hour	£4.60	£8	£1.50
Maintenance cost £ per annum	£200 (IR Heaters)	£400	£250
Capital Cost in £		£349,104	£262,038
Benefits		Good controllability	Lowest running costs, maintenance costs and capital cost. A renewable and energy efficient solution. Least disruption to the main hall. No additional plant room needed.
Limitations		Highest running cost, maintenance cost and capital cost. Highest level of disruption. Needs large plant room.	Relies on natural ventilation so controllability is an issue. Risk of draughts as air is not pre-heated on entering space.

Table 5.7a: Main Hall Heating and Ventilation Option Appraisal

5.8. Conclusions

It is concluded that if the level of fine controllability and risk of draughts on cold days can be excepted by Neuadd Dyfi then the best option is to pursue the Natural Ventilation and Ground Source Heat Pump option.

If Neuadd Dyfi can also improve the fabric U values at the same time then ground source heat pump drilling costs could reduce slightly.

Whichever option is selected it is recommended that a full design proposal is developed (with input from Building Control, Fire Officer and Architect) and competitively tendered based on a number of different suppliers and installers in order to achieve best value.

6. Recommendations

The following recommendations are made in relation to the studio ventilation system, main hall thermal insulation and main hall heating and ventilation system.

6.1. Studio Ventilation System

1. Neuadd Dyfi consider the risk of potential draughts associated with the low temperature heating in the air handling unit from the existing ground source heat pump.
2. The specification and drawings are amended with:
    a. Air handling unit air flow rate of 0.65 m^3/s (to suit 65 people).
    b. More project specific and reduced preliminaries are within the specification.
    c. At least 3 suppliers are specified for the air handling units
    d. Updated controls quotation to include studio room controls with a push button and green and red light labelled “studio ventilation 1.5 hour provision”. The room controls to include 3 settings below on a dial fully labelled as; Position 1 – up to 15 people, Position 2 – up to 30 people, Position 3 – up to 65 people. An over-ride key switch is to be provided.
    e. At least 3 suppliers are specified for the controls installation.
3. A cost for ventilation should budgeted for at least £35,000 in future funding bids – allowing a 15% contingency on previously stated figures.
4. The specification and drawings should be tendered to a list of 4/5 contractors ranging from local to National and should include consideration to some Cardiff and Swansea contractors.
5. The selected contractor should be closely managed and all final proposals verified especially in terms of:
    a. Final controls panel drawings
    b. Acoustic performance of the system and attenuators
    c. Air handling unit access and maintenance
    d. Health and Safety

6.2. Main Hall Thermal Insulation

It is recommended that;:

1. Improvements to the roof and floor insulation are made in accordance with section 4.3. Namely that the roof is over clad with at least 185mm of thermal insulation and that the stage floor and tiered floor is provided with at least 150mm of thermal insulation.
2. These works should include sealing the roof voids between the main hall area and the stage to prevent draughts.
3. Budget costs to provide insulation to the roof and floor are to be obtained from an architect or building surveyor as they will be part of a wider project.
4. Final fabric designs are also provided by an architect or surveyor.
5. Improvements are implemented at the same time as the new roof and floor projects are rolled out.

6.3. Main Hall Heating and Ventilation System

It is recommended that funding is sought for a natural ventilation and ground source heat pump heating and ventilation system in the main hall. It is suggested that a sum of £260,000 is applied for.

It is recommended that Neuadd Dyfi accept controllability limitations and the risk of draughts on cold days.

If possible, it is recommended that improvements are made to the fabric U values at the same time as this project so to reduce ground source heat pump drilling costs.

It is recommended that a full design proposal is developed (with input from Building Control, Fire Officer and Architect) and competitively tendered based on a number of different suppliers and installers in order to achieve best value.

Appendix A – Site Photographs

Figure A1.1 – Stage floor void

Figure A1.2 – stage floor void

Figure A1.3 – ceiling void above main hall area

Figure A1.4 – underside of roof as viewed from the stage

Figure A1.5 – Gas meter

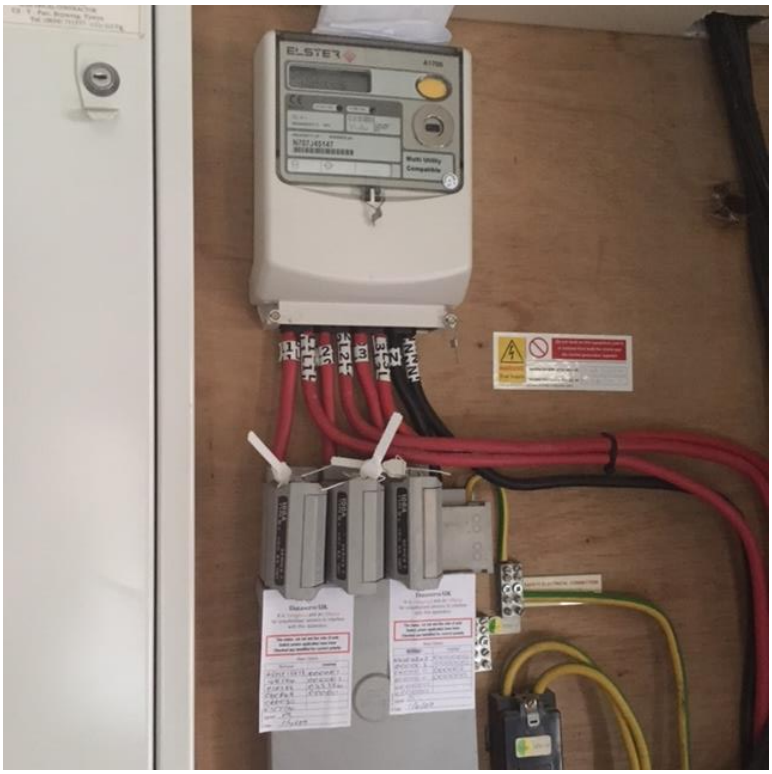

Figure A1.6 – Electricity meter

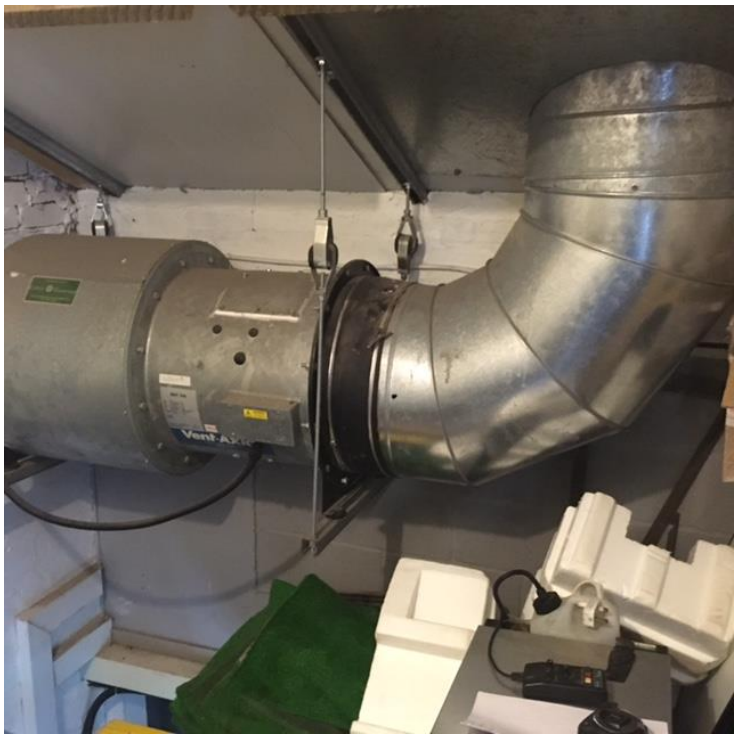

Figure A1.7 – Existing hall extract fan

Figure A1.8 – Studio ground source heat pump – heating emitter

Figure A1.9 – Studio underside of roof – note acoustic panels

Figure A1.10: Studio

Figure A1.11: Studio Roof