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ENERGY & ARCHITECTURE

NORTHALLERTON METHODIST CHURCH

PATHWAYTO NET ZERO

THIRSK & NORTHALLERTON CIRCUIT

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THIRSK & NORTHALLERTON CIRCUIT

NORTHALLERTON METHODIST CHURCH

PATHWAY TO NET ZERO

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D3 Associates Ltd

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1.0 INTRODUCTION

This feasibility study for Northallerton Methodist Church, the largest Methodist Church in the Thirsk & Northallerton Circuit, was designed to assist the Church to develop a viable Pathway to reducing the building carbon emissions to Net Zero. This study, funded by the Northern Powergrid Net Zero Community Energy Fund, stems from the commitment made by the Yorkshire North and East District of the Methodist Church to become Net Zero by 2040.

For the purposes of this report, we are using the term Operational Net Zero, meaning the aim is to generate as much electricity as the church consumes over one year.

When undertaking a project to reduce carbon emissions and particularly when considering the installation of a heat pump, it is important to use a holistic, whole building, approach to avoid high electricity costs.

In order of priority these are:

1. Energy demand should be reduced as much as possible
2. Heating and electricity should come from the lowest possible carbon source, ideally removing fossil fuel boilers and replacing with electric heating
3. Generate renewable electricity on site to match demand as much as possible

Improving the building fabric insulation, control systems and energy management (lighting, heating, ventilation) will assist in reducing the overall demand, whilst the deployment of appropriate renewable energy generation will help reduce the carbon footprint.

The current incoming electrical supply will be reviewed to determine whether an upgrade is required to support any additional loads from heat pumps and the potential to export surplus renewable electricity. It is anticipated an application to the District Network Operator will be required for the heat pump installation along with a planning application.

1.1 DESCRIPTION OF THE BRIEF

The Client is looking to identify a viable approach to Net Zero and includes the following scope of works:

1. Attend the church for a site visit
2. Identification of recommended energy saving measures
3. Assess options for a heat pump system to replace the gas boiler
4. Calculate the most appropriate solar PV and battery storage solution
5. Write up a Pathway to Net Zero Report
6. Prepare a specification for the proposed solar PV and battery storage installations
7. Technical design of the preferred heat pump system including specification
8. Submit a planning application
9. Undertake the role of Principal Designer

1.2 NOTES ON THIS REPORT

The following are notes on the inputs used for this report:

- The proposed energy saving measures are those considered appropriate for the building energy consumption and usage.
- The anticipated heat loss reduction, following installation of these measures, is based on past experience and general guidance published by the Carbon Trust .
- All budget costs are for capital costs excluding VAT and are based on recent projects and costings from the RIBA and Spon's estimating guides. Costs are provided as Day 1 costs with no allowance for inflation or interest.
- Note that 0% VAT for solar PV and battery installations is for domestic properties only, for all other buildings it is 20%.
- Total project cost includes fees for Contractors Preliminaries and OH&P at 15%, and Project Management at 10%.
- A conservative air source heat pump seasonal COP of 2.7 has been used.
- Where it is anticipated the electrical supply will need upgrading, a nominal sum of £8,000 has been used; this will be confirmed following an application to NPG.
- The outputs from PV*SOL modelling software are based on a theoretical scenario, therefore the future figures quoted are indicative; to provide an accurate prediction existing half hourly data would be required.
- The solar PV arrays are based on a highly efficient 400W panel, the battery storage is based on a typical battery.
- Carbon emissions for grid electricity are based on the long-term marginal 2030 figure of 0.13kgCO2e/kWh.

2.0 EXISTING BUILDING

The following information is from information provided by the Church and observations during a visit to the Church on the 8th December 2022.

2.1 SUMMARY OF BUILDING FABRIC & USAGE

Original Church building fronting onto the High Street was constructed in 1865. Adjoining to the rear is a two storey link building comprising entrance lobby & stairs, offices, meeting rooms, vestry, kitchen & toilets. The boiler room is below the vestry. The link building connects the Church with the Main Hall which, in turn, connects to a single storey Cottage meeting room with coffee-bar kitchen, toilets and separate secure entrance (refer to Existing Floor Plan in Appendix A).

Major refurbishment and remodeling works were undertaken in 1999.

Generally, all buildings are masonry wall construction - brickwork walls, with stone detailing to the main original building.

Approximately, 30° pitched slate roofs to the Link building, Main Hall and Cottage meeting room. Church roof is around 45 to 50°. Orientation of all roofs is north west/south east.

Timber framed stained glass single glazed windows to the Church, uPVC double glazed windows in rest of property.

External doors are timber to Church and uPVC elsewhere, most likely installed as part of 1999 refurbishment works.

Insulation levels to Link building and Cottage meeting room are likely to be in accordance with 1999 Building Regs. In addition, the Main Hall has 250mm insulation above the ceiling. Insulation levels to the Church are unknown and therefore assumed to be minimal.

Usage: Very active and well attended, used daily.

2.2 SUMMARY OF MECHANICAL & ELECTRICAL SYSTEMS

- **Heating System:** The Main Church, Link building and Main Hall are heated by two gas fired boilers supplying two pumped heating circuits, each with 3 port diverting valves. These circuits supply steel panel radiators throughout and fan convectors located in the Main Hall. These boilers also heat the domestic hot water requirement via a storage cylinder and control valve. The single-story west end extension is heated by a dedicated gas fired combi boiler that also generates domestic hot water.
- **Condition:** Fair to poor, the main boilers appear to have been installed in 1999, which would mean they are approximately 24 years old. The CIBSE guide M Appendix 13.A1 'Indicative life expectancy' for plant would suggest 25 years, this and the boilers are starting have breakdowns and there has also been a recent circuit pump and a heating circuit control valve replacement. The radiators are in fair condition, however the fan convectors in the Main Hall are poor and showing signs of age. The small extension boiler age is unknown however appears to be in fair condition.

- **Heating Plant:** Each of the main gas boilers have a rated output of approximately 80kW (160kW Total). The extension combi boiler has an output of approximately 12kW.
- Estimated Peak Space Heating Load: 80 - 100kW
- **Domestic Hot Water:** The domestic hot water is generally produced by an indirect storage cylinder heated by the gas fired boiler.
- **Electrical Supply:** Three Phase (TP&N), 125A
-

2.3 ANNUAL ENERGY USAGE AND CARBON EMISSIONS WITH COSTS

The following figures are from information provided by the Church and based on energy usage between November 2021 and October 2022:

- **Electricity**: 10,100kWh
- **Gas:** 85,633kWh
- Total Carbon Emissions: 17.8tonnesCO2e
- **Current tariffs**: Gas 3.3584p/kWh, standing charge 95p/day; electricity 15.38p/kWh, standing charge 38p/day
- Approximate Cost: £10,630

3.0 PROPOSED ENERGY SAVING MEASURES

The energy saving measures recommended in the table below are those deemed most appropriate and cost effective for the Church. Priority to be given to the areas of the building with the highest usage, i.e., the Link building and Hall. Reducing the heat loss and electricity demand in those areas will result in lower energy usage and carbon emissions.

The budget costs include 10% Project Management, however, exclude VAT.

No.	Energy Saving Measure	Budget Cost
1	Draught proofing, particularly of windows, doors and pipe entry points into the building.	£1,000
2	Install new suspended ceiling in Hall, area 119m2, include for new LED lighting, insulation above and moving fire detection and extract fan ducts	£20-25,000
3	Insulate underside of ceiling in Church, skim & decorate	£20-25,000
4	Repairs to the existing stained glass leaded	£5,000
5	Secondary glazing to all windows in the Sanctuary	£42,000
6	Thermal improvements to the glazed Link corridor – application of a Thermal Window Film	£1,000

Table 1:Recommended energy saving measures

The cost for item 5 is based on a quotation received from EnviroGlaze Specialised Window Systems Ltd. However, prior to the installation the existing windows will need to be repaired. The sum included in item 4 is a Provisional Sum, a full specialist survey is required.

The glazed link corridor is a source of significant heat loss resulting in a cold passage way between the Church and Link Building. A lower cost solution is to apply a file which reflects heat back into the space; cost is for supply only, can be installed by a competent DIYer.

A more expensive solution would be to install a new insulated roof and secondary glazing to the windows, budget cost £15-20K, further detailed investigation is required.

To calculate the actual energy savings is often difficult to quantify as often, as a room becomes more comfortable, it is used more frequently.

The estimated heat loss reduction following installation of the measures is 10%. This may be conservative, however, allows for increased usage, therefore, higher number of hours of heating.

4.0 PROPOSED LOW CARBON HEATING OPTIONS

The most appropriate option for low carbon heating is utilizing heat pumps. The following are the types considered.

4.1 GROUND SOURCE HEAT PUMP

A Ground Source Heat Pump system is not practical due to the lack of space available for either vertical bore holes or a horizontal type of system.

4.2 AIR-TO-WATER HEAT PUMP

An Air-to-Water heat pump system would involve replacing the existing gas fired boiler plant and heating systems. Air-to-Water heat pump systems generally operate at a lower heating water flow temperature and a smaller temperature difference between the flow and return. To accommodate these different operating parameters, the existing radiators would either need to be replaced entirely or additional radiators installed. The existing pipe work will also need replacing and/or reconfigured.

The Air-to-Water heat pump would need to be located outside of building and would occupy a space of approximately 3m long x 2m wide x 2m high.

It should be pointed out that there is a limited amount of space around the building to locate such a heat pump and the installation and routing of new pipework may prove difficult through the existing voids etc. A more detailed survey would need to be carried out to investigate the feasibility of such an installation.

Budget Cost £190 - £220,000

4.3 AIR-TO-AIR HEAT PUMP

This type of heat pump system generally consists of an indoor fan convector type unit(s) and an outdoor evaporator unit with refrigerant pipes running between the indoor and outdoor units. Multiple indoor units can be fed from a single outdoor unit and as these outdoor units are generally smaller than the central Air-to-Water type unit, they can be mounted at high level on an external wall, therefore, more suitable to limited space. In areas where there is intermittent use such as WC'S, stores and kitchens it is more practical to install conventional electric heaters with individual time clocks, thermostats and frost protection facilities.

The usage of the spaces is an important factor in deciding whether a heat pump system is suitable. The following table provided by the user is indicative of the space usage.

Area	NOV 21-27	NOV 28-DEC 4	DEC 5- 11	DEC 12- 18	JAN 9- 15	JAN 16- 22	JAN 23- 29	AVE over PERIOD
Main Church and Sanctuary	2	3	8	6	1	1	2	3.3
HALL	22.25	20.75	22	16.5	23.25	27.75	19	21.6
BYLANDS ROOM	21.5	20.5	19.5	21.5	19.5	19.5	21.5	20.5
COTTAGE MTG ROOM	11.5	10.5	26	11.5	15	7	12.5	13.4
VESTRY	-	1.5	-	-	-	-	-	1.5
FOUNTAINS ROOM	2	2	4	-	2	-	2	1.7
RIEVAULX ROOM	3	6	5	3.5	1.5	1	1	3

Table 2: Room occupancy levels

The occupancies are a snapshot of the current diary however these may change from week to week in the future.

4.4 AIR-TO-AIR HEAT PUMP and HEATING PROPOSALS

The **Hall** and the **Cottage** meeting room are frequently used and therefore a dedicated Air-to-Air heat pump system is proposed for each area. The WC Lobby would have an electric heater.

The **Bylands'** room is also a frequently used room and could have its own heat pump system, however we propose the **Entrance lobby** and the **Vestry** are also added to this dedicated system. For the **Kitchen**, **WC's** and **Choir Vestry** areas which are much less used we would propose electric heaters.

The first floor **Offices** and the **Fountains** and **Rievaulx** rooms are less used, but we would propose that these areas and the **Lobby and Link Corridor** be provided by with a dedicated Air-to-Air heat pump system. Each room can have separate time clock and temperature/set back temperature control.

The **Main Church** and **Sanctuary** are generally used only a few hours a week, given this with the older construction and the large areas of stained-glass windows, an electric Radiant Heat type heating system would be appropriate. For the ground floor it is proposed that the central seating area have 8no. x 1200mm long x 800mm wide (or 1600mm long x 600mm wide) white radiant panels mounted on an angle long the curved section of architrave below the side balconies. The side galleries each fitted with two of the same panels. The first-floor balcony area is best served by pendant type radiant

heaters, as the ceilings are high, beyond the effective recommended distance between heater and occupant. Both types of radiant heaters can be controlled in gangs via relays, time clock, temperature/set back control. The **Entrance Lobby** should be heated by electric heaters each with time clock and temperature control/frost protection.

The new heat pump and electric heating systems may be installed on a phased basis with the existing gas fired boiler and radiator system remaining in areas not yet converted. A proposed heat pump layout plan, Drg. No. 1747-5601-P1, is included in Appendix B.

Although the existing electrical power supply (TP&N 125A) may be adequate to serve a conversion to heat pumps an electrical load test would have to be carried out, this would establish the existing demand on the electrical system and therefore establish the spare capacity and if an upgrade to the electricity supply will be necessary to power the entire heat pump and electric heater systems.

A summary of the budget costs for each building is included in the table below:

Area	Indoor Units	Outdoor Units	Heat Pump Budget Cost	Electric Heaters	Electric Heater Budget Cost
Main Church and Sanctuary	-	-	-	23	£31,000- £35,000
Link Building	8	2	£21-£25,000	5	£3,000- £4,000
Main Hall	4	1	£18-£22,000	-	-
Cottage Meeting Room	2	1	£11-£11,000	1	£2,500- £3,500
Total	14	4	£50-58,000	11	£36,000-£42,500

Table 3: Budget Costs

4.5 MAIN HALL NEW CEILING

The **Main Hall** is to have a new lay in grid tiled ceiling installed as part of this work. The existing lighting shall be replaced with 1200 x 600 LED recessed lighting. The existing smoke sensors, alarm sounder and ventilation grilles will be relocated to suit the new ceiling level.

4.6 DOMESTIC HOT WATER

The domestic hot water for the Link is presently generated from the gas fired boiler via a storage cylinder. This could be replaced by an electrically heated cylinder retaining the circulation pump and distribution system.

Domestic Hot Water requirements for the Cottage will eventually need to be provided by point of use electric heaters as the Combi gas fired boiler will eventually be decommissioned. These heaters would be located under sinks and wash hand basins.

Budget Cost: £5,500-£6,500

5.0 ELECTRICITY GENERATION AND BATTERY STORAGE

Photo 1: Google Earth Image with proposed PV arrays in blue superimposed

The aim is to be Net Zero, therefore, enough electricity needs to be generated annually to match the demand. The priority is to install as many panels as possible on the single storey buildings to reduce installation costs, i.e., the Link building, Hall and Cottage Meeting Room. The array on the Church is sized to bring the total up to the total size required to be Net Zero.

Two scenarios are considered, roof mounted PV panels with and without battery storage:

- Subject to a full survey, install solar PV panels on the main roofs to the south elevation, 12kWp above the Church, 8kWp above the Link building, 10.8kWp above the Hall and 8kWp above the Cottage Meeting Room, total 38.8kWp; **Budget Cost £60,000**
- Install battery storage, 48kWh, as recommended by the modelling software, to enable more of the electricity generated to be used within the building; **Budget Cost £25,000**

Modelling assumptions:

- Following the switch to a heat pump system, the anticipated future annual electricity demand for the building will be around 38,400kWh

5.1 SCENARIO 1: WITHOUT BATTERY STORAGE

Modelling output using PV*SOL:

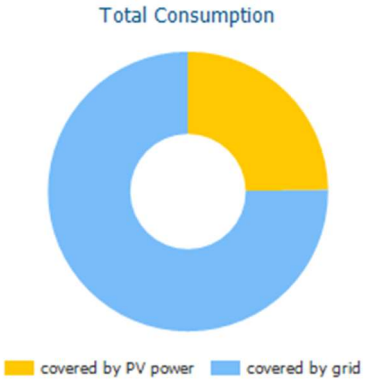


Figure 1: Scenario 1 – Consumption Pie Chart

- Solar PV - annual electricity generation = 38,188kWh
- Consumption covered by PV power = 9,521kWh
- Electricity exported to grid = 28,667kWh
- Consumption covered by the Grid = 29,038kWh

The Energy Flow Graph below represents the figures in graphical format, note the figures do not add up due to losses in the inverter, converting DC to AC and the battery.

Energy Flow Graph
Project: Northallerton Methodist Church - Net Zero

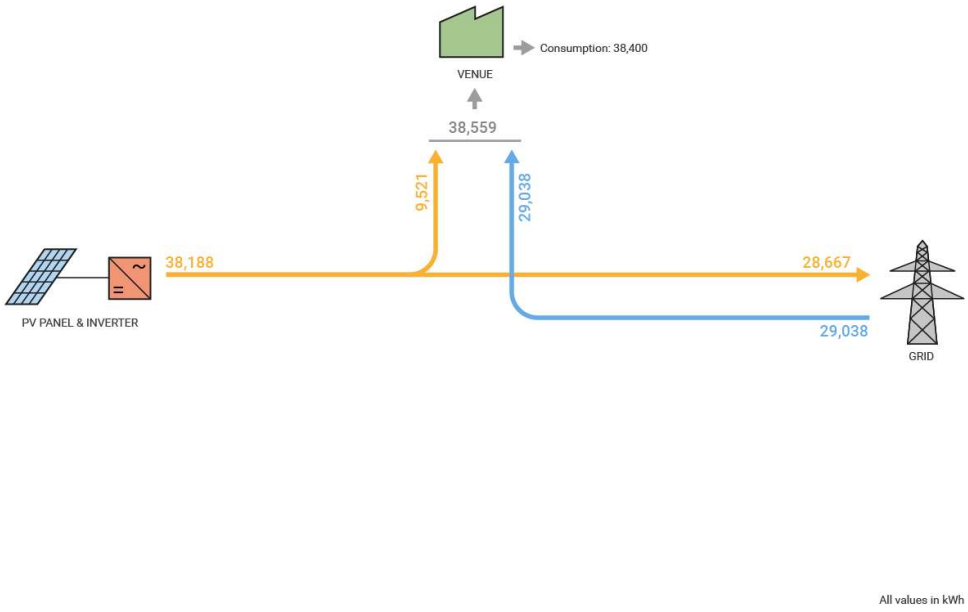


Figure 2: Scenario 1 Energy Flow Graph

Based on the above figures, a Smart Energy Guarantee 6p/kWh and an electricity tariff of 15.38p/kWh (and a standing charge of £140/year) the anticipated net annual energy cost would be around £2,900.

5.2 SCENARIO 2: WITH BATTERY STORAGE

Modelling output using PV*SOL:

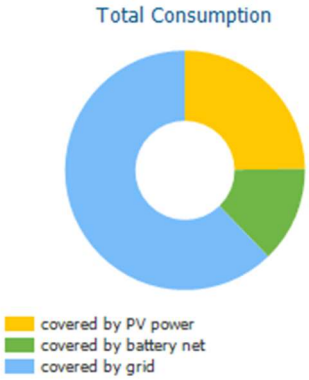


Figure 3: Scenario 2- Consumption Pie Chart

- Solar PV - annual electricity generation = 38,188kWh
- Consumption covered by PV power = 9,521kWh
- Consumption covered by the battery = 4,956kWh
- Electricity exported to grid = 22,964Wh
- Consumption covered by the Grid = 24,082kWh

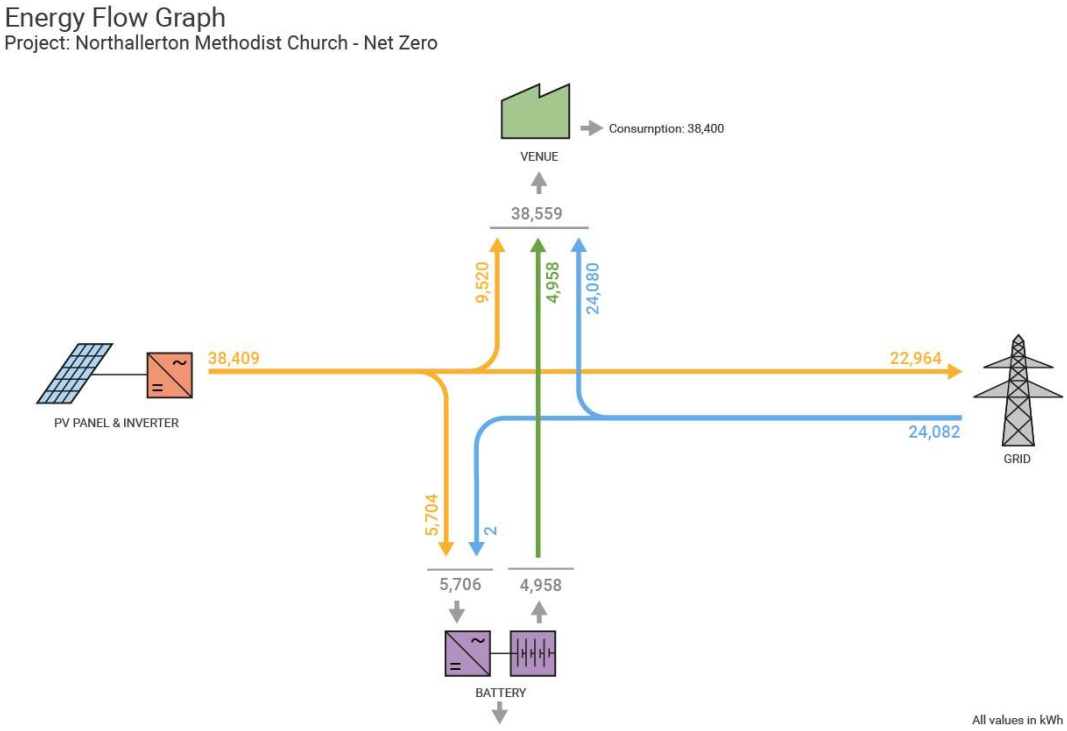


Figure 4: Scenario 2 Energy Flow Graph

Therefore, the addition of a battery reduces the amount of electricity imported by 4,956kWh and the anticipated net annual energy cost would be around £2,500.

6.0 PERMISSIONS

6.1 PLANNING PERMISSION

The planning requirements for a heat pump installation appear to vary between authority. An enquiry has been sent to Hambleton District Council to confirm their requirements, however, based on previous experience the following may be required:

- Location Plan
- Existing and Proposed Site Plan
- Existing and Proposed Floor Plan
- Existing and Proposed Elevations
- Heritage Statement
- Noise Impact Assessment

6.2 BUILDING CONTROL

The proposed project incorporating energy saving measures, new heat pump system and solar PV installation will require a Building Regulations application.

If either the new heat pump system or PV installation is installed separately, the installers, providing they are on the Competent Persons Register can self-certify.

It is anticipated the energy saving measures will not require a Building Regulations application as they are general improvements to the building to improve the thermal properties of the building fabric.

6.3 NORTHERN POWERGRID

Two applications will be required to submit to Northern Powergrid (NPG).

Firstly, a G99 for the solar PV installation. This required as the proposed installation size is above 3.68A per phase of the incoming electrical supply. This is usually submitted by the installer and requires approval prior from NPG to installation (takes up to 45 working days).

Secondly, for the heat pump installation. All commercial heat pump installations require prior approval by NPG which usually includes a load survey to determine the maximum demand at the premises.

7.0 SUMMARY TO NET ZERO

The adoption of the proposed energy saving measures, the installation of an ASHP system and solar PV arrays with battery storage will result in Northallerton Methodist Church being operational Net Zero, saving 17.8tonnesCO2e per year.

Total Budget Cost for all energy saving measures, heat pump and electric heating system and solar PV with battery storage is £291,000. This is a very high sum and the overall project can be split into phases, prioritising the areas of the church used the most.

The anticipated future annual energy cost for the church is hugely dependent on the electricity tariff for both import and export, therefore, it is worth shopping around for the best available tariff and SEG.

Timescale

The above measures are achievable within an 18 months to 2 years' timescale.

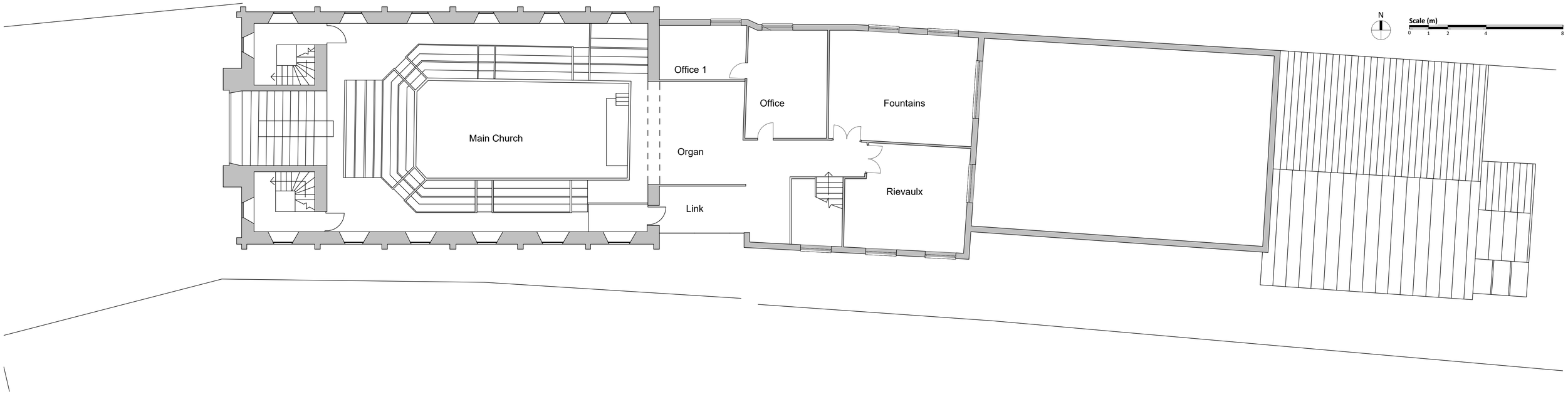
8.0 APPENDICES:

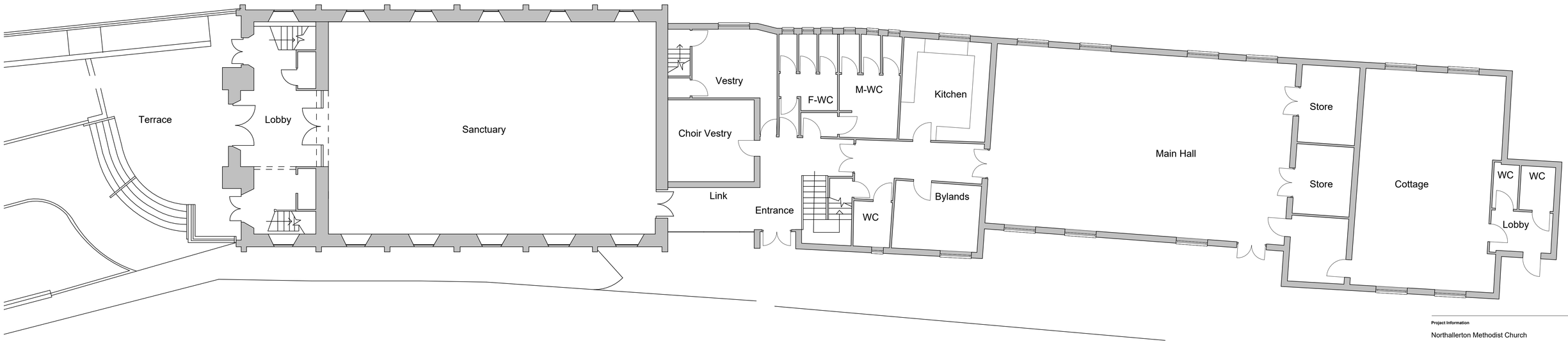
8.1 APPENDIX A – EXISTING FLOOR PLAN

- Responsibility is not accepted for errors made by others in scaling from this drawing. All construction information should be taken from figured dimensions only
- Report errors & omissions to d3-associates
- Check all dimensions on site

N

Scale (m)
0 1 2 4 8





Project Information

Northallerton Methodist Church

Northallerton Methodist Church

Drawing Information

Existing Plans

Project ID	Project No.
NOR	1747
Drawing No.	**Role**
0101	AS

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8.2 APPENDIX B – PROPOSED FLOOR PLAN

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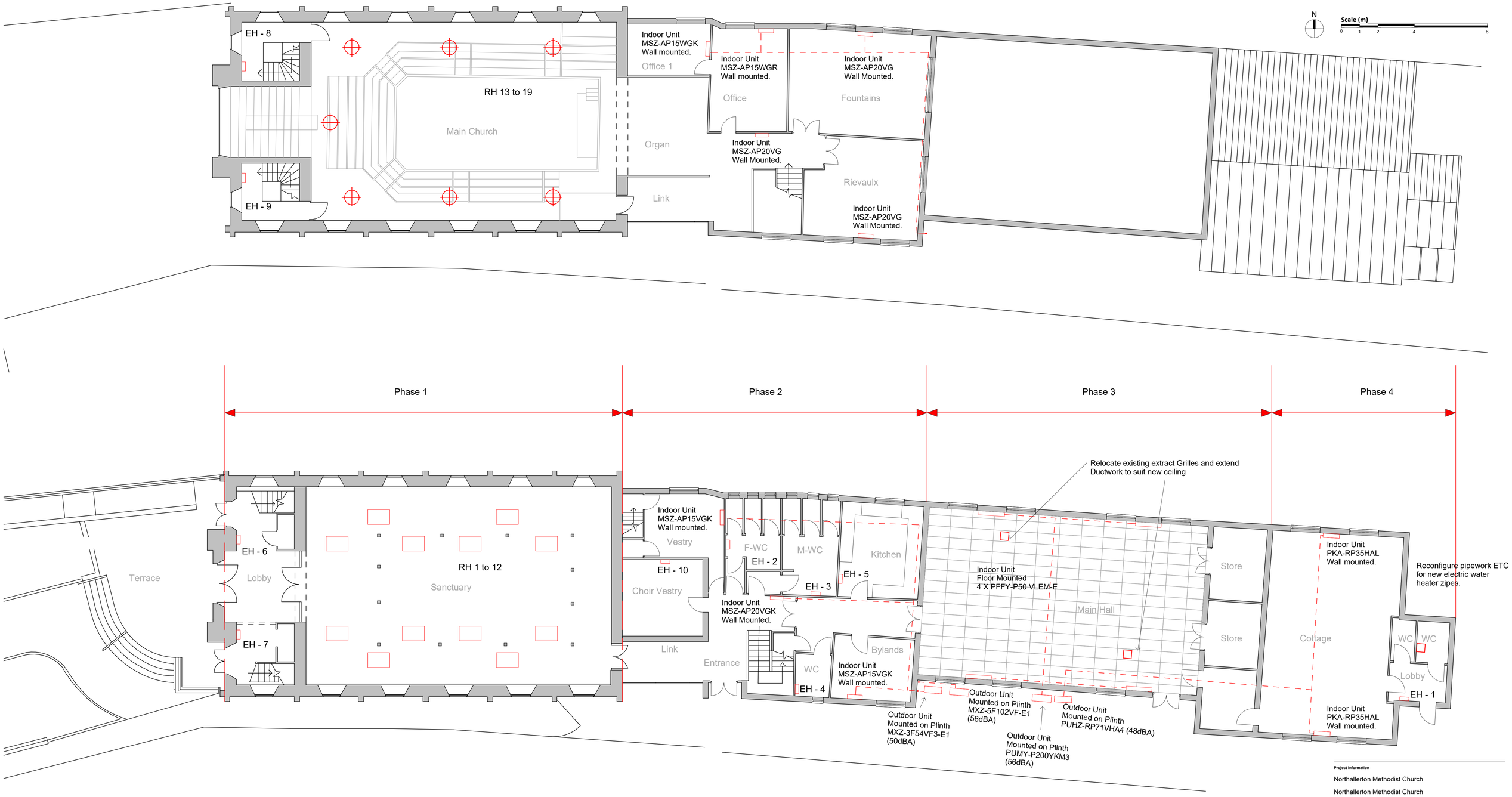

Legend
EH - Electric Heater
RH - Radiant Heater

Project Information

Northallerton Methodist Church

Northallerton Methodist Church

Drawing Information

Proposed Heat Pump Layout

Project ID	Project No.
NOR	1747
Drawing No.	**Role**
5601	AS

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