UCLH

National Hospital of Neurology and Neurosurgery

Stage 0 & 1 Feasibility of Generator & Substation Report

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1 Executive Summary

The P03 revision of this report has verified the options that were proposed in 2016. There has not been any work that would impact the Mains Infrastructure Proposal, or in areas that would impact the options proposed. As part of the ongoing engagement with UCLH the design team were kept up to date with other works but no suitable locations have become available in the interim. Therefore, the options reviewed and proposed in this report are still valid.

The design of the options has subsequently been developed in the interim period, details of which can be found in the design documents.

- **Mains Infrastructure Upgrade Strategy** – with reference to the Department of Health Technical Memorandum HTM 06-01: *Electrical services supply and distribution* indicates that electrical supplies in the healthcare sector are growing at a rate of between 3% and 6% year on year.

  Using the load record and a growth rate of 3%, and taking into account of the new development in NHNN, the electrical Engineering upgrade scheme proposes to upgrade the existing NHNN electrical infrastructure with 2 no. new twin substations.

  2 x 2000kVA transformers for new Chandler Wing new substation.

  2 x 1250kVA transformers for Albany Wing new substation.

- **Essential power** – Generator power supply shall be upgraded from 600kW Broadcrown generator to 1200kW new generator. Scheme includes new UKPN intake room, client owned 11kV switching station, new transformers, new LV switchboards, new generator, ventilation, sound attenuation, fuel pipe, exhaust flue, etc.

- **New 11kV Plantrooms** – New UKPN intake room and Client owed 11kV Switching Station shall be located in at the current Audio Visual Department in Albany Wing Basement. Further coordination work and confirmation with UKPN is required for the new 11kV intake room at basement.

- **New Substation Locations** – Arup has investigated agreed possible locations of the new Substations. It is recommended that the new Albany Wing substation would be located in the current Audio Visual Department and the new Chandler Wing substation would be located in the in the current Broadcrown generator room space.

- **Substation at Audio Visual Department** – Relocation of the AV department shall be agreed with all concerned parties by the Trust. A delivery hatch is required for the equipment replacement for every 25 – 30 years. The delivery hatch is likely to require planning permission (including possible Listed Building Consent) and pre-application advice.

- **Substation at Broadcrown generator room** – Agreement with UCLH that the proposed heavy duty delivery hatch can be located on the GOSH loading bay as a feasible scheme. It is requested UCLH and GOSH review the possibility that part of the loading bay be utilised for the delivery hatch for initial Transformer installation and future replacement if required (expected 25 – 30 years change interval).

- **New Generator Room Locations** – Arup has investigated all agreed possible locations of the new generator. It is recommended that the new generator would be located on the Chandler Wing roof.

- **Chandler Wing Roof Generator**– Planning approval will be required to install a generator container approximate 12m length x 3m width x 3m height and additional inlet penthouse would be on top of the container with approximate 3m length x 3m width x 4.5m height on top of Chandler Wing.

  The Generator container will overhang the roof and be close to the adjacent GOSH Southwood Building. It is requested UCLH and GOSH review the possibility of the generator container to overhang and install close to the GOSH.

- **HTM Derogations** – UCLH derogation acceptance required regarding reuse of underground fuel tank, fuel storage quantity of 136hrs fuel is less than 200 hours as required in clause 8.84 of HTM 06-01.

  N+1 Generator support, required in clause 6.8 & 6.13 of HTM 06-01, is provided as the measured (NHNN & QSH) maximum demand is 1108kW with two 1200kW generator. However the predicted essential load would be 1295kW following the theatre upgrade and QMW wards project completion, so N+1 Generator support is not fully provided from that point. A mobile generator plug at the generator switchboard is provided for future mobile generator connection to compensate for the N+1 generator requirement.

- **Design team comment** – Comments from Medical Architect and Roughton have been incorporated in this report. Details shall refer to Appendix K and Appendix L.

2 Introduction

This report has been produced to verify the feasibility for the upgrade of the existing electrical engineering services infrastructure at the National Hospital for Neurosurgery and Neurology UCLH estate at Queen Square, London.

- 2 no. new 11kV/400V substations
- 1 no. new LV generator – as a replacement and upgrade to the existing Broadcrown generator

2.1 Substations Commentary

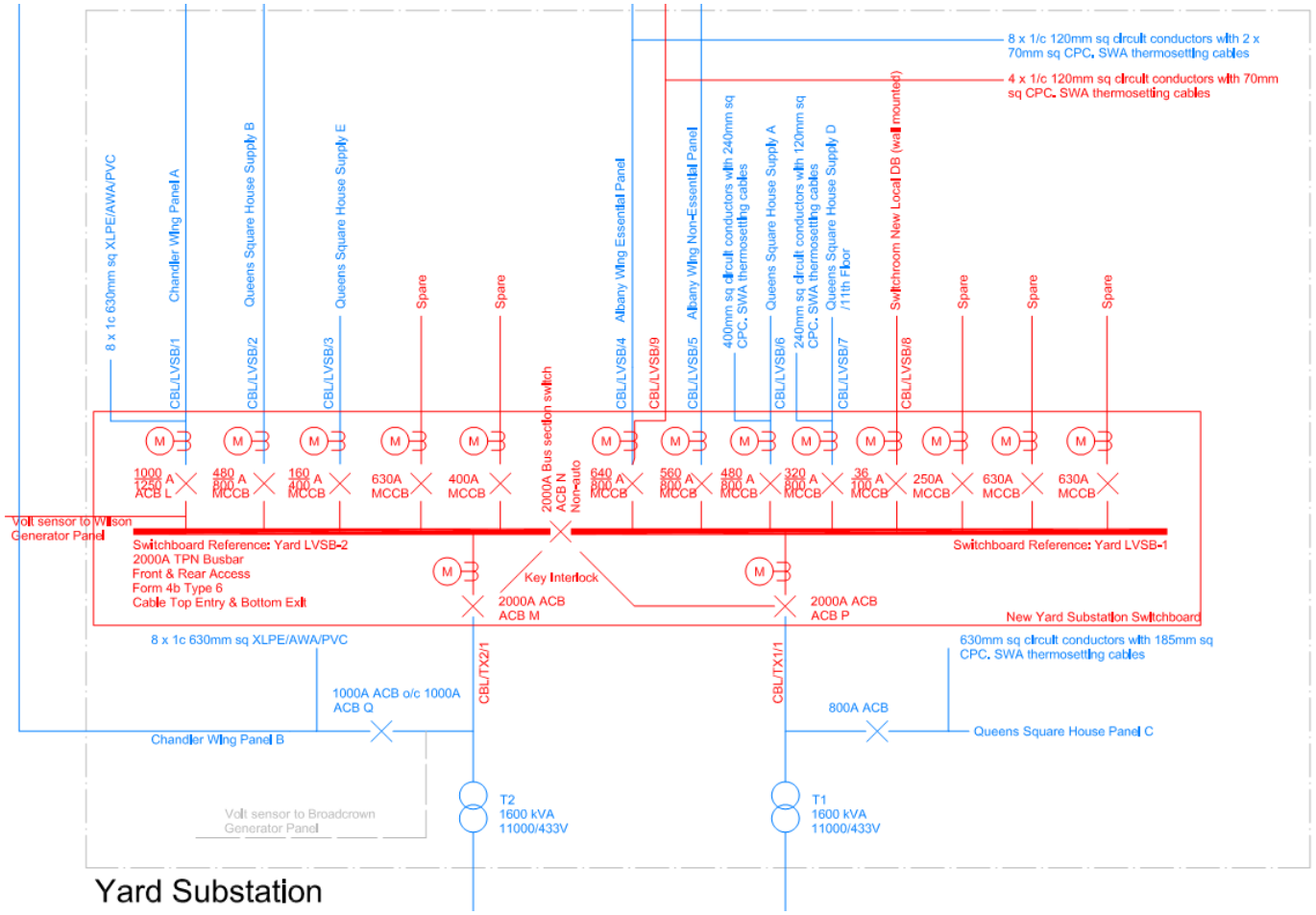


Figure 1 Latest LV distribution set up in NHNN

The existing Yard substation switchgear is being upgraded by a new 2000A switchboard. The new 2000A switchboard is programmed to be installed in the first quarter of 2017. Figure 1 shows the future arrangement after the Yard substation switchboard (in red) has been installed.

The existing transformers (in blue) have long since lost their 100% redundancy as the measured max demand (NHNN & QSH) is approximately 2.2MVA, and is predicted to increase to 2. 6MVA with the Additional Theatre load and QMW ward loads added.

Moreover, the ACB 'Q' supplying to Chandler Wing panel B is only 1000A, which is not capable of supporting the whole Chandler Wing supply in the case of panel 'A' failure given the measured Chandler Wing max demand is 1062A (approximately 1300A after completion of Chandler Wing theatre Upgrade). This arrangement is a deviation from the HTM requirements, that generally requires a dual transformer and generator arrangement for supplying critical patient environments such as operating theatres.

It is our recommendation that the following electrical Switchgears are upgraded as part of the refresh and replacement (R&R) programme, given the service age of the switchgears exceeding the CIBSE guide M (25 years), and is generally obsolete, in poor condition and lack of spare ways and capacity.

- Yard LV Switchpanel – Constructed in 1990
- Albany Basement (Essential) Switchboard Installed – Constructed in 1990
- Albany Basement (Non-Essential) Switchboard – Constructed in 1990
- QMW Basement Non-Essential Switchgear arrangement – Age not clear - estimated as 1980's.

In addition to the switchgears above, the following R&R should also be considered

- Chandler Wing A & B Switchboards constructed in 1993, so will exceed service life in 2018.

Building new substations will provide opportunity for electrical load demand growth over the next 25 years.

Therefore, given the requirement for new substations and LV distribution shall be replaced by larger capacity substations for future proofing. In the following sections, different options for the new substations will be discussed.

i. Broadcrown Generator room
ii. Chandler Wing Roof
iii. Void adjacent to Spice of Life Café
iv. Audio Visual Department

2.2 Broadcrown Replacement Generator Commentary

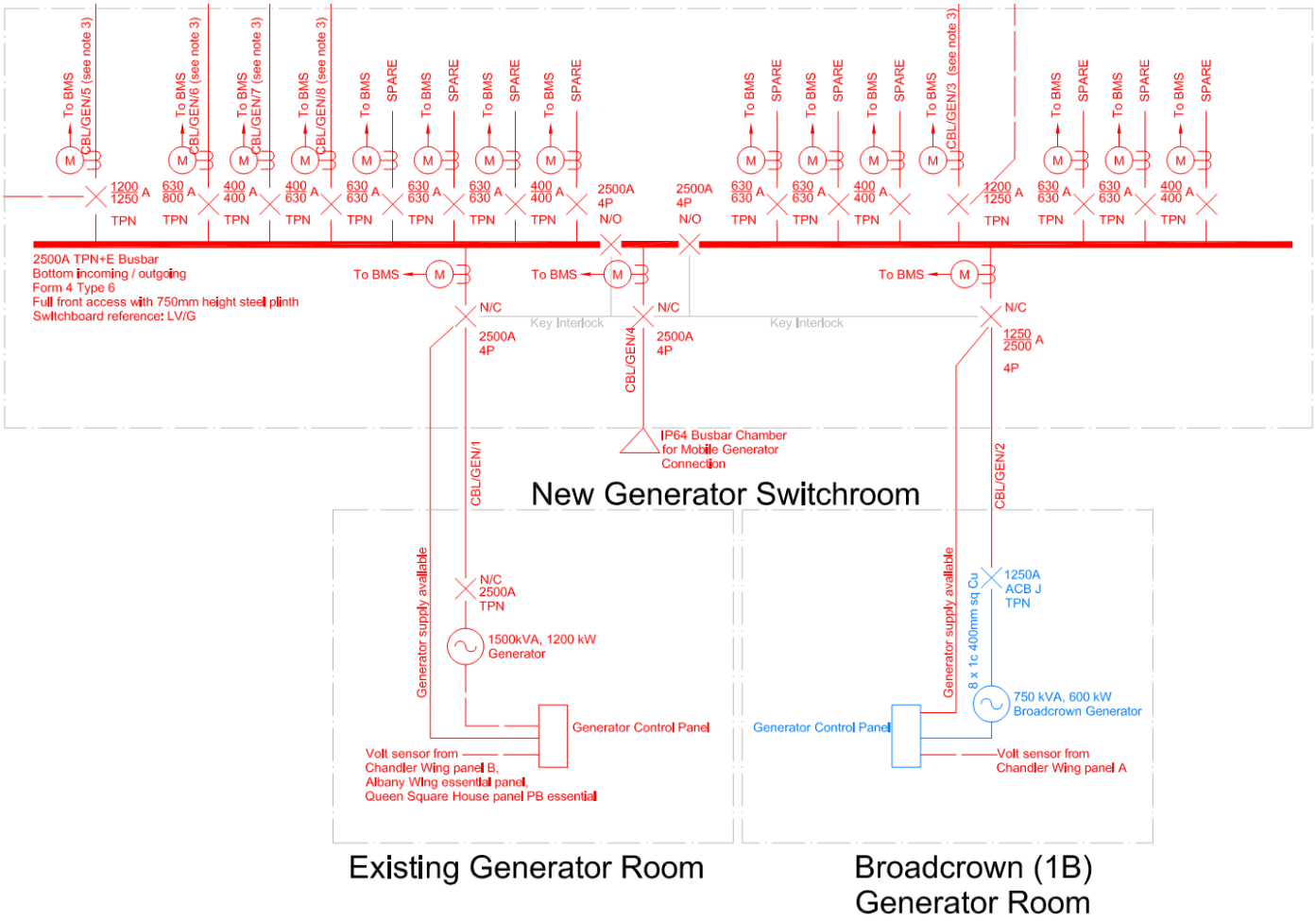


Figure 2 Latest generator power distribution setup in NHNN

The existing FG Wilson generator is being upgraded to a new 1500kVA/1200kW generator and the programme outlines the new generator switchboard will be installed by first quarter of 2017.

Figure 2 shows the future schematic arrangement setup after the new FG Wilson replacement generator and generator switchboard (in red) have been installed.

Considering the existing Broadcrown generator (in blue) has been installed since 1992 and is approaching the 25 design service life expectancy suggested by CIBSE part M guide. The existing Broadcrown generator shall be replaced by a larger capacity generator for future proofing.

In the following sections, different options for the new generator location will be discussed.

i. Broadcrown Generator room
ii. Chandler Wing Roof
iii. Void adjacent to Spice of Life Café
iv. RLHIM Generator (Building Above)
v. 33 Queen Square

During the generator replacement, a temporary generator is not required for suggested locations ii – v (as shown above) given the existing Broadcrown generator will continue to backup the Chandler Wing panel A until the new generator is being installed. However, if the new generator is to be located in the existing Broadcrown generator room, the trust will need to hire a temporary generator and connect to the mobile generator connection in the new generator switchboard during the entire generator replacement period.

3 NHNN Electrical Maximum Demand

3.1 Existing Substation Capacity

The existing Yard Substation of the NHNN is located in front of the loading / unloading bay of Great Ormond Street Hospital at Guilford Street, and there are two existing 1600kVA transformers. Currently the Yard Substation LV switchboard is supplying the whole building, which includes

- Queen Square House (A, B, C, D, E) Switchboards.
- Chandler Wing (A, B) Switchboards.
- Albany Basement (Essential) Switchboard.
- Albany Basement (Non-Essential) Switchboard.

With reference to the load measurement carried out during July 2016 and including the future additional load after Chandler Wing theatre and QMW ward redevelopment completion, TX1 has a worst case load of 1284.93 kW and 1352.56 kVA at power factor of 0.95, TX2 has a worst case load of 1186.58 kW and 1249.03 kVA at power factor of 0.95. Details refer to tables below.

Equipment	Maximum I1 (amps)	Maximum I2 (amps)	Maximum I3 (amps)	Maximum kW
Queen Square House Panel C	208.60	203.30	192.10	139.10
QMW Redevelopment (Ess. LTG+SP)	38.6	38.6	38.6	25.50
QMW Redevelopment (Non-Ess. Chiller)	111	111	111	58.00
MP07 TX1 ACB 'P'	1606.50	1530.48	1481.86	1062.33
TX1 Total	**1964.70**	**1883.38**	**1823.56**	**1284.93**

Table 1 TX1 load worst case

Equipment	Maximum I1 (amps)	Maximum I2 (amps)	Maximum I3 (amps)	Maximum kW
Chandler Wing Panel B	426.50	485.90	460.10	304.60
Chandler Wing (A) Theatre Upgrade	10.5	10.5	10.5	7.25
Chandler Wing (B) Theatre Upgrade	222.5	222.5	222.5	153.53
Queen Square House Panel B	418.20	331.40	319.30	245.85
TX2 ACB 'M'	698.80	713.34	654.64	475.36
TX2 Total:	**1776.50**	**1763.64**	**1667.04**	**1186.58**

Table 2 TX2 load worst case

The original design capacity of the Yard Substation is a total of 1600kVA, although there are two supplies there both capable of 1600kVA. This is reflected by the current UKPN supply of 1600kVA, though this is being exceeded.

It is assumed that the original design expected TX1 and TX2 to be run 800kVA and 800kVA respectively and for the loss of either feeder the remaining one supports all of the load, as a dual redundant arrangement. This is also the requirement as per HTM06-01 part A given the critical loads supplied. Therefore, new substations shall be built in order to design a HTM compliance electrical infrastructure.

3.2 Proposed Substation Capacity

Reference to the Department of Health Technical Memorandum HTM 06-01: *Electrical services supply and distribution* indicates that electrical supplies in the healthcare sector are growing at a rate of between 3% and 6% year on year.

Using the load record and a growth rate of 3%, and taking into account of the newly development in NHNN, the forecasted load over next 25 years on Chandler Wing is **1757 kW** (**1849 kVA** @ p.f.0.95) and **1124 kW** (**1184 kVA** @ p.f 0.95) for Albany Wing / Queen Mary Wing.

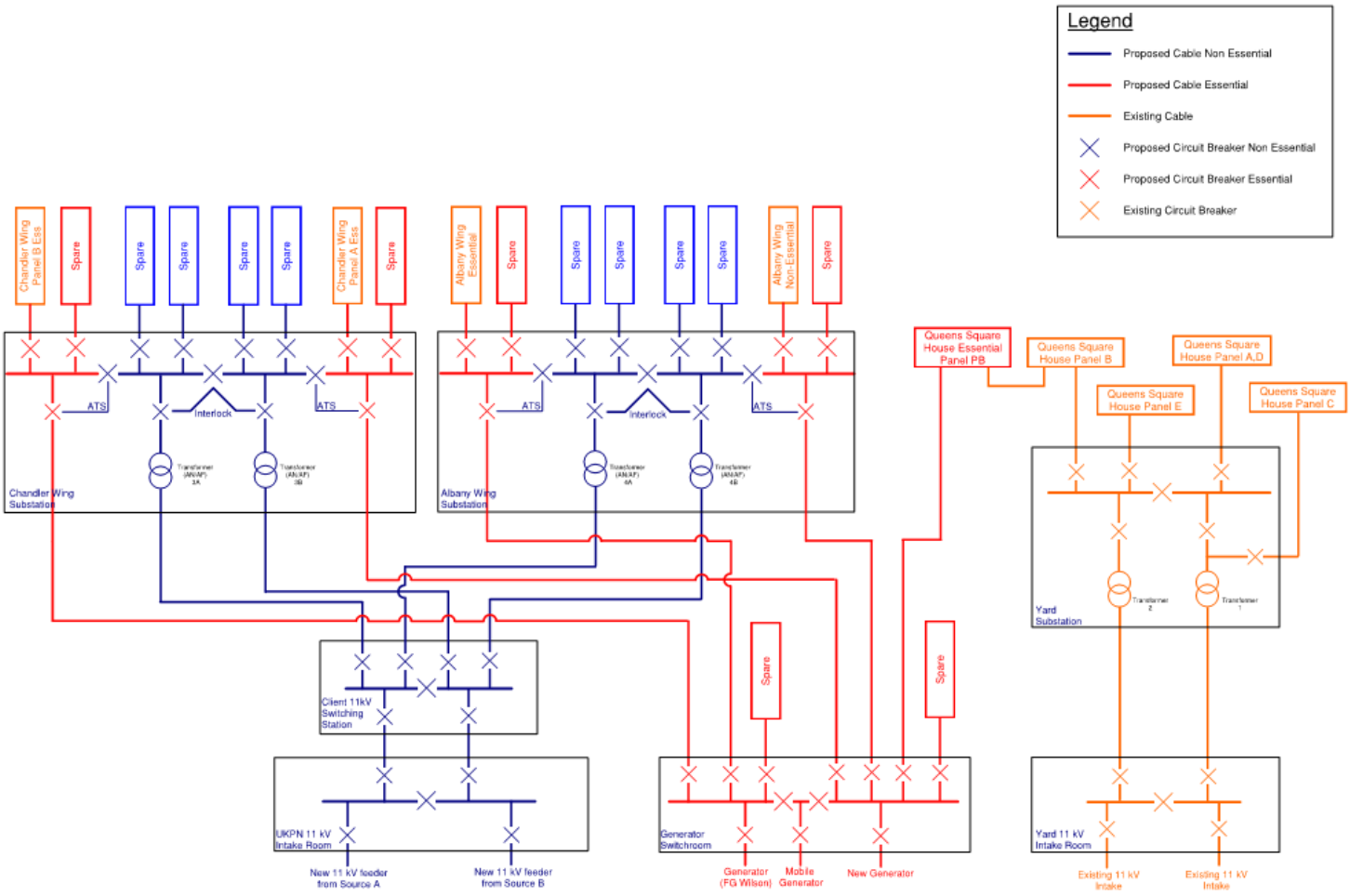
Two new substations shall be proposed to fulfil the increasing demand in the next 25 years and the N+1 transformers arrangement. Twin transformers would be required for both Chandler Wing and Albany Wing. The setup of each substation would be:

- Substation 1: 2 x 1250 kVA transformers to supply Albany Wing / Queen Mary Wing
- Substation 2: 2 x 2000 kVA transformers to supply Chandler Wing

The forecast of the growth of the electrical demand on the site is outlined in Appendix B in line with the growth outlined, Arup are currently in negotiation with UKPN for a dual supply rated at 3.2MVA. Though this needs some further clarification, it seems this may be available from Q4 2018 from the planned new primary substation at **Calshott Street**. Costs will be in the region of £3 million we understand, but this subject to formal quotation.

4 New Substation Design

A proposal for the new electrical configuration is outlined below (also larger version included in Appendix C)



4.1 UKPN 11kV Intake Room

It is proposed the original UKPN supply to the Guildford street yard is left untouched during the substation upgrade.

The preferred proposal is to obtain 2 no. new UKPN 11kV incoming feeders with diverse routes and preferably independent upstream source shall be required for two new substations. A UKPN intake rom is proposed in the Albany Wing Basement (existing Audio Visual Department). Figure 3 shows a UKPN intake room (4602mmW x 5065mmD) arrangement from another project for reference. The proposed UKPN intake room location refers to Figure 4. The exact dimension and exact requirement shall be developed in later detail design stage.

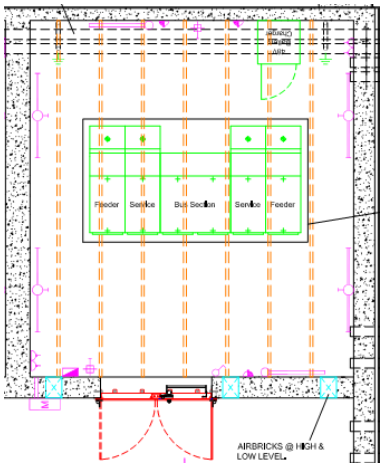


Figure 3 Typical UKPN Intake Room

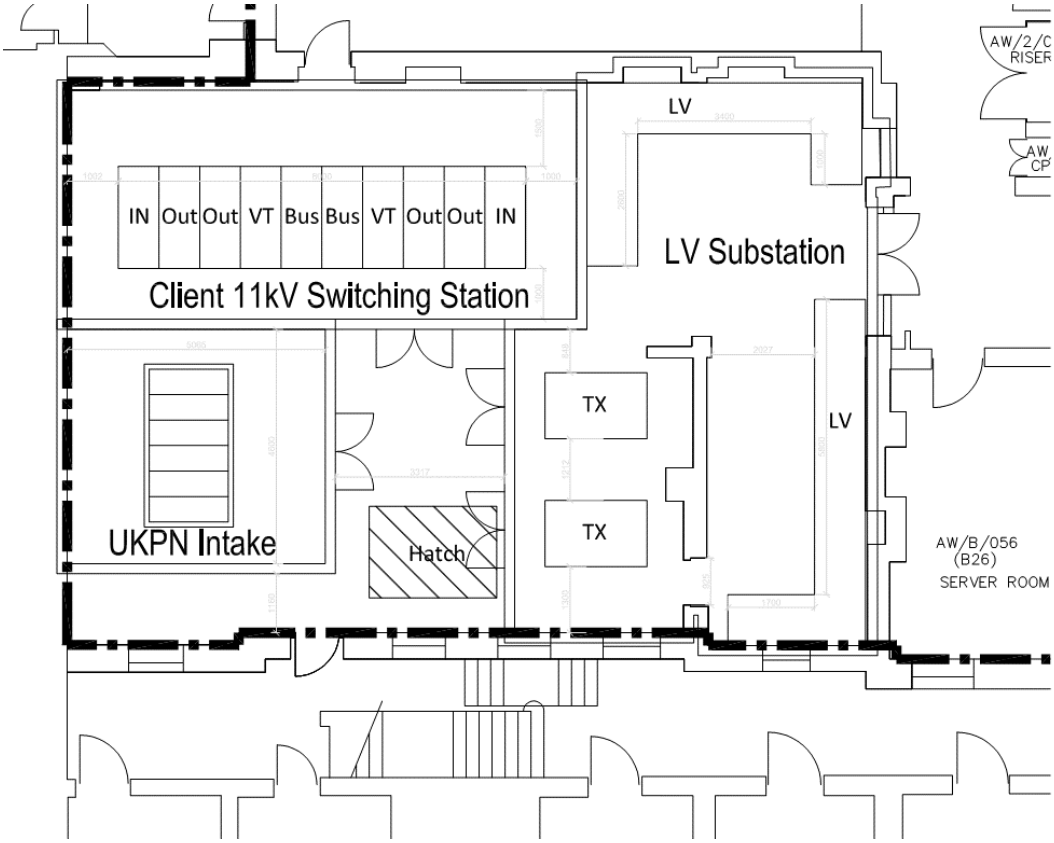


Figure 4 Proposed location for UKPN intake room and Client Owned 11kV Switching Station

For UKPN approval on the basement intake room scheme, 24 hours access shall be provided to the UKPN Intake Room. Delivery hatch (2500mm x 1800mm) is allowed in the common access area for equipment delivery / replacement.

Further coordination work with UKPN would be required.

4.2 Client Owned 11kV Switching Station

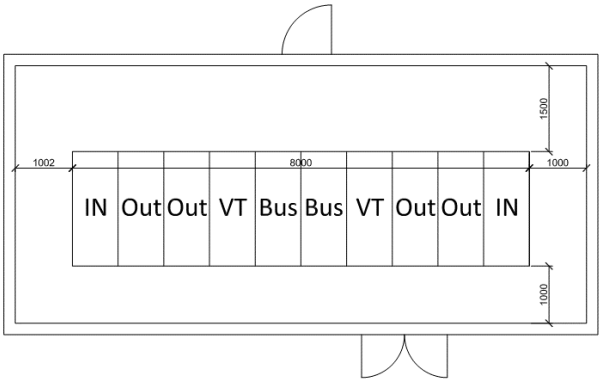


Figure 5 Client Owned 11kV Switching Station Layout

Note: IN: Incoming feeder, Out: Outgoing feeder, Bus: Bus section, VT: Voltage transformer

Client Owner 11kV Switching station is proposed to give the client possession of 11kV switching ability in case of maintenance, failure and protection. The 11kV supply to transformer can be adjusted by the Client when necessary. Also, the HV circuit breakers shall be provided with shunt trip coil to accept the transformer restricted earth fault inter trip signal from the relay mounted at the LV incomers.

4.3 11kV Distribution

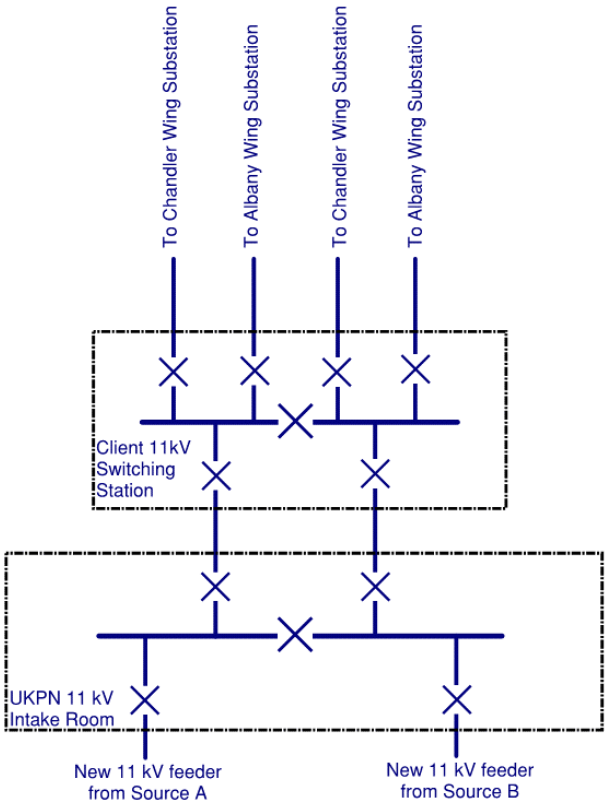


Figure 6 HV Schematic

The schematic diagram Figure 6 gives an outline of the upgrade arrangement proposed for the substation developments. A new UKPN 11kV Intake Substation is outlined for the NHNN. A client owned 11kV switching station would distribute the UKPN 11kV feeders to the new substations. Each of the 11kV feeder can take up the entire substation diversified load in case one of the 11kV feeders is isolated or fails providing dual redundancy on the mains network.

4.4 Transformers

Eco Design Cast Resin Transformer with IP31 metal enclosure (AN/AF) is proposed for all the new substations. 2 no. 1.25MVA transformers (TX4A & TX4B for Albany Wing) and 2 no. 2MVA transformers (TX3A & TX3B for Chandler Wing) supplied from the client owned switching substation at Albany Wing Basement. The transformers shall be located in different rooms separated by wire mesh in the package substation in order to minimise access to the 11kV switching areas.

Each transformer will supply the corresponding A&B LV switchboards located adjacent to the transformer. In the event of a transformer failure or other supply failure to a single transformer, the remaining transformer will supply the full diversified switchboard load.

The transformers shall be fitted with restricted earth fault protection and high temperature alarms.

The electrical substations shall be fitted with emergency push buttons with a safety cover that will isolate the upstream Utility supply if operated.

Transformers will be close coupled to the LV panels (commonly termed packaged substations). This is adopted as a space saving measure. Additional cage separation will be provide in the switchroom to ensure 11kV equipment is not accessible to non 11kV authorised persons in the room.

The switching arrangements necessary to ensure a secure and resilient system will be incorporated within the design. Single points of failure will be avoided wherever possible.

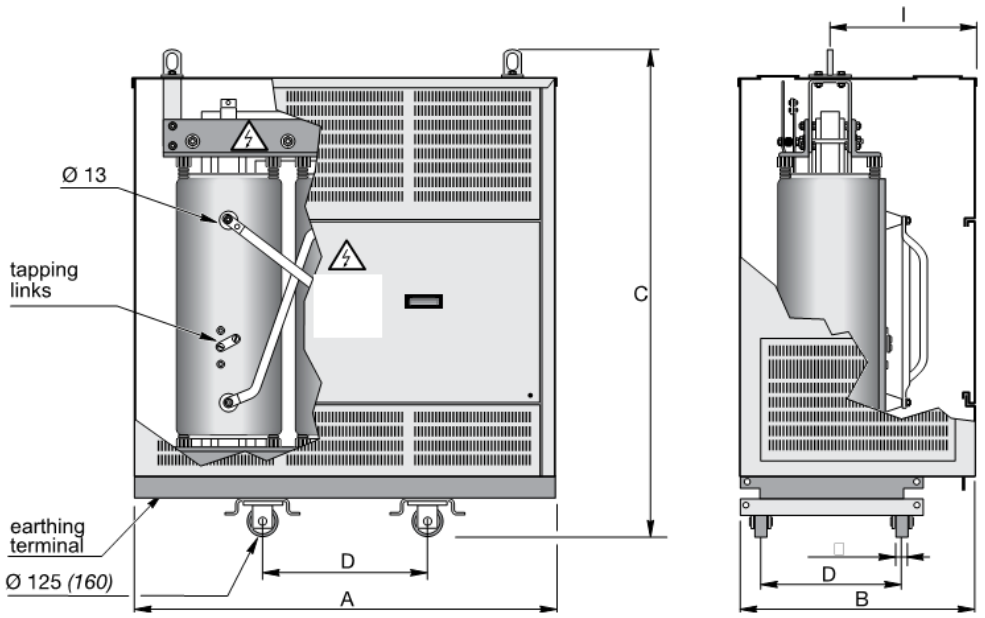


Figure 7 Cast Resin Transformer

Rated Power (kVA)	Length (A) mm	Width (B) mm	Height (C) mm
1250	2150	1170	2480
2000	2180	1230	2620

Table 3 Transformer Dimension

4.5 LV Switchboards

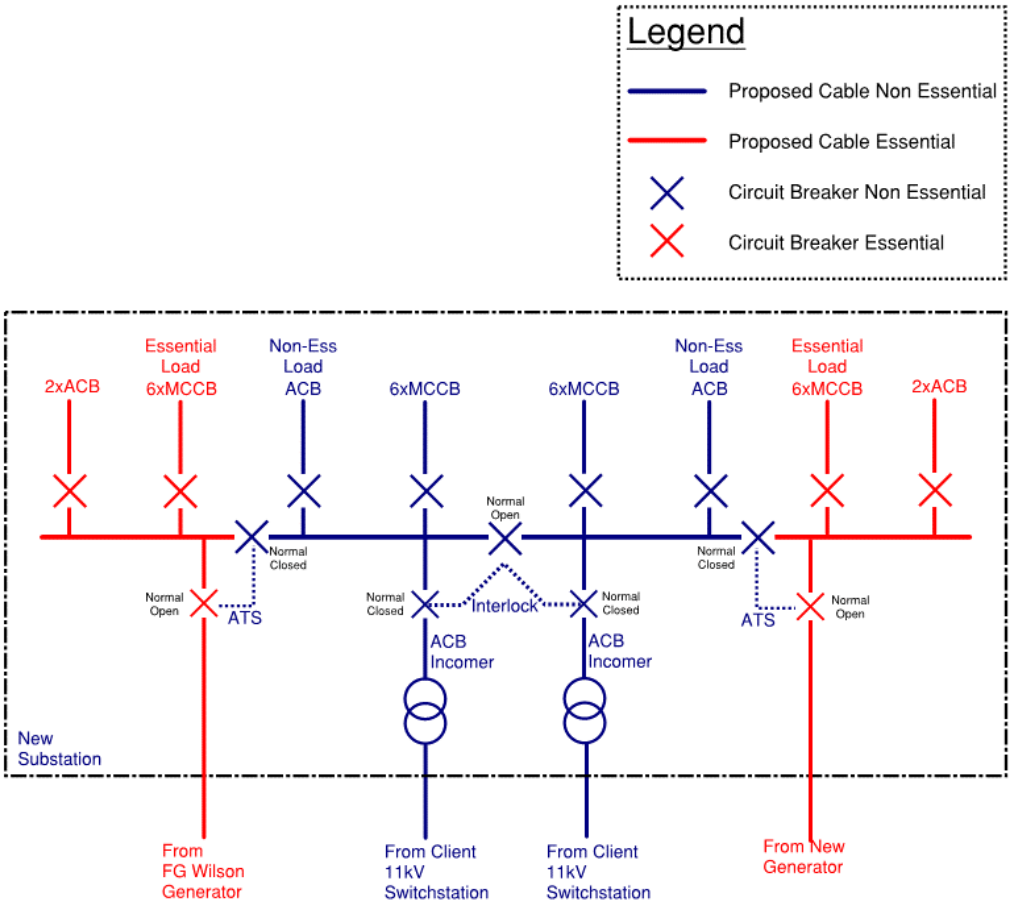


Figure 8 Typical Switchboard Schematic
(quantity of breaker is subjected to detail design)

Figure 8 indicates the proposed typical LV substation design. Each main LV switchboard of a transformer will be split into essential and non- essential section. The essential section of each main LV switchboard will be fed by a LV generator via a generator LV switchboard as detailed in the overall HV/LV schematic.

- Chandler Wing will be fed via two main LV switchboards located in a packaged substation.
- Albany Wing will be fed via two main LV switchboards in another substation.

The switchboard shall be type tested to BS EN 61439-2, have Form 4 Type 6 separation, floor standing rear access or front access cubicle type and will consist of Air circuit breakers (ACB) on the incoming supplies and moulded case circuit breakers (MCCB) on the outgoing ways. The switchboard shall be designed for top entry and outgoing cabling. Exact quantity and design of the LV switchboard will be developed in detail design stage.

The main switchboard electrically will be in two halves linked by a bus section with each side fed independently from the mains via associated transformers. The

transformer supplies shall be electrically and mechanically interlocked to prevent parallel operation and switching to the healthy supply will be automatic. The incoming supplies will be provided with surge suppressers to protect against transient overvoltages. The switchboard shall have a fully sized neutral busbar with the earth bar sized at a minimum of 50% of the main phase busbars. When both incomer are failure, the ATS at the switchboard essential section will change to generator supply automatically.

Busbars and bus couplers should be fully rated. All outgoing ways will have digital metering in accordance with Part L2A of the Building Regulations linked to Building Management System.

Typical switchgears size are applied to estimate the size of LV switchboards. According to the schematic, the following dimensions are obtained:

Size of the LV switchboard for a transformer:

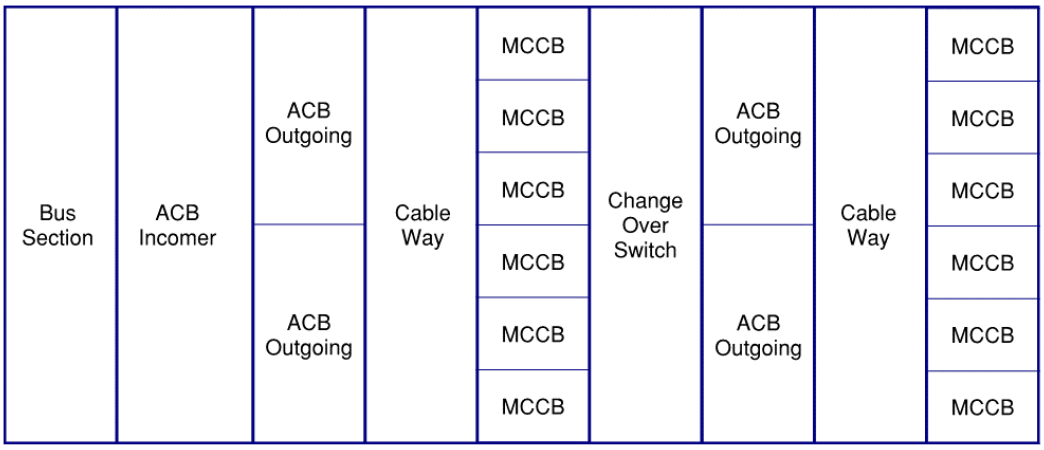


Figure 9 Typical Front Access LV Switchboard General Arrangement
(quantity of breaker is subjected to detail design)

The maximum physical dimension of the LV switchboards allowed in the proposed substation shall be:

Height: 2300mm

Depth: 800mm (Front access) / 1000mm (Rear access)

Length: 7500mm (Front access) / 6000mm (Rear access)

The proposed Overall HV/LV schematic of the NHNN shall refer to the Appendix C.

4.6 Earthing System

The existing earthing system in the Yard substation shall be used for the Albany Wing and Chandler Wing new substations.

The exact earthing requirement of the UKPN intake room shall be detailed in the next stage. New earth mat or earth rod may be required for the new UKPN room and substations.

4.7 Fire Suppression

It is proposed at part of the scheme a new fire suppression system is provided in the new substations.

This will consist of a water mist or gas suppression system as agreed in detail design stage. The system will incorporate a control panel, storage tanks, sensing and interfaces as required.

4.8 Ventilation

It is proposed that cooling shall be provided in the new substation. This will consist of chilled water or refrigerant as agreed in detail design stage.

5 New Substation Location

The locations listed below were agreed with the UCLH Trust as suitable location for further investigation for possible Substation placing.

Option 1. Broadcrown generator room space

Option 2. Void adjacent to the Spice of Life Café

Option 3. Audio Visual Department

Option 4. Chandler Wing Roof

The following sections will discuss in detail the cable distribution route, delivery & replacement route, switch room design and pros & cons of each option. All the plantroom location and distribution drawings are stated in Appendix G and Appendix E.

5.1 Broadcrown Generator Room

A new substation is proposed in the existing Broadcrown generator room in Chandler Wing Basement as shown on the figure below. The clear headroom would be 4.2m which is sufficient for substation installation. This substation would be supplied by the Client Owned 11kV Switching Station as mentioned in Section 4.2.

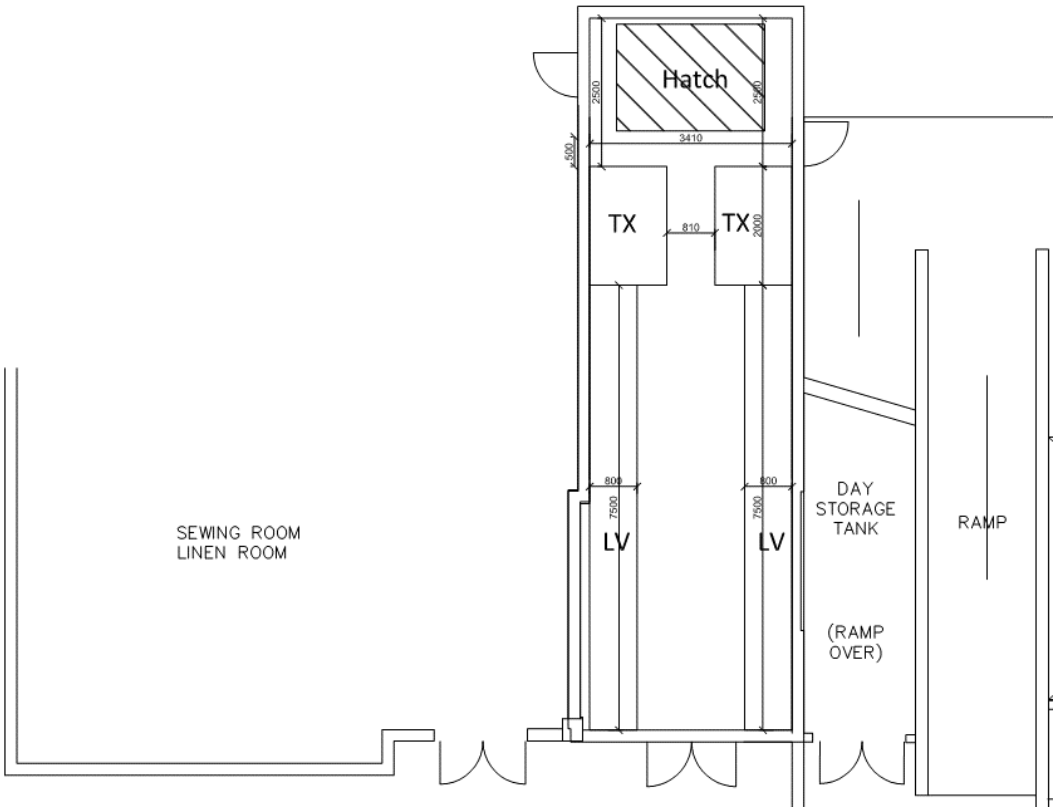


Figure 10 Substation Layout in Broadcrown Generator Room

Switch Room Design - Transformers and LV switchboards are proposed to place against the wall. LV switchboards shall be full front access and top exit/entry.

Distribution Route – The substation to be located in existing Broadcrown generation room will be solely to serve for Chandler Wing. Albany Wing will be supplied from another substation in order to optimize the cable length. The cable run to the Chandler Wing Switchroom would be approximately 40m.

Maintenance access – Primary access to substation by the double leave door at the substation front. A secondary door shall be provided as per HTM 06-01 Part A requirement. The second door is suggested to open to sewing / linen room or the access ramp and will only be used in case of emergency. Detail arrangement of the secondary access door shall be verify in detail design stage.

Delivery & Replacement Route – A heavy duty access hatch shall be allowed at the loading bay on ground level. Mobile crane shall be parked in the Yard loading bay area and transformers shall be delivered through hatch located in the switch room. Details of the heavy duty access hatch shall refer to Appendix D.

5.1.1 Pros

- Shortest distance to the Chandler Wing Switchroom
- Fit into unused space, following Broadcrown generator upgrade
- Proposal will most likely not require any planning permission
- Not major changes are expected on the basement slab.

5.1.2 Cons

- Secondary exit will affect GOSH sewing / linen room or the delivery ramp.
- New heavy duty delivery hatch is required which will affect the GOSH loading bay, during construction.
- 11kV cable route from the Client HV substation to new substation is relatively long.
- Coordination with GOSH is required.
- Structural assessment shall be carried out for the access hatch.

5.2 Void adjacent to the Spice of Life Café

A new substation is proposed in the light well next to the 'Spice of Life' restaurant in the basement area between Albany Wing and Chandler Wing. It is proposed to be a double storey substation as shown on the figure below. The clear headroom would be subjected to our design which is approximate 7.5 meter height. A minimum 3.5m clear height for each level is required for substation.

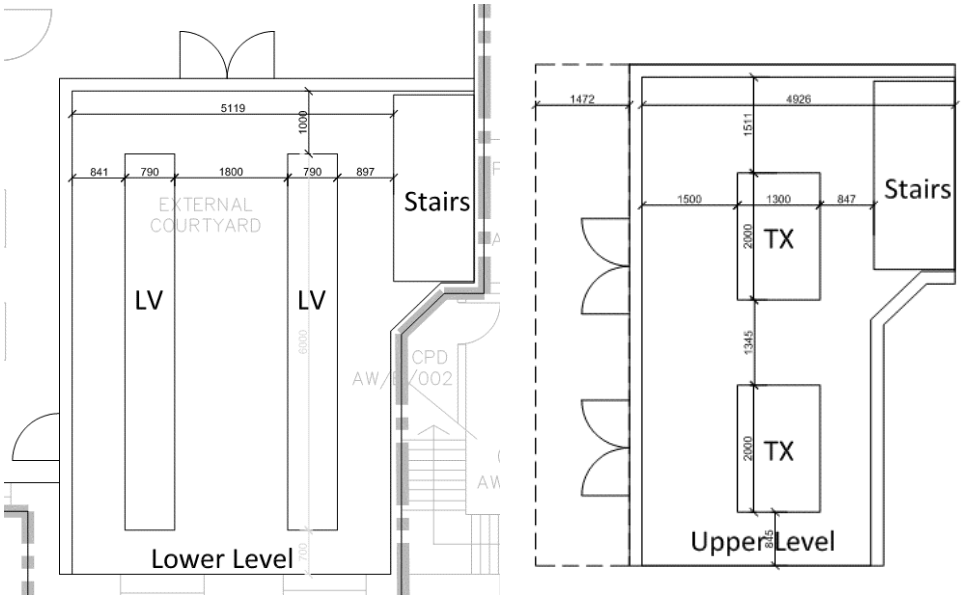


Figure 11 Substation Layout in Void adjacent to the Spice of Life Café

Switch Room Layout – Transformers are proposed to be located at the upper level, LV switchboards shall be placed at the lower level. LV switchboard shall be front & rear access and top exit/entry. A staircase shall be provided for access to the upper level.

Distribution Route – It is proposed that the Void adjacent to the Spice of Life Café substation could provide supply for either Albany Wing or Chandler Wing. The

main cable will run across Chandler corridor or Albany Wing corridor and rooms along the distribution route. The cable run for Chandler Wing switchroom and Albany Wing switchroom would be approximate 50m and 30m respectively.

Maintenance access – Primary and secondary access can be provided to the substation by the double leafs door and a single leaf door at the substation lower level. Internal stairs shall be provided to connect lower floor and upper floor.

Delivery & Replacement Route – Mobile crane is required to deliver / replace the transformer. Mobile crane shall be parked at the Queen Square.

5.2.1 Pros

- Future extension for switchboards may be possible.
- Located in centre of the building which would be easier for cabling in future.
- Short LV cable run from Substation to Albany Wing Switchroom
- Fit into unused space.
- Coordination with GOSH is not required.
- Not major changes are expected on the basement slab.

5.2.2 Cons

- Substantial builder's work involved, in a confined location.
- The overall height of the substation would be approximate 7.5m height. Severe visual implication to the café outdoor area.
- Reduce all natural light for neighbouring rooms to almost 0 and would significantly reduce the visual quality of the light well.
- Substation installation may block some of the Albany Wing windows.
- Lengthy negotiations with Camden Council as the substation would be placed against the grade II Albany Wing listed building.
- Likely require planning permission and pre-application advice.

5.3 Audio Visual Department

A new substation is proposed at the Audio Visual Department in Albany Wing Basement as shown on the figure below. The headroom in the studio area is 3.2 metres. It is assumed same headroom applies to the whole department.

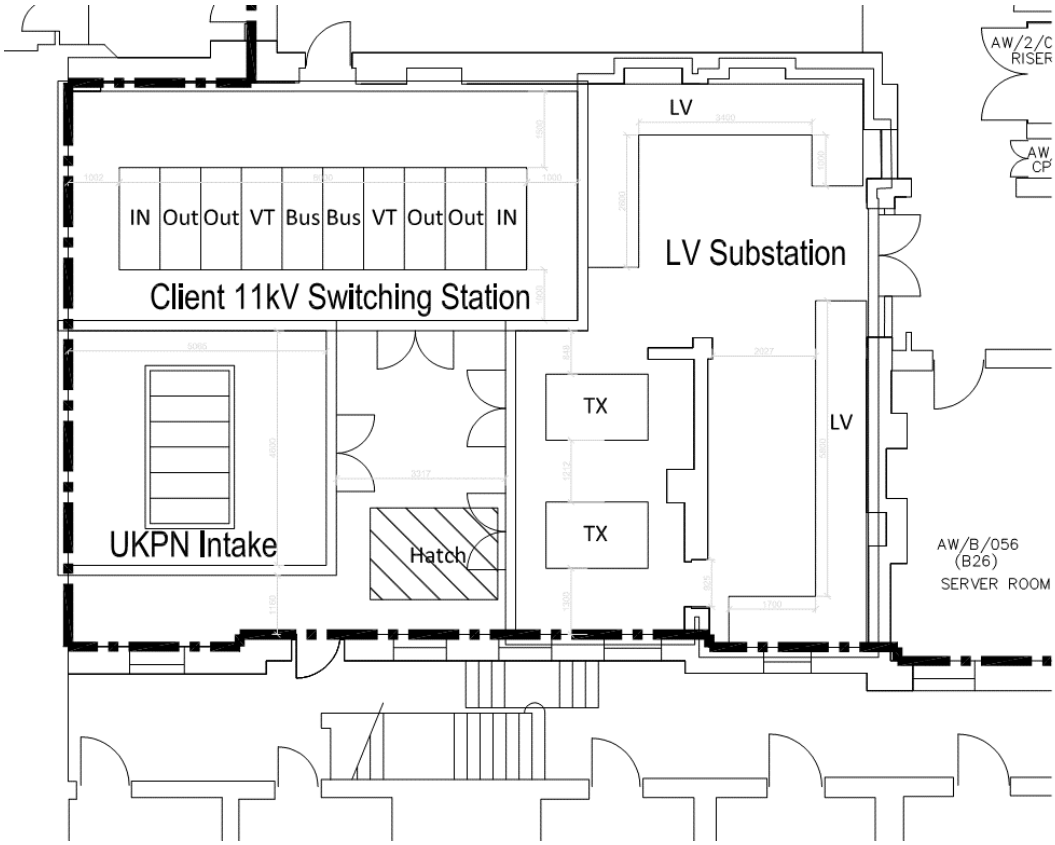


Figure 12 Substation Layout in Audio Visual Department

Switch Room Layout – The new substation would be located next to the new UKPN Intake room and Client HV Switching Station. LV switchboard shall be front access and top exit/entry.

Distribution Route – It is proposed only Albany Wing shall be supplied from this Audio Visual Department substation. Chandler Wing panels shall be supplied from the other substation to reduce cable length. The cable run to the Albany Wing switchroom would be approximate 35m.

Maintenance access – Primary and secondary access can be provided to the substation by the two double leafs door at the substation. 24 access would be provided to the UKPN intake room, Client 11kV Switching Station and LV Substation.

Delivery & Replacement Route – A hatch is proposed next to the ground level walkway area of Audio Visual Studio Substation roof which seems to be non-original from Albany Wing. Mobile crane shall be parked on Queen Square road to deliver the transformers or any other equipment into the switchroom.

Figure 13 Proposed access hatch location at the existing roof walkway

5.3.1 Pros

- Existing Hatch could be enlarged and used for delivery and replacement.
- Location close to UKPN intake, shortest 11kV cable length.
- Short LV cable run from Substation to Albany Wing Switchroom
- No visual implication to the development.
- Coordination with GOSH is not required.
- Not major changes are expected on the basement slab.

5.3.2 Cons

- Builders work is required for the hatch and partition wall.
- Entire Audio Visual department shall be moved and liaise with UCL would be required.
- Most likely require planning permission (including possible Listed Building Consent) and pre-application advice.
- Structural assessment shall be carried out for the access hatch.

5.4 Chandler Wing Roof

A new substation is proposed at the Chandler Wing Roof as shown on the figure below.

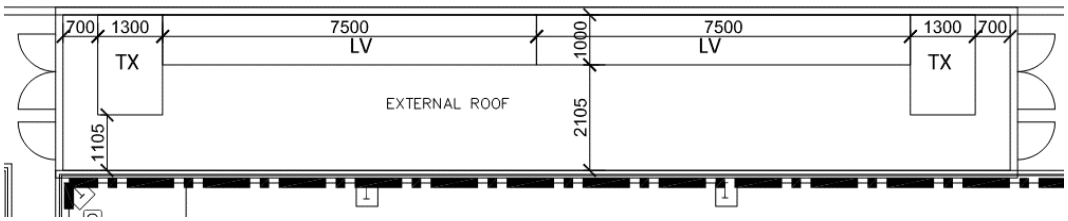


Figure 14 Substation Layout on Chandler Wing Roof

Switch Room Layout - The LV distribution board shall be front access and top entry / exit due to the space limitation.

Distribution Route - The distribution cable shall go through the plant riser 'R1' CWN/5/003, located in Chandler Wing North. The substation will be solely served for Chandler Wing. Albany Wing will be supplied from another substation in order to optimize the cable length. The cable run to the Chandler Wing Switchroom would be approximate 80m.

Maintenance access – Primary and secondary access can be provided to the substation by the double leave door and a single leaf door at both end of the substation.

Delivery & Replacement Route – Mobile crane is required to deliver & replace the transformers located in the Chandler Wing roof. The crane is proposed to park in the Yard loading bay area.

5.4.1 Pros

- Fit into unused space.
- Coordination with GOSH is not required.

5.4.2 Cons

- Longer HV and LV cable route is required.
- Severe visual implication to the Chandler Wing Roof. Planning permission is required.
- The existing unused gondola rail plinth would be blocked by the generator container.
- Not possible if Broadcrown replacement generator is sited here.
- Most likely require planning permission
- A complete intrusive structural survey would be required for new substation foot plinth from level 5 to basement.
- If the result of the structural assessment is not acceptable for the current structure, the structural elements (beams, slabs, columns) should be strengthened to carry the new load.

5.5 Substation Location Summary

	Broadcrown Generator Room	Spice of Life Café Void	Audio Visual Department	Chandler Wing Roof
Impact to Existing Installation	5	4	5	2
LV Cable Route	5	3	5	2
HV Cable Route	4	4	5	2
Visual Implication	5	1	5	3
GOSH Approval	3	5	5	5
Maintenance access	4	3	4	3
Cost	4	2	4	3
Total	**30**	**22**	**33**	**21**

Table 4 Substation location scouring summary

Note: Score 5 – the most favourable; Score 1 the most unfavourable

Referring to the scoring in Table 4 above, it is concluded that the Broadcrown generator space would be the most favourable location for the new Chandler Wing substation and the Audio Visual Department would be the most favourable location for the new Albany Wing substation. However, Chandler Wing substation scheme is subjected to the approval from GOSH to have a heavy duty delivery hatch in the loading / unloading bay for transformer delivery / replacement. Otherwise, Spice of Life Café void would be the second favourable scheme for Chandler Wing substation from technical point of view. However, Medical Architect's concerns regarding "*the lengthy negotiations with Camden Council as the substation would be placed against the grade II Albany Wing listed building, with possible alterations to the building fabric*" shall be considered. Client should confirm with GOSH for the delivery hatch at loading / unloading bay prior to take forward for Chandler Wing substation detail design.

Substation in Audio Visual Department is recommended to take forward for Albany Wing substation detail design

6 Generator Replacement

6.1 Broadcrown Generator Capacity

The existing Broadcrown generator is located under the Queen Square loading bay, and has a capacity of 600kW and 750kVA at 0.8 power factor. Given that hospitals typically have a power factor in the 0.95-1.0 range the limiting capacity parameter of hospital generators is usually assumed to be the kW rating, so 600kW in our case.

The electrical load measurement of entire development of NHNN and Queen Square House result taken in July 2016 are used as reference for generator capacity selection. Recent electrical load increase due to new projects in the NHNN have also been considered.

- Chandler Wing panel A
- Chandler Wing panel A (theatre upgrade)
- Chandler Wing panel B
- Chandler Wing panel B (theatre upgrade)
- Albany Wing essential panel
- QMW Redevelopment
- Queen Square House essential panel PB

6.2 Option 1 – Generator backup essential load

Reference to the Department of Health Technical Memorandum HTM 06-01: *Electrical services supply and distribution* indicates that electrical supplies in the healthcare sector are growing at a rate of between 3% and 6% year on year.

Using a load growth rate of 3% based on the existing load currently consumed on the site (excluding Queens Square House essential panel) for 25 years period the estimated total electrical supply demand is forecast to increase from 1,201kVA to 2,515kVA.

With the addition of the existing essential load demand for Queen Square House essential panel PB, no electrical load growth is allowed for QSH essential panel PB, a total electrical essential demand of 2,677kVA is forecast over the next 25 years to year 2040.

Considering the existing FG Wilson generator is going to be replaced by a 1200kW/1500kVA generator by the first quarter of 2017. The existing Broadcrown generator shall be replaced by another 1200kW/1500kVA generator in order to achieve 2,677kVA over the next 25 years.

The forecast of the growth of the electrical demand on the site is outlined in the Appendix B.

6.3 Option 2 – Generator backup entire NHNN

The measured maximum electrical load of Albany Wing (essential and non-essential) and Chandler Wing are 1376kW where the proposed total generator power is 2400kW. Therefore, the entire NHNN (Albany Wing & Chandler Wing) can be fully backed by generator.

Reference to the Department of Health Technical Memorandum HTM 06-01: *Electrical services supply and distribution* indicates that electrical supplies in the healthcare sector are growing at a rate of between 3% and 6% year on year.

Using a load growth rate of 3% based on the existing load currently consumed on the site (excluding Queens Square House essential panel) for 18 years period the estimated total electrical supply demand is forecast to increase from 1,448kVA to 2,466kVA. With the addition of the existing essential load demand for Queen Square House essential panel PB, no electrical load growth is allowed for QSH essential panel PB, a total electrical essential demand of 2,628kVA is forecast over the next 18 years to year 2033.

6.4 Way Forward

From technical point of view, it is not necessary to have generator back up for those non-clinical non-essential load. However, since there is spare capacity of the generator load, the client could consider to have a fully backup scheme for the first 18 years and disconnect those non-essential load before the generator capacity is full.

The Trust shall confirm which option would be the preferred option to backup the NHNN electrical load.

Early confirmation is required as it would affected the new generator switchboard design and the new substation LV switchboard design.

7 New Generator Design and Location

7.1 Generator Design

A new 1200kW/1500kVA prime rated generator will be provided. A new free standing switchgear would be located inside the generator container

Figure 15 Typical container type generator

Figure 16 Typical container type generator (roof mounted intake)

7.2 Generator Ventilation

When running, the new generator requires combustion and cooling air flow from outside. The following flow rates are required:

Inlet air flow: 22.0 m^3/s

Extract airflow: 20.2 m^3/s

New attenuators are sized as follows:

Inlet attenuator: face area 9.6m^2 x 3.4m long

Extract attenuator: face area 8.4m^2 x 4.0m long

The attenuator sizing is a balance of what fits reasonably in the generator room and sound levels at the boundary. With the sizing currently proposed in the scheme the noise level at 1m from louvre would be about 60dBA. All louvre shall be weatherproof.

If greater sound reduction is required for the hospital or lower for the local residents then the length of each attenuator would increase.

7.3 Exhaust Flue

A new generator flue will be required – size 450mm internal diameter and 525mm external diameter. The exhaust will be fitted with silencer in order to meet the noise level requirement.

7.4 Fuel System

Underground bulk fuel storage indicates 50,000 litre tank with 40,000 litres currently stored. The bulk fuel storage is an underground tank in the Guildford Street Yard. The fuel fill point is fixed to the external wall of the Guildford Street Yard substation.

A new 3hr fuel oil day-tank will be provided in the generator container with fire rated separation from the generator. The tank would be approximately a 1,000 litres capacity sized 1500mmH x 1000mmL x 1000mmW. The new day tank will be connected to the existing underground bulk tank.

It is proposed the existing underground fuel tanks will be retained and reused.

With a new 1200kW generator set installed to replace 600kW Broadcrown sets, the 40,000 litres in the bulk fuel store will provide 133 hours of fuel storage at full load.

This would be reduced in the event of both generators running concurrently.

The 133hrs plus the addition of the 3 hour day tank would provide a total of 136hrs fuel storage. HTM requires 200hrs fuel storage.

If both 1200kW generators are running full load at the same time during total power outage of the new substation in future, the 40,000 litres in the bulk fuel store will provide 67 hours of fuel storage at full load. The 67 hours plus the addition of the 3 hour day tank would provide a total of 70 hours fuel storage.

Therefore UCLH would have to accept this figure as a derogation from 200hrs if the tanks were to be reused. This is commonly done and would seem acceptable given the central London location, and associated options for supply resilience.

7.5 Generator Controls Upgrades

The new generator will require controls integration with the new Comap Inteligen Control system that to be installed in the FG Wilson generator replacement project

package, details refer to Appendix J generator control schematic. It would ensure the changeover and control will operate correctly in the future.

The new system control will work on the same principle as the existing. Failure of the mains supply is monitored at a localised changeover location. In the event of a mains failure a generator start signal is relayed to the generator start panel. Any one of a number of start signals will start the generator. The generator switchgear operates as a 'dead bus, meaning the panel is usually dead, unless a mains failure is detected. At that point the generator starts and the localised auto-changeover switches to the generator supply.

The existing outgoing ways requiring changeover is only Chandler Wing panel A.

The main change we are suggesting is to provide controls to allow short term mains/ generator paralleling. This will allow no-break load testing so the generator is allowed to conveniently run on the building load during regular testing.

Chandler Wing Panel A Change-over proposal

The existing Chandler Wing A changeover is 23 years old and there are no record drawings. Therefore, in order to ensure reliability of operation we propose replacing the existing generator controls to control the 1250Amp mains and generator supply with Schneider Masterpact circuit breakers.

It is proposed that the existing changeover 1250Amp breakers are controlled by a Deep Sea DSE8660 or equivalent. This controller when used in conjunction with a G59 relay and a DSE8610 on the generator will allow G59 compliant no break changeovers to take place.

7.6 Local Services Upgrades in the Generator Room.

It is proposed at part of the scheme a new SP&N Distribution board is provided. This will supply a new lighting and small power installations within the room / container, appropriate for the environment.

Additionally a fire alarm break glass & heat detector will be provided in the room / container connected to the fire alarm that would not shut the generator down. It is proposed that a physical weighted Langdon Kingsway drop valve be fitted controlled from a wired thermal link along with a wired stop button by the door. This thermal link should only operate if the engine were on fire. The drop valve can have an auxiliary switch that is wired to a new fire alarm interface.

7.7 Fire Suppression in the Generator Room.

It is proposed at part of the scheme a new fire suppression system is provided in the room /container.

This will consist of a water mist or gas suppression system as agreed in detail design stage. The system will incorporate a control panel, storage tanks, sensing and interfaces as required.

7.8 Sundry builders works

It is recommended the following builders works (in addition to the structural works to the loading bay) are included within the business case:

- Acoustic lining of the generator room / container
- Acoustic doors to the generator room / container
- Minor builders works associated with the flue upgrade (larger penetrations, sealing etc)
- Cable penetrations associated with generator supplies
- Fire stopping of new penetrations on completion
- Structural reinforcement to the new proposed generator location

8 New Generator Location

As discussed with the Trust, a feasibility study shall be carried out in the following location.

i. Existing Broadcrown generator room

ii. Chandler Wing Roof

iii. Void adjacent to the Spice of Life Café

iv. RLHIM plantroom (building above)

v. 33 Queen Square Roof Space

Following section will discuss into detail of essential cable distribution route, flue route, fuel pipe route, ventilation, noise treatment, fire suppression system, delivery & replacement route, generator room design and pros & cons of each option.

All the plantroom location drawings are located in Appendix H.

8.1 Existing Broadcrown generator room space

A new generator is proposed in the existing Broadcrown generator room space as shown on the figure below. Room location and distribution layout can be found in the Appendix F & Appendix H.

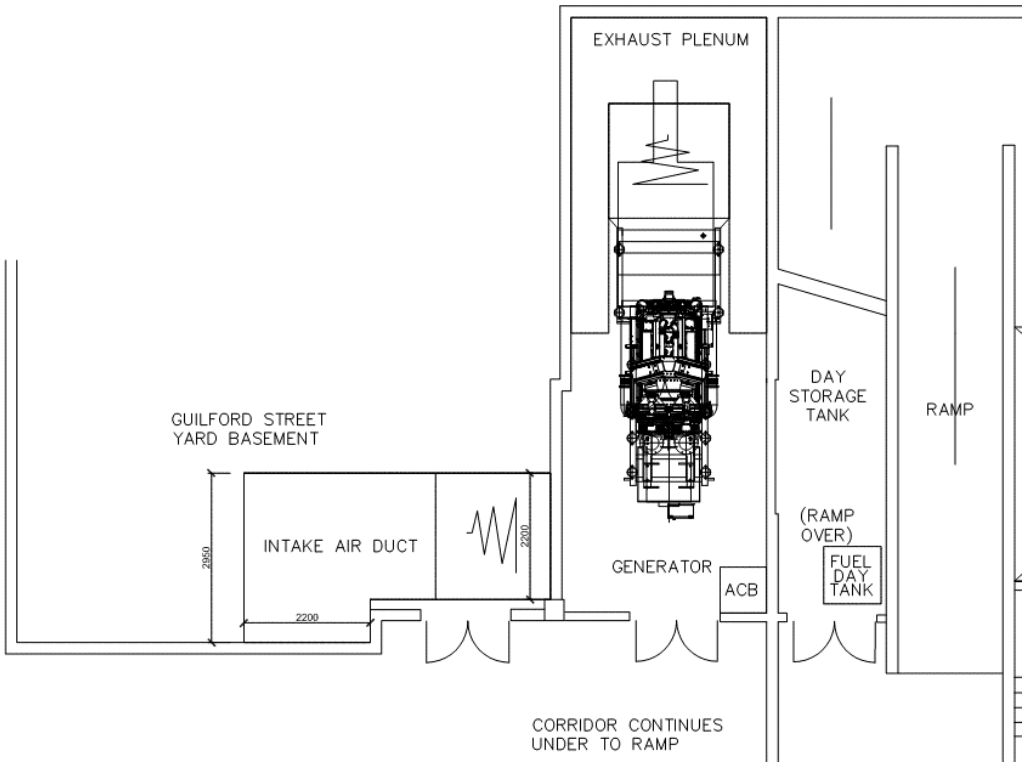


Figure 17 Generator room layout in Broadcrown Room

Generator intake – Generator intake louvre and attenuator are located in the sewing/linen room adjacent to the generator room. Approximate 14m² would be required to accommodate the attenuator and air ducts. The new air intake area in sewing/linen room would require coordination with GOSH.

Generator exhaust – Generator exhaust attenuator will be connected to the generator at the low level and a 'U' shape exhaust plenum at high level is required to discharge the exhaust air. The 'U' shape plenum will be connected to new louvres at ground level loading bay low level. The new penetration would require coordination with GOSH.

Flue discharge – Flue will be discharged using the same route as the existing Broadcrown generator flue.

Generator main cables – The generator main cable will penetrate directly to the generator switchroom outside the generator room.

Fuel pipes – The fuel pipe route would be reused.

Delivery / replacement route – The generator would be delivered / replaced via ramp. A mobile crane would be required to set at the loading/unloading Yard.

Maintenance access – Generator room entrance door would be for safety / fire exit and equipment brought in/out.

Physical dimension – The existing Broadcrown generator room and additional 14m² space at sewing / linen room.

Temporary Generator – A 600kW temporary generator shall be hire during the replacement work. The temporary generator shall be parked at the Yard and connected to the generator switchboard mobile generator plug as detailed in Figure 2.

8.1.1 Pros

- Shortest distance of fuel pipe and generator main cables less implication to other area.
- Existing flue route could be used. Less implication to other area.
- Noise level requirement is not as stringent as other outdoor option.
- Less visual implication to the development
- Not major changes are expected on the basement slab.

8.1.2 Cons

- 14m² space required for air intake from sewing/linen room of GOSH. Scheme may not be approved by GOSH.
- New exhaust louvre and penetration are require at the loading bay low level. Scheme may not be approved by GOSH.
- Temporary generator is required during the replacement work.
- Most likely require planning permission.

8.2 Chandler Wing Roof

A container type generator is proposed on the Chandler Wing Roof as shown on the figure below. Room location and distribution layout can be found in the Appendix F & Appendix H.

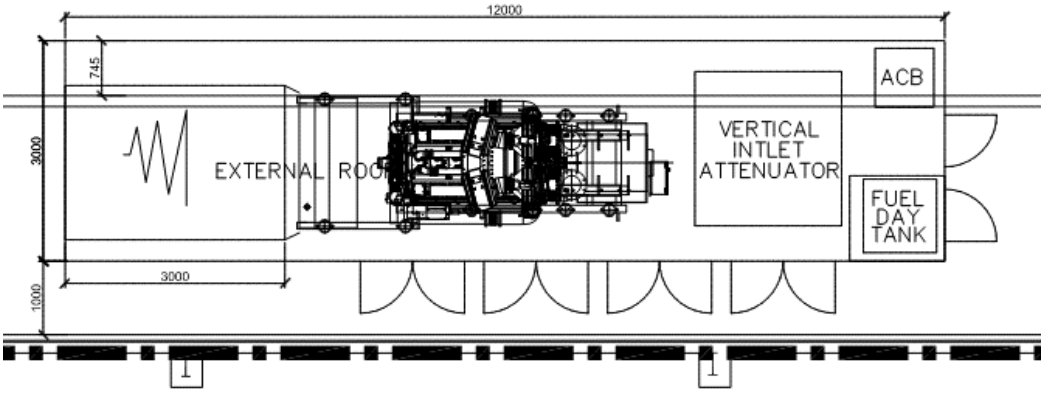


Figure 18 Generator room layout on Chandler Wing roof

Generator intake – Generator intake louvre and attenuator are at the roof of the generator container.

Generator exhaust – Generator exhaust louvre and attenuator will be at the low level end of the generator container.

Flue discharge – Flue will be discharged at the existing Broadcrown generator flue location in order to minimize the visual implication.

Generator main cables – The generator main cable will run across level 5 plant area and connect to plant riser 'R1' to basement. Then the main cable will turn up to the generator switchboard on ground level next to the loading bay through FG Wilson inlet room. The cable run would be approximate 80m.

Fuel pipes – The fuel pipes will run across level 5 plant area and connect to plant riser 'R1' to basement. Then pipe will connect to the external fuel pump cabinet next to the yard substation on ground level through FG Wilson inlet room, UCL area and existing trench.

Delivery / replacement route – The generator container would be delivered / replaced by a mobile crane set at the loading/unloading Yard.

Maintenance access – A side door and a far end door would be for safety / fire exit rather than having equipment brought in. The largest single piece item that would have to be removed is the alternator, so with inlet on the roof, literally crane off the inlet attenuator and then remove the alternator out the top or providing the tank and standalone ACB can be disassembled and take out the end.

Physical dimension – The generator container would be approximate 14m length x 3m width x 3m height. The inlet penthouse would be on top of the container with approximate 3m length x 3m width x 4.5m height. There is a slightly overhang of the generator container which may require coordination with GOSH.

8.2.1 Pros

- Shortest distance of flue to discharge point. Less implication to other area.
- Straightforward intake and exhaust design for outdoor environment.

8.2.2 Cons

- Longer cable and fuel pipe run, may affect other existing installation.
- Any major maintenance would require to remove the inlet attenuator by mobile crane.
- The overall height of the generator container, inlet attenuator and louvres would be approximate 7.5m height. Severe visual implication to the development.
- The existing gondola rail plinth would be blocked by the generator container.
- Coordination with GOSH may be required for the overhang.
- Most likely require planning permission and pre-application advice

8.3 Void adjacent to the Spice of Life Café

A container type generator is proposed at the void area adjacent to the Spice of Life Café as shown on the figure below. Room location and distribution layout can be found in the Appendix F & Appendix H.

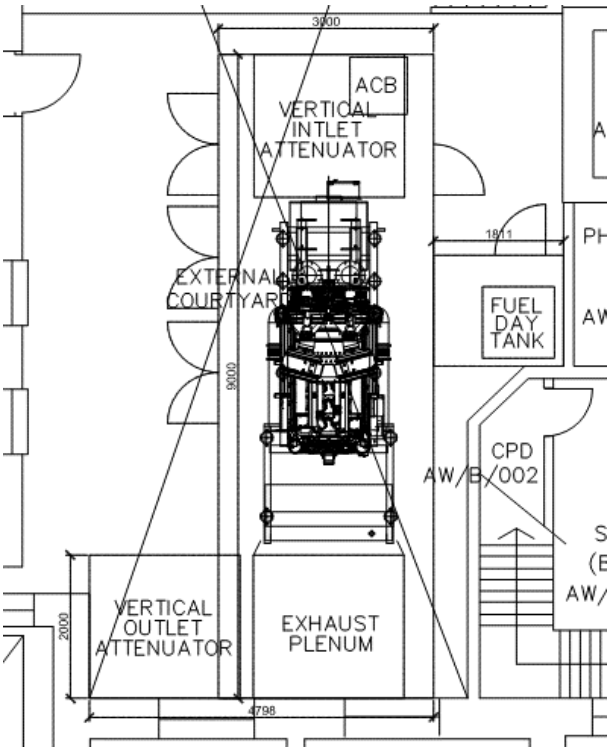


Figure 19 Generator room layout in Void adjacent to the Spice of Life Café

Generator intake – Generator intake louvre and attenuator are at the roof of the generator container.

Generator exhaust – Generator exhaust louvre and attenuator are at the roof of the generator container. Exhaust air duct shall be extended to the top of the Albany Wing in order to prevent short circuit for intake and exhaust.

Flue discharge – Flue will be mounted along the façade and discharged at the top of the building. The flue discharge point shall keep at least 5 metre away from any intake louvres.

Generator main cables – The generator main cable will run across Spice of Life Café, Chandler corridor and FG Wilson generator room. And then turn up to the generator switchroom on ground level next to the loading bay. The cable run would be approximate 70m.

Fuel pipes – The fuel pipe will run across Spice of Life Café, Chandler corridor and FG Wilson generator room. Then pipe will connect to the external fuel pump cabinet next to the yard substation on ground level through FG Wilson inlet room, UCL area and existing trench.

Delivery / replacement route – The generator container would be delivered / replaced by a mobile crane set at the loading/unloading Yard or Queen Square.

Maintenance access – Access double door at both side door would be for safety / fire exit and equipment brought in. The largest single piece item that would have to be removed is the alternator, it can be replaced via the double door and crane off.

Physical dimension – The generator container would be approximate 9m long x 3m wide x 3m height. The inlet penthouse would be on top of the container with approximate 3m length x 3m width x 4.5m height. The outlet penthouse would be at the side of the container with approximate 3m length x 3m width and the height would discharge to the top of building.

8.3.1 Pros

- Shortest distance of flue to discharge point. Less implication to other area.
- Straightforward intake and exhaust design for outdoor environment.
- Coordination with GOSH is not required.
- Proper maintenance access can be provided.
- Major maintenance work for the generator can be thought the container double door and crane off.
- Not major changes are expected on the basement slab.

8.3.2 Cons

- Longer cable and fuel pipe run, may affect other existing installation.
- The overall height of the generator container, outlet attenuator and air duct would be close to the top of Albany Wing. Severe visual implication to the café outdoor area.
- New generator installation may block some of the Albany Wing windows.
- Lengthy negotiations with Camden Council as the substation would be placed against the grade II Albany Wing listed building.

- Likely require planning permission and pre-application advice.
- A complete intrusive structural survey would be required for new generator container foot plinth from roof to basement.
- If the result of the structural assessment is not acceptable for the current structure, the structural elements (beams, slabs, columns) should be strengthened to carry the new load.

8.4 RLHIM plantroom roof

A container type generator is proposed at the top of the RLHIM plantroom area as shown on the figure below. The plantroom below are the boiler and flue dilution plant of RLHIM. Room location and distribution layout can be found in the Appendix F & Appendix H.

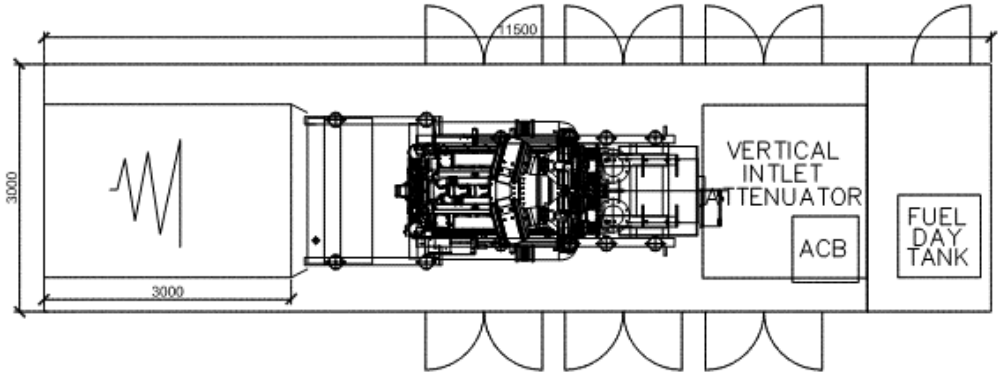


Figure 20 Generator room layout on RLHIM plantroom roof

Generator intake – Generator intake louvre and attenuator are at the roof of the generator container.

Generator exhaust – Generator intake attenuator are at the roof of the generator container. A long air duct would be require to connect to the louvre at the top of the building.

Flue discharge – Flue will be mounted along the façade and discharged at the top of the building. The flue discharge point shall keep at least 5 metre away from any intake louvres.

Generator main cables – The generator main cable will run across the whole Chandler Wing South & North to connect to the generator switchroom on ground level next to the loading bay. The cable run would be approximate 150m.

Fuel pipes – The fuel pipe will run across the whole Chandler Wing South & North to connect to the external fuel pump cabinet next to the yard substation on ground level.

Delivery / replacement route – The generator container would be delivered / replaced by a mobile crane set at the Powis Place.

Maintenance access – Access double door at both side door would be for safety / fire exit and equipment brought in. The largest single piece item that would have to be removed is the alternator, it can be replaced via the double door and crane off.

Physical dimension – The generator container would be approximate 9m long x 3m wide x 3m height. The inlet penthouse would be on top of the container with approximate 3m length x 3m width x 4.5m height.

8.4.1 Pros

- Generator flue would be discharged with the existing boiler flues.
- Straightforward intake and exhaust design for outdoor environment.
- Coordination with GOSH is not required.
- Proper maintenance access can be provided.
- Major maintenance work for the generator can be thought the container double door and crane off.

8.4.2 Cons

- The overall height of the generator container, inlet attenuator and louvres would be approximate 7.5m height. Severe visual implication to the development and 2-3 Powis Place.
- 2nd longest cable and fuel pipe run, may affect other existing installation.
- Likely require planning permission and pre-application advice. Permission will most likely be rejected.
- A complete intrusive structural survey would be required for new generator container foot plinth from level 1 to basement.
- If the result of the structural assessment is not acceptable for the current structure, the structural elements (beams, slabs, columns) should be strengthened to carry the new load.

8.5 33 QS Roof Space

A container type generator is proposed at the top 33 Queen Square roof plant area as shown on the figure below. The plantroom below are the AHUs and Chiller plant. Room location and distribution layout can be found in the Appendix F & Appendix H.

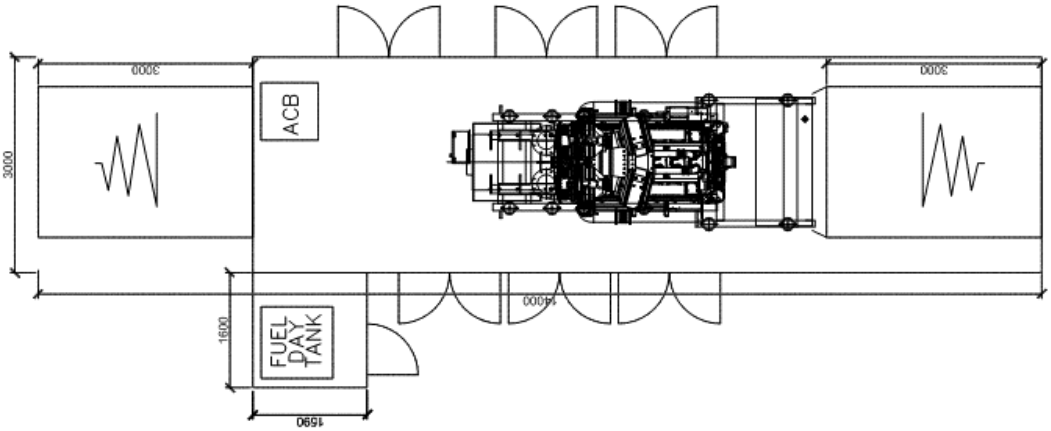


Figure 21 Generator room layout on 33 Queen Square roof

Generator intake – Generator intake louvre and attenuator will be at the low level end of the generator container.

Generator exhaust – Generator exhaust louvre and attenuator will be at the low level another end of the generator container.

Flue discharge – Flue will be discharged at the top of the building. The flue discharge point shall keep at least 5 metre away from any intake louvres.

Generator main cables – The generator main cable will run across 33 QS, QMW and half of the Chandler Wing to the generator switchboard on ground level next to the loading bay. The cable run would be approximate 200m.

Fuel pipes – The fuel pipe will run across 33 QS, QMW and half of the Chandler Wing to the external fuel pump cabinet next to the yard substation on ground level.

Delivery / replacement route – The generator container would be delivered / replaced by a mobile crane set at the Queen Square.

Maintenance access – A side door and a far end door would be for safety / fire exit rather than having equipment brought in. The largest single piece item that would have to be removed is the alternator, so with inlet on the roof, literally crane off the inlet attenuator and then remove the alternator out the top or providing the tank and standalone ACB can be disassembled and take out the end.

Physical dimension – The generator container would be approximate 15m length x 3m width x 3m height including all inlet and outlet attenuator and louvres.

8.5.1 Pros

- Generator flue would be discharged at the top of building.
- Straightforward intake and exhaust design for outdoor environment.
- Coordination with GOSH is not required.
- Proper maintenance access can be provided.
- Major maintenance work for the generator can be thought the container double door and crane off.

8.5.2 Cons

- The overall height of the generator container, inlet attenuator and louvres would be approximate 3.5m height. It would be the highest point among RLHIM, Albany Wing, Chandler Wing and GOSH. Planning may not approved.
- Longest cable and fuel pipe run, will affect other existing installation.
- Flue and exhaust air may affect AHUs and Chiller plant below.
- Likely require planning permission and pre-application advice. It is likely the application will be rejected.
- A complete intrusive structural survey would be required for new generator container foot plinth from roof to basement.
- If the result of the structural assessment is not acceptable for the current structure, the structural elements (beams, slabs, columns) should be strengthened to carry the new load.

9 Generator Location Summary

	Broadcrown Generator Room	Chandler Wing Roof	Spice of Life Café Void	RLHIM Plantroom Roof	33 QS Roof Space
Impact to Existing installation	5	4	3	3	1
GOSH approval	1	4	5	5	5
Cable route	5	4	3	1	1
Fuel route	5	4	3	3	1
Flue discharge	4	5	3	3	3
Visual Implication	5	2	2	4	1
Maintenance access	5	3	4	4	4
Total	**30**	**26**	**23**	**23**	**16**

Table 5 Generator location scouring summary

Note: Score 5 – the most favourable; Score 1 the most unfavourable

Referring to the scoring in Table 5 above, it is concluded that the Broadcrown generator would be the most favourable location for the new generator. However, this scheme is subjected to the approval from GOSH to obtain 14m² in sewing/linen room for generator air intake. This is unlikely to be accepted by GOSH we understand. Chandler Wing Roof would be the second most favourable scheme for new generator. This option is recommended to take forward for detail design and the generator container overhang would need to be negotiated with GOSH as extends towards GOSH Southwood Building.

10 UCLH Input

Summary of items where UCLH input is requested to allow the scheme to proceed.

- **Substation / Generator room location** – Agreement that the new substation and generator room shall be provided by UCLH.
- **GOSH Loading Bay Modifications** – Negotiation with UCLH and GOSH regarding part of the loading bay be utilised for the transformer delivery hatch.
- **Audio Visual Department –** Negotiation with UCL and UCLH regarding the entire AV department to be utilised for UKPN intake room, Client 11kV switching station and Albany Wing substation.
- **HTM Derogations** – Acceptance regarding:

i. Reuse of fuel tank – Possible diversions from 06-01A Chapter 8

ii. Fuel storage quantity – Diversion from 06-01A chapter 8 (200 hour storage)

iii. Confirmation that N+1 support Generator is not provided – 06-01A fig 17 after the theatre upgrade and QMW wards projects completion.

- **Growth rate –** UCLH to confirm the acceptance of 3% growth rate for the substation and generator capacity design which is the lower end of electrical supplies in the healthcare sector are growing at a rate of between 3% and 6% year on year.
- **Generator backup scheme –** UCLH shall confirm full Albany Wing back up scheme (Non-essential & essential load) for the first 18 years or Essential only back up scheme for 25 years will be adopted.

Appendix A

Proposed Plant Location

Appendix B

Electrical Load Forecast

Appendix C

Overall HV/LV Schematic

Appendix D

Delivery Hatch

Appendix E

LV Distribution Route

Appendix F

Essential Distribution Route

Appendix G

Substations Layout

Appendix H

Generators Layout

Appendix I

Generator Container Sample

Appendix J

Generator Control Schematic

Appendix K

Comment from Medical Architect

Appendix L

Comment from Roughton