BURO HAPPOLD

University of Huddersfield Solar PV

Electrical Specification Section A: Preliminaries “Design and Build” and Section B: Project Specific Particular Requirements

UOH-BHE-XX-XX-SP-E-0001

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A Preliminaries

A1 Introduction to Project

A1.1 Project Overview

A Buro Happold (BH) has been appointed to provide a technical performance specification on behalf of the University of Huddersfield (UOH) for the retrofit of a photovoltaic generation system to a total of two existing buildings at the University of Huddersfield campus:

1 Barbara Hepworth Building
2 3M Buckley Innovation Centre building

B Aim: Harness the available area to generate renewable energy, reduce the university's net operational carbon emissions, and provide the university with a satisfactory return on investment while remaining within the university's capital expenditure budget.

A1.2 Tender Contact

A All project correspondence shall be directed to:

Humma Rehman
Executive Assistant
University Of Huddersfield
Property Services
Queensgate
Huddersfield

A1.3 Site Visit Contact

A All project correspondence shall be directed to:

Paul Heath
Electrical Services Engineer
University Of Huddersfield
Director Of Estates and Facilities
Property Services
Queensgate
Huddersfield

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A1.4 Site Description

A Barbara Hepworth building:

1 A modern education building with a flat roof, largely free except for some existing plant areas and vent openings.
2 Address: Barbara Hepworth Building, University of Huddersfield, Queensgate, Huddersfield, HD1 3DH.
3 Accessible from Queensgate (A62) via University Road.

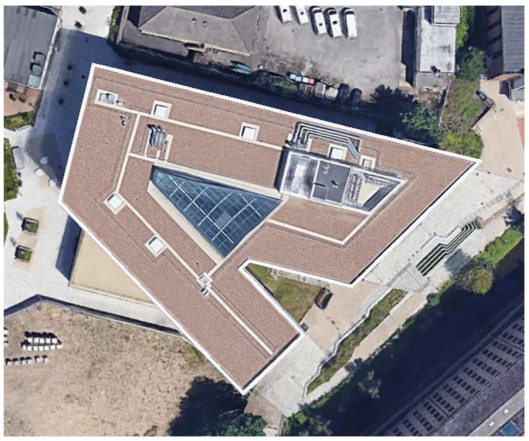

Figure 1 Barbara Hepworth (Google Earth, 01.04.2025)

B 3M Buckley Innovation Centre:

1 An existing office and lab space with a shallow pitched roof and multiple varied roof extrusions.
2 Address: 3M Buckley Innovation Centre, Firth Street, Huddersfield, HD1 3BD.
3 Accessible from Firth Street (B6432) via Wakefield Road (A629).

Figure 2 3M Buckley Innovation Centre (Google Earth, 01.04.2025)

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A2 Introduction to Electrical Specification

A2.1 Performance Design and Build Preliminaries

A This project is classed as a Performance Design & Build in which Buro Happold produces the performance specifications as part of the overall employer's requirements. Design responsibility sits wholly with the Contractor. The Contractor is entirely responsible for the technical design, coordinated working drawings, installation drawings, supply, installation, testing, commissioning, setting to work, builders' work information and details, record drawings and operation and maintenance manuals per this specification and Main Contract Preliminaries.

B Read in conjunction with:

1 Main Contract Documents: Preliminaries/Project Information
2 Section C: Materials and Workmanship
3 University of Huddersfield Electrical Specification
4 University of Huddersfield Estates and Facilities Guidance Note EHSGN – 1 Electrical Safety

C This specification outlines the key performance criteria for the photovoltaic systems for the following buildings within the University of Huddersfield campus:

1 Barbara Hepworth
2 3MBIC

A2.2 Contractor Definitions

A Within this document, references are made to "contractors" as set out below:

1 Main Contractor (or management contractor), employed by the client and contracts out packages or trades to sub-contractors
2 Building Services Contractor; a sub-contractor employed by the Main Contractor to carry out the work described by this specification. This is a generic term and includes the Mechanical and Electrical Services sub-contractors whether part of the same company or separate companies
3 Electrical Services Contractor: a sub-contractor employed by the Main Contractor to carry out the electrical services installations
4 Specialist Contractors: normally employed by the Main Contractor or Building Services Contractor and often supplying a design function with warranty.

B This document is addressed to the Main Contractor unless stated otherwise.

A2.3 Using the Specification

A Per Design & Build, this specification does not constitute an exhaustive set of requirements as the design responsibility is wholly with the Contractor. The Contractor shall include within their scope all elements associated with the design, installation, testing, commissioning, and electrical services installation associated with this project.

B The systems shall be designed per all relevant statutory and non-statutory documentation including but not necessarily limited to those contained within section

C It is the Contractor's responsibility to define by calculation and planning all equipment selections, service network distribution, access and maintenance requirements and operating efficiencies.

D This specification shall be subject to the terms and conditions specified by the University of Huddersfield.

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E Should any part of this specification be inconsistent with other sections or documents, identify this to the specified Tender Contact at the earliest possible opportunity before the tender return.

F The Contract Administrator reserves the right to reject any part of the installations not complying with this performance specification. The Contractor shall carry out the necessary remedial work or replacement, free of charge, without delay to the contract.

G No approval or acceptance by UOH shall relieve the Contractor of their responsibilities under the contract for the quality of materials and the standard of workmanship in the works.

H The photovoltaic system installer and products used shall be certified by the microgeneration certification scheme. The photovoltaic installer shall provide proof of certification as part of the tender return.

I The following documents shall be referenced:

Table 1 Reference Documents

Document Code	Document Name
UOH-BHE-3M-RF-DR-E-1000	3MBIC Roof Proposed PV Layout
UOH-BHE-3M-ZZ-DR-E-1100	3MBIC LV Schematic
UOH-BHE-BH-RF-DR-E-2000	Barbara Hepworth Roof Proposed PV Layout
UOH-BHE-BH-ZZ-DR-E-2100	Barbara Hepworth LV Schematic
-	University of Huddersfield Electrical Specification
-	University of Huddersfield Estates and Facilities Guidance Note EHSGN – 1 Electrical Safety

A2.4 Definitions Used in the Specification

A The following abbreviations are used in this specification and drawings:

1 CA: Contract Administrator: (University of Huddersfield)
2 CIBSE: Chartered Institution of Building Services Engineers
3 IET: Institution of Engineering and Technology
4 ECA: Electrical Contractors Association
5 A.C.: Alternating Current
6 D.C.: Direct Current
7 LV: Low Voltage: Voltage
   a A.C: ≥ 50V and ≤ 1000V or 600V between conductors and earth
   b D.C: 1500V between conductors or 900V between conductors and Earth
8 ELV: Extra Low Voltage:
   a A.C: <50V
   b D.C. <120V ripple-free
9 XLPE: Crosslinked Polyethylene
10 LSF: Low Smoke and Fume
11 SCADA: Supervisory Control and Data Acquisition.
12 ACB: Air Circuit Breaker
13 DNO: District Network Operator
14 SWA: Steel Wire Armoured

A2.5 Contractor Design and Submittals

A Provide drawings, calculations and submittals in accordance with the requirements indicated in all Sections of the specification. Calculations shall include the following and reference should be made to the cables schedules if they are provided:

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1 Cable sizing and current-carrying capacity
2 Discrimination/Selectivity
3 Fault characteristics.
4 Installed kilowatt peak
5 Annual energy yield (MWh)
6 Earth loop impedance
7 Voltages and voltage drop from the source to load centres
8 Financial payback based on the KWe system installed, KWh/yr annual yield, and cost (£/KWh)
   a Use an electricity unit rate of £0.24 per KWh.
9 Any other calculations necessary to show that the required performance characteristics have been achieved.
10 Assumed annual solar irradiance used to calculate the annual MWh yield. Include a reference/citation.

B Provide instruction to the Client staff, residents, and maintenance team as to the operation of the installations.

C Provide the Client with all technical information to support necessary applications including but not necessarily limited to: Planning, Building Control, and the Distribution Network Operator.

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A3 Tendering / Sub-contracting / Supply

A3.1 Selection of Manufacturers / Suppliers

A Sections B and C of this specification detail the manufacturers, makes and types of plant and equipment on which the drawings and specification have been prepared. Base the tender on these requirements.

B Where manufacturers, suppliers and/or installers of products are identified by name, or names, and no reference is made to "equal and approved" or "or approved equivalent", use these exclusively.

C Where manufacturers, suppliers and/or installers of products are identified by name, or names, and reference is made to "equal and approved" or "or approved equivalent" the submitted tender shall be based on these. This is necessary to ensure that tenders are compliant and comparable. Alternatives may be offered but costs shall be submitted separately to the CA for approval, provided that:

1 They meet the design criteria
2 They are equal in every respect to those specified (as and when requested, demonstrate this to the CA at no additional expense to this contract)
3 They comply with any stated British Standard (or other equivalent recognised standards)
4 Any constructional, cost, programme, maintenance or other differences are identified.

D Where manufacturers, suppliers and/or installers of products are not identified by name, select products that comply in all respects with this specification and, as and when requested, demonstrate such compliance.

E Alternatives that would involve significant changes to other work will not be considered. The acceptance of any alternatives shall be at the discretion of the CA, who is not bound to accept any alternatives.

A3.2 Subcontracting

A Where it is proposed to sublet any portion(s) of the Building Services works a list shall be submitted with the tender defining such portion(s) and giving, for each, the names and addresses of the proposed companies.

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A4 Site / Existing Buildings

A4.1 Site Visit

A Take responsibility for obtaining the information necessary to make decisions regarding the content of the tender and undertake any investigations necessary to verify any information provided during the tender process. Conduct site visit(s), review as-built documentation, and/or conduct modelling as required to be satisfied as to the following project parameters before the tender return:

1 Site location
2 Site conditions including but not limited to roof structural condition/capacity, weather, and climate
3 Factors affecting photovoltaic performance such as shading and obstructions
4 Existing electrical infrastructure configurations and capacities
5 Access to the site
6 Adjoining rights of way for the public
7 Storage space
8 Restrictions for loading and unloading materials
9 Conditions of any adjoining properties
10 Relevant existing systems' locations and conditions
11 Any other conditions which may affect the tender price and carry out the works
12 Existing installations
13 Restrictions and obstructions

B No claim will be entertained with respect to lack of knowledge of the site and/or the existing installation.

C Arrangements to visit site should be made by contacting the UOH Tender Contact:

D The proposed design shall include sizing and selection of electrical equipment, location of plant with due consideration for maintenance of each item of equipment, and overall energy conservation of the system. The system design and equipment selection shall be carried out after a full appraisal of both running and capital costs to provide a cost effective and economical installation.

E If there are any clarifications required as part of the tender process, the Contractor shall send these through to the specified Tender Contact. All clarifications will be circulated to all tenderers via a clarifications log to ensure a fair tender process.

F Interface with all trade packages to ensure satisfactory integration of the works with all other trade packages and ongoing works onsite including but not limited to the following where applicable:

1 Architectural
2 Lightning protection

G Provide the following:

1 Safe access for all other relevant trades to an agreed programme of works where applicable.
2 Attendance by any other contractors required to carry out necessary work.
3 Attendances for the Client or third party (including statutory authorities) for witnessing, testing, commissioning, and inspections of the photovoltaic and related installations.

A4.2 Strip out

A Skips where required shall be placed in locations agreed with the University. All skips located on site shall be lockable and secured when not in use.

B Strip out all redundant services within the contract areas, extent to be agreed on site with the CA.

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C Offer to the University any items removed prior to disposal off site, in accordance with all current legislation.

D All works shall be carried out by a NICEIC or ECA registered contractor.

E Provide copies to the CA of all electrical staff CSCS cards prior to any operative working on the electrical installation.

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A5 Provision, Content and Use of Documentation

A5.1 Technical Design, Drawings, and Calculations

A Provide Technical Design Layouts/model and schematic drawings in a timely manner.

B Provide all necessary design calculations for review as listed above:

A5.2 Installation Drawings

A Provide the Installation Drawings in a timely manner.

B Provide also:

1 Manufacturer's certified drawings for major items of plant
2 Installation drawings based on information obtained from manufacturer's certified drawings for construction

C Submit to the CA, installation drawings of all the systems for review before they are fabricated. Unless otherwise agreed in writing, no work may start on site until the relevant installation drawings have been inspected by the CA.

D Where revisions take place to the works under the authority of the CA's Instruction, by written agreement with the CA or when revised Employer's Requirements are issued, modify the installation drawings accordingly and re-issue for construction purposes any such modified drawings.

E Specific installation drawings may, by the prior specific and express written permission of the CA, omit minor details such as conduit provided that a method statement rigorously covers the installation intent. This permission will not be unreasonably withheld but will not be given where:

1 Employer's operation is affected
2 Visual appearance is affected
3 Details are needed for co-ordinating trades.

F The work described on the installation drawings shall be carefully checked for all clearance, maintenance of architectural and structural elements and proper co-ordination with all trades.

A5.3 Builders Work

A The Contractor should note that all facilitating builders work for the works including making good to existing structures and finishes will be carried out by others at no additional cost to the contract

B All fire stopping shall be carried out by the contractor, using proprietary materials, to ensure any fire rated structure breached is returned to the original standard.

C Where the contractor requires holes up to 50mm diameter they shall be responsible for the formation of these holes. The contractor shall also be responsible for all fixings to the structure, where permitted. No fixing shall impair the structural properties of any building member.

D Provide the preliminary Builderswork Information and produce the Builderswork Details to suit the services installations. For openings less than 300 x 300 the contractor may elect to mark them on site in preference to dimensioning them on drawings.

E Provide builders work documentation (drawings and details) in a timely manner. This may require detailed site survey work to ascertain the exact conditions on site.

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F Submit the documentation to, and obtain approval from, the CA before any structural work requiring holes or other modification is executed.

G Where appropriate, mark on site the actual locations of the following:

1 Holes through walls, partitions, floors, etc.
2 Chases in walls, floors, etc.
3 Pockets cast in concrete
4 Inserts and any built in sleeves or similar items.

H Holes may not be cut in steelwork, reinforced or precast concrete without written permission from the CA/Project Manager.

A5.4 Examination of Drawings / Information

A Review the tender/ contract drawings and specification information with the CA prior to starting work on site. Note the following:

1 The CA or their appointed External Review Team will examine and make comments on, but not approve, one copy of the proposed installation drawings submitted
2 Comments will be made for compliance with the design intent, appearance, clashes with structure, etc.
3 Each drawing will be dated and signed by the CA to show that it has been inspected and returned.
4 Such examination and comments shall not relieve the Contractor of any responsibility and obligations for design and documentation, correctness of the document / drawing or its suitability for purpose under this contract
5 Allow two weeks for this process.

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A6 Security, Safety, and Protection

A6.1 Safety

A Comply with all safety regulations including but not limited to the following:

1 Health and Safety Executive (HSE) Guidance Notes
2 CDM regulations
3 Control of Substances Hazardous to Health (COSHH) Regulations
4 HSE Guidance Note GS 7
5 Electricity at Work Regulations.

A6.2 Delivery

A Provide adequate and safe protection for all materials and products during transport to site.

B Deliver all conduit, trunking and associated equipment with open ends effectively plugged, capped or sealed.

A6.3 Handling

A Offload and transport all materials and products as recommended by the manufacturers and after consideration of any risks involved.

A6.4 Storage

A Ensure all plant, materials, etc. are adequately protected against weather and other potential damage, arising from any cause, at all times.

B Store all materials and products as in conditions as recommended by the manufacturers.

C Provide sufficient, safe and secure storage for all materials and products.

D Ensure existing items to be re-used, either on the works or elsewhere, are adequately protected.

E In so far as is practicable, keep all plant, materials, fittings, accessories and sundry items in their packing cases until required for use. If this is not possible, store in clean bins or bagged and stowed in racks and maintained under suitable weatherproof protective covers.

A6.5 Protection of Installed Engineering Services Works

A Provide adequate and safe protection for all materials and products after installation. Check regularly the protection provided after installation of equipment and correct if inadequate.

B Ensure all items are protected against ingress of water and dust, formation of condensation, extremes and rapid changes of temperature, building works and operations of others.

C Protect during erection all easily damaged materials with hardboard covers or heavy duty polythene sheet. Such items include but are not limited to:

1 Control panels
2 Switchboards
3 Distribution boards

D Protect all finished items from damage and paint splashes. Install items such as switches, accessories, etc. as near to completion as practicable.

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E Cover all plant items with polythene sheeting except when being worked upon.

F Cap all open ends of conduit and trunking, etc. except when being worked upon.

G Paint parts liable to corrosion immediately after removal of any temporary protection.

H Any existing defects shall be reported to the CA before work commences in each area to show to the satisfaction of the CA that the damage has not been caused during the contract period. Otherwise rectify the damage at no additional expense to this contract.

I Repair or replace material, plant or equipment where deterioration or damage has occurred during the contract period prior to handover, whether caused by the Building Services Contractor or not, at no additional expense to this contract.

A6.6 Maintenance of Existing Services

A Provide Asset Protection and Maintenance (APM) of the existing services in accordance with the Main Contract Preliminaries/Project Information.

B Fully maintain all existing services to existing premises during the progress of the Engineering Services works unless the CA has given agreement, in writing, which specific services do not need to be maintained.

C Provide any additional work and materials necessary to maintain these services at all times during the duration of the contract.

D Any existing services disturbed by the Engineering Services works are to be reinstated fully in accordance with the standards of quality defined in this specification and to the satisfaction of the CA.

E Make all connections to existing services out of normal working hours.

A6.7 Ordering of Materials and Products

A Ensure procurement details of materials are incorporated into the programme.

B To avoid delays, submit details of alternative manufacturers or types of materials / products to the CA in time to comply with the agreed programme.

C Order all materials / products necessary for the completion of the Engineering Services works immediately after receipt of comments received and/or instructions to proceed. Note the following:

1 No delay to practical completion, or completion of any part thereof, caused by delays in ordering will be accepted.

A6.8 Routine Maintenance

A Include for all necessary routine maintenance required on the new systems from the date that equipment is first run to the handover date. During this period, maintenance of all plant and equipment shall be carried out strictly in accordance with the manufacturer's instructions. All costs incurred by the above shall be included in the tender.

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B Project Specific Particular Requirements

B1 Scope of Electrical services installations

B1.1 Extent of Electrical Installations

A This specification section introduces the design of the photovoltaic and associated electrical systems for the University of Huddersfield and defines the operating parameters and the scope of works for the MEP subcontractor. The drawings and specifications indicate the full extent of the works, and this section is primarily to assist the subcontractor in understanding the design concepts for each of the services.

B Read in conjunction with:

1 Main Contract Documents: Preliminaries/Project Information
2 Section C: Materials and Workmanship
3 University of Huddersfield Electrical Specification
4 University of Huddersfield Estates and Facilities Guidance Note EHSGN – 1 Electrical Safety

C Unless otherwise noted in this specification, the Contractor shall supply, deliver, off load, position, erect, test, commission and set to work all equipment necessary to complete the works detailed in the following sections of this specification.

D Note that section C of this specification defines the plant and equipment materials, construction and workmanship.

E Where equipment models and services network distribution, duties or dimensions are quoted in the MEP documentation they are representative only of a quality standard or as a need to assist with architectural space planning. It is the Contractor's responsibility to define by calculation and planning all equipment selections, service network distribution, access and maintenance requirements and operating efficiencies.

F The Electrical Services comprise the following:

1 Photovoltaic Installations
2 LV distribution and Switchgear
3 Submains distribution
4 Power Installation
5 Lightning Protection
6 Earthing and Bonding
7 Testing and Commissioning of the Electrical Services

B1.2 Strip Out

A Isolate, disconnect, and strip out the existing photovoltaic system on the roof of the 3MBIC building.

B1.3 Photovoltaics

A Design, configure, programme, procure, supply, install, test, commission, and demonstrate to work new photovoltaic generation systems and their integration with the main electrical infrastructure for the following buildings within the University of Huddersfield:

1 3MBIC
2 Barbara Hepworth

B Design, configure, procure and provide all equipment, hardware, documentation, labour and supervision required for the installation of the photovoltaic systems. List all the equipment necessary to complete the installation within the tender return.

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C Include the following:

1 Design of the photovoltaic systems and their integration with the electrical system of the building including but not necessarily limited to:
   a Preparation of design drawings
   b Provision of a functional description of operation
   c Undertaking of design calculations
   d Indication as to what percentage of the buildings' demand is met by the photovoltaic installations.
2 Design and installation of any required electrical distribution components including new and alterations of existing to integrate the photovoltaic systems with the existing electrical distribution networks.
3 Procurement of the required materials for the installation as designed.
4 Enabling works prior to commencement of construction, including the removal and disposal of any existing systems (if required).
5 Provision of a risk assessment, method statement and programme for the works.
6 Liaison with the University of Huddersfield to arrange site access and to ensure that disruption to the operation of the site is minimised as much as possible.
7 Installation of the photovoltaic system.
8 Commissioning, testing, and setting to work the new systems.
9 Provision of safe access to the complete installation for visual inspection by the Client/Consultant.
10 Application to the Distribution Network Operator for the connection of the system to the distribution network.
11 Provision of an Operation and Maintenance manual for the installed equipment.
12 Provision of as-installed drawings
13 Provision of shut-down strategy for the photovoltaic system.
14 An allowance for regular updates to the University of Huddersfield on project progress.
15 An allowance for ad-hoc correspondence with University of Huddersfield as required.
16 Any additional requirements such as welfare facilities, segregated waste bins etc.
17 Option to undertake periodic energy monitoring and routine maintenance if deemed necessary.
18 CDM obligations as required.

D In addition to the above, provide the cost of replacing the 3MBIC PV inverter as a standalone line item. Include:

1 Replacement of existing 3MBIC PV inverter and associated connections.
2 Testing and commissioning of the new inverter and overall PV system.

B1.4 Lightning Protection

A The Photovoltaic Contractor shall advise on technical requirements relating to lightning protection, earth faults, transient over-voltages and power line surges which may cause high voltage in an otherwise low-voltage system. The photovoltaic Contractor shall advise as to the requirements for surge protection.

B A qualified Lightning Protection Contractor shall be appointed to perform the following:

1 Conduct a condition survey of the existing lightning protection system, if applicable, and identify any shortcomings against BS EN 62305.
2 Design, programme, procure, supply, install, and test a complete lightning protection system to provide the most appropriate Lightning Protection Level (LPL) as defined by BS EN 62305, to accommodate the complete photovoltaic installation and any ongoing architectural works.
3 Interface with the Photovoltaic Contractor to determine the impacts of the photovoltaic design on the lightning protection system.
4 Interface with all trade packages to ensure satisfactory integration of the works with the architectural scheme and all other trade packages.
5 Programme and coordinate any lightning protection remedial works and/or upgrades with all other trade packages and ongoing works on site including but not limited to the following where applicable:
   a Architectural

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b Photovoltaic

6 Provide the following:

a Safe access for all other relevant trades to an agreed programme of works.

b Attendance by any other contractors required to carry out necessary work.

c Attendances for the Client or third party (including statutory authorities) witnessing, testing, commissioning, and inspections of the photovoltaic and related installations.

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B2 Photovoltaic Systems

B2.1 Scope

A Design, supply, install, test, commission, and demonstrate to work a complete photovoltaic system as described in this specification and the Main Contract. Read in conjunction with the Buro Happold design drawings and University of Huddersfield record information.

B2.2 System Performance Criteria

B2.2.1 Energy Yield

A The photovoltaic system shall achieve the following capacities/yields as a minimum:

Table 2 Energy Yield Criteria

Building	Installed Capacity (KW_{peak})	First Year Energy Yield (MWh/yr)
3MBIC	74	65.8
Barbara Hepworth	158	142.8

B The photovoltaic system shall be designed to achieve the required energy yields after all systemic energy losses have been accounted for.

B2.2.2 Financial Payback

A The photovoltaic systems shall be designed to achieve the shortest monetary payback period possible. Submittals with shorter payback periods will be viewed in favourably over submittals with longer payback periods.

B2.2.3 Components General

A The photovoltaic system shall include but not necessarily be limited to the following components:

1 Photovoltaic modules and associated structural framing and support.
2 Energy distribution cabling and containment from photovoltaic modules up to and including the connection to the existing electrical infrastructure.
3 Power conditioning equipment
4 Energy monitoring meters
5 Circuit protective devices

B All electrical components shall conform to the requirements of the IET Wiring Regulations (BS 7671) and have appropriate voltage, current and temperature ratings for the application.

C Where possible, equipment and cabling shall be concealed from view from the public realm.

B2.2.4 PV Panels

A All photovoltaic modules shall be of the same make and model to ensure interoperability.

B The following minimum warranty standards shall apply to the individual photovoltaic modules to maximise the energy efficiency:

1 Minimum power output warranty: 30 years
2 Minimum product warranty: 25 years
3 Minimum inverter warranty: 25 years
4 Year 1 minimum warranted output: 98.0 %

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C The photovoltaic panels shall be provided with low-glare back-sheet and low-glare (black) frame.

B2.2.5 PV Interconnecting Wiring

A Each series of connected modules shall be suitably protected per BS 7671.

B Photovoltaic modules shall not be connected in parallel where modules are part of the same circuit with a single source.

C Each photovoltaic module shall be installed with a bypass diode to allow individual modules to be taken out of the circuit so that maintenance works to any individual panel shall have a minimal effect on the rest of the system.

D The system shall be designed such that reverse currents are prevented. If blocking diodes are used, these shall have voltage and current ratings at least twice that of the open-circuit voltage and short-circuit ratings. Blocking diodes shall not exceed the maximum voltage drop limit.

E All system components intended for outdoor use shall be designed for outdoor installation, accounting for the prevailing weather conditions for the location of the site. Equipment shall be rated and warranted to withstand and operate under these conditions. Assessed conditions shall include but not necessarily be limited to sunlight hours, precipitation, and wind speed.

B2.2.6 Supports, Fixings, and Mountings

A Design, procure, provide, supply, install, test, commission, and demonstrate to work all roof mounting and other necessary materials required for the installation of a photovoltaic system.

B The PV mounting systems shall be determined to suit the individual building, accounting for roof materials, structural load capacity, and waterproofing. The PV mounting systems shall be of the following types:

Building	Mounting Type	Description
3MBIC	Fixed	Fixed to the roof via penetrations
Barbara Hepworth	Ballasted	Held to the roof via ballasts on a non-penetrating frame

C Any proposed ballast mounting system shall be viewed favourably if consisting of low-carbon ballast materials including but not limited to:

1 Site-won materials
2 Recycled materials
3 Low-carbon alternatives to new materials

D If a low-carbon ballast system is proposed, provide certification as to the embodied carbon of the proposed material.

E If a low-carbon ballast system is proposed, indicate the monetary impact of the proposed low-carbon ballast compared to the common traditional alternative.

F Any mounting system requiring penetrations of a roof shall:

1 Be carried out so as not to void or negatively impact any existing warranties.
2 Be fully compatible with the roof membrane and structure. The contractor shall be responsible for ensuring that the photovoltaic system meets the requirements of the roof.
3 Be carried out following consultation with the roofing systems manufacturer.
4 Be carried out following consultation with the project Structural Engineer.

G All mechanical and structural hardware shall be durable and resistant to corrosion and ultraviolet rays. Stainless steel fasteners and an aluminium support structure are preferred. The use of ferrous metals, wood or plastic materials shall not be permitted.

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B2.2.7 Structural Compatibility

A The Contractor shall be responsible for establishing the weight distribution of the photovoltaic system complete with mounting system for approval by a Structural Engineer who has carried out a full structural survey of the roof.

B2.2.8 Access and Maintenance

A Include suitable space for access and maintenance within the design including and not necessarily limited to a continuous, unobstructed access walkway of at least 900mm in width.

Table 3 Access and Maintenance Approach

Building	Access
3MBIC	Propose a new access walkway
Barbara Hepworth	Maintain the existing access walkway

B The design shall enable easy access for operation and maintenance and make use of readily available plant/materials with a proven high level of quality and technical support.

C Subject to assessment of each individual site, provide edge protection in the form of a guard rail or parapet in accordance with all relevant health and safety standards to mitigate the risks of maintaining roof-mounted equipment.

D Plant that cannot be fully accessed in a safe manner, to maintain in line with manufacturer's instructions, shall not be accepted and shall be rectified by the Contractor at no cost to the contract.

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B3 LV Distribution, Cabling, and Containment

B3.1 Scope

A Design, supply, install, test, commission, and demonstrate to work a complete LV distribution including and not limited to all necessary cabling and containment systems to support the full operation of the Photovoltaic system as described in this specification and the Main Contract. Read in conjunction with the Buro Happold design drawings and University of Huddersfield record information.

B3.2 System Performance Criteria

B3.2.1 Energy Consumption Principles

A The photovoltaic system and downstream distribution network shall be designed and installed to achieve the following distribution hierarchy:

1 When the total demand of the building meets or exceeds the generation of the photovoltaic system, the power generated by the photovoltaic system shall be used entirely within the building.
2 When the total generation of the photovoltaic system exceeds the total demand of the building, energy will be shared on the University of Huddersfield private wire network.
3 When the generation of the photovoltaic system exceeds the demand of the entire University of Huddersfield private wire network, energy will be exported offsite to the public distribution network in accordance with the Distribution Network Operator's requirements. This scenario is not anticipated.

B3.2.2 LV Distribution

A Distribution systems shall utilise existing electrical infrastructure. The Contractor shall be responsible for verifying the condition and spare capacities of existing electrical infrastructure and may utilise the existing survey information in the first instance.

B The photovoltaic systems shall link to the nearest main LV switchboard via a new dedicated PV section board as indicated in the LV schematics. The PV system integration shall utilise spare ways in the existing LV switchboards.

C The Contractor shall make an allowance for providing additional switchgear cubicles and/or new distribution boards to accommodate the incoming connection from photovoltaic system.

D Include all cabling, circuit protective devices, necessary electrical accessories, equipment, and materials required for the photovoltaic installation.

E All overcurrent circuit protective devices shall have trip ratings less than the de-rated current-carrying capacity of the conductors they protect under the peak-load scenario.

F The contractor shall be responsible for providing adequately rated circuit protection devices designed to protect against:

1 Overcurrent
2 Short-circuit
3 Instantaneous fault
4 Earth fault
5 Temperature exceeding rated limits

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B3.2.3 Cabling and Containment

A Sub-main cabling shall generally be Copper SWA/XLPE/LSF/0H four-core in steel galvanised perforated cable tray or ladder.

B Route cables and containment efficiently to provide a cost-effective system, utilising existing risers and distribution routes where possible.

C Cable calculations shall be based on the peak-load scenario and include appropriate deratings. Deratings shall include and not necessarily be limited to temperature, circuit grouping and installation method.

D All cables connections shall be clearly identifiable and permanently marked.

B3.2.4 Power Conditioning

A Provide a power conditioning systems to optimise the PV generated energy for use by the buildings' existing LV distribution network. Power conditioning systems shall include but not necessarily be limited to the following components and functionalities:

1 Current inverter(s).
2 Automatic visual indicators showing whether the system is online.
3 Earth-fault protection consisting of detection of the earth fault, shunting the fault current to ground, and disabling the photovoltaic array until the fault has been cleared.
4 Voltage synchronisation

B The power conditioning system shall consist of PV inverters from ABB, Huawei, Schneider Electric or equal and approved manufacturer.

C All PV inverters shall be of the same make and model to ensure interoperability.

1 Solis Inverters are preferred to ensure compatibility with the new PV systems and the existing PV monitoring systems.

D The design shall incorporate the following principles applied to the inverters:

1 Inverters shall be located as close to the source as practical to minimise DC cable lengths per CIBSE Technical Memoranda 25.
2 Inverters shall be located per the manufacturer's requirements including but not necessarily limited to the following examples:
   a Any requirement for the inverters to be located away from direct sunlight.
   b Any requirement for the DC cable runs to be below a specified maximum permitted length.
   c The type of inverters used shall be that which maximise the output, reliability, and longevity of the system.

E Minimum inverter warranty: 25 years.

F Where equipment is planned to be in readily accessible locations (for example, outside of existing plant rooms), this shall be contained within a lockable, ventilated enclosure suited to its environment. If outdoors, the lockable enclosure shall be weather-sealed, IP65, resistant to corrosion and able to withstand the peak wind and precipitation loads in the region.

B3.2.5 Grid Interface and Exportation

A Design the photovoltaic systems to operate in parallel with the DNO connection to the building.

B Design the photovoltaic systems to be able to supply energy to the site as well as export energy to the Distribution Network Operator's (DNO) network.

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C Interface with the Distribution Network Operator to achieve a G99 agreement. Also, if required by the DNO, obtain any other necessary agreements such as G100 (exportation limitation).

D Provide a DNO trip switch facility to the Barbara Hepworth building:

1 Provide in accordance with the DNO's technical requirements.
2 Liaise with the DNO to establish the requirements.
3 The DNO trip switch shall be incorporated into the PV panel as indicated in the Barbara Hepworth LV schematic drawing.
4 Open/Closed signals shall be transferred such that a confirmation of disconnection is received at the substation within 0.4 seconds.

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B4 Lightning Protection

B4.1 Scope

A Design, supply, install, test, commission, and demonstrate to work a complete protection system to facilitate the photovoltaic system according to all relevant statutory requirements. Read in conjunction with the Buro Happold design drawings and University of Huddersfield record information.

B4.2 System Performance Criteria

A The lighting protection systems shall be designed to provide the highest level of protection (LP1) in accordance with BS EN 62305.

B The photovoltaic installations shall be incorporated within the existing lightning protection systems. Where required, the lightning protection systems shall be extended to incorporate the photovoltaic system in accordance with BS EN 62305.

C All metallic structures including PV modules shall be bonded to a grounding conductor by the Lightning Protection Specialist Contractor. Provisions for the grounding of the neutral conductor of the power conditioning systems. Examples of metallic structures to be grounded shall include but are not necessarily limited to the following:

1 Module frames
2 Panel support and mounting structures
3 Metal enclosures
4 Distribution/section boards

D Multiple connections to ground shall not be permitted for current-carrying conductors of the system.

E The surge protection requirements shall be determined by the Specialist Lighting Protection Contractor and, where applicable, be informed by a Lightning Protection Risk Assessment per BS EN 62305. It is recommended that Type 1 surge protective devices are connected on:

1 The DC side of the inverters.
2 The AC side of the inverters.
3 Distribution boards

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B5 Metering & Monitoring

B5.1 Scope

A Design, supply, install, test, commission, and demonstrate to work a complete metering system to monitor the performance of the photovoltaic system according to this specification, all relevant statutory requirements, and University of Huddersfield specifications. Read in conjunction with the Buro Happold design drawings and University of Huddersfield record information.

B5.2 Metering System Performance Criteria

A Metering in Barbara Hepworth shall following the existing metering strategy in the building. Meters shall output via ModBus to the existing metering collection gateway system (Schneider ComX). The metering collection gateway shall link to the existing PV monitoring system. Refer to the existing O&Ms for details.

B Provide a new metering collection device and associated communications cabling and data fixtures to transmit metering data from the PV system on the 3MBIC building to the existing University Energy Management System. Communications links from the PV system to the University Energy Management system shall be via Secure File Transfer Protocol (SFTP).

C New metering shall interface with the existing metering system. Ensure that all new metering components are compatible with existing head-end metering equipment.

D Provide adequate metering to enable the output of the photovoltaic system to be recorded and measured in comparison to the design. The metering shall be designed to provide metrics including but not necessarily limited to the following:

1	Generation	(KWh)
2	Reactive Power per phase	(KVAr)
3	Active power per phase	(KW)
4	Apparent power per phase	(KVA)
5	Current per phase	(A)
6	Total reactive power	(KVAr)
7	Total active power	(KW)
8	Total apparent power	(KVA)
9	Frequency	(Hz)
10	Voltage	(V)
11	Time and date of reading	(HH:MM DD/MMM/YYYY)

E Meters shall be positioned to record the following supplies:

1 Total photovoltaic generation
2 Total photovoltaic generation used onsite (self-consumption)
3 Photovoltaic generation exported offsite.

F The metering system shall provide real-time and historic half-hourly, daily, monthly, and annual totals.

G The annual generation of the photovoltaic installation shall be measured after all losses are accounted for at the Renewables Obligation Certificate (ROC) meter. Examples of types of losses include but are not necessarily limited to the following:

1 Cable distribution losses
2 Losses from overshadowing
3 Inverter losses

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H Provide and install all necessary equipment required by the District Network Operator per the G99 agreement and any other necessary DNO agreement including but not necessarily limited to the following:

1 Meters
2 Relays
3 Switches

B5.3 Monitoring System Performance Criteria

A Provide data logging facility to the photovoltaic inverters to indicate the following:

1 Generation (KVA)
2 Fault Status
3 Inverter temperature
4 Individual array currents (Amps)

B Inverter monitoring systems on Barbara Hepworth shall link to the existing Barbara Hepworth building monitoring network.

C Inverter monitoring systems on 3MBIC shall link to the existing 3MBIC building monitoring network.

D Solis inverters are preferred so that the new inverters can be monitored via the existing PV monitoring platform.

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B6 Testing and Commissioning

B6.1 Scope

A Perform all necessary testing and commissioning of all systems per the requirements of all relevant statutory documents, University of Huddersfield specifications, and as described in this specification.

B6.2 PV Specific Testing and Commissioning

A Prior to running the installed systems the contractor shall commission all installed equipment as required by the equipment manufacturer. Load consuming devices shall have their running loads/ current measured and recorded in the record information.

B Sufficient time shall be allowed in the construction schedule for testing and commissioning of the photovoltaic system and for any equipment faults and defects are identified and rectified before handover.

C Submit testing and commissioning results to UOH for review prior to handover. The data shall include but not necessarily be limited to the following:

1 Metered energy generation of the photovoltaic system demonstrating compliance with the performance targets.
2 Complete NICEIC certificates.

D Provide access to the complete installation to UOH or appointed client-side Engineer for visual inspection and allow at least one full working day for this to occur.

E All tests shall be performed per BS 7671.

F Visual inspections shall involve special attention to:

1 Cracked or broken cells
2 Signs of delamination or water infiltration
3 Discoloured cells
4 Loose electrical connections

G Electrical tests shall include but not necessarily be limited to:

1 Continuity of circuit, protective conductors, and equipotential bonding
2 Earth electrode impedance
3 Insulation resistance
4 Polarity
5 Earth loop impedance
6 Functions of protective devices

H Photovoltaic array commissioning tests shall be carried out under reasonable sunlight conditions in which the global irradiance on the photovoltaic panels is greater than 400 Wm^{-2}.

I The photovoltaic array commissioning procedure shall record the following items to be checked against the system specification and detailed design, considering any changes made during installation:

1 String open circuit voltage
2 String short circuit current
3 String maximum power point voltage
4 String maximum power point current
5 Array open circuit voltage
6 Array short circuit voltage
7 Array maximum power point voltage

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8 Array maximum power point current
9 Array rated power
10 Physical installation including mounting details orientation and tilt angle.

J Power conversion unit function tests shall include but not necessarily be limited to the following:

1 Anti-islanding
2 Disconnection capability for voltage and frequency disturbances
3 Total harmonic distortion and individual harmonics measurements
4 Isolation between DC and AC sides
5 Power factor recording
6 Electromagnetic interference measurement
7 Acoustic noise recording
8 Visual check on markings

K On completion of the electrical installation works, and satisfactory testing, a signed and dated Electrical Installation Certificate together with a Schedule of Inspections, Test Results, and Micro Generation Certification declaration shall be completed for inclusion in the O&M's.

L The following events shall be witnessed on site by UOH and/or their representative, and a representative of the DNO if required:

1 Commissioning
2 Photovoltaic controls demonstration

M The UOH and/or their representative shall perform a visual inspection of the completed system before Handover. The Contractor shall allow for at least half a day for this inspection.

N The contractor shall provide a hard copy and an electronic version of the Operation and Maintenance Manual and record drawings for this project, the manual shall be specific to the project and shall list each individual item of equipment [inc. serial No's and date of manufacture/installation] with operational guidance and complete maintenance schedules for the life of the equipment. The record drawings shall show installation layouts and schematics as well as associated cable routes. A minimum of one copy of the schematic drawing for the photovoltaic installation shall be framed and mounted on the intake room wall in an accessible location together with circuit charts at connected distribution boards.

O The contractor shall provide, in a compatible format, data for the client's asset registers.

P Testing shall take place prior to labelling to ensure there is no mismatch of point numbering between ends of each individual cable. Any incorrectly labelled points are to be rectified at the contractors cost.

B6.3 General Testing and Commissioning

B6.3.1 Inspection and Test Information

A Inspection records, test records and test certificates shall include, but not be limited to, the following:

1 Project title
2 Specific location in the Building Services works, including plant identification, system and section under inspection / test
3 Details of the element, item, batch or lot, including manufacturer's reference number
4 Details, nature and number of inspections / tests
5 Date, time and duration of inspection / test
6 Weather conditions during the test, where applicable
7 Instruments used, serial numbers and calibration dates, where applicable
8 Number and type of deficiencies found, where applicable
9 Any corrective action taken, where applicable
10 Itemised readings for all tests, where applicable

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11 Name and signature of those inspecting / testing / witnessing test
12 Other relevant particulars.

B Maintain records of all specified inspections and tests performed including third party and works test certificates on site.

C Submit copies of records within one week of request. On completion of the Engineering Services works, include copies in the O&M manuals.

B6.3.2 Inspections and Tests – On or Off Site

A Ensure all materials, equipment, etc. meet the requirements of this specification and carry out any inspections, as necessary, prior to site inspections by the CA. Note:

1 All installations offered up for inspection shall be substantially complete
2 The CA will not prepare extensive defects lists
3 If significant defects exist, correct defects and re-offer the systems for inspection when defects are rectified.

B If any part of the Engineering Services works is shown to be defective or not conforming to this specification make good at no additional expense to this contract. Note:

1 The CA will reject any defective parts by written notice indicating the area of dispute.

C Submit inspection and test schedules for those parts of the Building Services works where:

1 They are required by this specification
2 They are required to substantiate conformity with this specification
3 Records are required to be maintained.

D Should any alternative item be proposed that does not carry appropriate certification, ensure independent testing is carried out to confirm compliance at no additional expense to this contract.

E Provide all necessary facilities to enable tests to be witnessed and inspections carried out either on site or at manufacturer's works.

F Provide method statements, supported by risk elimination procedures, detailing the procedures for carrying out on-site tests.

G Agree in advance procedures for inspections and testing including periods of notice with the CA.

H Where a test indicates non-compliance with this specification, immediately submit details of the non-compliance and proposals for corrective action and repeat the procedure until satisfactory results are obtained.

I Arrange access to the manufacturer's, or other, off-site premises for personnel who are required to be in attendance when any inspections and/or tests are carried out.

J Carry out all tests required by legislation under the direction of a 'competent' person. Note:

1 Attendance or otherwise of the supervisory personnel during specified inspections or tests will not reduce the obligations or restrictions of the contract.

K Employ a specialist commissioning manager to supervise and witness the whole of the inspection and testing of the Building Services works. Refer to specification section C, Y50 of this project specification for details and scope of works for commissioning and commissioning management.

L Employ a specialist commissioning engineering company to undertake the commissioning of all systems in the Building Services works. Provide all specialised personnel (including manufacturer's representatives) and

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co-ordinate their activities. This appointment is to include the following responsibilities over a minimum 12 month period following occupation:

1 Provide testing of all building services under full load conditions
2 Provide and record interviews with building occupants (where they are affected by the complex services) to identify problems or concerns regarding the effectiveness of the systems
3 Re-commission systems (following any work needed to serve revised loads), and incorporate any revisions in operating procedures into the O&M manuals.

M Comply with the requirements of section C of this specification with regard to Testing and Commissioning. In addition comply with requirements of the current Building Regulations and BSRIA/CIBSE Guidelines.

N Agree with the CA a programme for inspection, testing, pre-commissioning checks, setting to work, commissioning and performance testing and allow for all costs incurred.

O Provide method statements, supported by risk eliminations procedures, detailing all commissioning, demonstration and instruction procedures.

P Give at least two weeks written notice to the CA before each (or series of) test, inspection, commissioning or demonstration procedure is carried out, stating any requirements for the attendance and co-operation of others.

Q Demonstrate to the CA that test instruments and equipment are accurate. Note:

1 The CA will only witness test proceedings, confirm recorded results and determine if the specified requirements have been satisfied.

R Provide all gas, fuel oil, electricity and water for testing and commissioning at no additional expense to this contract.

S Ensure the CA has the opportunity to witness all static testing. Systems to be tested shall include, but not be limited to, the following:

1 Insulation resistance tests
2 Earth fault loop impedance tests
3 Earth continuity tests

T Note: The systems shall be "de-snagged" to the satisfaction of the CA prior to any testing and/or commissioning.

U Test all equipment, material and systems as detailed in this specification. If an inspection or test fails, repeat the procedure, until satisfactory results are obtained at no additional expense to this contract.

V Complete all tests before any paint, cladding or similar materials are applied or before services are concealed.

W Following satisfactory completion of testing and when the Engineering Services installations are in a safe and satisfactory condition, ensure the following requirements apply prior to commissioning:

1 The installations are complete and in a satisfactory and safe condition (e.g. all fixtures have been tested for operation, polarity, phase sequence and impedance, etc.)
2 All systems are cleaned
3 Systems are protected from harmful external and internal elements
4 Notices are displayed stating their condition ('completion' indicates that the bulk of the snagging has been offered to the CA and that remedial work has been completed)
5 Set to work, regulate and adjust all systems, as necessary, to meet the specified design requirements

X Provide all necessary instruments and recorders to monitor systems during commissioning and performance testing. Note:

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1 All test equipment shall be subject to a quality assurance procedure complying with the following:
   a BS 5781-1
   b ISO 10012-1: Quality assurance requirements for measuring equipment. Metrological confirmation system for measuring equipment.

Y Do not start performance testing, including system demonstration, system proving or environmental and capacity testing, until commissioning of the system is completed to the satisfaction of the CA.

Z Maintain on site full records of all commissioning and performance testing, cross referenced to system components and, on completion of the Engineering Services works, include a copy in the O&M manuals.

AA Provide the following information before any system is offered for final acceptance:

1 A written statement to the CA confirming that each installation has been correctly tested and commissioned and that the performance requirements can be achieved
2 All certification documents for approval by the CA
3 A logbook and record of all hours run.

BB Provide the following commissioning information for agreement with the CA at an early stage to ensure sufficient time is available for commissioning the system prior to practical completion:

1 A separate and detailed commissioning programme
2 A separate and detailed commissioning specification describing in detail the technical requirements with which the service has to comply
3 A logic diagram
4 Full commissioning method statements detailing all procedures
5 Risk elimination procedures describing health and safety considerations.

CC Make due allowance for the following in the commissioning programme:

1 Availability of related services
2 Access required for controls, etc
3 Commissioning, demonstration and instruction procedures
4 Provision of written notice before each (or series of) test, inspection, commissioning or demonstration procedures are to be carried out, not less than two weeks' notice to the CA
5 Demonstration to the CA that test instruments and equipment are accurate.

DD The commissioning specification shall include, but not be limited to, the following information:

1 Scope of works, i.e. details of the systems to be commissioned, their functions and duration of operation, and an explanation of their inter-relationship with other engineering systems
2 Technical specification of the commissioning work, i.e. the relevant standards to be complied with, the instruments to be used, the tolerances for test results, and the witnessing and reporting procedures required
3 Design data relevant to commissioning such as flow rates, temperatures, operating pressures, plant capacities, illumination levels and glare indices, control logic statements, plan schematics, fault levels, noise ratings, etc
4 Set of schematic drawings, together with a set of either detailed design drawings or co-ordination drawings each with clearly marked details of electrical fault levels, current ratings, short circuit capacities and tripping times
5 System preparation details, i.e. the requirements for, and methods by which systems shall be prepared ready for commissioning. This shall include flushing and cleaning details in the case of water systems
6 Note the following:
   a It is recommended that the commissioning specification is included with the associated scope, materials and workmanship requirements for each engineering service.
   b At least two weeks will be required prior to practical completion for performance testing after the systems have been fully commissioned.

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B6.3.3 Operational Demonstration

A Provide a written statement to the CA confirming that each installation has been correctly tested and commissioned and that the performance requirements can be achieved.

B Demonstrate to the CA that all system components are operating correctly and the complete building services works will function in accordance with the specified performance requirements. Carry out performance testing in both summer and winter conditions to allow for the full load testing of the system(s) over an appropriate period of time to be agreed with the CA.

B6.3.4 Outstanding Acceptance Tests

A Any items that have failed their acceptance tests, or where such tests are delayed by the Employer, are to be listed and dates agreed, during the defects liability period when reasonable demands for consumer requirements are available.

B6.3.5 Systems Used Before Practical Completion

A Systems may not, without the prior written approval of the CA, be used prior to practical completion.

B Systems to be used before practical completion shall have all defective consumable elements replaced by new elements not more than one week prior to practical completion.

C No system shall be put into use prior to handover, except for testing and commissioning, without a written instruction from the CA. In such a case, operate the designated parts of the Engineering Services works which are permitted to be operated, provided that such operation is practicable and does not prejudice any responsibility or obligation.

D If instructed by the CA, provide adjustment to the contract sum, to take account of the following:

1 Comprehensive insurance including indirect loss for any plant being operated
2 Re-instatement of the installation to 'as new' condition prior to handover to the Employer
3 Defects liability period to commence on handover

B6.4 Operation of Systems Before the Production of Record Drawings and/or Operation and Maintenance (O&M) Manuals

A In the event that the record drawings and/or O&M manuals are not available when the Engineering Services works would, in the opinion of the CA, otherwise qualify for practical completion, provide attendance to put into service, operate 24 hours a day and maintain the systems to the Employer's requirements, including the provision of suitable competent labour, at no additional expense to this contract. Note:

1 Failure to provide this service satisfactorily shall entitle the Employer to make separate arrangements and recover the full cost through the contract.

B6.4.2 Cleaning on Completion of the Engineering Services Works

A Remove from site all debris, dirt and redundant items created by the works in accordance with the requirements indicated in the Main Contract preliminaries/Project Information.

B Clean the services installations thoroughly, removing all splashes, deposits, temporary markings, coverings and rubbish. Leave the site in a fit condition for occupation and use.

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B7 Handover

A The following materials/services listed in this section shall be provided at handover of the complete installation to UOH

B A price list for all replacement components including but not necessarily limited to photovoltaic modules and power conditioning equipment.

C Complete part lists including all electrical components, mechanical fixings and other equipment required for the installation. The part list shall include the make/model and source for all equipment required.

D Warranty information on all individual components.

E All equipment manufacturer's specifications and operations manuals including but not necessarily limited to those for:

1 Photovoltaic modules
2 Power conditioning units
3 Overcurrent devices
4 Switches
5 Optional equipment.

F Documented procedure for commissioning, operating, disconnecting, servicing, and maintaining the complete system and individual components.

G Documented cost options for the following maintenance strategies over and above the standard 12-month defects liability period:

1 12 months maintenance contract with a 24-hour callout period.
2 3-year maintenance contract with a 24-hour callout period.
3 5-year maintenance contract with a 24-hour callout period.

H Routine maintenance is defined as the act of ensuring that the photovoltaic system operates as designed. This includes but Is not limited to:

1 Replacing fuses
2 Replacing diodes
3 Replacing other minor equipment
4 Labour required to replace components in the event of component failure.

I The complete system shall be labelled including and not necessarily limited to:

1 All required warning signs.
2 Date of installation

J A framed schematic drawing of the solar PV installation shall be installed in the Main LV Switch Room of the building to which the PV system is connected, together with a 2nd supply warning notice.

B7.2 Record Documentation

A Provide the following record documentation at handover:

1 Record drawings comprising and schedules (including drawing(s) for:
   a Schematic drawings of all services showing as installed information
   b General arrangement plans and sections of all Building services
2 Equipment schedules for equipment actually installed
3 Manufacturing drawings for all equipment

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4 O&M manuals (see Appendix E)
5 Log book for all maintenance work, meter readings, etc

B7.3 Record Drawings and Schedules

A Prepare record drawings and schedules from the as-Installed drawings maintained on site. Endorse all such documentation 'Record'. Where agreed with the CA certain detailed information may be provided in schedule form.

B Provide reduced scale copies for inclusion in the O&M manuals.

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B8 Standards

B8.1 Standards General

A The Building Services installations for this project shall be carried out in accordance with the following Codes of Practice, guides and standards:

1 Life Safety Standards
2 Building Regulations
3 Electrical Services standards
4 Project Specific standards.

B8.2 Life Safety Standards

A The following documents relate to Life Safety but the list is not exhaustive and other British standards will apply. When dated the version indicated applies and when not dated use the latest edition including amendments:

1 BS 7671 Requirements for Electrical Installations – IET wiring Regulations 18th Edition

B8.3 Building Regulations

A Comply with the following Building Regulations: Approved Documents:

1 Structure
2 Vol2 Buildings other than Dwellings
3 Site preparation and resistance to contaminations and moisture
4 Protection from falling, collision and impact
5 Access to and use of buildings

B Comply with the following where appropriate:

1 Local Authority Regulations
2 Environment Agency Regulations and Codes of Practice
3 Health and Safety Executive: Guides and Codes of Practice

B8.4 Electrical Services Standards

A Comply with the following British Standards where applicable:

1	BS 7671	Requirements for Electrical Installations – IET wiring Regulations 17th Edition
2	BS EN 62305-1	Protection against Lightning. General Principles
3	BS EN 62305-2	Protection against Lightning. Risk Management
4	BS EN 62035-3	Protection against Lightning. Physical damage to structures and life hazard
5	BS EN 62035-4	Protection against Lightning. Electrical and electronic systems within buildings
6	BS 7430	COP for protective earthing of electrical installation
7	BS EN 60439-1	Specification for Low Voltage Switchgear and Control gear Assemblies.
8	BS EN 30012	Quality Assurance Requirements for Measuring Equipment.

B Comply with the following Guidance notes and technical memoranda:

1	CIBSE	Guides to Current Practice and Technical Memoranda
2	ECA	Electrical Contractors Association.

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B8.5 Project Specific Standards

A University of Huddersfield

1 University of Huddersfield Electrical Specification
2 University of Huddersfield Estates and Facilities Guidance Note EHSGN – 1 Electrical Safety

B CIBSE

1 Guide A design data
2 Guide B installation and equipment data
3 Guide C reference data
4 TM25

C British Standards

1 BS IEC 62548 Photovoltaic arrays design requirements
2 BS EN IEC 61730 Photovoltaic module safety qualification – requirements for testing.
3 BS EN 62466: Photovoltaic systems – requirements for testing, documentation and maintenance.

D Other

1 MCS Microgeneration Product Standards
2 Manufacturer's Instructions
3 The Planning (Listed Buildings and Conservation Areas) Act 1990
4 ENA Engineering Recommendations G98/G99.
5 BRE recommendations and guidance; N.B. FB 60, BR 514, IP 8/11, DG 532-1

E In addition to the above, the following standards may be applicable. Variations brought about due to these will be incorporated in discussion with the Client, for both mechanical and electrical services.

1 Financier
2 Insurance Companies
3 Local Authorities
4 Local Utility Suppliers Regulations.

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