SYSTEM DESIGN REPORT

Roof Mounted Solar PV at Stradbroke Swimming Pool and Fitness Centre

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Introduction

CorEnergy Limited has been appointed by the Councils to design, install and commission a roof mounted solar PV system at Stradbroke Swimming Pool and Fitness Centre, Wilby Road, Stradbroke, Eye, IP21 5JN. The system will be installed across various roofs across the leisure centre.

It is intended that the system will generate zero carbon electricity for consumption on site, reducing reliance on grid supplied energy and CO^2 emissions. It is expected that – at times of peak production, when site consumption is relatively lower - the system will export a minimal amount of electricity to the local electricity grid.

The contract is limited to the design, installation and commissioning of the rooftop array, optimisers, inverters and associated DC/AC cabling, containment, controls, electrical distribution equipment, isolators, energy meters, communications cables.

The system design is based on drawings and data provided by the Babergh and Mid Suffolk District Councils, as well as further measurements and details taken during a site survey.

The site visit was conducted during working hours. No testing of existing electrical systems took place. It is assumed that all existing LV electrical distribution equipment and systems comply with BS 7671 IET Wiring Regs (18th Edition).

Summary of Scope:

- Site survey and detailed design
- Agree final system capacity and costs with Babergh and Mid Suffolk District Councils
- Arrange scaffolding, edge protection and/or fall arrest/other safety systems to permit safe completion of works.
- Supply and fit PV modules, mounting systems, inverters, DC/AC isolators, distribution board, cables and containment as required to comply with BS 7671 IET Wiring Regulations [18th Edition]
- Undertake independent structural assessment on all proposed roofs - prior to installation
- Replace electricity meters to allow import/export monitoring (where applicable)
- Test and commission installed systems [to BS 7671 18th Edition]
- Set up online system monitoring, including a publicly accessible web page for reporting on current and historic energy generation data
- Lead the DNO liaison and G99 application process
- Provision of O&M information, including a solar panel user guide including;
    - System and electrical schematics
    - System physical layout diagram
    - AC electrical and earthing topology within the building
    - Manufacturers product specifications for all equipment installed
    - Warranties for workmanship and from manufacturers for equipment installed
    - Maintenance schedule, including information on spares to keep in stock
    - Predicted energy output, payback period and expected lifespan of system
    - Information on end-of-life recycling of equipment
    - Online monitoring system details
- Handover meeting upon completion of works with nominated officers from Babergh and Mid Suffolk District Councils. Handover shall include demonstration of system safe isolation/re-

energising procedure overview of user guide contents and on-site walk-through of equipment installed.

Proposed System Overview

A 40.56kWp Solar PV system which will consist of x104 monocrystalline modules (198m² overall surface area) on 2 separate roof elevations across the leisure centre. Please see visual overview of the proposed arrays overleaf.

Suitable roof space has been selected to optimise system energy production and ensure a worthwhile contribution to the overall site electricity demand.

Pairs of Solar PV modules will be optimised, to enable better production efficiency and to ensure safe DC isolation when the system is shutdown. The optimisers & inverters have Arc-Fault detection built into the electronics to cease power production if a fault occurs.

Installation Cost

The total installed system cost is £52,374 +VAT, this includes the design, supply, installation and handover of a functional system including all associated works covered within the project scope.

Equipment Selection

Information regarding the selected OEM components can be found in Appendix A. All proposed equipment holds the relevant compliance and standards in accordance with MIS3002 Issue 4.0 of the Microgeneration Certification Scheme Service Company (MCS). MCS has become the recognised standard for the UK products and their installation in the renewable sector.

All equipment will comply with the tender technical specification as set out in 3.1 Specifications – Category 1. Solar PV, **with the following notable exceptions**:

Tender Section 3. Performance Specification – Solar PV Equipment

Mains Panel and Metering

- *A dedicated PV mains distribution board with switch into the existing plantroom shall be installed for the PV array(s).*
- *A Code 5 approved MID 3-phase generation meter complete with pulsed-output should be installed to record the solar PV generation*

Proposed deviations to specification:

1) AC connection from PV inverter to spare way in existing MCB Distribution Board
2) No MID generation meter is required (as no export or feed-in tariffs will apply)

Equipment Selected:

- PV Modules – 104 x Hanwha Q-Cells Q.PEAK-G9-DUO-ML-G9 390W modules
- Inverter/s – 1 x SolarEdge Technologies SE33.3K
    - Optimisers – 52 x P801 Optimisers

    - Energy Meter (mains incomer) – 1 x SolarEdge Modbus Energy Meter
- Mounting – Nicholson IFP's, upon which a K2 Mounting Systems will be affixed

MODULES

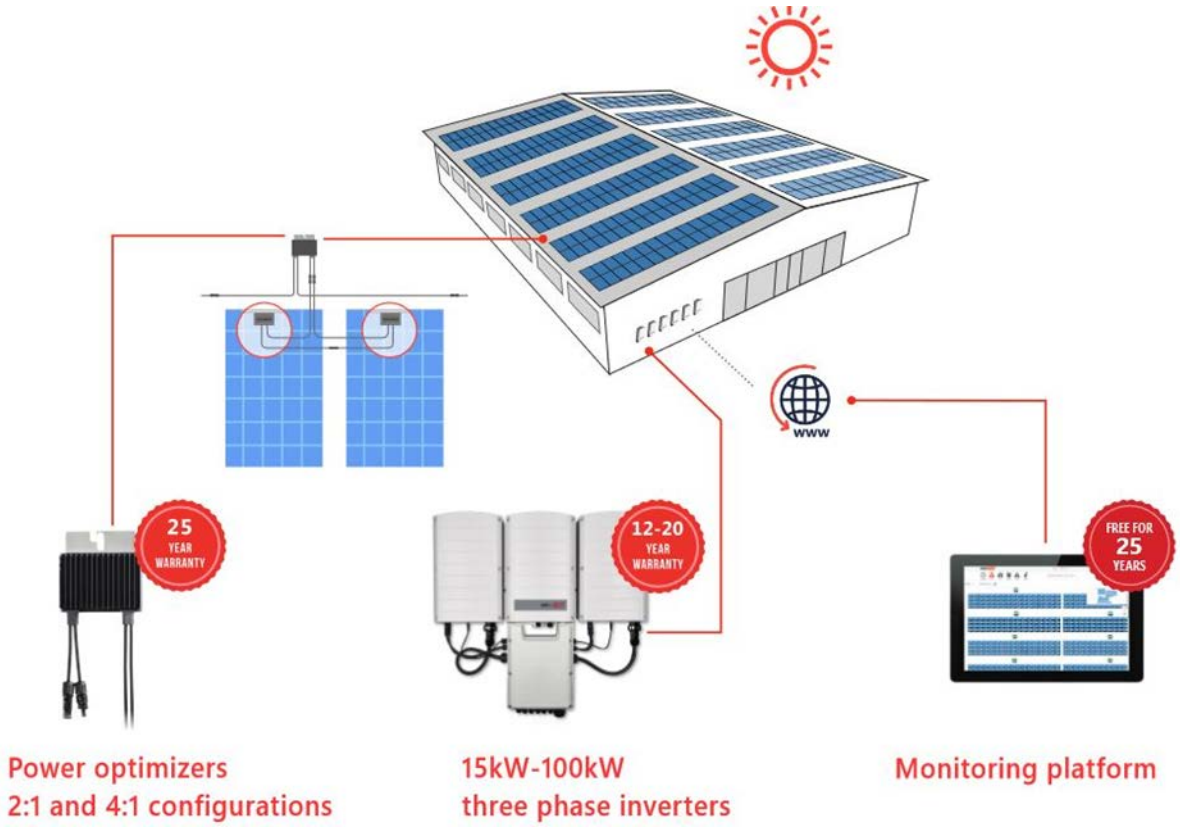
CorEnergy recommends Q.Cells monocrystalline modules manufactured by Hanwha. Headquartered in South Korea with revenues exceeding $55 Billion, they are one of the world's largest companies and their product support and warranties are credible and assured. Their Q.Cells division manufacturers high performance PV cells with market-leading efficacy and performance which is optimised for irradiance levels in the UK. The Q.Cells performance warranty is based on maintaining ≥85% of initial output after 25 years of service; over and above the MCS requirement.

The Company's Q.PEAK DUO module series were rated as a Top Performer in the 2020 PV Module Reliability Scorecard published by PVEL and DNV GL, marking the fifth consecutive year of Hanwha Q CELLS' Top Performer status. Based on the performance, reliability, warranty and cost point, CorEnergy's assessment of the Solar PV market identifies these products as the achieving best value and optimum performance for this project.

INVERTERS AND OPTIMIZERS

SolarEdge are the market leading manufacturers of PV inverter and optimizer technology. Their innovations in inverter/module-level optimization deliver significant advantages relating to generation yield and system performance in 'low light' conditions [when compared with 'traditional' string inverters].

SolarEdge is the only system which offers automatic optimization of individual PV modules, as opposed to string or array level, a critical performance factor in situations of either lower light levels, spot shading, spot dirt or debris, spot thermal issues, or damage to an individual panel. Based on the product lifetime performance and reliability, SolarEdge is CorEnergy's preferred manufacturer of inverters.



SYSTEM PERFORMANCE MONITORING

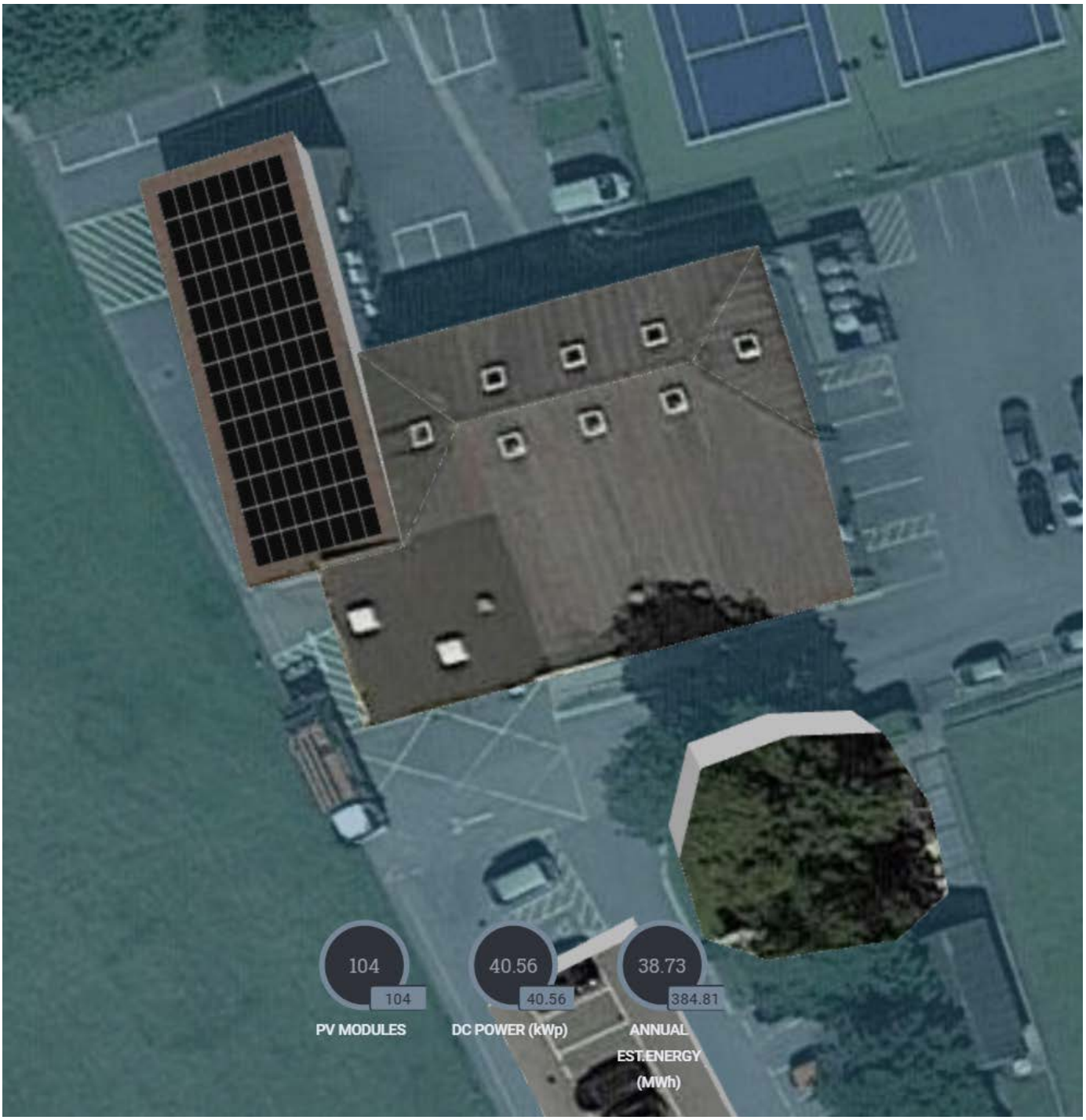
SolarEdge inverters include an advanced remote monitoring system, which is free to use for 25 years without subscription. This app is used for remote system performance monitoring, interrogation and fault notification/self-diagnosis, via a straightforward web-based software app.

Both CorEnergy technicians and Babergh and Mid Suffolk District Councils staff can easily monitor real-time system generation output and performance, from their mobile phone / tablet or desktop to ensure the project is achieving optimal performance. The system tracks and records historical system performance and generates periodic reports.

This data can also be delivered to an LCD display screen, located in a key public area of the site, to inform site staff and visitors of the clean electricity being generated and CO^2 emissions avoided, both in real time and historically. CorEnergy finds this to be a highly popular option for its clients and will be happy to provide and install a monitor at a prime location on the site to advertise the system performance if requested*.

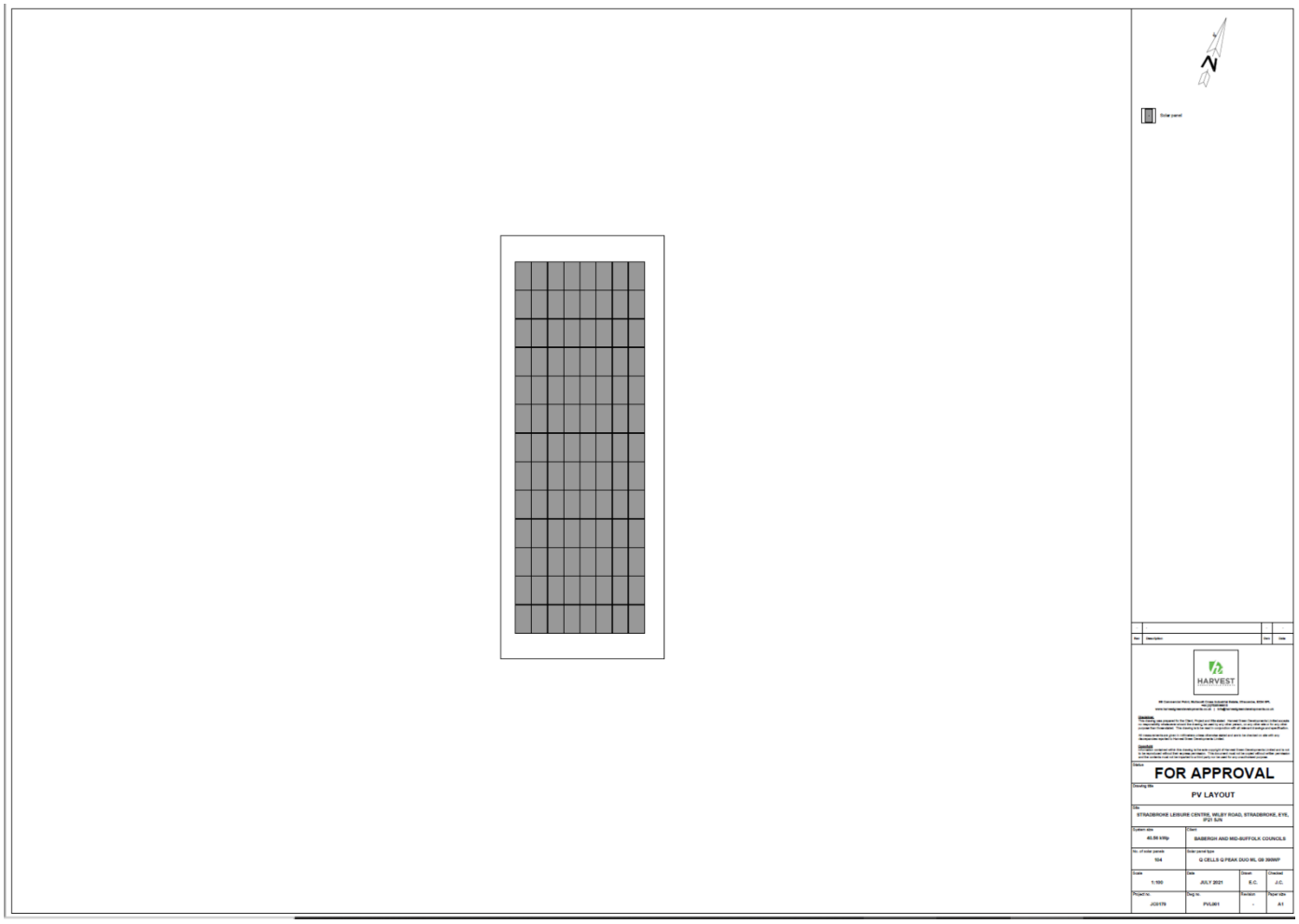
**access required to site data infrastructure [via a dedicated CAT5 (RJ45) network data connection near to the display] and access via the LAN/firewall to the internet.*

Module Layout



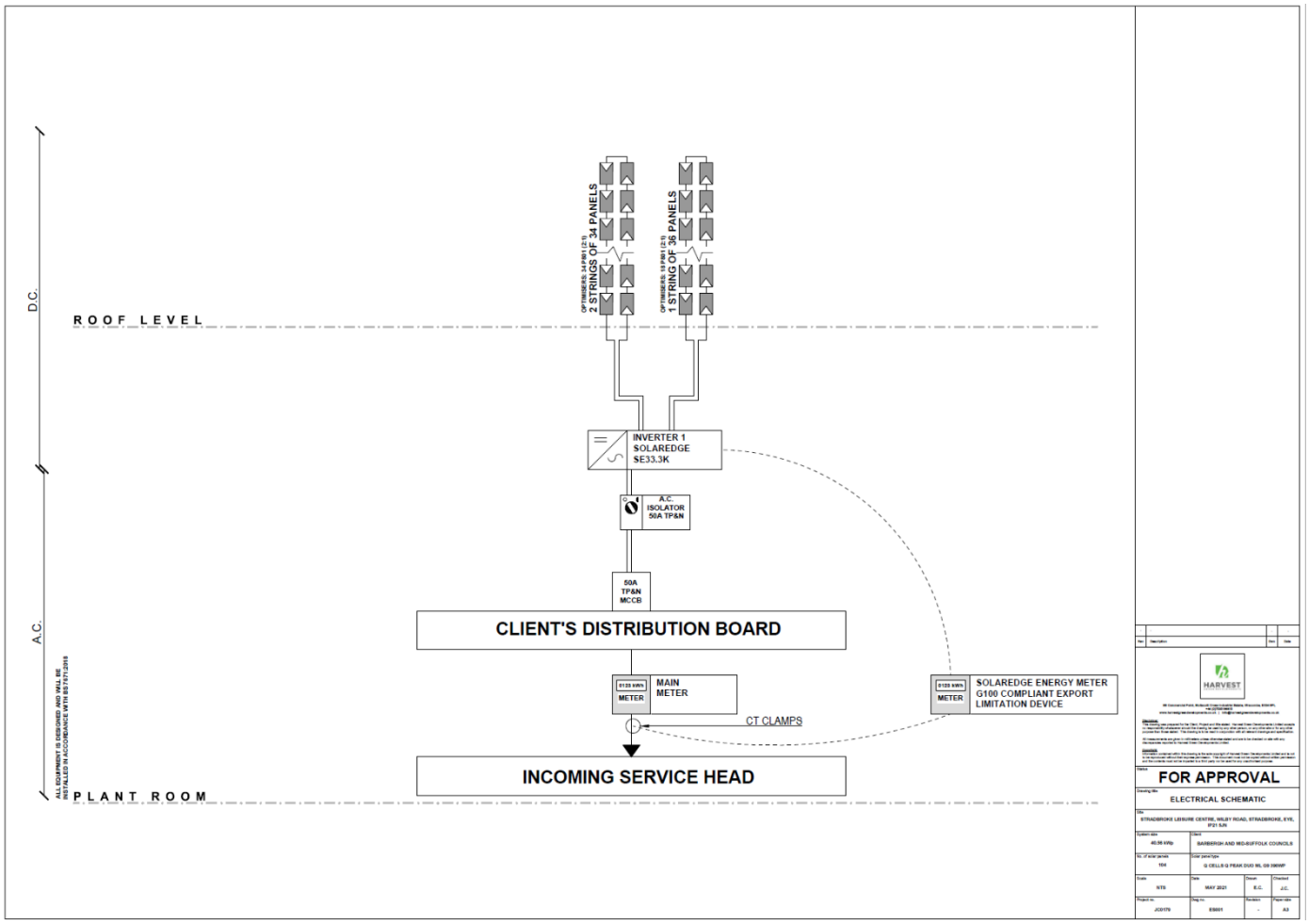
Dimension Plans

Please see below and attached for the full drawing plan:



System Line Diagram

The following SLD sets out the boundary demarcation for the existing site LV supply and the proposed PV connection points. This was submitted to UK Power Networks and forms the basis of the connection request to them.



System Performance

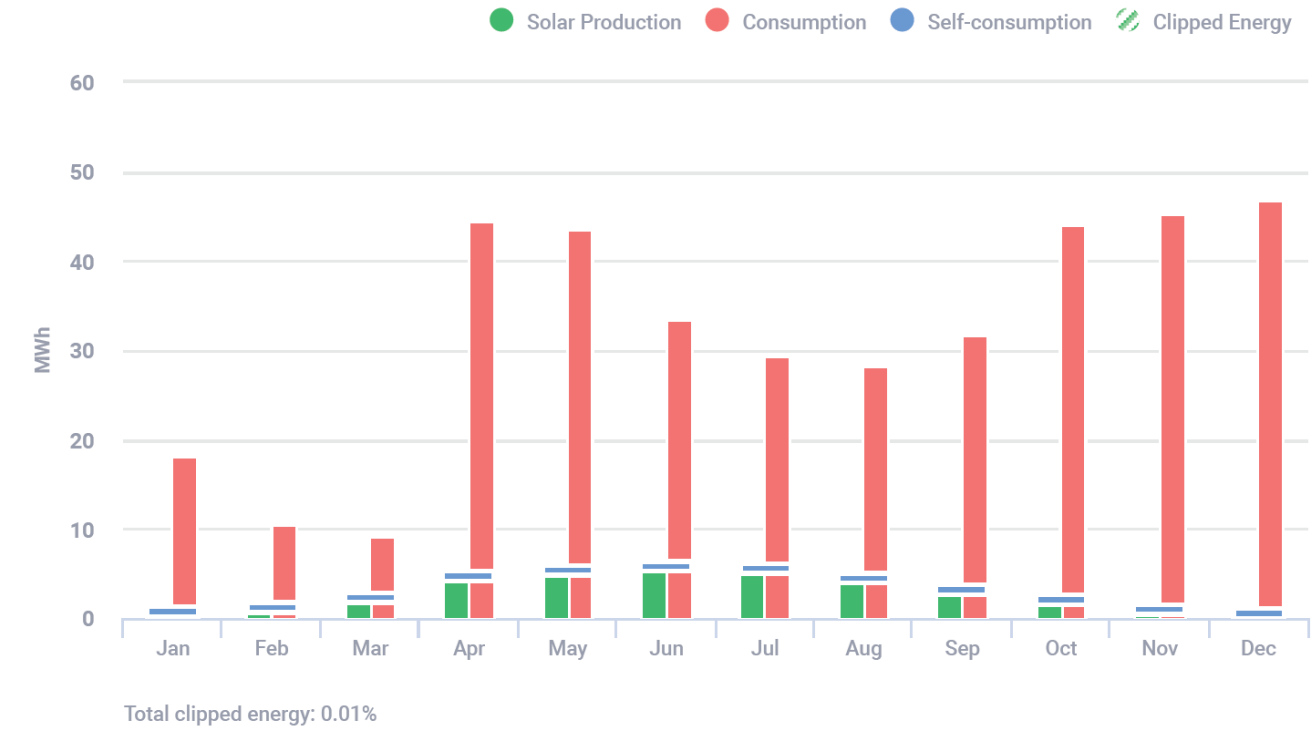
Software Simulation via SolarEdge Designer

SIMULATION RESULTS

Installed DC Power	Max Achieved AC Power	Annual Energy Production	CO2 Emission Saved	Equivalent Trees Planted
40.56 kWp	33.30 kW	39.05 MWh	10.97 t	504

Max Achieved DC Power	DC/AC Oversizing	Max Active AC Power	Performance Ratio	Performance Index
36.67 kW	110 %	33.30 kW	89 %	963 kWh/kWp

ESTIMATED MONTHLY ENERGY



Total clipped energy: 0.01%

PV System

- PV Generator Output 40.56kWp
- Spec. Annual Yield 963kWh/kWp
- Performance Ratio (PR) 89%
- PV Generator Energy (AC grid) 39,050kWh/Year
- CO_2 Emissions avoided 10,970kg/Year

System Efficiency & Losses

SYSTEM LOSS DIAGRAM

AC Electrical Design

Within this section are the details of the circuit requirements for the installation. These have been designed and will be installed, tested and commissioned in accordance with BS 7671 and the IET Code of Practice for Grid Connected Solar Photovoltaic Systems .

Existing Main Supply & Distribution Board

The proposed Microgeneration System will be connected in parallel with the Grid Supply. The main electrical intake room for the site, along with DNO ring main unit and LV meter and main MCCB LV distribution panel is situated in a plant room on the southern side of the building facing into the main car park.

AC SUPPLY CONNECTION

The existing AC supply cables into the electrical switch room will be sufficient and no work is required to upgrade.

We did not carry out an inspection of existing cabling and supplies to the LV DB's. We have however identified suitable connection points on the existing DB's which will be connecting into.

AC Equipment Selection

Main building - 3PH & N AC Isolator – Electrical switch room

SolarEdge MODBUS Energy Meter - The Meter has been selected to monitor imported electricity from the Grid Supply and exported electricity generated by Microgeneration. Information from the Energy Meter will be available to the Client with accurate consumption data and reporting via the SolarEdge Portal.

Surge Protection Devices are built into the SolarEdge inverters on the DC side and are also on the communications connections.

Reference voltage required for the Generation Meter and Modbus Meter: This will be taken from a panel nearby to the mains incoming supply and will be a 3 phase MCB rated at 6A.

The SolarEdge Inverter is selected as the most suitable option for the size of the proposed Photovoltaic System. This determination is based upon designing the array through the proprietary SolarEdge Designer software which has confirmed that the inverters are correctly sized for the array proposed upon Stradbroke:

Main building - 1 x SolarEdge SE33.3k inverter

The SolarEdge firefighter gateway provides centralized safety management of SolarEdge systems: If the firefighter gateway is properly installed and fully functional, firefighters can halt production of a SolarEdge photovoltaic (PV) power harvesting system and have visual acknowledgement that the installation outputs a safe DC voltage. The power production can be stopped either manually through an emergency stop button or automatically through a Fire Alarm Control Panel system.

A manual 'firefighters switch' PV isolator will be installed by each of the PV array connections into the DB's.

Lockable Isolation

The installation will have a correctly rated 4-Pole Switched Isolator at the origin of supply within each electrical switch room. The device will provide 4-Pole disconnection from paralleled Grid and Microgeneration Supplies. The device will be lockable with the use of a padlock should it be required.

DC Electrical Design

Within this section are the details of the circuit requirements for the installation. These have been designed and will be installed in accordance with all relevant standards and regulations, including but not limited to those nominated in the tender specification.

DC String Layout

ELECTRICAL DESIGN

Inverters & Storage	Strings per inverter	Optimizers per string	PV modules per string
1 x SE33.3K 36.67kW | 110%	2 x strings	17 x P801 (2:1)	34
	1 x string	18 x P801 (2:1)	36

DC CABLE TYPE AND LIVE CONDUCTOR SIZE:

- 4mm^2 -40°C to +90°C Single Core Double Insulated (EN50618)
  - Voltage Rating (Uo/U) AC: 600/1000V DC: 900/1800V
  - Temperature Rating Fixed: -40°C to +90°C
  - Minimum Bending Radius: Fixed: 4 x overall diameter / Flexed: 5 x overall diameter
  - Maximum Voltage (Umax): 1.8kV DC (conductor/conductor, non-earthed system, circuit not under load)
  - Maximum Conductor Temperature: +120°C (for 20000h)
  - Test Voltage: 6.5kV AC according to BS EN 50395
  - Sheath Colour: Black
  - UV Resistant: HD 605/A1
  - Low Smoke Halogen Free: BS EN 50267-2-1, BS EN 60684-2, BS EN 61034, BS EN 50267-2-2
  - Ozone Resistant: BS EN 50396
  - Flame Retardant: BS EN/IEC 60332-1-2
  - Thermal Endurance: BS EN/IEC 60216-1

CABLE CONTAINMENT:

- 50-200mm Hot-Dipped Medium Duty Cable Tray

ADDITIONAL PROTECTION:

- Arc Fault Protection – When connecters or cables in a PV system are improperly connected or are damaged, the electric current may pass through the air, causing an electric arc. Arcs generate heat which can cause fires and they also pose an electrocution risk to those working near them. As PV systems age and connectors and cables degrade, the risk of electric arcs, while still low, increases. In Europe, there are currently no standards for arc fault detection. In addition, there is no IEC or EN product standard available for arc fault detection (however there are recommendations in installation standards, e.g. IEC 62548). Since the risk of arcs in PV systems exists everywhere, arc fault detection is recommended and may be required in the future. SolarEdge inverters are designed to identify arc detections and subsequently shut down.
    - The Inverter has a built in Arc Detection Device with manual and automatic reconnection.
- DC Surge Protection is also present within the inverter

DNO APPROVAL OF GRID-TIED MICROGENERATION SYSTEMS

The proposed microgeneration system exceeds 16 Amps/phase. As such CorEnergy have submitted an application to UK Power Networks for an ENA G99 grid connection.

Once parallel connection of the microgeneration system as designed within this report is made with the Grid Supply, the installer is required to notify the DNO.

We await confirmation of any requirements by UKPN for a witness test or any export limitation.

Planning

The rooftop array has been designed in accordance with the Town & Country Planning Act to comply with the General Permitted Development Order (as amended 2015). In light of this the installation is permitted development and should not require planning permission.

However, local restrictions may apply and it will be the responsibility of the building owners and/or operator to satisfy themselves of any specific local planning conditions.

In this regard CorEnergy will assist with information and drawings as may be requested.

Structural Assessment

An independent structural assessment will be carried out by a registered structural engineer, to confirm the suitability of the proposed roof structure for the Solar Array. The assessment will take into account wind uplift and snow loadings for the particular installation location.

The report will be carried out in accordance with BS EN 1991-1 BRE, the Digest 489 (2014), MIS 3002 & specifically Sections 4.3.6 to 4.3.8 of the Guide to the Installation of Photovoltaic Systems as required.

Construction Phase Plan

A detailed construction phase plan will be prepared and submitted to the Client for approval, as part of the pre-construction planning process. CorEnergy will make all necessary arrangements and provide sufficient information to enable safe working practices throughout the Installation.

Existing Electrical Installation Condition

It is expected that existing electrical infrastructure at the site complies fully with the requirements as set out in BS7671 IET Wiring Regs (18th Edition). Electrical Installation Condition Reports will be made available by the building owners/operator prior to commencement of the construction phase.

Any non-compliances which directly or indirectly affect the installation, testing, commissioning or operation of the proposed solar PV system may require rectification prior to installation of the PV system. CorEnergy and its subcontractors can accept no liability for such non-compliances, or cost for their rectification. However, they will undertake to cooperate fully to bring about cost-effective such upgrades as may be necessary to rectify any non-compliance.