

PV system verification report (IEC 62446-1)

Greenfold Community Energy, Riverside Business Park



System	Riverside Building 2 roof array
Site	Greenfold Community Energy, Building 2 Riverside Business Park, Wharf Road, Marlbury
Client	Greenfold Community Energy Co-operative
Report reference	RK-2026-0512
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Prepared by	Anika Sorensen

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Name	Organisation	Copies
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1 Part A – System documentation

System data

System name	Riverside Building 2 roof array	Rated power DC (kWp)	98.40
Rated power AC (kW)	90	PV modules (make / model / quantity)	Helion HX-410M, 410 Wp, 240 modules
Inverters (make / model / quantity)	Veltis V-30K-3P, 30 kW, 3 units	Installation date	27 Sep 2023
Commissioning date	11 Oct 2023	Customer name and address	Greenfold Community Energy Co-operative,
Site address	Greenfold Community Energy, Building 2 Riverside Business Park, Wharf Road, Marlbury, MB5 9CK	Designer (name / company / contact)	Not applicable
Installer (name / company / contact)	Not applicable		

1.1 Single-line diagram



Figure 1.1 — Inverters, DC isolators and AC distribution as installed (single-line diagram GCE-E-001 is in the O&M manual)

1.2 Datasheets and as-built records

Document	Reference / version	Supplied
Module datasheet	HX-410M rev C	Yes
Inverter datasheet	V-30K-3P	Yes
Mounting system datasheet	SSC-200	Yes
Array layout drawing	GCE-E-002 rev B	Yes
Cable schedule	GCE-E-003	Yes
Inverter firmware version	4.12.1	Yes

1.3 Mechanical design

Mounting

Mounting type (roof parallel / tilted / in-roof / ground)	Roof parallel on standing-seam clamps	Orientation (azimuth)	185° (south-south-west)
Inclination (°)	12	Structural assessment reference	Structural check by Example Engineers, ref EE-2023-114

1.4 Operation and maintenance information

The system operates automatically; the inverters start when the array voltage exceeds the start threshold and shut down at dusk. If generation stops, check the AC isolator, the inverter display for fault codes and the DC isolators in that order. Emergency shutdown: open the AC isolator in the plant room, then the DC isolators at the inverters; the array remains live in daylight. Maintenance: visual inspection and cleaning annually, electrical re-test every two years, thermography every two years or after any fault.

2 Part B – Inspection

The installation was inspected visually before testing. Tests were carried out in a safe order: AC circuits first, then DC earth continuity and bonding, polarity, string open-circuit voltage, string current, functional tests and finally array insulation resistance.

DC system

Item	Result	Note
DC cables rated for the system voltage and current and suitable for the environment	✓ Pass	
PV-rated (not mixed-brand) connectors throughout	✓ Pass	
String fusing or overcurrent protection as designed	✓ Pass	
DC isolator(s) correctly rated and accessible	✓ Pass	
Surge protection devices fitted where specified	✓ Pass	
DC cables supported, protected from mechanical damage and sunlight	✓ Pass	
No damaged, chafed or UV-degraded cable sheath	✓ Pass	

AC system, protection and labelling

Item	Result	Note
AC isolator and protection as designed	✓ Pass	
Inverter installed to the manufacturer's instructions and ventilated	✓ Pass	
Loss-of-mains protection settings correct for the network operator	✓ Pass	
Metering and monitoring connected	✓ Pass	
Dual-supply and shutdown labels fitted at the origin, meter position and inverter	✓ Pass	
Warning labels on DC isolators, junction boxes and combiner boxes	✗ Fail	Label on DC-3 faded; replaced

Mechanical, enclosures, bonding and cable routing

Item	Result	Note
Mounting system installed to the design and the manufacturer's instructions	✓ Pass	
Roof penetrations weather-tight	✓ Pass	
Modules clamped with the correct torque and clamp zones	✓ Pass	
Enclosures of the specified IP rating, glands sealed	✗ Fail	CB-2 gland loose; tightened on site
Earthing and equipotential bonding of frames and metalwork as designed	✓ Pass	
No corrosion between dissimilar metals	✓ Pass	
Cable routing avoids trip, chafe and rodent hazards	✓ Pass	

The installation is tidy and consistent with the design drawings. Non-conformities: the warning label on DC

isolator DC-3 is faded and illegible (minor); the gland on combiner box CB-2 is not tightened and the box IP rating is compromised (major, rectified on site); the roof-edge guard rail is missing one post cap (minor). All other inspection items passed.

3 Part B – Test results

Table 3.1 — Test instruments

Instrument	Serial number	Calibration due	Used for
Seaward PV150 installation tester	PV150-23311	2026-01-09	Voc / polarity
Seaward PV150 installation tester	PV150-23311	2026-01-09	Isc / current
Megger MIT1025	MIT-77102	2025-11-20	Insulation resistance
Seaward Solar Survey 200R	SS200-0451	2026-01-09	Irradiance
Megger MFT1741	MFT-50921	2025-11-20	Earth continuity

Table 3.2 — String open-circuit voltage, polarity and earth continuity

String ref	Modules / string	Voc STC per module (V)	Module temp (°C)	Voc temp coeff (%/°C)	Voc expected (V)	Voc measured (V)	Deviation (%)	±5 % check	Polarity OK	Earth continuity (Ω)
S1	18	49.50	25.0	-0.290	891.0	881.2	-1.3	Pass	Correct	0.30
S2	18	49.50	25.0	-0.290	891.0	879.6	-0.9	Pass	Correct	0.30
S3	18	49.50	25.0	-0.290	891.0	883.0	-1.4	Pass	Correct	0.30
S4	18	49.50	25.0	-0.290	891.0	878.1	-1.2	#REF!	Correct	0.30
S5	18	49.50	25.0	-0.290	891.0	880.4	#REF!	#REF!	Correct	0.30
S6	18	49.50	25.0	-0.290	#REF!	876.9	#REF!	#REF!	Correct	0.30

Table 3.3 — String current test (irradiance-adjusted)

String ref	Irradiance (W/m²)	Isc STC (A)	Isc expected (A)	Isc / operating current (A)	Deviation (%)	±10 % check	Method
S1	812	10.90	8.85	8.72	-1.8	Pass	Isc
S2	812	10.90	8.85	8.69	-1.1	Pass	Isc
S3	812	10.90	8.85	8.75	-2.7	Pass	Isc
S4	812	10.90	8.85	8.61	-1.7	#REF!	Isc
S5	812	10.90	8.85	8.70	#REF!	#REF!	Isc
S6	812	10.90	#REF!	8.44	#REF!	#REF!	Isc

Table 3.4 — PV array insulation resistance (each pole to earth)

String ref	Voc STC string (V)	System voltage (V)	Required test V	Minimum (MΩ)	Test voltage used (V)	Ri + to earth (MΩ)	Ri – to earth (MΩ)	Lowest (MΩ)	Result
S1	891	1,114	1,000	1.0	1,000	212.0	205.0	190.0	Pass
S2	891	1,114	1,000	1.0	1,000	198.0	190.0	231.0	Pass
S3	891	1,114	1,000	1.0	1,000	240.0	231.0	199.0	Pass
S4	891	1,114	1,000	1.0	1,000	205.0	199.0	181.0	Pass
S5	891	1,114	#REF!	#REF!	1,000	188.0	181.0	169.0	#REF!
S6	891	#REF!	#REF!	#REF!	1,000	176.0	169.0	#REF!	#REF!

Functional tests

Item	Result	Note
Switchgear and isolators operate correctly	✓ Pass	
Inverter start-up and shutdown per manufacturer procedure	✓ Pass	
Loss-of-mains protection trips on disconnection	✓ Pass	
Monitoring reports generation	✓ Pass	
Emergency shutdown procedure demonstrated	✓ Pass	

Verification summary

Circuits inspected and tested	Six strings, three inverters, two combiner boxes, AC distribution	Category 2 tests performed (I-V curve, IR)	I-V curve traces on all strings; thermography of the array and combiner boxes
Recommended interval to next verification (years)	2	Tester	Anika Sorensen
Date	12 May 2026		

I confirm that the installation was inspected and tested as recorded and that, apart from any items listed as non-conforming, it was found to comply with the design and the applicable requirements.

Prepared by

Anika Sorensen

BEng (Hons), MCS accredited, ISO 9712 Level 2 thermographer

Report Kit 360

Date: 19 May 2026

4 Part C – Thermographic inspection (annex)

This annex records an outdoor infrared inspection of the PV modules and balance-of-system components, following the approach of IEC TS 62446-3. Inspection level: **detailed**.

Personnel

PV expert	Anika Sorensen	Thermographer and qualification (ISO 9712 level or equivalent)	Anika Sorensen, ISO 9712 Level 2
Attending persons	Site caretaker; co-operative energy officer	Day and time of inspection	12 May 2026

Camera system

Make and model	FLIR T560	Serial number	FT560-004412
Lens	24° (f = 17 mm)	Spectral range (μm)	7.5 to 14
Thermal sensitivity NETD (mK)	30	Resolution (px)	640 x 480
Last traceable calibration	14 Oct 2025	Months since calibration	7
Visual camera (make / resolution)	Built-in 5 MP		

Environmental conditions

Air temperature (°C)	19	Wind (Bft) and direction	2 Bft SW
Cloud cover (okta) and type	1 okta, cirrus	In-plane irradiance (W/m ²)	812
DC load during imaging (% of rated)	Not applicable	Thermal steady state reached (≥15 min after >10 %/min change)	Yes; inverters on for over 60 minutes before imaging

Inspection condition limits

For a meaningful module inspection the in-plane irradiance should be at least 600 W/m², wind no more than 4 Bft (about 28 km/h), cloud no more than 2 okta of cumulus, soiling none or low, and the plant at thermal steady state. Where the survey departed from these limits the deviation and its effect on the findings must be stated in the procedure section.

4.1 Soiling



Figure 4.1 — Bird soiling on module 1-7 at the time of inspection

Light, uniform dust with localised bird droppings on rows 1 and 2 (about 2% of module area). The soiling was not sufficient to affect the thermal results except at module 1-7, which is recorded as a CoA 1 anomaly.

4.2 Scope

Contracted scope

Component type designations	Crystalline silicon modules; string inverters; DC combiner boxes	PV module efficiency (%) / BOS nominal rating	21.0% / 90 kW AC
Components inspected (list or reference)	All 240 modules; CB-1 and CB-2; three inverters	Mounting, orientation and inclination	Roof parallel, 185°, 12°

BOS location (roof / conduit / open air)	Combiner boxes on the roof; inverters in the plant room
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4.3 Inspection procedure

The array was inspected from the roof walkway at a viewing angle of 60° to 80° to the module plane using a FLIR T560 with the 24° lens, emissivity set to 0.85 for glass and reflected temperature measured by the reflector method (31 °C). Irradiance was logged with a reference cell in the plane of the array and remained above 780 W/m² throughout. The inverters were on and the strings loaded. Each module was imaged individually and the combiner boxes were imaged with the covers removed.

4.4 Classes of abnormality

Each anomaly is classified as follows:

Colour	Rating	Meaning
	CoA 1	No abnormality: the component is working normally and no action is imminent.
	CoA 2	Thermal abnormality: establish the cause and, where necessary, put it right within a reasonable period.
	CoA 3	Safety-relevant thermal abnormality: interrupt operation promptly, establish the cause and rectify within a reasonable period.

4.5 Anomaly register

Table 4.1 — Thermal anomaly register

ID	Location (≥2 identifiers)	Abnormality	CoA	T max (°C)	T ref (°C)	ΔT (K)	G (W/m²)	x	ΔT at 1000 W/m² (K)	Module Wp	Est. loss (%)	Est. kWh/yr	Est. £/yr	Remedial action
A1	Row 3, module 14	Single hot cell	CoA 2	48.6	31.2	8.8	812	1.00	34.4	410	2.5	143	£19.11	Inspect module; replace if cell cracked
A2	Row 5, module 2	Substring open circuit (bypass diode active)	CoA 2	39.8	31.0	27.9	812	1.00	6.0	410	33.0	78	£1.72	Test diodes; replace module
A3	Combiner box CB-2	Heated connection, string 4 fuse holder	CoA 3	61.4	33.5	4.9	812	1.00	#REF!	7,380	1.0	7	#REF!	Isolate and remake the connection immediately
A4	Row 1, module 7	Cells shaded by soiling (bird droppings)	CoA 1	36.1	31.2	#REF!	812	1.00	#REF!	410	1.5	#REF!	#REF!	Clean at the next maintenance visit

Estimated annual energy loss from listed anomalies

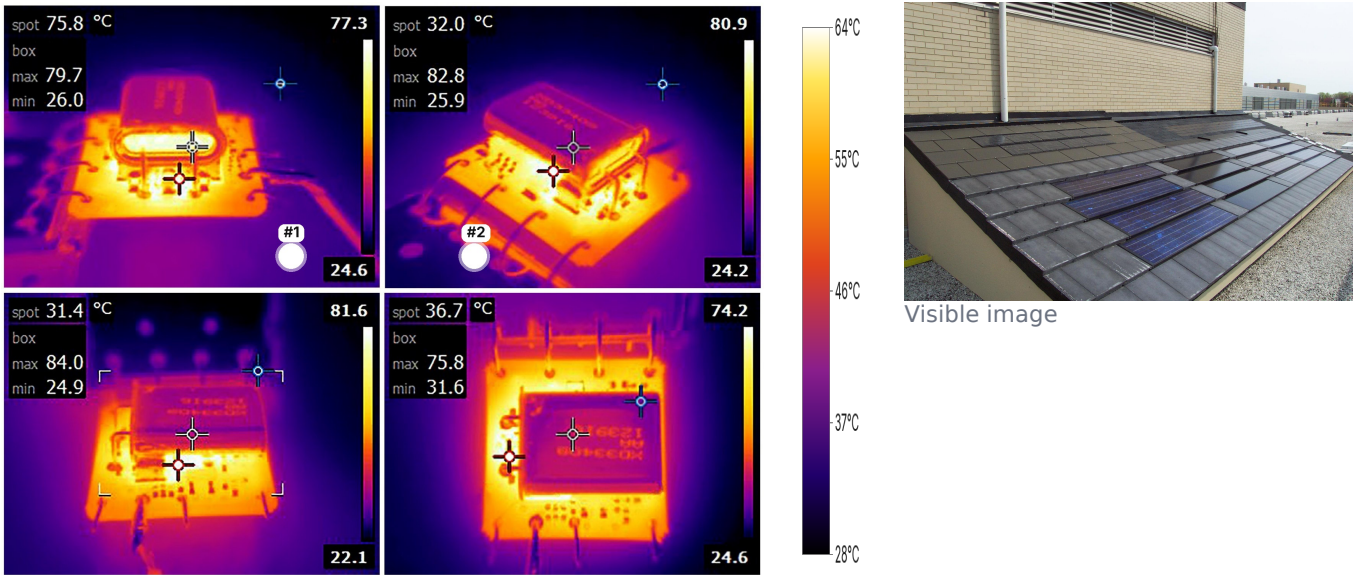
#REF! kWh/yr

Estimated annual cost of losses

#REF! £/yr

Thermogram

Anomaly A3



Infrared image — Ironbow palette

Scale	28.0 to 64.0 °C	Emissivity (ε)	0.95
Reflected temperature	31.0 °C	Ambient temperature	19.0 °C
Distance	0.8 m	Relative humidity	48 %
Classification	Electrical		
Severity	CoA 3		

#	Label	Type	Position	Temperature
S1	Sp1 string 4	Spot	38%, 44%	61.4 °C
S2	Sp2 string 5	Spot	62%, 44%	33.5 °C

Interpretation

String 4 fuse holder 28 K hotter than its neighbours under the same load: a high-resistance connection. Classified CoA 3 (fire risk); rectified on site and re-imaged.

Image record

Object description	Combiner box CB-2, cover removed, string fuse holders	File name	IR_CB2_0412.jpg
Date and time	2026-05-12 12:40	Camera serial and lens	FT560-004412, 24° lens
Emissivity used	0.95	Reflected temperature (°C)	31
Ambient temperature (°C)	19	Exact location in plant (row / column / serial)	Roof, north-east corner, CB-2
Cell designation (row letter / column number)	Not applicable (combiner box)		

Combiner box CB-2, string 4 fuse holder, 28 K above the neighbouring holders at 61 °C. This is a loose or corroded connection and is classified CoA 3 because of the fire risk. The connection was isolated and remade on the day; a repeat image after 30 minutes showed the holder within 2 K of its neighbours. Recommend checking torque on all fuse holders in CB-1 and CB-2 and repeating the thermography in two years.

5 Summary of results and recommendations

All six strings passed the open-circuit voltage, current and insulation resistance tests with deviations within 5% and insulation resistance above 160 MΩ. Functional tests passed. Thermography found four anomalies: one CoA 3 (combiner box connection, rectified on site), two CoA 2 (hot cell at 3-14 and an open substring at 5-2, to be replaced) and one CoA 1 (soiling). The estimated annual loss from the listed anomalies is small. The system is fit for continued operation; the next periodic verification is due in two years.

Unless stated otherwise, the next periodic thermographic inspection is recommended in 2 years.

The findings describe the condition observed on the inspection date. Buildings and assets change with time, weather and use; if a decision is to be made more than three months after the inspection date we recommend that the relevant areas are re-inspected.

Appendix A – Thermal abnormality reference

Typical patterns for crystalline and thin-film modules, summarised from the IEC TS 62446-3 matrix in our own words. ΔT values are at 1000 W/m².

Abnormality	CoA	Typical ΔT	Pattern / action
Module in open circuit	2	2–7 K (typically 4–6 K)	Whole module uniformly warm; check module, inverter state, cabling, connectors and fuses
Module in short circuit	2	2–7 K average	Patchy pattern similar to PID or cell defects; check module and cabling
Broken front glass (crystalline)	3	0–7 K average	Insulation lost — high-voltage hazard; may look normal at first
Substring in short circuit	2	Substring 2–7 K warmer	Check module and bypass diodes under reverse bias
One substring open circuit	2–3	2–7 K	One third of module warm with active bypass diode; an arc at the rear raises it to CoA 3
Two substrings open circuit	2–3	2–7 K	Two thirds of module warm; arc raises it to CoA 3
Single hot cell	2 / 3	10–40 K over the cell / above 40 K	Broken cells; check shading and soiling; may damage encapsulant or diodes
Cells shaded by soiling	1 / 2	A few K (wet climates) / above 40 K (dry)	Clean where the climate is dry
Broken front glass (thin film)	3	0–7 K average	Insulation lost
Transfer resistance at cross-connections (thin film)	2–3	Above 10 K	Point abnormality, poor soldering; review by a Level 2 thermographer
Transfer resistance at cell connections (crystalline)	2–3	Above 10 K	Broken ribbon or missed solder joint; review by a Level 2 thermographer
Heated junction box	2–3	3 K or more against neighbouring boxes	Contact resistance or leaky bypass diode; high voltage

Declaration

I confirm that the inspection, tests and thermographic survey recorded in this report were carried out as stated.

Prepared by

Anika Sorensen

BEng (Hons), MCS accredited, ISO 9712 Level 2
thermographer

Report Kit 360

Date: 19 May 2026

Checked by

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