Potential of Solar Photovoltaic (PV) in Belfast Area for the Department for the Economy Northern Ireland

10X Economy Project

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Executive Summary

GIA have successfully completed a desk-based solar photovoltaic (PV) rooftop assessment across 56 properties in Belfast in response to the Department for the Economy's (the Department) 10X Economy Open Call. The properties included a mix of both domestic and non-domestic properties, including two car park sites. The results of the project represent a pilot into the cutting-edge use of 3D modelling, bespoke spatial analysis tools, and expert daylight and sunlight assessment by Gordon Ingram Associates (GIA). The results demonstrate the potential application of solar PV across 56 properties as a first step to inform at scale climate change policies and renewable energy strategies, particularly in response to the recent introduction of the Climate Change Act (Northern Ireland) 2022[1]. Crucial to the rationale for this project in providing a technical evidence base to support renewable energy transitions in Northern Ireland, Article 15 of the Climate Change Act (Northern Ireland) 2022 sets the following target for the Department:

> *"The Department for the Economy must ensure that at least 80% of electricity consumption is from renewable sources by 2030…" (Climate Change Act (Northern Ireland) 2022).*

Assessments and Scenarios

Two solar assessments were carried out:

1. **The Standard Assessment Procedure (SAP):**

SAP is the United Kingdom (UK) Government's National Calculation Methodology for assessing the energy performance of dwellings. It is used to facilitate various national, devolved, and local government policies including Building Regulations and the production of Energy Performance Certificates (EPCs) (BRE, 2023[2]).

2. **Climate Based Daylight Modelling (CBDM):**

CBDM is the prediction of various radiant or luminous quantities (e.g., irradiance, illuminance, radiance and luminance) using sun and sky conditions that are derived from standard meteorological datasets.

CBDM is the preferred methodology adopted nationally and at European level for testing daylight and sunlight within the urban environment. The methodology for assessing solar irradiance (the quantum of solar energy reaching a prospective solar PV array) adopted in this study, follows the recommendations of BRE's BR 209[3] as well as BS EN 17037[4].

This report provides both SAP and CBDM assessment results.

The reason for this is to offer the reader an opportunity to evaluate the solar potential based on two leading methodologies available.

SAP represents the UK government's standardised assessment procedure for building energy measurement, while CBDM represents a methodology that makes use of the latest climate based meteorological files and shading analysis.

Both SAP and CBDM approaches are viable to assessing solar PV and their comparison represents an important feature of the project results to help inform best practice solar analysis in future.

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[1] *The Climate Change Act (Northern Ireland) 2022 is available at the following link: Climate Change Act (Northern Ireland) 2022 (legislation.gov.uk)*
[2] *SAP 10.2 is available at the following link: SAP 10.2*
[3] *BRE 209 is available at the following link: BRE 209*
[4] *BS EN 17037 is available at the following link: BS EN 17037*

While the assessments were run at individual PV panel level, results are presented at four different scales:

1. Individual solar PV panel scale.
2. Roof scale.
3. Building / Property scale.
4. Cumulative scale (56 properties combined).

Eight scenarios were run as standard, as set out in Table 1:

Table 1: Scenarios Assessed

Scenario No.	Scenario Description
1	**100% self-consumption** and installation of PV on 100% of usable roof space. This scenario represents the maximum future baseline based on the calculated usable roof space.
2	**75% self-consumption**, 25% export and installation of PV on 100% of usable roof space.
3	**50% self-consumption**, 50% export and installation of PV on 100% of usable roof space.
4	**50% self-consumption**, 0% export and installation of PV on 100% of usable roof space. This scenario demonstrates the potential option for, and impact of, zero export agreements with the electricity Distribution Network Operator (DNO).
5	**100% self-consumption** and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel**.
6	**75% self-consumption,** 25% export and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel**.
7	**50% self-consumption**, 50% export and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel**.
8	**50% self-consumption**, 0% export and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel.** This scenario demonstrates the potential option for, and impact of, zero export agreements with the electricity DNO.

Background to the Results

Results reporting within the main body of the report focussed on Scenario 1:

1. **Scenario 1**: A maximum future baseline scenario of installing PV across 100% of the usable roof space of the properties and 100% self-consumption from the electricity generated by PV installations.

This scenario was chosen for reporting given that the primary aim of the project was to identify the maximum solar potential of the Belfast properties (Scenario 1) based on the calculated usable roof space. The remainder of the scenario tested results are available in the project's associated data files. The report also makes comparisons with other scenarios to demonstrate the impact of panel filtering based on annual performance viability requirements and reduced self-consumption.

While every property reviewed had solar PV potential, various site-specific factors influenced each property's generation potential, including existing roof features, roof orientation and pitch, and the shading associated with the existing and consented surrounding built environment features.

The total installation sizes are subject to further on-site detailed assessments, such as structural assessments, system configuration assessments, and mounting kit layout assessments.

Additionally, the capacity of installations may be constrained by the DNO for Northern Ireland, in this case Northern Ireland Electricity (NIE), and access to the national electricity grid. NIE have various connection processes and limitations depending on the size of the proposed installation (micro-generation, small scale, and large scale), the existing grid network capacity, existing site infrastructure, future network capacity, and infrastructure upgrade costs.

G99 grid connection costs for small- and large-scale generators (typically installations above 11.04kW on three phase electricity supplies and 3.68kW on single phase electricity supplies) can vary significantly and impact on system design and viability. As such, early engagement with NIE is advised ahead of any potential installation to ascertain connection costs and alternative design options. Options exist for smart metering and export limiting agreements that can help overcome some of these potential constraints by reducing the reliance and impact on the national electricity grid. On this, self-consumption is a crucial determinant and should influence system design.

GIA emphasise that the economic forecasts contained in this report are purely estimates and based on desktop research findings. The installation cost estimates are based on data by the UK Government's Department for Energy Security and Net Zero[5] (DESNZ) and the Department of Agriculture and Rural Development of Northern Ireland[6] (DAERA) . Any interested partners would need to obtain quotations from accredited installers for official cost projections in addition to further detailed on-site investigations. The price per unit of electricity is also an estimate based on Power NI's commercial trend data[7] when assessing commercial properties, the Northern Ireland Consumer Council's domestic trend data[8] when assessing domestic properties and Power NI's export price data, as the only NI electricity supplier obligated to offer an export tariff to potential customers. These units can be highly variable. Additionally, grid connection agreements may include export limits and therefore influence the potential financial return from systems which produce in excess of their on-site demand.

Results

The following provides key high-level results from both SAP and CBDM analyses for Scenario 1.

<u>Scenario 1</u> (installation of PV on 100% of usable roof space and 100% self-consumption of PV generated electricity):

- Across the 56 properties 21,598,484 kWh of electricity is consumed each year.
- If PV installations were maximised across 100% of the properties calculated usable roof space, an estimated 24,171 PV panels (350wp) could be installed, equating to a combined system size of 8,459.9 kilowatts peak (kWp) with an estimated generation potential between 6,985,537 kWh/year (SAP) and 5,561,672 kWh/year (CBDM).
- If the 56 properties could use all 100% of the electricity generated by PV on-site, this could see combined self-sufficiency from PV create between a 32.3% (SAP) and 25.8% (CBDM) reduction in the use of electricity from the national grid and reduce carbon emissions by between 2,590.9 tonnesCO_{2e} per year and 2,062.8 tonnesCO_{2e} per year (includes an allowance for the carbon cost of PV installation).
- If the properties used 100% of the electricity generated by PV on-site, the estimated payback period could be between 6.45 (SAP) and 8.09 (CBDM) years based on an estimated installation [one-off] cost of £8,596,265 and financial benefit of between £1,332,821 (SAP) and £1,062,591 (CBDM) per year.

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[5] *DESNZ cost data is available at the following link: DESNZ*

[6] *DAERA cost data is available at the following link: DAERA*

[7] *Power NI cost data available at the following link: Power NI*

[8] *Consumer Council cost data available at the following link: Consumer Council*

- Considering only the non-domestic properties assessed, the payback period for 36 properties could be between 6.49 years (SAP) and 8.17 years (CBDM).
- Considering only the domestic properties assessed, the payback period could be between 4.21 years (SAP) and 4.62 years (CBDM). However, it must be recognised that no existing electricity usage data was provided as part of the project and therefore an estimated annual electricity consumption rate for domestic properties was set at 3,588kWh based on data from the Utility Regulatory for Electricity, Gas and Water Northern Ireland's (URGENI) Annual Retail Energy Marketing Monitoring report for 2021, as discussed further in Section 5.
- For comparison purposes, across the 56 properties, if an annual panel performance viability threshold was applied to only install panels which generated a minimum of 188.17kWh/year (aims to filter out each panel which does not achieve a capital payback within 10 years based on the combined data across the 56 assessed properties), system sizes would be reduced to 6,844.6kWp based on the impact of the SAP methodology and 7,785.4kWp based on the CBDM methodology. Additionally, the estimated PV generation from the total installations would be reduced to 6,243,198kWh/year (SAP) and 5,263,279 kWh/year (CBDM). However, the estimated payback periods would also be reduced to 5.85 years (SAP) and 7.9 years (CBDM) due to the impact of effective filtering that removes panels that do not meet annual viability requirements.

The Top 3 Highest Electricity Using Properties:

1. Property 47 - Belfast City Hospital - Cancer Centre: 4,409,518kWh/year.
2. Property 52 - Mater Hospital – Dempsey: 2,426,201 kWh/year.
3. Property 56 - Belfast Metropolitan College (BMC) - Titanic Quarter: 1,167,274kWh/year.

The Top 3 Properties with the Highest Potential Electricity Generation from PV:

1. **Property 18 - Grove Wellbeing Centre:**
- SAP Modelling: 682,559kWh/year.
- CBDM Modelling: 499,248kWh/year.

2. **Property 20 - Ozone Leisure Centre:**
- SAP Modelling: 552,133kWh/year.
- CBDM Modelling: 421,834kWh/year.

3. **Property 56 - Belfast Metropolitan College (BMC) - Titanic Quarter:**
- SAP Modelling: 530,276kWh/year.
- CBDM Modelling: 419,747kWh/year.

The Top 3 Properties with the Highest Potential Carbon Emissions Saving:

1. **Property 18 - Grove Wellbeing Centre:**
- SAP Modelling: 253.2 tonnesCO_{2e} per year.
- CBDM Modelling: 185.2 tonnesCO_{2e} per year.

2. **Property 20 - Ozone Leisure Centre:**
- SAP Modelling: 204.8 tonnesCO_{2e} per year.
- CBDM Modelling: 156.5 tonnesCO_{2e} per year.

3. **Property 56 - Belfast Metropolitan College (BMC) - Titanic Quarter:**
- SAP Modelling: 196.7 tonnesCO_{2e} per year.
- CBDM Modelling: 155.7 tonnesCO_{2e} per year

<u>The Top 3 Non-Domestic Properties with the Quickest Estimated Payback Period:</u>
Based on SAP modelling –

1. **Property 93 - Woodstock Library:**
- SAP Modelling: 5.27 years.

2. **Property 27 - National Museums Northern Ireland, Unit 12-21:**
- SAP Modelling: 5.29 years.

3. **Property 91 - Ormeau Road Library:**
- SAP Modelling: 5.47 years.

Based on CBDM modelling –

1. **Property 27 - National Museums Northern Ireland, Unit 12-21:**
- CBDM Modelling: 7.66 years.

2. **Property 19 - Duncrue Complex:**
- CBDM Modelling: 7.68 years.

3. **Property 91 - Ormeau Road Library:**
- CBDM Modelling: 7.69 years.

<u>The Top 3 Domestic Properties with the Quickest Estimated Payback Period:</u>
Based on SAP modelling –

1. **Property 76 - Anon ID: 8:**
- SAP Modelling: 3.65 years.

2. **Property 75 - Anon ID: 7:**
- SAP Modelling: 3.66 years.

3. **Property 77 - Anon ID: 9:**
- SAP Modelling: 3.70 years.

Based on CBDM modelling –

1. **Property 70 - Anon ID: 2:**
- CBDM Modelling: 4.32 years.

2. **Property 73 - Anon ID: 5:**
- CBDM Modelling: 4.33 years.

3. **Property 84 - Anon ID: 16:**
- CBDM Modelling: 4.39 years.

Other property specific findings are discussed in detail in the main body of the report.

Report: Solar Photovoltaic Assessment for the Department for the Economy

1 Introduction

Gordon Ingram Associates (GIA) were commissioned by the Energy Intelligence, Energy Group, of the Northern Ireland Department for the Economy (The Department) to conduct an evidence-based research proposal related to understanding the potential application and electricity generation of solar photovoltaic (PV) across 56 properties in Belfast. The assessment included a mix of both domestic and non-domestic properties, including two car park sites. Car park sites were included as part of the proposal as demonstrators to the potential for covering typically underutilised spaces and combining PV with electric vehicle (EV) infrastructure. A similar initiative is currently being undertaken in France where legislation has recently been approved by the French Senate that requires existing and new car parks with over 80 vehicles to be covered by solar PV as part of the country's climate commitments[9].

The proposal was part of GIA's response to the Department's 10X Economy Open Research Call and the project involved undertaking a desk-based technical assessment of the 56 properties PV potential based on cutting-edge use of 3D modelling, bespoke spatial analysis tools and expert daylight modelling techniques. The results of the assessment were designed to provide the Department with a technical evidence base to understand the solar potential of a sample of Belfast properties as an initial step to help inform at scale climate change policies and renewable energy strategies, particularly in response to the recent introduction of Northern Ireland's formal Climate Change Act (Northern Ireland) 2022 and the targets it sets for the country. Crucial to the rationale for this project in providing a technical evidence base to support renewable energy transitions in Northern Ireland, Article 15 of the Climate Change Act (Northern Ireland) 2022 sets the following target for the Department:

"The Department for the Economy must ensure that at least 80% of electricity consumption is from renewable sources by 2030…" (Climate Change Act (Northern Ireland) 2022).

The following report begins by providing an overview of the project context, its deliverables and stakeholders involved. It then spatially illustrates the site context of the 56 properties reviewed, followed by setting out the methodology that underpinned the analysis. The results of the analysis are then reported, demonstrating the solar PV potential for the properties individually and cumulatively from two comparable assessment approaches.

These assessment approaches were the Standard Assessment Procedure (SAP) and a Climate-Based Daylight Modelling (CBDM) approach. Both are discussed in the Methodology. Scenario modelling based on self-consumption options, panel performance viability thresholds and financial variables are also provided. While eight scenarios were run in total (see the associated appendix), reporting in the main body focuses on the future maximum baseline scenario of installing solar PV on 100% of the calculated usable roof spaces across all 56 properties and 100% self-consumption of the electricity generated by solar PV.

This scenario was prioritised for reporting as the aim of this project was to provide a technical evidence base as to the maximum solar potential of the 56 properties. The remaining seven scenarios demonstrate options for potential viability filtering and self-consumption options. The results from these scenarios are available in the associated appendix. The report concludes with a project summary.

[9] Link to information on French legislation on PV and car parks.

2 Project Context and Deliverables

2.1 Background

In October 2022 the Department published its '10X Economy Research Programme 2022-23 and Beyond'. The programme highlighted the key research areas for the Department as it seeks to deliver on its 10X Economy Vision. The aim for the research programme was:

> *"To produce research and analysis that shapes policy decisions. The evidence-base should drive successful delivery, well informed Departmental economic priorities, rebuild a stronger economy and set us firmly on the journey to realise our vision for innovation led, inclusive and sustainable growth" (The Department, 2022, p.4[10]).*

In November 2022 the Department sought proposals to address the 10X Programme's research needs through the '10X Economy: An Open Call for Research Proposals' publication. GIA responded to that Open Call with a three-stage proposal (Stage One – Short Term; Stage Two – Medium Term; Stage Three – Long Term). Each stage could be commissioned individually or collectively as part of a long-term delivery plan with the Department.

On this occasion, GIA were commissioned by the Department to implement Stage One of the proposal.

2.2 Project Aim and Deliverables

The aim of the project was to demonstrate the solar PV potential and electricity generation of 56 properties in Belfast. The deliverables for the project related to Stage One of GIA's initial research proposal dated 16th of December 2022. The deliverables were clarified as part of a kick-off meeting with the Department on the 2nd of February 2023 and through on-going engagement. The final handover deliverables that were agreed are summarised as follows:

1. **Geographic Information System (GIS)** polygon files for 56 properties, as selected by the Department based on a 3D review of Belfast within the context and coverage of VU.CITY's 3D city model.
2. **SAP and CBDM assessments** of the solar PV potential of the 56 properties. The assessments were to be based on a desktop 3D analysis and include pitched and flat roof structures.
3. **Spreadsheets listing**:
    a. Building addresses and calculated usable roof surface areas for solar PV on the 56 identified properties.
    b. Potential electricity generation related to rooftop solar PV on the 56 identified properties expressed in kilowatt hours (kWh) and based on two comparative methodologies (SAP and CBDM).
    c. Electricity Consumption data for the assessed properties (where data is provided by the Department) and a comparison between potential electricity generated by solar PV, expressed in kilowatt hours, against the properties existing use of electricity in kilowatt hours.
4. **Report** detailing the solar assessments for the assessed properties, the processes and methodologies used, the findings and recommendations (this report).
5. **Summary presentation** delivered to the Department and its interested partners.

The project and all associated deliverables, along with additional resources beyond the initial scope of works, were delivered within deadline (30th of June 2023).

[10] *The Department's 10X Economy Research Programme is available at the following link: 10X Economy Research Programme*

3 Project Location - Sites Overview

Figure 1 provides a spatial overview of the majority of the properties selected for the solar PV assessment. The basemap is based on Open Street Maps[11].

Table 2 then provides each assessed property's ID reference, name, address, and use. For confidentiality purposes, some properties are referenced only by their unique property ID in the associated Table and their location is not identified on the map below. Combined, the map and table illustrate the diversity of individual site locations selected and the project's geographic scale across Belfast.

Figure 1: Overview Map of the 56 Assessed Properties - Some properties locations have been removed for confidentiality purposes.

[11] *Road data from OpenStreetMaps copyright link: https://www.openstreetmap.org/copyright*

Table 2: 56 Properties Summary and Map IDs

Property ID	Property Name	Property Address	Property Use
1	Housing Centre	2 Adelaide Street, Belfast	Non-Domestic
2	The Plaza	31-35 Chichester Street, Belfast	Non-Domestic
5	Causeway Exchange	1-7 Bedford Street, Belfast	Non-Domestic
7	Adelaide House	39-49 Adelaide Street, Belfast	Non-Domestic
13	Belfast City Hall	Donegal Square North, Belfast	Non-Domestic
14	Ulster Hall	34 Bedford Street, Belfast	Non-Domestic
15	Cecil Ward	4-10 Linenhall Street, Belfast	Non-Domestic
16	St Georges Market	East Bridge Street, Belfast	Non-Domestic
17	Shankill Leisure Centre	100 Shankill Road, Belfast	Non-Domestic
18	Grove Wellbeing Centre	120 York Road, Belfast	Non-Domestic
19	Duncrue Complex	Duncrue Road, Belfast	Non-Domestic
20	Ozone Leisure Centre	Ormeau Embankment, Belfast	Non-Domestic
21	GLL Connswater Gym, Unit 11 Connswater Shopping Centre	Unit 11 Connswater Shopping Centre, Belfast	Non-Domestic
22	Whiterock Leisure Centre	Whiterock Close, Whiterock Road, Belfast	Non-Domestic
23	Morton Community Centre	10 Lorne St, Belfast	Non-Domestic
25	Department for Communities Offices, James House	Department for Communities Offices, 2-4 Cromac Avenue, Belfast	Non-Domestic
27	National Museums Northern Ireland, Unit 12-21	Unit 14-21, 22 Heron Road, Belfast	Non-Domestic
28	Public Records Office of Northern Ireland	Public Records Office of Northern Ireland, 2 Titanic Boulevard, Belfast	Non-Domestic
35	106-108 Holywood Road	106-108 Holywood Road, Belfast	Non-Domestic
43	Royal Victoria Hospital - New Maternity	274 Grosvenor Road, New Maternity, Belfast	Non-Domestic
44	Royal Victoria Hospital - Kelvin	274 274 Grosvenor Road, Kelvin, Belfast	Non-Domestic
47	Belfast City Hospital - Cancer Centre	51 Lisburn Road, Cancer Centre, Belfast	Non-Domestic
48	Belfast City Hospital - Multi Storey Car Park 2	51 Lisburn Road, Car Park 2, Belfast	Non-Domestic
49	Belfast City Hospital - Multi Storey Car Park 1	51 Lisburn Road, Car Park 1, Belfast	Non-Domestic
51	Mater Hospital - McAuley	45-54 Crumlin Road, McAuley, Belfast	Non-Domestic
52	Mater Hospital - Dempsey	45-54Crumlin Road, Dempsey, Belfast	Non-Domestic
53	Mater Hospital - Dorrian	45-54 Crumlin Road, Dorrian, Belfast	Non-Domestic
56	Belfast Metropolitan College (BMC) - Titanic Quarter	7 Queens Road, Belfast	Non-Domestic
58	Ulster Museum	1 Botanic Gardens, Belfast	Non-Domestic
69	Anon ID: 1	Anon ID: 1	Domestic
70	Anon ID: 2	Anon ID: 2	Domestic
71	Anon ID: 3	Anon ID: 3	Domestic
72	Anon ID: 4	Anon ID: 4	Domestic
73	Anon ID: 5	Anon ID: 5	Domestic
74	Anon ID: 6	Anon ID: 6	Domestic
75	Anon ID: 7	Anon ID: 7	Domestic
76	Anon ID: 8	Anon ID: 8	Domestic

77	Anon ID: 9	Anon ID: 9	Domestic
78	Anon ID: 10	Anon ID: 10	Domestic
79	Anon ID: 11	Anon ID: 11	Domestic
80	Anon ID: 12	Anon ID: 12	Domestic
81	Anon ID: 13	Anon ID: 13	Domestic
82	Anon ID: 14	Anon ID: 14	Domestic
83	Anon ID: 15	Anon ID: 15	Domestic
84	Anon ID: 16	Anon ID: 16	Domestic
85	Anon ID: 17	Anon ID: 17	Domestic
86	Anon ID: 18	Anon ID: 18	Domestic
87	Anon ID: 19	Anon ID: 19	Domestic
88	Anon ID: 20	Anon ID: 20	Domestic
89	Shankill Road Library	298-300 Shankill Road, Belfast	Non-Domestic
90	Fall Road Library	49 Falls Road, Belfast	Non-Domestic
91	Ormeau Road Library	Ormeau Road, Belfast	Non-Domestic
92	Belfast Central Library	Royal Avenue, Belfast	Non-Domestic
93	Woodstock Library	358 Woodstock Road, Belfast	Non-Domestic
94	Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 1	125-153 Millfield, Building 1, Belfast	Non-Domestic
95	Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 2	125-153 Millfield, Building 2, Belfast	Non-Domestic

4 Methodology

In completing the project GIA combined 3D modelling, 3D spatial analysis based on VU.CITY's photogrammetric model of Belfast, and solar insolation and PV analysis based on GIA's SAP and CBDM software.

SAP is defined by the Building Research Establishment Group (BRE) as follows:

> *"The Standard Assessment Procedure (SAP) is the UK Government's National Calculation Methodology for assessing the energy performance of dwellings. It is used to facilitate various national, devolved, and local government policies including Building Regulations and for the production of Energy Performance Certificates (EPCs)" (BRE, 2022[12]).*

The latest version of SAP is SAP 10.2. It is upon this version that GIA's SAP calculations are based.

CBDM is then defined as follows:

> *"Climate-based daylight modelling (CBDM) is the prediction of various radiant or luminous quantities (e.g., irradiance, illuminance, radiance and luminance) using sun and sky conditions that are derived from standard meteorological datasets. Climate-based modelling delivers predictions of absolute quantities (e.g., illuminance) that are dependent both on the locale (i.e., geographically-specific climate data is used) and the building orientation (i.e., the illumination effect of the sun and non-overcast sky conditions are included), in addition to the building's composition and configuration" (Daylight Experts, 2017[13]; see also Loughborough University, 2021[14])*

Based on utilising SAP and CBDM principles, the methodology undertaken by GIA when completing the assessment of the 56 properties solar potential can be described as follows:

Firstly, GIA and the Department reviewed the coverage of VU.CITY's 3D model of Belfast. VU.CITY are an industry leading 3D city platform that Belfast City Council subscribe to and encourage multi-stakeholder use of for planning and placemaking purposes[15]. Belfast City Council are the Local Government Authority within which the project took place. VU.CITY are a collaborator on this project and GIA partner organisation. Therefore, as the 3D platform represented a well-established and recognised tool used by local government in Belfast, it was considered ideal and reputable as an initial base map for this central government project with the Department.

Based on the VU.CITY coverage review, the Department provided a list and address lookup of properties that were of interest to the project. GIA reviewed the initial properties high-level suitability for solar assessment using 3D spatial analysis in VU.CITY and GIA's bespoke solar assessment software. Where properties were deemed highly unsuitable due to their low levels of usable roof space, an iterative process of identifying and selecting replacement properties was undertaken with the Department. This was part of a 'kick-off' stage screening process. This resulted in 56 properties confirmed for detailed assessment.

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[12] *SAP and EPC's information is available at the following link: BRE SAP*
[13] *Information on CBDM is available at the following link: CBDM*
[14] *CBDM and Loughborough University information available at the following link: Loughborough.*
[15] *Information on BCC's use of VU.CITY available at the following link: BCC and VU.CITY*

GIA obtained VU.CITY's original 3D model files for Belfast and identified the relevant 'blocks' that included the 56 properties. A 'block' within this context is a solid 3D massing entity comprising one or more addresses or roofs within VU.CITY. VU.CITY's 3D city models are created using expert 3D CAD modelling techniques based on commissioned aerial photogrammetric imagery. This provides 3D model accuracy with a tolerance threshold of approximately +/- 15cm at roofscape and, as standard, a Level of Detail categorised as level 3 (LOD3)[16]. However, due to the input aerial imagery capture and at scale modelling processes, 3D massing blocks are typically created where there are not clearly defined ownership boundary lines from the imagery. This meant that individual addresses and their associated 3D massing were not always individually extractable from VU.CITY. Instead, this required additional technical processing by GIA. Therefore, where a VU.CITY block comprised more than one address or building from the Department's target property list, GIS software, in combination with the most recent Google aerial and Streetview imagery, was used to assess and refine parts of the massing that did not belong to the property of interest. This review was also supported by GIA being provided with access to a Spatial NI property boundary file for Belfast as a sub-licensee to data from the Northern Ireland Mapping Agreement. This was provided by the Department as part of the initial technical review process and the accuracy of the property boundaries was confirmed by the Department and their project partners. Following this, the properties were processed for analysis.

Roofs with a gross area smaller than 10m² were discarded based on an assumption that they would not provide enough usable space for a minimum feasible installation for existing high electricity consumption commercial properties (the dominate property type in the assessment) yet would also provide enough space for viable domestic installations. The Energy Savings Trust suggests that average domestic installations require approximately 10m² usable roof space (Energy Savings Trust, 2023[17]; 2015[18]). This minimum parameter assumption could be revised as part of future assessments to meet various consumption and occupancy patterns.

The roofs then had to be categorised for analysis purposes as a 'horizontal' ('flat') or 'sloped' (pitched) roof. GIA applied the assumption that any roof polygon with an inclination greater than 2 degrees was a sloped roof and anything below was a horizontal or flat roof. Barrel shaped roofs were not considered as part of the assessment process.

It was important then to analyse the roofs' existing gross area and from this calculate the net usable area for a PV installation. To do this, all roofs' gross area boundaries were inset by the following parameters to get the usable net area:

- flat roof: 1.0m.
- sloped roof: 0.5m.

In assessing each property's potential layout configuration for solar PV, GIA then considered the gross area, and aligned to the roof's surface normal, generated PV panels based on the following parameters:

- **flat roof:** a grid of squares 1.6m x 1.6m in size. Each square grid represented a standard 1.6 x 1.0m PV panel, as well as providing enough space between the panels for access and maintenance.

[16] *Information on VU.CITY models available at the following link: VU.CITY Models*
[17] *Information on the Energy Savings Trust PV Usable Space Estimate 2023: Energy Savings Trust 2023*
[18] *Information on the Energy Savings Trust PV Usable Space Estimate 2015: Energy Savings Trust 2015*

- **sloped roof:** a grid of rectangles 1.6 x 1.0m in size, representing the actual PV panels, without any space between them. Both portrait and landscape panel orientations were tested to optimise the number of panels that can fit into the net usable roof area.

To be included in the layout configuration, all four corners of all PV panels on both horizontal and sloped roofs had to be situated within the net (i.e., inset) area of the roof modelling assessment.

These steps are summarised and illustrated by Figure 2 to Figure 5.

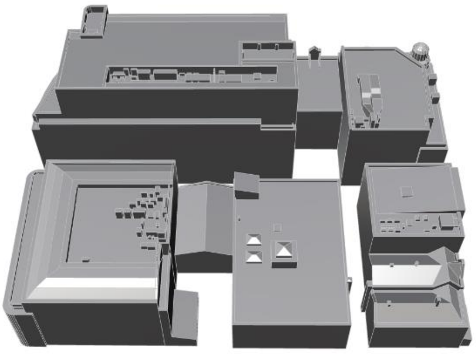

Figure 2: Block Massing of Example Building.

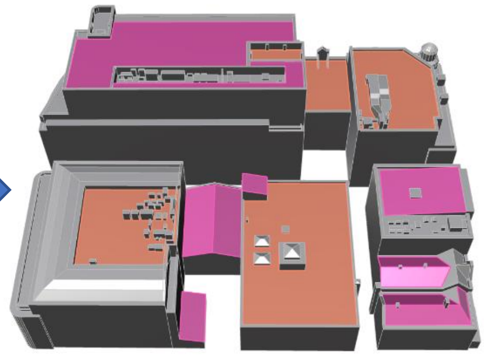

Figure 3: Calculation of Roof Polygons (pink = pitched roof, orange = flat roof).

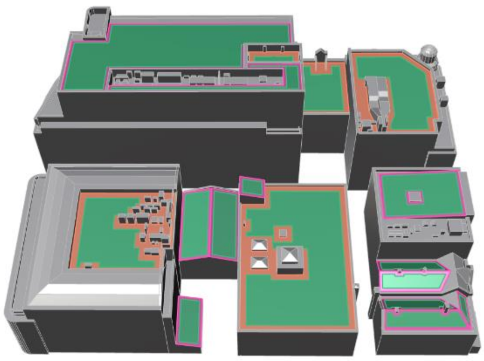

Figure 4: Calculation of Insets based on Flat and Pitched Roof parameters.

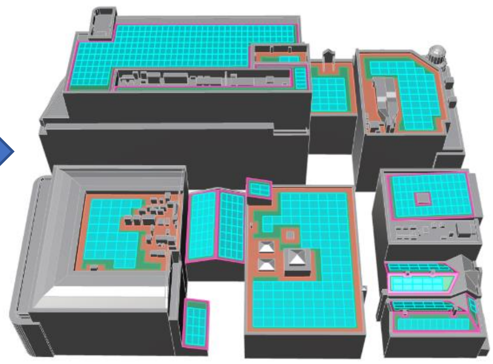

Figure 5: Panel placement based on calculated usable inset area.

Once the PV panels layout had been configured, in-house raytracing software was used to generate:

a) the SAP shading factor (derived from the 'percentage of southern sky blocked by obstructions' as per SAP 10.2 specifications).
b) the CBDM-derived Annual Cumulative Irradiance (ACR) based on Typical Meteorological Year (TMY) data obtained from https://energyplus.net/weather-location/europe_wmo_region_6/GBR/GBR_Belfast.039170_IWEC.

Annual electricity production was calculated from the shading factor following SAP 10.2 specifications and from ACR. GIA applied the assumption that a standard 1.6 x 1.0m panel has an installed peak power of 350Wp and an efficacy of 22 %. This is a typical figure for monocrystalline panels in 2023[19]. Monocrystalline panels were selected as part of this project as monocrystalline cells typically provide a higher efficacy compared to polycrystalline cells in solar PV panels. The electricity generated by each PV panel was then calculated per-roof and per-building to complete the property assessment.

For SAP assessment, the electricity produced by each individual PV panel was calculated using the following formula from SAP 10.2:

- $E_{PV} = 0.8 * kWp * S * Z_{PV}$

S is the general annual solar radiation (kWh/m²) for Northern Ireland based on SAP 10.2's mean global irradiance on a horizontal plane and based on the applicable orientation and tilt of the PV panel.

Z_{PV} is the overshading factor determined from Table M1 of SAP 10.2, as illustrated in Table 3.

Table 3: Table M1 from SAP 10.2 - Overshading Factor Categorisation

Overshading description	% of southern[31] sky blocked by obstructions	Z_{PV}
Severe	> 80%	0.2
Heavy	> 60% - 80%	0.35
Significant	25% - 60%	0.5
Modest	10% - 25%	0.8
None or very little	< 10%	1

For CBDM assessment, climate weather files were obtained for Belfast in Energy Plus Weather (EPW) format. EPW files provide data to represent a Typical Meteorological Year (TMY) that is derived from measurements typically spanning some 10 to 15 years. The data has a one-hour timestep. The data was then processed using bespoke radiance software for daylight simulations and the timestamps for sky brightness calculated for both diffuse irradiance and direct irradiance. Irradiance measurements were then calculated for each individual panel accounting for shading, orientation, and pitch along with the surrounding contextual environment.

In terms of the assessments, while the assessments were run at individual PV panel level, results are presented at four different scales:

1. Individual solar PV panel scale.
2. Roof scale.
3. Building / Property Scale.
4. Cumulative (56 properties combined).

Eight scenarios were run as standard based on various self-consumption and export rates related to the generated electricity from PV installation and a viability threshold for minimum panel performance per year. These scenarios are described in Table 4.

[19] *Estimate for monocrystalline PV panel efficiency available at the following link: Panel Efficiency*

Table 4: Scenarios and Descriptions

Scenario No.	Scenario Description
1	**100% self-consumption** and installation of PV on 100% of usable roof space. This scenario represents the maximum future baseline based on the calculated usable roof space.
2	**75% self-consumption**, 25% export and installation of PV on 100% of usable roof space.
3	**50% self-consumption**, 50% export and installation of PV on 100% of usable roof space.
4	**50% self-consumption**, 0% export and installation of PV on 100% of usable roof space. This scenario demonstrates the potential option for, and impact of, zero export agreements with the electricity Distribution Network Operator (DNO).
5	**100% self-consumption** and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel**.
6	**75% self-consumption,** 25% export and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel**.
7	**50% self-consumption**, 50% export and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel**.
8	**50% self-consumption**, 0% export and installation of PV panels which generate a minimum **of 188.17kWh/ year electricity per panel.** This scenario demonstrates the potential option for, and impact of, zero export agreements with the electricity DNO.

Assumptions were also made based on desktop research related to carbon emissions, average installation costs, average commercial electricity prices, average export tariff rates and ultimately potential payback periods.

Table 5: Summary of Parameters for Solar Assessment

Parameter/ Specification	Assumption	Source (where required)
Flat Roofs (inclination)	< 2 degrees.	
Pitched Roofs (inclination)	> 2 degrees.	
Panel Dimensions	1.6m x 1.0m (L x W) – can vary depending on manufacturer.	Solar Together. Green Match.
Panel Wattage (Wp)	350Wp.	
Panel Efficiency	22%.	Hybrid Energy Systems Models. Solar Learning Centre.
Panel Cell Technology	Monocrystalline.	
Installation Cost Per kWp	£1,016.12 - estimate includes cost of generating equipment (panels, mounting kit, inverter, meters etc) and labour. Does not fully account for potential grid connection / infrastructure costs.	Department for Energy Security and Net Zero (DESNZ).
Electricity Price (£/kWh) - Commercial	£0.189 / kWh.	Power NI.
Electricity Price (£/kWh) – Domestic	£0.36398 / kWh.	Consumer Council.
Export Price (£/kWh) – Commercial	£0.0495 / kwh (connection agreements can limit export potential and so prevent systems availing of financial return from exports).	Power NI. The Eco-Experts.
Generation Incentive Scheme Tariff (£/kWh)	Assumption is zero[20].	
Grid Carbon Intensity (2021)	0.375 $kgCO_{2e}$/kWh.	The Department for Agriculture, Environment and Rural Affairs (DAERA). SONI.
Carbon Cost of Production and Installation of PV	41 gCO_{2e}/kWh.	Intergovernmental Panel on Climate Change (IPCC).
Scenarios Modelled	100% self-consumption, 75% self-consumption, 50% self-consumption (with and without minimum panel generation threshold and export scenarios).	
Panel Viability Parameter Applied	Option 1 – No parameter. Option 2 – Panel must produce a minimum of 188.17kWh / year.	

[20] *There is no incentive scheme currently available in Northern Ireland for new solar installations.*

5 Limitations and Other Information

In terms of the results presented in this report, the following sets out some limitations and additional information to be considered.

5.1 Analysis Based on Desktop 3D Analysis

Firstly, the results presented are based on desktop analysis and 3D spatial analysis. As such, GIA do not claim that the roofs identified by this project are structurally sound for solar PV installation or compliant with local planning requirements. It is up to the relevant stakeholders to use the data contained in this report as an early-stage guide to help understand the potential solar opportunities across Belfast and their property portfolio.

Similarly, an accredited installer would need to review and confirm the optimal system configuration in terms of costing, sizing to inverters, and network connection. A planning compliance analysis would also need to be undertaken and a planning application submitted for installations where necessary.

5.2 Panel Filtering and Scenarios

Additionally, as the primary aim of this project was to estimate the solar potential for the 56 properties, roof identification and PV panel placement was based on GIA's bespoke software and considers the size of the 'useable' roof space based on the input parameters previously discussed. Scenarios 1 to 4 present results which maximise the usable roof space without filtering out panels which might not meet an interested stakeholder's annual performance viability threshold. As such, this may affect cost amortisation, installation, and maintenance requirements. Scenarios 5 to 8 then apply a minimum annual generation threshold to filter out underperforming panels.

The threshold set was 188.17kWh per panel per year. This generation threshold was calculated and selected based on only installing panels that would have a maximum estimated payback period of approximately 10 years[21] based on the projects total cost, calculated usable space and number of panels, individual and average panel generation yields, existing cost of electricity per kilowatt hour used and consumption rates.

As solar PV panels typically have an estimated minimum lifespan of 20-25 years (Energy Savings Trust, 2023[22]) and many come with performance warranties up to 25/30 years[23], this threshold aims to provide approximately at least 15 years (60% of average estimated lifespan) of additional benefit (carbon savings, financial benefits etc) post-payback. However, it should be noted that the results in the main body of this report do not include the average loss factor in panel efficiency over time, but rather focus on average annual performance. Annual loss factors vary between panel providers.

5.3 Electricity Distribution Network – Grid Connection

It must also be acknowledged that the results demonstrate the maximum solar PV potential for the 56 properties based on installing 350wp panels and without consideration of existing network capacity, infrastructure, connection limits and connection design. It is therefore important to note that the capacity of installations may be constrained by the distribution network operator (DNO), in this case Northern Ireland Electricity (NIE), and site-specific infrastructure. NIE have various

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[21] *£8,596,265.08 (total install costs) / 24,171 (total panels) = £355.64 cost per panel. £355,64375 / £0.189/kWh Power NI commercial electricity rate = 1,881.72kWh required for lifetime panel payback. 1,881.72kWh / 10 years (maximum payback threshold) = 188.17kWh/year per panel for a 10-year payback.*

[22] *Information on panel lifespans available at the following link: PV Panel lifespan*

[23] *Information on panel product and performance warranties available at the following link: Performance Warranties*

connection processes and limitations dependent on the proposed size of installation (micro-generation, small scale, and large scale).

On this, the processes vary between G98/NI (typically fit and inform process for microgeneration up to 3.68kW on single phase electricity supplies and 11.04kW on three phase electricity supplies) and G99/NI connections (typically anything above the G98/NI thresholds). Dependant on system design, inevitably these processes can affect an installation project's viability. However, estimating connection capacity, costs and processes is beyond the scope of this high-level report. As such, early engagement with NIE is advised ahead of any potential installation to ascertain connection costs, design options and key requirements. Options exist for smart metering and export limiting agreements that can help overcome some potential constraints by reducing the reliance and impact on the national electricity grid. However, again, this would need to be discussed with the DNO. Additionally, self-consumption is a crucial determinant to influence viable system design.

5.4 Result Reported at Annual Scale

It is also important to recognise that the PV generation and consumption data used was compared at annual scale as part of this project, as agreed between the Department and GIA. Therefore, the results of the analysis do not provide insights into daily or hourly generation and consumption matching opportunities. As such, the results do not infer that the properties will consume all of the PV generated electricity on-site daily due to typical differences between generation and consumption times. Rather, should the sites be able to use the potential electricity generated against their existing annual electricity consumption patterns, they could achieve the net benefits demonstrated by the scenarios run. A generation and consumption analysis could be performed at different temporal scales e.g., seasonal, monthly etc. However, this would require further in-depth analysis and data availability.

5.5 Domestic Properties: Anonymity and Estimated Consumption

Additionally, it must also be noted that when assessing domestic properties, due to data protection requirements, an average figure for domestic annual electricity usage was estimated at 3,588kWh per domestic property. This estimate was agreed with the Department in the absence of accurate individual domestic property electricity consumption data. The estimate was based on data from the Utility Regulatory for Electricity, Gas and Water Northern Ireland's (URGENI) Annual Retail Energy Marketing Monitoring report for 2021[24]. Therefore, the lack of accurate domestic usage data for each domestic property assessed will have reduced the accuracy of PV generation and electricity usage comparisons. Consumption data was also not available for Properties 48 and 49 as these represented multi-storey car park sites at Belfast City Hospital.

5.6 Carbon Intensity Estimates

In terms of assumptions used as part of scenario modelling, the input data on carbon emissions savings was derived from the annual Carbon Intensity Indicator datasets available from the Department for Agriculture, Environment and Rural Affairs (DAERA)[25] and based on the System Operator for Northern Ireland (SONI)'s data. SONI estimated that the carbon intensity of NI's national electricity grid was 375gCO_{2e}/kWh in 2021 (the latest annual data available). Calculations also took into account the minimal carbon footprint of manufacturing and installing solar PV panels based on the Intergovernmental Panel on Climate Change (IPCC) estimate that the life-cycle emissions for solar PV

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[24] URGENI data link: Total domestic consumption for Northern Ireland in 2021 was 2,975.6GWh and total domestic connections was 829,376. Total consumption divided by total connections gives average domestic usage (per domestic connection) of 3,588kWh.

[25] Carbon Intensity Indicators data available at the following link: DAERA

equates to 41gCO_{2e}/kWh. However, it should be noted that this figure can vary depending on the manufacturer and installer chosen.

5.7 Economic Modelling

Finally, GIA emphasise that the economic forecasts contained in this report are purely estimates and based on desktop research findings. The cost estimates are based on data by the UK Government's Department for Energy Security and Net Zero[26] (DESNZ) and the Department of Agriculture and Rural Development of Northern Ireland[27] (DAERA) Northern Ireland. For accurate cost information, any interested stakeholder would require professional installer quotations, including other on-site assessments such as structural assessments and, in particular, DNO grid connection assessment and upgrade costs. The price per unit of electricity and export tariffs are also estimates based on Power NI's commercial trend data[28] and the Consumer Council's domestic trend data[29]. These units can be highly variable. Additionally, connection agreements may include export limits and therefore influence the potential financial return from systems which produce in excess of their on-site demand. No incentive tariff has been included in the results; however, this could be modelled in future.

6 Results

The results from the solar PV assessment are reported at cumulative scale (56 properties combined) and individual property scale. Results at individual panel and roof scale are available in the associated data files provided. As previously mentioned, to meet the aim of this project, the results discussed in the main body of this report focus predominately on Scenario 1:

- **100% self-consumption** of electricity generated from PV and installation of PV on 100% of the calculated usable roof space.

The justification for primarily reporting the results from Scenario 1 are that it represents the core deliverable of demonstrating the solar PV generation potential across the 56 properties based on the usable space identified. The results from Scenarios 2 to 8, where various self-consumption and panel filtering parameters are applied, are available in the associated data files provided with this report.

6.1 Cumulative Scale Results

Table 6 summarises the results from SAP and CBDM analysis for Scenario 1 (100% self-consumption and installation of PV on 100% of the usable roof space). It should be recognised that 100% self-consumption represents an idealised future baseline scenario for the 56 properties and therefore the property uses and electricity consumption profiles will impact whether this can be achieved.

The results demonstrate that:

- Across the 56 properties 21,598,484 kWh of electricity is consumed each year.
- If PV installations were maximised across 100% of the properties calculated usable roof space, an estimated 24,171 PV panels (350wp) could be installed, equating to a combined system size of 8,459.9 kilowatts peak (kWp) with an estimated generation potential between 6,985,537 kWh/year (SAP) and 5,561,672 kWh/year (CBDM).
- If the 56 properties could use all 100% of the electricity generated by PV on-site, this could see combined self-sufficiency from PV create between a 32.3% (SAP) and 25.8% (CBDM) reduction in the use of electricity from the national grid and reduce carbon emissions by between 2,590.9 tonnesCO_{2e} per year and 2,062.8 tonnesCO_{2e} per year (includes an allowance for the carbon cost of PV installation).

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[26] DESNZ cost data is available at the following link: DESNZ
[27] DAERA cost data is available at the following link: DAERA
[28] Power NI cost data available at the following link: Power NI
[29] Consumer Council cost data available at the following link: Consumer Council

- If the properties used 100% of the electricity generated by PV on-site, the estimated payback period could be between 6.45 (SAP) and 8.09 (CBDM) years based on an estimated installation [one-off] cost of £8,596,265 and financial benefit of between £1,332,821 (SAP) and £1,062,591 (CBDM) per year.
- Considering only the non-domestic properties assessed, the payback period for 36 properties could be between 6.49 years (SAP) and 8.17 years (CBDM).
- Considering only the domestic properties assessed, the payback period could be between 4.21 years (SAP) and 4.62 years (CBDM). However, it must be recognised that no existing electricity usage data was provided as part of the project and therefore an estimated annual electricity consumption rate for domestic properties was set at 3,588kWh based on data from the Utility Regulatory for Electricity, Gas and Water Northern Ireland's (URGENI) Annual Retail Energy Marketing Monitoring report for 2021, as discussed further in Section 5.
- For comparison purposes, across the 56 properties, if an annual panel performance viability threshold was applied to only install panels which generated a minimum of 188.17kWh/year (aims to filter out each panel which does not achieve a capital payback within 10 years based on the combined data across the 56 assessed properties), system sizes would be reduced to 6,844.6kWp based on the impact of the SAP methodology and 7,785.4kWp based on the CBDM methodology. Additionally, the estimated PV generation from the total installations would be reduced to 6,243,198kWh/year (SAP) and 5,263,279 kWh/year (CBDM). However, the estimated payback periods would also be reduced to 5.85 years (SAP) and 7.9 years (CBDM) due to the impact of effective filtering that removes panels that do not meet annual viability requirements.

Table 6: Scenario 1: 100% self-consumption and application of PV on 100% of usable roof space.

Scenario 1: • **56 properties** • **100% self-consumption and 0% export.** • **PV Installed on 100% of usable roof space**	**SAP**	**CBDM**
Existing Electricity Usage (kWh)	21,598,484	21,598,484
System Size (kWp)	8,459.9	8,459.9
Estimated PV Generation (kWh/Year)	6,985,537	5,561,672
No. of Panels	24,171	24,171
% Contribution to Existing Electricity Usage / Self-Sufficiency (%)	32.3%	25.8%
Estimated Carbon Emissions Savings (tonnesCO_{2e}/ year)	2,590.9	2,062.8
Estimated System Cost (£)	£8,596,265	£8,596,265
Estimated Financial Return (£/year)	£1,332,821	£1,062,591
Estimated Payback Period (years)	6.45	8.09

Results from all eight scenarios run as standard are available in Appendix One and the results files.

6.2 Individual Property Scale Results

Table 7 and Table 8 then summarise the results from SAP and CBDM analysis at individual property scale for Scenario 1 (100% self-consumption and installation on 100% of each property's usable roof space). Following a discussion on these results, visualisations demonstrating the panel positioning for each property based on installations on 100% of the usable roof areas and representing the total annual electricity generated is provided. Full datasets and GIS files are also provided along with this report where the user can model various scenarios to meet their site-specific requirements.

Based on Scenario 1, key results are summarised as follows:

The Top 3 Highest Electricity Using Properties:

1. Property 47 - Belfast City Hospital - Cancer Centre: 4,409,518kWh/year.
2. Property 52 - Mater Hospital – Dempsey: 2,426,201 kWh/year.
3. Property 56 - Belfast Metropolitan College (BMC) - Titanic Quarter: 1,167,274kWh/year.

The Top 3 Properties with the Highest Potential Electricity Generation from PV:

1. **Property 18 - Grove Wellbeing Centre:**
- SAP Modelling: 682,559kWh/year.
- CBDM Modelling: 499,248kWh/year.

2. **Property 20 - Ozone Leisure Centre:**
- SAP Modelling: 552,133kWh/year.
- CBDM Modelling: 421,834kWh/year.

3. **Property 56 - Belfast Metropolitan College (BMC) - Titanic Quarter:**
- SAP Modelling: 530,276kWh/year.
- CBDM Modelling: 419,747kWh/year.

The Top 3 Properties with the Highest Potential Carbon Emissions Saving:

1. **Property 18 - Grove Wellbeing Centre:**
- SAP Modelling: 253.2 tonnesCO_{2e} per year.
- CBDM Modelling: 185.2 tonnesCO_{2e} per year.

2. **Property 20 - Ozone Leisure Centre:**
- SAP Modelling: 204.8 tonnesCO_{2e} per year.
- CBDM Modelling: 156.5 tonnesCO_{2e} per year.

3. **Property 56 - Belfast Metropolitan College (BMC) - Titanic Quarter:**
- SAP Modelling: 196.7 tonnesCO_{2e} per year.
- CBDM Modelling: 155.7 tonnesCO_{2e} per year

The Top 3 Non-Domestic Properties with the Highest Potential Impact on Existing Electricity Usage (Percentage Impact) are:

Based on SAP modelling –

1. **Property 20 - Ozone Leisure Centre:**
- SAP Modelling: 284.5%.

2. **Property 23 - Morton Community Centre:**
- SAP Modelling: 153.9%.

3. **Property 90 - Fall Road Library:**
- SAP Modelling: 141.9%.

Based on CBDM modelling –

1. **Property 20 - Ozone Leisure Centre:**
- CBDM Modelling: 217.3%.

2. **Property 90 - Fall Road Library:**
- CBDM Modelling: 127.1%.

3. **Property 23 - Morton Community Centre:**
- SAP Modelling: 121.2%.

These results indicate that if these properties maximised a PV installation across their roofs, they would produce in excess of their existing electricity needs at annual level. However, these results are subject to generation and consumption time matching. On this, battery storage and other means of converting and diverting electricity generated could represent important features to these properties as a means to help them most effectively utilise their PV based electricity generation and consumption potential. Scaling the installations adequately to meet existing and future consumption needs will also be important to project feasibility, particularly should export limits be put in place.

As previously discussed, it must also be noted that when assessing domestic properties, due to data protection requirements, an average figure for domestic annual electricity usage was estimated at 3,588kWh per domestic property. Therefore, the lack of accurate domestic usage data for each domestic property assessed reduced the accuracy of PV generation and electricity usage comparisons on domestic sites. That said, should the domestic properties use the estimated 3,588kWh per year, then across the 20 properties the average PV impact on total existing electricity usage would be 91% while Property 88 – Anon ID: 20 would have the highest PV potential; potentially generating in excess of its annual electricity needs (148.7% based on SAP generation assessment and 141.8% based on CBDM generation assessment).

<u>The Top 3 Non-Domestic Properties with the Quickest Estimated Payback Period:</u>

Based on SAP modelling –

1. **Property 93 - Woodstock Library:**
- SAP Modelling: 5.27 years.

2. **Property 27 - National Museums Northern Ireland, Unit 12-21:**
- SAP Modelling: 5.29 years.

3. **Property 91 - Ormeau Road Library:**
- SAP Modelling: 5.47 years.

Based on CBDM modelling –

1. **Property 27 - National Museums Northern Ireland, Unit 12-21:**
- CBDM Modelling: 7.66 years.

2. **Property 19 - Duncrue Complex:**
- CBDM Modelling: 7.68 years.

3. **Property 91 - Ormeau Road Library:**
- CBDM Modelling: 7.69 years.

<u>The Top 3 Domestic Properties with the Quickest Estimated Payback Period:</u>

Based on SAP modelling –

4. **Property 76 - Anon ID: 8:**
- SAP Modelling: 3.65 years.

5. **Property 75 - Anon ID: 7:**
- SAP Modelling: 3.66 years.

6. **Property 77 - Anon ID: 9:**
- SAP Modelling: 3.70 years.

Based on CBDM modelling –

4. **Property 70 - Anon ID: 2:**
- CBDM Modelling: 4.32 years.

5. **Property 73 - Anon ID: 5:**
- CBDM Modelling: 4.33 years.

6. **Property 84 - Anon ID: 16:**
- CBDM Modelling: 4.39 years.

Scenario 1 (SAP Results): 100% self-consumption and installation of PV on 100% of usable roof space

Table 7: (SAP) Scenario 1: 100% self-consumption and installation of PV on 100% of usable roof space.

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
1	Housing Centre	699,681	58.8	38,850	168	38,850	14.4	660,831	5.6%	£59,748	£7,343	8.14
2	The Plaza	257,526	156.5	111,995	447	111,995	41.5	145,531	43.5%	£158,973	£21,167	7.51
5	Causeway Exchange	431,155	76.7	37,832	219	37,832	14.0	393,323	8.8%	£77,886	£7,150	10.89
7	Adelaide House	576,450	91.4	70,181	261	70,181	26.0	506,269	12.2%	£92,823	£13,264	7.00
13	Belfast City Hall	925,435	299.6	151,062	856	151,062	56.0	774,373	16.3%	£304,431	£28,551	10.66
14	Ulster Hall	248,217	165.9	115,056	474	115,056	42.7	133,161	46.4%	£168,575	£21,746	7.75
15	Cecil Ward	466,475	19.3	6,914	55	6,914	2.6	459,561	1.5%	£19,560	£1,307	14.97
16	St Georges Market	218,861	270.2	181,376	772	181,376	67.3	37,485	82.9%	£274,557	£34,280	8.01
17	Shankill Leisure Centre	401,128	212.8	179,429	608	179,429	66.6	221,699	44.7%	£216,231	£33,912	6.38
18	Grove Wellbeing Centre	783,600	743.8	682,559	2,125	682,559	253.2	101,041	87.1%	£755,743	£129,004	5.86
19	Duncrue Complex	958,477	566.0	529,345	1,617	529,345	196.3	429,132	55.2%	£575,076	£100,046	5.75
20	Ozone Leisure Centre	194,093	615.3	552,133	1,758	552,133	204.8	- 358,040	284.5%	£625,222	£104,353	5.99
21	GLL Connswater Gym, Unit 11 Connswater Shopping Centre	166,313	193.9	174,522	554	174,522	64.7	- 8,209	104.9%	£197,027	£32,985	5.97
22	Whiterock Leisure Centre	328,931	57.8	41,478	165	41,478	15.4	287,453	12.6%	£58,681	£7,839	7.49

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
23	Morton Community Centre	54,447	98.7	83,816	282	83,816	31.1	- 29,369	153.9%	£100,292	£15,841	6.33
25	Department for Communities Offices, James House	111,361	134.4	126,134	384	126,134	46.8	- 14,773	113.3%	£136,567	£23,839	5.73
27	National Museums Northern Ireland, Unit 12-21	382,828	482.3	490,568	1,378	490,568	182.0	- 107,740	128.1%	£490,077	£92,717	5.29
28	Public Records Office of Northern Ireland	963,163	207.6	185,068	593	185,068	68.6	778,095	19.2%	£210,897	£34,978	6.03
35	106-108 Holywood Road	149,447	33.6	26,279	96	26,279	9.7	123,168	17.6%	£34,142	£4,967	6.87
43	Royal Victoria Hospital - New Maternity	989,645	169.1	124,810	483	124,810	46.3	864,835	12.6%	£171,776	£23,589	7.28
44	Royal Victoria Hospital - Kelvin	366,106	401.1	297,328	1,146	297,328	110.3	68,778	81.2%	£407,568	£56,195	7.25
47	Belfast City Hospital - Cancer Centre	4,409,518	209.3	181,033	598	181,033	67.1	4,228,485	4.1%	£212,675	£34,215	6.22
48	Belfast City Hospital - Multi Storey Car Park 2	No data	454.0	320,010	1,297	320,010	118.7	- 320,010	No data	£461,270	£60,482	7.63
49	Belfast City Hospital - Multi Storey Car Park 1	No data	483.4	420,344	1,381	420,344	155.9	- 420,344	No data	£491,144	£79,445	6.18
51	Mater Hospital - McAuley	1,133,827	292.6	266,714	836	266,714	98.9	867,113	23.5%	£297,318	£50,409	5.90
52	Mater Hospital - Dempsey	2,426,201	12.6	9,761	36	9,761	3.6	2,416,440	0.4%	£12,803	£1,845	6.94

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings ($tonnesCO_{2e}$ year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
53	Mater Hospital - Dorrian	522,942	67.2	40,855	192	40,855	15.2	482,087	7.8%	£68,284	£7,722	8.84
56	Belfast Metropolitan College (BMC) - Titanic Quarter	1,167,274	646.8	530,276	1,848	530,276	196.7	636,998	45.4%	£657,230	£100,222	6.56
58	Ulster Museum	1,031,844	263.2	217,327	752	217,327	80.6	814,517	21.1%	£267,444	£41,075	6.51
69	Anon ID: 1	3,588	4.2	2,712	12	2,712	1.0	876	75.6%	£4,268	£987	4.32
70	Anon ID: 2	3,588	4.9	3,356	14	3,356	1.2	232	93.5%	£4,979	£1,222	4.08
71	Anon ID: 3	3,588	5.6	4,200	16	4,200	1.6	- 612	117.1%	£5,690	£1,529	3.72
72	Anon ID: 4	3,588	7.7	3,206	22	3,206	1.2	382	89.4%	£7,824	£1,167	6.70
73	Anon ID: 5	3,588	4.2	2,904	12	2,904	1.1	684	80.9%	£4,268	£1,057	4.04
74	Anon ID: 6	3,588	4.9	3,178	14	3,178	1.2	410	88.6%	£4,979	£1,157	4.30
75	Anon ID: 7	3,588	5.6	4,272	16	4,272	1.6	- 684	119.1%	£5,690	£1,555	3.66
76	Anon ID: 8	3,588	5.6	4,280	16	4,280	1.6	- 692	119.3%	£5,690	£1,558	3.65
77	Anon ID: 9	3,588	4.2	3,168	12	3,168	1.2	420	88.3%	£4,268	£1,153	3.70
78	Anon ID: 10	3,588	5.6	3,608	16	3,608	1.3	- 20	100.6%	£5,690	£1,313	4.33
79	Anon ID: 11	3,588	5.6	3,608	16	3,608	1.3	- 20	100.6%	£5,690	£1,313	4.33
80	Anon ID: 12	3,588	5.6	3,608	16	3,608	1.3	- 20	100.6%	£5,690	£1,313	4.33

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
81	Anon ID: 13	3,588	5.6	3,608	16	3,608	1.3	- 20	100.6%	£5,690	£1,313	4.33
82	Anon ID: 14	3,588	5.6	3,608	16	3,608	1.3	- 20	100.6%	£5,690	£1,313	4.33
83	Anon ID: 15	3,588	5.6	3,624	16	3,624	1.3	- 36	101.0%	£5,690	£1,319	4.31
84	Anon ID: 16	3,588	5.6	4,128	16	4,128	1.5	- 540	115.1%	£5,690	£1,503	3.79
85	Anon ID: 17	3,588	7.0	4,736	20	4,736	1.8	- 1,148	132.0%	£7,113	£1,724	4.13
86	Anon ID: 18	3,588	3.2	2,250	9	2,250	0.8	1,338	62.7%	£3,201	£819	3.91
87	Anon ID: 19	3,588	3.5	2,358	10	2,358	0.9	1,230	65.7%	£3,556	£858	4.14
88	Anon ID: 20	3,588	8.4	5,335	24	5,335	2.0	- 1,747	148.7%	£8,535	£1,942	4.40
89	Shankill Road Library	25,844	36.1	20,903	103	20,903	7.8	4,941	80.9%	£36,631	£3,951	9.27
90	Fall Road Library	22,973	51.1	32,590	146	32,590	12.1	- 9,617	141.9%	£51,924	£6,160	8.43
91	Ormeau Road Library	23,942	32.2	31,672	92	31,672	11.7	- 7,730	132.3%	£32,719	£5,986	5.47
92	Belfast Central Library	175,478	46.9	36,071	134	36,071	13.4	139,407	20.6%	£47,656	£6,817	6.99
93	Woodstock Library	13,670	3.5	3,570	10	3,570	1.3	10,100	26.1%	£3,556	£675	5.27
94	Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 1	400,418	302.8	262,004	865	262,004	97.2	138,414	65.4%	£307,632	£49,519	6.21

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
95	Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 2	499,455	395.9	333,925	1,131	333,925	123.9	165,530	66.9%	£402,233	£63,112	6.37
Totals / Averages		**21,598,484**	**8,459.9**	**6,985,537**	**24,171**	**6,985,537**	**2,590.9**	**14,612,947**	**32.3%**	**£8,596,265**	**£1,332,821**	**6.45**
Non-Domestic Only		**21,526,724**	**8,351.7**	**6,913,790**	**23,862**	**6,913,790**	**2,564.3**	**16,030,403**	**25.5%**	**£8,486,371**	**£1,306,706**	**6.49**
Domestic Only		**71,760**	**108.2**	**71,747**	**309**	**71,747**	**26.6**	**6,409**	**91.1%**	**£109,894**	**£26,114**	**4.21**

Scenario 1 (CBDM Results): 100% self-consumption and installation of PV on 100% of usable roof space

Table 8: (CBDM) Scenario 1: 100% self-consumption and installation of PV on 100% of usable roof space.

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} /year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
1	Housing Centre	699,681	58.8	33,727	168	33,727	12.5	665,954	4.8%	£59,748	£6,374	9.37
2	The Plaza	257,526	156.5	96,435	447	96,435	35.8	161,091	37.4%	£158,973	£18,226	8.72
5	Causeway Exchange	431,155	76.7	39,868	219	39,868	14.8	391,287	9.2%	£77,886	£7,535	10.34
7	Adelaide House	576,450	91.4	59,710	261	59,710	22.1	516,740	10.4%	£92,823	£11,285	8.23
13	Belfast City Hall	925,435	299.6	162,002	856	162,002	60.1	763,433	17.5%	£304,431	£30,618	9.94
14	Ulster Hall	248,217	165.9	106,406	474	106,406	39.5	141,811	42.9%	£168,575	£20,111	8.38
15	Cecil Ward	466,475	19.3	6,355	55	6,355	2.4	460,120	1.4%	£19,560	£1,201	16.29
16	St Georges Market	218,861	270.2	167,568	772	167,568	62.2	51,293	76.6%	£274,557	£31,670	8.67
17	Shankill Leisure Centre	401,128	212.8	142,322	608	142,322	52.8	258,806	35.5%	£216,231	£26,899	8.04
18	Grove Wellbeing Centre	783,600	743.8	499,248	2,125	499,248	185.2	284,352	63.7%	£755,743	£94,358	8.01
19	Duncrue Complex	958,477	566.0	396,188	1,617	396,188	146.9	562,289	41.3%	£575,076	£74,880	7.68
20	Ozone Leisure Centre	194,093	615.3	421,834	1,758	421,834	156.5	- 227,741	217.3%	£625,222	£79,727	7.84
21	GLL Connswater Gym, Unit 11 Connswater Shopping Centre	166,313	193.9	131,673	554	131,673	48.8	34,640	79.2%	£197,027	£24,886	7.92
22	Whiterock Leisure Centre	328,931	57.8	37,505	165	37,505	13.9	291,426	11.4%	£58,681	£7,088	8.28

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} /year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
23	Morton Community Centre	54,447	98.7	65,963	282	65,963	24.5	- 11,516	121.2%	£100,292	£12,467	8.04
25	Department for Communities Offices, James House	111,361	134.4	93,385	384	93,385	34.6	17,976	83.9%	£136,567	£17,650	7.74
27	National Museums Northern Ireland, Unit 12-21	382,828	482.3	338,329	1,378	338,329	125.5	44,499	88.4%	£490,077	£63,944	7.66
28	Public Records Office of Northern Ireland	963,163	207.6	135,109	593	135,109	50.1	828,054	14.0%	£210,897	£25,536	8.26
35	106-108 Holywood Road	149,447	33.6	22,882	96	22,882	8.5	126,565	15.3%	£34,142	£4,325	7.89
43	Royal Victoria Hospital - New Maternity	989,645	169.1	104,731	483	104,731	38.8	884,914	10.6%	£171,776	£19,794	8.68
44	Royal Victoria Hospital - Kelvin	366,106	401.1	247,949	1,146	247,949	92.0	118,157	67.7%	£407,568	£46,862	8.70
47	Belfast City Hospital - Cancer Centre	4,409,518	209.3	138,460	598	138,460	51.4	4,271,058	3.1%	£212,675	£26,169	8.13
48	Belfast City Hospital - Multi Storey Car Park 2	No data	454.0	297,534	1,297	297,534	110.4	- 297,534	No data	£461,270	£56,234	8.20
49	Belfast City Hospital - Multi Storey Car Park 1	No data	483.4	328,617	1,381	328,617	121.9	- 328,617	No data	£491,144	£62,109	7.91
51	Mater Hospital - McAuley	1,133,827	292.6	203,489	836	203,489	75.5	930,338	17.9%	£297,318	£38,459	7.73
52	Mater Hospital - Dempsey	2,426,201	12.6	8,090	36	8,090	3.0	2,418,111	0.3%	£12,803	£1,529	8.37

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} /year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
53	Mater Hospital - Dorrian	522,942	67.2	40,375	192	40,375	15.0	482,567	7.7%	£68,284	£7,631	8.95
56	Belfast Metropolitan College (BMC) - Titanic Quarter	1,167,274	646.8	419,747	1,848	419,747	155.7	747,527	36.0%	£657,230	£79,332	8.28
58	Ulster Museum	1,031,844	263.2	169,530	752	169,530	62.9	862,314	16.4%	£267,444	£32,041	8.35
69	Anon ID: 1	3,588	4.2	2,604	12	2,604	1.0	984	72.6%	£4,268	£948	4.50
70	Anon ID: 2	3,588	4.9	3,170	14	3,170	1.2	418	88.4%	£4,979	£1,154	4.32
71	Anon ID: 3	3,588	5.6	3,433	16	3,433	1.3	155	95.7%	£5,690	£1,250	4.55
72	Anon ID: 4	3,588	7.7	3,700	22	3,700	1.4	- 112	103.1%	£7,824	£1,347	5.81
73	Anon ID: 5	3,588	4.2	2,710	12	2,710	1.0	878	75.5%	£4,268	£986	4.33
74	Anon ID: 6	3,588	4.9	3,039	14	3,039	1.1	549	84.7%	£4,979	£1,106	4.50
75	Anon ID: 7	3,588	5.6	3,430	16	3,430	1.3	158	95.6%	£5,690	£1,248	4.56
76	Anon ID: 8	3,588	5.6	3,415	16	3,415	1.3	173	95.2%	£5,690	£1,243	4.58
77	Anon ID: 9	3,588	4.2	2,530	12	2,530	0.9	1,058	70.5%	£4,268	£921	4.63
78	Anon ID: 10	3,588	5.6	3,391	16	3,391	1.3	197	94.5%	£5,690	£1,234	4.61
79	Anon ID: 11	3,588	5.6	3,382	16	3,382	1.3	206	94.3%	£5,690	£1,231	4.62
80	Anon ID: 12	3,588	5.6	3,384	16	3,384	1.3	204	94.3%	£5,690	£1,232	4.62

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} /year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
81	Anon ID: 13	3,588	5.6	3,390	16	3,390	1.3	198	94.5%	£5,690	£1,234	4.61
82	Anon ID: 14	3,588	5.6	3,402	16	3,402	1.3	186	94.8%	£5,690	£1,238	4.60
83	Anon ID: 15	3,588	5.6	3,436	16	3,436	1.3	152	95.8%	£5,690	£1,251	4.55
84	Anon ID: 16	3,588	5.6	3,559	16	3,559	1.3	29	99.2%	£5,690	£1,295	4.39
85	Anon ID: 17	3,588	7.0	4,223	20	4,223	1.6	- 635	117.7%	£7,113	£1,537	4.63
86	Anon ID: 18	3,588	3.2	1,905	9	1,905	0.7	1,683	53.1%	£3,201	£693	4.62
87	Anon ID: 19	3,588	3.5	2,160	10	2,160	0.8	1,428	60.2%	£3,556	£786	4.52
88	Anon ID: 20	3,588	8.4	5,088	24	5,088	1.9	- 1,500	141.8%	£8,535	£1,852	4.61
89	Shankill Road Library	25,844	36.1	20,110	103	20,110	7.5	5,734	77.8%	£36,631	£3,801	9.64
90	Fall Road Library	22,973	51.1	29,192	146	29,192	10.8	- 6,219	127.1%	£51,924	£5,517	9.41
91	Ormeau Road Library	23,942	32.2	22,504	92	22,504	8.3	1,438	94.0%	£32,719	£4,253	7.69
92	Belfast Central Library	175,478	46.9	30,895	134	30,895	11.5	144,583	17.6%	£47,656	£5,839	8.16
93	Woodstock Library	13,670	3.5	2,431	10	2,431	0.9	11,239	17.8%	£3,556	£459	7.74
94	Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 1	400,418	302.8	207,403	865	207,403	76.9	193,015	51.8%	£307,632	£39,199	7.85

Property ID	Property Name	Existing Electricity Usage (kWh/year)	System Size (kW)	Estimated PV Generation (kWh/year)	No. of Panels	Electricity from PV Usage (kWh/year)	Carbon Emissions Savings (tonnesCO_{2e} /year)	Difference Between Generation & Existing Usage (kWh/year)	Contribution to Existing Electricity Usage (%)	Estimated System Cost (£)	Estimated Financial Return (£/year)	Estimated Payback Period (years)
95	Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 2	499,455	395.9	268,755	1,131	268,755	99.7	230,700	53.8%	£402,233	£50,795	7.92
Totals / Averages		**21,598,484**	**8,459.9**	**5,561,672**	**24,171**	**5,561,672**	**2,062.8**	**16,036,812**	**25.8%**	**£8,596,265**	**£1,062,591**	**8.09**
Non-Domestic Only		**21,526,724**	**8,351.70**	**5,496,321**	**23,862**	**5,496,321**	**2,038.6**	**16,030,403**	**25.5%**	**£8,486,371**	**£1,038,805**	**8.17**
Domestic Only		**71,760**	**108.15**	**65,351**	**309**	**65,351**	**24.2**	**6,409**	**91.1%**	**109,894**	**£23,786**	**4.62**

6.3 Individual Property Results Visualised

The following subsections provide map images of the results from CBDM analysis across the 56 properties at annual level. The map images demonstrate the panel positioning on each property's usable roof space and includes a legend which references the estimated annual cumulative irradiance for each individual panel.

Property ID: 1 - Housing Centre, 2 Adelaide Street

Figure 6 provides a map which illustrates the CBDM solar results for Property ID 1.

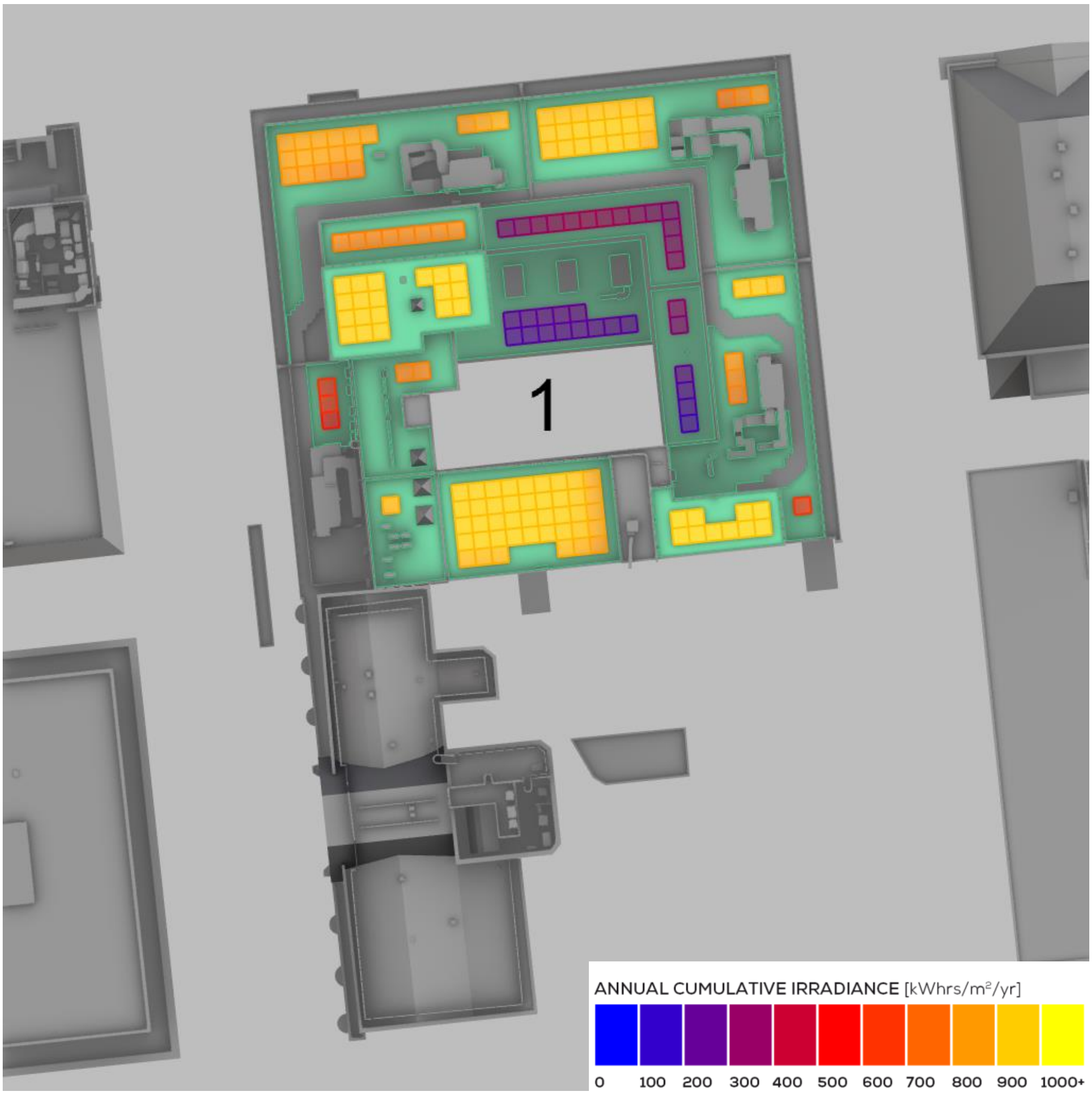

Figure 6: Property ID: 1 – Solar PV Map

Property ID: 2 - The Plaza, 31-35 Chichester Street

Figure 7 provides a map which illustrates the CBDM solar results for Property ID 2.

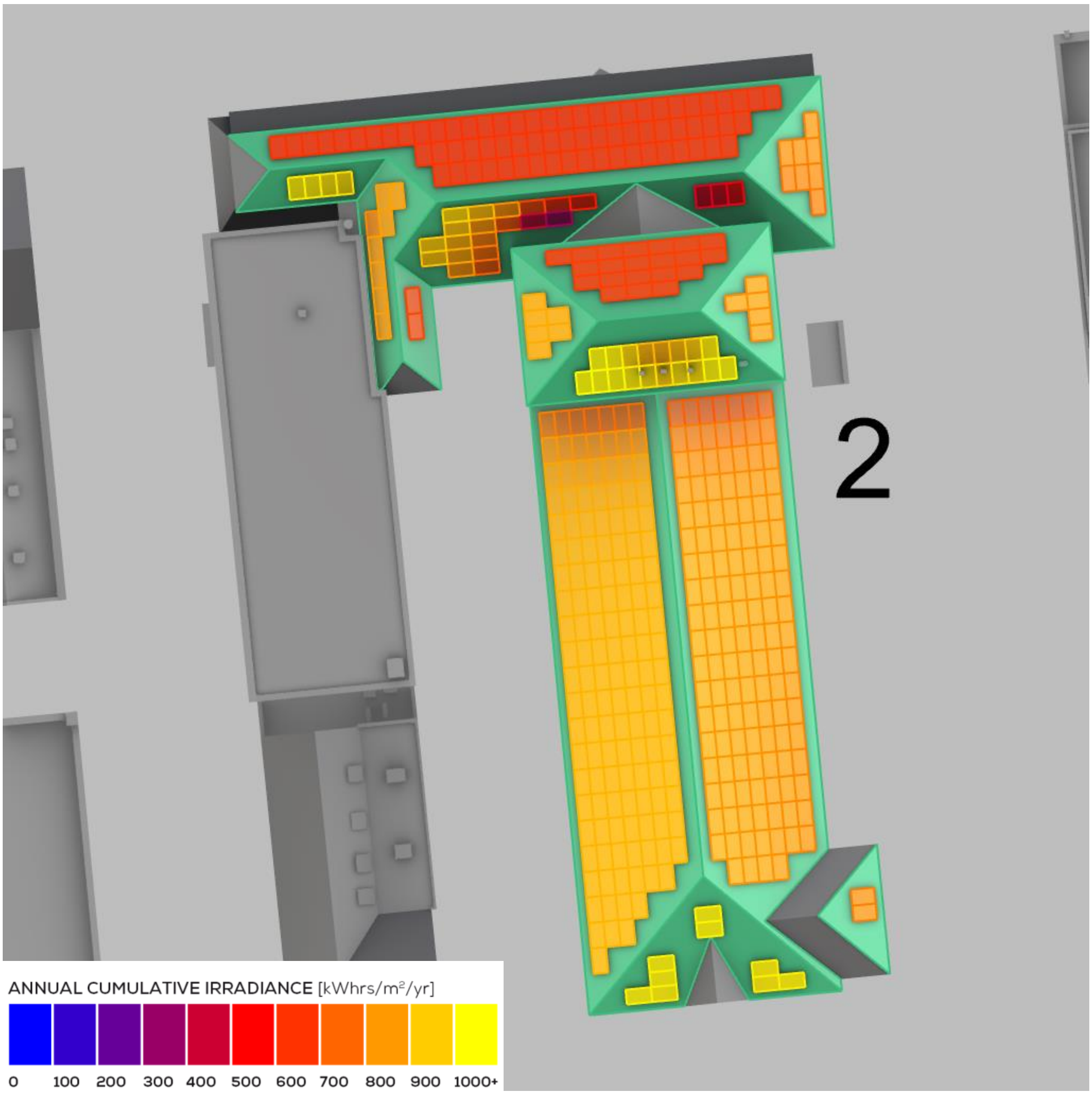

Figure 7: Property ID: 2 - Solar PV Map

Property ID: 5 - Causeway Exchange, 1-7 Bedford Street

Figure 8 provides a map which illustrates the CBDM solar results for Property ID: 5.

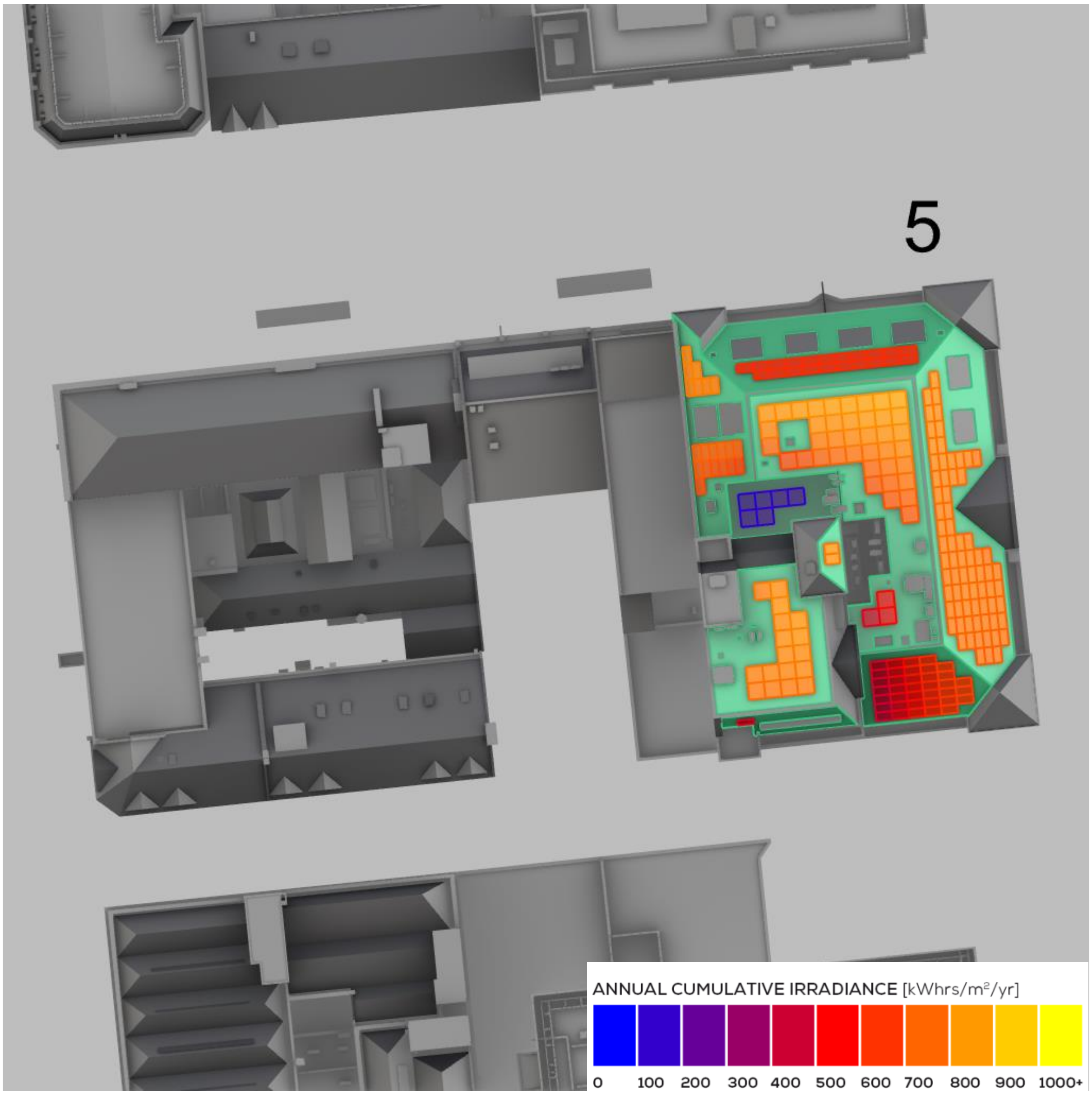

Figure 8: Property ID: 5 – Solar PV Map

Property ID: 7 - Adelaide House, 39-49 Adelaide Street

Figure 9 provides a map which illustrates the CBDM solar results for Property ID: 7.

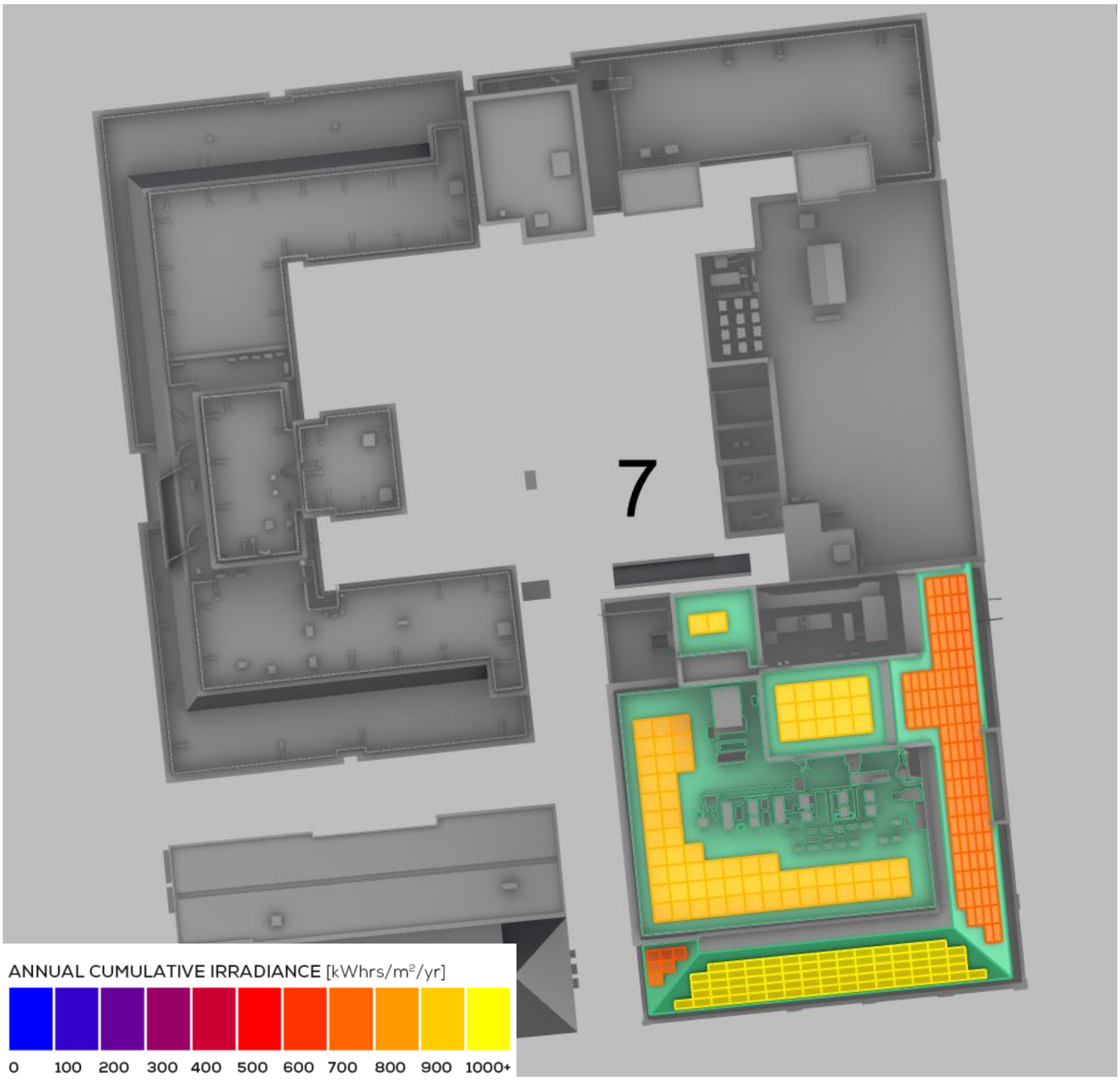

Figure 9: Property ID: 7 – Solar PV Map

Property ID: 13 - Belfast City Hall, Donegall Square North

Figure 10 provides a map which illustrates the CBDM solar results for Property ID: 13.

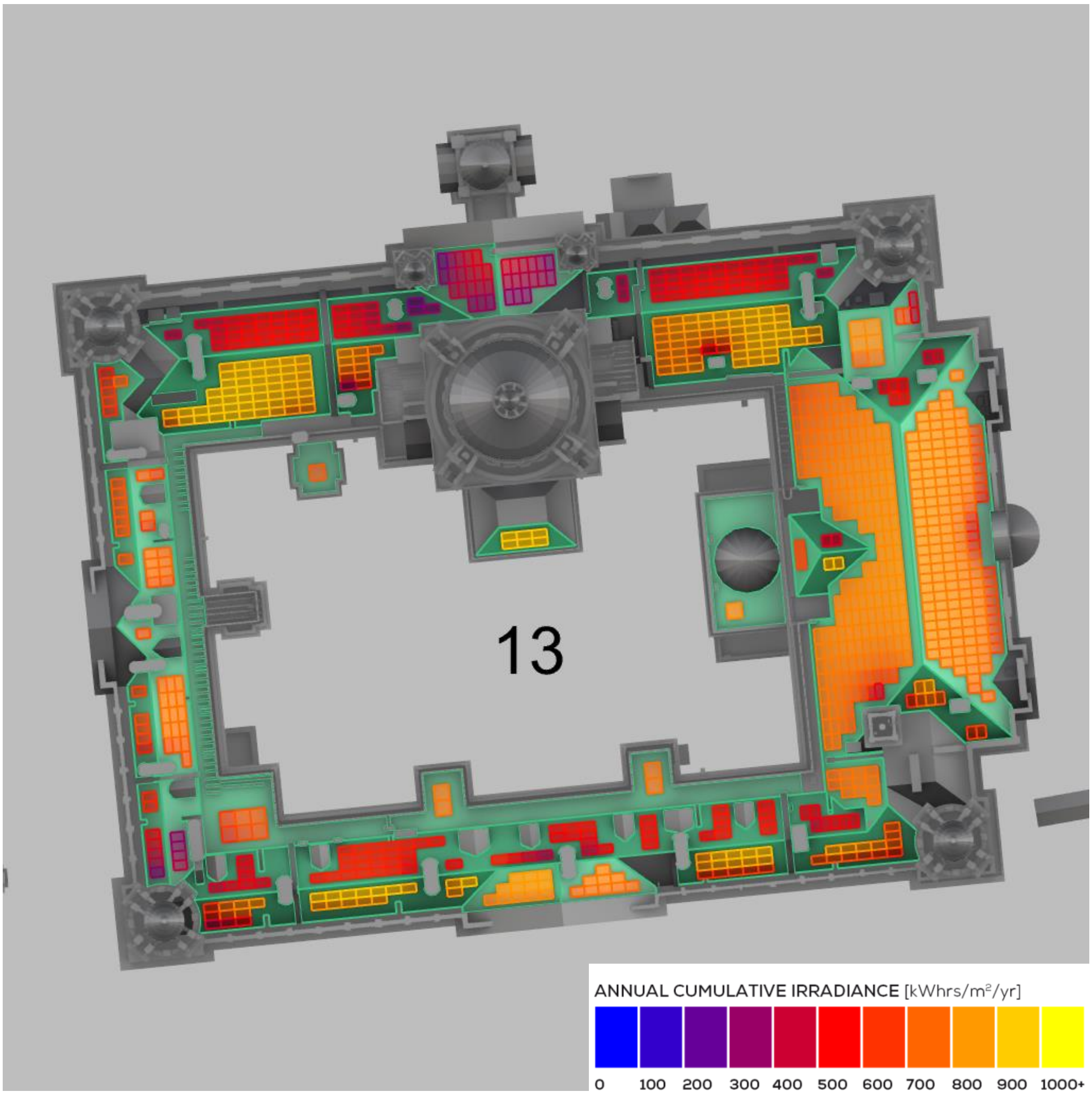

Figure 10: Property ID: 13 – Solar PV Map

Property ID: 14 - Ulster Hall, 34 Bedford Street

Figure 11 provides a map which illustrates the CBDM solar results for Property ID: 14.

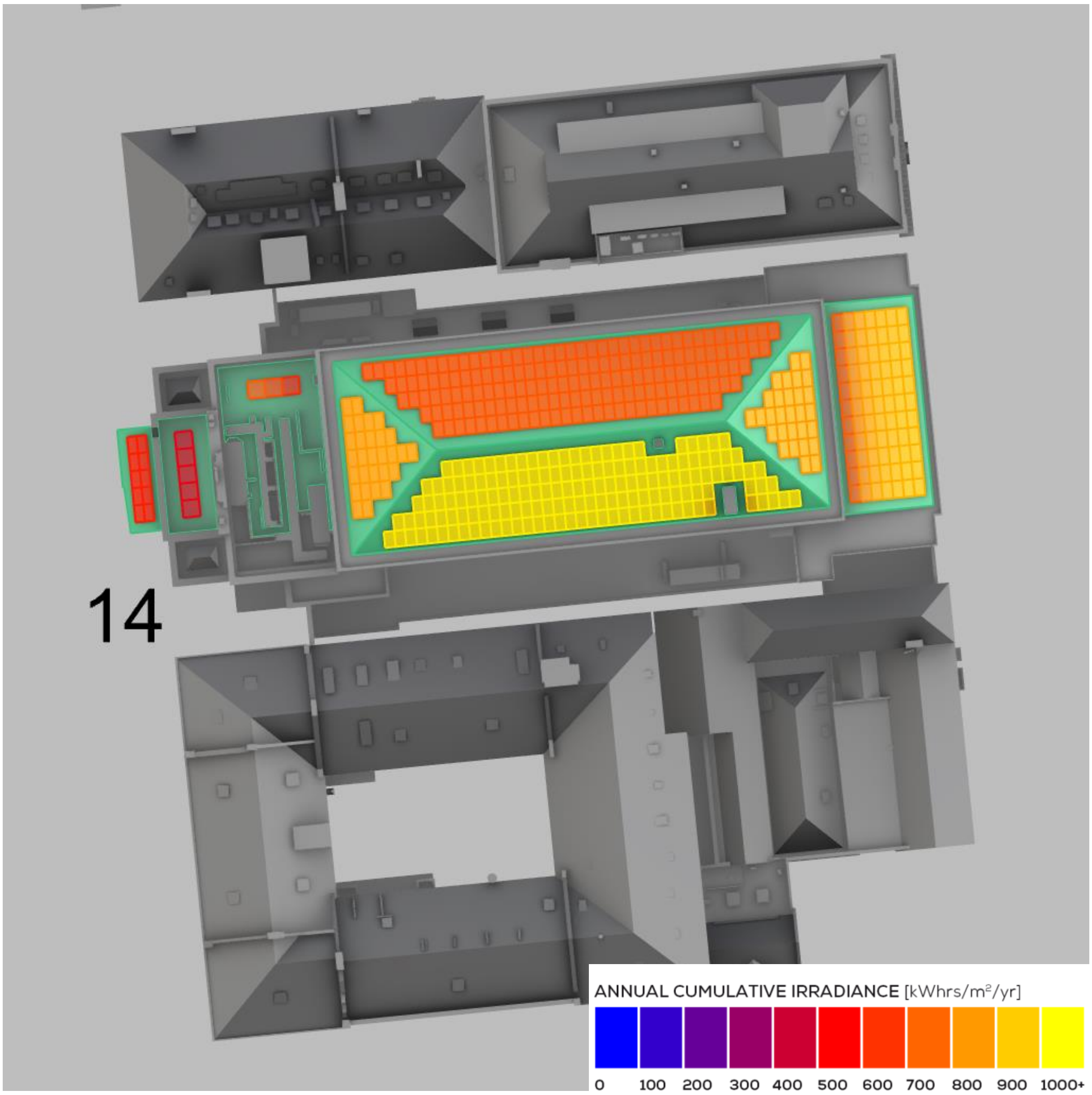

Figure 11: Property ID: 14 - Solar PV Map

Property ID: 15 - Cecil Ward, 4-10 Linenhall Street

Figure 12 provides a map which illustrates the CBDM solar results for Property ID: 15.

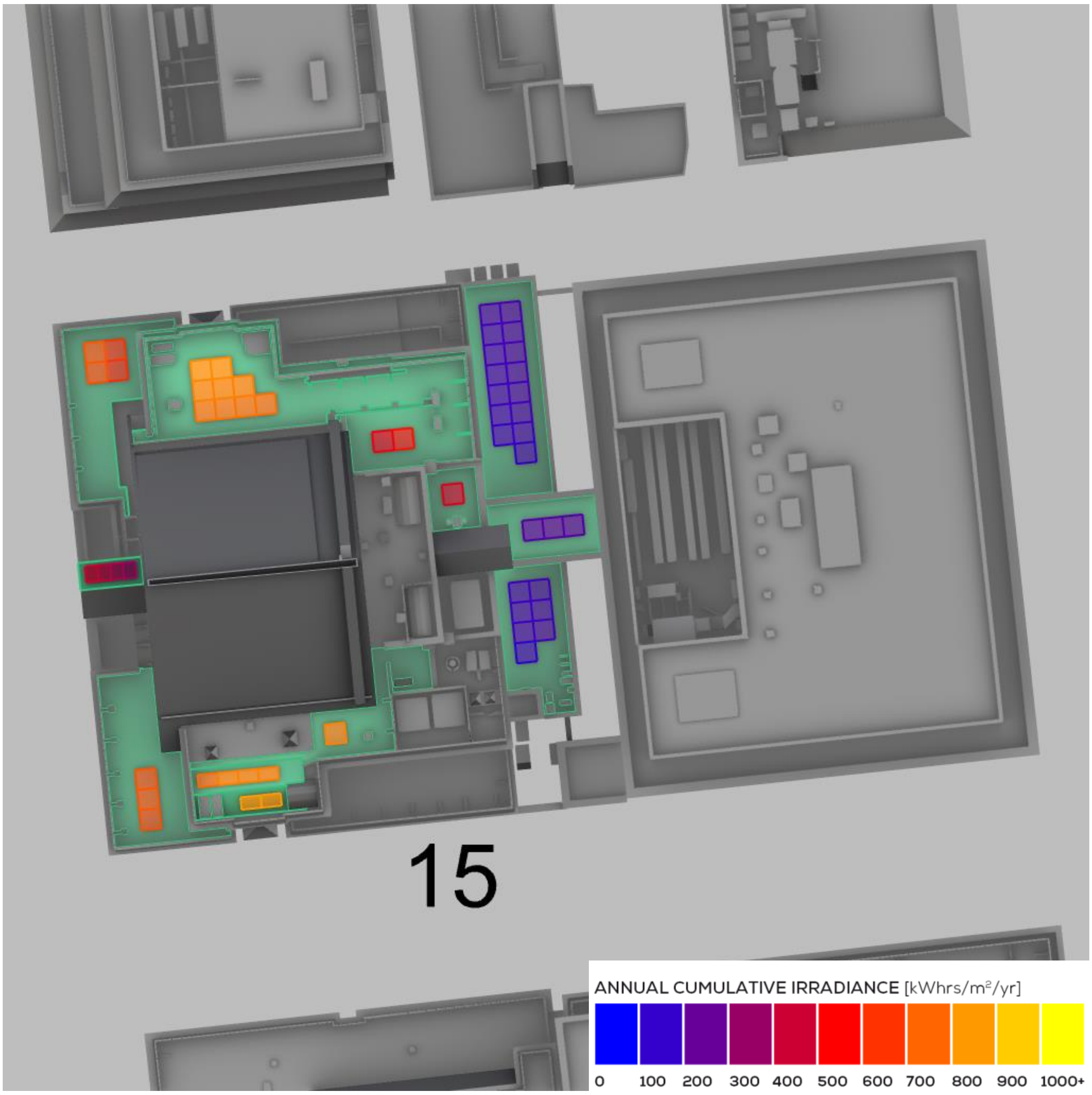

Figure 12: Property ID: 15 - Solar PV Map

Property ID: 16 - St Georges Market, East Bridge Street

Figure 13 provides a map which illustrates the CBDM solar results for Property ID: 16.

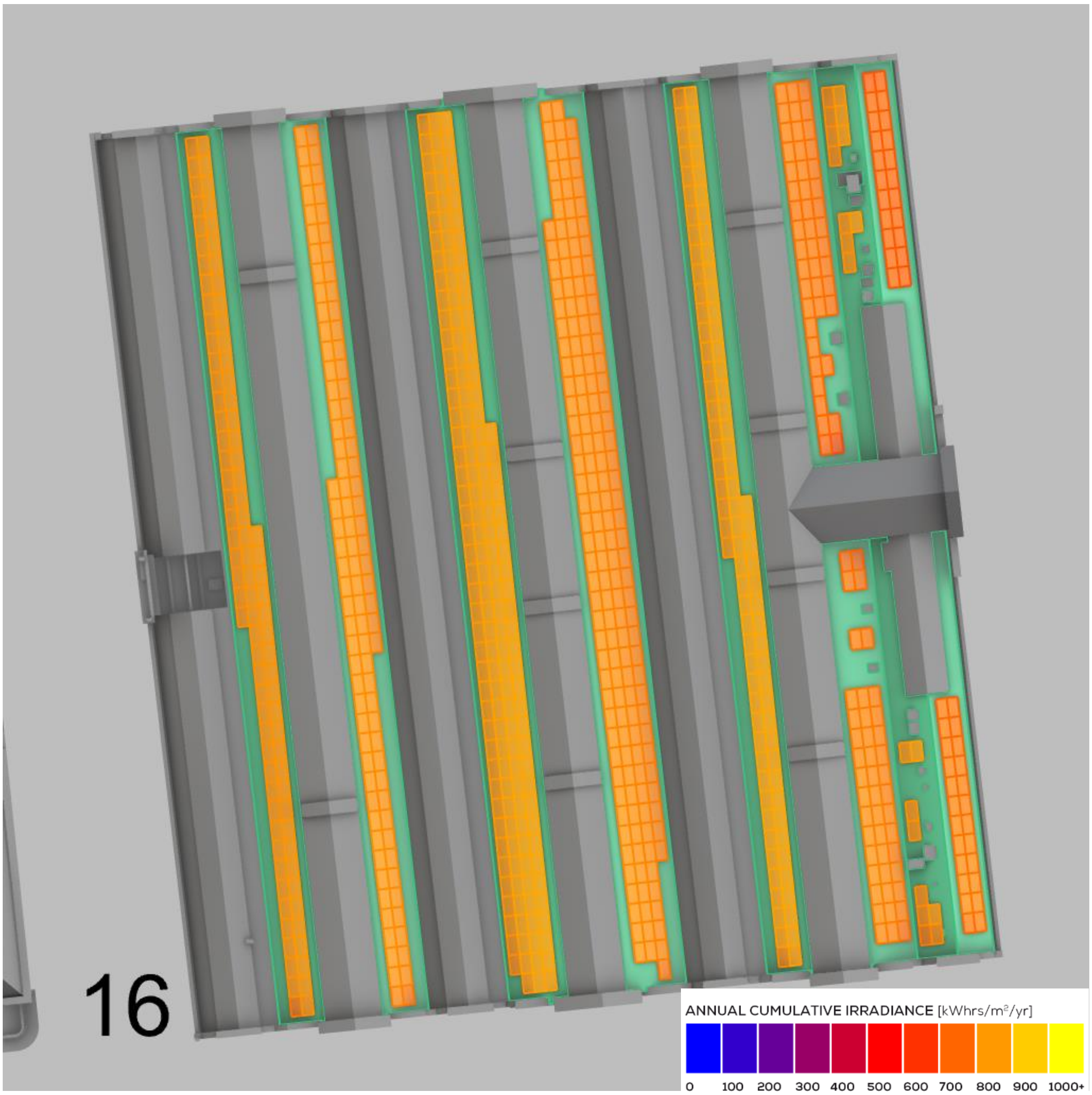

Figure 13: Property ID: 16 - Solar PV Map

Property ID: 17 - Shankill Leisure Centre, 100 Shankill Rd, Belfast

Figure 14 provides a map which illustrates the CBDM solar results for Property ID: 17.

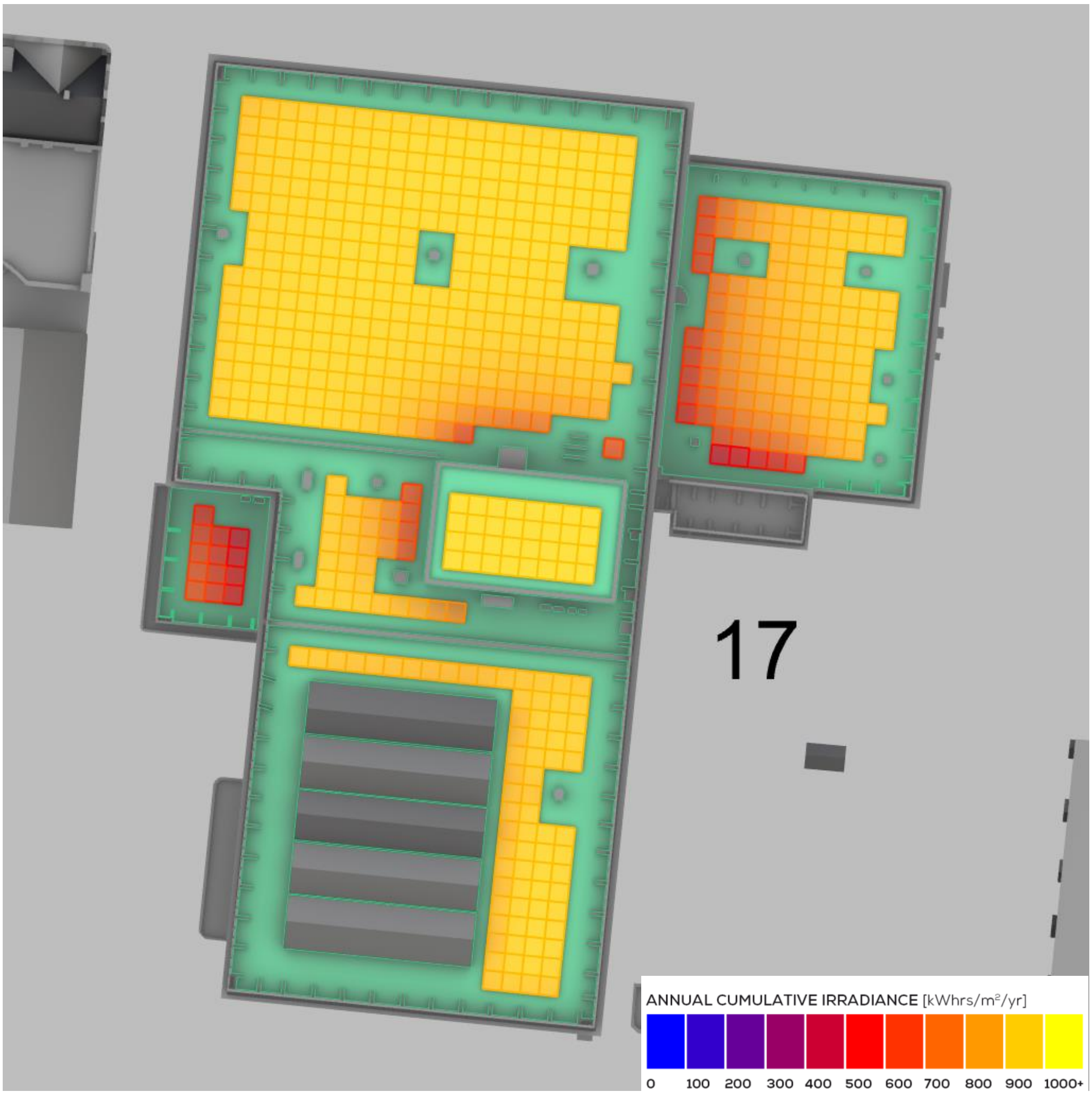

Figure 14: Property ID: 17 - Solar PV Map

Property ID: 18 - Grove Wellbeing Centre, 120 York Rd, Belfast

Figure 15 provides a map which illustrates the CBDM solar results for Property ID: 18.

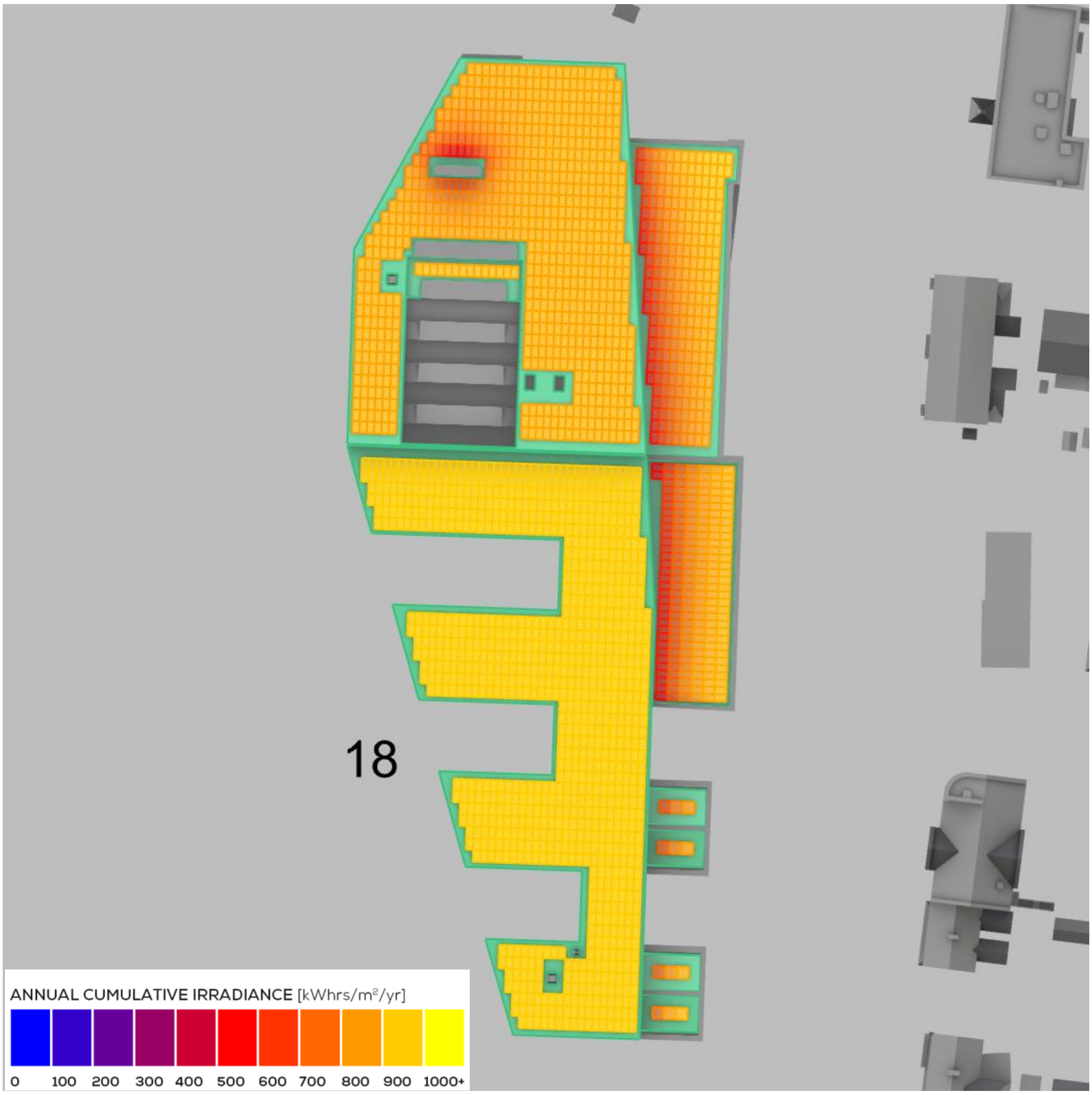

Figure 15: Property ID: 18 - Solar PV Map

Property ID: 19 - Duncrue Complex, Duncrue Road, Belfast

Figure 16 provides a map which illustrates the CBDM solar results for Property ID: 19.

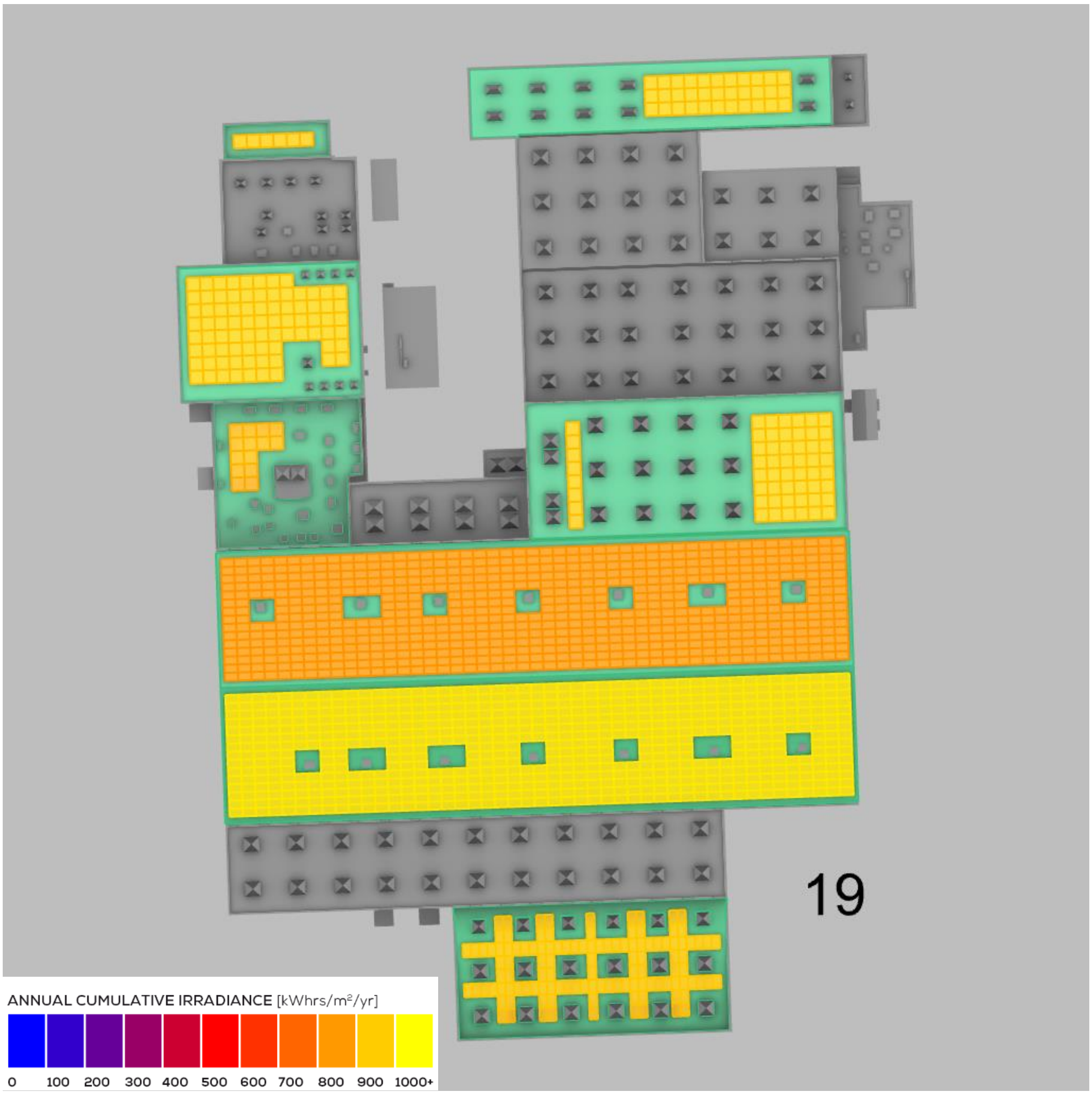

Figure 16: Property ID: 19 - Solar PV Map

Property ID: 20 - Ozone Leisure Centre, Ormeau Embankment

Figure 17 provides a map which illustrates the CBDM solar results for Property ID: 20.

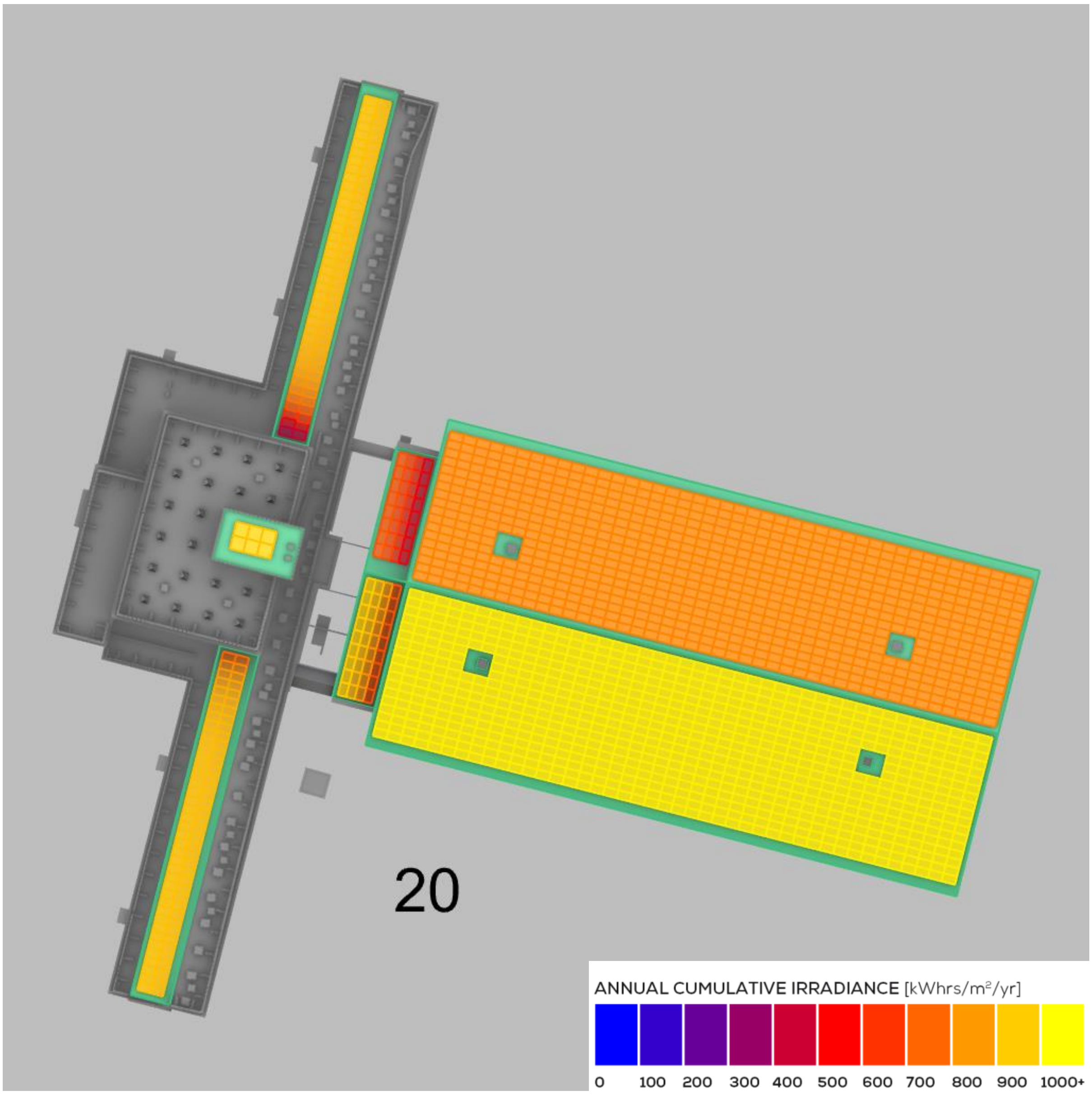

Figure 17: Property ID: 20 - Solar PV Map

Property ID: 21 - GLL Connswater Gym, Unit 11 Connswater Shopping Centre

Figure 18 provides a map which illustrates the CBDM solar results for Property ID: 21.

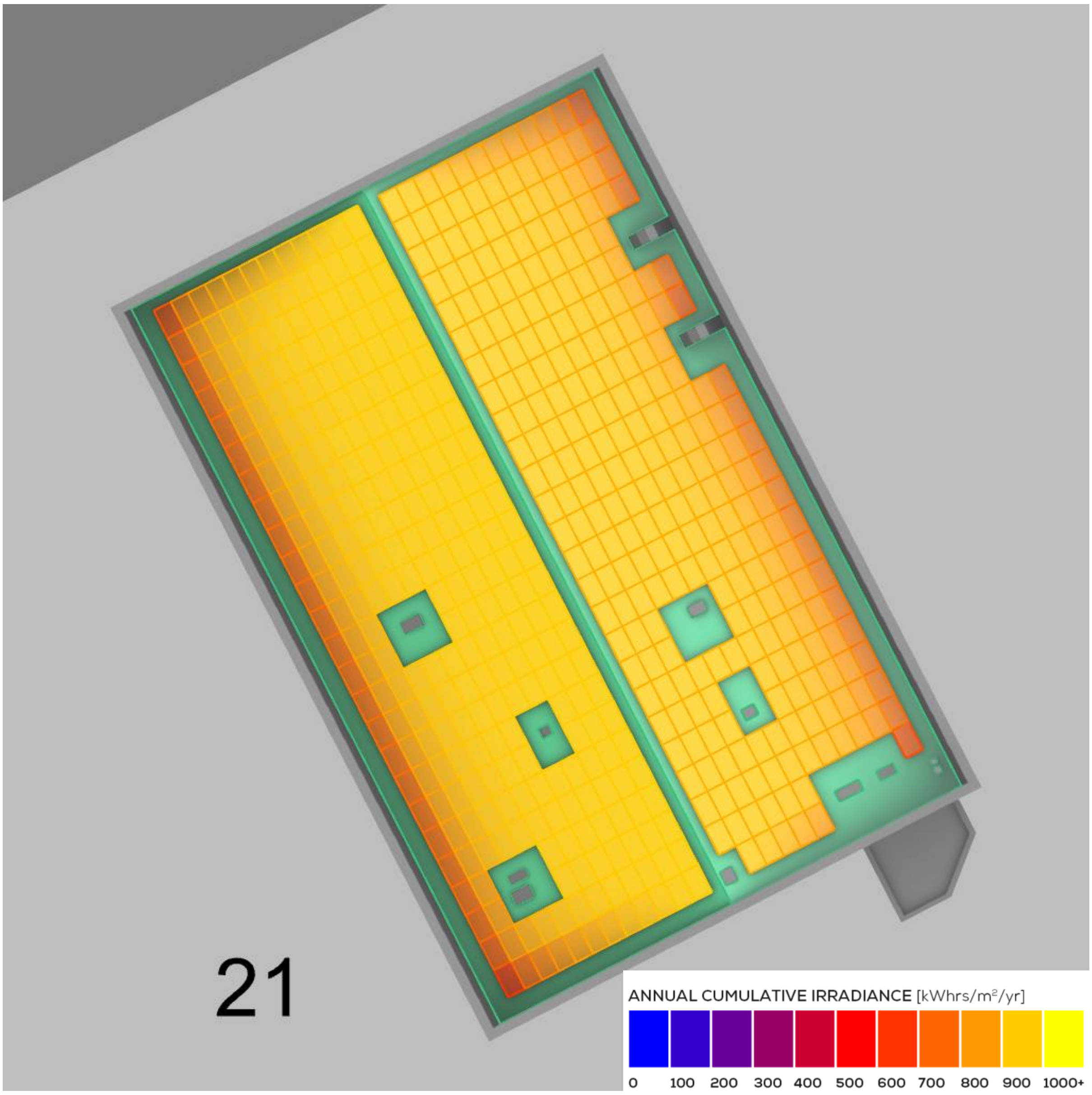

Figure 18: Property ID: 21 - Solar PV Map

Property ID: 22 - Whiterock Leisure Centre, Whiterock Close, Whiterock Road

Figure 19 provides a map which illustrates the CBDM solar results for Property ID: 22.

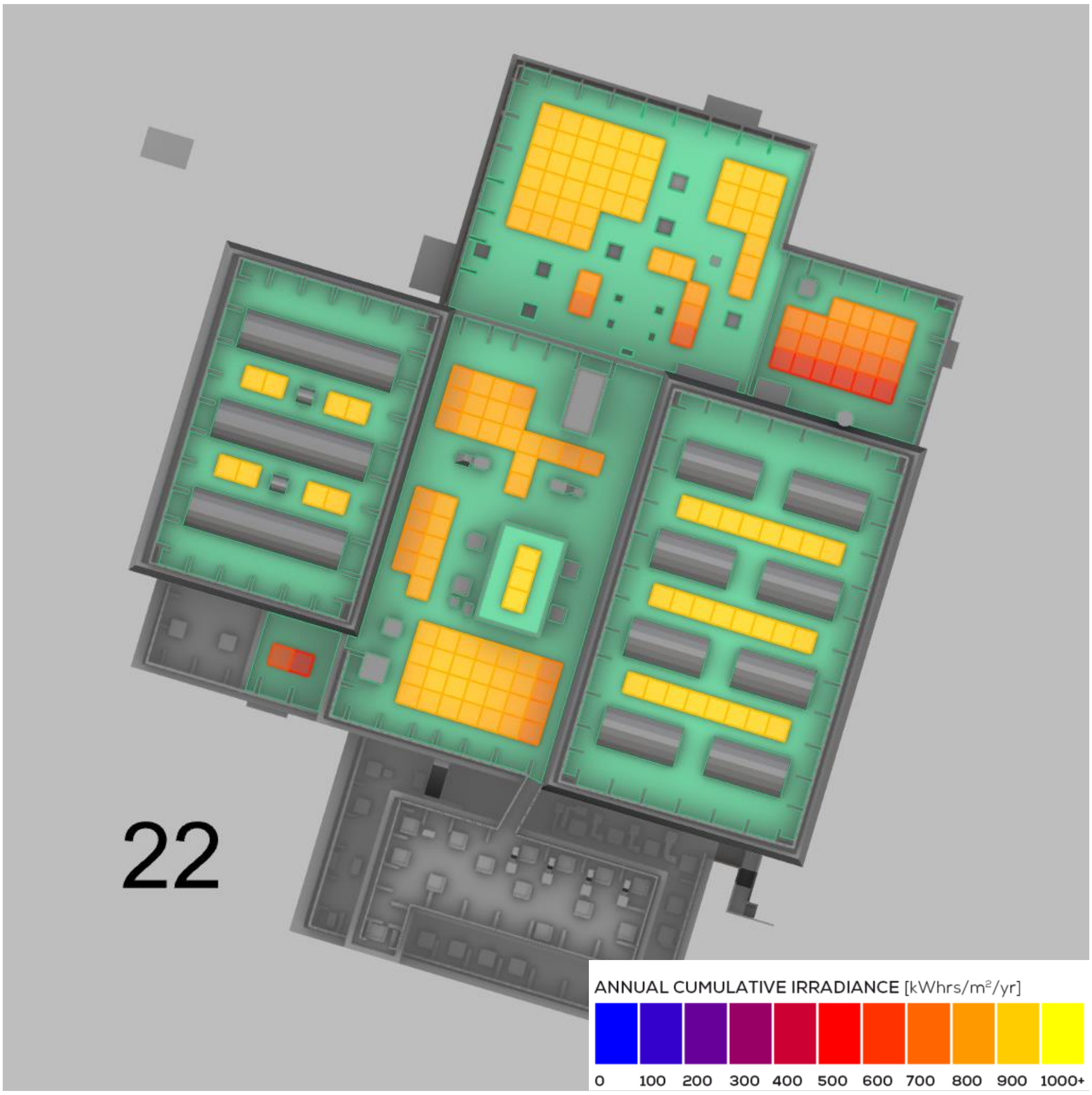

Figure 19: Property ID: 22 - Solar PV Map

Property ID: 23 - Morton Community Centre, 10 Lorne Street

Figure 20 provides a map which illustrates the CBDM solar results for Property ID: 23

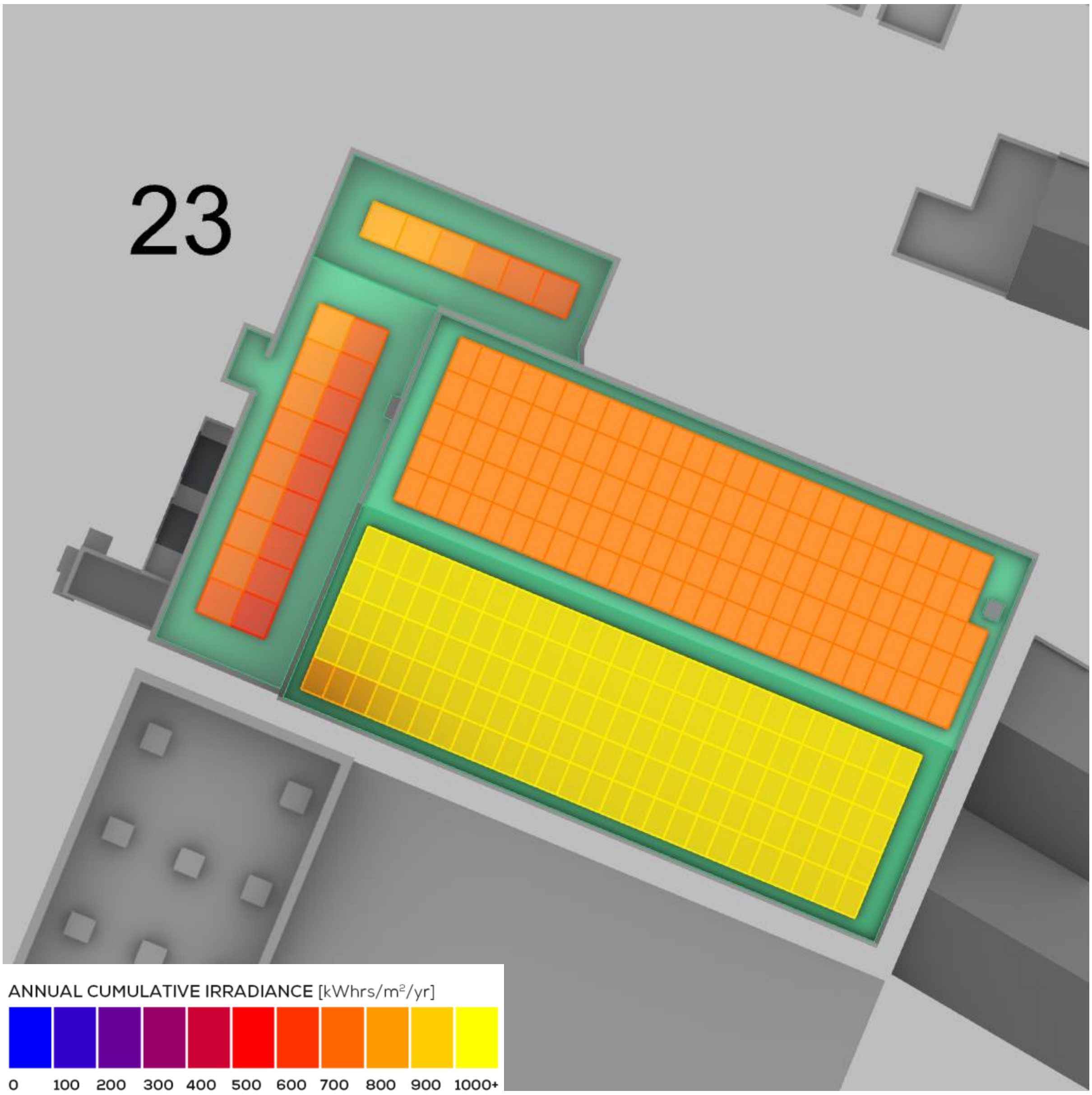

Figure 20: Property ID: 23 - Solar PV Map

Property ID: 25 - Department for Communities Offices, James House, 2-4 Cromac Avenue, Belfast

Figure 21 provides a map which illustrates the CBDM solar results for Property ID: 25.

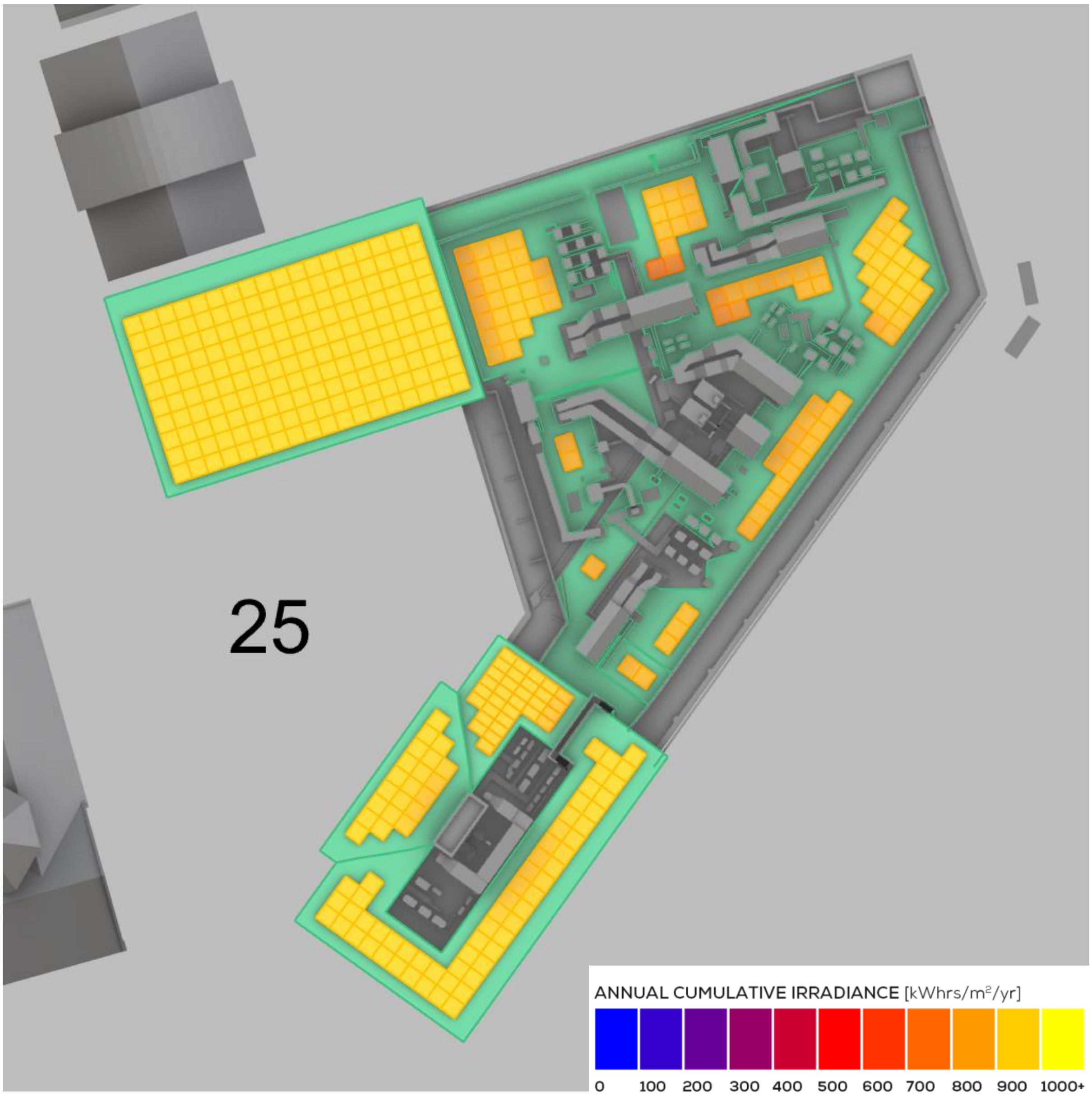

Figure 21: Property ID: 25 - Solar PV Map

Property ID: 27 - National Museums Northern Ireland, Unit 14-21, 22 Heron Road

Figure 22 provides a map which illustrates the CBDM solar results for Property ID: 27.

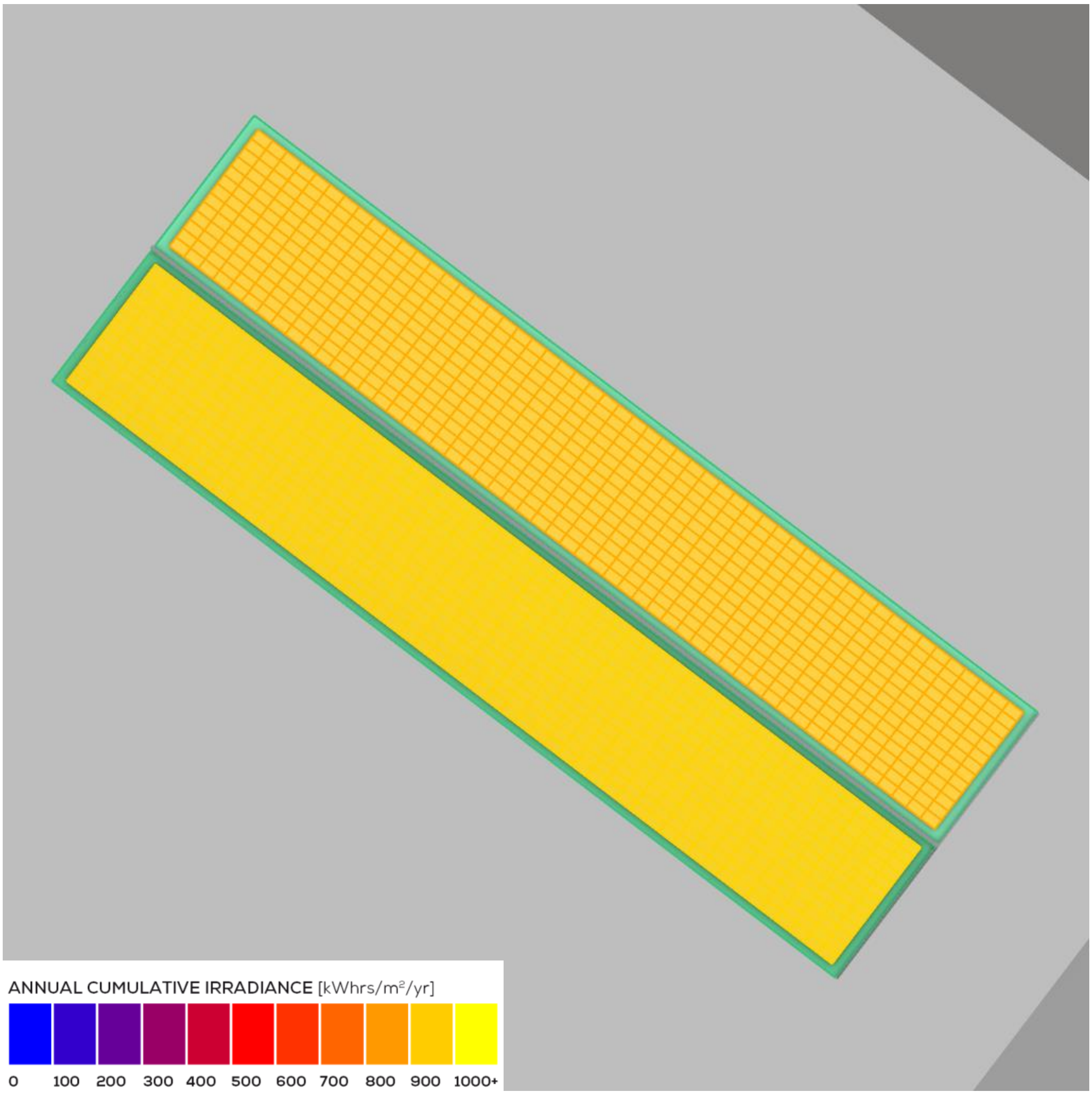

Figure 22: Property ID: 27 - Solar PV Map

Property ID: 28 - Public Records Office of Northern Ireland, 2 Titanic Boulevard

Figure 23 provides a map which illustrates the CBDM solar results for Property ID: 28.

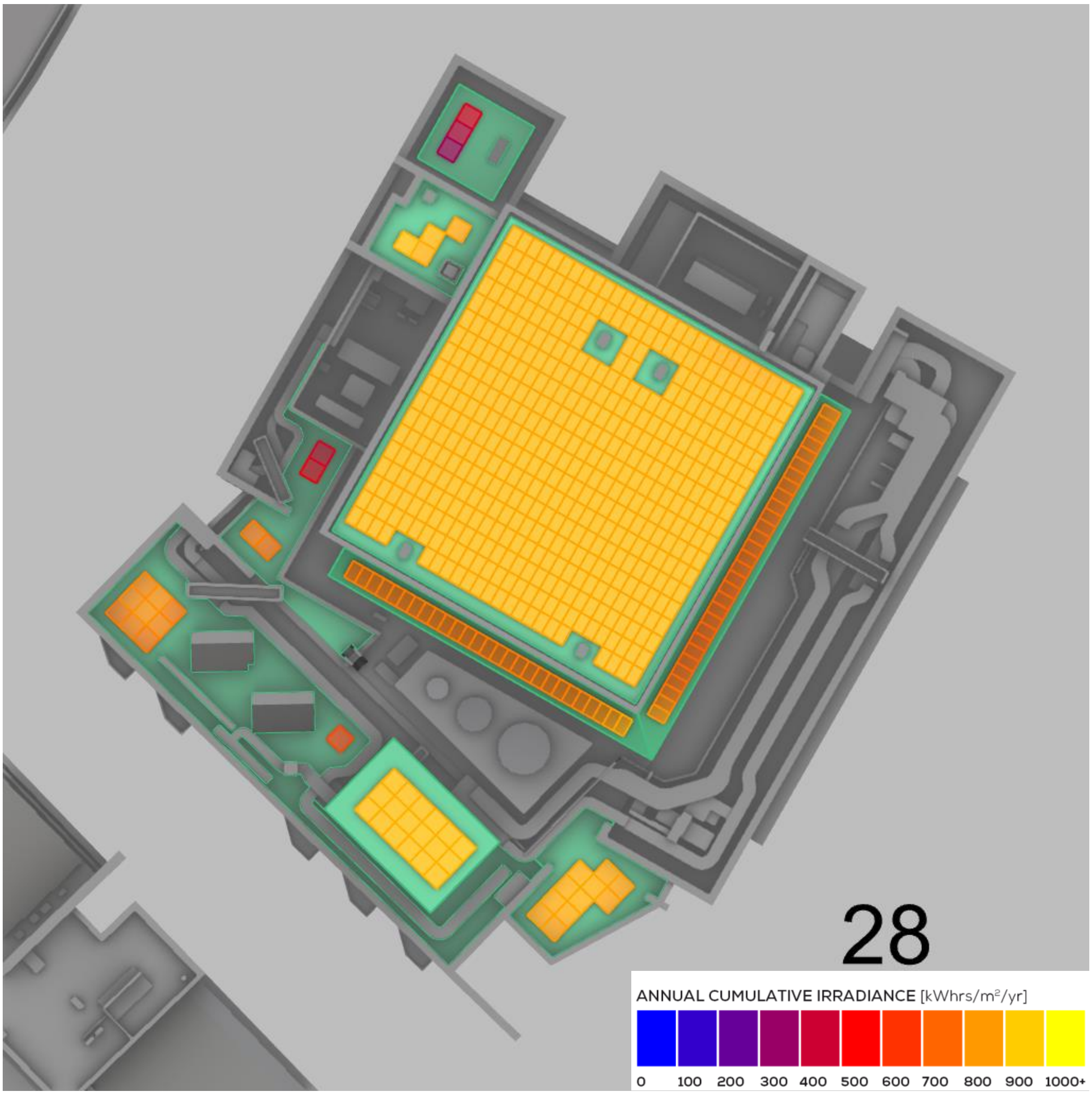

Figure 23: Property ID: 28 - Solar PV Map

Property ID: 35 - 106-108 Holywood Road

Figure 24 provides a map which illustrates the CBDM solar results for Property ID: 35.

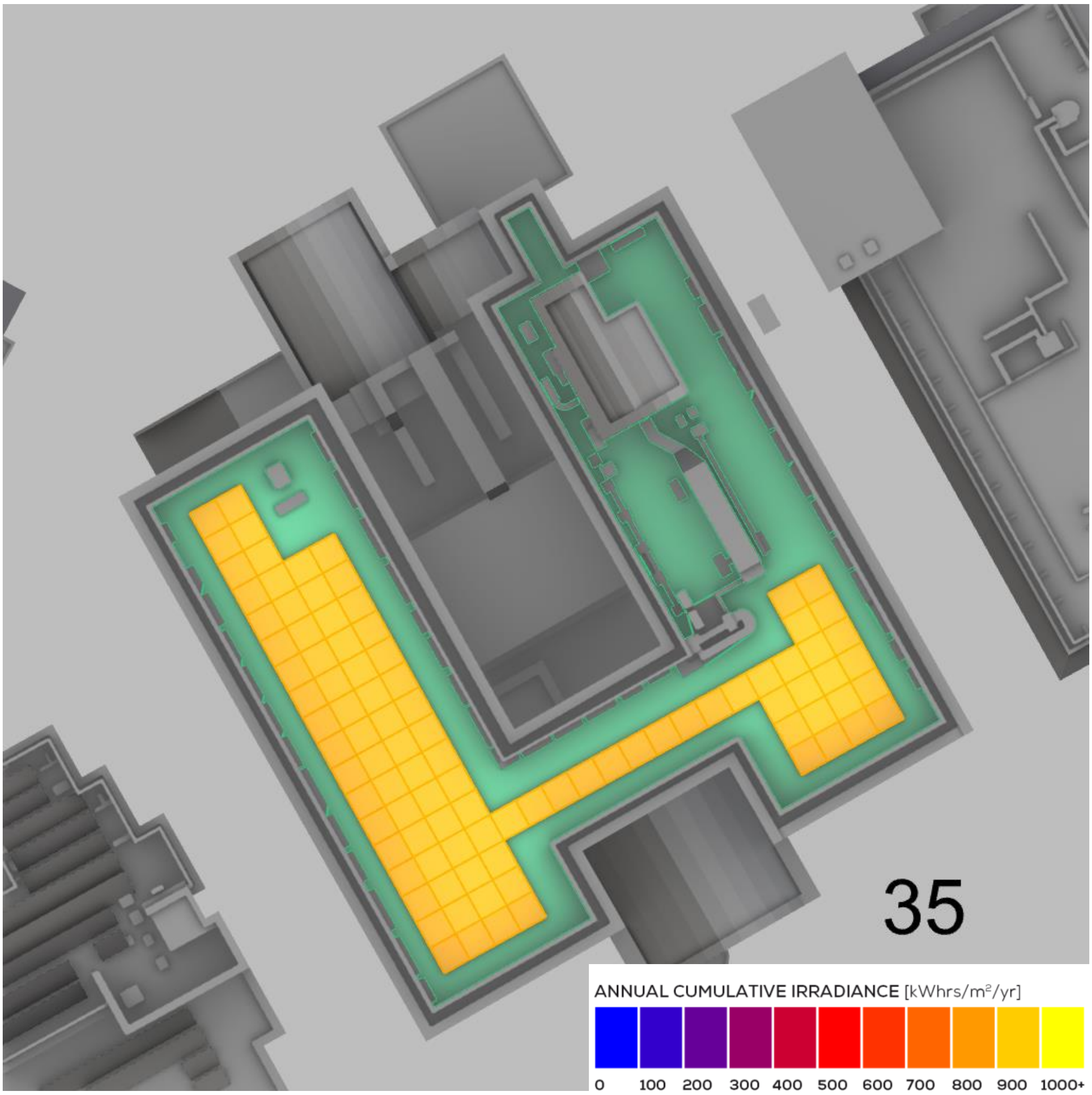

Figure 24: Property ID: 35 - Solar PV Map

Property ID: 43 - Royal Victoria Hospital - New Maternity, 274 Grosvenor Road

Figure 25 provides a map which illustrates the CBDM solar results for Property ID: 43. It is important to note that property 43 has an existing 15kWp solar PV array installed. As such, the PV assessment only considered the remaining usable roof. The location of the existing array is illustrated in Figure 26.

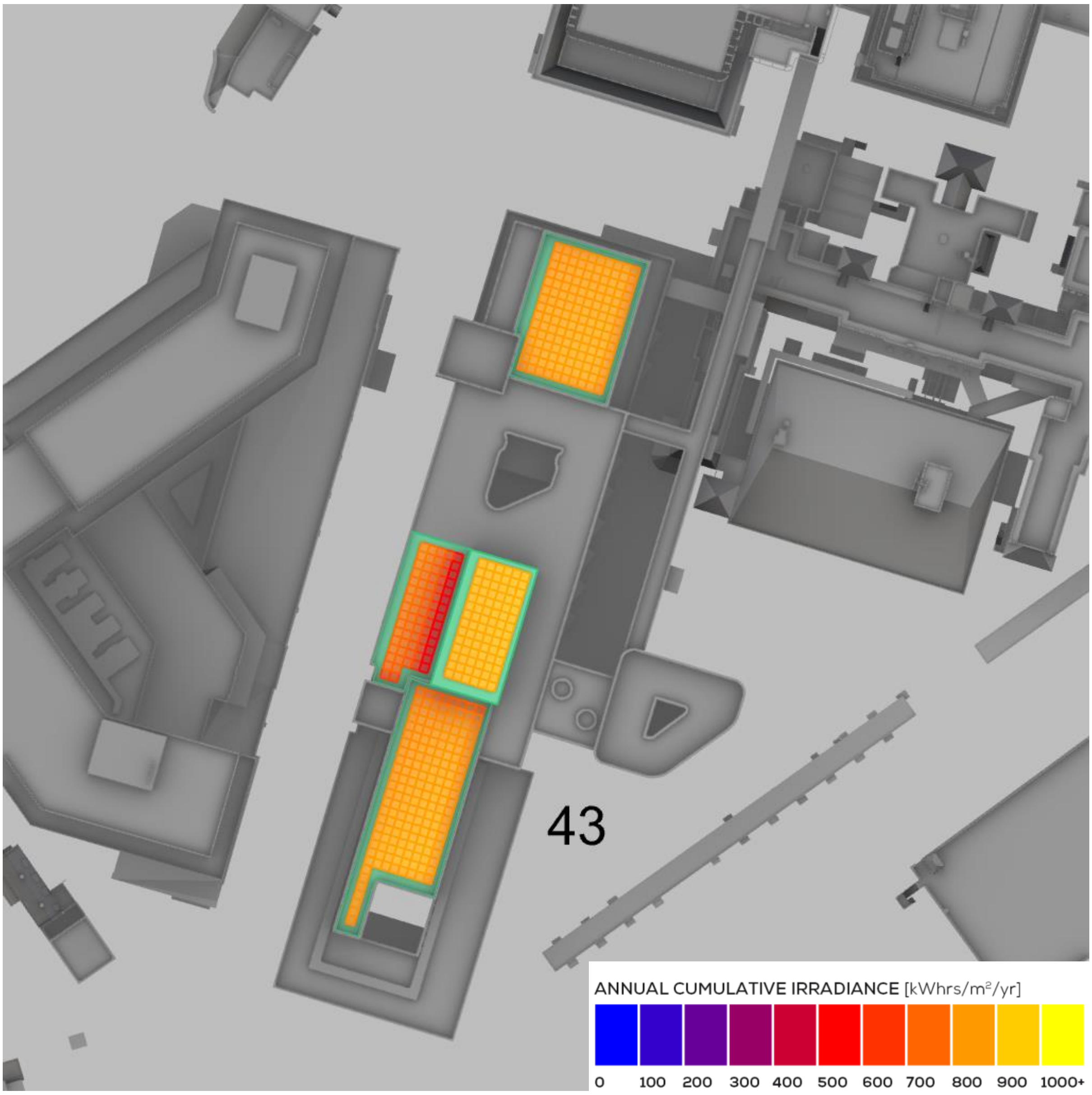

Figure 25: Property ID: 43 - Solar PV Map

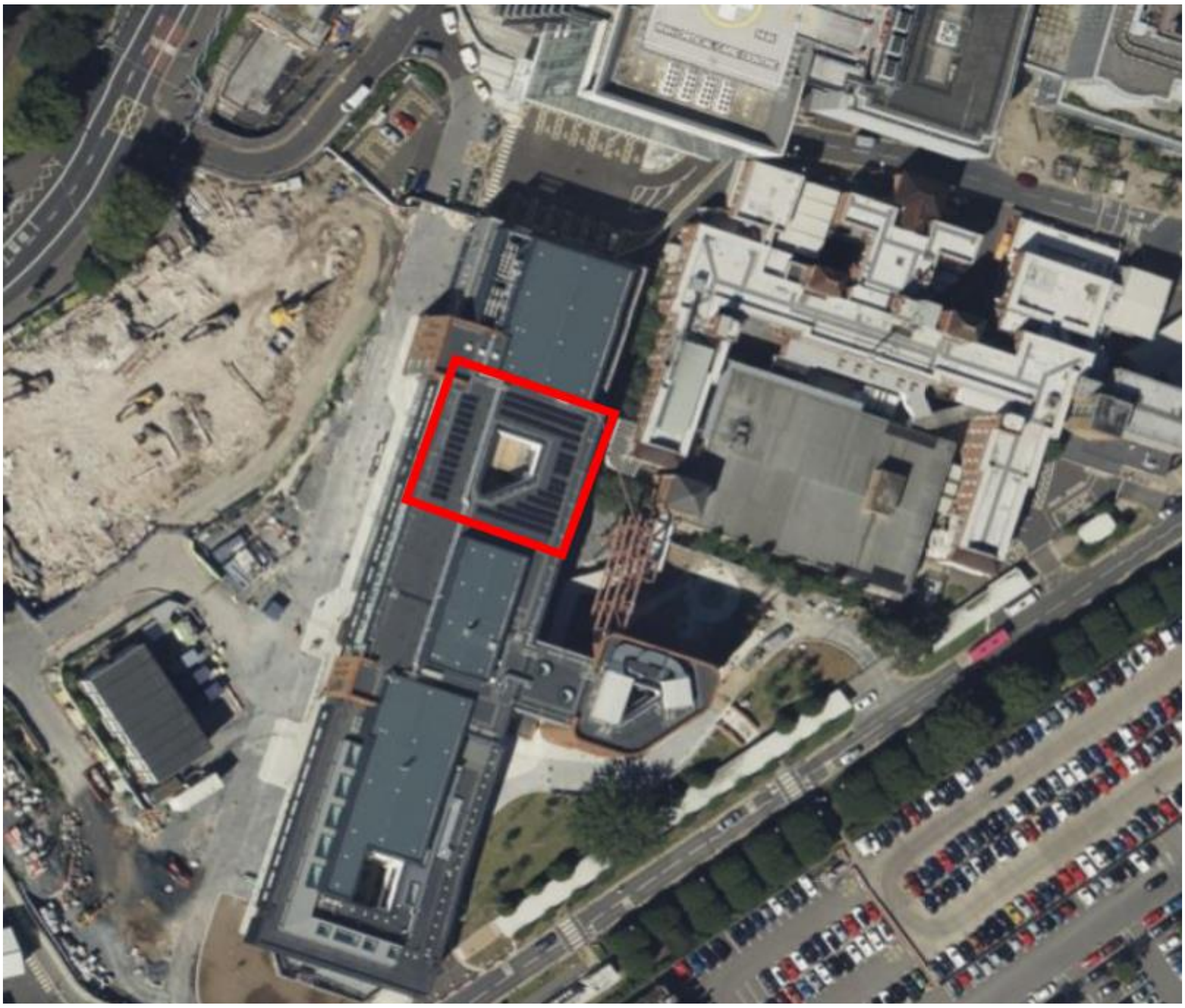

Figure 26: Existing PV Panels on Property ID: 43

Property ID: 44 - Royal Victoria Hospital – Kelvin, 274 Grosvenor Road

Figure 27 provides a map which illustrates the CBDM solar results for Property ID: 44.

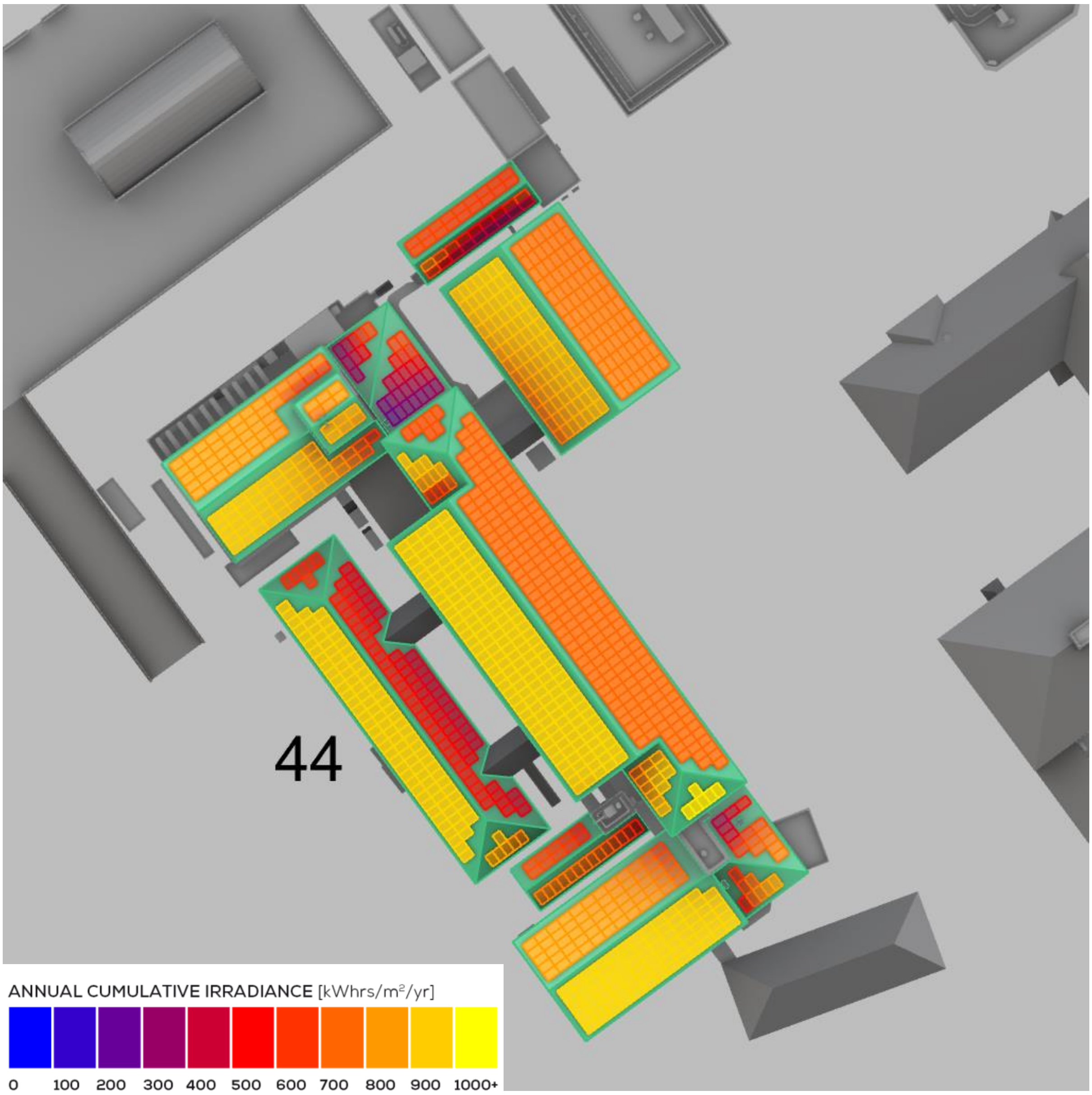

Figure 27: Property ID: 44 - Solar PV Map

Property ID: 47 - Belfast City Hospital - Cancer Centre, 51 Lisburn Road

Figure 28 provides a map which illustrates the CBDM solar results for Property ID: 47.

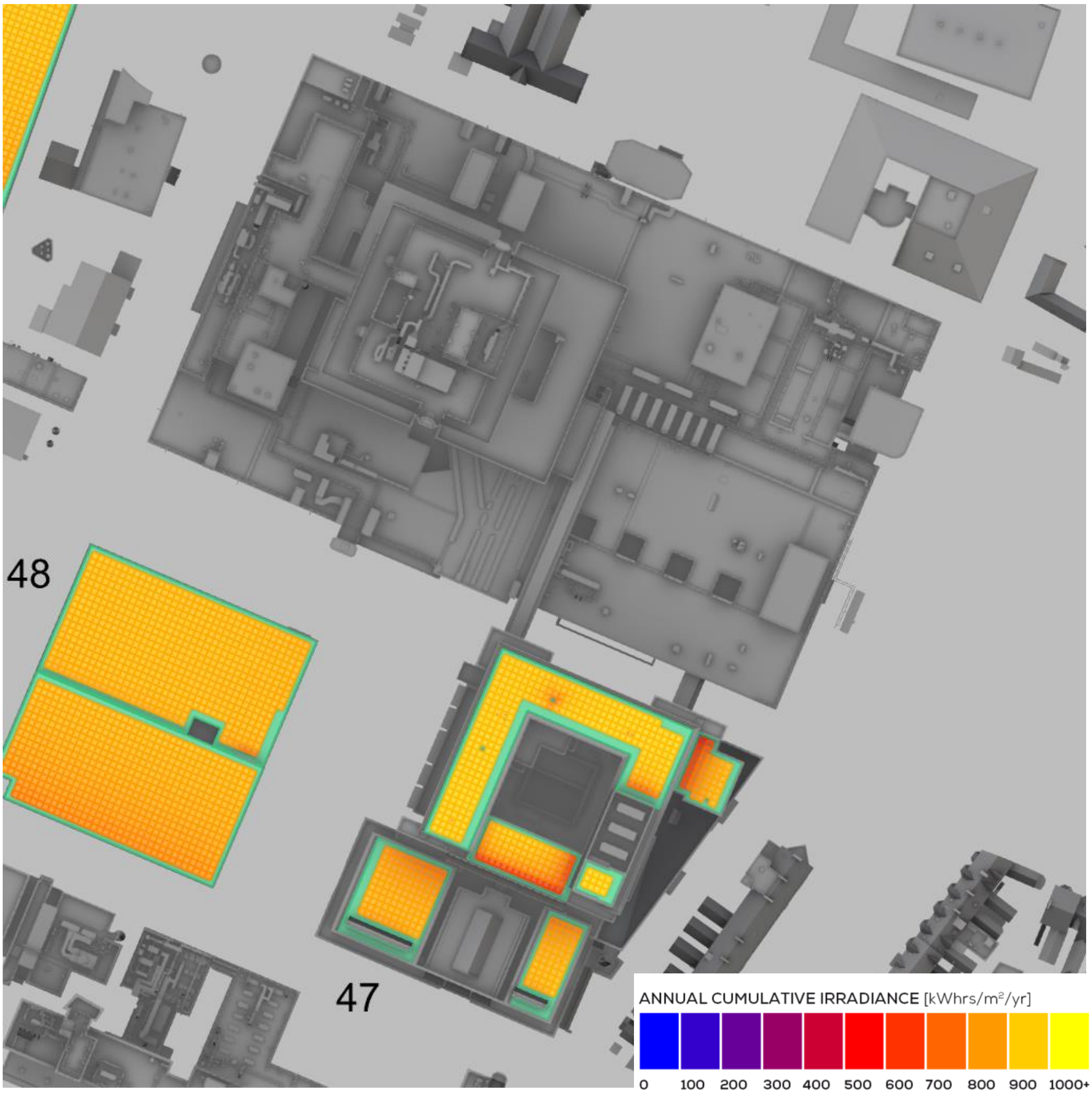

Figure 28: Property ID: 47 - Solar PV Map

Property ID: 48 - Belfast City Hospital - Multi Storey Car Park No.2, 51 Lisburn Road

Figure 29 provides a map which illustrates the CBDM solar results for Property ID: 48. It is worth noting that this site represents a multi-storey car park (see Figure 30) and therefore the potential array has been designed to create an overhead structure on the usable space available.

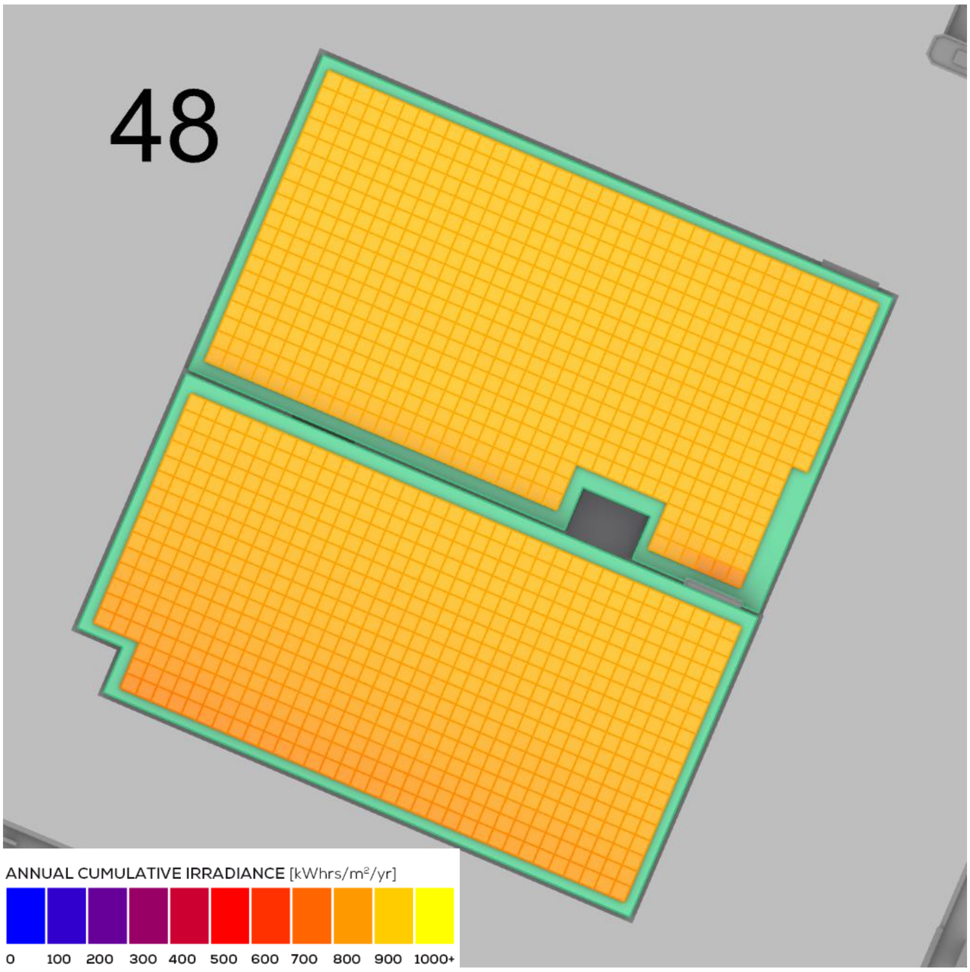

Figure 29: Property ID: 48 - Solar PV Map

Figure 30: Property ID: 48 - Multi Storey Car Aerial Imagery

Property ID: 49 - Belfast City Hospital - Multi Storey Car Park No.1, 51 Lisburn Road

Figure 31 provides a map which illustrates the CBDM solar results for Property ID: 49. It is worth noting that this site represents a multi-storey car park (see Figure 32) and therefore the potential array has been designed to create an overhead structure on the usable space available.

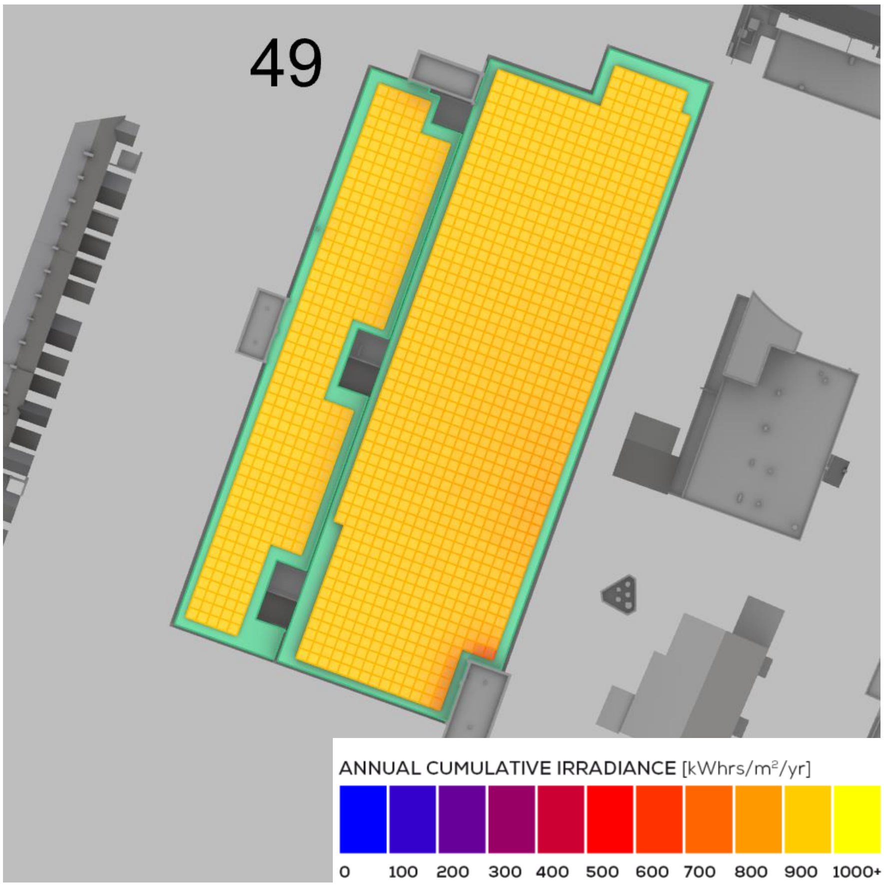

Figure 31: Property ID: 49 - Solar PV Map

Figure 32: Property ID: 49 - Multi Storey Car Aerial Imagery

Property ID: 51 - Mater Hospital - McAuley, 45-54 Crumlin Road

Figure 33 provides a map which illustrates the CBDM solar results for Property ID: 51.

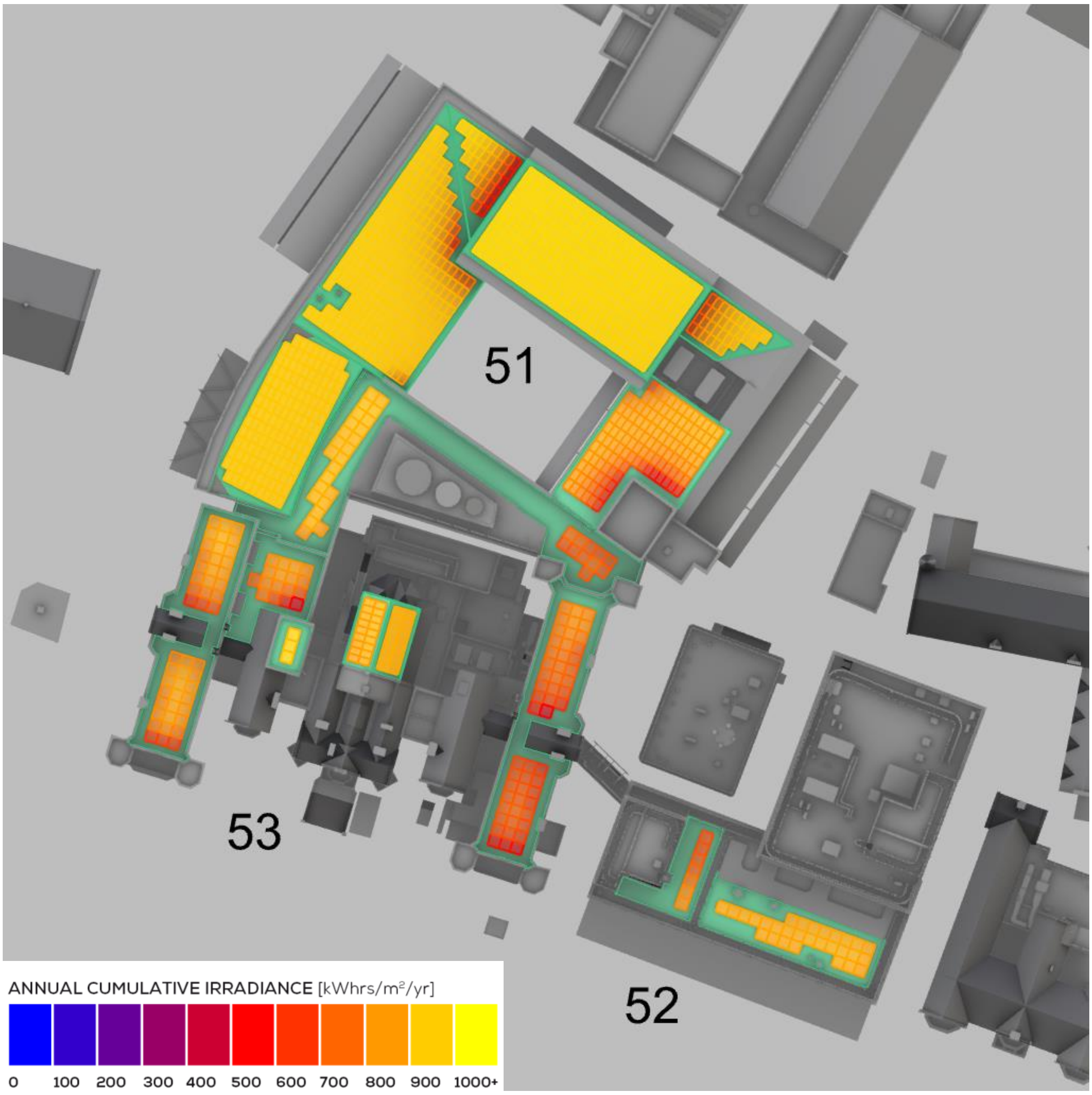

Figure 33: Property ID: 51 - Solar PV Map

Property ID: 52 - Mater Hospital - Dempsey, 45-54 Crumlin Road

Figure 34 provides a map which illustrates the CBDM solar results for Property ID: 52.

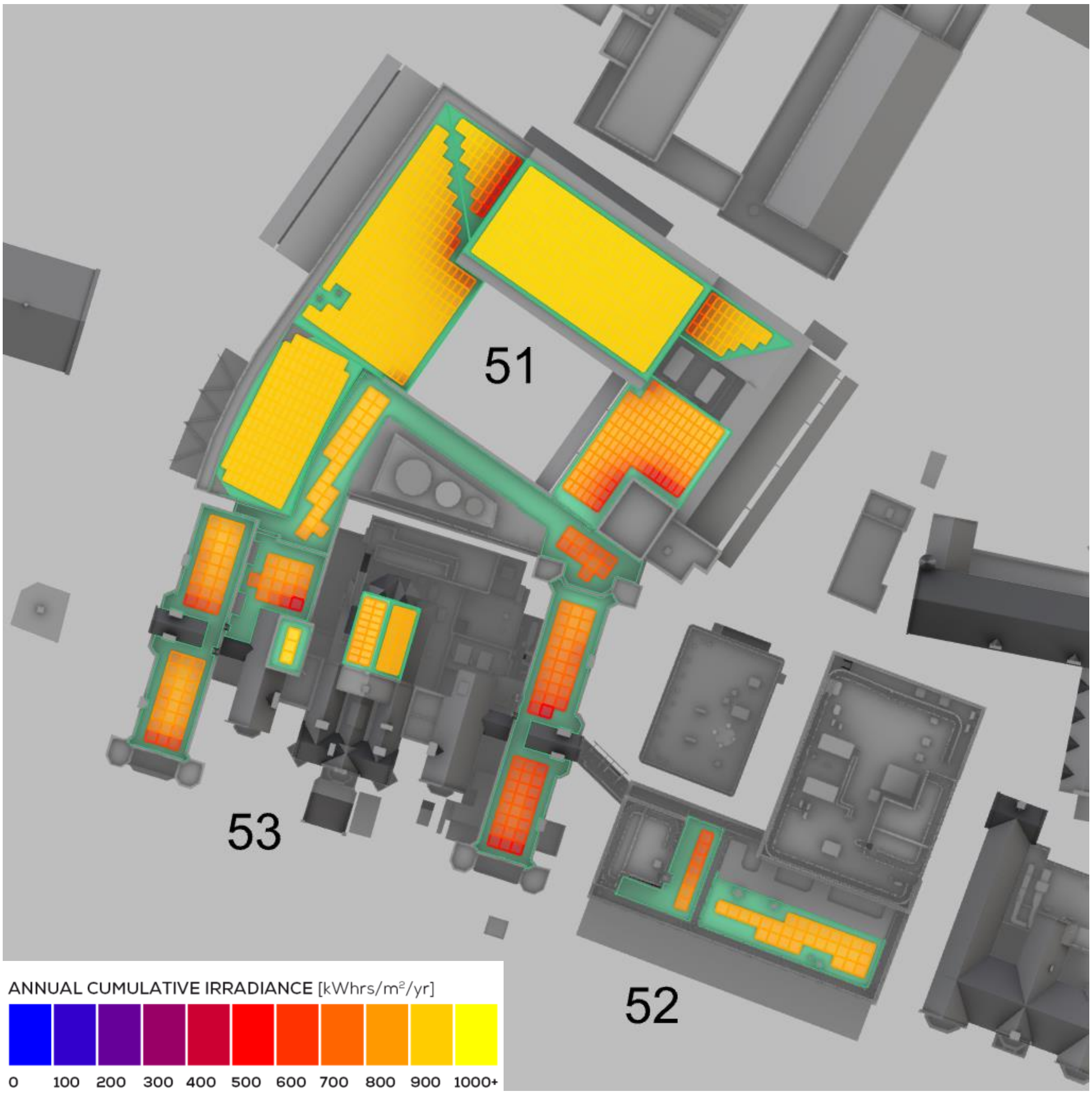

Figure 34: Property ID: 52 - Solar PV Map

Property ID: 53 - Mater Hospital – Dorrian, 45-54 Crumlin Road

Figure 35 provides a map which illustrates the CBDM solar results for Property ID: 53.

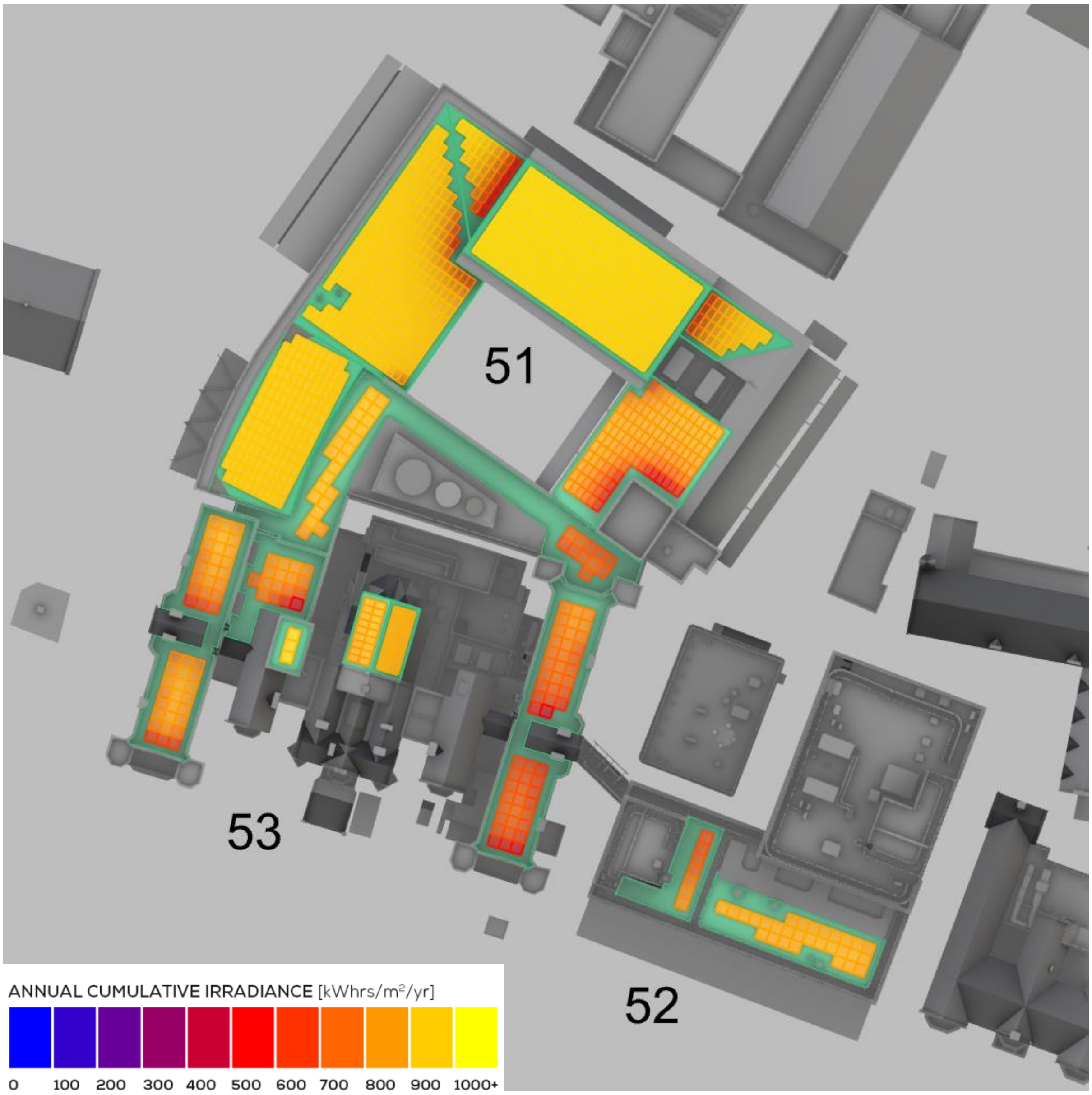

Figure 35: Property ID: 53 - Solar PV Map

Property ID: 56 - Belfast Metropolitan College (BMC) - Titanic Quarter, 7 Queens Road

Figure 36 provides a map which illustrates the CBDM solar results for Property ID: 56.

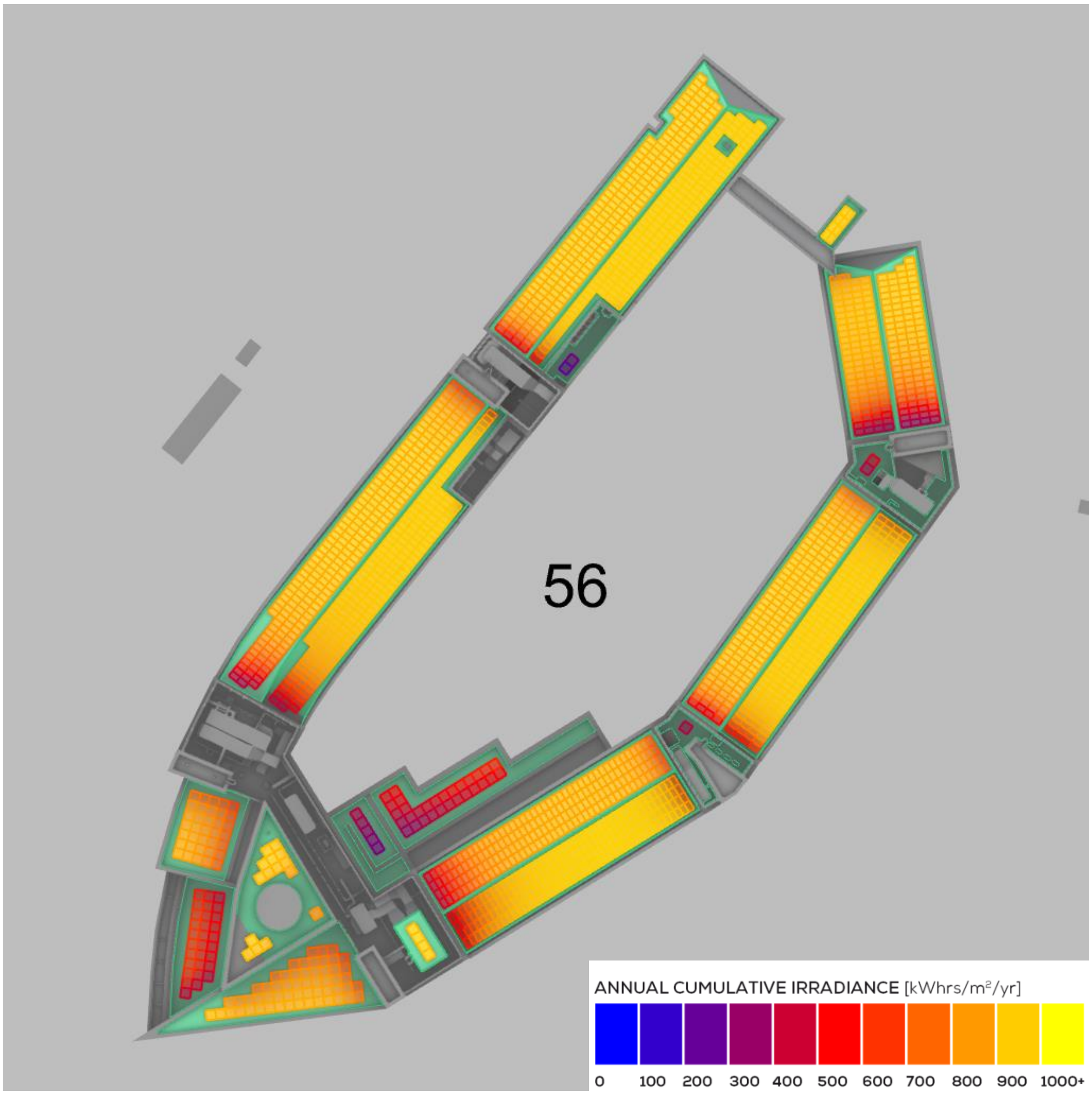

Figure 36: Property ID: 56 - Solar PV Map

Property ID: 58 - Ulster Museum, 1 Botanic Gardens

Figure 37 provides a map which illustrates the CBDM solar results for Property ID: 58.

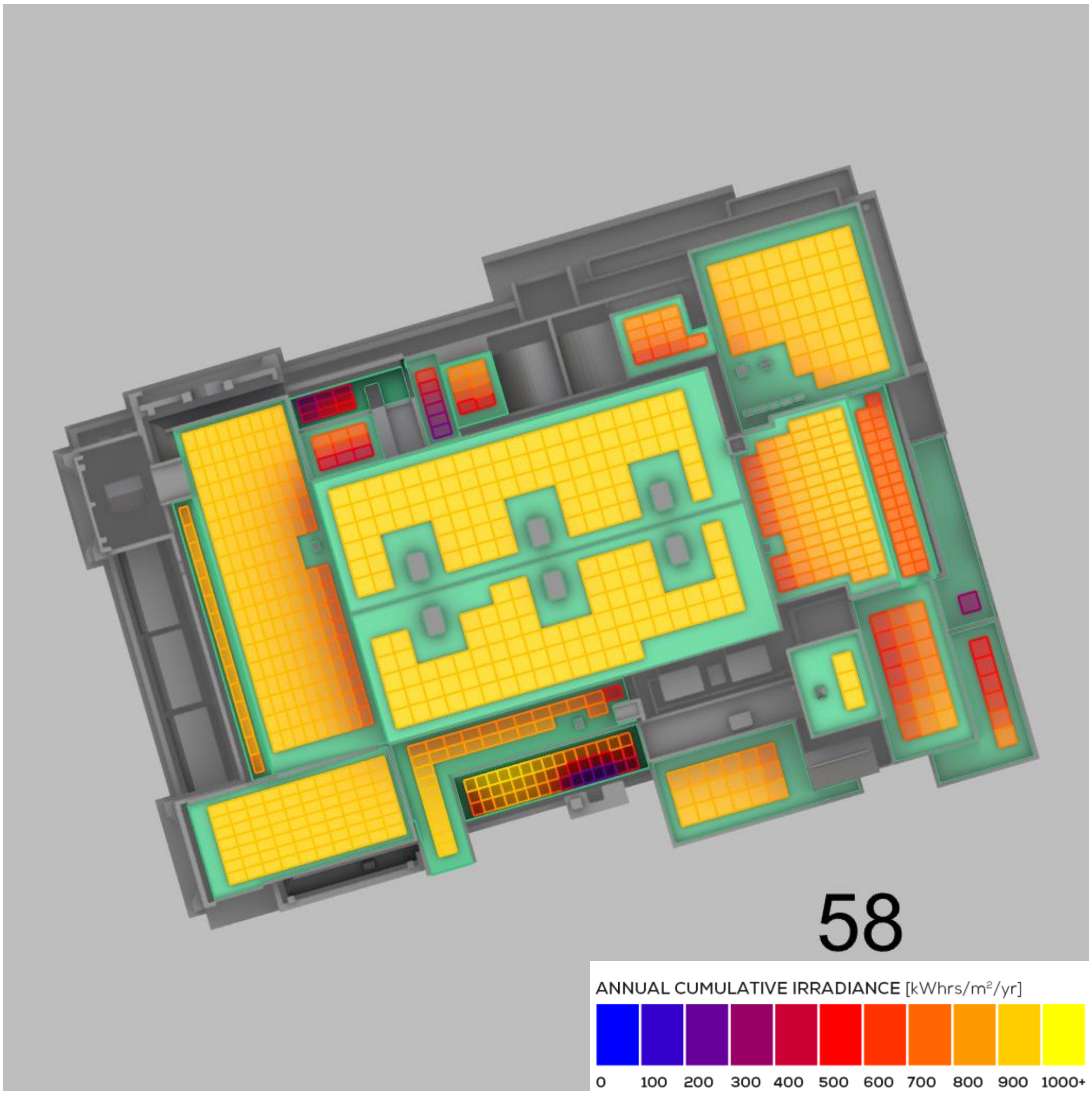

Figure 37: Property ID: 58 - Solar PV Map

Property ID: 69 - Anon ID: 1

Figure 38 provides a map which illustrates the CBDM solar results for Property ID: 69.

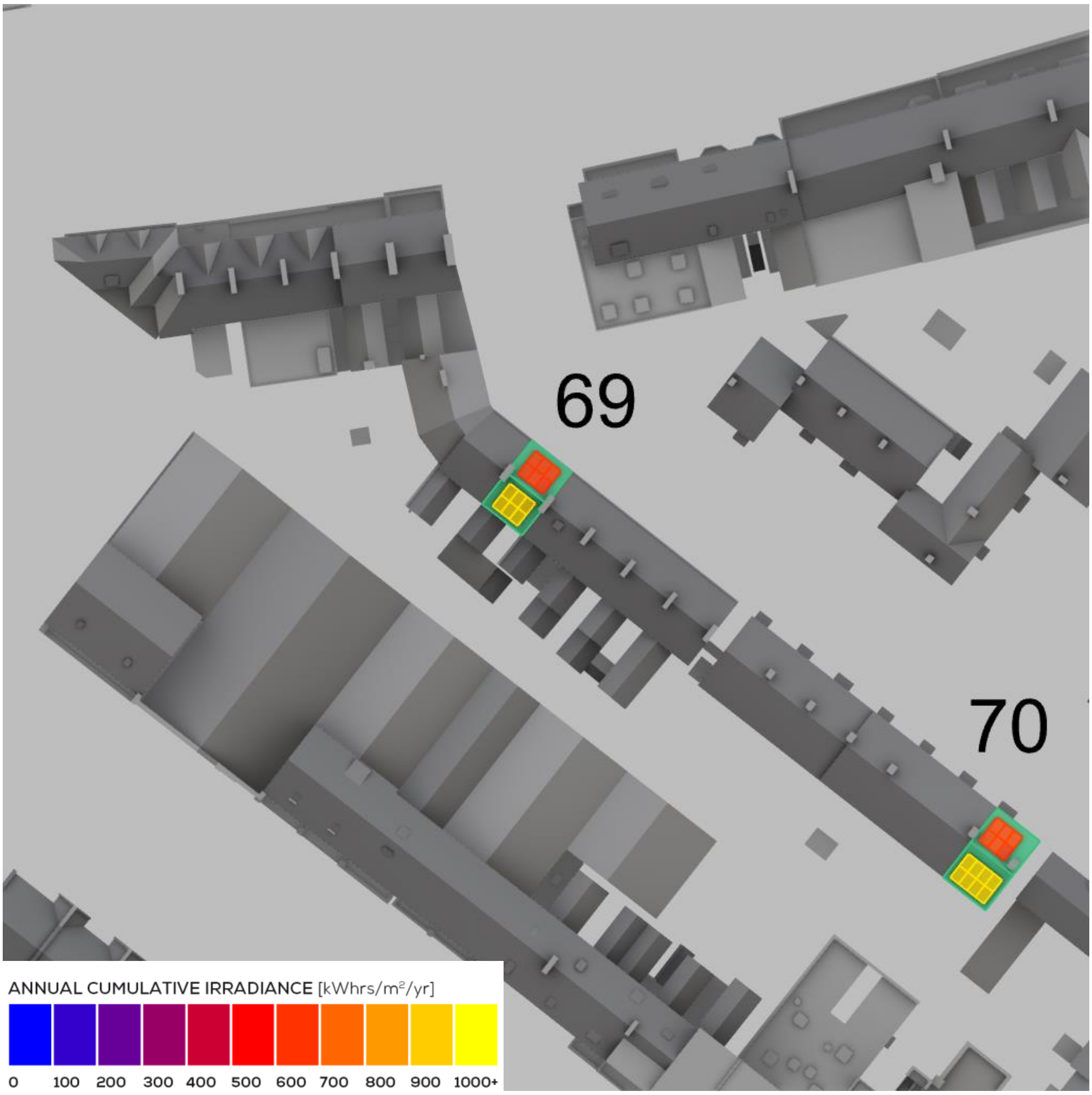

Figure 38: Property ID: 69 - Solar PV Map

Property ID: 70 - Anon ID: 2

Figure 39 provides a map which illustrates the CBDM solar results for Property ID: 70.

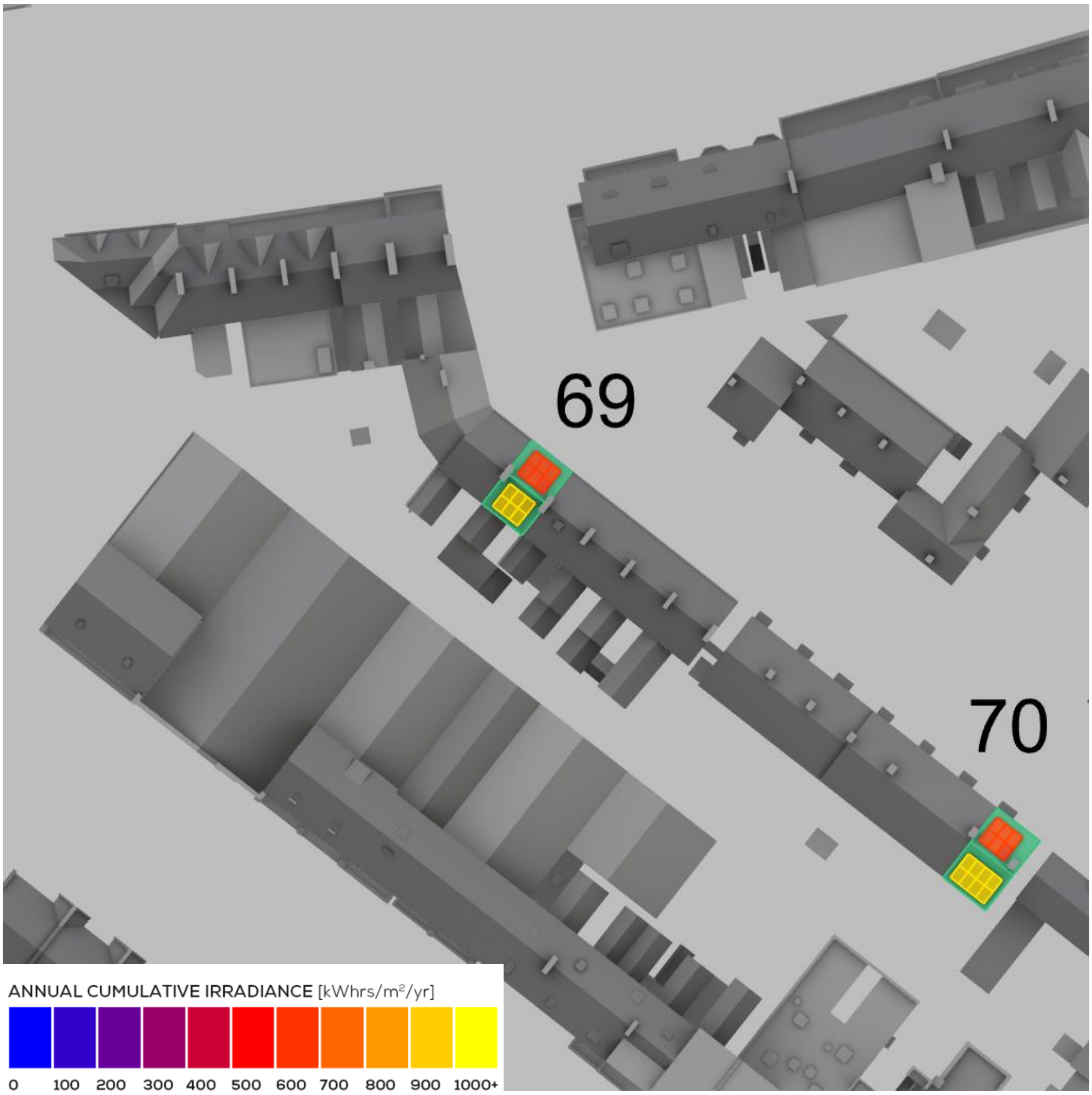

Figure 39: Property ID: 70 - Solar PV Map

Property ID: 71 - Anon ID: 3

Figure 40 provides a map which illustrates the CBDM solar results for Property ID: 71.

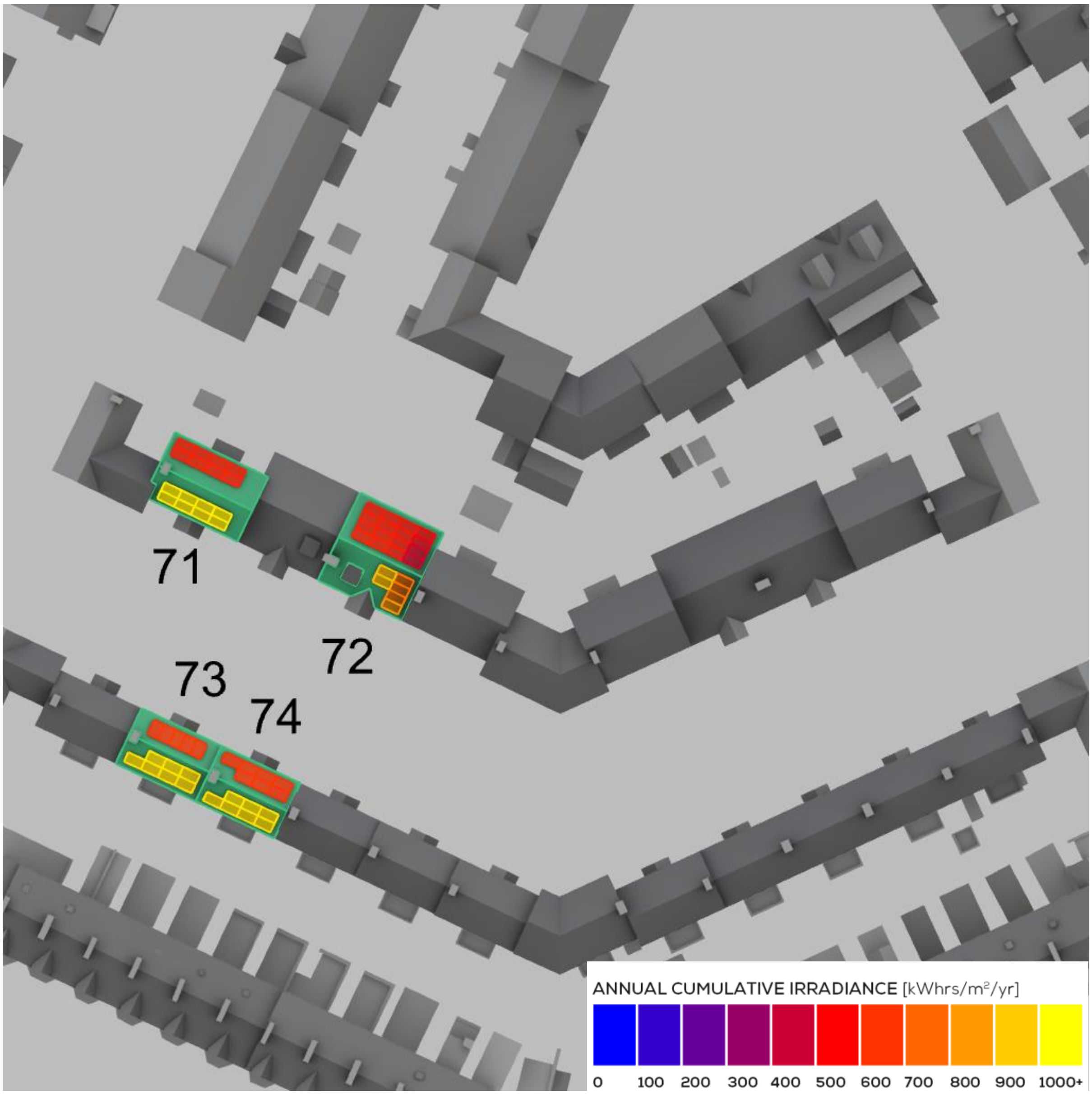

Figure 40: Property ID: 71 - Solar PV Map

Property ID: 72 - Anon ID: 4

Figure 41 provides a map which illustrates the CBDM solar results for Property ID: 72.

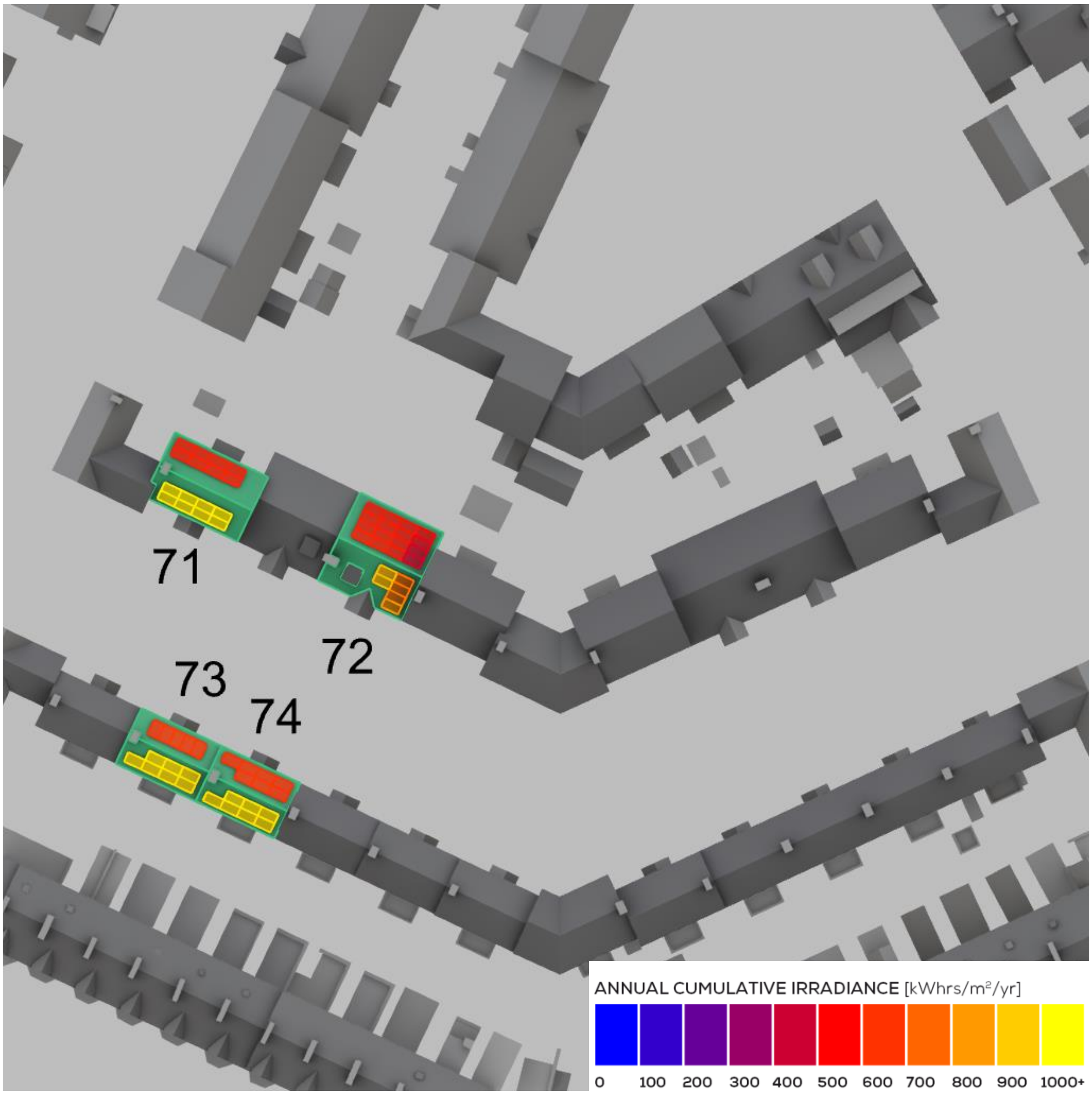

Figure 41: Property ID: 72 - Solar PV Map

Property ID: 73 - Anon ID: 5

Figure 42 provides a map which illustrates the CBDM solar results for Property ID: 73.

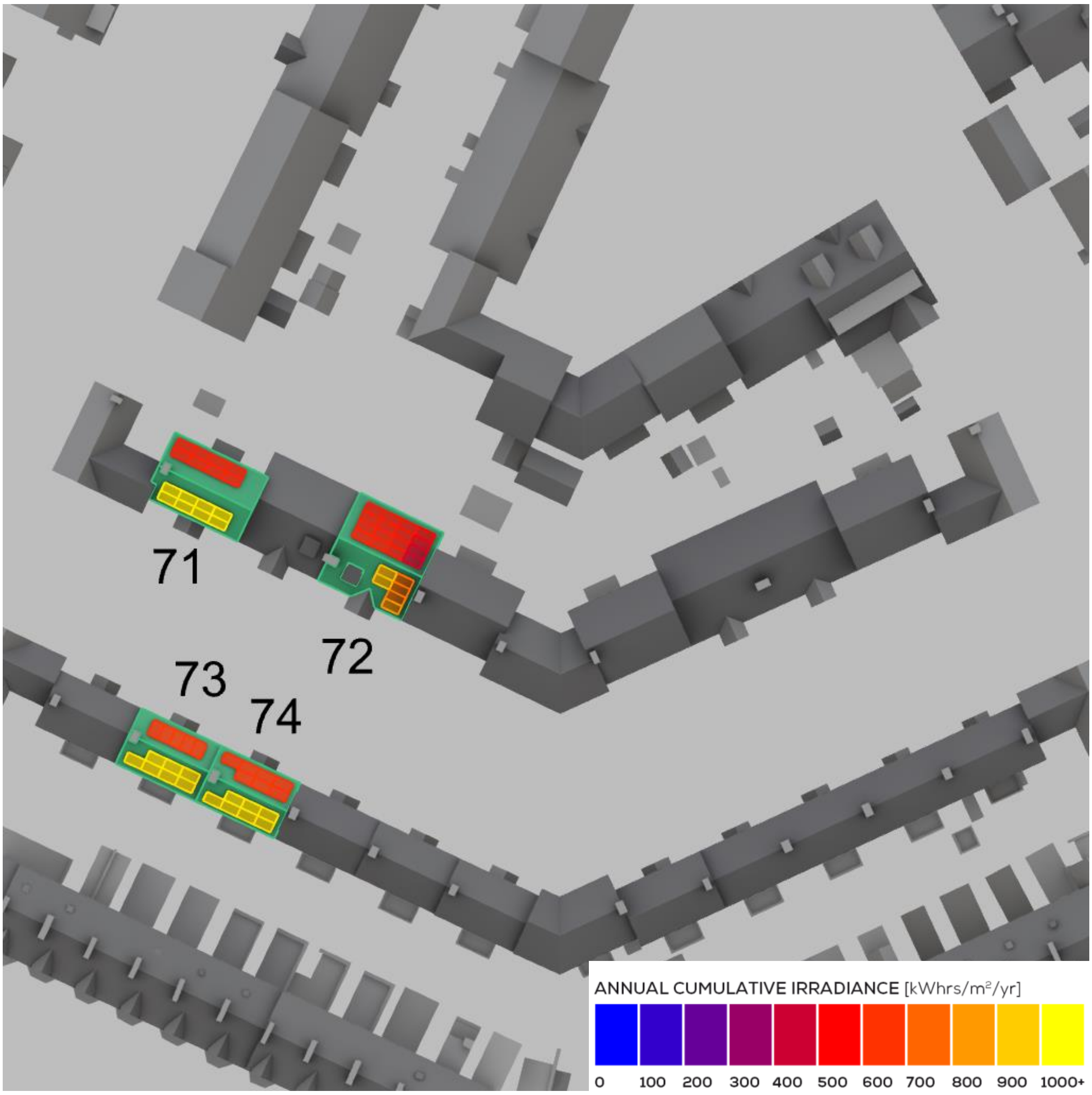

Figure 42: Property ID: 73 - Solar PV Map

Property ID: 74 - Anon ID: 6

Figure 43 provides a map which illustrates the CBDM solar results for Property ID: 74.

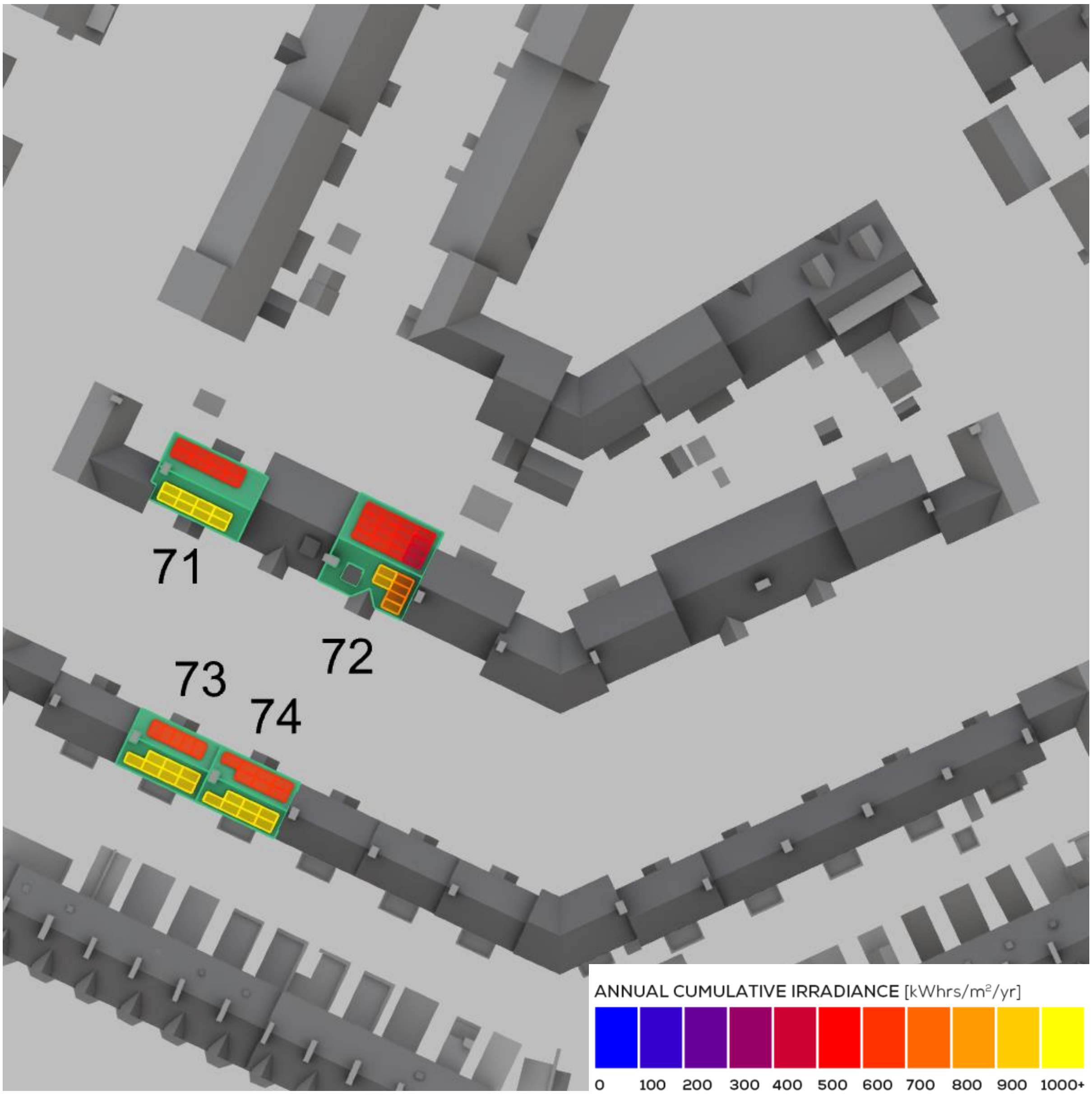

Figure 43: Property ID: 74 - Solar PV Map

Property ID: 75 - Anon ID: 7

Figure 44 provides a map which illustrates the CBDM solar results for Property ID: 75.

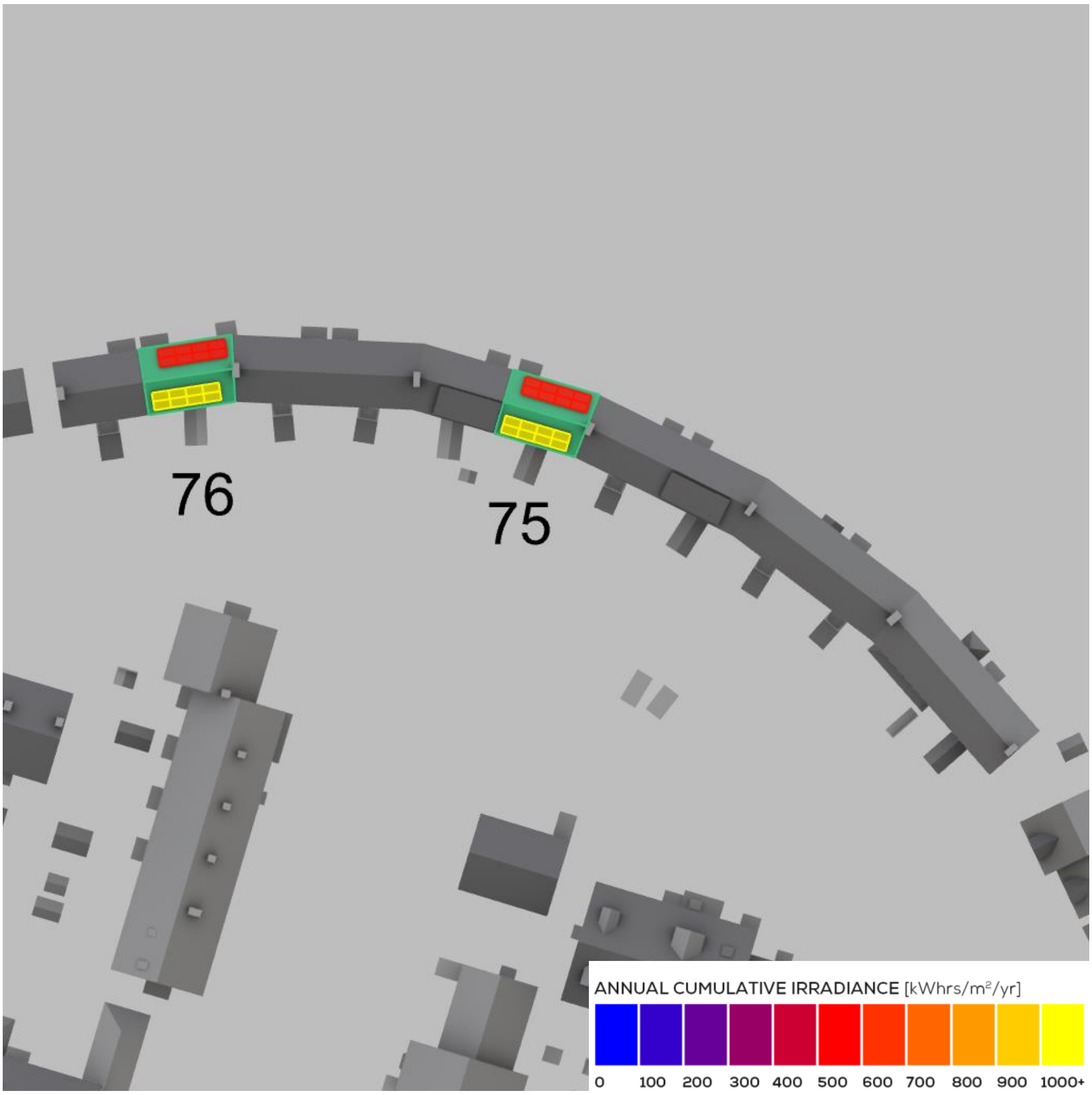

Figure 44: Property ID: 75 - Solar PV Map

Property ID: 76 - Anon ID: 8

Figure 45 provides a map which illustrates the CBDM solar results for Property ID: 76.

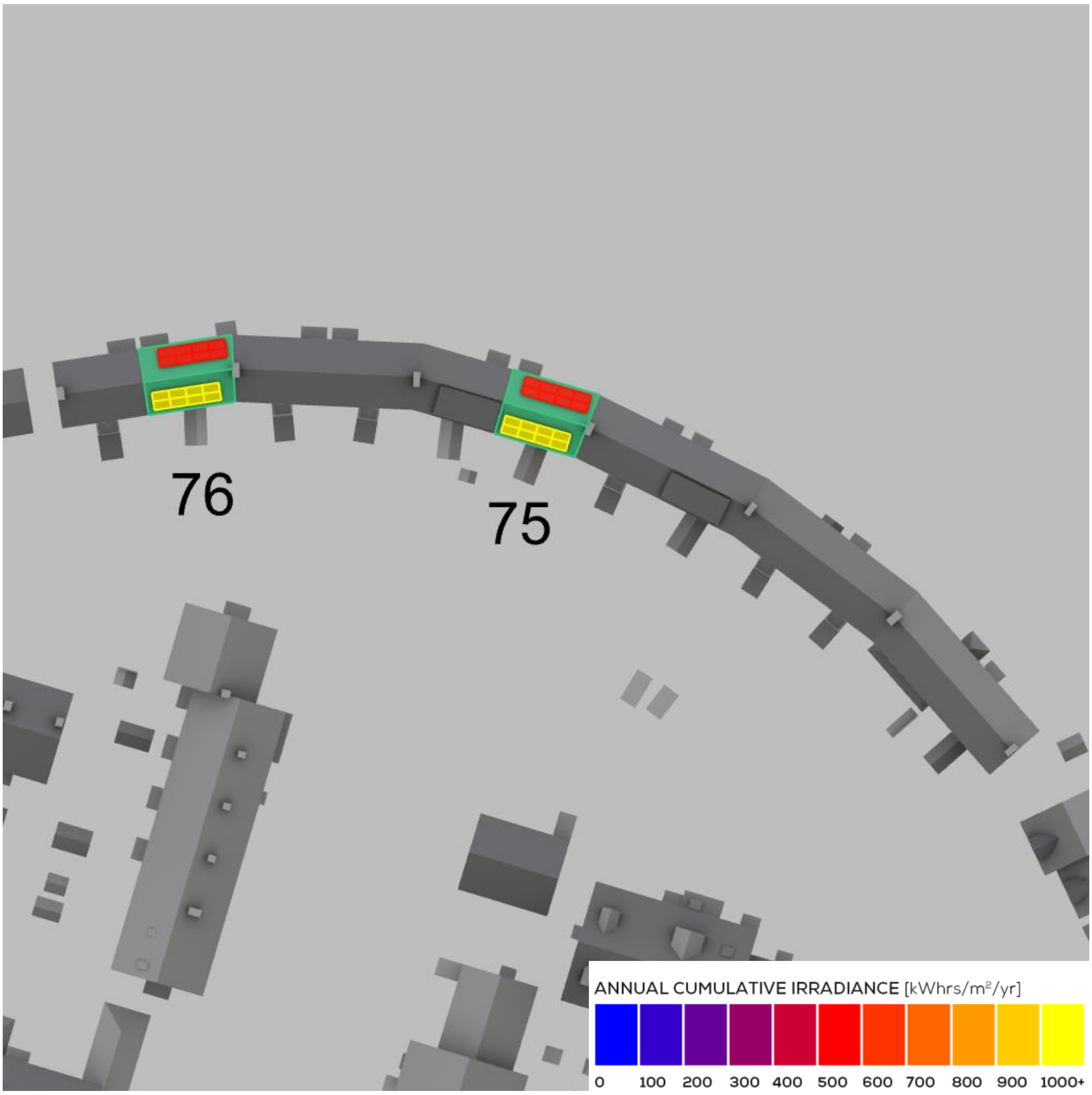

Figure 45: Property ID: 76 - Solar PV Map

Property ID: 77 - Anon ID: 9

Figure 46 provides a map which illustrates the CBDM solar results for Property ID: 77.

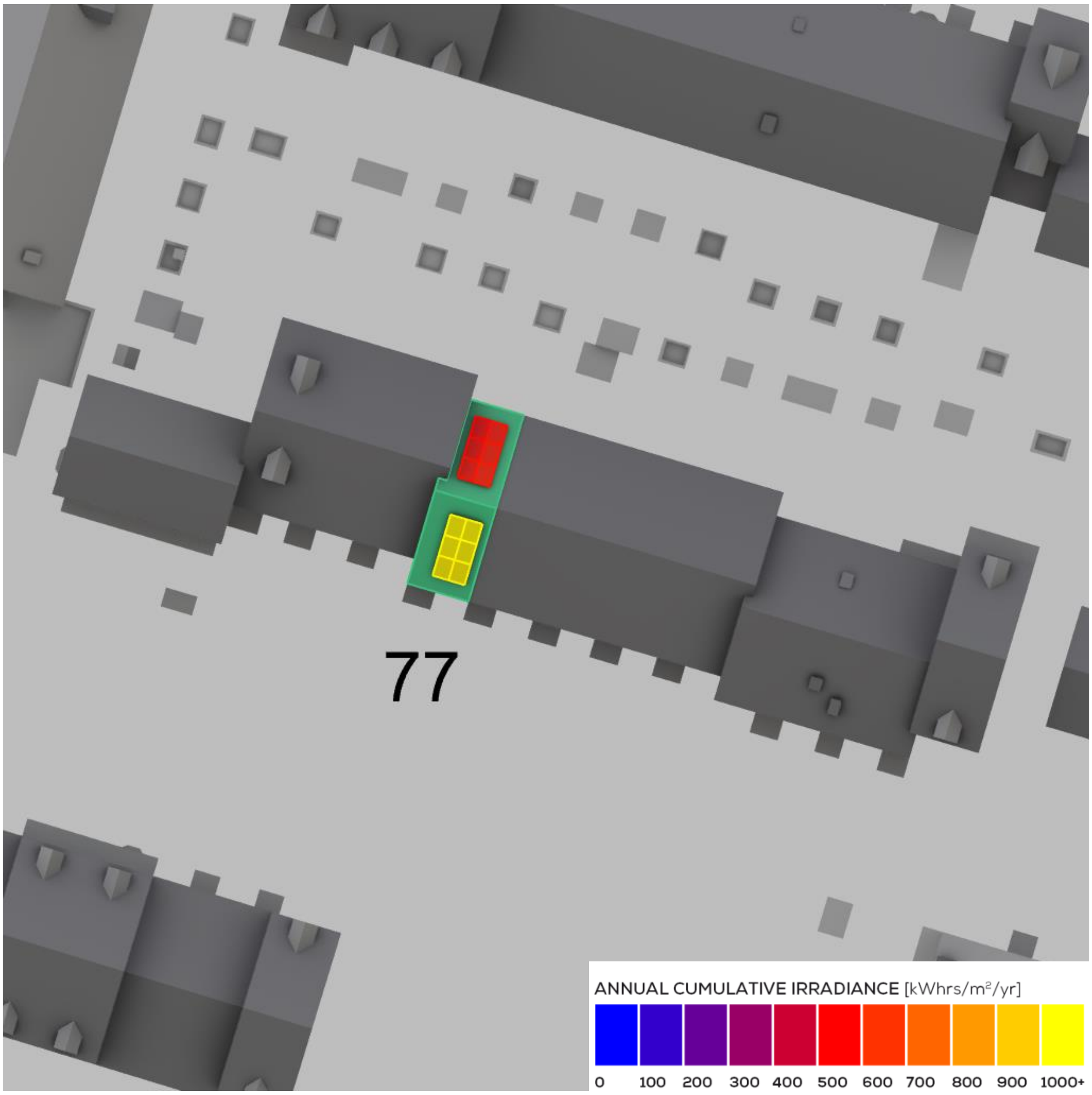

Figure 46: Property ID: 77 - Solar PV Map

Property ID: 78 - Anon ID: 10

Figure 47 provides a map which illustrates the CBDM solar results for Property ID: 78.

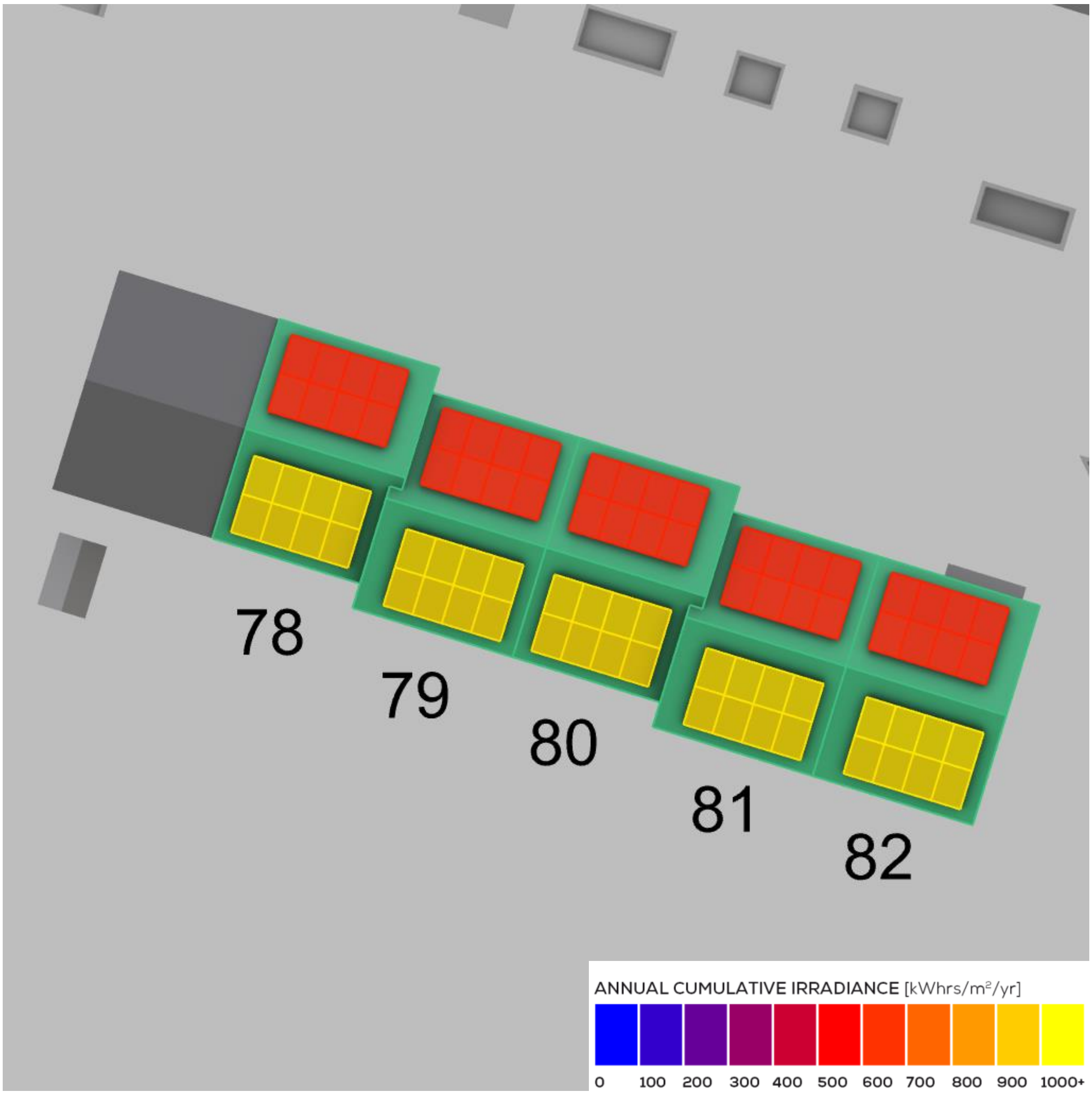

Figure 47: Property ID: 78 - Solar PV Map

Property ID: 79 - Anon ID: 11

Figure 48 provides a map which illustrates the CBDM solar results for Property ID: 79.

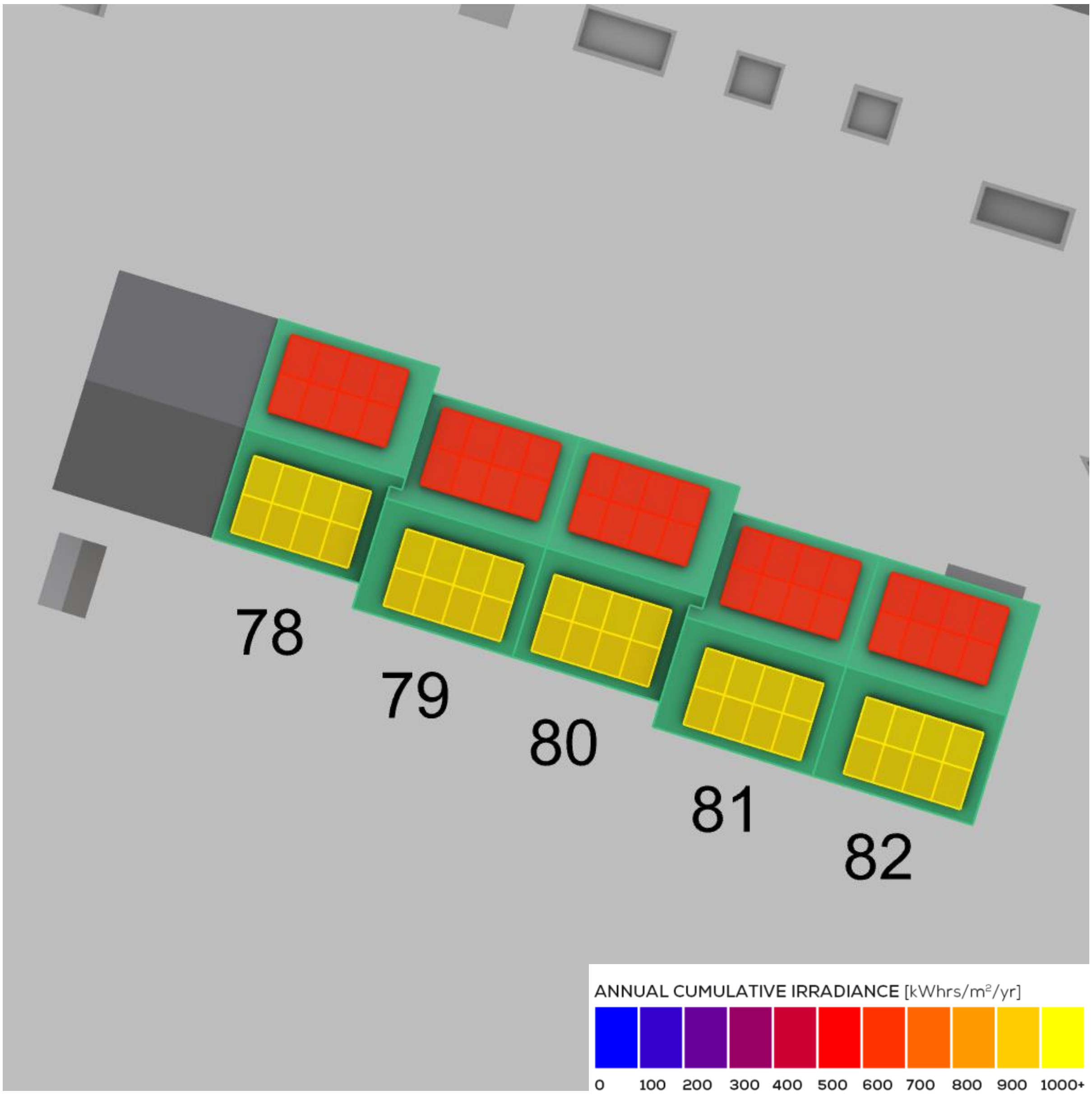

Figure 48: Property ID: 79 - Solar PV Map

Property ID: 80 - Anon ID: 12

Figure 49 provides a map which illustrates the CBDM solar results for Property ID: 80.

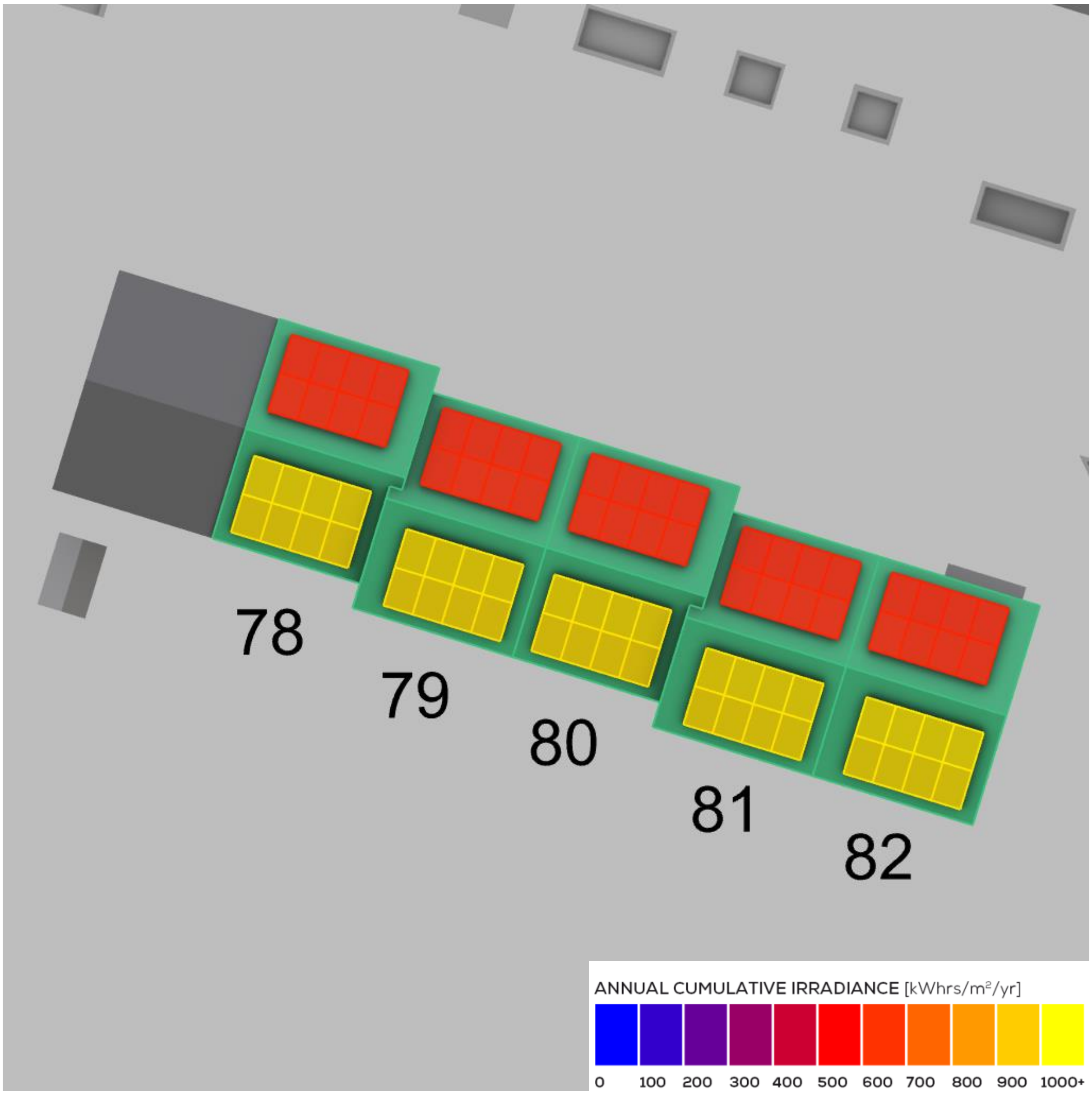

Figure 49: Property ID: 80 - Solar PV Map

Property ID: 81 - Anon ID: 13

Figure 50 provides a map which illustrates the CBDM solar results for Property ID: 81.

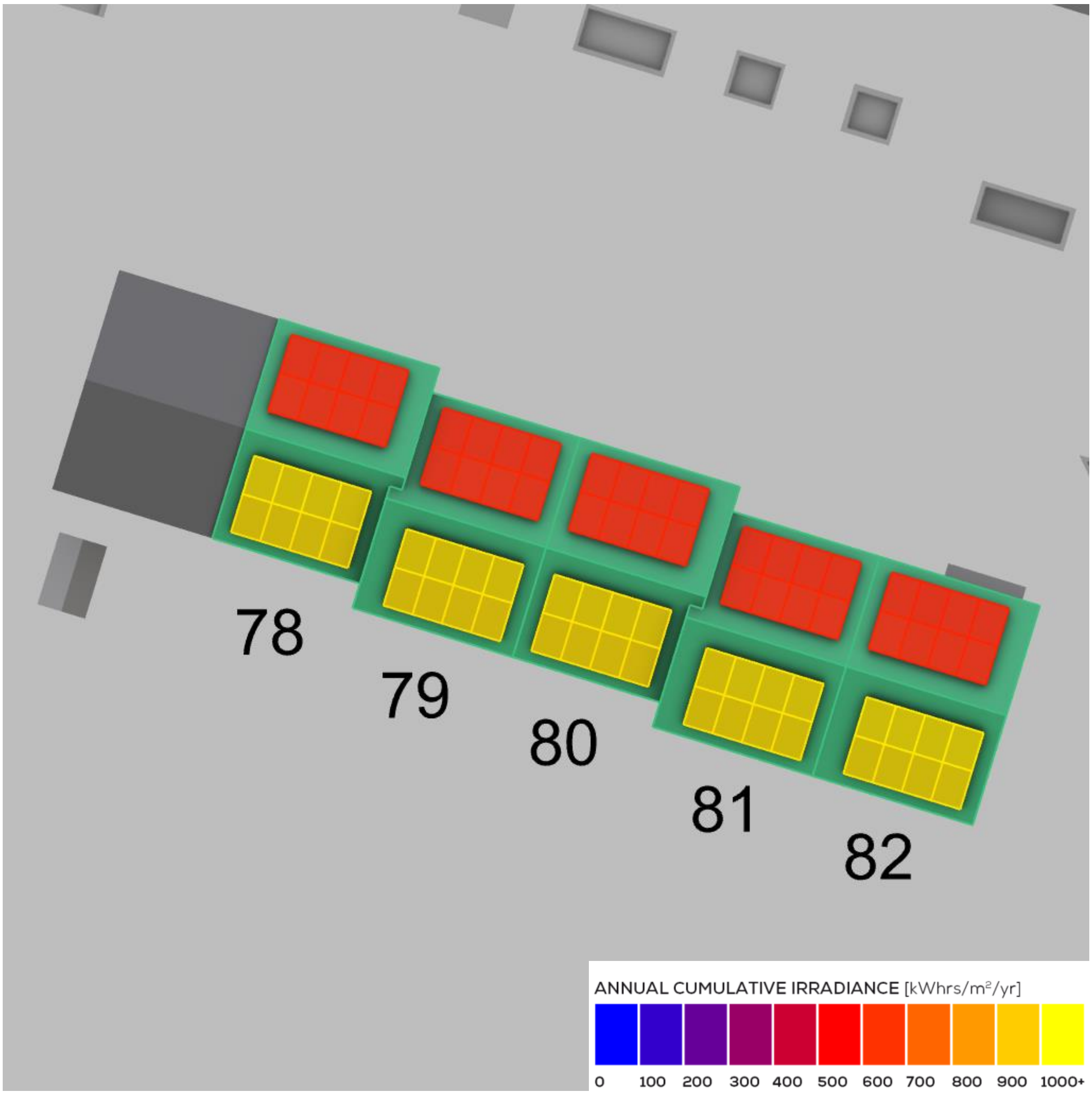

Figure 50: Property ID: 81 - Solar PV Map

Property ID: 82 - Anon ID: 14

Figure 51 provides a map which illustrates the CBDM solar results for Property ID: 82.

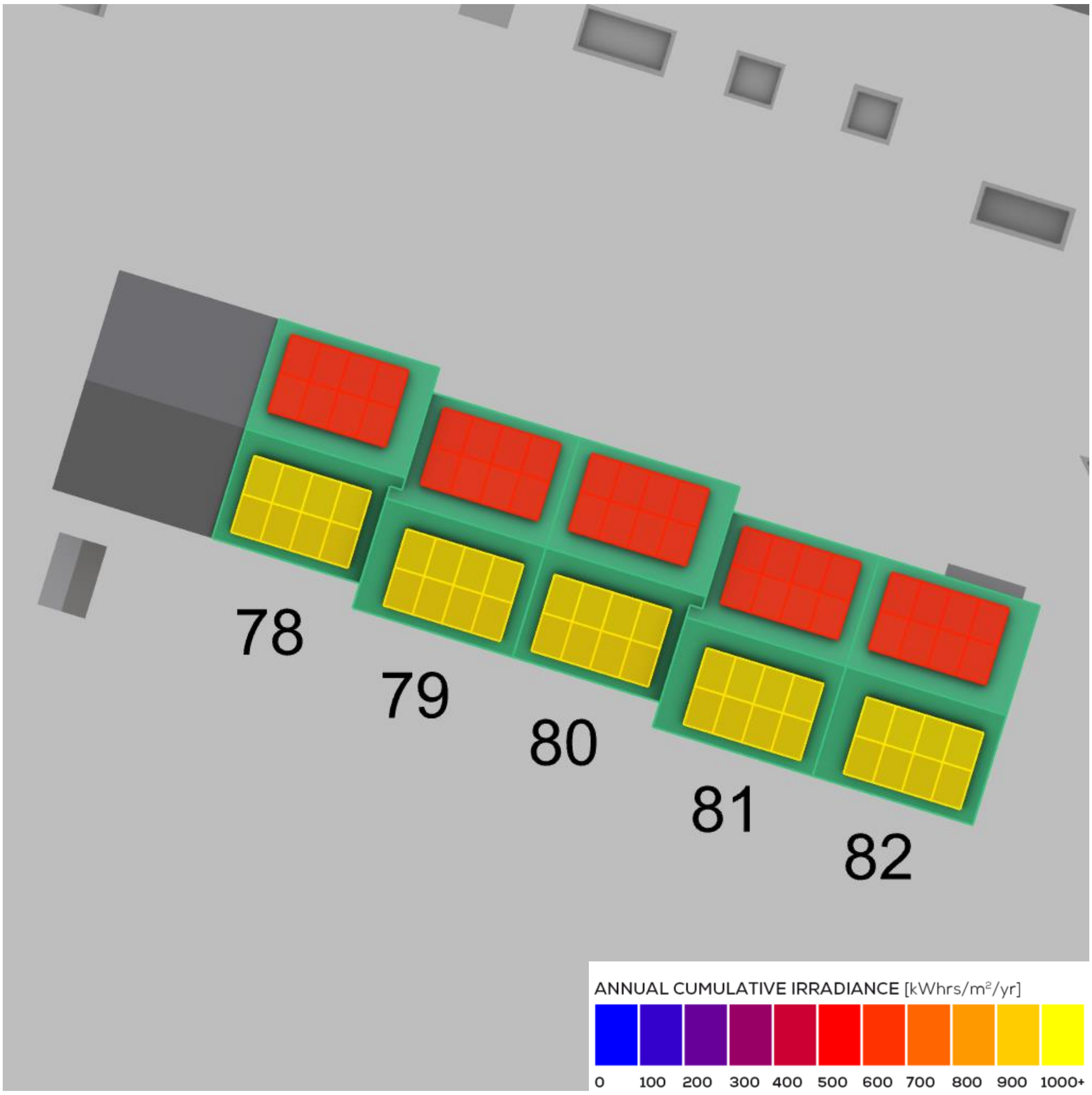

Figure 51: Property ID: 82 - Solar PV Map

Property ID: 83 - Anon ID: 15

Figure 52 provides a map which illustrates the CBDM solar results for Property ID: 83.

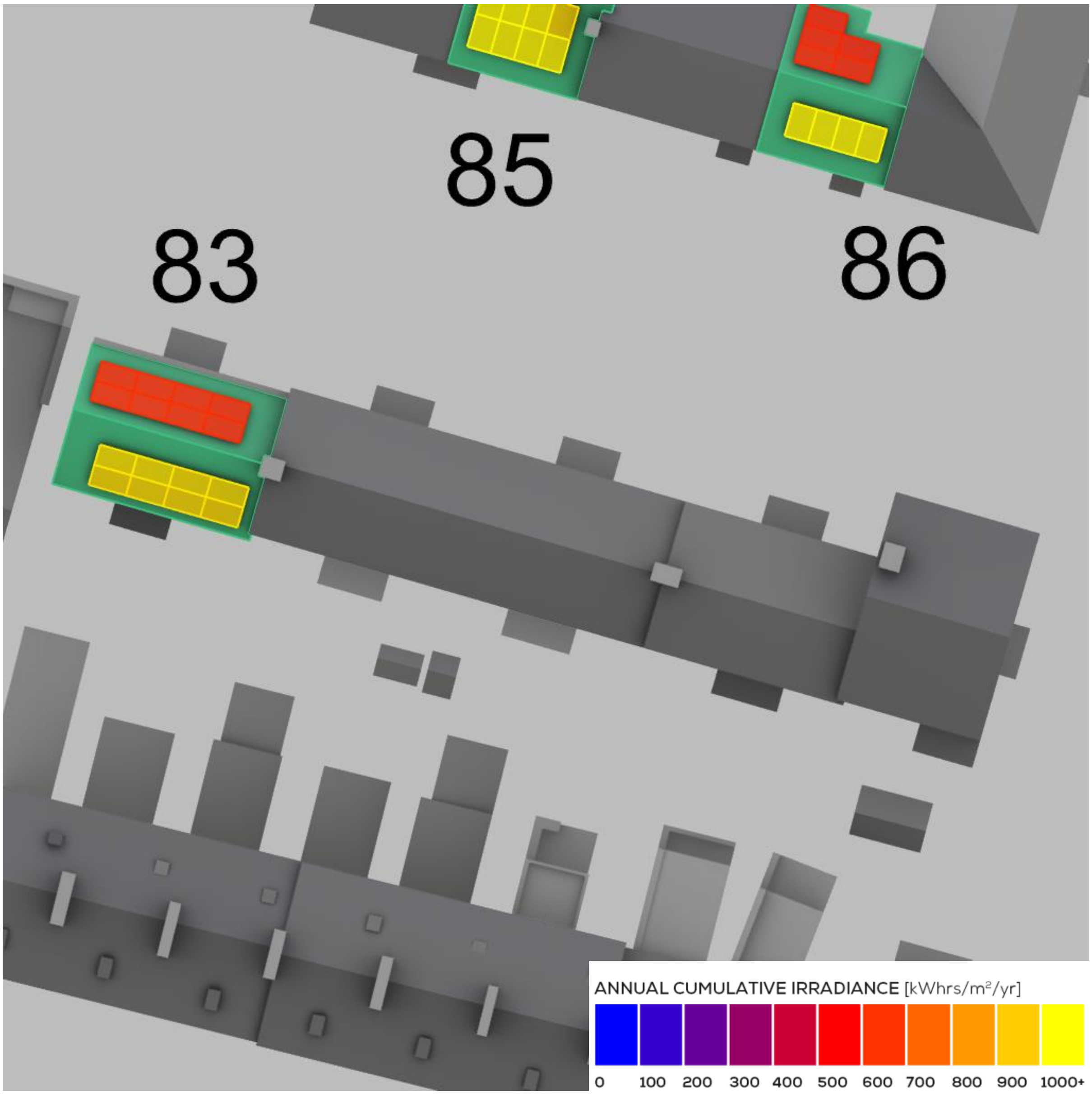

Figure 52: Property ID: 83 - Solar PV Map

Property ID: 84 - Anon ID: 16

Figure 53 provides a map which illustrates the CBDM solar results for Property ID: 84.

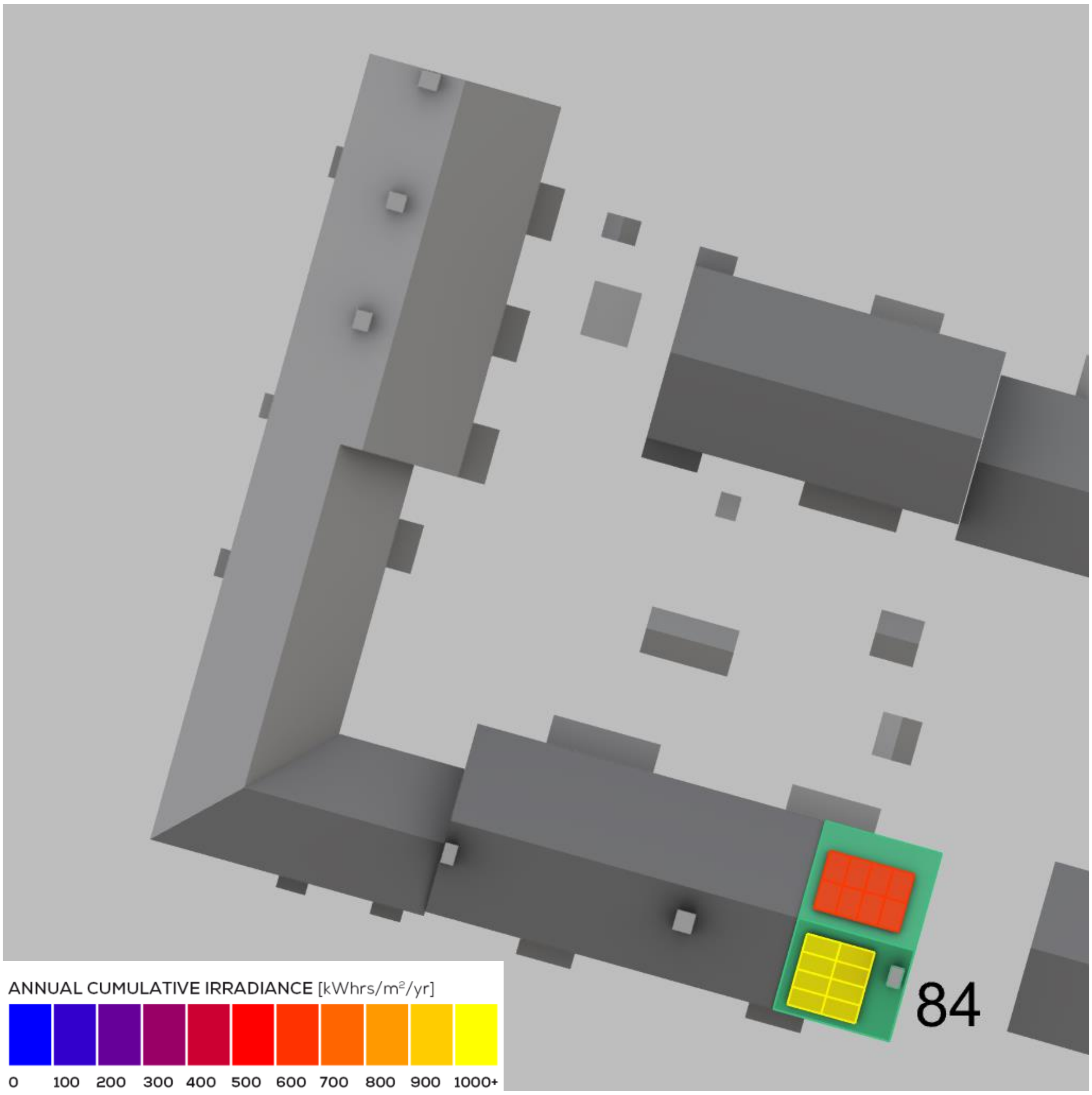

Figure 53: Property ID: 84 - Solar PV Map

Property ID: 85 - Anon ID: 17

Figure 54 provides a map which illustrates the CBDM solar results for Property ID: 85.

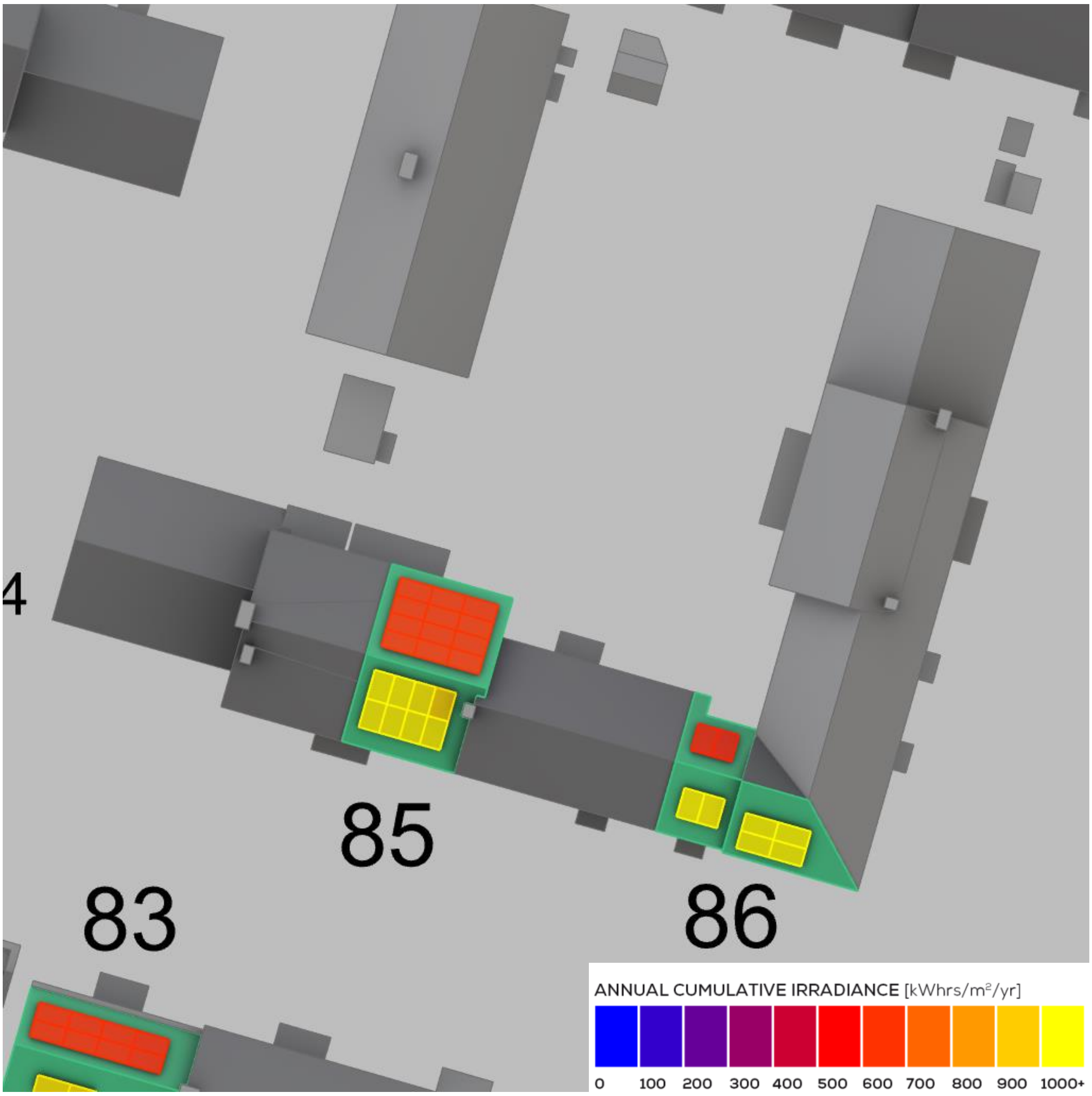

Figure 54: Property ID: 85 - Solar PV Map

Property ID: 86 - Anon ID: 18

Figure 55 provides a map which illustrates the CBDM solar results for Property ID: 86.

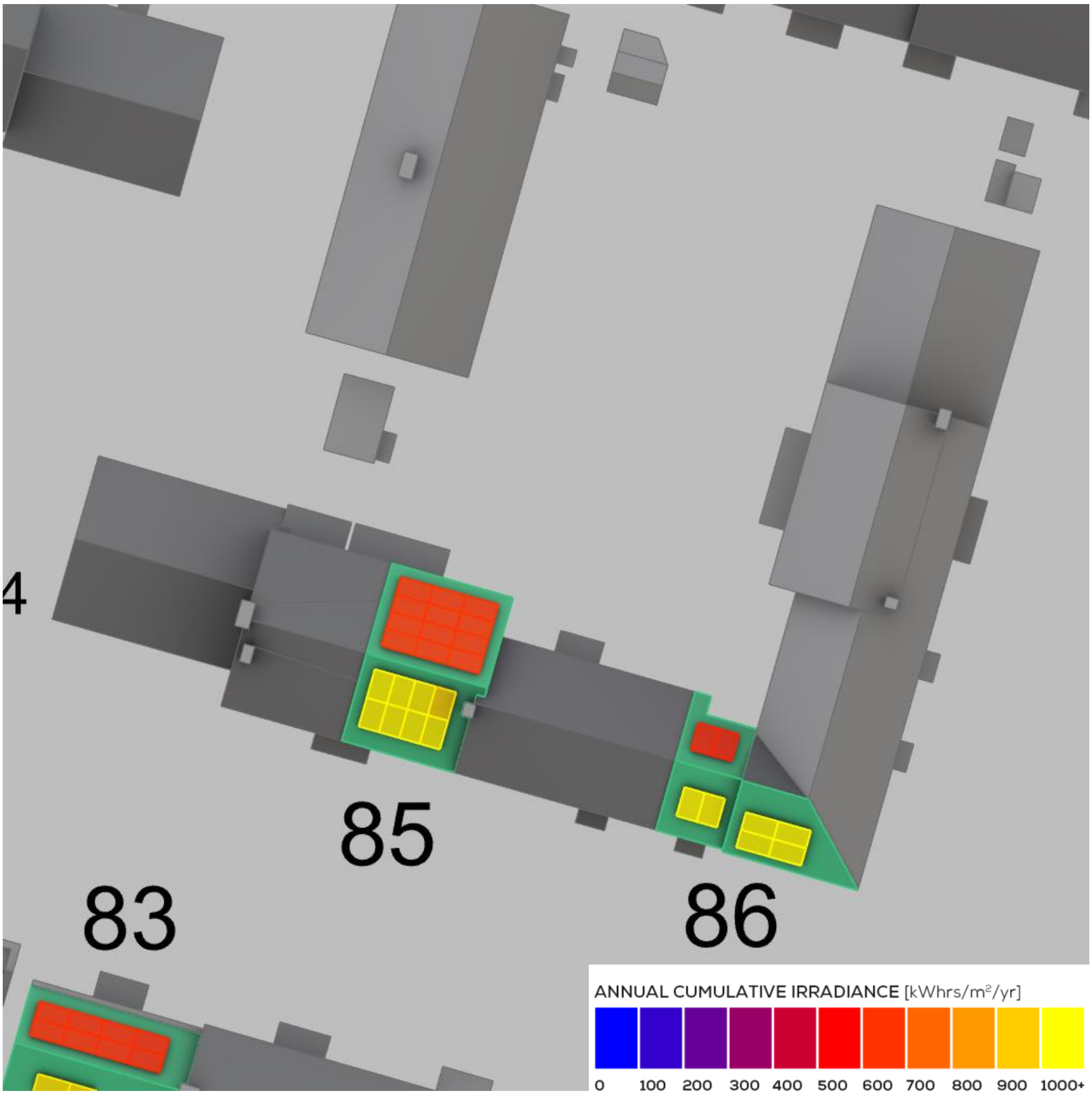

Figure 55: Property ID: 86 - Solar PV Map

Property ID: 87 - Anon ID: 19

Figure 56 provides a map which illustrates the CBDM solar results for Property ID: 87.

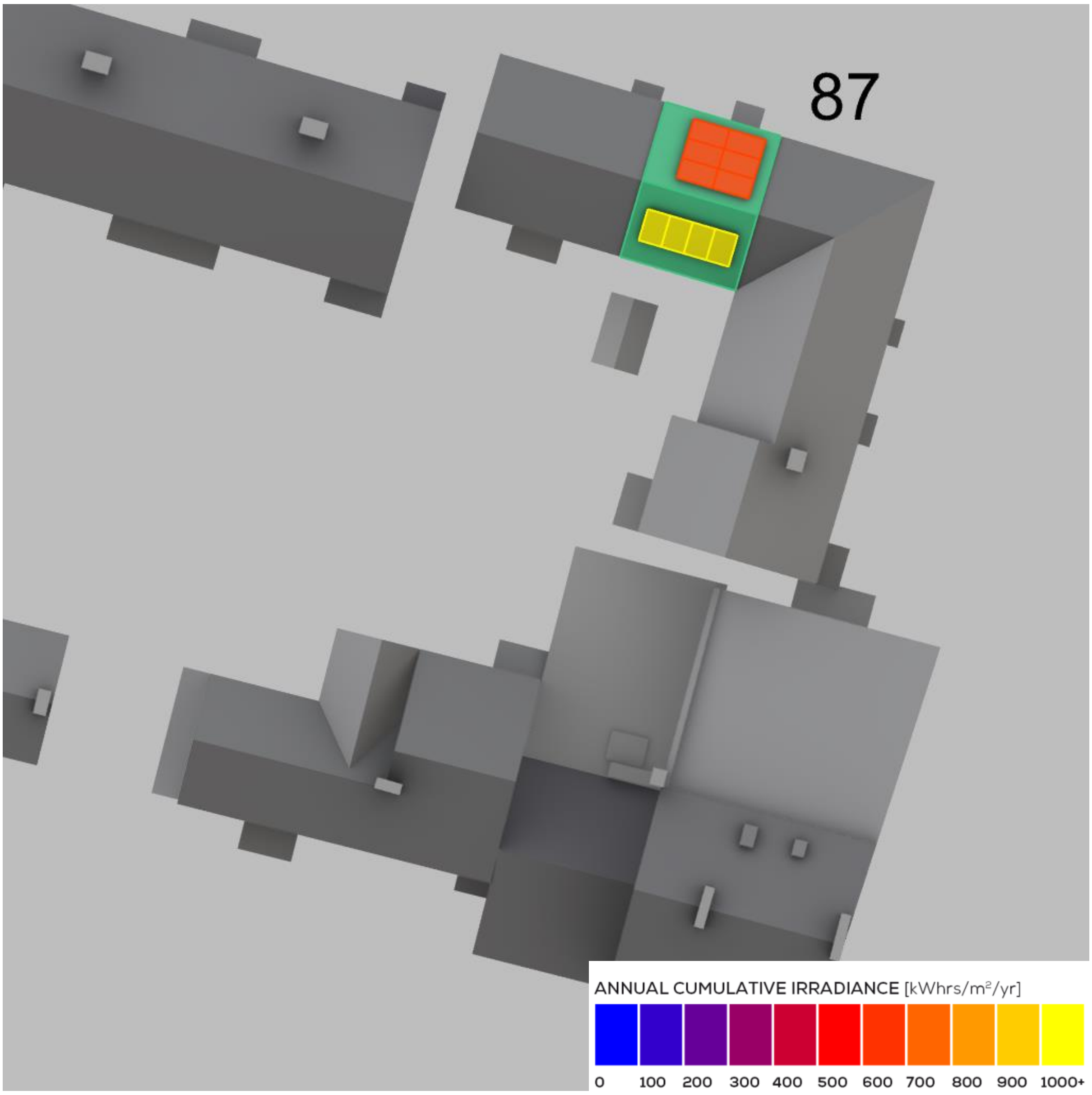

Figure 56: Property ID: 87 - Solar PV Map

Property ID: 88 - Anon ID: 20

Figure 57 provides a map which illustrates the CBDM solar results for Property ID: 88.

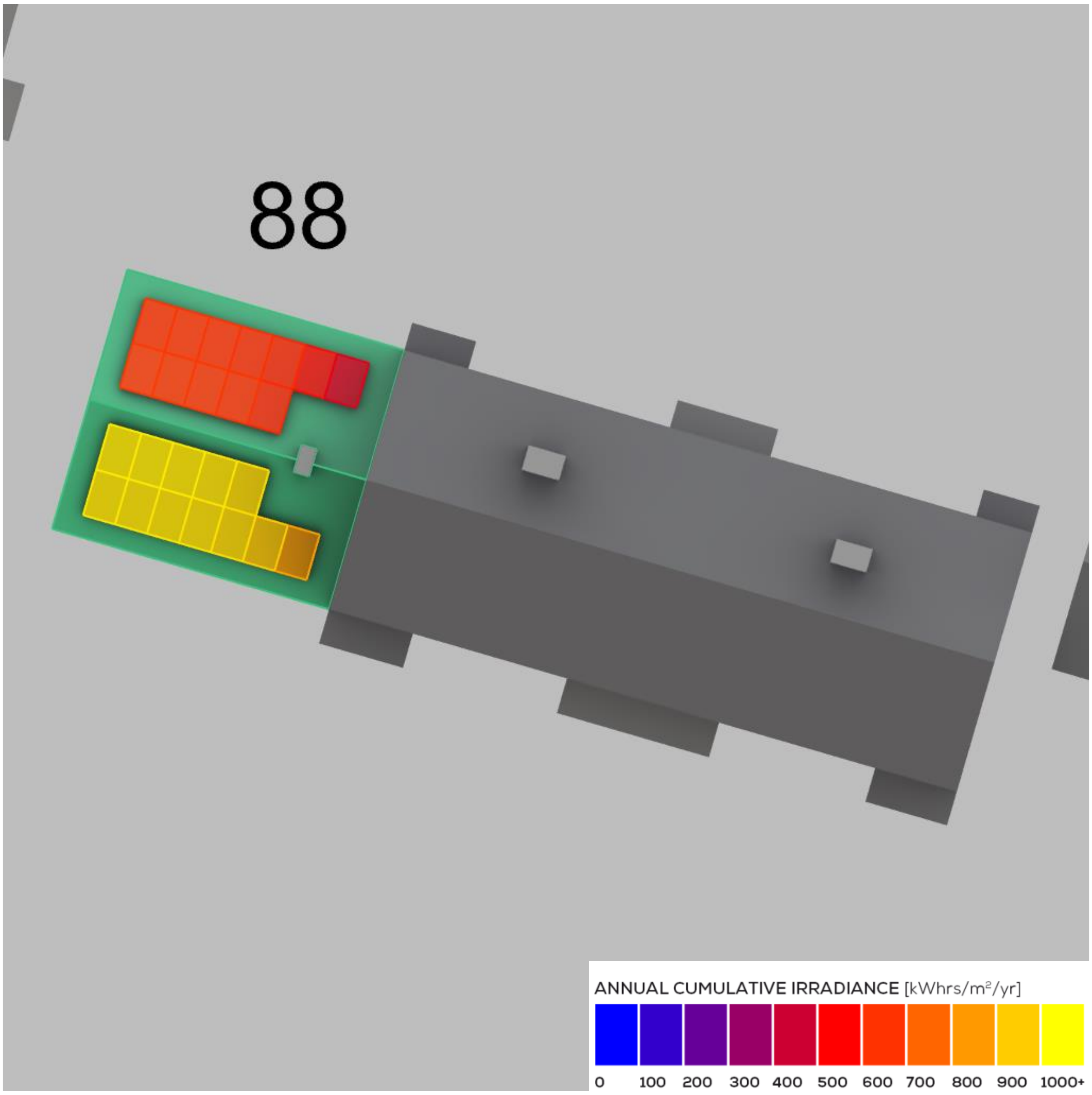

Figure 57: Property ID: 88 - Solar PV Map

Property ID: 89 - Shankill Road Library, 298-300 Shankhill Road

Figure 58 provides a map which illustrates the CBDM solar results for Property ID: 89.

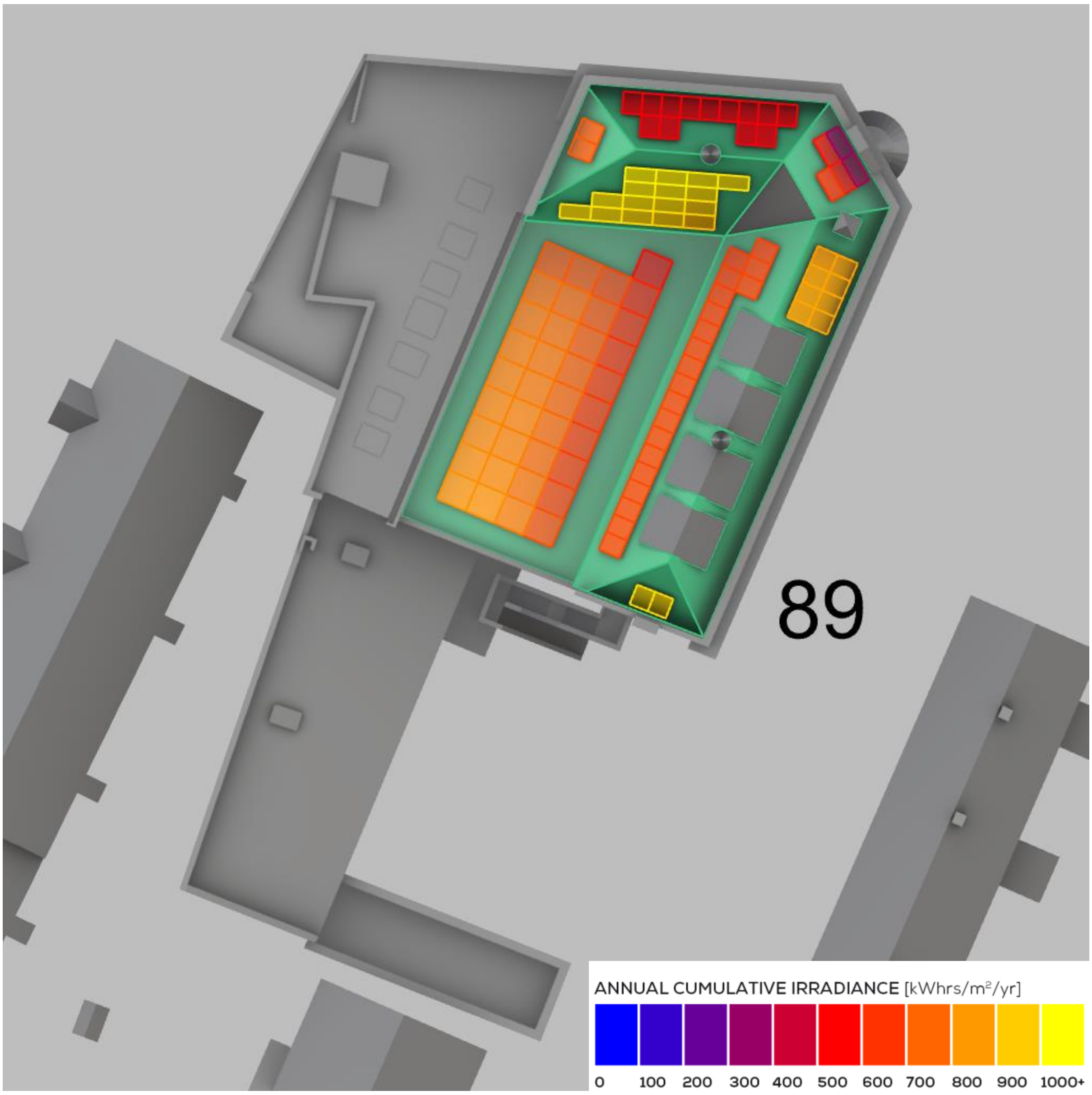

Figure 58: Property ID: 89 - Solar PV Map

Property ID: 90 - Fall Road Library, 49 Falls Road

Figure 59 provides a map which illustrates the CBDM solar results for Property ID: 90.

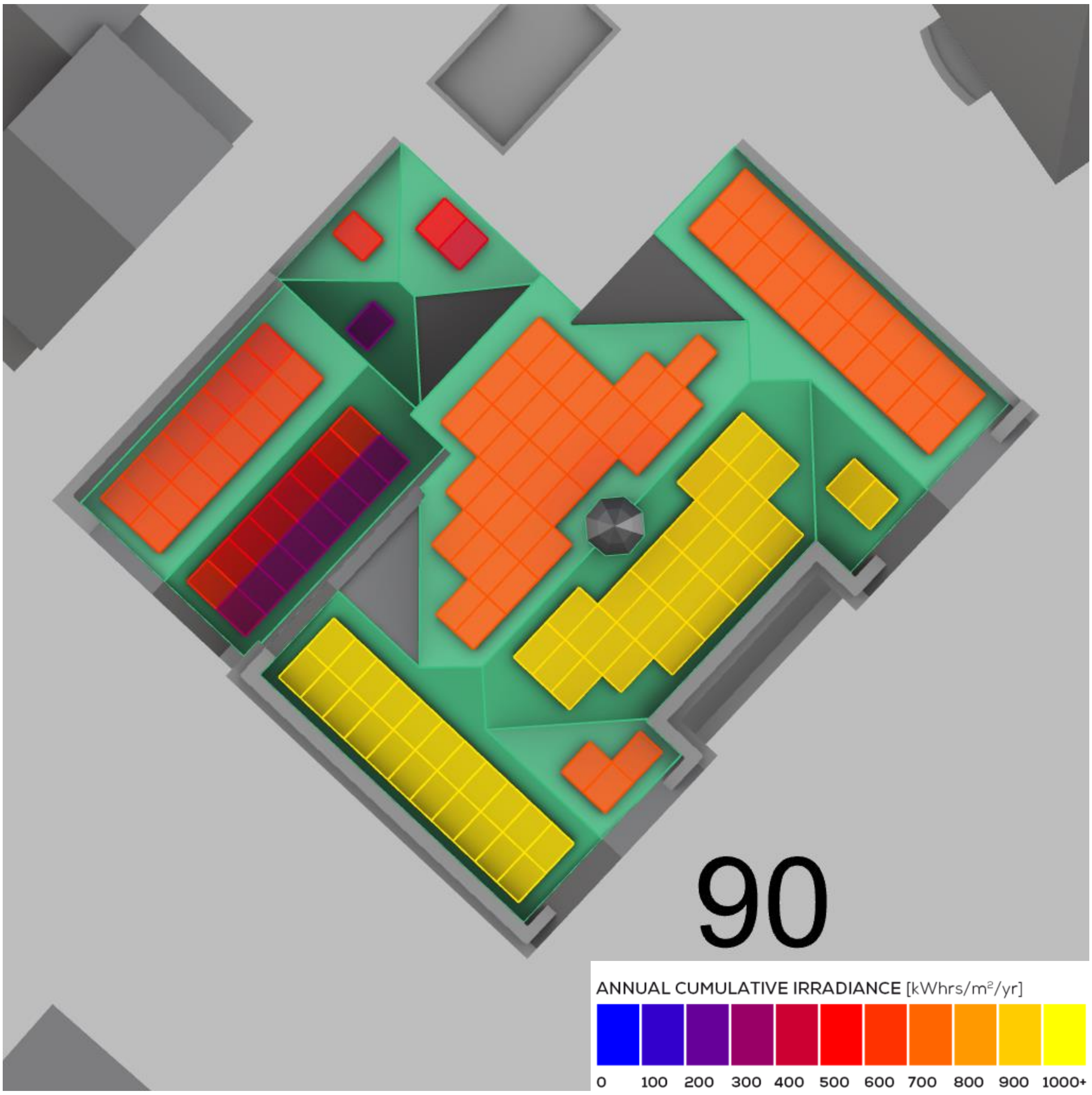

Figure 59: Property ID: 90 - Solar PV Map

Property ID: 91 - Ormeau Road Library, Ormeau Road

Figure 60 provides a map which illustrates the CBDM solar results for Property ID: 91.

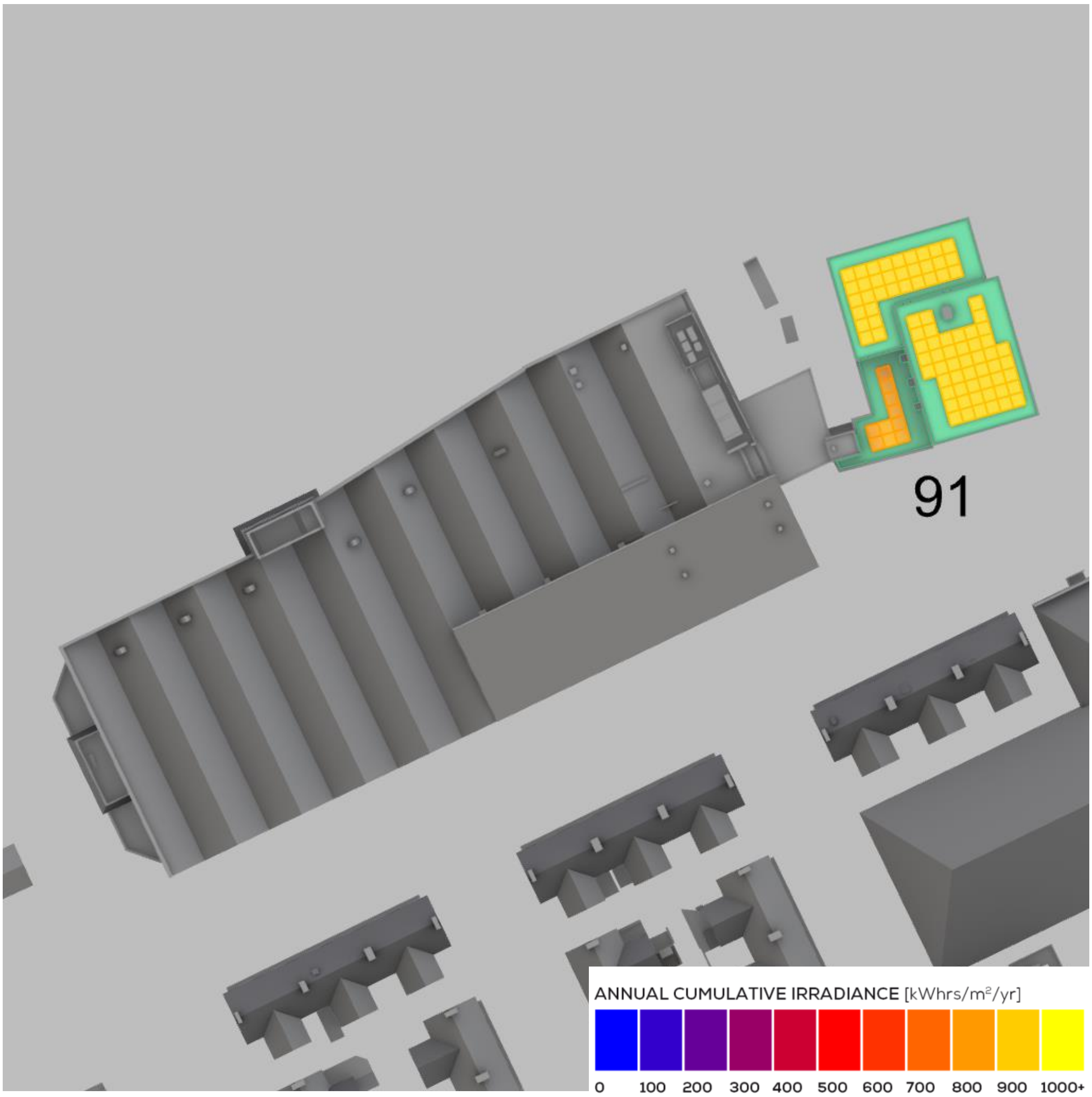

Figure 60: Property ID: 91 - Solar PV Map

Property ID: 92 - Belfast Central Library, Royal Avenue

Figure 61 provides a map which illustrates the CBDM solar results for Property ID: 92.

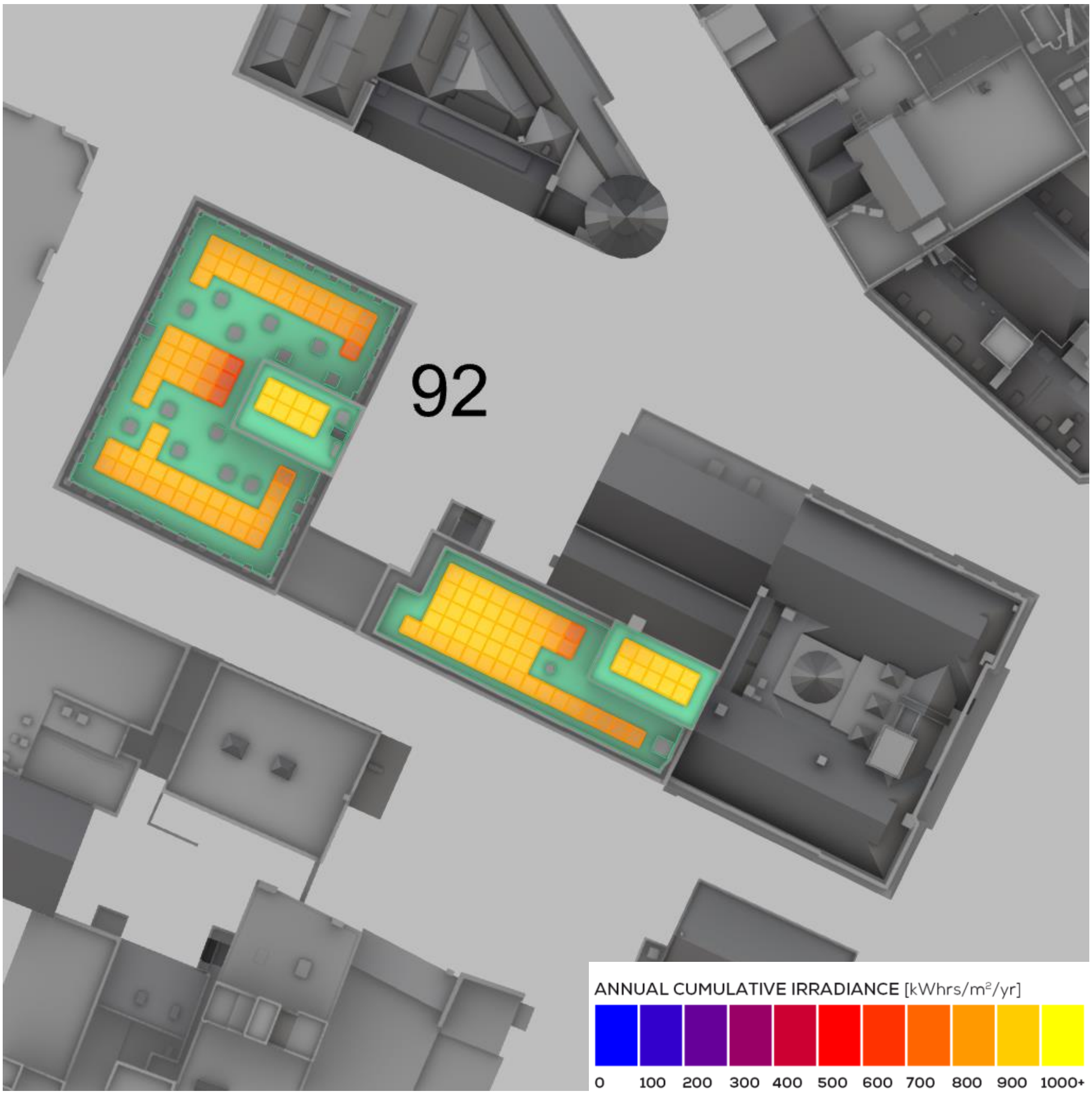

Figure 61: Property ID: 92 - Solar PV Map

Property ID: 93 - Woodstock Library, 358 Woodstock Road

Figure 62 provides a map which illustrates the CBDM solar results for Property ID: 93.

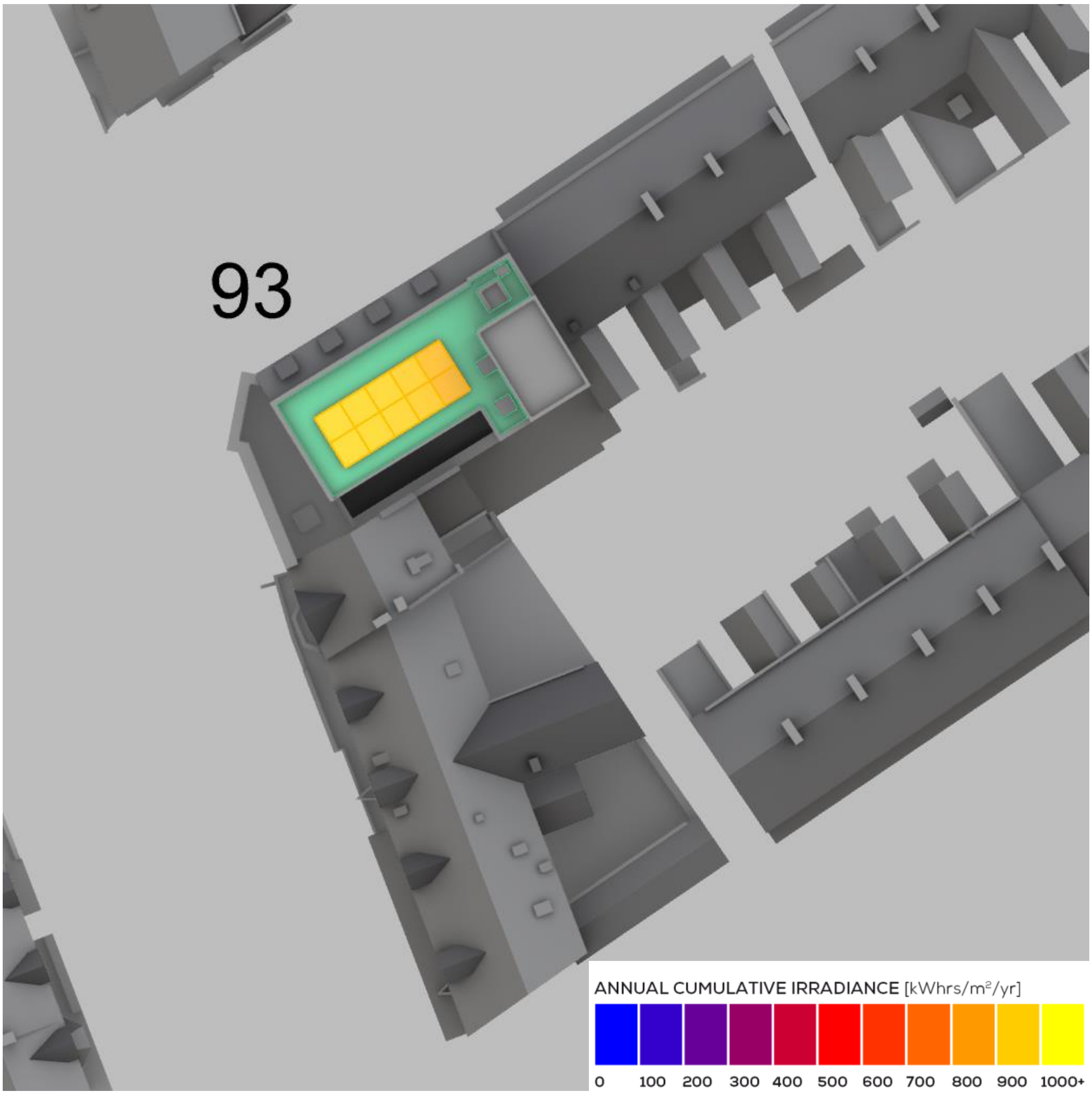

Figure 62: Property ID: 93 - Solar PV Map

Property ID: 94 - Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 1, 358 Woodstock Road

Figure 63 provides a map which illustrates the CBDM solar results for Property ID: 94.

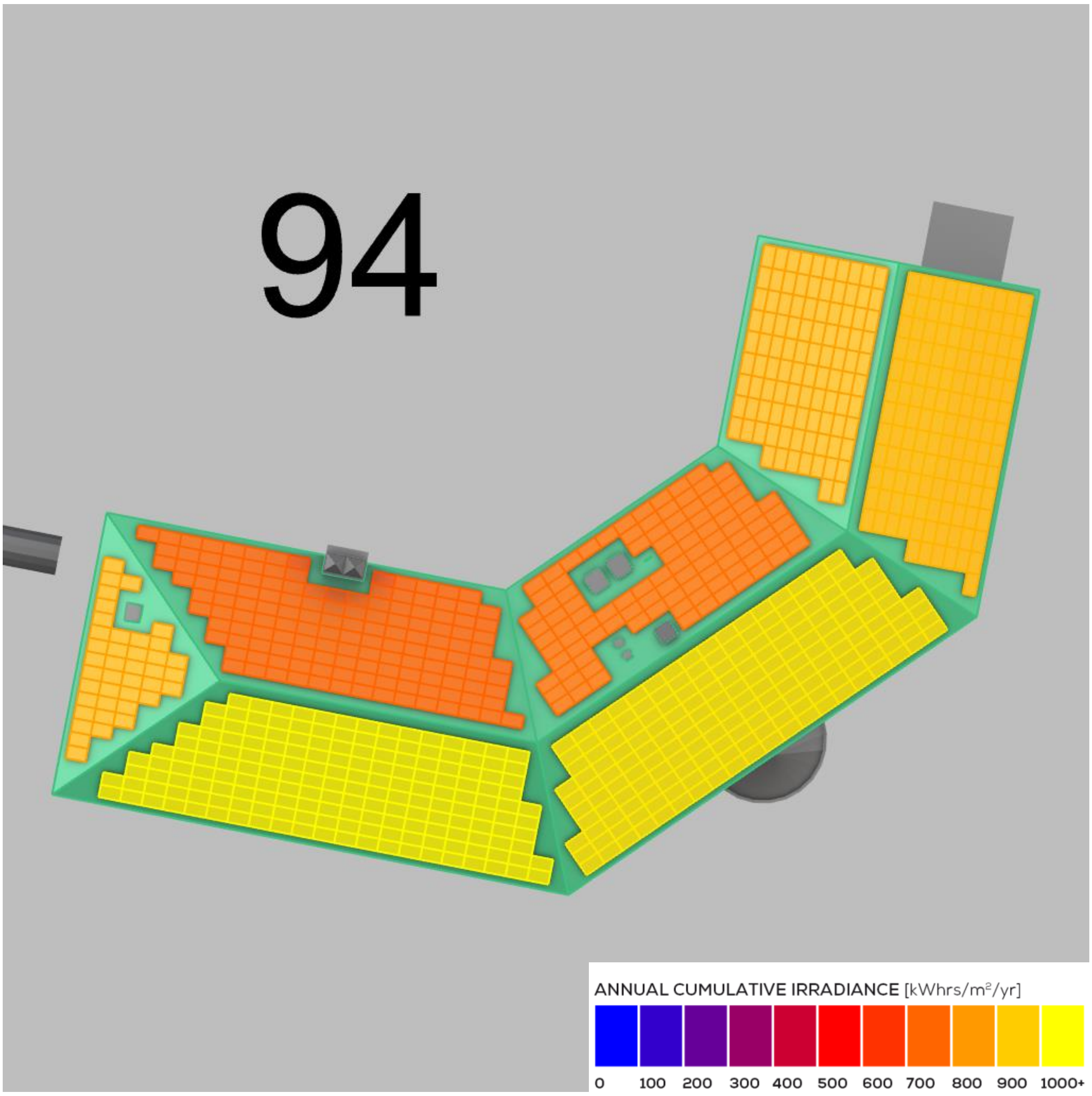

Figure 63: Property ID: 94 - Solar PV Map

Property ID: 95 - Belfast Metropolitan College (BMC) - 125-153 Millfield, Building 2, 358 Woodstock Road

Figure 64 provides a map which illustrates the CBDM solar results for Property ID: 95.

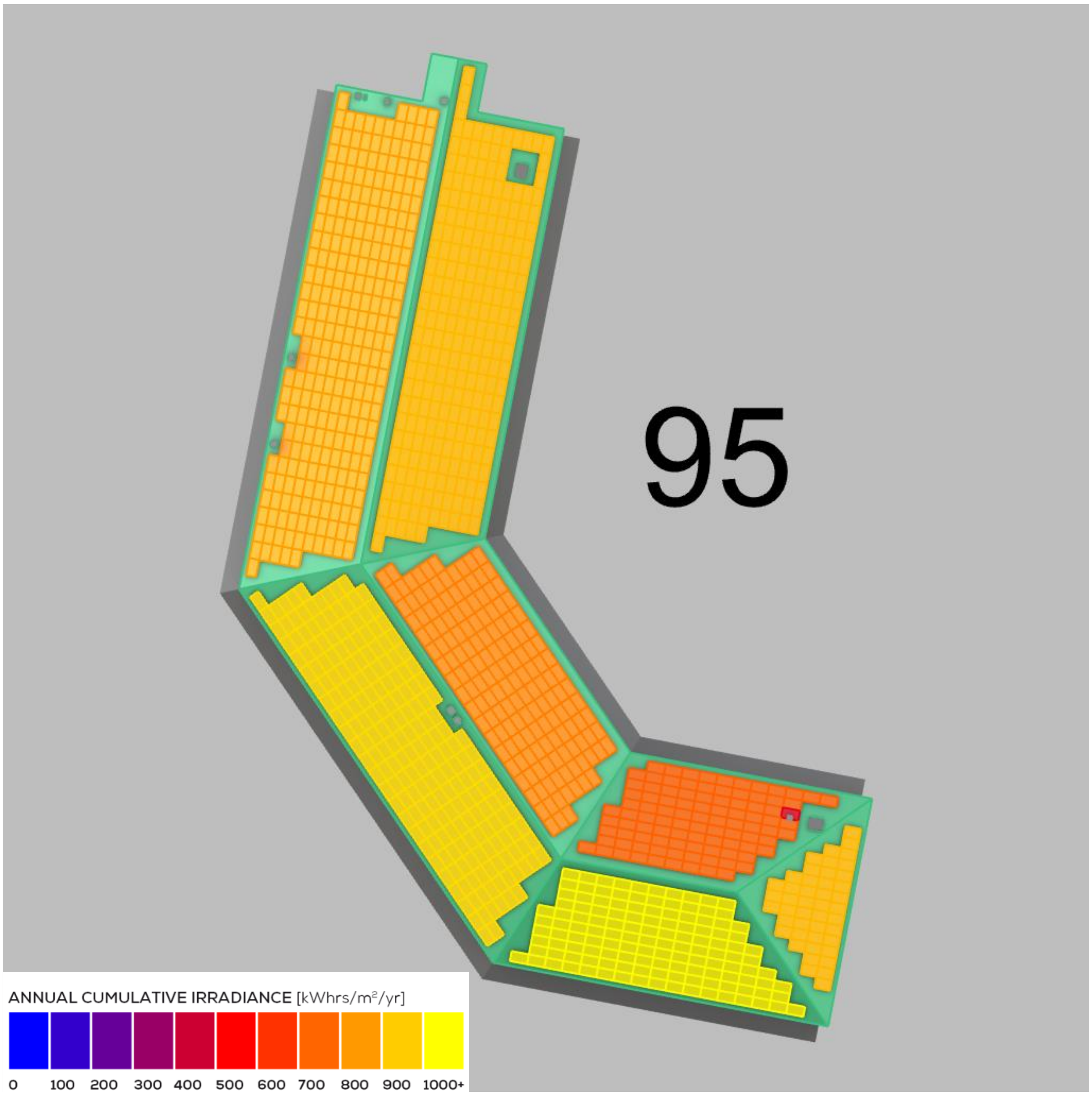

Figure 64: Property ID: 95 - Solar PV Map

7 Conclusion

GIA have successfully delivered a desk-based solar PV rooftop assessment across 56 properties in Belfast in response to the Department's 10X Economy Open Call. The results of the project represent a pilot into the cutting-edge use of 3D modelling, bespoke spatial analysis tools, and expert daylight and sunlight assessment. The results demonstrate the potential application of solar PV across the 56 government owned properties as a first step to inform at scale climate change policies and renewable energy strategies. This technical evidence base can be particularly useful to the Department and other strategic partners as part of their commitments to the Climate Change Act (Northern Ireland) 2022 and the targets it sets for the country.

Key Findings:

- Across the 56 properties 21,598,484 kWh of electricity is consumed each year.
- If PV installations were maximised across 100% of the properties calculated usable roof space, an estimated 24,171 PV panels (350wp) could be installed, equating to a combined system size of 8,459.9 kilowatts peak (kWp) with an estimated generation potential between 6,985,537 kWh/year (SAP) and 5,561,672 kWh/year (CBDM).
- If the 56 properties could use all 100% of the electricity generated by PV on-site, this could see combined self-sufficiency from PV create between a 32.3% (SAP) and 25.8% (CBDM) reduction in the use of electricity from the national grid and reduce carbon emissions by between 2,590.9 tonnesCO_{2e} per year and 2,062.8 tonnesCO_{2e} per year (includes an allowance for the carbon cost of PV installation).
- If the properties used 100% of the electricity generated by PV on-site, the estimated payback period could be between 6.45 (SAP) and 8.09 (CBDM) years based on an estimated installation [one-off] cost of £8,596,265 and financial benefit of between £1,332,821 (SAP) and £1,062,591 (CBDM) per year.
- For comparison purposes, across the 56 properties, if an annual panel performance viability threshold was applied to only install panels which generated a minimum of 188.17kWh/year (aims to filter out each panel which does not achieve a capital payback within 10 years based on the combined data across the 56 assessed properties), system sizes would be reduced to 6,844.6kWp based on the impact of the SAP methodology and 7,785.4kWp based on the CBDM methodology. Additionally, the estimated PV generation from the total installations would be reduced to 6,243,198kWh/year (SAP) and 5,263,279 kWh/year (CBDM). However, the estimated payback periods would also be reduced to 5.85 years (SAP) and 7.9 years (CBDM) due to the impact of effective filtering that removes panels that do not meet annual viability requirements.
- The results from solar PV panel filtering based on annual performance viability requirements and other input parameters are available in the associated results files and appendix. The results from filtering demonstrate the benefits of establishing clear viability parameters for PV installation from the outset and how various scenarios influence impact forecasts.
- Individual property level results have been discussed in Section 6.2.

Overall, the project has provided an assessment of 56 properties and demonstrated their solar PV potential at both cumulative and individual property scale based on two comparative methodologies: SAP and CBDM. Additionally, this report and the associated results files delivered provided results for eight different scenarios based on numerous parameters, including self-consumption, usable roof space, and panel viability filtering.

Relevant stakeholders could view the findings from this project as an opportunity to enhance collaborative working relationships, particularly in regard to delivering Solar PV at scale across a sample of their Belfast property portfolio and ensuring the properties sustainably contribute to Northern Ireland's Net Zero Carbon Emission's ambitions and Climate Change legislative responsibilities.

8 Appendix One

The results from scenario modelling based on eight self-consumption and panel viability filtering options. (See associated document).