Opportunity mapping for urban renewables generation

Stage 1: Photovoltaics

Final report

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Summary

An opportunity map has been developed for Glasgow City Council to support informed decisions about siting community scale renewable energy systems, as part of the Future City Energy Efficiency demonstrator project. The map was developed for the test case of freestanding solar photovoltaic (PV) farms in the city's Vacant and Derelict Land (VDL), but it can equally be applied for other energy systems and in other geographies. The development process involved close collaboration between the planning experts in GCC and technical experts within ESRU and elsewhere; this depth of expert input and review gives the tool credibility. It was implemented as an interactive Geographic Information System (RenMap), running on a freely downloadable application (QGIS).

In evaluating whether a site is suitable for renewable energy deployment, two different sets of potential constraints need to be considered. Technical factors may be imposed by the location on the economically achievable power level; and planning and environmental policies will affect the likelihood of receiving planning permission for a technically feasible scheme. A location may be affected by several individual technical and policy factors, so a realistic combined view of the constraints requires weighting and combining factors to give an overall technical and policy score

Technical factors are technology specific. Four were identified as affecting freestanding solar PV: the connection distance to an electricity substation; the degree of congestion around the substation; the degree of overshadowing from surrounding buildings; and terrain access problems or flooding risk. Scoring criteria to rate these as favourable, likely or unlikely, and weightings to give a combined technical score, involved the input of the distribution network operator SPEN. Policy factors are the same for all technologies but will vary by Local Authority. Five were identified for Glasgow: environmental designation (such as Site of Special Scientific Interest or Listed Building); development zoning (such as industrial or housing); glare that might constitute a safety risk; possible existence of endangered species; and visual impact on neighbouring housing. Scoring criteria to assess each of these as possible, intermediate or sensitive and weightings to give a combined policy score were developed in joint GCC-ESRU workshops.

The RenMap tool presents how individual and combined scores vary spatially across the whole city, allowing the user to look not just at overall suitability of a site but also to drill into detail about the specific issues that apply so that management or mitigation possibilities can be assessed. Each individual factor and combined score is displayed in a layer (shapefile) on a 50 x 50 m grid across the city. For some factors data existed to map it across the whole city, while others required detailed survey of individual sites. So a three-stage process was built into RenMap: citywide scoring; mapping these onto the VDL sites; and finally a combined scoring for the surveyed VDL sites only.

Different combination methods can be applied, which give rise to different perceptions about the size of the opportunity available. The stringent method - which applies the worst score for any individual layer as the combined score - shows 15.7% of the VDL area as technically favourable, while the lenient method - which adds up individual factor scores - shows 42.9%. Similarly, stringent combination of policy scores shows 7.8% as possible, while the lenient method shows 46.8%. A third, hybrid combination method was also implemented. Policy makers can select the most appropriate combination method depending on whether they wish to encourage maximum deployment of renewables or to minimise technology impact.

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1. Introduction

As part of the Future City Glasgow demonstrator project on Energy Efficiency[1], Glasgow City Council (GCC) has undertaken to develop a process for producing Opportunity Maps for urban renewable energy schemes. This is intended as a concrete example of how technology can help make life in the city smarter, safer and more sustainable. Opportunity Maps will become publicly available tools that will help to identify land where community renewables projects could most easily be developed, and to give a guide to the kinds of challenges which might apply there; this should avoid wasted effort during the normal technical development and planning control stages of a project.

ESRU has been contracted to develop a re-usable method to estimate resource, evaluate potential constraints, and display these on an interactive map. The methodology was established through considering the potential for deploying free-standing solar photovoltaic (PV) farms on vacant and derelict land (VDL). This is land that at one time had been used for housing or industry, and so is a priority for putting to productive use; renewable energy generation is one – though not the only - possible use.

Solar PV is most often deployed on roofs and integrated into the building's electricity supply, with generation power constrained by the available surface area. Beyond the household level, the Scottish Government has set a target of 500 megawatts of community and locally-owned renewable energy to be deployed by 2020[2]. Solar PV has advantages in a city context: it is not unsightly, and can be installed without disruption. However, it is a relatively expensive technology so it is important to understand how to make the best use of it to minimise costs and maximise income.

When evaluating the suitability of a site for renewable energy generation, two different sets of potential issues must be considered. The first are technical – not the soundness of the technology itself, but the constraints imposed by the location on the achievable power level. Assuming these can be managed, the policy constraints that might constrain or facilitate the likelihood of receiving planning permission to build at that location need to be understood by potential developers. With multiple possible factors affecting each of the technical and policy issues, a critical aspect of the method is to weight each factor appropriately to give a realistic screening of the resource. In addition, technical and policy evaluations can conflict, so in order to understand options for management it is important to be able to identify the specific issues at play in any one location.

This document describes the methodology used to produce an opportunity map for free-standing solar PV farms in Glasgow and its functional implementation in a Geographic Information System (GIS). Technical implementation on the Quantum GIS platform is described in a separate document (*User Guide to RenMap for QGIS 2.6, 25 February 2015*).

[1] Energy Efficiency Demonstrator, http://futurecity.glasgow.gov.uk/index.aspx?articleid=10249
[2] Scottish Government: Renewable Energy for Communities, http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Communities

2. The technology of freestanding solar photovoltaic farms

2.1 How solar PV works

The sun is the main source of all our energy, delivering about 12,000 times as much power to the earth as we consume globally. Some of this is absorbed by the atmosphere where it drives wind and waves. What arrives at the surface is in the form of ultraviolet, visible and infra-red radiation with wavelength of 0.3-2.5 μm and maximum power intensity around $1kW/m^2$. The individual packets of energy or *photons* have different, fixed energy levels, with the shorter wavelength radiation (ultraviolet or blue light) carrying more energy.

Electricity can be produced directly from sunlight by a photovoltaic cell, in which radiation falling on two different semiconductors in close contact generates an electrical voltage. A photon which has sufficient energy will knock an electron out of its normal condition of being bound in the crystal structure of the cell; these free electrons can move across the junction between the two materials more easily in one direction than the other, giving one side a negative charge and therefore voltage relative to the other.

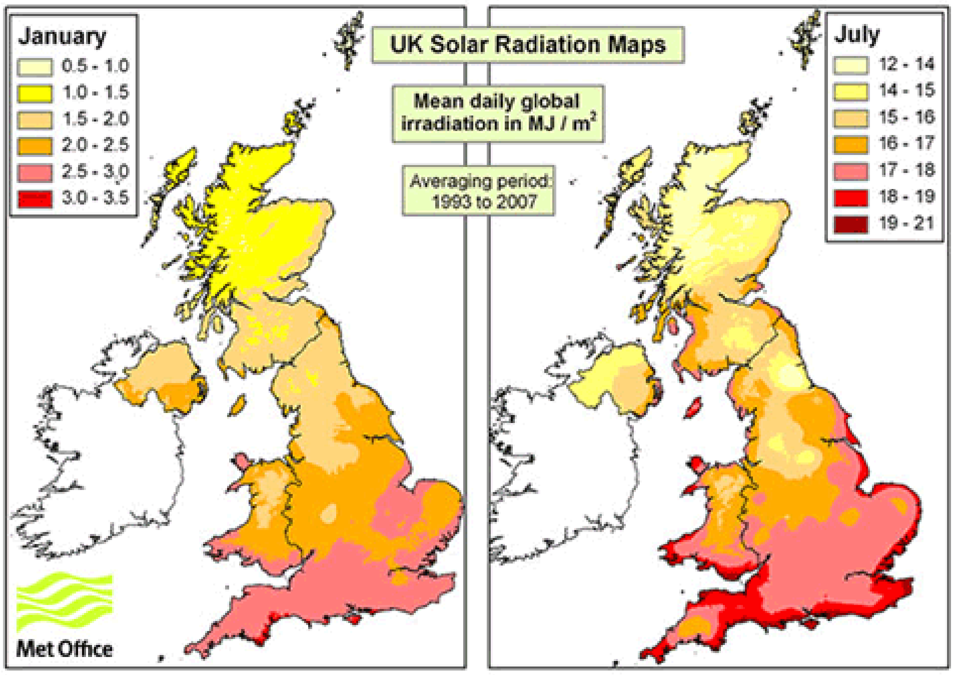

Figure 1: Solar radiation map for the UK

Source: Met Office: Solar Energy . http://www.metoffice.gov.uk/renewables/solar, accessed 21 August 2014

The amount of energy generated by a PV cell depends on the amount of sunlight that falls on it, and this in turn depends on location: the more southerly the location and the more direct sunshine it has, the more energy a given PV cell can harvest. Figure 1 shows how solar radiation varies across the UK in winter and summer. For any location there is an optimal orientation that allows the maximum energy to be collected over a year. In Glasgow, an unobstructed south facing panel angled at 60 degrees to the vertical receives about 960 kWh/m^2, and 75% this arrives between the spring and autumn equinoxes.

Because only some of the photons carry the correct amount of energy, only a small fraction of the radiation can be turned into useful electricity, typically 4-25% - although this is an evolving area and cells with over 40% efficiency are under test[3]. Commercially available solar cells can be made of monocrystalline silicon grown from a seed crystal (efficient but expensive), or polycrystalline silicon made from grains of the monocrystalline version (less efficient but cheaper), or a thin film of amorphous silicon (least efficient and cheapest).

2.2 Components of a solar PV farm

The voltage and current generated by an individual cell are very small, so many of these are connected in series (to increase the voltage) and in parallel (to increase the current), to form a panel. Panels are still relatively low powered, typically 1.5-2 m^2 in area producing 100-250 W depending on the type of cell. Multiple panels are in turn connected in series and in parallel to make an array (Figure 2). An array needs to be held in place by a frame, and fixed in place either by piled foundations or concrete weights on the legs.

a) typical solar panel made up of cells connected in series and in parallel

b) an array of solar panels connected in series and in parallel
Source: http://cdmsmith.com/en-US/Insights/Features/Looking-High-and-Low-for-Alternative-Energy-Options.aspx

Figure 2: Solar photovoltaic technology illustrated

The PV array produces direct current, and this must be passed through an inverter to turn it into alternating current with a frequency of 50 Hz before it can be fed into the electricity grid. When considering a possible layout, it is important to understand that where panels are connected, if any one becomes shaded then the whole array feeding that inverter will turn off. Shading can arise from surrounding buildings and trees, but also from other parts of the PV farm itself if multiple arrays are lined up too closely behind each other. This means in practice that in Glasgow the total panel area is limited to about 30% of the horizontal area, to ensure that optimally tilted arrays never cast a shadow over each other.

There are cost-benefit tradeoffs to be made when choosing the number of inverters and protective devices for a farm[4]. It is also possible to add equipment to increase the energy yield, such as

[3] NREL National Center for Photovoltaics. Research cell efficiency records. http://www.nrel.gov/ncpv/images/efficiency_chart.jpg, accessed 21 August 2014
[4] Gevorkian, P: Large scale solar power system design. McGraw Hill, New York, 2011

concentrating lenses and tiltable frames to track the sun for at least part of the day, but each of these adds cost and multiplies opportunities for breakdowns.

Other components include a network of circuit breakers and bypass diodes to protect against overloads and reverse current; transformers to match the output voltage to that of the grid and if necessary protect the grid from a failure in the PV farm itself; monitoring and logging equipment; and cabling to connect to a grid substation. The installation will require access paths, fencing and security systems especially in an urban environment.

During operation dust will collect on the panels and vegetation will grow under and around them: these will reduce output unless regularly kept in check. Although the panels themselves have lives over 25 years, the ancillary equipment does not, and inverters and other components will need to be replaced periodically. The site will also be vulnerable to vandalism and accidental cutting of cables during road maintenance.

On the basis of monitored data collected from deployments throughout the UK, it is likely that a well-designed PV farm will give an energy yield around 900 kWh per year for each kW of installed peak capacity. When scaled to an area equivalent to 1% of the derelict and vacant land area presently available to Glasgow, this equates to around 16,500 MWh per year, which is sufficient to meet the present electricity needs of 5,000 homes or 1,000 future homes with all-electric heating.

3. Approach

The approach evolved from that used previously to aid Highland Council to formulate an energy action plan for wind power in Caithness[5]. Its key stages are:

- Identifying the factors that might constrain power offtake or economic return. Examples of policy factors include the existence of protected species or archaeological monuments. The distance to the nearest grid connection point is an example of a technical factor.
- Defining criteria by which policy and technical factors at any location can be evaluated on a 3 or 4 point scale.
- Finding or generating the base data to allow the evaluation to be carried out across the whole geography of interest.
- Scoring each individual factor for each location using the data and the criteria.
- Weighting and combining the individual factors to give a combined policy score and a combined technical score, to give the most realistic view of the constraints for each location.
- Selecting a suitable visual representation of the above on a GIS system

3.1 Method

The individual factors and scoring criteria were determined through working with appropriate professionals. Policy factors were defined at joint workshops held between ESRU and GCC planning staff, and data relevant to policy evaluation were supplied by GCC (Section 4). Technical factors

[5] Clarke J A, Evans M S, Grant A D, Kelly N (1997): Simulation tools for exploitation of renewable energy in the built environment. *5th Conf. International Building Performance Simulation Association,* Prague, Czech Republic September 1997

were identified by ESRU: some of the relevant geographic data was supplied by the distribution network operator SPEN via GCC, and some was generated using publicly available data (Section 5).

For policy factors, a 4-point scale was chosen, with each location evaluated as one of 'Possible', Intermediate', 'Sensitive' or 'Showstopper'. The 'Showstopper' rating was used sparingly, applied only in certain cases where it was deemed important distinguish between locations where it might be possible to find mitigations that would allow development and those where in the judgement of GCC planners it would be nearly impossible to do so. Technical factors were assessed on a 3-point scale as one of 'Favourable', 'Likely' or 'Unlikely'.

The individual scores were combined to give an overall evaluation for each of the Policy and Technical issues. There are several possible ways to calculate a combined score: each gives a slightly different view of the total area that looks favourable technically or possible from a policy perspective; and each has its virtues and disadvantages, discussed in Section 6. Three different combination methods were implemented in the system: the lenient method where the scores for each layer are added together; the stringent method under which the highest score for any one factor is applied as the combined score; and a hybrid of the two which was judged to give the most realistic result.

Before embarking on building the GIS tool, the methodology was tried out manually for a group of sites at the old Meat Market; the distribution network operator was also asked for an opinion about possible grid connection issues.

3.2 RenMap tool

A freely downloadable Geographic Information System, Quantum GIS, was used to build the interactive tool. Data is held in a series of layers called shapefiles, which hold the location information as well as a set of user-defined attributes. Appendix V gives details of where this tool, RenMap, is located and shows some screenshots. Layers can be combined, filtered and used in calculations; each can be formatted according to need. In this case, a colour coding was used to show the geographical variation in scoring: darker shades represent increasing levels of difficulty.

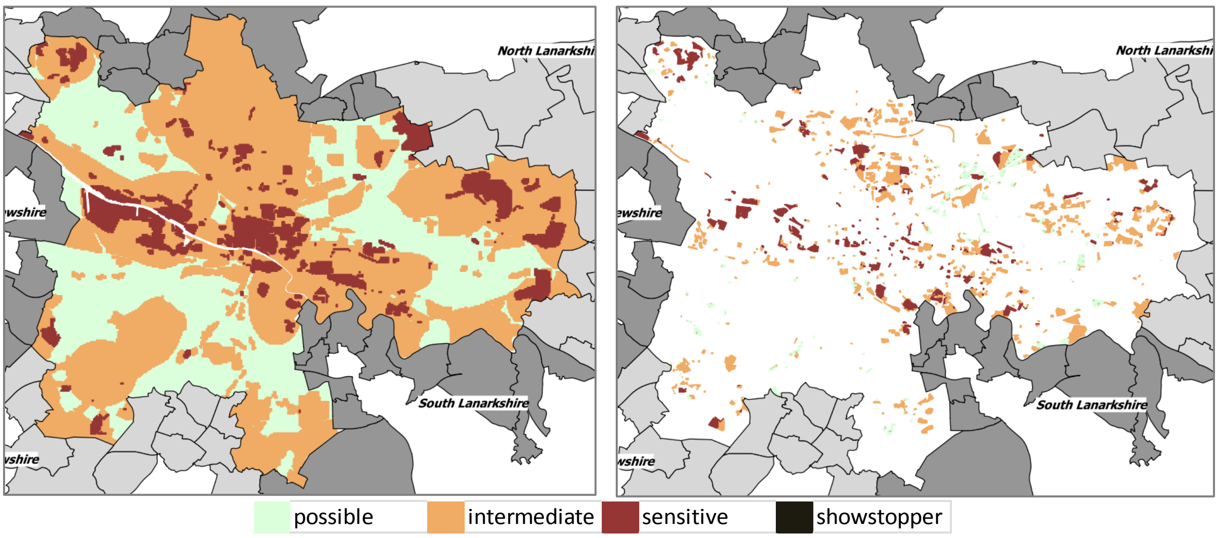

Figure 3: layers showing development policy scoring only across the whole city and for VDL sites only

For some of the factors it was possible to evaluate the entire city using centrally held data. However, in other cases the relevant data had to be obtained through a site-by-site survey. Only a selection of the 863 sites could be surveyed because of time constraints. Therefore, since the aim of the tool is to provide a guide to choosing the best locations and minimizing the need for rework, it was decided to structure it in three sequential steps:

Step 1 – Mapping those policy and technical factors that can be assessed centrally across the whole city, individually and in combination

Step 2 – Mapping the citywide factors onto all the VDL sites, individually and in combination.

Figure 3 illustrates how the first two steps appear in the tool: it shows a layer showing a single factor (development policy), both citywide and mapped onto the VDL sites. From this, potential sites can be selected for the next step.

Step 3 – Adding those policy and technical factors that can be assessed only by a site survey. The additional data is available only for the VDL sites, and only for those that have actually been surveyed, so the final combined scoring layers will also show only those sites.

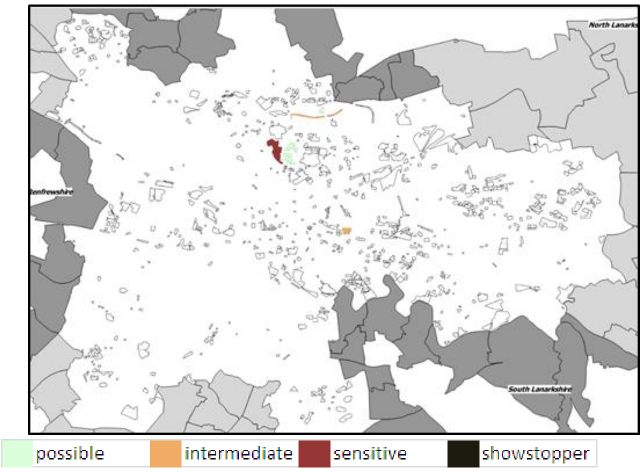

Figure 4: A layer showing a single factor assessed through survey (biodiversity)

Figure 4 illustrates how this appears in the tool for a single factor assessed by manual survey of individual VDL sites (biodiversity). Sites that have not been surveyed are shown only in outline. This view is replicated in the final layers presenting the combined technical and policy scores for the surveyed sites.

The Glasgow city area was divided into a 10m x 10m grid, and each grid square was scored separately for each technical and policy factor. However, at this scale the whole city requires 1.76 million individual grid squares and this makes the application very slow in use. A 50 m x 50 m grid was therefore implemented in the interactive map, which results in 71,688 grid cells. The individual VDL sites were mapped onto the grid: to facilitate analysis the attribute table for each layer shows the area of intersection of each grid square with a VDL site.

The RenMap application is hosted by the Development Plan Group in Glasgow City Council's Development & Regeneration Services. It requires QGIS version 2.6. The structure of the individual layers in the tool is given in Appendix I.

3.3 Applicability elsewhere

The approach used is transportable to other locations and other technologies. Technical factors and evaluation criteria will be different for each renewable technology but will not vary by location: the method can be copied directly for solar PV in any other city. However, each local authority has its own approach to policy, so only the framework can be used elsewhere and appropriate evaluation criteria must be determined in each case. So, if Glasgow City Council wish to produce an opportunity map for solar heating they could use the policy evaluation as it stands, but would have to come up with an appropriate new set of technical evaluations. On the other hand, if a different council wanted to produce a PV opportunity map, they could apply the technical evaluations directly but would need to come up with their own policy definitions and criteria.

Finally, this is a screening exercise that does not address issues of technical design, costs, revenues, or opportunities to enhance for example by integrating with commercial development to provide demand, or alternative uses for land such as putting on bike shed roofs. Neither does it remove the requirement to go through the normal planning control process for a new development.

4. Policy factors

Policy constraints can affect whether a site is suitable for renewable energy systems. Most will apply to all technologies, but there will also be some specific to any given one. The following five factors have been identified for freestanding solar PV:

- Environmental designations of land or buildings, such as Sites of Special Scientific Interest or Listed Buildings.
- The development zoning of the location, for example for housing or industrial use.
- Glare that might constitute a safety risk to aircraft or cars (visual intrusion).
- The possible existence of protected or endangered species, requiring surveys and mitigation plans (biodiversity).
- How visible the facility is from neighbouring housing (visual impact).

This section considers each factor in turn, outlining the evaluation criteria and their rationale, describing how the relevant data are sourced, and discussing its scope and transportability to other locations and other renewable technologies. The outcomes for each individual layer are presented at both city and VDL level. Appendix II gives detailed mappings of how data has been generated and stored in the tool.

4.1 Environmental policy

Glasgow City has 13 different policy designations covering environmental issues. GIS maps of the city are maintained with a shapefile for each designation. The data for this Environmental policy layer is taken from the GCC policy shapefiles, and scoring for the layer is based on the consensus view from the planners as to how big a hurdle each imposes. Appendix II lists the shapefiles and their scoring individually.

Possible, score =1: Green corridors, Local nature reserves, and all non-designated areas.

Intermediate, score = 2: Conservation areas, Listed buildings, Ancient woodlands, Tree preservation orders, World Heritage site buffer zone.

Sensitive, score = 3: Sites of special landscape importance; Gardens and designed landscapes; Scheduled ancient monuments; Local sites of importance for nature conservation.

Showstopper, score = 4: Sites of Special Scientific Interest (SSSI), City-wide sites of importance for nature conservation; World Heritage site (Antonine Wall).

These designations can overlap in many areas, where they are scored as follows:

- If the scores are different, the highest one applies
- If scores are all 'Possible' then the overall scoring is 'Possible'
- If 3 or more 'Intermediate' scores are found then the overall scoring is 'Sensitive'
- If 3 or more 'Sensitive' scores are found then the overall scoring is 'Showstopper'

This layer covers the whole city, and is applicable to any renewable generation technology. It should be updated each time GCC issues new GIS maps for environmental designations.

4.2 Development policy

Development policy in GCC comprises 15 separate designations covering the city, each with its own GIS shapefile. The data for this layer is taken from these GCC policy shapefiles, and the scoring is based on the consensus view from the planners as to how big a hurdle each imposes. Appendix II lists the shapefiles and their scoring individually. In general this is a less onerous factor than the previous one and no development policy designation was rated as a showstopper.

Possible, score =1: Regeneration areas, Strategic economic investment areas, Master plan areas as well as all non-designated areas.

Intermediate, score = 2: All other designations

Sensitive, score = 3: Housing land supply with consented developments

Areas with overlapping designations are scored as follows:

- If the scores are different, the highest one applies
- If scores are all 'Possible' then the overall scoring is 'Possible'
- If 3 or more 'Intermediate' scores are found then the overall scoring is 'Sensitive'

This layer covers the whole city, and is applicable to any renewable generation technology. It should be updated each time GCC issues new GIS maps for developmental designations.

4.3 Visual intrusion

Strong glare from reflections can cause flash blindness, a temporary loss of vision. The UK Civil Aviation Authority (CAA) in its interim guidance on solar PV systems recognizes this but currently offers no quantitative standard as to what may or may not be acceptable[6]. Flash blindness for a period of 4-12 seconds can be caused by 7-11 W/m^2 reaching the eye[7]. However, the risk of

[6] Interim CAA guidance – Solar Photovoltaic Systems, UK Civil Aviation Authority, 2010 https://www.caa.co.uk/docs/697/srg_asd_solarphotovoltaicsystguidance.pdf

[7] Technical Guidance for Evaluating Selected Solar Technologies on Airports, US Federal Aviation Authority, November 2010

encountering this intensity from solar PV is low – only 2% of energy is reflected, which in Glasgow would equate to a maximum of 20 W/ m^2 very close to the panels. In the US, solar PV farms have been installed on a number of airports without any reported incidents of glare affecting pilots[8]. Analysis of glare from solar concentrators indicates that at ground level people are safe from flash blindness at a distance of 150 feet[9]. An overview of the sources and information used is given in Section 3 of Appendix II.

However, the existing regulations do require CAA to be consulted for major solar PV developments within 15 miles of an officially safeguarded aerodrome such as Glasgow, although the aerodrome may choose to reduce this distance to 5 km[10]. Glasgow's Aerodrome Traffic Zone also covers a radius of just less than 5 km[11]. With this in mind, and with the intention of taking a conservative view, the following criteria have been chosen:

Possible, score =1: All other areas

Intermediate, score = 2: Between 1 and 5 km radius to the south of an airport or heliport or within 100m of a motorway

Sensitive, score = 3: Within a 1 km radius semicircle to the south of an airport or heliport, or 100m from a runway

This layer covers the whole city, but is specific to solar PV: its applicability would require to be reviewed even for other solar technologies such as concentrating mirrors. The CAA intend to update their guidance after the US Federal Aviation Authority completes their own review which has been under way since October 2013, and the layer should be revised to reflect the new guidance.

4.4 Biodiversity

Protected or endangered species habitats are not necessarily covered by an environmental designation such as SSSI, and habitats can change over time faster than formal designation. The UK legislation in the Wildlife & Countryside Act 1981, the Habitats Regulations 1994, and Protection of Badgers Act 1992 mandates specific environmental surveys to be carried out if a site is thought to harbor certain designated species, and a planning application may be turned down if no suitable mitigation measures can be found. This legislation is reflected in guidance from Scottish Natural Heritage[12] and in GCC's Local Biodiversity Action Plan[13]. The evaluation criteria for this factor therefore are:

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[8] Solar photovoltaic energy facilities: Assessment of potential for impact on aviation. Report No 10/344/RPS/1, Spaven Consulting, January 2011

[9] Ho C, Ghanbari, C, Diver R: Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. Sandia National Laboratories. SolarPACES 2009, Berlin Germany.

[10] Interim CAA guidance – see above

[11] Briefing Information for flying into or in the vicinity of Glasgow Airport or its control zone http://www.caa.co.uk/docs/299/DAP_ACD_Glasgow.pdf

[12] Protected species known to occur naturally in Scotland and their protection. Scottish Natural Heritage 2012, http://www.snh.gov.uk/docs/B551085.pdf

[13] Local Biodiversity Action Plan. Glasgow City Council, www.glasgow.gov.uk/index.aspx?articleid=6054

Possible, score =1: No species on the protected list believed to occur

Intermediate, score = 2: UK Protected species possibly occur, requires environmental survey and mitigation measures

Sensitive, score = 3: European protected species possibly occur, requires environmental survey and serious mitigation measures

Information about species likely to occur in Glasgow is held by the Land and Environmental Services department at GCC. This information is sensitive so will be released on a site-by-site basis only; and the RenMap tool will include only the scoring for each location without details of the species in question. This layer is therefore part of the manual survey process defined in Appendix IV.

Advice from the Land and Environmental Services is that some general issues with the solar panels also need to be considered in terms of biodiversity impact:

1. the amount of ground disturbance for installation fixings such as poles or platforms.
2. the size of the panels – this will cause more or less shading onto habitats.
3. the density of panels per location – which will determine the size of area of shading, plus access to grassland for birds and other animals to forage, nest and so on.

Where several species may occur, the highest score applies. Where three or more species with Intermediate score occur in one location, the overall score is increased to 'Sensitive'.

This layer applies to surveyed sites only, but applies to any renewable generation technology planned to be deployed there. It should be updated when GCC issues new Local Biodiversity Action Plans.

4.5 Visual impact

Solar PV arrays can take up a large area, but they are not tall: in an urban environment they are unlikely to make a big difference to the quality of a view. A distinction can be made between sites which are not overlooked by residential areas or where the view from residential areas is an existing industrialised landscape or where there is suitable screening; and sites where the introduction of a solar PV farm would significantly change the character of the view from housing. Establishing which applies at a given site requires a degree of subjective judgement, reflected in the simplified scoring criteria. This layer is generated for each site individually through the survey process defined in Appendix IV.

A qualitative judgement is made based on how close any residential properties are and what the overall view from them looks like, i.e. a large solar array will be more intrusive against a park background than against a street landscape. Elevation effects also need to be taken into account, with longer visibility from tall buildings or rising ground.

Possible, score =1: No residential areas overlook the site

Intermediate, score = 2: Residential areas overlook the site

This layer applies to surveyed sites only, and for solar PV generation only. It will require updating if there is new building in the area, or old buildings are demolished, so even sites that have already been surveyed should be reviewed when they come up as a possibility through screening.

5. Technical factors

Technical factors will generally be different for each technology, although issues to do with grid connection and access will affect many. Four different technical factors have been identified as affecting whether a site is suitable for an urban solar farm:

- The distance to the nearest 11kV substation on the grid.
- The capacity of the circuits in that substation to absorb new renewables generation (grid congestion).
- Overshadowing from nearby buildings or trees.
- Suitability of terrain from the point of view of access, steepness, flooding risk.

This section considers each factor in turn, outlining the evaluation criteria and their rationale, describing how the relevant data are sourced, and discussing its scope and transportability to other locations and other renewable technologies. It is important to bear in mind that the evaluations are intended as a guide to relative difficulty and do not give detailed technical assessments. Appendix III gives mappings of how data has been generated and used in the tool.

5.1 Grid connection distance

The distribution network operator SPEN publishes guidelines on connection opportunities for renewable energy generation[14]. An urban solar farm could be connected to the grid at a primary or secondary substation, or at some point in an 11kV circuit. Only installations of less than 12 kW can be connected to the low voltage network, and this is too small scale for a freestanding facility. In general the location and cost of a possible grid connection must be determined for each specific project as it depends on multiple considerations around the power and type of equipment proposed for the development, as well as on the layout of nearby 11kW circuits and secondary substations.

However, SPEN operates 74 primary substations in the city or immediately adjacent to its boundary[15], and each of these is at the centre of around a dozen 11kV circuits feeding many secondary substations. The density of the circuits is higher close to the substation. So the probability of there being a suitable secondary substation or an accessible section of circuit will be higher the closer a site is to a primary substation, and a criterion based on the straight-line distance to the nearest substation will give a good picture of the relative suitability of different sites. It should however be remembered that this will *not* be the actual distance covered by a connection cable which must be routed along roadsides.

Glasgow city has a surface area around 750 km^2, giving an average density of one primary substation per 12.5 km^2, roughly the area of a circle with a 2 km radius. This leads to the following criteria:

Favourable, score =1: within 750 m of a primary substation.

Likely, score = 2: between 750 and 1500 m of a primary substation

Unlikely, score = 3: further than 1500 m from a primary substation

[14] http://www.spenergynetworks.co.uk/pages/connection_opportunities.asp

[15] Ciaran Higgins email of 28 April 2014, *GlasgowPrimarySubstations.zip*

This layer covers the whole city, and is applicable to any renewable generation technology. It should be updated each time SPEN revise their list of substations for Glasgow and the immediately surrounding areas.

5.2 Grid congestion

Even if there is a substation close by, it still may not be possible to connect to it if the existing circuits are overloaded, or if there is already a lot of renewable generation on it with the risk of reverse current flows. This factor is distinct from the grid connection distance because the situation may change over time as loads change and substations are upgraded.

SPEN assesses congestion around primary substations from two perspectives: the ability of each 11 kV circuit to take distributed generation (Circuit level), and the impact of distributed generation on other circuits (Primary Area level)[16]. They have published GIS heat maps scoring each circuit at each substation on a 3-point scale for each of seven different issues. On examination however, the heat maps show no variation between the different circuits at any substation in the Glasgow area.

The total score for any substation could therefore theoretically range from 7 (best) to 21 (worst), but in practice all the scores for the 74 primary substations in or immediately adjacent to Glasgow fall between 8 and 12 with 10 being the most frequent score. Hence the criteria applied are:

Favourable, score =1: Combined heat map score under 10

Likely, score =2: Combined heat map score equals 10

Unlikely, score = 3: Combined heat map score greater than 10

This layer covers the whole city, and is applicable to any renewable generation technology. It should be updated each time SPEN revise their Network Heat Maps.

5.3 Overshadowing

Solar PV generation depends on sunlight striking the panel, and if a panel is shaded even some of the time it will not generate the expected output. Indeed, if only part of an array connected to an inverter is shaded then the whole array ceases to generate (Section 2.2).

The shade cast by an adjacent building varies throughout the day and over the year, and a detailed assessment of the shade footprint needs to be made during the design stage. However, the RenMap tool does not attempt to estimate of the potential generation capability, and the overshadowing factor is intended merely as a guide, so this factor was evaluated by estimating the shadow footprint from surrounding buildings over the year. A daily footprint was calculated from the Ordnance Survey Digital Elevation Model[17] for four key dates: the summer and winter solstices and the spring and autumn equinoxes. A composite annual footprint was estimated by superimposing these. On examination, the difference between the annual footprint and that for spring, summer and autumn only was generally small, generally less than 10m in width. For this reason, it was decided not to attempt to include an intermediate score.

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[16] http://www.spenergynetworks.co.uk/userfiles/file/DG_Heat_Maps_Overview.pdf accessed 14 August 2014
[17] http://www.ordnancesurvey.co.uk/business-and-government/products/os-terrain-5.html accessed 12 January 2015

Favourable, score =1: Falls outside the estimated annual shade footprint

Unlikely, score = 3: Falls within the estimated annual shade footprint

The annual footprint shows the areas that will be shaded by surrounding buildings at some point over the year, but it does not mean that all of it will be shadowed all the time and therefore precluded from consideration. It also does not give a definitive answer on where there will be problems with shadowing as trees, large signs or hoardings are not included in the Digital Elevation Model. So it is not a substitute for a rigorous calculation of annual energy available; however, the footprint does give an indicator of where it is most useful to look.

This layer covers the whole city, and is applicable to all solar technologies (PV, thermal, concentration). It should be updated when a new Ordnance Survey Digital Elevation Model is issued.

5.4 Terrain

Most urban land will not present any problems for freestanding solar PV. There may be the occasional piece of ground which has been built round so that there is no road access, but this should be rare. The technology does not require deep foundations, panels can be held in place with ground anchors if necessary. However, heavily sloping or broken ground with limited access - such as a railway cutting – or a site liable to flooding[18] will be more difficult to develop than an open flat piece of land.

This layer is generated for each site individually through the survey process defined in Appendix IV. A qualitative judgement is made based on shape, slope and access to site using Google Earth and contour lines or Digital Elevation Map, and SEPA's interactive flood map[19].

Favourable, score =1: Flat ground, no access issues, or risk of flooding.

Likely, score =2: Heavily sloping or broken ground, restricted access, unsafe buildings, medium risk of river or coastal flooding or high risk of surface water over large area.

Unlikely, score = 3: No direct access, site under water or with high risk of river or coastal flooding.

This layer covers VDL sites only, and is applicable to solar PV only. It will require updating only occasionally when for example flood risk assessments are updated, but even so sites that have already been surveyed should be reviewed when they come up as a possibility through screening.

6. Combining and weighting the factors

The individual policy and technical factors can be combined in various ways to give a view of the relative ease or difficulty of deploying a renewable technology at a specific location. Each will give a different view of the opportunity available, and each is potentially useful during screening.

[18] Technical Guidance to the National Planning Policy Framework. Department for Communities and Local Government, March 2012

[19] Flood Extent Map. SEPA, 2014 http://map.sepa.org.uk/floodmap/map.htm

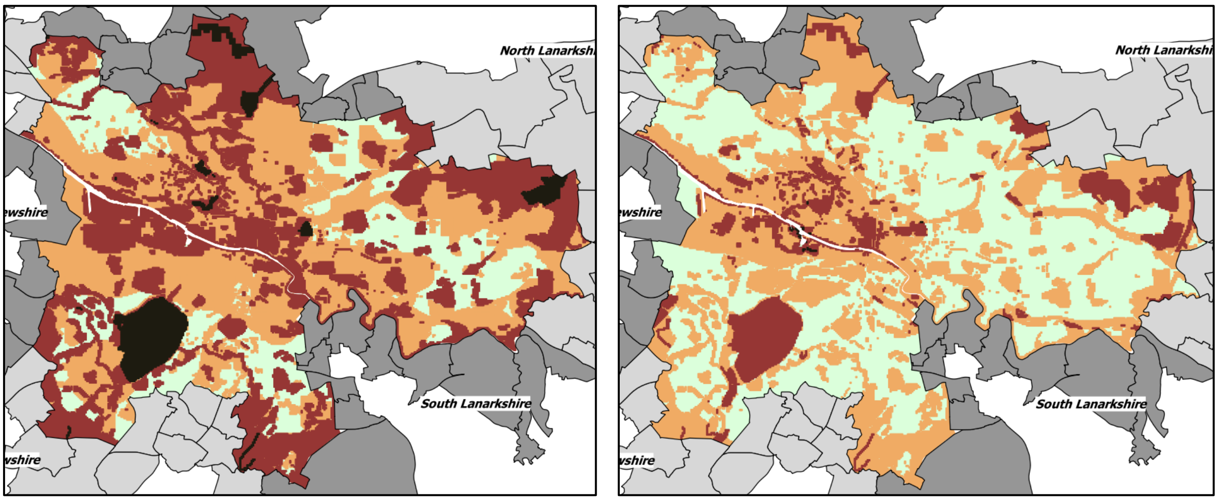
The most straightforward method is to add up the scores for each set of constraints: this is the lenient method. It will give the most optimistic view of the opportunity available, and is most useful where the intention is to encourage as much development as possible. However, it has the disadvantage of hiding individual high constraint factors or showstoppers. An alternative is the stringent method, under which the highest score in any one factor is applied as the combined score. This is also a simple approach, giving the most pessimistic view of the degree of difficulty involved as some policy and technical constraints can in fact be mitigated or designed around. Therefore a third, hybrid method has also been implemented which effectively weights certain factors higher than others, applying the stringent method when those factors are unfavourable and the lenient method otherwise. This hybrid method gives a realistic view of where the really intractable difficulties lie, but encourages development as far as possible.

This section describes the various combination methods implemented in detail, and illustrates these through the citywide views of the combinations and individual factors.

6.1 Combined Policy score

The Policy scores for the whole city are shown in Figure 5, calculated by both the stringent and lenient methods. It can be seen that the area evaluated as 'Possible' is much greater with the lenient method and the showstopper area is much less. Two of the individual factors are also shown for comparison in Figure 6: the combined Policy score appears to be dominated by environmental policy, as much of the dark shading on the stringent combination map corresponds to the Environmental layer. The exception is around the river where Development policy dominates.

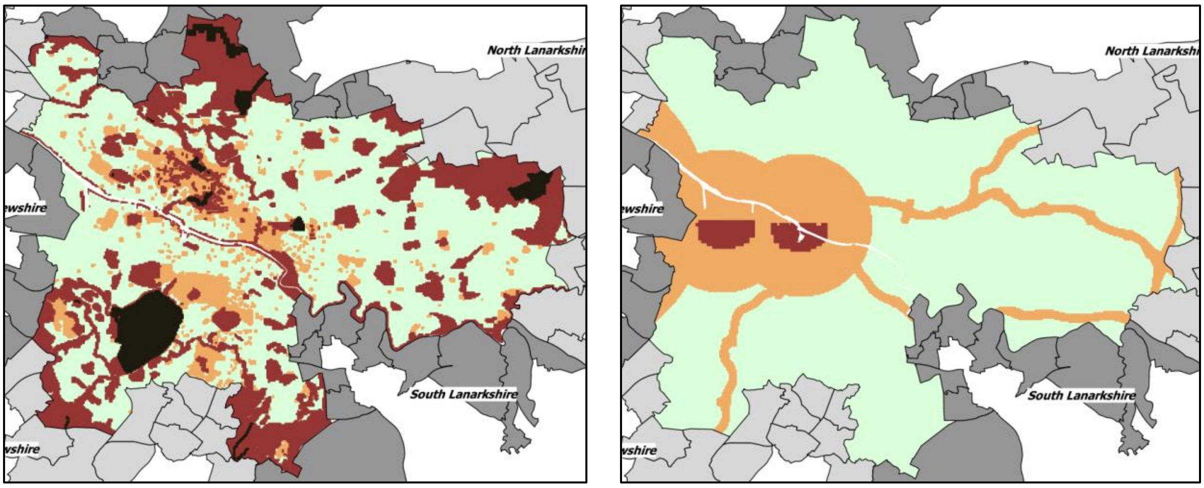
The view of the planning experts from GCC was that developers often perceive policy factors as bigger stumbling blocks than they themselves do, so the lenient method was preferred on the whole in order to encourage the installation of urban renewables. However, some Environmental designations are genuine blockers: for example, the course of the Antonine Wall, a World Heritage site. So the hybrid method was also implemented to give a realistic picture: scores were added leniently, except where the Environmental designation was 'Sensitive' or 'Showstopper', in which case the stringent method applied: this hybrid method is illustrated in Figure 9. Table 1 compares the scoring and colour coding for each of the three methods.



Stringent combination | Lenient combination

possible | intermediate | sensitive | showstopper

Figure 5: Combined Policy score citywide by two different methods



Environmental policy layer | Visual intrusion policy layer

possible | intermediate | sensitive | showstopper

Figure 6: Two individual Policy layers that feed into the combined scores

For the surveyed sites, a similar combination logic was used, but with an additional rule that the overall designation may not be lower than the citywide designation of the same grid square. The logic applied is given in Table 1.

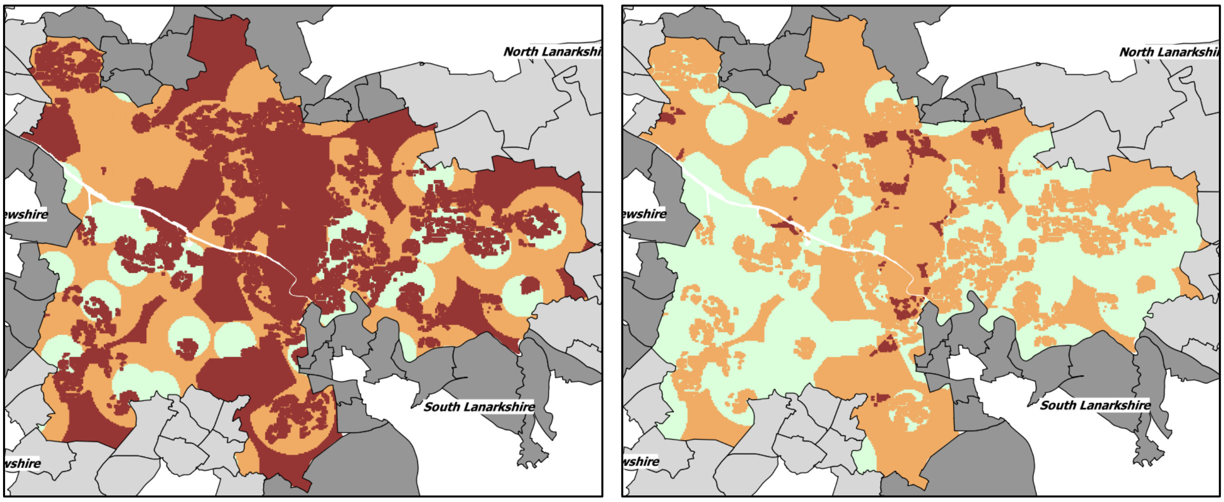
Table 1: Combined Policy scoring: possible ranges of scores under combination different methods

Combined score	Colour	Citywide			Surveyed sites		
		Lenient method score	Stringent method score	Hybrid method score	Lenient method score	Stringent method score	Hybrid method score
Possible		3 4	1	3 4	5 6 7**	1	5 6 7**
Intermediate		5 6	2	5 6	8 9 10***	2	8 9 10***
Sensitive		7 8	3	7 8	11 12 13	3	11 12 13
Showstopper		9* 10	4	9* 10	14* 15	4	14* 15

**Except in cases where individual Environmental policy score is 3; then show as 'sensitive'*
***Except in cases where Citywide score is 5, the mark as 'intermediate'*
**** Except in cases where Citywide score is 7 or 8, then mark as 'sensitive'*

6.2 Combined Technical score

Figure 7 shows the combined Technical score across the city by the stringent and lenient methods. Here, the difference between the two scoring methods is even more marked. In this case, the 'Unlikely' areas for the three individual factors rarely coincide: applying the stringent method means that more than half the city appears to be unsuitable for solar PV for technical reasons.

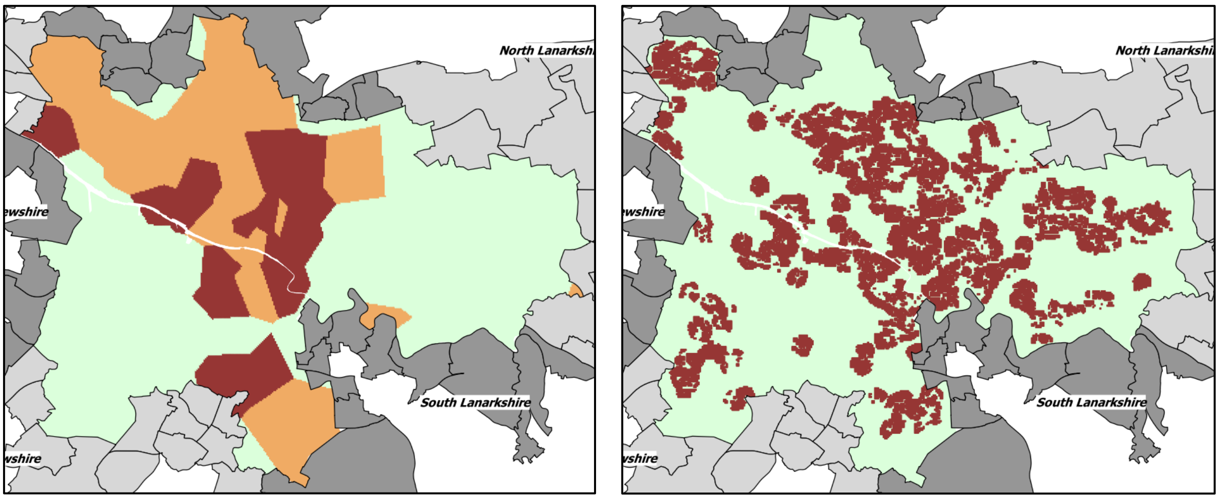


Stringent combination   Lenient combination

favourable   likely   unlikely

Figure 7: Combined Technical score citywide by two different methods

Once again however there is a qualitative difference between the three factors included in the view. Within the city, connecting to the grid may pose a challenge but this is not insurmountable: advice received from the distribution network operator SPEN for the trial sites at the Meat Market confirmed this[20]. However, if an area is in shadow all the time then cannot be mitigated – Figure 8.



Grid congestion layer for comparison   Overshadowing layer for comparison

favourable   likely   unlikely

Figure 8: Two individual Technical layers that feed into the combined scores

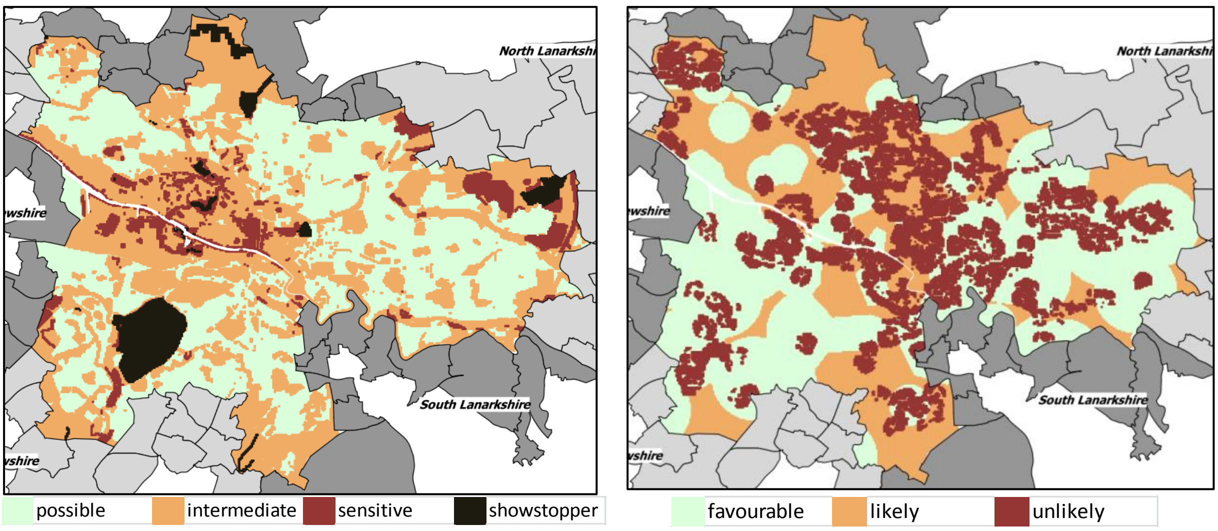
[20] Renewables Mapping - SPEN analysis of network around Meatmarket site. In: Email C Higgins to K Svehla, 20 Mar 2014

A hybrid combination score was therefore also introduced here to give the most realistic picture of the technical constraints. Scoring is lenient except where overshadowing makes it ‘Unlikely’, when the whole score becomes ‘Unlikely’. Figure 9 shows the hybrid Technical score and Table 2 compares the scoring and colouring for each of the three methods.

Scoring for the surveyed sites was on the same basis, but again with the additional rule that the overall designation may not be lower than the citywide designation of the same grid square. The logic applied is shown in Table 2.

Table 2: Combined Technical scoring: possible ranges of scores with different methods.

Combined score	Colour	Citywide			Surveyed sites		
		Lenient method score	Stringent method score	Hybrid method score	Lenient method score	Stringent method score	Hybrid method score
Favourable	(light green)	3 4	1	3 4	4 5 6*	1	4 5 6*
Likely	(orange)	5 6 7	2	5 6 7	7 8	2	7 8
Unlikely	(dark red)	8 9	3	- 9	9 10 11 12	3	9 10 - 12
Except in cases where Citywide score = 5, then designate as ‘likely’							



Policy view

Technical view

Figure 9: Comparison of Policy and Technical constraints across the city, using hybrid scoring method

6.3 Integrated Policy and Technical view

The sites that will be the most straightforward to develop are those where the combined Policy scoring is 'Possible', and the combined Technical scoring is 'Favourable'. Comparing the combined hybrid scoring layers in Figure 9 it appears that in many cases the areas that are favourable technically are not possible from a policy point of view. It is therefore important to be able to establish the nature of the technical or policy constraint – this can easily be done within RenMap visually by viewing successively detailed layers; alternatively, for any particular grid square it is possible to see a table of attributes that show the scoring and the specific evaluation criteria that apply.

An additional layer has been built into the RenMap tool to show an integrated Policy and Technical view of the city and of the VDL sites. In this view however only the overall scores are visible in the attribute table. Figure 10 shows the whole city from this perspective, in which the degree of shading now represents the overall degree of difficulty of implementing solar PV.

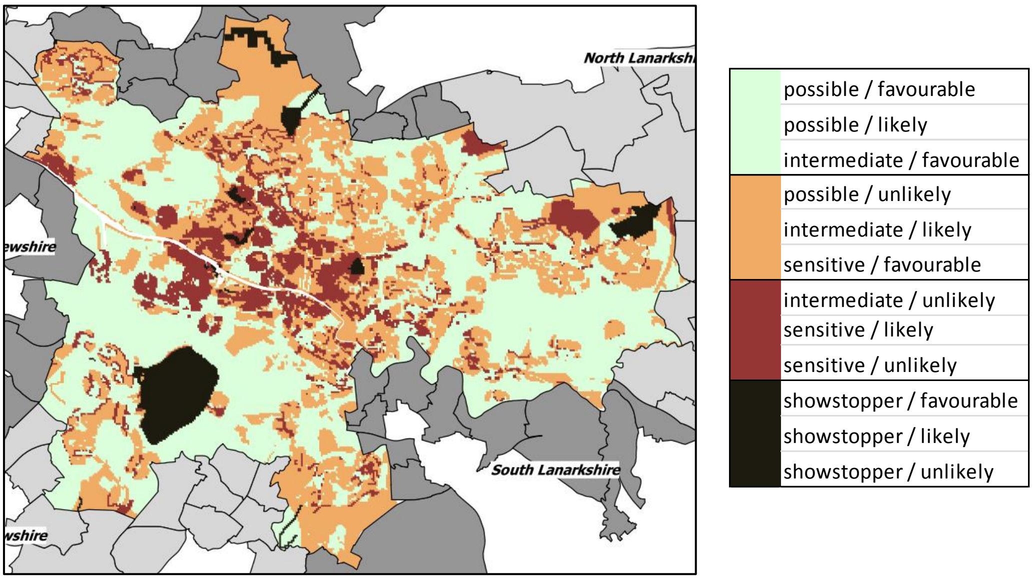


Figure 10: Integrated Policy and Technical view of opportunity for solar PV

6.4 Surveyed sites view

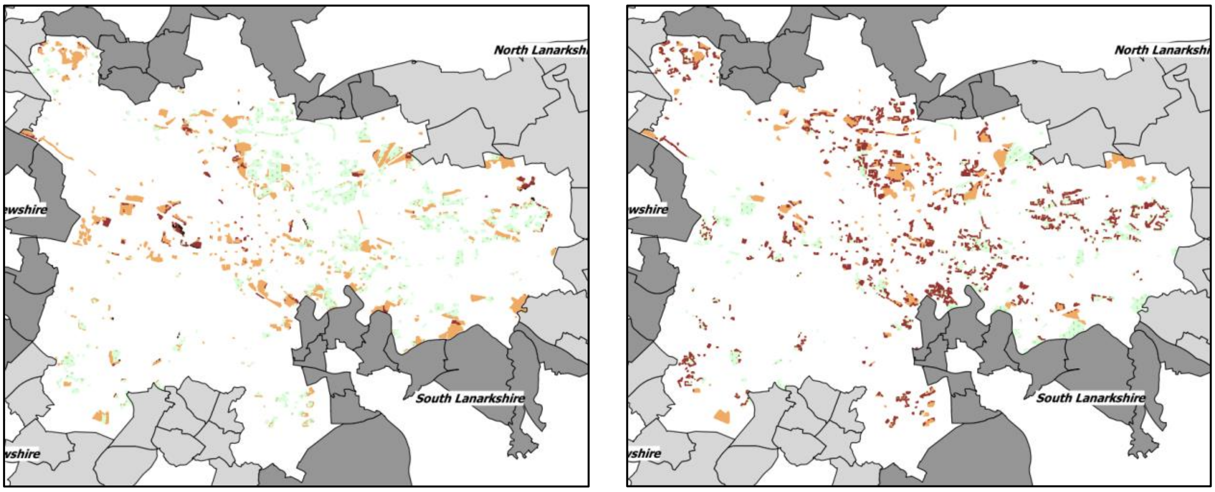
In order to distinguish between the factors that have been assessed citywide and those which have been surveyed for the additional layers, the latter shows shading applied only to the surveyed sites only. The non-surveyed sites are shown in outline only both for individual layers and for the combined views, as shown in Figure 4.

7. Using the tool

The RenMap tool was intended to evaluate the suitability of individual pieces of vacant and derelict land for installing free-standing solar PV farms. This section presents examples of the kinds of insights available from using the tool, but is not intended to be an exhaustive analysis. Detailed instructions on how to find individual layers in the tool are given in the *User Guide to RenMap for QGIS 2.6*, section 3.1.

7.1 Visual inspection of citywide layers

Views of the combined policy and technical scores mapped onto individual Vacant and Derelict Land (VDL) sites are shown on Figure 11. Even a brief glance shows a much more positive picture than the citywide scores in Figure 9 for policy issues, with only a small fraction of sites showing as 'Sensitive' or 'Showstopper'. This is of course is not unexpected since very little parkland or listed buildings would be expected to be classified as vacant or derelict land.



possible | intermediate | sensitive | showstopper

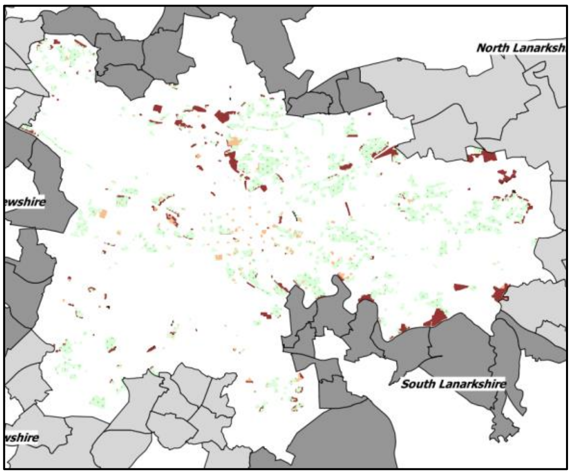
Policy

favourable | likely | unlikely

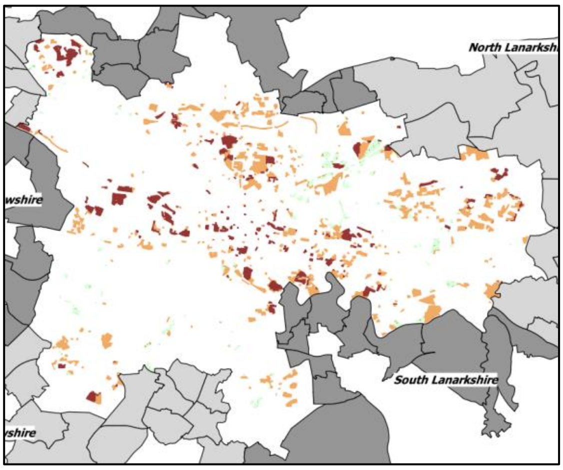
Technical

Figure 11: Combined Policy and Technical scores for all VDL sites – citywide layers only

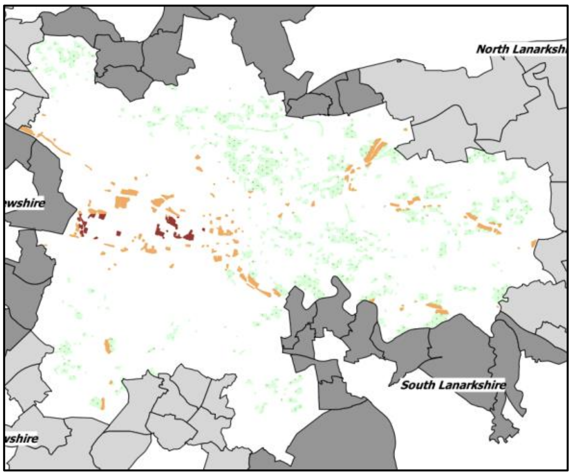
Drilling down into the individual layers in Figure 12 it can be seen that the highest number of 'Sensitive' scores appears in the Development layer. These represent land with housing consents, although not all consented land will in fact be developed. In Environmental layer the 'Sensitive' and 'Showstopper' areas mostly have several components, where for example the same site can be an SSSI, a designed landscape and a green corridor. The 'Sensitive' sites in the Visual intrusion layer are also understandable given that the city heliport is in the docks area which has a high number of vacant and derelict sites.



Environmental



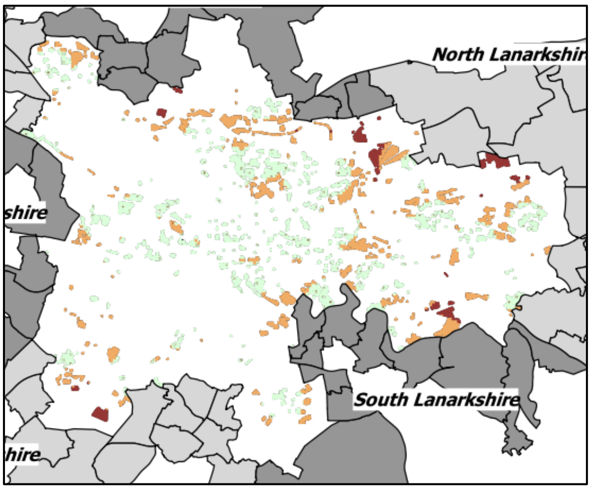
Development



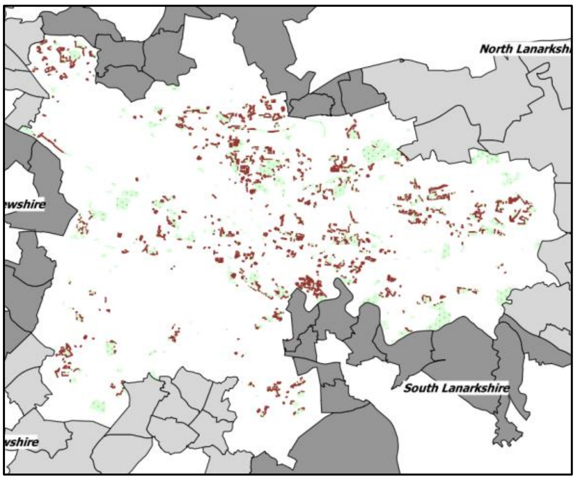
Visual intrusion

Figure 12: Individual citywide Policy layers for all VDL sites

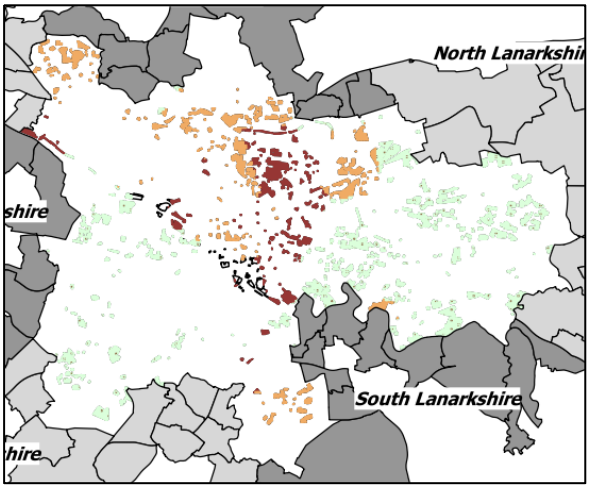
In contrast to the visual message in Figure 7 for the city as a whole, Figure 11 shows that technical factors appear to be more constraining for vacant and derelict sites than policy.   The large number of 'Unlikely' sites is driven by overshadowing especially in areas with high-rise blocks – see Figure 13. However, as discussed in section 5.3, this does not necessarily mean that the site is totally out of question. Distance to a grid substation is only an issue around the city boundary, whereas grid congestion is worst in the city centre.



Grid connection distance



Overshadowing



Grid congestion

Figure 13: Individual citywide Technical layers for all VDL sites

7.2 Area analysis for citywide layers

The total area of Vacant and Derelict land in Glasgow city is 1194 hectares. Figure 14 shows how this total is distributed by overall ease of deployment, for each of the Technical and Policy constraints. The calculations have been carried out using the area of each 50 x 50m grid square intersected by a VDL site; this information is included in the attribute table for each grid cell. Deeper shades indicate increasing level of constraint. The dominance of overshadowing as a constraint on the potential of solar PV in a city comes out even more clearly.

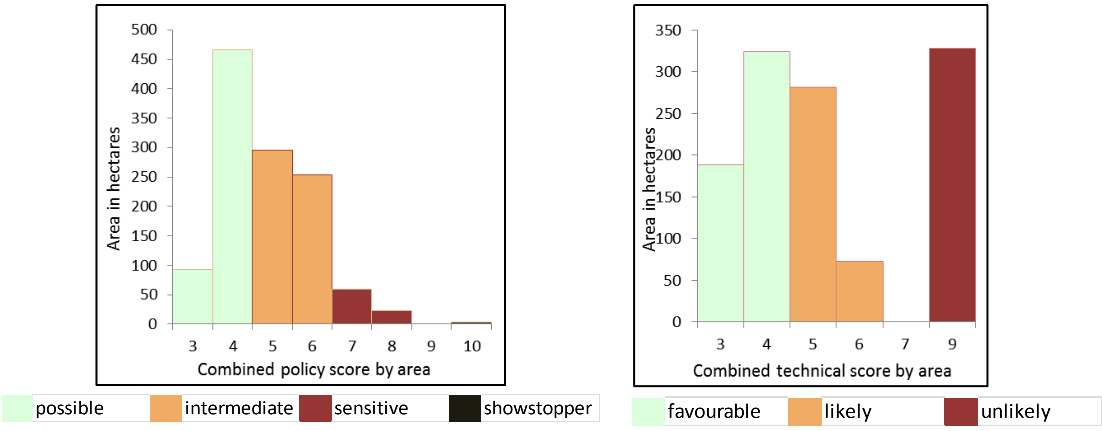


Figure 14: Vacant and derelict land opportunity: Policy and Technical scores by acreage

The difference in outcomes from using different scoring methods can be seen in Table 3. Applying the lenient method does not give a significantly different picture for policy constraints than the hybrid. However, there is a big jump in the area scored as unlikely because of technical constraints. The difference between the two represents areas that may, although not necessarily will, be overshadowed and therefore truly unsuitable. If stringent scoring is applied then the level of apparent difficulty appears daunting – whereas in fact there may well be ways to get round many of the apparent constraints.

Table 3: Comparison of proportion of VDL area scores by stringent and hybrid methods

	% VDL area	Stringent	Hybrid	Lenient
Policy				
	Possible	7.8%	46.8%	46.8%
	Intermediate	49.0%	46.0%	46.0%
	Sensitive	42.9%	6.9%	7.1%
	Showstopper	0.3%	0.3%	0.0%
Technical				
	Favourable	15.7%	42.9%	42.9%
	Likely	36.1%	29.7%	55.5%
	Unlikely	48.2%	27.5%	1.6%

Table 4 summarises the total area of opportunity for installing freestanding solar PV on Glasgow's vacant and derelict land. Almost 53% of the area scores as both possible and favourable, while only 0.6% is in the showstopper category. Just 16% is both technically unlikely and sensitive or worse from a policy perspective.

Table 4: Vacant and derelict land opportunity: Integrated view
Darker shades represent increasing degrees of difficulty

		Policy score						
	hectares	3	4	5	6	7	8	10
Technical score	3	28.6	130.8	34.4	53.4	9.7	2.3	0.2
	4	59.0	151.7	128.1	68.1	12.8	1.7	0.2
	5	20.4	151.1	76.2	77.2	8.2	2.7	0.3
	6	2.0	48.7	22.6	8.9	1.2	3.4	0.2
	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	14.8	44.3	15.7	11.0	3.2	0.2	0.0

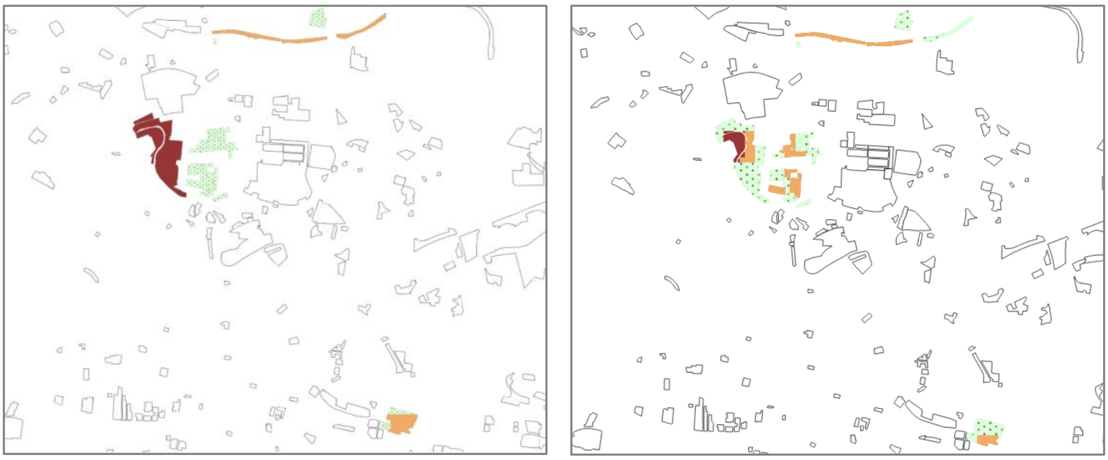
7.3 Visual inspection of surveyed layers

To demonstrate the manual survey step, a number of VDL sites were surveyed according to the procedure in Appendix IV and the results added to the RenMap tool. The sample areas were chosen to give a variety of terrains where a number of VDL sites are grouped. They comprise 4 sites around the old meat market, 6 round Heywood Road, 8 round the canal at Firhill and 17 close together at Possilpark. Altogether these 35 surveys covered 4.1% of all VDL sites, and 3.6% of their total area.

Figure 15 shows the final view in RenMap for the surveyed sites, and Figure 16 two of the three surveyed layers. The sites around Firhill now appear significantly more difficult from both perspectives: protected species are believed to be established near the canal, parts are overlooked and other parts are actually under water. The survey made some minor impacts on the meat market site (which is partly overlooked from flats to the south) and on the old railway cutting at Heywood road which is potentially a thoroughfare for wildlife. The empty and derelict blocks at Possilpark however were unaffected.

Policy Technical

Figure 15: Surveyed sites - final scoring



Biodiversity Terrain

Figure 16: Surveyed sites: individual surveyed layers

8. Lessons learned

The RenMap tool has been developed for Glasgow City Council to support informed decision making on where to locate renewable energy systems, taking into account both the technical constraints imposed by the location on the achievable power level and the policy constraints that affect the likelihood of getting planning permission. It uses a Geographic Information System to show how these constraints vary spatially across the whole city, allowing the user to look not just at overall suitability but also to drill into detail about the specific issues that apply at any location, so that management or mitigation possibilities can be assessed and compared. The specific example implemented was the opportunities for freestanding solar PV deployment on vacant and derelict land.

The tool was developed in a collaborative process involving different groups within GCC, the distribution network operator SPEN, and ESRU. These groups contributed expert input to identifying and quantifying the individual constraints, weighting them so that their relative degrees of difficulty could be evaluated appropriately, and reviewing the outcomes. This depth of expert input and review gives the tool credibility – the development process is as important as the final outcome.

Setting appropriate evaluation criteria for each constraint factor involves a high degree of subjectivity, even in the case of technical factors. In addition, only a limited amount of hard data was available for certain factors, and here again the expert input was very important in generating a robust and reasonable estimate.

Individual factors at a location must be combined to evaluate the overall magnitude of both the technical difficulty and the policy issues. Different combination methods (stringent, lenient hybrid) give rise to different outcomes, affecting the perception of the size of the opportunity and the scale of the problems to be overcome. Policy makers must select the most appropriate method depending on whether they aim to encourage maximum deployment of renewable options or to minimize impact on the status quo.

In order to maximize access to the tool, a freely downloadable GIS system, QGIS, was selected. The disadvantage of this system is that its range of built-in functionality is more limited than that in a commercial system such as ArcGIS. It is possible for the user to write additional functionality in Python script, but this requires expertise in Python scripting if the current tool is upgraded or for a new application to assess other renewable technologies. The most significant problem was that layer naming is not dynamic, meaning that scripts which combined or filtered data in lower layers had to be revised each time the name of any layer was edited. Also, QGIS is written to run on a single core for data processing so it runs slowly with large amounts of data: using a higher specification computer does not speed it up appreciably.

The data on the spatial distribution of planning and technical constraints is stored on a grid in each GIS layer. The size selected for the grid squares is important in terms of balancing ease of handling the tool against the granularity of the result. The smaller the grid size, the longer it takes to load up and see any layer interactively: a 10 x 10m grid required 1.76 million squares to cover Glasgow, and each layer took several minutes to load on an Intel Core i7 @3.6 GHz processor, whereas a 100 x 100m grid had only 18 thousand squares and layers could be loaded without any perceptible delay. However, since each grid square is scored only once for each layer, a coarser grid will give a more pessimistic overall assessment than a finer one – this is especially pronounced in the case of overshadowing, where a 5 meter wide strip of shadow will classify a whole 100 x 100m square as 'Unlikely'. Figure 19 shows how decreasing the grid size increased the total area of vacant and derelict land which looks possible from a policy perspective and favourable from a technical.

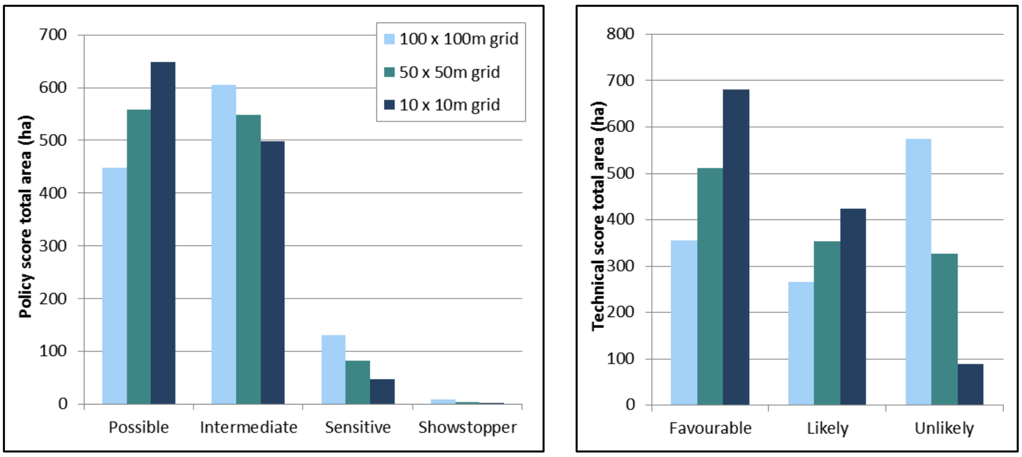


Figure 19: the effect of grid size on the apparent size of the opportunity

Using shapefiles from different sources gave rise to some locational discrepancies, which need to be dealt with pragmatically. For example, some of the sites on the Vacant and Derelict Land shapefile at the edge of the city fell partly outside the city boundary marked in the Planning and Environmental shapefiles. This meant that on the finer grids there exist some squares for which no score could be calculated by the scoring algorithm: these were assigned scores manually by looking at neighbouring squares.

Visual presentation is extremely important in making the tool understandable and intuitive to use, and the expert input and review should focus on these aspects as much as on the data itself. The sequence in which the layers are presented should match the steps in the process; layer names should be clear and consistent; and the layer hierarchy should be transparent and provide traceability from the combined scoring layers through to the base data. The colours used to denote different scorings need to be intuitive – for example, green shades and pale colours to denote 'good', and red shades and dark colours 'bad'.

In the final review, the exercise of tracking down the reason for each anomalous looking area or piece of analysis is time consuming but vital. This will show up not only scripting errors, but also any unanticipated inconsistencies in the formulation of the scoring logic. Each individual layer requires careful review by people who have a good gut feel for the logic involved.

APPENDIX I: Outline of GIS layers

This is the structure of the layers in the RenMap tool. Bold lines show the layer visible when first opening.

- **GEOGRAPHICAL CONTEXT LAYERS**
  - City outline and neighbouring councils
  - Glasgow city wards
  - Vacant and derelict land(VDL)
  - Surveyed site
- **STEP 1A: POLICY ISSUES, CITY**
  - C-PO - Combined policy score by stringent method, citywide
  - L-PO - Combined policy score by lenient method, citywide
  - H-PO - Combined policy score by hybrid method, citywide
  - Policy issue sublayers, citywide
    - P-EN - Environmental policy, citywide
    - P-DE - Developmental policy, citywide
    - P-VN - Visual intrusion, citywide
  - Processed policy data [*Original data transcribed to grid*]
    - Environment factor
      - (14 sublayers)
      - ...
    - Development factor
      - (15 sublayers)
      - ...
    - Visual intrusion factor
      - (2 sublayers)
      - ...
  - Original policy data
    - Environment factor
      - (14 sublayers)
      - ...
    - Development factor
      - (15 sublayers)
      - ...
    - Visual intrusion factor
      - (6 sublayers)
      - ...
- **STEP 1B: TECHNICAL ISSUES, CITY**
  - C-TE - Combined technical score by stringent method, citywide
  - L-TE - Combined technical score by lenient method, citywide
  - H-TE - Combined technical score by hybrid method, citywide
  - Technical issue sublayers, citywide

- T-GD - Grid connection distance, citywide
- T-GC - Grid congestion, citywide
- T-OS - Overshadowing, citywide

- Processed technical data [*Original data transcribed to grid*]
  - Grid connection distance factor
    - (1 sublayer)
  - Grid congestion factor
    - (1 sublayer)
  - Overshadowing factor
    - (1 sublayer)
- Original technical data
  - Grid connection distance factor
    - (1 sublayer)
  - Grid congestion factor
    - (1 sublayer)
  - Overshadowing factor
    - (1 sublayer)

- **STEP 1C: INTEGRATED POLICY AND TECHNICAL VIEW, CITYWIDE**
  - I-GLA - Integrated policy and technical view, citywide

- **STEP 2A: POLICY ISSUES, VDL**
  - C-PO - Combined policy score by stringent method, VDL
  - L-PO - Combined policy score by lenient method, VDL
  - H-PO - Combined policy score by hybrid method, VDL
  - Policy issue sublayers, VDL
    - P-EN - Environmental policy, VDL
    - P-DE - Developmental policy, VDL
    - P-VN - Visual intrusion, VDL

- **STEP 2B: TECHNICAL ISSUES, VDL**
  - C-TE - Combined technical score by stringent method, VDL
  - L-TE - Combined technical score by lenient method, VDL
  - H-TE - Combined technical score by hybrid method, VDL
  - Technical issue sublayers, VDL
    - T-GD - Grid connection distance, VDL
    - T-GC - Grid congestion, VDL
    - T-OS - Overshadowing, VDL

- **STEP 2C: INTEGRATED POLICY AND TECHNICAL VIEW, VDL**
  - I-VDL - Integrated policy and technical view, VDL

- **STEP 3: SURVEYED SITES**
  - S-PO Combined policy score by stringent method, surveyed
  - N-PO Combined policy score by lenient method, surveyed

- R-PO Combined policy score by hybrid method, surveyed
- Surveyed policy issue sublayers
    - P-BI - Biodiversity, surveyed
    - P-VM - Visual impact, surveyed
- Processed policy data [*Original data transcribed to grid*]
    - Biodiversity factor
        - (3 sublayers)
        - …
    - Visual impact factor
        - (2 sublayers)
        - …
- Original policy data
    - Biodiversity factor
        - (3 sublayers)
        - …
    - Visual impact factor
        - (2 sublayers)
        - …
- S-TE - Combined technical score by stringent method, surveyed
- N-TE - Combined technical score by lenient method, surveyed
- R-TE - Combined technical score by hybrid method, surveyed
- Surveyed technical issue sublayers
    - T-TR - Terrain, surveyed
- Processed technical data [*Original data transcribed to grid*]
    - Terrain factor
        - (3 sublayers)
        - …
- Original technical data
    - Terrain factor
        - (3 sublayers)
        - …

APPENDIX II: Evaluation criteria for Policy factors

II.1 Environmental Policy (P-EN)

Generated from GCC planning layers, GIS shapefile data provided by GCC; data attribute designations are in italics.
Criteria are those defined at ESRU-GCC workshops
A new GIS layer is generated from the overlap with the Vacant & Derelict Land (*VDL*) file.
The data imported into the new shapefile will be the basic data listed below plus any other attribute file columns listed in the table:

All the data in the *VDL* file
Environmental Policy Designation number
Designation description
Shape Layer description
OLCP code

If one site falls under multiple environmental designations, it is treated as follows:

- The highest category applies: e.g. a site in both 3A and 3D is 'Sensitive'
- If multiple categories are all 'Possible' then the scoring is 'Possible'
- If 3 or more 'Intermediate' categories are found then the evaluation is 'Sensitive'
- If 3 or more 'Sensitive' categories are found then the evaluation is 'Showstopper'

Criterion	GCC Planning layer name	Data
Possible		
All non-designated areas		
Green Corridors	GreenCorridors	Basic plus *CAT (T/C)*
Local nature reserve	LocalNatureReserves	Basic
2012 Local nature reserve proposals	2012 LNR proposals	Basic
Intermediate		
Conservation Area	ConservationAreas ProposedConservationAreas	Basic plus *NDSTATUS (01/02/PR/Null)*
Listed Building	ListedBuildingsandSAMs	Basic plus *CAT (A/B/C)* plus *OTHUSE (1/2/3)* (for *Listed Buildings* only)
Ancient, Long-established or Semi-natural Woodland	OldWood	Basic plus *Ancient/Long/Other*
Tree Preservation Order	TPOs	Basic
Antonine Wall Buffer Zone	WHSAntonineWall – Consultation zone only	
Sensitive		
Site of Special Landscape Importance	SitesofSpecialLandscapeImportance	Basic
Garden and Designed Landscape	HistoricGardensDesignedLandscape	Basic
Scheduled Ancient Monuments	ListedBuildingsandSAMs	Basic

Criterion	GCC Planning layer name	Data
		(for *SAMs* only)
Local Site of Importance for Nature Conservation	SiteofImportanceForNatureCons	Basic plus *GreenBelt/ GreenSpace/Null* (for *LI* only)
Showstopper		
City-wide Site of Importance for Nature Conservation	SiteofImportanceForNatureCons	Basic plus *GreenBelt/ GreenSpace/Null* (for *CI* only)
Sites of Special Scientific Interest	SSSI	Basic
World Heritage Site	WHSAntonineWall	Basic

Italics = data attribute in name GCC shapefile

II.2 Development policy (P-DV)

Generated from GCC planning layers, GIS shapefile data provided by GCC; data attribute designations are in italics.

Criteria are those defined at ESRU-GCC workshops

In the latest GCC maps, not all areas are covered by Development Policies.

The new Development Policy layers will have some fuzzy boundaries. ESRU will make a best fit shapefile from these using the Glasgow Districts map, creating buffer zones between boundaries in these cases.

The basic data imported into the new shapefile is:

All the data in the *VDL* file

Shape Layer description

OLCP code

If one site falls under multiple environmental designations, it will be treated as follows:

- The highest category applies in an overlap
- If multiple categories are all 'Possible', then the scoring is 'Possible'
- If 3 or more 'Intermediate' categories are found, then the evaluation is 'Sensitive'
- If 3 or more 'Sensitive' categories are found, then the evaluation is 'Showstopper'

Criterion	GCC Planning layer name	Data
Possible		
All non-designated areas		
Transformational Regeneration Areas	TRAs_CDP	Basic
Strategic Economic Investment Locations	SEILS_Feb2013	Basic
Master Plan Area	CDP2_MasterplanArea	Basic

Criterion	GCC Planning layer name	Data
Intermediate		
Economic Areas - Network of Centres	NetworkCentres_Mar2014	Basic
Economic Areas - Industrial/Business Marketable Land Supply	LDP_Marketable0913	Basic
Housing Land Supply 2012,	H12_50plus_new	Basic , for '*Potential*' only
Housing Land Supply - New Housing Sites to be included in Supply	Addition_To_HLSupply	Basic
Green Belt	GreenBelt_Apr14	Basic
Green Network Opportunity Areas	GCC_GN_Opps_Feb14	Basic
Community Growth Masterplan Area	GB_Release_Housing	Basic
Economic Policy Areas	Economy_Nov2013	Basic
Strategic Development Framework - River	Draft_SDF_River_Nov2013	Basic
Strategic Development Framework	Draft_SDF_Boundaries_Oct2013	Basic
Local Development Framework	Draft_LocalDevFramework_Nov2013	Basic
Sensitive		
Housing Land Supply 2012, consented developments	H12_50plus_new	Basic , for '*Consented*' only

II.3 Visual Intrusion (P-VN)

Little guidance is available on glare risk to aircraft from solar PV from UK, Australian or US aviation authorities; although CAA intends to review their guidance once the FAA has completed theirs. Criteria were developed after looking at existing guidance and from academic studies. Sources and relevant data are given below

The RenMap tool has applied these as follows:

- Build up as a series of individual sub-layers: safeguarded aerodromes; other aerodromes and heliports; motorways
- A smaller inner circle of 'sensitive' is proposed round air and heliports: 1 km radius from the centre
- For safeguarded airports such as Glasgow, 'intermediate' would be 1 to 5 km and for heliports 1 to 2 km radius
- For motorways, 100m either side is 'intermediate'

Where overlaps occur, the more stringent criterion will apply

Criterion	GIS sublayer name	Data
Possible		
All other areas – no glare risk		
Intermediate		
Between 1 and 5 km from centre of major airport,	Airport	Distance to airport
Between 1 and 2.5 km from centre of smaller airport or heliport	Heliport	Distance to heliport
Within 100m of motorway	Motorway	Length of motorway
Sensitive		
Within 1 km of centre of airport or heliport	Airport, Heliport	Distance to airport & heliport

Sources used:

- 'Briefing Information for flying into or in the vicinity of Glasgow Airport or its control zone' http://www.caa.co.uk/docs/299/DAP_ACD_Glasgow.pdf
  - The Glasgow Aerodrome Traffic Zone (ATZ) is where pilots on Visual Flight Rules (VFR) are guiding themselves in.
  - The ATZ round Glasgow airport is the volume up to 600m above a 2.5nm (4630 m) radius circle centred on longest runway; however, aircraft would still be quite high up in the outer area.

- Air Navigation: The Order and Regulation 2009.
  - Section 1 Paragraph 222 states that 'lights must not dazzle or distract' but does not define further

- Interim CAA guidance – Solar Photovoltaic Systems, UK Civil Aviation Authority, 2010 https://www.caa.co.uk/docs/697/srg_asd_solarphotovoltaicsystguidance.pdf
  - Greatest concern is with height restrictions if solar pv is mounted on a tall building, and with potential for interference with communications equipment.
  - Statement made about need to consider visual intrusion but without quantification.
  - CAA has to be consulted for and major solar PV development within 15 miles of an officially safeguarded aerodrome and for other en route developments from a comms hazard perspective. But also stets that aerodromes can reduce the consultation distance at their discretion; a 5km distance is suggested.

- CAP 738 Safeguarding of Aerodromes, UK Civil Aviation Authority, 2006: https://www.caa.co.uk/application.aspx?catid=33&pagetype=65&appid=11&mode=detail&id=576.
  - Guidance to those responsible for the safe operation of an aerodrome or a technical site, to help them assess what impact a proposed development or construction might have on that operation.
  - Calculating the 'at risk' volume around an aerodrome, mainly with respect to structure height

- Scottish Planning Circular 2 -2003:
  - Glasgow airport is an officially safeguarded aerodrome

- Technical Guidance for Evaluating Selected Solar Technologies on Airports, US Federal Aviation Authority, November 2010
  - Guidance on building solar PV on or near airports, as of October 2013 it is under review.
  - Flash blindness for a period of 4-12 seconds (i.e., time to recovery of vision) occurs when 7-11 W/m2 reaches the eye
  - Oakland airport fixed a 400m exclusion zone round the runway for PV, and 500m from radar installations 'just in case'
  - FAA states they have no specific guidance to offer, but suggest that the potential glare risk from solar panels should be assessed in the context of other glare risks in the vicinity (e.g. from tall buildings, cars etc) and mitigating mesures taken in line with these.

- Spaven Consulting: Solar Photovoltaic energy facilities: Assessment of potential impact on aviation. Report no 10/344/RPS/1. January 2011
  - Glare can cause flash blindness, a temporary loss of vision if strong enough
  - Typical panels are designed to reflect only 2% of the incoming sunlight
  - There are solar pv installations on several airports in US and no record of any incidents of concerns with dazzle

- Ho C, Ghanbari, C, Diver R: Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. Sandia National Laboratories. SolarPACES 2009, Berlin Germany.
  - Flash blindness for a period of 4-12 seconds (i.e., time to recovery of vision) occurs when 7-11 W/m2 reaches the eye.
  - Distance decreases the intensity of the light; looking at highly reflective (~900 W/m2) solar collector technology, the authors concluded that 60 feet from plant perimeter was the minimum safe distance for a person for retinal damage; twice that for flash blindness. So 100 metres from boundary would be a safe distance from solar concentrators
  - Measurements 240m above a 10 MW solar collector did not exceed the safe limit and were not bright enough to cause momentary hazard

- Other:
  - In Glasgow, the optimal angle for solar PV is 60° from vertical and the sun is never high enough to hit perpendicularly - so reflections will tend to be high except when sun is very low to the east or west. Impact on aircraft is therefore greater than impact on road traffic
  - Max. irradiance at Glasgow for optimally positioned pv panel: 1002 W/m2. At 2% reflection, this is 20 W/m2 at the panel; using 100m as a safe distance should be conservative.

II.4 Biodiversity (P-BI)

This layer is generated only at Step 3, the site survey outlined in Appendix IV. GCC's Natural Environment Officer (Biodiversity/Ecology) will give advice on what protected or endangered species habitats may exist.

Data is entered in the Biodiversity (O) layer against the relevant VDL polygon, then mapped onto the grid for generating the factor layer.

Criterion	GIS sublayer name	Data
Possible		
No endangered or protected species	Biodiversity (P)	WWF Category & species
Intermediate		
Requires an environmental survey for protected species	Biodiversity (P)	WWF Category & species
Sensitive		
Requires an environmental survey for a European protected species	Biodiversity (P)	WWF Category & species

II.5 Visual Impact (P-VM)

This layer is generated only at Step 3, the site survey outlined in Appendix IV. Carried out in the site survey process outline in Appendix IV - review of elevation maps and Google Earth

Qualitative judgement to be made based on how close any residential properties are and what the overall view from them looks like, i.e. a large solar array will be more intrusive against a park background than against a street landscape

Elevation effects also need to be taken into account such as views from tall buildings or rising ground.

Data is entered in the *Visual impact (O)* layer against the relevant VDL polygon, then mapped onto the grid for generating the factor layer.

Criterion	GIS sublayer name	Data
Possible		
No residential areas overlook site	Visual impact (P)	Description & VM Type 1
Residential areas overlook an already industrialised landscape	Visual impact (P)	Description & VM Type 1
Intermediate		
Residential areas overlook green site	Visual impact (P)	Description & VM Type 2
Sensitive		
Not applicable	Visual impact (P)	Description & VM Type 3

APPENDIX III: Evaluation criteria for Technical factors

III.1 Grid connection distance (T-GD)

Connections can be to primary or secondary substation or to a point in an 11kV circuit. Low voltage connection is available only for <11.98kW, which is still domestic level

SPD DG Heat map spreadsheet shows 60 primary substations in the Glasgow area, although this is not exactly same as GCC area

- Area covered is in the region of 750 km^2, therefore density is 1 primary substation per 12.5 km^2; this approximately represents a circle of radius 2 km.
- So on average the maximum distance from any primary substation is 2 km
- Each substation has around a dozen 11kV circuits ranging from it. The density of the circuits is higher near the substation, so the chances of there being a suitable secondary or an accessible piece of circuit are higher closer in (see circuit map around the Meat Market site, provided by SPEN via Ciaran Higgins in email of 20 March 2014)
- Therefore 750 m and 1500 m are proposed as the distances within which the designation is 'Favourable' or 'Likely'

From *GlasgowPrimarySubstations* shapefile showing primary substation locations, provided by Scottish Power (SPEN), via GCC[21] . Note that the primary substations are published by SPEN in *SPD DG Heat map spreadsheet*[22]

New GIS layer is generated covering the whole of Glasgow. The straight line distance of the centre of each grid square to the nearest substation is calculated, and evaluation is based on that

Criterion	GIS sublayer name	Data
Favourable		
Within 750m of a primary substation	Distance from grid to primary substation (P)	Nearest substation name and distance
Likely		
750-1500m from a primary substation	Distance from grid to primary substation (P)	Nearest substation name and distance
Unlikely		
Over 1500m from a primary substation	Distance from grid to primary substation (P)	Nearest substation name and distance

[21] Ciaran Higgins email of 28 April 2014, *GlasgowPrimarySubstations.zip*

[22] http://www.spenergynetworks.co.uk/pages/connection_opportunities.asp

III.2 Grid congestion (T-GC)

This is distinct from the Grid connection distance factor because the congestion on individual circuits may change over time as loads change and substations are upgraded

SPEN look at two independent sets of congestion criteria around each substation:

- at the Circuit level, the ability of each 11 kV circuit to take distributed generation
- at the Primary Area (PA) level, the impact of distributed generation on other circuits

(see also discussion of these issues around the Meat Market site, provided by SPEN via Ciaran Higgins in email of 20 March 2014)

The SPEN heat maps give an assessment for each circuit at each substation over a 3-point scale for each of the following issues: Generation capacity; Voltage rise; Reverse power flow, 11kV fault level; 33kV fault level; Transmission constraint. Gen Capacity Voltage rise; Reverse power flow; 11kV fault level; 33kV fault level; Overall fault level; Transmission constraint. On examination however there appeared to be no variation between circuits at any Glasgow substation, so these were applied to the substation as a whole. The scores for each are added. Total scores theoretically could range from 6 to 18, but in practice for Glasgow and surrounding areas they all fall between 7 and 12, so the scoring basis is as below.

Data is entered in the layer *Grid congestion points (O)*, and the nearest substation is mapped to each grid square.

Criterion	GIS sublayer name	Data
Favourable		
Circuits and Primary Areas score less than 10	Grid congestion points (P)	Nearest substation name, distance and combined congestion score
Likely		
Circuits and Primary Areas score = 10	Grid congestion points (P)	Nearest substation name, distance and combined congestion score
Unlikely		
Circuits and Primary score greater than 10	Grid congestion points (P)	Nearest substation name, distance and combined congestion score

III.3 Overshadowing (T-OS)

- An unobstructed South facing panel in Glasgow that is optimally angled (60^o from vertical) receives 960 kWh/m^2 insolation in a typical year.
- 75% of this total annual insolation arrives between 21 March and 21 September

- On 21 December at noon, the sun is 10.5° above the horizon to the South. If an area is not overshadowed at that point, it is likely to receive most of the energy available
- On 21 March and 21 September, at noon, the sun's elevation is 34°. Areas that are not overshadowed at that point will still be able to access 75% or more of the available energy
- A 20 storey block of flats will cast a 340m shadow when the sun is at 10.5°

A daily footprint was calculated from the Ordnance Survey Digital Elevation Model for four key dates: 21 March, 21 June. 21 September and 21 December. Superimposing these gave a composite annual footprint. On examination, the difference between the annual footprint and that for spring, summer and autumn only was generally small, generally less than 10m in width. For this reason, it was decided not to attempt to include an intermediate score.

Criterion	GIS sublayer name	Data
Favourable		
Outside the composite shadow footprint	Merged annual shade (P)	Shading calculation sublayer name/date
Unlikely		
Within the composite shadow footprint	Merged annual shade (P)	Shading calculation sublayer name/date

III.4 Terrain (T-TR)

This layer is generated only at Step 3, the site survey outlined in Appendix IV. Carried out in the site survey process outline in Appendix IV, comprising a review of elevation maps, Google Earth and SEPA Flood Map.

Qualitative judgement to be made on shape, slope and access to site based on the possible issues visible from reviewing the various data sources.

Data is entered in the *Terrain (O)* layer against the relevant VDL polygon, then mapped onto the grid for generating the factor layer.

Criterion	GIS sublayer name	Data
Favourable		
a) Flat ground, no issues, no flooding issues	Terrain (P)	Description and terrain type 1
Likely		
b) Sloping or broken ground	Terrain (P)	Description and terrain type 2
c) Site with restricted access		Description and terrain type 3
d) Unsafe derelict buildings		Description and terrain type 4
Unlikely		
e) Site with no direct access	Terrain (P)	Description and terrain type 5
f) Site under water or high risk of flooding		Description and terrain type 6

APPENDIX IV: Procedure for manual site survey

Factors that need to be evaluated manually for each site are:

Policy: Biodiversity
Policy: Visual Impact
Technical: Terrain

1. Select sites of interest from RenMap, and find these sites on the map view Google Maps https://www.google.co.uk/maps/
2. Switch to Earth view, and look at the general topography of the sites and the surrounding area. Make notes about locations of surrounding buildings, trees, water.
3. Look at the area on a large-scale contour map, (eg OS Explorer sheet 342 Glasgow, 1:25,000) and note where the slopes are
4. Switch into Street View and walk around the sites, taking screen shots of selected views from as many angles as possible. Make notes about the appearance of the sites. Turn to look at the view away from the sites as well, to see what buildings overlook it and how far away they are.
5. Things to look for under Visual impact:
    a. how close residential properties are;
    b. how much screening is offered by trees or high hedges;
    c. what is the background view behind the site, i.e. a large solar array will be more intrusive against a park background than against a streetscape;
    d. elevation effects eg views from tall buildings or rising ground.
6. Record notes against each site in the survey sheet under 'Visual Impact notes', and give it a rating 1-3 according to Appendix III.5
7. Things to look for under Terrain:
    a. where is the access,
    b. are there derelict buildings,
    c. is there visible surface water,
    d. steep embankments which may not show up on the contour map
8. Look at SEPA's Flood Extent Map and note the likelihood of flooding http://map.sepa.org.uk/floodmap/map.htm
9. Record notes against each site in the survey sheet under 'Terrain notes', and give each a rating a-f according to Appendix IV.4
10. For Biodiversity, send an email request stating location, site name and ID, to the GCC Biodiversity Officer:

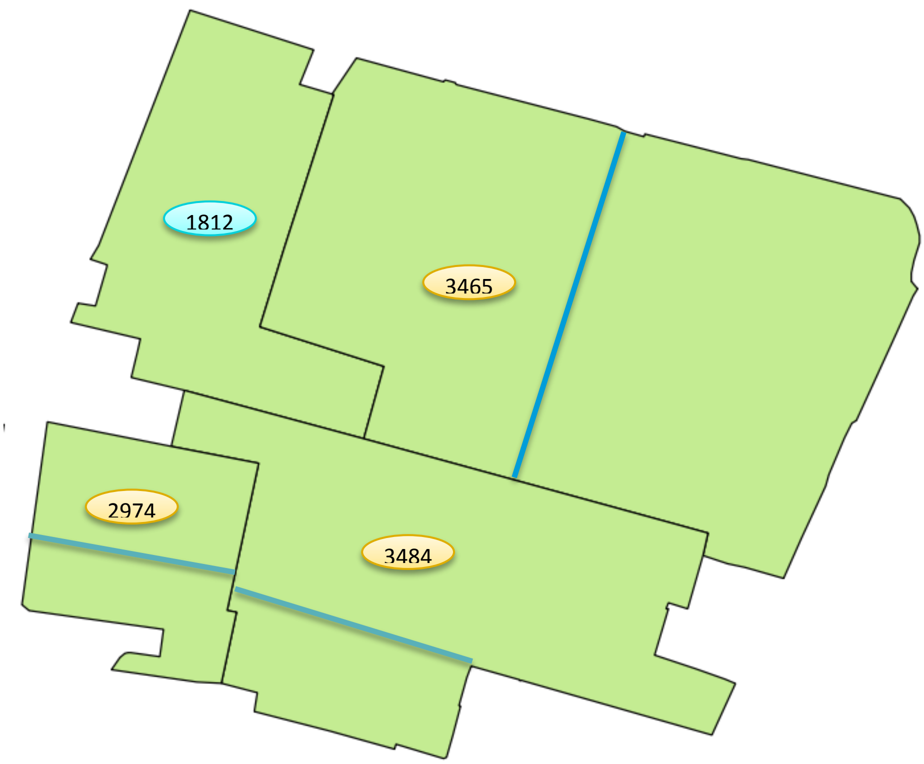
    Carol MacLean
    Natural Environment Officer (Biodiversity/Ecology)
    Land and Environmental Services
    Glasgow City Council
    231 George Street
    Glasgow G1 1RX
    E-mail: carol.maclean@glasgow.gov.uk

11. Find the status of any species that may be involved in SNH's list 'Protected species known to occur naturally in Scotland and their protection' http://www.snh.gov.uk/docs/B551085.pdf
12. Record notes against each site in the survey sheet under 'Biodiversity notes', and give each a rating 1-3 according to Appendix III.4

EXAMPLE SURVEY NOTES

VACANT & DERELICT SITES ROUND THE OLD MEAT MARKET

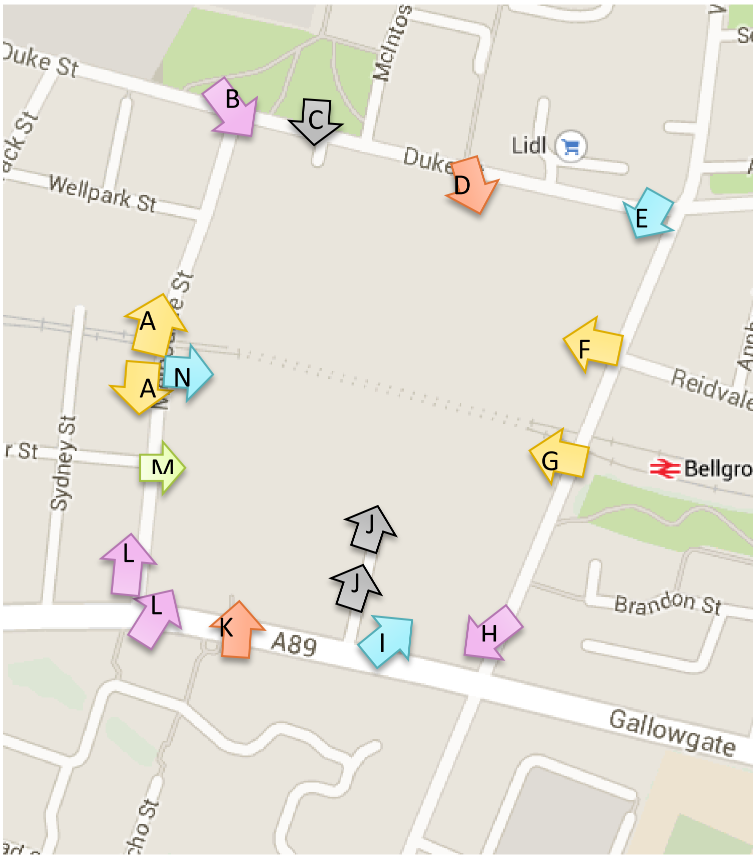
SITES ON VDL REGISTER



ID	Visual Impact notes	Biodiversity notes	Terrain notes	P-VM rating	P-BI rating	T-TR rating
1812	Some visibility from medium rise on other side of wide main road but screened off by trees	Protected, deep hedges, possible badgers	Flat, easy access Small patches where surface water may lie	1	2	a
3465 E	Overlooked from medium rise on Bellgrove St	Protected, deep hedges, possible badgers	Flat, easy access Small patches where surface water may lie	2	2	a
3465W	Distantly overlooked from medium rise on other side of Duke St, a wide main road	Protected, deep hedges, possible badgers	Flat, easy access Patches where surface water may lie	1	2	a
3484 N	Overlooked from medium rise on Duke St and from Graham Square but rest of view is of old run down buildings	Derelict building, possible bats	Derelict building on site, no access problems No water issues	1	3	d

ID	Visual Impact notes	Biodiversity notes	Terrain notes	P-VM rating	P-BI rating	T-TR rating
3484 S	Overlooked from Armour St flats	Open grass, no hedges, bordering road	Flat, easy access No water issues	2	3	a
2974 N	Overlooked from Armour St flats but quite far away	Open grass, no hedges, bordering road	Flat, easy access Low risk of surface water	1	2	a
2974 S	Overlooked from Armour St flats	Open grass, no hedges, bordering road on 3 sides	Flat, easy access Low risk of surface water	2	2	a

STREET MAP


Duke St
Wellpark St
McIntos
Lidl
Duke
Reidvale
Bellgro
Sydney St
A89
Gallowgate
Brandon St
A
B
C
D
E
F
G
H
I
J
K
L
M
N


Duke St
Wellpark St
McIntosh
Melbourne St
Sydney St
Reidvale S
Annbank St
Brandon St
A89

A1. Middle of Melbourne St looking S site 2974

A2. Mid Melbourne St looking N (railway cutting is behind wall) site 1812

B. Corner of Melbourne ST & Duke St, looking SE site 1812

C. Just past corner of Duke St & Melbourne St. looking S site 1812

D. From Duke St looking SSE site 3465

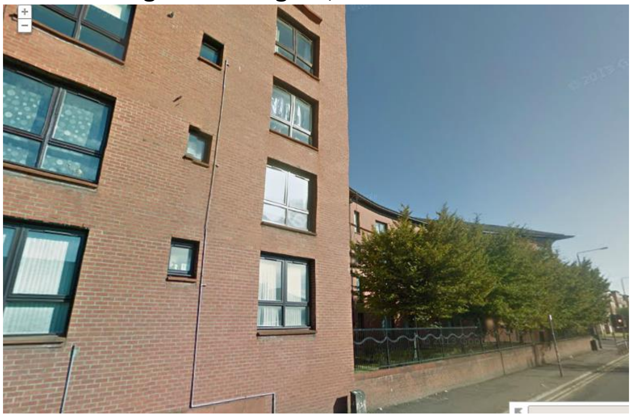
E. Corner Duke St/ Bellgrove St looking SSW site 3465

F. Mid Bellgrove St looking W site 3465, 3484

G.Travelling S on Bellgrove St looking W site 3484

H. Looking SSW towards corner of Bellgrove St & Gallowgate

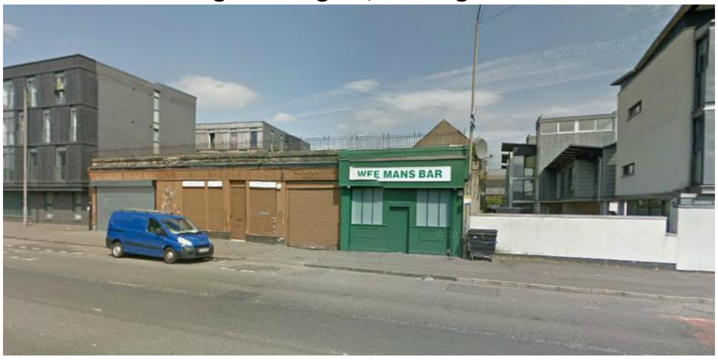
I. Gallowgate looking NE, near Graham St



J1. Looking N on Graham Square

J2. Top of Graham Square site 3484

K. Further W along Gallowgate, looking N



L1. Corner of Gallowgate & Melbourne St, looking NNE

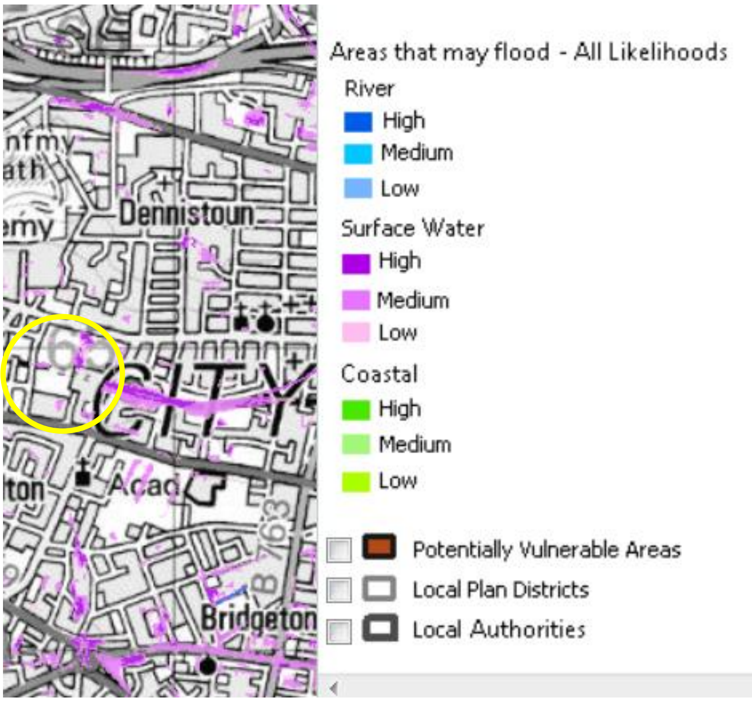
L2. Looking NE on entering Melbourne St

M. Looking W into Armour St site 2974, 3484

N. Mid Melbourne St looking W site 2974, 3484

Flooding

From SEPA Flood Map, http://map.sepa.org.uk/floodmap/map.htm



Biodiversity:

Extract from GCC Biodiversity officer email

From: MacLean, Carol (LES)
Sent: 28 July 2014 16:48
To: Dick, Gillian (DRS)
Subject: RE: biodiversity query

The issues with the solar panels that have to be considered generally in terms of biodiversity impact are:

1. the amount of ground disturbance for installation fixings eg poles, platforms etc
2. the size of the panels – this will cause more or less shading onto habitats
3. the density of panels per location – which will determine the size of area of shading, plus access to grassland for birds and other animals to forage, nest etc.

The Meat Market (Duke Street) – as there are still old buildings on site, I would recommend a Bat survey be carried out – ideally a Protected Species survey should be done which would cover Badger as well.

APPENDIX V: RenMap tool in QGIS

QGIS is a free, open source Geographic Information System which can be run on a variety of operating systems. It allows users to create, edit, visualise, analyse and publish geospatial information[23].

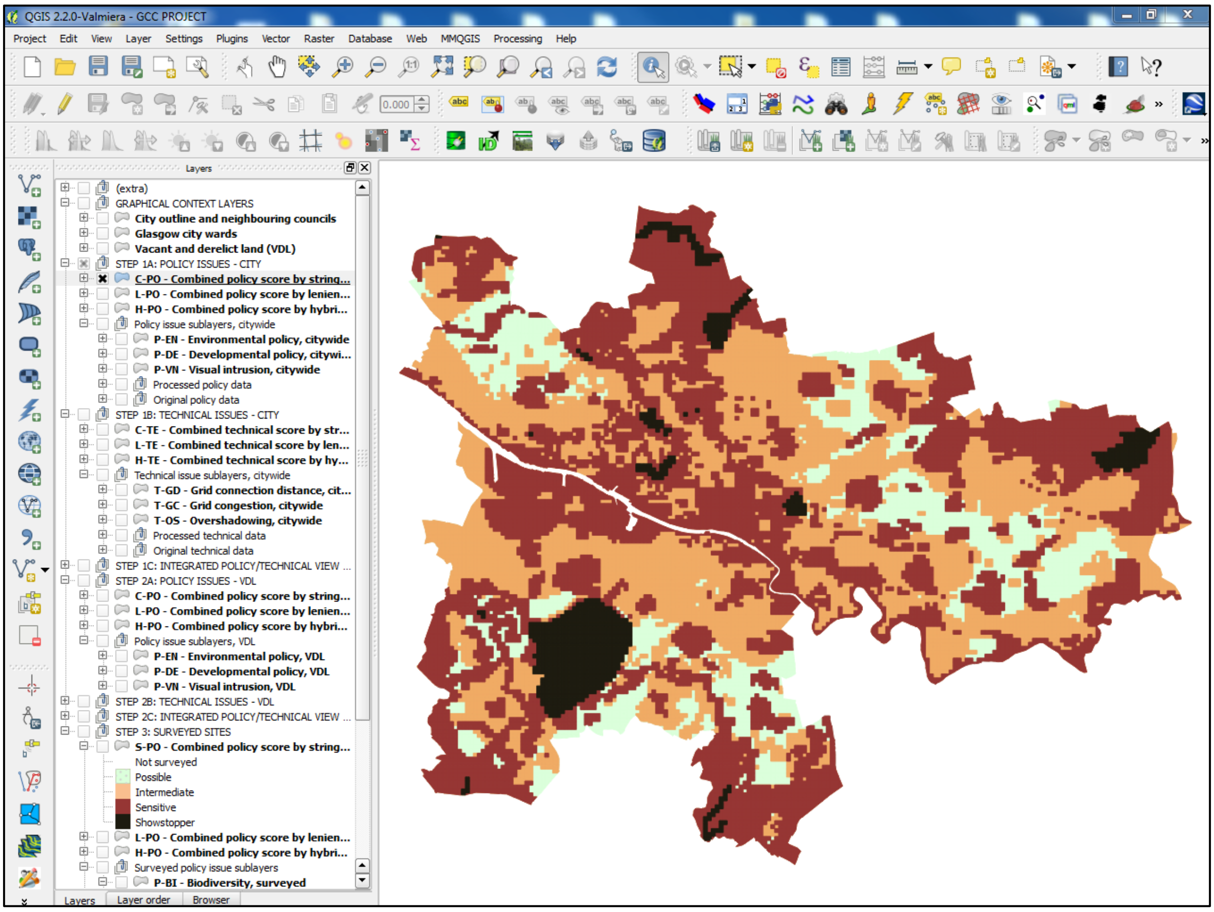


Figure V.1: Screenshot of one layer on RenMap

[23] QGIS website. http://www.qgis.org/en/site/ accessed 15 September 2014