Runnymede Borough Council

Runnymede Climate Change Study

Renewable Assessment Key Assumptions Note

Final report
Prepared by LUC
December 2023

Runnymede Borough Council

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Renewable Assessment Key Assumptions Note

Project Number
12212

Version	Status	Prepared	Checked	Approved	Date
1.	Draft Key Assumptions Note	N. Collins O. Dunham	S. Young	S. Young	10.11.2022
2.	Second Draft Key Assumptions Note	N. Collins O. Dunham	S. Young	S. Young	13.01.2023
3.	Draft Report Key Assumptions Note	N. Collins	O. Dunham	S. Young	12.05.2023
4.	Final Report Key Assumptions Note	N. Collins	O. Dunham	S. Young	04.12.2023

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Contents

Chapter 1
Introduction

1.1 This note sets out the key assumptions that were used within the assessments of technical potential for the different types of renewable energy technology including:

- Wind;
- Ground-mounted solar;
- Rooftop solar;
- Hydropower;
- Heat pumps;
- Geothermal;
- Biomass;
- Energy from waste;
- Landfill gas; and
- District heating.

1.2 This note also outlines how electricity grid capacity was considered.

Appendix A

Key Assumptions to be Applied in the Assessment of Renewable and Low Carbon Energy Resource

Existing Property Statistics for Runnymede

A.1 The existing stock of domestic dwellings and non-domestic properties within Runnymede was derived from LLPG Address data.

A.2 The overall proportion of 'off-gas' properties (those not connected to the gas network) was derived from the 2021 BEIS LSOA estimates[1].

Table A - 1: Properties in Runnymede (Source: Runnymede LLPG Address data)

Property type	Number of properties in Runnymede
Detached dwelling	10,847
Semi-detached dwelling	14,118
Terraced dwelling	5,633
Flat	11,277
Other dwelling[2]	2,902
Total dwellings	**44,777**

[1] BEIS (2023) LSOA estimates of properties not connected to the gas network 2015 to 2021. Available at: https://www.gov.uk/government/statistics/lsoa-estimates-of-households-not-connected-to-the-gas-network

[2] Excluding ancillary buildings, car parking, garages, house boats, caravans and chalets.

Property type	Number of properties in Runnymede
Properties other than dwellings[3]	4,543
Total properties	**49,320**

Emission Factors

A.3 To determine the potential CO_2 savings from the identified potential renewable resources, the identified potential electricity/heating output was multiplied by the emissions factors of the fuels the renewable energy generation would replace:

- Grid electricity: 0.136 kgCO2e/kWh[4]
- Mains gas: 0.210 kgCO2e/kWh[5]
- Heating oil: 0.298 kgCO2e/kWh[6]
- Woodfuel: 0.011 kgCO2e/kWh[7]

A.4 The actual proportions of electricity and oil usage by off-gas properties for heating is unknown. As such, an illustrative 50% of these properties are estimated to be fuelled by electricity and 50% by oil for the purposes of this study.

UK Capacity Factors

A.5 Regional capacity factors, where available, were used when calculating technical potential within Runnymede[8]. Where unavailable, national BEIS and RHI data on annual load factors were used when calculating technical potential.

Table A - 2: UK Capacity Factors

Technology	UK-level Capacity Factor
Anaerobic Digestion[9]	67.9%
Hydro[10]	38.2%
Micro CHP[11]	12.9%
Solar PV[12]	9.7%
Wind[13]	25.3%

[3] Commercial properties excluding land, ancillary buildings, military buildings, objects of interest, parent shells, waste sites, minerals sites, ancillary buildings, parking, and other inappropriate locations including fisheries, telephone boxes, lighthouses, beach huts; ATMs, cemeteries; and utilities.
[4] BRE (2022) Standard Assessment Procedure (SAP 10.2): The Government's Standard Assessment Procedure for Energy Rating of Dwellings. Available at: https://bregroup.com/sap/sap10
[5] BRE (2022) Standard Assessment Procedure (SAP 10.2): The Government's Standard Assessment Procedure for Energy Rating of Dwellings. Available at: https://bregroup.com/sap/sap10
[6] BRE (2022) Standard Assessment Procedure (SAP 10.2): The Government's Standard Assessment Procedure for Energy Rating of Dwellings. Available at: https://bregroup.com/sap/sap10
[7] BEIS (2022) Greenhouse gas reporting: conversion factors 2022. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022. Wood logs/chips/pellets.
[8] Regional capacity factors have been used for Wind, Ground mounted solar and Roftop solar.
[9] BEIS (2022) Quarterly and annual load factors. Available at: https://www.gov.uk/government/publications/quarterly-and-annual-load-factors. The average of all the available load factors was used.
[10] BEIS (2022) Quarterly and annual load factors. Available at: https://www.gov.uk/government/publications/quarterly-and-annual-load-factors. The average of all the available load factors was used.
[11] BEIS (2022) Quarterly and annual load factors. Available at: https://www.gov.uk/government/publications/quarterly-and-annual-load-factors. The average of all the available load factors was used.
[12] BEIS (2022) Quarterly and annual load factors. Available at: https://www.gov.uk/government/publications/quarterly-and-annual-load-factors. The average of all the available load factors for the South East was used.
[13] BEIS (2022) Quarterly and annual load factors. Available at: https://www.gov.uk/government/publications/quarterly-and-annual-load-factors. The average of all the available load factors for the South East was used.

Technology	UK-level Capacity Factor
Solar Water Heating[14]	4.5%
Air Source Heat Pumps[15]	18.4%
Ground Source Heat Pumps[16]	18.2%
Biomass (plant-based)[17]	67.5%
Sewage Sludge Digestion[18]	47.3%

[14] BEIS (2023) Non-domestic RHI mechanism for budget management: estimated commitments – RHI budget caps. Available at: https://www.gov.uk/government/publications/rhi-mechanism-for-budget-management-estimated-commitments

[15] BEIS (2023) Non-domestic RHI mechanism for budget management: estimated commitments – RHI budget caps. Available at: https://www.gov.uk/government/publications/rhi-mechanism-for-budget-management-estimated-commitments

[16] BEIS (2023) Non-domestic RHI mechanism for budget management: estimated commitments – RHI budget caps. Available at: https://www.gov.uk/government/publications/rhi-mechanism-for-budget-management-estimated-commitments

[17] BEIS (2022) Load factors for renewable electricity generation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1094495/DUKES_6.3.xlsx

[18] Statista (2023) Load factor of electricity from sewage sludge digestion in the United Kingdom (UK) from 2010 to 2021. Available at: https://www.statista.com/statistics/555718/sewage-sludge-digestion-electricity-load-factor-uk/

Wind Resource Assessment Parameters

A.6 The potential wind development resource within Runnymede was assessed using a Geographical Information Systems (GIS) approach. This involved mapping a variety of technical and environmental parameters to identify parts of the borough which are constrained with respect to wind development at various scales. The remaining land was then identified as having 'technical potential' (subject to further site-specific assessment at application stage). The parameters of the GIS tool are set out in **Table A - 2**.

A.7 The maximum theoretical wind generation capacity of the areas of technical potential was estimated using:

- Standardised turbine densities and assumed turbine maximum generation capacities (the latter expressed in Megawatts (MW));
- One or more assumed capacity factors based on historic data broken down at least to regional level (using data from the Department for Business, Energy and Industrial Strategy (BEIS) relating to Feed in Tariff (FiT) installations)[19]; and
- The assumption that, where land has technical potential for multiple turbine scales, the largest scale will be developed in preference to smaller scales.

[19] An energy generator's 'capacity factor' can be defined as the actual energy yield produced over a period of time expressed as a proportion of the energy yield that would have been produced if the generator had operated at its full generation capacity continuously over the same period.

Table A - 3: Proposed assumptions to be used for assessment of technical potential for onshore wind – Constraints

Parameter	Assumption	Data Source	Justification and Notes
Wind Turbine Size	Five turbine sizes were considered: ■ Very large (150-200m tip height) ■ Large (100-150m tip height) ■ Medium (60-100m tip height) ■ Small (25-60m tip height) ■ Very small (<25m tip height) Assessment was based on notional turbine sizes, approximately intermediate within each class size i.e.: ■ Very large: 175m tip height, 4MW capacity ■ Large: 125m tip height, 2.5MW capacity ■ Medium: 80m tip height, 0.5MW capacity ■ Small: 45m tip height, 0.05MW capacity No mapped-based assessment of 'very small' turbines was undertaken. The type of buffers applied to constraints for the assessment of other turbine size categories in many cases do not reasonably apply to very small turbines. Equally, mapping a strategic district-wide 'resource' for very small turbines (which are generally developed singly in association with	■ LUC ■ Research into turbine manufacturers ■ BEIS renewable energy planning database and other databases containing information on wind turbine applications.	There are no standard categories for wind turbine sizes. The categories chosen are based on consideration of currently and historically 'typical' turbine models at various different scales. The approach is intended to be flexible in the light of uncertainty regarding future financial support for renewable energy. A review of wind turbine applications across the UK showed tip heights ranging from less than 20m up to around 200m, with larger turbine models in demand from developers following the reduction in financial support from Government[20]. Due to the structure of the financial support system in the past, smaller turbines (those in the medium to small categories) have tended to be deployed as 1-2 turbine developments.

[20] LUC review in July 2022.

Parameter	Assumption	Data Source	Justification and Notes
	particular farm or other buildings) is not particularly meaningful. Instead, it is recommended that policy references the entire plan area as suitable for very small wind in principle (subject to site-specific assessment).		
Wind Speed	Exclude: ■ All areas with mean annual average wind speed <5m/s at 50m above ground level (agl).	■ Global Wind Atlas/Vortex ■ Industry practice	Wind speed requirements change with turbine scale and model. Some turbine manufacturers produce models which may operate at lower wind speeds and the configuration of certain turbine models can be altered to improve yield in lower wind speed environments. Future changes in government policy and turbine technology could allow developments to be deliverable at lower wind speeds than are currently viable. A 5m/s threshold was applied to take account of such changes.
Roads	Exclude: ■ Roads (excl. restricted access tracks) with a buffer of the height of the turbine (to blade tip height) +10%.	■ Ordnance Survey OpenRoads	These buffers were applied as a safety consideration. The proposed buffer distance is based on standard safety distances used by wind turbine developers and the DECC Renewable and Low-carbon Energy Capacity Methodology[21]. Restricted access tracks were excluded from consideration as these predominantly comprise of forestry and other tracks which could be more easily diverted than standards roads.
Railways	Exclude: ■ Railways with a buffer of the height of the turbine (to blade tip height) +10%.	■ Ordnance Survey VectorMap District	This buffer was applied as a safety consideration, based on the same principles as used for roads.
Electricity Lines	Exclude: ■ Major transmission lines (132kV minimum) with a buffer of the height of the turbine (to blade tip height) +10%.	■ Ordnance Survey OpenMap ■ National Grid ■ SSE/UKPN	This buffer was applied as a safety consideration. It is derived from guidance by the Energy Networks Association (Engineering Recommendation L44) and National Grid (Technical Advice Note 287). It is noted that this guidance also states that a buffer of 3x the rotor diameter should be applied to account for turbine wake downwind of a turbine impacting the weathering of electricity lines. However, this also states that this impact is variable

[21] DECC (2010) Renewable and Low-carbon Energy Capacity Methodology. Available at: https://www.gov.uk/government/news/decc-publishes-methodology-for-renewable-and-low-carbon-capacity-assessment

Parameter	Assumption	Data Source	Justification and Notes
			depending on factors including turbine positioning. This would require site-level study and consultation with the relevant DNO. As such, this buffer distance was not applied as a constraint.
Airports and Airfields	Exclude: ■ Operational airports and airfields.	■ Ordnance Survey OpenMap Local Functional Site layer with the theme 'Air Transport'	OS VectorMap Local Functional Site data with the theme Air Transport was used in the assessment. It is noted that land within consultation zones surrounding airports and airfields may also be unsuitable for wind turbine development, and further consultation between potential developers and airport and airfields is required to determine if there is any impact from a proposed development.
Noise	Exclude: ■ Residential and commercial buffer zones based on turbine size: – Very large scale: 500m for residential/other sensitive receptors[22], 250m for non-residential. – Large scale: 480m for residential/other sensitive receptors, 230m for non-residential. – Medium scale: 400m for residential/other sensitive receptors, 180m for non-residential. – Small scale: 180m for residential/other sensitive receptors, 80m for non-residential. For properties outside (but close to) the Authority Boundary, indicative buffers were applied to the available property/buildings	■ OS Addressbase ■ OS OpenMap	Wind turbines generate sound during their operation, and their noise impacts upon nearby properties must be limited to appropriate levels, defined in particular by the 'ETSU' Guidance – The Assessment and Rating of Noise from Wind Farms (1995) (as supplemented by the Institute of Acoustics). The relationship between turbine size and the separation distance from properties at which acceptable noise levels will be achieved is in practice quite complex and variable. However, the present assessment has applied specialist acoustic advice to define minimum distances below which it is generally unlikely that the required noise levels under ETSU-R-97 will be achievable. The approach taken necessarily involves applying various assumptions, including: ■ An assumed single turbine development in all cases (rather than multiple turbines); and ■ The assumption that no properties will be 'financially involved' in the wind development (financial involvement may allow higher noise levels to be accepted in individual cases). The limitations associated with such assumptions are considered preferable to avoiding the use of noise-related separation distances for the assessment, bearing in mind that noise is a key factor that influences the acceptable siting of turbines in practice. The assessment defines the minimum distances below which adherence to the Industry standard (ETSU-R-97) noise guidance would not be possible and it

[22] Sensitive receptors include schools, hospitals and care homes. These were identified via the LLPG data.

Parameter	Assumption	Data Source	Justification and Notes
	data from OS VectorMap. As this data does not distinguish commercial and residential properties, and it was not possible to verify uses by other means, non-residential buffers were used throughout.		should not be inferred that the proposed distances represent acceptance of any given proposal within the areas of identified suitable potential as site based noise monitoring and assessments would still be required. Note: Within the Authority, where address points did not overlay OS OpenMap buildings data, points were buffered 5m to estimate building footprint. Where OS OpenMap buildings did not overlay address point data, these buildings were assumed to be of non-sensitive use. Moreover, due to lack of sufficient data, buildings outside of the authority were assumed to be of non-sensitive use. This was to ensure that land was not unnecessarily ruled as being constrained to wind development, as a result of non-sensitive buildings being mistakenly assessed as being sensitive. It is noted further site specific study would be required to determine the necessary buffer distance between specific buildings and proposed turbines.
Buildings	Exclude: ■ Buildings with a buffer of the height of the turbine (to blade tip height) +10%.	■ OS Addressbase ■ OS OpenMap	National Planning Practice Guidance notes that the topple distance + 10% is a safe separation distance between turbines and buildings. The same building and addressbase datasets used in the consideration of noise was used to determine the location of buildings for this parameter.
Future Developments, Safeguarded Land and Employment Sites	Exclude: ■ Housing and employment allocations from Runnymede Borough Council Plan	■ Runnymede Borough Council	Generally unsuitable for wind turbine development, unless allocations contain relatively large undeveloped portions. Identification of suitable land for wind within specific allocation boundaries would require a separate site-specific study. In addition, it is assumed that opportunities for renewables within such sites will already be considered as part of their design. In agreement with the Council, Strategic Employment Areas were not treated as constraints. The Council confirmed that these sites are not “allocated” for future development and instead are areas of protected existing employment developments.
Existing Renewable Energy Developments	Exclude: ■ Land boundaries of consented and operational renewable energy installations.	■ BEIS ■ Aerial imagery ■ LUC windfarm database	The quarterly BEIS Renewable Energy Planning Database and the LUC internal windfarm database was used to determine the locations of operational and consented renewable energy installations. These datasets did not indicate that there were any consented or operational wind turbine or ground mounted solar development present within Runnymede. As such, no land was excluded on this basis.

Parameter	Assumption	Data Source	Justification and Notes
			Existing roof-mounded solar PV developments were not excluded, as these are building-integrated and therefore excluded via the consideration of existing build development as a constraint. Additionally, existing landfill gas developments were not considered a constraint to wind developments, as there is potential that turbines could be incorporated onto such existing sites. A single operational anaerobic digestion installation was identified within the authority and this was treated as a constraint to wind developments.
Terrain	Exclude: ■ Slopes greater than 15%.	■ OS Terrain 50	This is a development/operational constraint. Developers have indicated that this is the maximum slope they would generally consider feasible for development. Although it is theoretically possible to develop on areas exceeding 15% slopes, turbine manufacturers are considered unlikely to allow turbine component delivery to sites where this is exceeded.
Water Environment	Exclude: ■ Watercourses and waterbodies with a 50m buffer.	■ Ordnance Survey VectorMap Local	A 50m buffer was applied around all rivers and waterbodies to take account of good practice such as that relating to pollution control during construction. OS Survey OpenMap Local surface water area data includes waterways of approximately a minimum of 2m width. OpenMap Local surface water line data is line data, and so a 1m buffer was applied to approximate a footprint of smaller waterways.
Woodland	Exclude: ■ Ancient Woodland Inventory with a 50m buffer; and ■ Woodland as shown on the National Forest Inventory with a 50m buffer including: – Assumed woodland; – Broadleaved;	■ Forestry Commission ■ Natural England	All areas of woodland were excluded with a +50m buffer to reduce risk of impact on bats. A 50m clearance distance of turbines from trees and other habitat features is standard practice and endorsed by Natural England guidance set out in 'TIN051'. A 50m horizontal buffer is a reasonable proxy clearance for the purposes of a strategic study bearing in mind unknowns concerning tree height and turbine dimensions. A 50m buffer cannot be applied to all linear habitat features and individual trees due to a lack of data for a study of this scale.

Parameter	Assumption	Data Source	Justification and Notes
	– Conifer; – Coppice; – Coppice with standards; – Low density; – Mixed mainly broadleaved; – Mixed mainly conifer; and – Young trees.		The following National Forestry Inventory categories of woodland were considered non-permanent or non-woodland and therefore not excluded as wind turbine development may be suitable in these locations: ■ Cloud/shadow; ■ Failed; ■ Felled; ■ Group prep; ■ Shrub; ■ Uncertain; and ■ Windblown.
Biodiversity (International Designations)	Exclude international designations[23]: ■ Special Protection Areas (SPA); ■ Special Areas of Conservation (SAC); and ■ Ramsar sites.	■ Natural England	As protected by: ■ Conservation of Habitats and Species Regulations 2017 (as amended)
Biodiversity (National Designations)	Exclude national designations[24]: ■ Sites of Special Scientific Interest.	■ Natural England	As protected by: ■ Wildlife and Countryside Act 1981 ■ Conservation of Habitats and Species Regulations 2017 (as amended)
Biodiversity (Regional and Local Designations)	Exclude other designations[25]: ■ Local Nature Reserves; and	■ Natural England ■ Runnymede Borough Council	Generally, would not be suitable for renewables development based on law/policy/guidance including: ■ NPPF

[23] There are no Potential SAC, Potential SPA or Proposed Ramsar sites present within Runnymede.
[24] There are no National Nature Reserves within Runnymede.
[25] There are no RSPB Reserves within Runnymede.

Parameter	Assumption	Data Source	Justification and Notes
	■ Sites of Nature Conservation Importance.		■ Natural Environment and Rural Communities Act 2006 ■ 2030 Local Plan
Cultural Heritage	Exclude[26]: ■ Registered Parks and Gardens; ■ Scheduled Monuments; ■ Listed Buildings; ■ Locally Listed Buildings; ■ Conservation Areas; and ■ Locally Listed Heritage Assets.	■ Historic England ■ Runnymede Borough Council	As protected by: ■ NPPF ■ The Convention Concerning the Protection of the World Cultural and Natural Heritage ■ National Heritage Act 1983 ■ Ancient Monuments and Archaeological Areas Act of 1979 ■ Planning (Listed Buildings and Conservation Areas) Act 1990 ■ 2030 Local Plan and Neighbourhood Plans The council's polygon version of the Nationally Listed Buildings dataset was used to represent Listed Buildings more accurately than the Historic England point dataset. Although wind development may not be strictly prohibited by policy within designated World Heritage Site Buffer Zones, is should be noted that it would likely be highly problematic to seek planning permission within these. It is noted that further site specific study would be required to determine if any unexpected archaeological remains or undesignated but nationally significant features are present that would require consideration, as well as the setting of historic features. Note: Locally Listed Heritage Asset point data was buffered 5m to estimate building footprints where they did not intersect the Locally Listed Building polygon data.
Minimum Development Size	Unconstrained areas of land were excluded if they were below a minimum developable size of 40m width and an area that varied per turbine size:	■ N/A	The minimum development size was based on developer knowledge of recent wind turbine developments, and accounts for the estimated land take requirements for a single turbine base, the adjacent laydown area and other immediate infrastructure requirements adjacent to the turbine itself.

[26] There are no Registered Battlefields or World Heritage Sites within Runnymede.

Parameter	Assumption	Data Source	Justification and Notes
	■ Very large: 0.8ha ■ Large: 0.6ha ■ Medium: 0.4ha ■ Small: 0.2ha		However, further site specific study would be required in order to determine the land take requirements of individual turbines depending on factors such as their model and location.
Turbine Spacing	The following standardised turbine densities were considered when determining the overall potential for turbine development across Runnymede: ■ Very large: 4 per km2 (assuming a rotor diameter of 130m) ■ Large: 8 per km2 (assuming a rotor diameter of 90m) ■ Medium: 22 per km2 (assuming a rotor diameter of 55m) ■ Small: 167 per km2 (assuming a rotor diameter of 20m)	■ N/A	The calculation of potential wind capacity involved applying an assumption concerning development density. In practice, turbines are spaced within developments based on varying multiples of the rotor diameter length. Although turbine separation distances vary, a 5 x 3 rotor diameter oval spacing[27], with the major axis of the oval oriented towards the prevailing wind direction, taken to be south-west as the 'default' assumption in the UK (see **Figure A - 1**), was considered a reasonable general assumption at the present time in this respect. In practice, site-specific factors such as prevailing wind direction and turbulence are taken into account by developers, in discussion with turbine manufacturers. Bearing in mind the strategic nature of the present study, the density calculation did not take into account the site shape, and a standardised rectangular grid density based on a 5 x 3 rotor diameter was used instead (see image below).

[27] To mitigate impacts on the productivity of wind turbines located close to one another caused by wind turbulence, it is standard practice for developers to maintain an oval of separation between turbines that is equal to 5 times the turbine rotor diameter (the cross sectional dimension of the circle swept by the rotating blades) on the long axis, and 3 times the rotor diameter on the short axis.

Figure A - 1: Wind turbine spacing

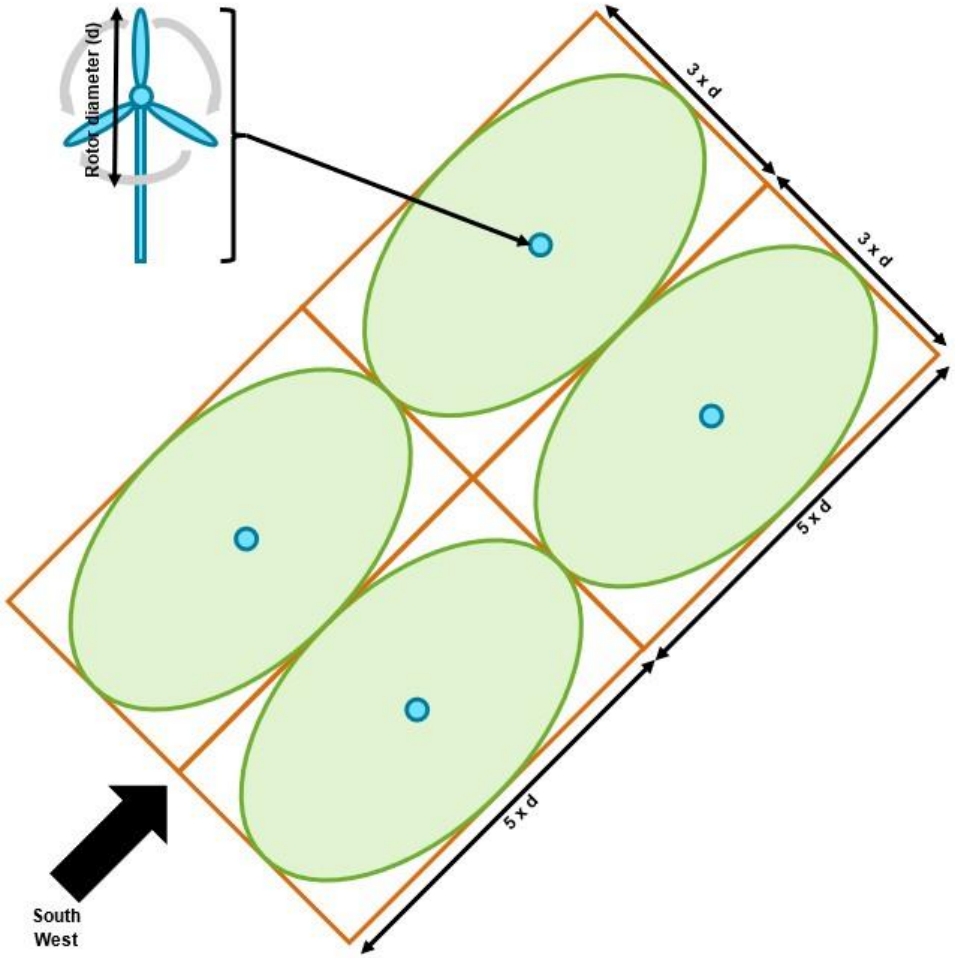

Table A - 4: Proposed assumptions to be used for assessment of technical potential for onshore wind – Constraints considered but not used

Parameter	Assumption	Data Source	Justification and Notes
MOD Land	No land excluded on this basis.	■ OpenStreetMap ■ Runnymede Borough Council	Based on Open Street Map and council data there are no MOD sites within Runnymede. As such, no land was excluded on this basis.
Areas of Outstanding Natural Beauty	No land excluded on this basis.	■ Natural England	There are no Areas of Outstanding Natural Beauty located within Runnymede. As such, no land was excluded on this basis.
National Park	No land excluded on this basis.	■ Natural England	There are no National Parks located within Runnymede. As such, no land was excluded on this basis.
Electricity Grid	No land excluded on this basis.	■ SSE/UKPN	General commentary was provided on the current state of grid capacity within Runnymede to inform the assessment of deployment potential. Moreover, the proximity of land to substations and major transmission lines (132kV minimum) was mapped for information to indicate the locations were potential substation and T-in connections respectively could be more feasible, such as for individual community-scale wind developments. However, as grid capacity is so variable with little certainty in advance of where there could be capacity for additional electricity generation to be connected, no land was excluded on this basis for the technical assessment. Further consultation would be required with SSE/UKPN to determine the feasibility to connect specific sites to the electricity grid. Moreover, for larger wind turbine schemes, developers commonly deliver substations and additional grid infrastructure as required to support the additional generation capacity requirements of the development, limiting concerns regarding connecting to constrained parts of the existing grid.
NATS Safeguarding Areas	Guidance includes reference to the following safeguarding areas: ■ 30km for aerodromes with a surveillance radar facility; ■ 17km for non-radar equipped aerodromes with a runway of 1,100m	■ NATS	Further consultation between potential developers and NATS is required to determine if there is any impact from a proposed development. NATS safeguarding areas were therefore not excluded. They were mapped for information only.

Parameter	Assumption	Data Source	Justification and Notes
	or more, or 5km for those with a shorter runway; ■ 4km for non-radar equipped unlicensed aerodrome with a runway of more than 800m or 3km with a shorter runway; ■ 10km for the air-ground-air communication stations and navigation aids; and ■ 15 nautical miles (nm) for secondary surveillance radar. These are indicative of potential constraints to wind development but cannot be used to definitely exclude land as unsuitable. They are generally presented as separate figures alongside the main assessment of technical potential.		
Shadow Flicker	No land excluded on this basis.	■ N/A	Wind turbines may in some circumstances cause 'shadow flicker' within nearby properties. However, shadow flicker effects are readily mitigated and so shadow flicker was not considered as a constraint for the purposes of this study.
Residential Amenity	No land excluded on this basis.	■ N/A	It is noted that it may be inappropriate to develop wind turbines in proximity to residential properties, due to impacts upon residential amenity. However, due to the potential for micro siting, property aspect and potential for mitigation, it would require further site specific study to determine whether wind turbines would be suitable in proximity to residential properties. Therefore, this factor was considered within the landscape sensitivity assessment and no land was excluded on this basis from the technical assessment.
Public Rights of Way and Cycle Paths	No land excluded on this basis.	■ Runnymede Borough Council ■ SusTrans	Public Rights of Way and cycle paths can be relatively easily diverted to ensure they are safely distanced from wind turbines. Public Rights of Way and cycle paths were therefore not excluded. They were mapped for information only.

Parameter	Assumption	Data Source	Justification and Notes
Blade Oversail of Biodiversity and Cultural Heritage Designations	No land excluded on this basis.	■ N/A	Depending on individual designated site characteristics, it may not be suitable for the blades of adjacent wind turbines to oversail the site. However, this is site dependent and would require further studies. As such, a blade oversail buffer was not excluded.

Ground-Mounted Solar Resource Assessment Parameters

A.8 Runnymede's technical potential for ground mounted solar PV development was assessed in a similar way to the potential for wind. The key GIS tool parameters are set out in **Table A - 2** below.

A.9 The maximum solar PV capacity of the area of technical potential was estimated using an assumed development density expressed as Megawatts (MW) per hectare; and regional capacity factor[28] (again, derived from historic data broken down to at least regional level).

A.10 As solar PV is essentially modular, the land with technical potential was not differentiated by project scale.

Table A - 5: Proposed assumptions to be used for assessment of technical potential for commercial/large scale ground-mounted solar – Constraints

Parameter	Assumption	Data Source	Justification and Notes
Development Size Categories	None.	■ N/A	Solar development is more 'modular' than wind (development size is dictated by the number of panels, which themselves do not differ greatly in size) and constraints are not affected by project scale in the way that they are for wind. Therefore, the identification of available land for ground-mounted solar has not been broken down into discrete project sizes but rather any land technically suitable for development has been identified.
Roads	Exclude: ■ Roads.	■ Ordnance Survey OpenRoads	Physical features preventing the development of ground-mounted solar PV were excluded. There is no requirement for safety buffers in relation to these with respect to ground-mounted solar PV. Restricted access tracks were excluded from consideration as these predominantly comprise of forestry and other tracks which could be more easily diverted than standards roads. Note: Only line data for roads was available and in order to create a footprint from the road centre, it was assumed that single carriageways are 10m in width, dual carriageways 20m and motorways 30m.
Railways	Exclude: ■ Railways.	■ Ordnance Survey OpenMap	Physical features preventing the development of ground-mounted solar PV were excluded. There is no requirement for safety buffers in relation to these with respect to ground-mounted solar PV. Note: In order to create a footprint from the railway centrelines data, it was assumed that railways were 15m in width.

[28] An energy generator's 'capacity factor' can be defined as the actual energy yield produced over a period of time expressed as a proportion of the energy yield that would have been produced if the generator had operated at its full generation capacity continuously over the same period.

Parameter	Assumption	Data Source	Justification and Notes
Planning/Land Use Other	Exclude: ■ Registered Common Land; ■ Open Access Land; ■ Suitable Alternative Natural Green Space; ■ Local Open Space; and ■ Local Green Space.	■ Natural England (Common Land) ■ Runnymede Borough Council	Due to land take requirements, these land uses/types were considered generally to constrain ground-mounted solar development, particularly at larger scales, although in some circumstances they may offer opportunities for smaller scale development collocated with their other facilities. They were excluded from the resource assessment but may be subject to bespoke policies with the Local Plan allowing development to take place in principle subject to defined criteria being satisfied.
Buildings	Exclude: ■ All buildings with a 10m buffer.	■ OS OpenMap Local data	Buildings were buffered by 10m to account for shading and impacts on solar output. It is noted that further site specific study considering building heights and orientation in relation to the site would be required to determine the exact buffers required to account for shading.
Future Developments, Safeguarded Land and Employment Sites	Exclude: ■ Housing and employment allocations from Runnymede Borough Council Plan.	■ Runnymede Borough Council	Generally these will be unsuitable for ground-mounted solar, although there may be some potential for installations on undeveloped land/open space within these areas. Identification of this potential would require a separate, site-specific study. In addition, it is assumed that opportunities for renewables within such sites will already be in development as part of their allocation. In agreement with the Council, Strategic Employment Areas were not treated as constraints. The Council confirmed that these sites are not “allocated” for future development and instead are areas of protected existing employment developments.
Existing Renewable Energy Developments	Exclude: ■ Land boundaries of consented and operational renewable energy installations.	■ BEIS ■ Aerial Imagery ■ LUC windfarm database	The quarterly BEIS Renewable Energy Planning Database and the LUC internal windfarm database was used to determine the locations of operational and consented renewable energy installations. These datasets did not indicate that there were any consented or operational wind turbine or ground mounted solar development present within Runnymede. As such, no land was excluded on this basis. Existing roof-mounded solar PV developments were not excluded, as these are building-integrated and therefore excluded via the consideration of existing build development as a constraint.

Parameter	Assumption	Data Source	Justification and Notes
			Additionally, existing landfill gas developments were not considered a constraint to wind developments, as there is potential that solar panels could be incorporated onto such existing sites. A single operational anaerobic digestion installation was identified within the authority and this was treated as a constraint to solar developments.
Minerals Sites with a 250m buffer	Exclude: ■ All operational minerals sites with a 250m buffer ■ Allocated minerals sites with a 250m buffer	■ Runnymede Borough Council	The IAQM 2016 Guidance on the Assessment of Mineral Dust Impacts for Planning indicates that adverse dust impacts from sand and gravel sites are uncommon beyond 250m and beyond 400m from hard rock quarries measured from the nearest dust generating activities.
All operational waste Sites	Exclude: ■ All operational waste sites ■ Allocated waste sites	■ Runnymede Borough Council	Waste sites will frequently be quite highly constrained with respect to ground-mounted solar development (e.g. areas of active landfill) but equally may present opportunities in some circumstances, particularly when they are to be decommissioned/restored during a plan period. Waste sites should be excluded from the identified ground-mounted solar resource but potentially subject to bespoke policy wording in the local plan.
Terrain	Exclude: ■ Areas with north-east to north-west aspect and inclinations greater than 7 degrees; and ■ All areas with inclinations greater than 15 degrees.	■ OS Terrain 50	Although it is possible to develop Ground-mounted solar PV installations on slopes facing north-east to north-west, it would generally not be economically viable to do so. However, slopes that are north-east to north-west facing and below 7° are considered potentially suitable[29], as generation output will not be significantly affected.
Agricultural Land Use	Exclude: ■ Agricultural land use classifications grades 1 and 2.	■ Natural England ■ Runnymede Borough Council	Agricultural Land Use is a consideration, with grades 1, 2 and 3a land being classed as *"the best and more versatile (BMV)"* land and having higher value for food production. Further investigation would be required of grade 3 land to determine whether it is grade 3a or b, as available data does not distinguish these. Ground-

[29] Based on current standard developer practice.

Parameter	Assumption	Data Source	Justification and Notes
			mounted Solar PV projects, over 50kWp, should ideally utilise previously developed land, brownfield land, contaminated land, industrial land or agricultural land preferably of classification 3b, 4, and 5. However, solar developments can be built on BMV land, if they have been deemed to pass the sequential test, whereby sites on lower grade a non-agricultural land are prioritised over BNM land. Within Runnymede, the majority of agricultural land is grade 3 or 4 agricultural land. As such, only grade 1 (excellent) and grade 2 (very good) agricultural land was treated as a constraint to solar development, and further site-specific study would be required to determine if sites on lower grade BMV would be suitable based on the sequential text.
Water Environment	Exclude: ■ Watercourses and waterbodies with a 50m buffer.	■ Ordnance Survey VectorMap Local	A 50m buffer was applied around all rivers and waterbodies to take account of good practice such as that relating to pollution control during construction. OS Survey OpenMap Local surface water area data includes waterways of approximately a minimum of 2m width. OpenMap Local surface water line data is line data, and so a 1m buffer was applied to approximate a footprint of smaller waterways.
Woodland	Exclude: ■ Ancient Woodland Inventory with a 20m buffer; and ■ Woodland as shown on the National Forest Inventory with a 20m buffer including: – Assumed woodland; – Broadleaved; – Conifer; – Coppice; – Coppice with standards;	■ Forestry Commission ■ Natural England	Forested areas were buffered by 20m to account for shading and impacts on solar output. It is noted that further site specific study considering woodland heights and orientation in relation to the site would be required to determine the exact buffers required to account for shading. The following National Forestry Inventory categories of woodland were considered non-permanent or non-woodland and therefore not excluded as ground mounted solar development may be suitable in these locations: ■ Cloud/shadow; ■ Uncertain; and Windblown.

Parameter	Assumption	Data Source	Justification and Notes
	– Failed; – Felled; – Group prep; – Low density; – Mixed mainly broadleaved; – Mixed mainly conifer; – Shrub; and – Young trees.		
Biodiversity (International Designations)	Exclude international designations[30]: ■ Special Protection Areas (SPA); ■ Special Areas of Conservation (SAC); and ■ Ramsar sites.	■ Natural England	As protected by: ■ Conservation of Habitats and Species Regulations 2017 (as amended)
Biodiversity (National Designations)	Exclude national designations[31]: ■ Sites of Special Scientific Interest.	■ Natural England	As protected by: ■ Wildlife and Countryside Act 1981 ■ Conservation of Habitats and Species Regulations 2017 (as amended)
Biodiversity (Regional and Local Designations)	Exclude other designations[32]: ■ Local Nature reserves; and ■ Sites of Nature Conservation Importance.	■ Natural England ■ Runnymede Borough Council	Generally, would not be suitable for renewables development based on law/policy/guidance including: ■ NPPF ■ Natural Environment and Rural Communities Act 2006

[30] There are no Potential SAC, Potential SPA or Proposed Ramsar sites present within Runnymede.
[31] There are no National Nature Reserves within Runnymede.
[32] There are no RSPB Reserves within Runnymede.

Parameter	Assumption	Data Source	Justification and Notes
Cultural Heritage	Exclude[33]: ■ Registered Parks and Gardens; ■ Scheduled Monuments; ■ Listed Buildings; ■ Locally Listed Buildings; ■ Conservation Areas; and ■ Locally Listed Heritage Assets.	■ Historic England ■ Runnymede Borough Council	As protected by: ■ NPPF ■ The Convention Concerning the Protection of the World Cultural and Natural Heritage ■ National Heritage Act 1983 ■ Ancient Monuments and Archaeological Areas Act of 1979 ■ Planning (Listed Buildings and Conservation Areas) Act 1990 The council's polygon version of the Nationally Listed Buildings dataset was used to represent Listed Buildings more accurately than the Historic England point dataset. Although solar development may not be strictly prohibited by policy within designated World Heritage Site Buffer Zones, is should be noted that it would likely be highly problematic to seek planning permission within these. It is noted that further site specific study would be required to determine if any unexpected archaeological remains or undesignated but nationally significant features are present that would require consideration, as well as the setting of historic features. Note: Locally Listed Heritage Asset point data was buffered 5m to estimate building footprints where they did not intersect the Locally Listed Building polygon data.
Minimum Development Size	Unconstrained areas of land were excluded if they were below a minimum developable size of 0.6ha.	■ N/A	A minimum development size of 0.6ha (0.5MW) was set in agreement with Runnymede Borough Council.
Development Density	1.2 hectares per MW.	■ N/A	The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) states that, along with associated infrastructure, generally a solar farm requires between 2 to 4 acres for each MW of output. This equates to 0.8-1.6ha per MW. For this study, the average of 1.2ha per MW was used.

[33] There are no Registered Battlefields or World Heritage Sites within Runnymede.

Parameter	Assumption	Data Source	Justification and Notes
			It its noted that on sites where solar farms are co-located with wind turbines, the value of MW per ha may increase as infrastructure may be able to be shared between the technologies.

Table A - 6: Proposed assumptions to be used for assessment of technical potential for commercial/large scale ground-mounted solar – Constraints considered but not used

Parameter	Assumption	Data Source	Justification and Notes
Solar Irradiance	No land excluded on this basis.	■ Global Solar Atlas	Using modern solar panel technology, the vast majority of land within England is deemed suitable for solar panel development in terms of solar irradiance. Any land unsuitable due to slope and aspect which limit the total hours of direct daily sunlight within a location, were excluded from consideration as based on the above constraints table. Therefore, no land was excluded from this assessment based on this, and solar irradiance levels they were mapped for information only to indicate where the more productive sites may be located.
MOD Land	No land excluded on this basis.	■ OpenStreetMap ■ Runnymede Borough Council	Based on Open Street Map and council data there are no MOD sites within Runnymede. As such, no land was excluded on this basis.
Areas of Outstanding Natural Beauty	No land excluded on this basis.	■ Natural England	There are no Areas of Outstanding Natural Beauty located within Runnymede. As such, no land was excluded on this basis.
National Park	No land excluded on this basis.	■ Natural England	There are no National Parks located within Runnymede. As such, no land was excluded on this basis.
Electricity Grid	No land excluded on this basis.	■ SSE/UKPN	Grid connection is a key consideration for solar developments, as additional grid connections costs, such as long cable distances and additional substation requirements, can significantly hinder the economic viability of this technology. General commentary was provided on the current state of grid capacity within Runnymede to inform the assessment of deployment potential. Moreover, the proximity of land to substations and major transmission lines (132kV minimum) was

Parameter	Assumption	Data Source	Justification and Notes
			mapped for information to indicate the locations were potential substation and T-in connections respectively could be more feasible. However, as grid capacity is so variable with little certainty in advance of where there could be capacity for additional electricity generation to be connected, no land was excluded on this basis for the technical assessment. Further consultation would be required with SSE/UKPN to determine the feasibility to connect specific sites to the electricity grid.
Residential Amenity	No land excluded on this basis.	■ N/A	It is noted that it may be inappropriate to develop solar farms in proximity to residential properties, due to impacts upon residential amenity. However, due to the potential for micro siting, property aspect and potential for mitigation, it would require further site specific study to determine whether solar developments would be suitable in proximity to residential properties. Therefore, this factor was considered within the landscape sensitivity assessment and no land was excluded on this basis from the technical assessment.
Public Rights of Way/Cycle Paths	No land excluded on this basis.	■ Runnymede Borough Council ■ DEFRA ■ SusTrans	Public Rights of Way and cycle paths can be relatively easily diverted around or safely through ground mounted solar developments, and these impacts are considered as part of the assumed development density. Public Rights of Way and cycle paths were therefore not excluded. They were mapped for information only.
Airports and Airfields	No land excluded on this basis.	■ Ordnance Survey VectorMap Local Functional Site layer with the theme 'Air Transport' ■ Aerial imagery	Glint and glare caused by solar panels is a consideration for aviation safety. However, this is site dependent and scheme design can enable solar developments to be situated within airports and airfields themselves. As such, only the airport and airfield buildings and hardstanding should treated as constraints to solar development. Although airport buildings were treated as constraints to solar development, considered under *"Buildings"*, no spatial data was available to map runways and in-use airport hardstanding. Therefore, further site-specific study would be required to make consideration of these.

Rooftop Solar Resource Assessment

A.11 The total potential capacity of roof mounted solar was estimated based on typical system sizes and the estimated percentage of suitable roof space within the study area. Roofs that have potential to deliver solar PV also have the potential to deliver solar water heating generation. However, this was treated as being mutually exclusive with solar PV potential, i.e. the same roof space can only be utilised for one of the technologies. Generation potential was therefore calculated for each technology for separate comparison.

Table A - 7: Proposed assumptions to be used for assessment of technical potential for rooftop solar PV

Parameter	Assumption	Data Source	Justification and Notes
System Size	Average size of system based on property type: ■ Detached: 4kW[34] ■ Semi-detached[35]: 2.6kW ■ Terrace/end-terrace[36]: 2.2kW ■ Non-domestic: 28.0kW[37]	■ BEIS	Typical system sizes for dwellings were estimated based on Energy Saving Trust Data[38]. Due to lack of appropriate data on typical system sizes and suitability of roofs, dwellings classed as 'flats', 'in part of a converted or shared house (including bedsits)' and those classed as 'other dwellings' were not included within the assessment. Average sized solar PV systems in Runnymede for non-domestic installations recorded on the FiT Register up to March 2019 was 27.8kW.
Suitable Roofs	Proportion of properties with suitable roofs (estimate): ■ 40% of dwellings[39]; and ■ 75% of non-domestic properties[40].	■ OS Addressbase ■ OS OpenMap	Proportions estimated from prior research undertaken by CSE, which considered suitable type and orientation of roof, and space availability[41]. Conservation areas and listed buildings were not treated as constraints to rooftop solar generation. Permitted development rights in England allow solar to be installed within conservation areas provided this is not on walls fronting a highway. In addition, rooftops solar generation has the potential to be installed in this circumstance and on any listed buildings through the granting of planning permission. Properties were included in the assessment based on Runnymede LLPG Address data (see **Table A - 1**).

[34] Average detached house.
[35] Average semi-detached house.
[36] Modern mid-terrace or end terrace.
[37] BEIS (2020) Sub-regional Feed-in Tariffs statistics: March 2019. Available at: https://www.gov.uk/government/statistical-data-sets/sub-regional-feed-in-tariffs-confirmed-on-the-cfr-statistics
[38] Energy Saving Trust (2015) Solar Energy Calculator Sizing Guide. Available at: https://www.pvfitcalculator.energysavingtrust.org.uk/Documents/150224_SolarEnergy_Calculator_Sizing_Guide_v1.pdf
[39] Detached, semi-detached and terrace/end terrace.
[40] Excluding land, car parking, utilities, marina and moorings, and objects of interest.
[41] LUC and CSE (2020) Test Valley Renewable and Low Carbon Energy Study. Available at: https://www.testvalley.gov.uk/planning-and-building/planningpolicy/evidence-base/evidence-base-environment

Parameter	Assumption	Data Source	Justification and Notes

Table A - 8: Proposed assumptions to be used for assessment of technical potential for rooftop solar water heating

Parameter	Assumption	Data Source	Justification and Notes
System Size	Average size of system based on property type: ■ Domestic: 2.8kW ■ Non-domestic: 18.8kW	■ BEIS	Average sizes for solar water heating systems obtained from RHI deployment data[42]. Due to lack of appropriate data on typical system sizes and suitability of roofs, dwellings classed as 'flats', 'in part of a converted or shared house (including bedsits)' and those classed as 'other dwellings' were not included within the assessment.
Suitable Roofs	See above – the same as for roof-mounted solar PV.	■ See above – the same as for roof-mounted solar PV.	See above – the same as for roof-mounted solar PV.
Heating Fuel Offset	Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties	■ BEIS	The actual proportions of electricity and oil usage by off-gas properties is unknown. As such, an illustrative 50% of these properties are estimated to be fuelled by electricity and 50% by oil for the purposes of this study.

Hydropower

A.12 It has not been possible within the scope of this study to undertake a new assessment of the potential hydropower resource within Runnymede.

A.13 However, in 2010 the Environment Agency published the findings of a study identifying hydropower opportunities within England and Wales. This was produced to provide an overview at national and regional scales of the potential hydropower opportunities available, as well as the relative environmental sensitivity of identified potential sites to development. These findings were reviewed as part of this study. It is noted that this data is indicative and that further site specific study would be required in order to determine the technical potential and suitability of sites for hydropower developments.

A.14 The study included identifying 'heavily modified water bodies' that are identified as being at significant risk of failing to achieve good ecological status because of modifications to their

[42] BEIS (2022) RHI monthly deployment data: January 2022. Available at: https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-january-2022

hydromorphological characteristics resulting from past engineering works, including impounding works. Due to these characteristics, such waterbodies were identified as having the potential to create hydropower barriers that would also be beneficial to the passage of fish upstream. These were overlayed with identified locations where suitable yearly flow characteristics are present and could feasibly support hydropower sites. The resultant identified sites were classified as 'win-win' opportunities where hydropower developments could potentially be installed whilst also improving the ecological status of waterways.

Heat Pumps

Air Source Heat Pumps

Almost any building theoretically has the potential for an air source heat pump to be installed. Therefore, the assessment considered the potential for air source heat pumps to be delivered in all buildings as based on Runnymede LLPG Address data (see **Table A - 1**).

Table A - 9: Proposed assumptions to be used for assessment of technical potential for air source heat pumps

Parameter	Assumption	Data Source	Justification and Notes
System Size	Average size of system based on property type: ■ Domestic: 10.1kW ■ Non-domestic: 60.8kW	■ BEIS ■ OS Addressbase ■ OS OpenMap	Average sizes for air source heat pump systems obtained from RHI deployment data[43].
Heating Fuel Offset	SPF: 3.5 (efficiency of 71%). Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties	■ BEIS	SPF derived from BEIS Renewable Heat Incentive data: 3.5[44]. For every 3.3kW of heat generated, offsetting CO_2 from the existing heating fuel (gas/oil/electricity), 1kW of energy is consumed, contributing to CO_2 generated by consuming electricity. The actual proportions of electricity and oil usage by off-gas properties is unknown. As such, an illustrative 50% of these properties are estimated to be fuelled by electricity and 50% by oil for the purposes of this study.

Ground Source Heat Pumps

A.15 Ground source heat pumps require more space than air source, requiring pipes to be buried vertically in a deeper system or horizontally in a shallow wider system. Due to these significant space constraints, this study did not estimate the potential capacity of ground source heat pumps across the study area, as it was not possible to estimate how many properties have access to the required space.

A.16 It is noted however that the average system size of domestic pumps are 14.6 kW[45].

Open Loop Ground Source Heat Pumps

A.17 The British Geological Survey has produced a map identifying the potential viability of open-loop ground source heat pumps across England and Wales, considering hydrogeological and economic factors[46]. This indicates that land within Runnymede is favourable for open-loop ground source heat pumps.

A.18 However, the British Geological Survey states that this is an initial screening assessment only and that identified areas favourable for open-loop systems are not automatically suitable for this technology to be installed. Instead, detailed environmental assessment of proposed sites would be required, considering local variations in environmental conditions and factors

[43] BEIS (2022) RHI monthly deployment data: January 2022. Available at: https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-january-2022
[44] BEIS (2022) RHI monthly deployment data: January 2022. Available at: https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-january-2022
[45] BEIS (2022) RHI monthly deployment data: January 2022. Available at: https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-january-2022
[46] British Geological Survey (2021) Open-loop ground source heat pump viability screening map. Available at: https://www.bgs.ac.uk/technologies/web-map-services-wms/open-loop-ground-source-heat-pump-viability-screening-map-wms/

such as the availability of water (i.e. the amount of water that is available for licensing by the Environment Agency) and discharge of water from a scheme[47]. Therefore, with the data available, it is not possible to determine the potential annual energy generation and carbon savings that could be produced by open loop ground source heat pumps within Runnymede.

Water-Source Heat Pump

A.19 The DECC 2014 water source heat map identified, at a high level, opportunities for water source heat pump technologies[48]. This was reviewed as part of this study.

A.20 Although it has not been possible within the scope of this study to assess the potential for water source heat pumps, the sensitivity analysis included in the 2014 DECC water source heat map identified the River Thames as having a heat capacity of between 334 MW. Viability would largely depend on having a sufficiently high heat demand local to the potential heat pump location.

Geothermal

A.21 At present, geothermal energy is understood to be exploited in a limited number of locations around the UK; predominantly within Cornwall and the Lake District/Weardale where the highest heat flows within the UK are present.

A.22 To investigate localised potential for geothermal energy generation, specialist surveys would need to be undertaken. However, before pursuing this it is recommended that the Council monitors the progress of this technology in other locations in order to understand the potential technical and economic viability of geothermal generation and how this is applicable to Runnymede.

Biomass Resource Assessment

Virgin Woodfuel Thermal Conversion: Forestry and Woodland

A.23 To determine the potential for biomass generation from forestry and woodland, it was assumed that all woodland within the study area has a sustainable yield of two odt/yr (oven-dried tonnes/ha/year)[49] and assumptions (see **Table A - 10**) were applied. Both the potential for heating and for combined heat and power were calculated.

A.24 To identify existing suitable woodland within the study area, the Forestry Commission's National Forest Inventory (NFI) was used. The NFI records the location and extent of all forests and woodland above 0.5ha across the UK and it is noted that although a sample of forests and woodland are ground surveyed every 5 years, the inventory is updated annually using aerial photography, interpretation of satellite imagery and administrative records of newly planted areas covered by government grant schemes[50]. Therefore, there can be occasional errors due to misidentification of sites not ground-surveyed.

A.25 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a national capacity factor was applied, as based on national data for plant-sourced biomass[51].

Table A - 10: Proposed assumptions to be used for assessment of technical potential for virgin woodfuel thermal conversion: forestry and woodland

[47] British Geological Survey (2012) Non-Technical Guide: A screening tool for open-loop ground source heat pump schemes (England and Wales). Available at: https://www.bgs.ac.uk/geology-projects/geothermal-energy/open-loop-gshp-screening-tool/

[48] DECC (2015) National Heat Map: Water source heat map layer. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416660/water_source_heat_map.PDF

[49] Forestry Research (2021) Potential yields of biofuels per ha p.a. Available at: https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/. Data for Wood (forestry residues, SRW, thinnings, etc.).

[50] Forestry Commission (2019) About the NFI. Available at: https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/about-the-nfi/

[51] BEIS (2022) Load factors for renewable electricity generation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1094495/DUKES_6.3.xlsx

Parameter	Assumption	Data Source	Justification and Notes
Woodland Resource	The following National Forestry Inventory (NFI) woodland categories within the study area were included: ■ Assumed woodland; ■ Broadleaved; ■ Conifer; ■ Coppice; ■ Coppice with standards; ■ Mixed mainly conifer; and ■ Mixed mainly broadleaved. Energy generation per hectare per year: 10.3 MWh/ha/year	■ Forestry Commission	These woodland categories were included as they were assumed to be mature and able to provide a sustainable yield of woodfuel. The following woodland categories were not included as they were assumed to currently be unable to provide a sustainable yield of woodfuel: ■ Assumed woodland; ■ Cloud\shadow; ■ Failed; ■ Felled; ■ Ground prep; ■ Low density; ■ Shrub; ■ Uncertain; ■ Windblow; and ■ Young trees. The non-woodland categories within the NFI were also not assessed as they do not provide woodfuel. The assumed energy generation per hectare per year is derived from Forestry Commission data[52].
Constraints	The following constrained areas of woodland were excluded from the assessment[53]: ■ Ancient woodland; ■ Special Protection Areas (SPA);	■ Natural England ■ Historic England ■ Runnymede Borough Council	As protected by: ■ Conservation of Habitats and Species Regulations 2017 (as amended) ■ Wildlife and Countryside Act 1981

[52] Forestry Research (2023) Potential yields of biofuels per ha p.a. Available at: https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-p-a/. Data for Wood (forestry residues, SRW, thinnings, etc.).
[53] There are no Potential SAC, Potential SPA, Proposed Ramsar sites, National Nature Reserves, RSPB Reserves Registered Battlefields, World Heritage Sites, MOD land or National Parks present within Runnymede.

Parameter	Assumption	Data Source	Justification and Notes
	■ Special Areas of Conservation (SAC); ■ Ramsar sites; ■ Sites of Special Scientific Interest; ■ Local Nature Reserves; ■ Sites of Nature Conservation Importance; ■ Registered Parks and Gardens; ■ Scheduled Monuments; ■ Listed Buildings; ■ Locally Listed Buildings; ■ Conservation Areas; ■ Locally Listed Heritage Assets; and ■ Housing and employment sites.		■ Conservation of Habitats and Species Regulations 2017 (as amended) ■ NPPF ■ Natural Environment and Rural Communities Act 2006 ■ Runnymede 2030 Local Plan
Heating Fuel Offset: Heating Only	Boiler efficiency assumed to be 77%[54]. Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties	■ BEIS	Biomass boiler efficiency derived from research by BEIS[55]. The actual proportions of electricity and oil usage by off-gas properties is unknown. As such, an illustrative 50% of these properties are estimated to be fuelled by electricity and 50% by oil for the purposes of this study.

[54] BEIS (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance. As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the boiler efficiency was considered to calculate the overall energy generation potential, not the load factor for biomass boilers, which considered the percentage of time a boiler is operating at peak output annually.
[55] BEIS (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance

Parameter	Assumption	Data Source	Justification and Notes
Fuel Offset: Combined Heat and Power (CHP)	CHP efficiency: ■ Electricity: 30% ■ Heating: 50% Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties	■ CSE	Average CHP efficiencies estimated from prior research undertaken by CSE[56].

Virgin Woodfuel Thermal Conversion: Energy Crops

A.26 To determine the potential for biomass generation via thermal conversion (burning within a boiler) from the two main woodfuel energy crops Miscanthus and Short Rotation Coppice (SRC), the below assumptions (**Table A - 4**) were applied. Both the potential for heating and for combined heat and power were calculated.

A.27 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a national capacity factor was applied, as based on national data for plant-sourced biomass[57].

Table A - 11: Proposed assumptions to be used for assessment of technical potential for virgin woodfuel thermal conversion: energy crops

Parameter	Assumption	Data Source	Justification and Notes
Energy Crop Resource	Yields: ■ Miscanthus: 13 odt/ha/year ■ SRC: 9 odt/ha/year Ratio of crops per hectare:	■ Forestry Commission	Miscanthus and SRC yields and assumed energy generation per hectare per year was derived from Forestry Commission data[58].

[56] LUC and CSE (2020) Test Valley Renewable and Low Carbon Energy Study. Available at: https://www.testvalley.gov.uk/planning-and-building/planningpolicy/evidence-base/evidence-base-environment
[57] BEIS (2022) Load factors for renewable electricity generation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1094495/DUKES_6.3.xlsx
[58] Forestry Research (2023) Potential yields of biofuels per ha p.a. Available at: https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-p-a/.

Parameter	Assumption	Data Source	Justification and Notes
	■ Miscanthus: 80% ■ SRC: 20% Energy generation per hectare per year: ■ Miscanthus: 63 MWh/ha/year ■ SRC: 46 MWh/ha/year		The average proportion of miscanthus and SRC grown in the UK was derived from Defra data[59]. The analysis assumed that of the land identified as suitable for energy crops, 4ha of Miscanthus would be delivered for every 1ha of SRC.
Constraints	Agricultural land constraints for miscanthus: ■ Grade 1 ■ Grade 2 ■ Grade 5[60] ■ Non-agricultural land Agricultural land constraints for SRC: ■ Grade 1 ■ Grade 2 ■ Non-agricultural land Physical constraints[61]: ■ Roads ■ Railways ■ Registered Common Land ■ Open Access Land	■ Aerial imagery ■ BEIS ■ Forestry Commission ■ Land Registry ■ Natural England ■ Ordnance Survey OpenMap ■ Ordnance Survey OpenRoads ■ Runnymede Borough Council	The NNFCC energy crops report produced for DECC indicates that miscanthus planting should be restricted to good and moderate quality (Grade 3) and poor quality (Grade 4) agricultural land and that SRC can grow on this land as well as very poor (Grade 5) land[64]. Excellent quality (Grade 1) and very good quality (Grade 2) agricultural land has the potential to deliver the highest crop yields and as such it was assumed that food crops would be prioritised above energy crops on this land. Physical features preventing the planting of energy crops were excluded. With regards to existing renewable energy developments, only existing ground-mounted solar farms were excluded as their land take prevents crop planting. Wind turbines have a far smaller land-take and crops could in theory be planted beneath and surround int turbines within a wind farm. In addition, designated sites were also excluded, as protected by: ■ Conservation of Habitats and Species Regulations 2017 (as amended) ■ Wildlife and Countryside Act 1981 ■ Conservation of Habitats and Species Regulations 2017 (as amended) ■ NPPF ■ Natural Environment and Rural Communities Act 2006

[59] Defra (2021) Crops Grown For Bioenergy in the UK: 2020. Available at:https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2020.
[60] There is no Grade 5 agricultural land located within Runnymede.
[61] There is no MOD land, National parks, Potential SAC, Potential SPA or Proposed Ramsar sites, National Nature Reserves, RSPB Reserves present within Runnymede.
[64] NNFCC (2012) Domestic Energy Crops; Potential and Constraints Review. Available at: https://www.gov.uk/government/publications/domestic-energy-crops-potential-and-constraints-review

Parameter	Assumption	Data Source	Justification and Notes
	■ Suitable Alternative Natural Green Space ■ Local Open Space ■ Local Green Space ■ Buildings ■ Airports and airfields ■ Housing and employment sites ■ Existing solar farms[62] ■ Watercourses and waterbodies ■ Woodland and ancient woodland Natural heritage constraints: ■ Special Protection Areas (SPA) ■ Special Areas of Conservation (SAC) ■ Ramsar sites ■ Sites of Special Scientific Interest ■ Local Nature Reserves ■ Sites of Nature Conservation Importance Cultural heritage constraints[63]: ■ Registered Parks and Gardens ■ Scheduled monuments		■ The Convention Concerning the Protection of the World Cultural and Natural Heritage ■ National Heritage Act 1983 ■ Ancient Monuments and Archaeological Areas Act of 1979 ■ Planning (Listed Buildings and Conservation Areas) Act 1990 Note: Only line data for roads was available and in order to create a footprint from the road centre, it was assumed that single carriageways are 10m in width, dual carriageways 20m and motorways 30m. In order to create a footprint from the railway centrelines data, it was assumed that railways were 15m in width. Locally Listed Heritage Asset point data was buffered 5m to estimate building footprints where they did not intersect the Locally Listed Building polygon data.

[62] The quarterly BEIS Renewable Energy Planning Database was used to determine the locations of operational and consented renewable energy installations. These datasets did not indicate that there were any consented or operational ground mounted solar development present within Runnymede. As such, no land was excluded on this basis.
[63] There are no Registered Battlefields or World Heritage Sites within Runnymede.

Parameter	Assumption	Data Source	Justification and Notes
	■ Listed Buildings ■ Locally Listed Buildings ■ Conservation Areas ■ Locally Listed Heritage Assets		
Heating Fuel Offset: Heating Only	Boiler efficiency assumed to be 77%[65]. Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties	■ BEIS	Biomass boiler efficiency derived from research by BEIS[66]. The actual proportions of electricity and oil usage by off-gas properties is unknown. As such, an illustrative 50% of these properties are estimated to be fuelled by electricity and 50% by oil for the purposes of this study.

[65] BEIS (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance. As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the boiler efficiency was considered to calculate the overall energy generation potential, not the load factor for biomass boilers, which considered the percentage of time a boiler is operating at peak output annually.
[66] BEIS (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance

Parameter	Assumption	Data Source	Justification and Notes
Fuel Offset: Combined Heat and Power (CHP)	CHP efficiency: ■ Electricity: 30% ■ Heating: 50% Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties	■ CSE	Average CHP efficiencies estimated from prior research undertaken by CSE[67].

Biogas from agricultural residues

A.28 Although Runnymede is not predominantly rural, agricultural waste is still a potential renewable energy resource, particularly from using livestock slurry as a feedstock for the anaerobic digestion process. Using estimates from Defra statistics on animal numbers for 2022[68] and resulting slurry and biogas yields, an estimate has been made of the potential emissions savings.

A.29 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a capacity factor was applied, as based on national data for anaerobic digestion[69].

[67] LUC and CSE (2020) Test Valley Renewable and Low Carbon Energy Study. Available at: https://www.testvalley.gov.uk/planning-and-building/planningpolicy/evidence-base/evidence-base-environment
[68] Defra (2023) Structure of the agricultural industry in England and the UK at June. Available at: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june
[69] BEIS (2022) DUKES chapter 6: statistics on energy from renewable sources. Load factors for renewable electricity generation (DUKES 6.5). Available at: https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes

Table A – 12: Proposed assumptions to be used for assessment of technical potential for biogas from agricultural residues

Parameter	Assumption	Data Source	Justification and Notes
Slurry Resource	Number of animals required to produce 1 tonne of slurry per day: ■ Cattle: 30 ■ Pigs: 275 ■ Poultry: 10,500 Biogas yield: ■ Cattle: 20m^3/tonne ■ Pigs: 20m^3/tonne ■ Poultry: 65m^3/tonne Energy content of biogas: ■ 6.7kWh per m^3	■ Shared Practice ■ The Andersons Centre	The number of animals required to produce 1 tonne of slurry per day was derived from the average of the figure brackets provided in the Shared Practice Anaerobic Digestion Good Practice Guidelines[70]: ■ Cattle: 20-40 ■ Pigs: 250-300 ■ Poultry: – Laying hen litter: 8,000-9,000 – Broiler manure: 10,000-15,000 Biogas yields derived from the average of the figure brackets provided in The Andersons Centre data[71]: ■ Cattle: 15-25 m^3/tonne ■ Pigs: 15-25 m^3/tonne ■ Poultry: 30-100 m^3/tonne Energy content of biogas also derived from The Andersons Centre data.
Heating and Electricity Fuel Offset	CHP plant efficiency[72]: ■ Heat: 50% ■ Electricity: 30%	■ The Andersons Centre	CHP plant efficiency derived from The Andersons Centre data[73]. The actual proportions of electricity and oil usage by off-gas properties is unknown. As such, an illustrative 50% of these properties are estimated to be fuelled by electricity and 50% by oil for the purposes of this study.

[70] Shared Practice (1997) Good Practice Guidelines: Anaerobic Digestion of farm and food processing residues. Available at: http://www.sharedpractice.org.uk/Library/library.html
[71] The Andersons Centre (2010) A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems. Available at: https://theandersonscentre.co.uk/service/economic-analysis/
[72] As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the CHP efficiency was considered to calculate the overall energy generation potential, not the load factor for biogas CHP units, which considered the percentage of time a boiler is operating at peak output annually.
[73] The Andersons Centre (2010) A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems. Available at: https://theandersonscentre.co.uk/service/economic-analysis/

Parameter	Assumption	Data Source	Justification and Notes
	Heating fuel assumed to be offset: ■ Electricity: 50% of off-gas properties ■ Oil: 50% of off-gas properties ■ Gas: All on-gas properties		

Energy from Waste

A.30 The Surrey County Council Waste Needs Assessment, Annual Monitoring Report and Waste Local Plan were reviewed to assess the energy generation potential from waste.

Landfill Gas

1.3 It is assumed that the large majority of opportunities for gas obtained from landfill in Runnymede have already been developed, although it has not been possible to quantify amount or the energy produced. BEIS[74] data indicates there are three operational landfill gas developments, totalling 9.6MW, within Runnymede. District Heating

A.31 Heat networks can provide a more efficient way of delivering heating to a group of buildings when compared to stand-alone heating systems. CSE undertook this assessment using a sophisticated 3D demand model to estimate building heat demand and identified areas with potential for heat networks, including producing a GIS map layer locating them. This included identifying the co-location of key 'anchor' heat loads and significant building energy demands, including development sites, identifying clusters with most potential for heat networks.

Grid Capacity

A.32 The ability to connect to the electricity grid can be a limiting factor in the deployment of all larger energy developments where the energy generated is to be exported.

A.33 In the UK, the distribution network was designed for a 'top down' flow of electricity, from small numbers of very large power stations. However, the increasing deployment of distributed generation from renewable and low-carbon sources is causing new challenges for the electricity network, with ever-larger areas of the network reaching maximum capacity. In these areas, the grid is no longer able to accept new grid connections for supply of power.

A.34 Due to this constrained nature of the network, the near-term opportunities for new renewable energy deployment are therefore limited to areas where there is capacity still available, or to an existing connection that isn't being fully utilised. Such sites provide the opportunity to host additional generating capacity without the need for a new grid connection. Identifying such sites within Runnymede will require engagement with site operators and/or SSE/UKPN. Additionally, DNOs regularly upgrade the network to create extra capacity, which can be applied for in advance, even when these upgrades take years to come online. It is therefore worth periodically checking with the DNO on capacity at a specific site of interest.

A.35 As noted above, grid connection is a particularly key consideration for ground mounted solar developments, as additional grid connections cost, such as long cable distances and additional substation requirements, can significantly hinder the economic viability of this technology in the current post-subsidy climate. General commentary was provided on the

[74] BEIS (2023) Renewable Energy Planning Database: quarterly extract - January 2023. Available at: https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract.

current state of grid capacity within Runnymede to inform the assessment of deployment potential. Further consultation where possible with the local DNO was undertaken to inform commentary on this topic.