UK GBC

The voice of our sustainable
built environment

REPORT 4

RENEWABLE ENERGY PROCUREMENT

The role of the built environment in decarbonising the UK's electricity system

AUGUST 2023

UK Green Building Council
ukgbc.org

ADVANCING NET ZERO

ACKNOWLEDGEMENTS

UKGBC PROJECT TEAM

AUTHORS

Tom Wigg
Emily Dodkin

EDITORS

Smith Mordak
Yetunde Abdul
Brooke Penman

RENEWABLE ENERGY PROCUREMENT WORKING GROUP

UKGBC would like to sincerely thank all members of the Working Group for their feedback, assistance and contributions over the course of the project.

ACCLARO ADVISORY
Brenda Sullivan

AMBER
Nick Proctor

AMPERSAND
Greg Borel

BURGES SALMON
Emma Andrews

BURO HAPPOLD
Ben Richardson

CBRE
Rebekah Needham

DERWENT LONDON
Samantha Carlsson

GROSVENOR
Andy Haigh

HOARE LEA
Laurence Johnson

JLL
David Mead

LANDSEC
Andy Mazzucchelli

LOW CARBON ALLIANCE
Simon Crowe

MACFARLANES
Alexander Crockford

SAVILLS
Phil Pearson

STANHOPE
Nils Rage

SYZYGY
Kirsty Berry

THE CROWN ESTATE
Kyle Gray

TURLEY
James Blake

We would like to thank the organisations below for their input during the development of this suite of guidance.

ARUP, CORNWALL INSIGHT, ECOTRICITY, ENERGYTAG, ENGIE UK, ETHICAL POWER, GOOD ENERGY, GOOGLE, GRANULAR, NPOWER BUSINESS SOLUTIONS, PERSE ENERGY, RE100, RE-SOURCE, RIPPLE ENERGY, TOTALENERGIES, UNIFY ENERGY, USWITCH, ZTP

ADVANCING NET ZERO PROGRAMME PARTNERS

bam
Berkeley Group
BURO HAPPOLD
CBRE
GROSVENOR
HOARE LEA
ISG
JLL
LLOYDS BANKING GROUP
ROCKWOOL
Turner & Townsend

PROJECT PARTNERS

AmpersandPartners
Landsec
Low Carbon Alliance
MACFARLANES
STANHOPE

CONTENTS

REPORT 4

THE ROLE OF THE BUILT ENVIRONMENT IN DECARBONISING THE UK'S ELECTRICITY SYSTEM

SECTION 4.0

INTRODUCTION TO THE 'WHY'

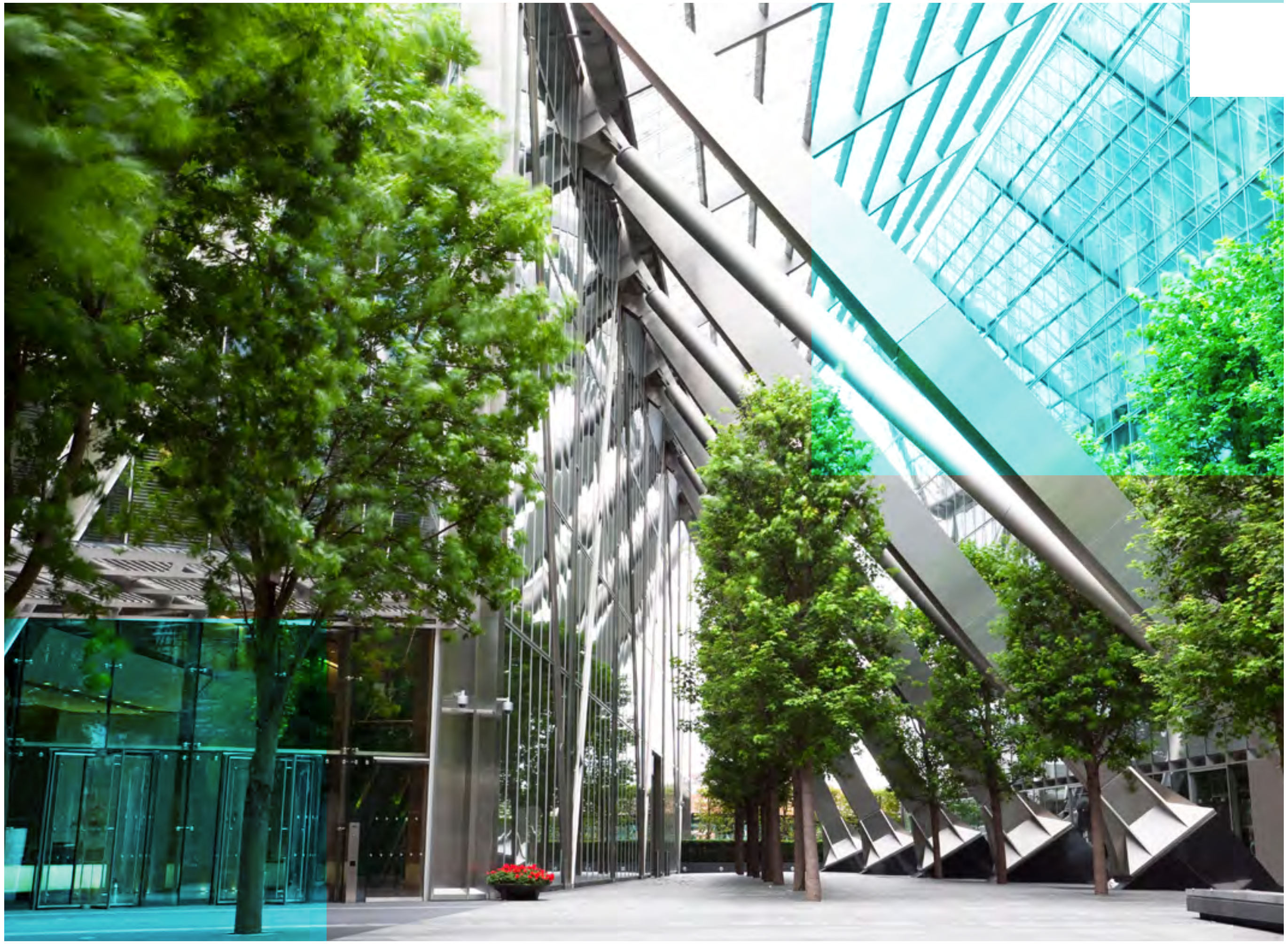
This report is the last in the series of four guidance documents on the topic of renewable energy procurement – this time focussed on the 'Why'.

It outlines why decarbonising the electricity system is critical in delivering against our national Net Zero target, and explores the challenges in doing so as we move to electrify heat and transport and transition from fossil fuels to intermittent renewable power.

It summarises the energy markets, the principles for quality electricity procurement that can help drive this transition, and the evolution in approaches to energy management and the energy products being offered that are required to enable a resilient, decarbonised electricity grid.

It describes the sources of emissions that result from the consumption of electricity and covers approaches to account for these emissions.

This report is important, contextual information which provides the rationale and reasoning behind the guidance on the 'How', presented in Reports 1 to 3.



SECTION 4.1
THE ELECTRICITY MARKET AND WHOLE SYSTEM DECARBONISATION

THE PHYSICAL SYSTEM

The electricity grid must operate at a constant frequency: when energy is taken from it, the frequency drops and this must be replenished by energy put in by electricity generators. This means that all energy on the system is 'pooled' – there is no way to distinguish in physical terms the electricity provided by a gas turbine or a wind farm.

Electricity networks are unique in the fact that the entire system is balanced by a central operator – in the case of Great Britain, the National Grid Electricity System Operator (ESO). They track and forecast supply and demand on a second by second basis to keep the system stable [1].

The electricity system is separated into the transmission network and a number of distribution networks. The transmission network is managed and controlled by National Grid ESO and transmits energy between the distribution networks, which are separately managed by local Distribution Network Operators (DNOs) and deliver the power to homes and buildings.

Historically, the flow of energy has been primarily 'one way' – from the large, industrial-scale coal- and gas-fired power plants on the transmission network, through the distribution networks, to consumers. However, as we transition to a higher proportion of renewable generation and storage connected to the distribution networks (including both smaller-scale commercial generators and 'behind the meter' building-level solutions), this 'decentralisation' results in much greater 'two-way' flow of energy. This is making it more challenging for National Grid ESO to balance this system and, as a result, many DNOs are transitioning to become Distribution System Operators (DSOs), taking a more active role in the management of the flow of energy within the distribution network and to the transmission network.

As well as the increasing number of decentralised generators being connected to the grid which necessitates more active management, other changes are causing challenges for the system. A transition from traditional forms of generation, that can increase or decrease their output in response to the demand (such as gas turbines), to intermittent renewable generation (such as wind and solar), means the grid is less equipped to handle times of peak demand on the system.

Low carbon solutions are being implemented at a grid level to manage times when demand exceeds supply, such as energy storage (including both short-term and seasonal), but more typically this demand is currently met through fossil fuel generation. At a local grid level, 'flexibility services' help overcome constraints, where DNOs pay consumers to reduce their demand at specific times. With solar and wind accounting for 29% of annual generation in the UK in 2022 [2], times where supply exceeds demand are also increasing in frequency, and this often leads to the output from wind farms being curtailed, wasting valuable zero carbon energy.

Due to this, it is increasingly evident that in order to enable an electricity system that can operate at net zero carbon, there is a need to build in greater levels of flexibility at the demand side. Delivering and operating buildings as active components of the energy system will, therefore, be of greater importance to decarbonising in line with our Net Zero target.

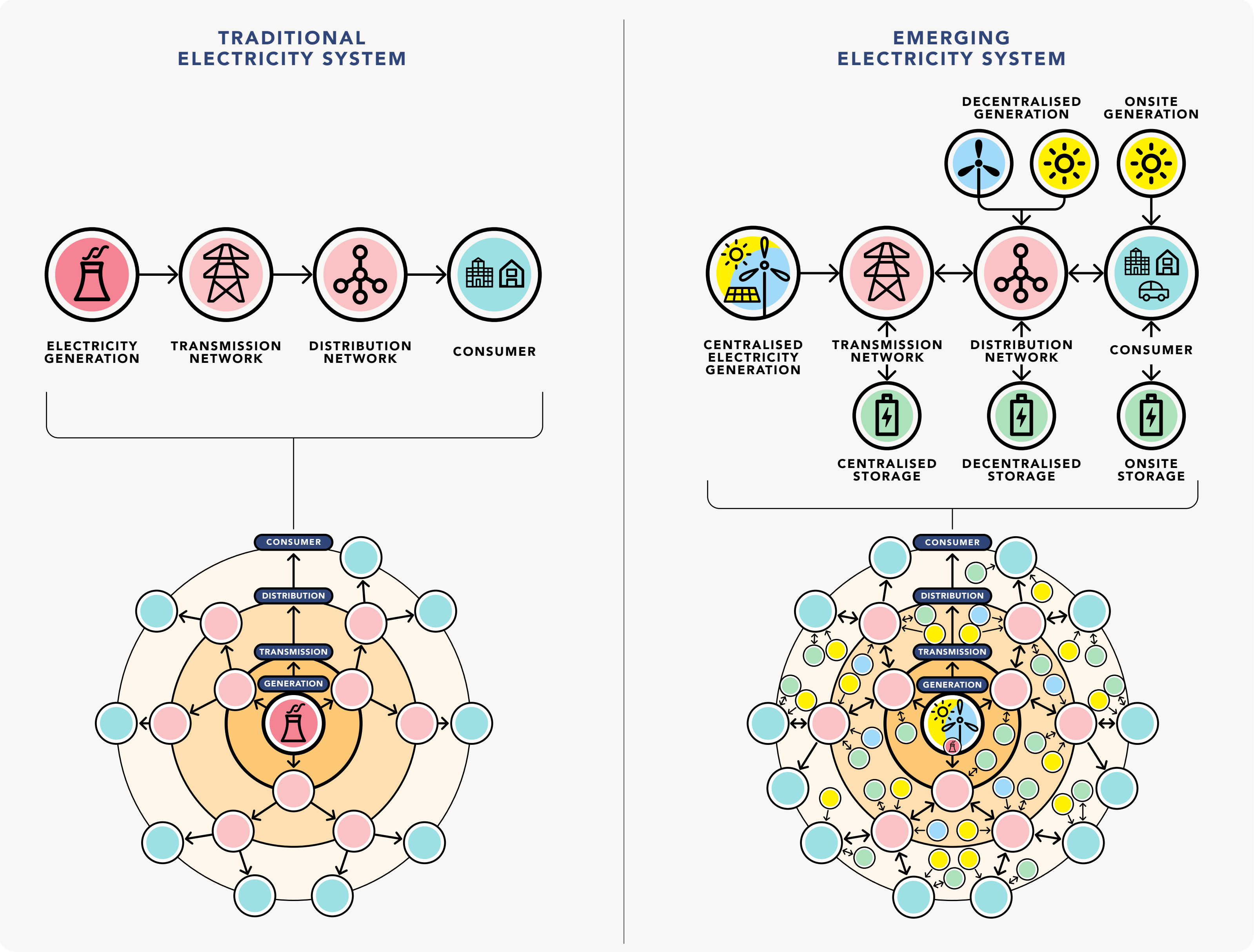


FIGURE 1:
Diagram showing the increasing complexity of the energy flows within the emerging electricity system compared to the traditional electricity system.

KEY TO SYMBOLS

- WIND GENERATION
- SOLAR GENERATION
- FOSSIL FUEL GENERATION
- TRANSMISSION NETWORK
- DISTRIBUTION NETWORK
- NON-RESIDENTIAL PROPERTY
- RESIDENTIAL PROPERTY
- ELECTRIC VEHICLE
- BATTERY STORAGE

THE MARKETS

Due to the fact that the GB electricity grid is one connected system, trading the 'physical' energy from generator to end customer – as you would other commodities – is not possible in most cases. Instead, specific market mechanisms are used to govern the sale of energy within the system.

As well as generators who create the power and the customers who use it, there are two other main participants in the electricity markets. These include suppliers, who buy electricity from generators and sell it to customers, and flexibility providers, who sell services which enable the system to be flexible to changes in supply and demand.

Suppliers sell electricity to customers on the retail market. They source this electricity through three key mechanisms:

- **Purchase from the wholesale market** – the way many suppliers source the majority of their electricity in GB, generators sell power to suppliers at a single price, set at a national level.
- **Direct contracts with generators** – rather than purchase entirely from the wholesale market, some suppliers engage directly with generators, procuring power through a contract called a Power Purchase Agreement (PPA).
- **Self-owned generation** – some suppliers have a proportion of their energy that is supplied from generators that they own and operate.

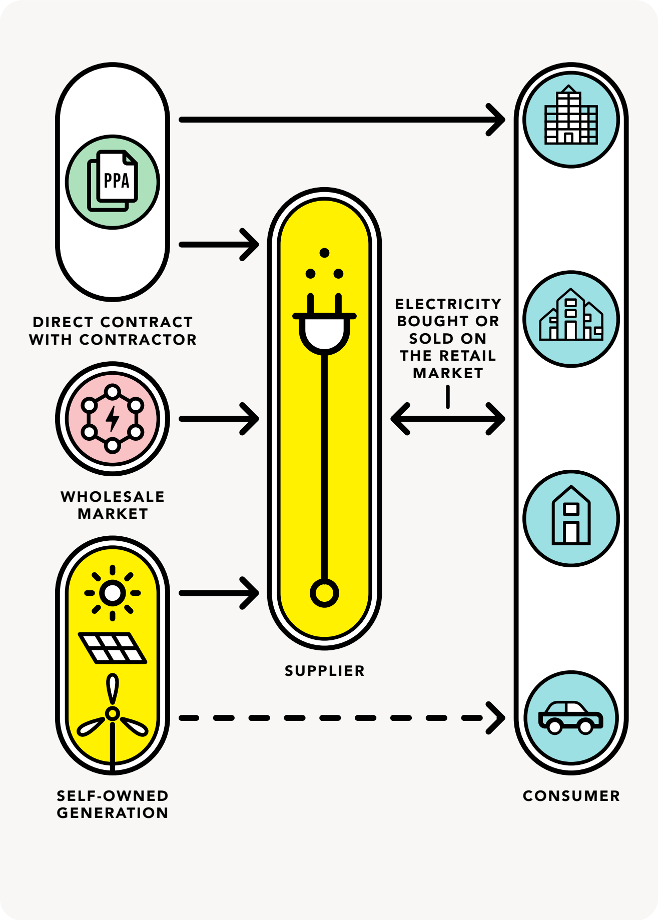


DIAGRAM 1: Diagram of the UK electricity market.

The price of electricity on the wholesale market is the cost of meeting the fluctuations in demand on the grid at any given time. Most of the time, the price is linked to the cost of the gas to supply the power plants that are meeting the remaining demand after non-fossil fuel sources are used up.

Basing the cost of all electricity sold on the wholesale market to this 'marginal' cost has been a major contributor to the energy crisis experienced in 2022. Gas provided under half of total electricity in the UK in recent years, but has set the price of electricity 84 per cent of the time [3]. As renewable generation is now typically cheaper than gas (it has high initial build costs but very low operating costs), if the retail price of electricity was based on the average cost to generate all electricity in the UK, bills would be substantially cheaper.

With most suppliers exposed to the wholesale market, the majority of customers in the UK share this exposure over the long term through the price they pay for electricity. Other than generating energy onsite (e.g., using solar panels), or owning a generator offsite, the most effective way for a consumer to avoid this exposure is to enter into a direct contract with a generator. As with energy suppliers entering into PPAs, this contract between an end consumer and a generator allows the price of electricity to be set independently of the wholesale market if desired. There are a number of forms a PPA can take and they can pose constraints due to being technically and legally complex. It is for this reason that most customers in the UK opt for a tariff, product, or contract offered by an energy supplier.

The range of different procurement routes in which a commercial customer can engage, including both supplier tariffs and PPAs, are summarised in Report 2.

DECARBONISING THE ELECTRICITY SYSTEM

A net zero power sector by 2035 is central to the UK meeting its carbon budgets and is still an achievable target, according to the Climate Change Committee's (CCC's) 2022 report Delivering a reliable decarbonised power system [4] [5]. However, in order to meet this target, a number of substantive changes to the electricity system and markets are likely to be needed.

The Department for Energy Security & Net Zero (DESNZ) **Review of Electricity Market Arrangements (REMA)**, published in 2022 [6], consults on changes to electricity market design to deliver their objectives of fully decarbonising the system, guaranteeing security of supply, and being cost-effective – shielding customers from increasing energy prices and providing value for money to the taxpayer. It proposes market changes to increase investment in generating capacity and system flexibility, minimise system cost, and manage price volatility.

The National Audit Office (NAO) has reviewed DESNZ's progress in decarbonising the electricity system since it set its 2035 target in 2021 [7]. It highlights the need for rapid and substantial investment in renewable generation and supporting technologies, and a need to modernise the system and markets to accommodate the intermittency of renewables and reflect the fundamentally different economic model of a renewable-led system in the price consumers pay. The report reiterates the **Climate Change Committee's (CCC's)** recommendation that the government creates a coordinated national delivery strategy to address these key challenges [8].

THE ROLE OF THE BUILT ENVIRONMENT IN THE ENERGY TRANSITION

Whilst a coordinated national strategy led by the government and the system operator has a primary role to play, customers can create the demand signals which are likely to influence the rate of change. Considering buildings, equipping them to become more flexible prepares them to engage with emerging energy products which help support wider system decarbonisation and resilience, whilst reducing the cost of energy to the consumer.

Later sections will outline how not all green energy products are created equal, and that the 'real' impact of electricity use varies substantially based on the decisions that customers make when procuring their energy.

SECTION 4.2
PRINCIPLES FOR QUALITY RENEWABLE ELECTRICITY PROCUREMENT

OVERVIEW

The unique mechanisms through which the electricity system is operated and energy is traded in the UK lead to challenges in assessing how 'green' the power being supplied to a customer really is. It is for these reasons that the v1 guidance introduced three principles for quality renewable electricity procurement.

These three principles of 'energy attribute', 'renewable sourced', and 'additionality' are still valid indicators of the quality of a procurement strategy, reflecting the carbon impact of the energy being consumed as well as contributing to wider system decarbonisation.

However, whilst the v1 guidance identified what best practice procurement responding to these three criteria looks like, these options are typically only accessible to a small fraction of the market. The guidance identified direct Power Purchase Agreements (PPAs) with new renewable generators and 'high quality' green tariffs from suppliers as two of these options, but stakeholders implementing the original guidance responded that these exemplar approaches are not available to most.

Rewarding the most ambitious players in the market, whose characteristics enable them to engage in such strategies, is important. This update still recognises those stakeholders who are pushing the envelope with their approaches to procuring electricity, but also reflects the range of different options available to built environment stakeholders, and gives the tools to help those procuring energy assess to what level their procurement is reducing emissions and driving system-wide decarbonisation. These guidance and tools can be found in Reports 1 to 3.

It is not realistic to expect all customers in the energy market to immediately transition to the most ambitious procurement strategies, and the greatest pace and scale of change will not be achieved by letting perfect be the enemy of the good. For this reason, this version does not present the principles of good quality procurement as absolutes, but rather recognises that there is a spectrum of performance and consequent impact in driving the decarbonisation of the energy system. In addition, the guidance also responds to factors of emerging importance, such as the need to enable greater flexibility to support the transition to a resilient, net zero carbon electricity grid.

PRINCIPLES FOR QUALITY RENEWABLE ENERGY PROCUREMENT

Reflecting this, the quality of renewable electricity procurement can therefore be established based on its performance against the following three principles:

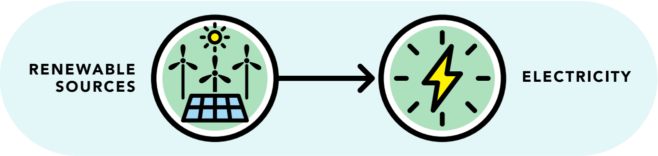
1. **RENEWABLE** – the proportion of the electricity that is from renewable sources, supplied with the associated energy attributes (e.g., REGOs).
2. **ADDITIONALITY** – to what extent it contributes to creating additional renewable capacity or supporting technologies/infrastructure.
3. **TIME-MATCHED** – the proportion of electricity consumed that is matched with renewable generation at an hourly resolution or better.

The following subsections explain the principles and the rationale behind them. Based on this, the recommended actions to respond to the three principles described in Report 1 were developed.

RENEWABLE

What is renewable energy?

The United Nations (UN) describes renewable energy as 'energy derived from natural sources that are replenished at a higher rate than they are consumed' [9]. When it comes to renewable electricity, it is the source of the energy used to generate the electricity that matters.



Fossil fuels

Fossil fuels such as coal and gas have provided the fuel to deliver the overwhelming majority of our electricity for the last 100 years [10]. Only in the last decade have efforts been made to actively transition away from fossil fuel sources due to the high amount of greenhouse gases that are released when they are burned. In 2021, 45 per cent of electricity was produced from fossil fuel sources, compared to 71% in 2011 [11] [12].

This reduction has been achieved by transitioning away from fossil fuels to renewable alternatives. The UK Government defines the sources that can claim to be renewable in the UK. However, whilst all are renewable in the sense that they are able to be replenished naturally, not all achieve the same level of emissions reductions and some have broader considerations that affect their suitability as energy sources to support the net zero transition.

Clean energy

Many renewable energy sources fall into the broader categorisation of 'clean' energy. Clean energy sources are those which are zero carbon, but not necessarily renewable, and also encompasses those technologies used to facilitate the decarbonisation of the wider system or other industrial processes.

Nuclear

The most common clean but not renewable electricity source – and one that experiences continuing controversy – is nuclear power. Nuclear power is not renewable as there is a finite (albeit plentiful) quantity of suitable radioactive material on Earth. It is controversial due to the nuclear waste that it produces and its relatively high build and running costs compared to technologies such as wind turbines and solar panels.

Proponents of nuclear argue its value in delivering a consistent and controllable output which can help support the system when renewable output is low. The UK Government, Climate Change Committee, and National Grid ESO Future Energy Scenarios all include some level of nuclear power in their 2050 Net Zero scenarios, so it appears likely that nuclear power will have a role to play in the future energy system [13] [14] [15]. As of summer 2022, nuclear power was included in the EU Taxonomy as an environmentally sustainable economic activity [16], and the 2023 UK budget includes a £20bn commitment to small-scale nuclear and carbon capture technologies [17].

However, those opposed to nuclear power highlight its high cost and long build times as a significant barrier to its ability to contribute to the immediate emissions reductions that are needed to tackle the climate crisis.

Hinckley Point C will be the first new UK reactor since Sizewell B began operating in 1995 and will deliver 3.3 gigawatts of power when it is completed, currently scheduled to be 2027 [18]. It was awarded a guaranteed price for its electricity by the government of £92.50/MWh in 2012, which rises with inflation and equates to around £140/MWh in today's money.

Compare this cost to the 7 gigawatts of new offshore wind, due to be completed by 2025, the government has secured for the price of £37/MWh in 2022 [19], and it's possible to conclude that new offshore wind can be delivered roughly five times faster and generate power four times cheaper than new nuclear. However, this is not a truly fair comparison, as nuclear plants can provide consistent generation, whereas wind and solar are dependent on the weather conditions. National Grid ESO anticipate that between 3 and 5 per cent of GB's future generation mix will come from nuclear power, so it is likely to have a role to play in a decarbonised electricity system. But the proliferation of relatively cheaper intermittent renewable generation can be supported by the deployment of grid-scale energy storage and incentivising demand-side flexibility to minimise the capacity of other dispatchable generation types that is required.

Nuclear power is very low carbon and will probably have a place in the UK's net zero transition. However, consumer demand and the way in which buildings procure and manage electricity is unlikely to accelerate the deployment of new nuclear generation nor impact how effectively nuclear power supports the system's decarbonisation, as it can for renewable power. This, along with the noted controversy to which nuclear power is subject, led to the decision to focus this guidance on renewable electricity sources only.

Biofuels

Whilst wind and solar – which are projected to become the dominant sources of renewable electricity in all net zero scenarios – are generally well supported, other renewable sources are more problematic. Whilst biomass is net zero carbon if managed correctly due to the carbon that is absorbed when it grows, it has been the subject of global controversy, as trading of biomass is known to result in double counting of the emissions reductions in some cases. As biomass produces CO_2 and other GHG emissions when burned, if the carbon deficit it creates when grown is counted twice or more, the net emissions impact at a global level is significant.

Some biomass and other organic feedstocks grown to create biofuels and biogas also utilise land that could otherwise be used for growing food. With the deforestation that is already happening in many places in order to grow feed for livestock and humans, encouraging an increase in demand for biomass and biofuels has the potential to exacerbate this existing issue.

Despite this, National Grid ESO Future Energy Scenarios conclude that bioenergy carbon capture and storage (BECCS) – where biofuel is grown capturing carbon, then used to generate electricity where the resultant CO_2 is captured and stored – is a critical component of a decarbonised electricity system. The 'negative' emissions produced by the process are likely to be needed to offset other hard-to-abate sectors such as aviation, shipping, and agriculture.

It is important to note that, whilst **just as polluting as coal** if the feedstock is not regrown, this is a supply chain issue, not a fuel issue [20]. If the source and supply of biomass is managed responsibly and accounted for accurately, it can meaningfully offset fossil fuel generation and has the advantage of being dispatchable (i.e., creating electricity on demand).

Waste incineration

Waste incineration is another such controversial energy source. The UK Government deems waste incineration – where domestic and other waste is burned to produce power – to be **'only partially renewable due to the presence of fossil based carbon in the waste'** [21]. This means that waste incineration produces between **0.7 and 1.2 tonnes** of CO_2 for every tonne burnt [22]. Considering approximately **550kWh of electricity are generated for every tonne of waste** [23], this is **over nine times the average carbon content of electricity in the UK in 2021** [24]. Whilst waste incinerators employ processes to scrub the outgoing emissions, as well as substantial GHG emissions, the fumes can also contain a number of toxic chemicals.

Hydrogen and carbon capture

Hydrogen is an emerging energy source. As well as providing a potential route to decarbonising industrial processes and as a direct fuel source for buildings (producing heat using a hydrogen boiler), it can also be used to support a decarbonising electricity grid by providing a longer term 'vector' for storing energy. Hydrogen can be produced in a number of ways. The two key low carbon approaches are green hydrogen, where renewable electricity is used to electrolyse water into hydrogen and oxygen, and blue hydrogen, where natural gas is reformed through an industrial process to produce hydrogen and CO_2, the latter of which is captured and stored.

Green hydrogen could be useful in utilising times of high renewable output but low demand on the grid to store energy long term that would otherwise be wasted. However, the process of electrolysing water, storing the hydrogen, and then using it to generate electricity at a later date is relatively inefficient. Blue hydrogen is predicated on the development of effective carbon capture, utilisation, and storage (CCUS), where GHG emissions from a process are captured and stored indefinitely so as not to contribute to global heating. There are few examples of CCUS being implemented in the UK, and as the CCUS process does not prevent all of the CO_2 from escaping to the atmosphere, the resultant hydrogen can only be considered low carbon. Whilst blue hydrogen is argued to be advantageous from an energy security perspective, as it can make use of existing natural gas supplies, the technology to produce it at scale is currently too immature.

Energy storage

Energy storage is another clean technology that is not considered renewable but is certain to have an important role to play in the future UK energy system. Energy storage can take many shapes, from a hot water cylinder in a home to a grid-scale lithium-ion battery with a 1 gigawatt output, as well as more novel examples such as liquid air or molten salt energy storage. Irrelevant of the type, as we move to a higher proportion of intermittent renewables and electrify heat and transport, the need for a means to store energy will increase.

What renewable energy sources are preferable?

This context is important in demonstrating that not all renewable energy is created equal. If you are a stakeholder in the built environment with agency over your energy procurement, then engaging in a strategy that supports the energy sources that will most robustly and rapidly decarbonise the built environment and the electricity system allows you to proactively drive change.

It is for this reason that this guidance update identifies a number of priority renewable energy sources from those defined by the UK Government – these are shown in Table 1.

PRIORITY RENEWABLE SOURCES	
Wind	**Ocean energy**
Solar	**Hydropower**
Geothermal	**Aerothermal**
Hydrothermal	
OTHER RENEWABLE SOURCES	
Biomass	**Biogases**
Landfill gas	Waste incineration*
Sewage treatment plant gas	Green hydrogen
CLEAN ENERGY SOURCES	
Nuclear	Energy storage
Blue hydrogen	Carbon capture and storage

TABLE 1:
Summarising the priority sources, other sources, and clean sources of energy. Items in pink are those identified by the UK Government as being renewable.

CHARACTERISTICS OF PRIORITY RENEWABLE ENERGY SOURCES

Whilst this guidance does not preclude the use of other renewable sources defined as renewable in legislation, it encourages the use of renewable sources that:

- Don't generate carbon emissions at the point of use (unlike any combustion-based renewable sources such as biomass, biogas and other renewable gases).
- Don't require significant imports of the fuel which can reduce energy security and risk double counting of the carbon benefit (such as biomass).
- Are not the result of man-made activities (e.g., landfill gas and sewage treatment gas), as demand signals for these technologies do not drive additional capacity in the same way, due to them being tied to other processes.

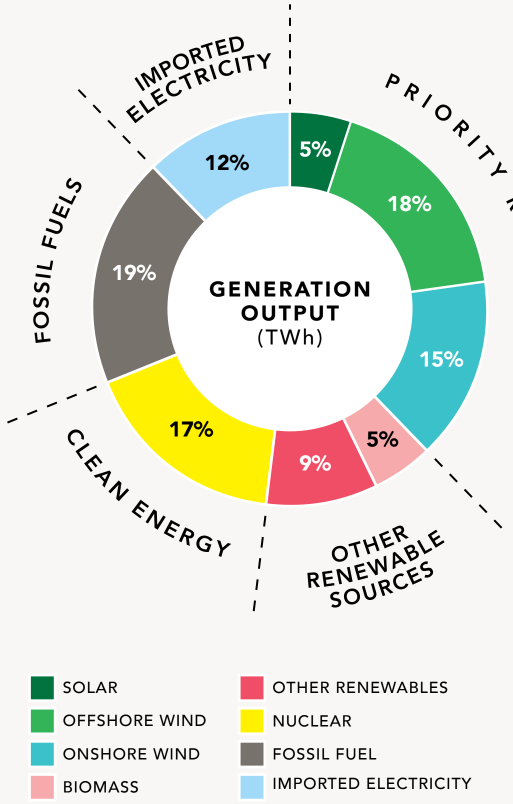


FIGURE 2:
Annual generation mix of the GB grid in 2021.
Source: National Grid Future Energy Scenarios 2022 [15].

What is the energy attribute?

For every megawatt hour of renewable electricity produced by a commercial generator, an accompanying Energy Attribute Certificate (EAC) is created. This represents the 'proof' of the zero emissions associated with that unit of power.

TYPES OF RENEWABLE CERTIFICATES USED GLOBALLY

'Energy Attribute Certificate' (EAC) is the general term for the range of renewable certificate mechanisms used globally. **Renewable Energy Certificates (RECs)** in North America, **Guarantees of Origin (GOs)** in the EU, and **International Renewable Energy Certificates** in a growing number of countries in Asia, Africa, the Middle East, and Latin America are all examples of EAC schemes. The UK has a system closely linked but independent from the EU GO system, utilising **Renewable Energy Guarantee of Origin certificates (REGOs)**. To help avoid the carbon benefit of renewable power does not get double counted, the unique certificates are retired on their respective tracking systems once 'used'.

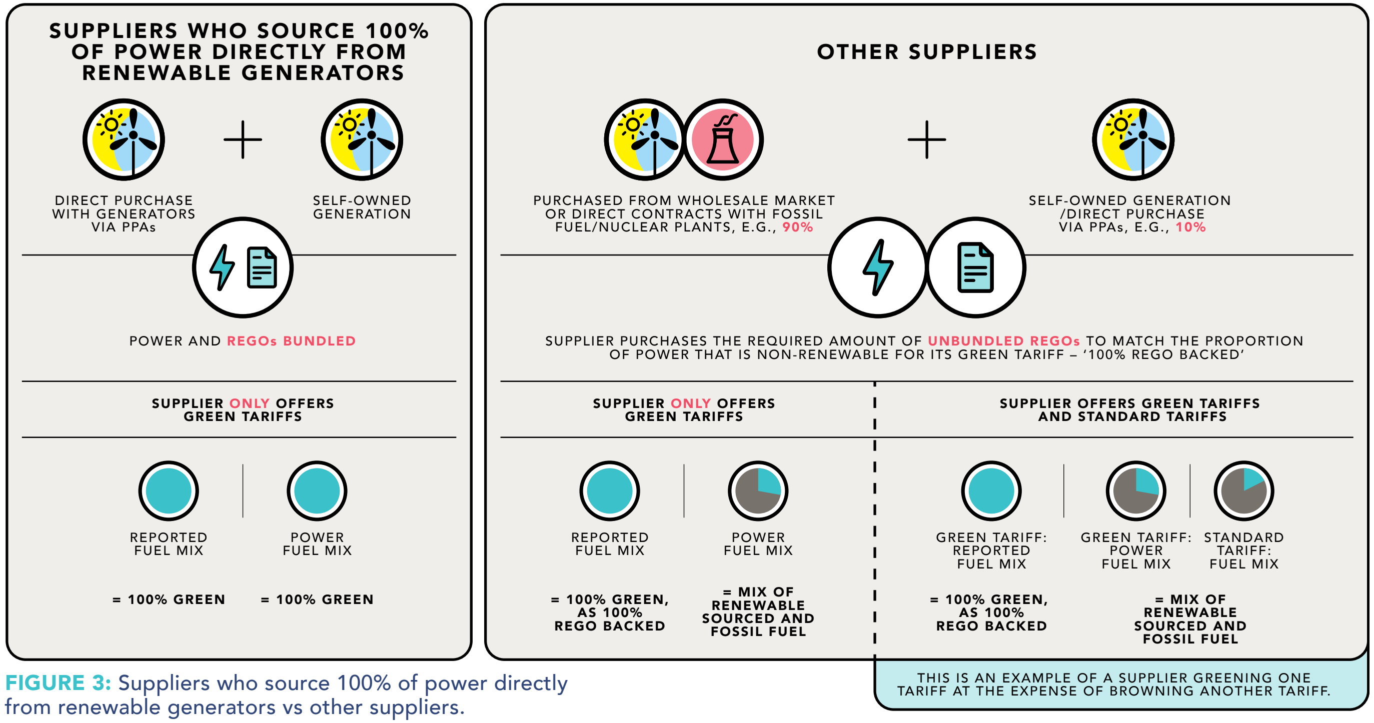


FIGURE 3: Suppliers who source 100% of power directly from renewable generators vs other suppliers.

The electricity and the certificate can be sold together – so called 'bundled' power. However, a quirk of this certificate-based framework is that there is no obligation to sell the EAC bundled with its electricity. All electricity on the wholesale market in the UK is sold 'unbundled' – or without the associated REGOs. This means both suppliers and end customers can purchase the REGOs from renewable generators separately to the power sold on the wholesale market. This allows them to green their tariffs and consumption respectively.

For suppliers, this approach allows them to procure energy from the wholesale market – whose mix of renewables and fossil fuels varies constantly – and still offer 100% renewable electricity tariffs, even though the constituent electricity is not necessarily from 100% renewable sources. In fact, the vast majority of suppliers and their tariffs are exposed to the wholesale market in some way, so it's very rare that a 'green tariff' is actually comprised of 100% renewable energy.

For end customers, by purchasing REGOs at an equivalent quantity to their annual energy consumption, they are able to claim zero emissions under the market-based (see Section 4.3) reporting allowed under the GHG Protocol Scope 2 Guidance, irrelevant of where their energy is sourced.

The price of an EAC is independent from the price of the power, but is dependent on the demand for them and the available supply. When demand increases, the price typically follows. In the UK, the average price of REGOs increased from 48p/MWh in April 2021 to £2.66/MWh in October 2022 – a 5.5x increase in 18 months [26].

What are the key considerations relating to EACs?

Whilst REGO-backed electricity tariffs have been the primary green offering from suppliers in the UK for some time, there are some important considerations when it comes to their effectiveness in driving system decarbonisation and in calculating the true impact of the electricity consumed.

Firstly, the location of the generator matters. The GO market in Europe allows certificates to be traded across the continent, irrespective of whether the power from that generator is even supplied to the same electricity grid.

Double counting of the zero emissions benefit of renewable power can also occur. If one building calculates their emissions using a location-based approach (where the average grid carbon factor is used) and another calculates their emissions using a market-based approach (where they claim zero operational emissions due to procuring a certificate-backed tariff or purchasing certificates themselves to green their consumption), the zero emissions from that renewable power has been counted twice. Once when the first building uses the carbon factor of the grid which is based on the overall mix of generation feeding the system (including the generator who produced the certificate), and twice when the second building claims the zero emissions benefit of the certificate from that power.

If any renewable power for which REGOs have been sold is removed from the total generation mix feeding the UK grid, the residual grid mix and associated carbon intensity can be calculated. A market-based framework can only avoid double counting if the emissions resulting from all consumption not matched by REGOs are calculated using this residual carbon factor. This is explained in more detail in Section 4.3.

The difference in the total mix and the residual mix of the UK grid is shown in Figure 4. Renewables make up around 45% of the total grid mix, but less than 5% are not 'claimed' through the sale of their associated REGOs. This shows the magnitude of double counting that can occur where both location-based and market-based accounting approaches are used.

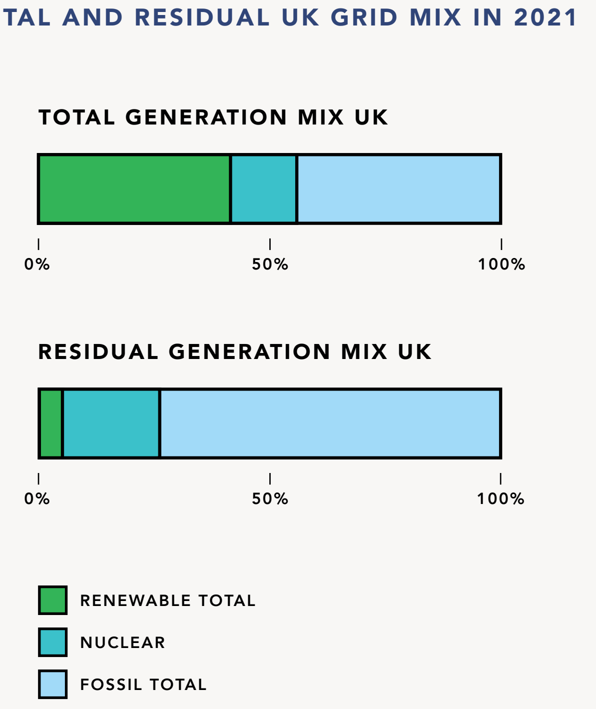


FIGURE 4: Graph showing the difference between the UK's total generation mix and the residual mix once all renewable power covered by renewable certificates has been removed. Source: International Energy Agency [26].

It is for this reason that, to claim net zero carbon, the v1 guidance required that operational emissions be calculated and offset using a location-based approach in all but very specific cases, even if a REGO-backed tariff has been procured.

The **International Energy Agency (IEA)** notes that, in principle, this market-based approach increases demand for clean electricity, leading to greater investment in renewables [27]. However, they identify the UK as an example of where the majority of renewable generation is simply reallocated to customers who opt in, so does not contribute to creating additional renewable generation which offsets existing fossil fuel sources. This concept of additionality is central to driving the energy transition and is discussed later in this section. Whilst the price of REGOs has increased substantially over the last few years, the cost still only equates to a fraction of a penny per kilowatt hour, which it would be hard to argue is actively contributing to new green generation over and above other market forces. However, with increased temporal granularity to better reflect the intermittency of renewables (see 'Time-matched' section) and at the right price point, they may be able to create effective funding streams for new renewable capacity.

How renewable are typical green products?

There are two key routes to procuring renewable energy in the UK:

- **Green tariffs/contracts**
  A supplier provides you with power and can fully match this supply with an equivalent number of REGOs, which are retired on your behalf.
- **Power Purchase Agreements (PPAs)**
  A contractual agreement directly with a renewable generator who supplies your power with the associated REGOs or retires them on your behalf.

Comparing one to the other, PPAs are typically considered the greener option, as 100 per cent of the power supplied via them is from renewable sources bundled with the REGOs from the generator itself. Whilst there are various permutations of PPAs which are discussed in Report 2, their legal, financial, and technical complexities make green electricity tariffs/contracts with suppliers a more attractive option for most consumers. However, due to the minimum qualification of a green tariff/contract being simply to demonstrate that 100 per cent of the supply volume is matched with renewable certificates, the proportion of a green tariff that actually comes from renewable sources is incredibly variable.

Taken to an extreme, a supplier could procure energy via PPAs with fossil-fuel generators and then 'green' this with by purchasing unbundled REGOs to offer a renewable product. More typically, the supplier will procure their energy from the wholesale market, which is likely to be comprised of a combination of renewable and non-renewable sources, and again match this with unbundled REGOs.

Alternatively, a supplier can procure some or all of its energy via PPAs with renewable generators or from their own renewable assets. The more exposed a supplier is to the wholesale market, the less a supplier can claim to be directly supporting the operation and construction of renewable generating capacity. As such, a higher proportion of self-owned or PPA-contracted renewable generation in a supplier's mix is preferable.

What does good look like?

The minimum qualification of renewable energy procurement is the ability to demonstrate that all electricity procured is matched with an equivalent number of renewable energy certificates. For the reasons listed previously, these must be REGOs from UK generators and should be from priority renewable sources as far as possible. These should be retired on the **Renewables and CHP Register** by the consumer (if purchased directly) or on the consumer's behalf (if energy is procured through a green tariff/contract or a power purchase agreement) [28].

The v1 guidance required that 100 per cent of the energy procured be from renewable sources. However, unless engaging in a PPA with a renewable generator to cover the entirety of your supply volume (which is very rare – typically only a fraction of energy demand would be secured via a PPA), your energy consumption is likely to, in some part, be met by supply from the wholesale market.

The Uswitch Green Accreditation provides a rating for domestic green energy tariffs that reflects their overall quality. Their 'Gold' rating requires that **100 per cent of the supplied volume for the tariff is renewable** [29]. It provides a useful precedent for defining a good practice threshold for the proportion of a supplier's mix that comes from renewable sources. To achieve a 'Silver' rating, a supplier's tariff must be comprised of a minimum of 43 per cent renewable electricity from self-owned or PPA-contracted assets. This reflects the proportion of **UK generation coming from renewable sources in 2020, according to National Grid** [30].

HOW RENEWABLE ARE RENEWABLE TARIFFS?

Even many of the greenest suppliers, who do not offer a 'standard', non-renewable product, procure a proportion of their supply from the wholesale market, which is likely to come from a mix of renewable, fossil fuel, and nuclear power. In fact, it is larger suppliers, who have enough self-owned and PPA-contracted renewable generation in their mix to meet all the energy demand from customers on their green tariffs, that may be able to offer a product that can claim to be 100 per cent from renewable sources. However, the supplier will preferentially allocate their renewable generation to their green products, which can result in a 'browning' – or increasing the carbon intensity – of their other products. They should not, therefore, be automatically preferred over suppliers offering only green products who are not afforded this ability.

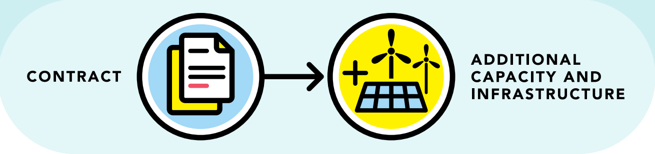
Whilst fundamentally related to the proportion of the supply that is sourced from renewable generators, this accounting quirk that allows suppliers to green one tariff by browning another, is related to the principle of additionality, which is covered later. Under 'renewable', the proportion of energy procured that is sourced directly from renewable generators should be maximised, but should be considered carefully alongside the principle of additionality, remembering that a higher proportion of renewables without considering the wider context does not necessarily equate to better quality procurement.

ADDITIONALITY

What is Additionality?

In the context of renewable energy, procurement which demonstrates additionality leads to real and verifiable emissions reductions that would not have happened if that procurement had not taken place. Whilst simple in principle, in reality it is complex.

ADDITIONALITY IS ACHIEVED WHEN ENTERING INTO AN ENERGY CONTRACT RESULTS IN THE CREATION OF RENEWABLE CAPACITY AND INFRASTRUCTURE.



When procuring a renewable energy product in the UK market in line with the principle of 'renewable', unless you are procuring a PPA with a brand new generator, you will be taking a share of the renewable electricity that already exists. This means that by claiming the zero emissions benefit of your procurement, you are causing the electricity being consumed by others on the system who are not procuring a green product to be more carbon intensive. At a national level, if using a market-based approach, the emissions for those on 'standard' tariffs (not REGO-backed) are around 50% higher than the grid average based on the residual emissions factor [31]. Put another way, unless new renewable capacity is created, the net emissions of the overall system remain unchanged in spite of a new renewable product being purchased.

To deliver real emissions reductions, the act of procuring renewable energy should contribute to the creation of additional renewable generation. This new capacity offsets existing fossil fuel generation on the grid, driving the decarbonisation of the system as a whole.

It is for this reason that additionality has been a central tenet of high quality renewable procurement for some time and one of the three principles it was necessary to robustly demonstrate to claim net zero carbon for operational energy emissions under the v1 guidance. The original guidance identified two routes to demonstrating additionality for electricity procured:

- A PPA contract with new unsubsidised renewable generator
- A 'high quality' green tariff

A PPA with a new unsubsidised renewable generator provides direct and demonstrable financial additionality – the generator is constructed due to the income stream the contract guarantees for the generator and without any support from government subsidies. In a way, the government's Contracts for Difference (CfD) subsidy model – where a guaranteed price for the electricity (in £/MWh) is promised for a given number of years – offers the same financial security as many PPA models for generators. It is for this reason that unsubsidised generation is argued to be preferable when a corporate is engaging in a PPA directly.

However, the argument that additionality can only be demonstrated where a contract directly funds the construction of a new renewable generator which then supplies the customer securing the PPA is an oversimplification. In fact, it can be limiting for corporates wishing to secure PPAs if they have to wait many years from signing the contract to actually receiving the power from that generator.

Energy suppliers can have a longer term view, investing in developing their own generation or engaging in PPAs with new generators that are yet to be constructed using the profits they make from selling energy to customers. However, when a customer signs up to a tariff with an energy supplier, they will naturally be receiving a share of the renewable energy already in the supplier's mix. This means any additionality to which their contract with the supplier contributes will not be realised until such a time as new generation funded by the supplier is operational.

The v1 guidance defined a 'high quality' corporate electricity tariff as one that comes from a supplier that has achieved derogation from the Ofgem price cap for a domestic tariff, by demonstrating that they are investing any profits over and above the price cap directly in new additional renewable generation. However, this is an imperfect proxy, as the derogation does not relate to the business tariffs offered. Furthermore, it does nothing to value the energy suppliers who have not been granted derogation, but are actively investing in additional capacity. It is for this reason that this guidance provides tools to better assess the extent to which a supplier meets the principle of additionality to inform procurement decisions.

The reducing cost of renewables and high price of electricity on the wholesale market is also changing the picture with respect to additionality. Offshore wind secured a 'strike price' in the 2015 CfDs of around £115/MWh, whereas in 2022 this had reduced to just £37/MWh, making wind and solar now the cheapest forms of new generation on the grid [32]. With the wholesale price of electricity averaging £50/MWh between 2001 and 2022 and peaking at nearly £800/MWh last year [30], government-subsidised generators have paid back millions to the taxpayer in energy profits over and above the strike price they were guaranteed, as is the requirement of the CfD model. In the six months of Q4 2021 and Q1 2022, renewable generators returned £275m to the treasury under the scheme [34].

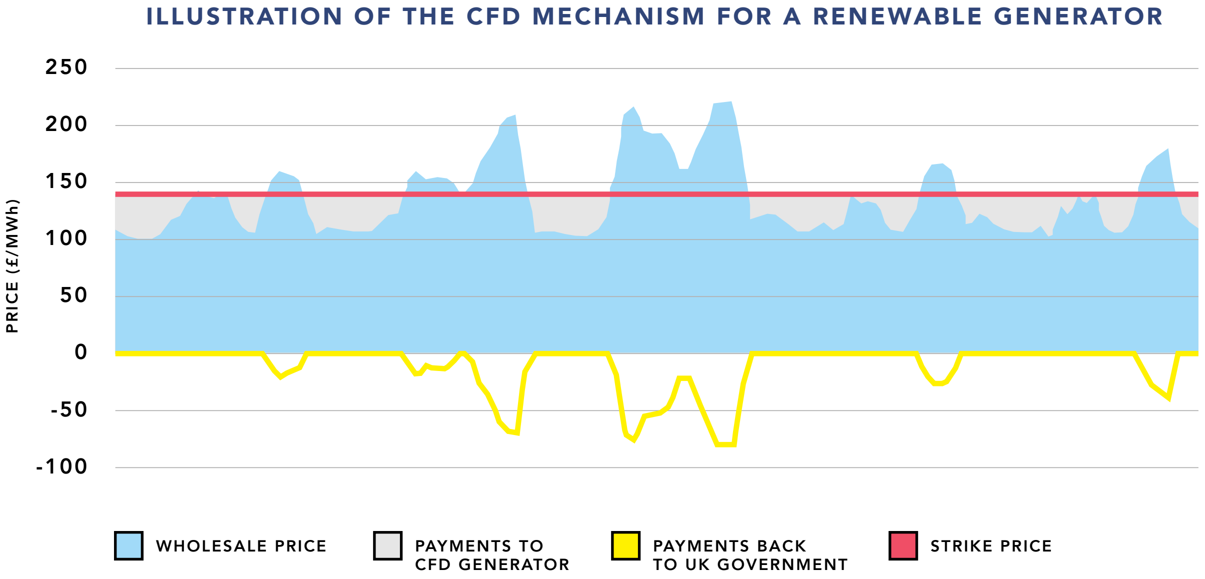


FIGURE 5:
Graph illustrating the UK's Contracts for Difference (CfD) mechanism in action. Source: Low Carbon Contracts [35].

This situation means that the business case for developing new renewable generators can be made on the basis of the wholesale price of electricity alone, unlike historically where new generation could rarely be delivered without the security of government subsidies or a PPA. The IEA describes additionality in the context of corporate procurement as that which 'adds to existing government targets and the schemes to achieve them' and 'provides financing for deployment that otherwise would not be cost-effective or for which investment would not take place'. As such, in the current market, delivering against these principles, when new renewable generation is the cheapest on the grid and is now often profitable without subsidies, becomes challenging.

There will also come a point in the future where the electricity system is fully decarbonised and any new demand on the grid is met by renewables. At such a point, the principle of additionality will no longer be a determinant of procurement quality in the same way. However, with such a rapid transition still necessary to achieve the 2035 target of a net zero grid, it will be an important factor for the foreseeable future.

How can the principle of additionality be demonstrated today?

Considering these complexities in demonstrating the principle of additionality is met, this guidance update proposes a more flexible, pragmatic approach, focused on driving the fastest deployment of renewable capacity to progress the decarbonisation of the system.

In addition to new renewable generating capacity, other enabling technologies will be necessary to deliver a resilient electricity system. This will include energy storage and transmission and distribution infrastructure to accommodate the additional demand on the grid, as well as a need for research and development to develop the novel technologies known to be needed to support the energy transition and mature them ready for wide scale use.

The importance of energy storage

National Grid's Future Energy Scenarios (FES) 2022 net zero-aligned scenarios project that nearly six times more (an additional 190 gigawatts) solar and wind power could be needed by 2050 than currently exists, but this will need to be supported by between 30 gigawatts and 50 gigawatts of electricity storage, excluding hydrogen and vehicle-to-grid capacity [15]. Energy storage does not contribute to the conventional definition of additionality, but is absolutely essential for supporting the intermittent renewables that will be the primary generation source on the UK grid in future. Whilst energy storage does not deliver the direct emissions reductions that new renewable generating capacity does, it can displace fossil fuel generation used to meet peak demand in the same way and is critical to the overall decarbonisation of the system. For these reasons, this guidance supports that both investment in new renewable generating and energy storage capacity can claim to achieve the principles of additionality.

Repowering existing generation renewable generators reach the end of their operational life, there is often the opportunity to 'repower' them, rather than completely deconstruct them. Repowering renewable assets again does not always contribute to additional capacity, but it does retain capacity that would otherwise be lost. As such, this guidance supports that investment in repowered assets can also meet the principle of additionality.

Subsidy-supported generation

On the topic of subsidised generation, it is true that new generation more strongly demonstrates additionality if it is not subsidised by government support schemes like the Contracts for Difference or otherwise. However, suppliers who contracted with early generators when renewable supply could not be delivered without subsidy support should not necessarily be seen as worse than those who are heavily investing in new renewables now they are profitable. In fact, it can be a positive indication of a supplier's ambition and progressive nature if their mix contains a high proportion of older renewables, and they can show that they proactively contributed to additional renewable capacity when support was needed more directly.

Energy suppliers

At a supplier level, the principle of additionality is achieved where any new customer's demand is met by new renewable generation. With the long lead times to deploy new generators, it can take years for the act of a customer contracting with a supplier to result in this new generation being operational. With a consistent stream of new customers, and income, a supplier should be able to demonstrate continuous investment in new capacity and supporting technologies.

However, a small supplier which secures a large new customer may have to procure supply to meet that additional demand from the wholesale market in the short term. This should not necessarily reflect poorly on them, provided they can demonstrate that in the long term that the additional revenue generated by supplying the new customer is reinvested in creating new renewable generating assets. For these reasons, other more qualitative factors can be an important indicator for meeting the principle of additionality alongside the volume of new capacity delivered in the short term.

Responding to this, this guidance supports that when procuring an electricity tariff, the onus should be placed on suppliers to demonstrate how they are aligned with the principles outlined in this section. Report 3 gives metrics to use to engage with energy suppliers that can act as a proxy for additionality, but a more qualitative assessment should not be avoided – it is advised to welcome an energy supplier to justify how they are meeting the principle of additionality in the way they feel is most effective. The Uswitch Green Accreditation for domestic tariffs provides a precedent for this, where the 'Gold' rating is given based on a combination of performance against quantitative metrics and a qualitative review by a panel of experts of any further information the supplier can provide to reinforce their claims of providing high quality green products [29]. This includes contributing to system-wide decarbonisation through additional generating capacity, storage, and broader interventions like supporting energy efficiency and the decarbonisation of heat and transport.

What role do renewable certificates play?

According to the CCC, the structure of the certificate system may 'never provide prices high enough that will act as a support mechanism for new generation on its own' [36]. However, if the certificate market was evolved to better reflect the interventions necessary to deliver system decarbonisation, they could provide an important tool.

Two such ways are to increase the granularity of renewable certificates to be at a resolution of an hour or less, rather than annually as they are currently, and with this greater resolution create a framework where stored renewable energy can be traded in a similar way.

This is covered in more detail in the 'Time-matched' section, but in relation to additionality, by tracking and selling renewable energy and storage at an hourly/sub-hourly level, and only enabling the zero emissions benefit of that power to be claimed against energy consumption in the same time period, strong demand signals are created for the type of generation and storage capacity that has highest value to the overall electricity system. Whilst this may not lead to the greatest amount of additional capacity, it can drive the creation of the capacity that is most important to decarbonise the energy system and should therefore be valued under the principle of additionality.

In the current absence of such a sub-hourly certificate market, suppliers who are actively time-matching their customers' supply with renewable assets can use this as a part of their justification for meeting the principle of additionality.

How does onsite generation contribute?

Onsite generation – typically rooftop solar PV – provides credible emissions reductions and therefore most robustly responds to the principle of additionality. National Grid's Future Energy Scenarios (FES) 2022 projects that between 60GW and 90GW of solar PV will be required nationally to achieve net zero, of which 20GW to 40GW must be delivered on homes and buildings. To achieve these levels of onsite capacity requires a proliferation of rooftop solar panels. The UK Net Zero Carbon Buildings Standard will determine target levels of solar PV for all key sectors and building types.

What does good look like?

Ofter maximising onsite renewable generation, corporate procurement of a PPA directly with a new renewable generator still provides the most robust additionality. However, it can take years for a new generator to secure approval and be constructed, which is unlikely to be attractive for most corporate customers. Instead, where options to secure a contract with a new generator are untenable, corporates should seek to engage in a PPA with a recently constructed or repowered generator of a priority renewable type.

To achieve maximum additionality, a PPA with a generator that is built or repowered as a direct consequence of the contract (i.e., unbuilt) should be sought. However, if this is not possible/viable, as a minimum, a PPA should be with a generator that is less than 3 years old. This is the threshold proposed by the EU Delegated Acts on Renewable Hydrogen to ensure that a generator supplying an electrolyser to produce hydrogen is delivering additionality [37]. In this case, the generator's owner/operator should also demonstrate that they are actively investing in the construction of further generating assets or storage.

For energy tariffs, suppliers should provide evidence that they are actively investing in new, unsubsidised renewable generation and storage, either by constructing their own assets or contracting PPAs with new generators. This additional capacity should provide a supply volume that is equivalent to or greater than the demand from new customers of their green products (i.e., showing that the proportion of their other customers' supply coming from renewables is not reduced by the supplier taking on new customers). Given the time to deliver new generating assets, this can be assessed over a longer-than-annual period (e.g., five years).

Similarly, for suppliers offering renewable products alongside a standard tariff – where they allocate their renewable generation in a higher proportion to the customers procuring their green tariff – they should provide evidence that the 'green premium' on their renewable products is being reinvested in new capacity. Ideally, this capacity should entirely offset the extent to which their standard tariff is 'browned' as a result.

If suppliers already have a high proportion of self-owned or PPA-contracted generation in their overall supply mix (i.e., their supply to all customers, not just those on renewable tariffs), this is a good indication of their strong investment in the creation of renewable capacity and commitment to providing robust green products.

Where a supplier offers a time-matched product of equivalent quality to their other green tariffs, this should be prioritised over an equivalent annually-matched product.

TIME-MATCHED

What is Time-matching?

To understand the proportion of the electricity you consume that is generated by renewable sources, matching supply with demand on an annual basis is no longer sufficient. We need to transition to tracking consumption and generation at an hourly resolution or better.

The International Energy Agency (IEA) notes the important role that the annual matching of renewable generation to corporate demand has played in decarbonising electricity systems [27]. However, continued progress will require a varied mix of renewable energy, storage, and other clean technologies that can continue to meet demand as systems transition to a higher proportion of intermittent generation.

In the UK, this intermittency leads to a grid whose generation mix changes constantly. This, in turn, means the carbon intensity of electricity at any given time can vary substantially – not all electricity consumed is created equal. This requires a mindset shift compared to fuels such as gas, which result in the same amount of carbon emissions no matter when they are used. This is compounded by the fact that electricity has, to date, been priced at a flat rate for most customers and carbon accounting approaches use annual average emissions factors to calculate the impact of electricity consumed.

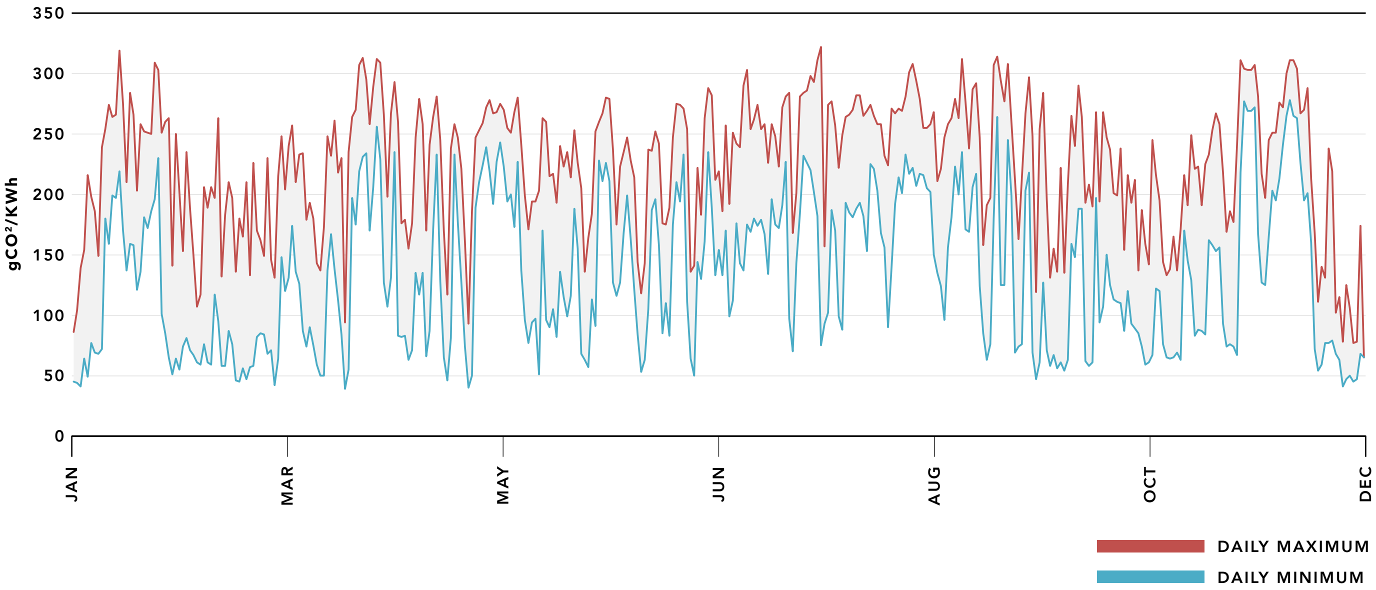


FIGURE 6:
Daily minimum and maximum carbon intensity of UK electricity generation in 2022. Source: carbonintensity.org [38].

Figure 6 shows the daily minimum and maximum carbon content of electricity in Great Britain during 2022. From this, the extent to which the carbon intensity varies on a seasonal and daily basis is evident. At times when demand is low and renewable output is high, the carbon intensity is low. Vice versa at times of peak demand on the system and there is a low proportion of renewables in the supply mix.

ISSUES WITH CURRENT ANNUAL MATCHING APPROACHES

As REGOs are currently matched on an annual basis, certificates from times of high renewable output and low carbon intensity can be used to offset emissions from times of high carbon intensity. Renewable energy from times of high supply and low demand is not as valuable to the system as generation during times of peak demand. Therefore, annual matching of REGOs can result in an inaccurate reflection of the net impact of that procurement, even ignoring the other noted issues with current market-based accounting.

Even if a customer procures electricity from renewable sources to meet 100 per cent of their energy demand over the course of the year – either through a direct PPA or an energy supplier who has sufficient self-owned or PPA-contracted renewable assets – the electricity being supplied won't actually be completely renewable all of the time. This is because the output from the renewable generators is extremely unlikely to perfectly match the demand profile of the customer.

As a result, annual matching (achieved with either renewable certificates or actual supplied volume) does not accurately reflect emissions associated with that electricity consumption.

Due to these issues with annual matching, some larger corporates and energy suppliers are beginning to assess the proportion of their or their customers' demand that is being met by renewable energy available for each hour of the year. This is then reported as a percentage over a month or year. The higher the percentage, the greater the proportion of renewables in the electricity actually consumed.

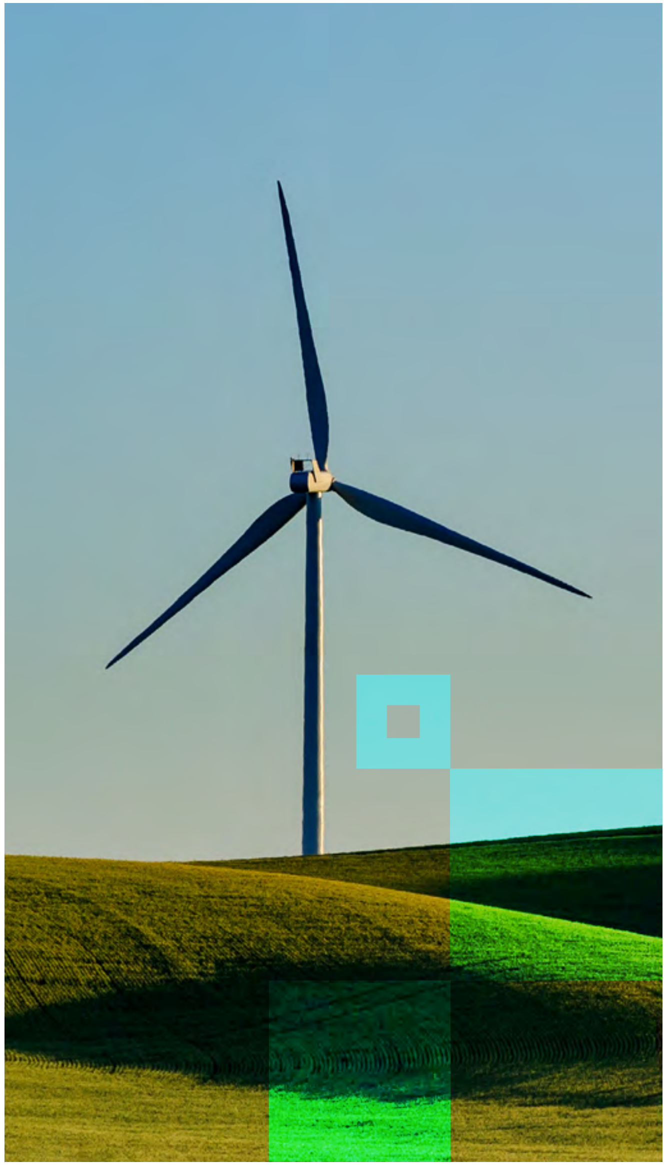
The end goal is to match carbon-free energy to demand, 24 hours a day, 365 days a year – so called 24/7 CFE. As part of their '24/7 Carbon-Free Energy Compact', the **UN notes** the importance of 24/7 CFE, recognising that **'It is both the end state of a fully decarbonized electricity system, and a transformative approach to energy procurement, supply, and policy design that is critical to accelerating its arrival.'** [39].

An increasing number of large global energy consumers have started to set 24/7 CFE targets, with the first step being to assess the proportion of their demand that is matched at an hourly/sub-hourly level and the second to begin actively procuring energy and flexing demand through management approaches and storage to increase the time-matched percentage.

Google – one of the UN Compact's 120 signatories – is one example, setting a target to achieve 24/7 CFE for its global operations by 2030. They are tracking their performance against this goal using a CFE 'score' for each of their major datacentres – a **methodology they created** [40]. The score out of 100 reflects the percentage of consumption that is time-matched with renewable electricity at an hourly/sub-hourly level. The energy supplier Engie worked with Google to **create a product that guaranteed achieving a CFE score of at least 80** over the course of the year for their two new datacentres in Germany – the first of its kind [41].

Whilst achieving 80 per cent time-matching for energy consumption may seem a long way from the 24/7 CFE goal, it represents a significant evolution from typical procurement approaches. Firstly, managing the increased data burden created by tracking demand and supply at an hourly resolution or higher, and secondly, promising a substantially greater proportion of hourly-matched carbon-free supply than is generally achieved via standard annual-matching routes.

A study by **Technische Universität Berlin** using energy systems modelling showed that, in Europe, if a customer relies on grid purchases alone, with no directly-contracted assets or active time matching, only around 60 per cent of demand is likely to be met with carbon-free energy [42].



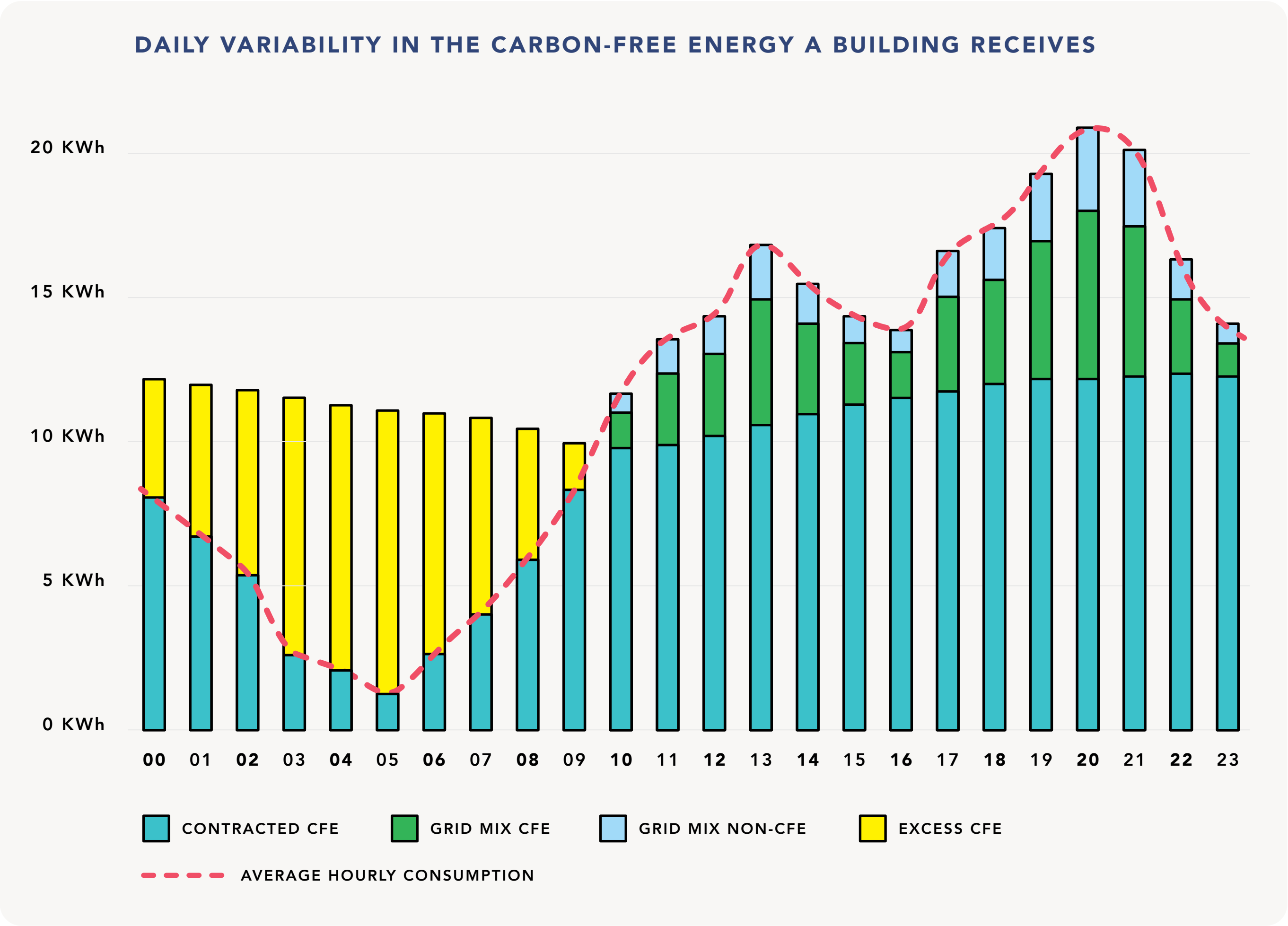


FIGURE 7:
Illustration of how the carbon-free energy (CFE) a building receives varies throughout the day.
Source: adapted from FlexiDAO [59].

Why is Time-matching important?

The Climate Change Committee identifies that 'Low-carbon flexibility will be needed on a range of timescales, to ensure the system is balanced both in the shorter-term (e.g., seconds, minutes, hours) and the longer-term (e.g., days and weeks)' to deliver a reliable decarbonised power system [5]. However, current annual matching approaches do not value the supporting technologies that will deliver this flexibility.

Whilst matching certificates and renewable power on an annual basis can create demand signals for new renewable capacity, these signals are primarily for the cheapest forms of generation which, in the UK, are solar and wind. Significant new wind and solar is needed to decarbonise the grid, but as we transition to a higher proportion of renewables, the importance of technologies that can support meeting demand with this inherently intermittent supply increases. Without a way to differentiate the benefit of storage and dispatchable (on demand) forms of generation to the system through the market, procurement does little to drive the deployment of this critical supporting infrastructure.

INTERNATIONAL ENERGY AGENCY (IEA) MODELLING HIGHLIGHTS THE IMPORTANCE OF TRANSITIONING TO HOURLY/SUB-HOURLY MATCHING

The IEA notes that 'Even before companies engage in large-scale deployment of 24/7 CFE-type strategies… market-based premiums for large-scale renewable energy can encourage deployment of technologies that generate at the times and locations that provide the greatest value for the system.'

From an emissions reduction perspective, IEA modelling also shows the reducing value of annual matching approaches as the grid transitions to a higher proportion of renewables. In India, where variable renewables accounted for around 15 per cent of total supply in 2020, employing annual matching approaches would achieve an emissions reduction of over 95 per cent. In a situation where the proportion of renewables on the grid rises to 50 per cent, emissions reductions from the same annual matching approach would almost halve. In the UK, where the proportion of wind and solar on the grid is already at 29 per cent [2], the ability of annual matching strategies to reduce customer's emissions is likely to already be substantially inhibited.

Moving from an annual to an hourly/sub-hourly approach of matching renewable energy to demand can create the investment signals for both renewable generation, storage, and other supporting technologies that reflect their relative value to the whole electricity system.

This can also help combat the unfair allocation of system costs that annual matching can cause, which the IEA highlights as an issue for regulators to address [27]. If corporate procurement drives additional wind and solar (with the benefit to the corporate of being able to claim zero emissions), the cost of providing the flexibility infrastructure to support the intermittency of those new renewables on the grid is not borne by the company, but by all consumers through their energy bills.

In their 2022 Review of Electricity Market Arrangements (REMA), the UK Government recognises that 'the increasing volume of variable renewables, such as wind and solar power, will pose great challenges for managing the electricity system' and the need for the market to evolve to 'unlock unprecedented levels of investment across the full range of low carbon technologies, including low carbon generation, electricity storage, and flexible demand from consumers' to support a fully decarbonised, cost-effective energy system [6]. Whilst the government's response to the consultation is still to be published, it demonstrates an appreciation of the need for the markets to effectively value flexibility in the energy transition.

How can renewable certificates be evolved to support the system transition?

ENTSO-E – the European Network of Transmission System Operators for Electricity – reinforces that the current certificate framework 'sends the wrong price signals' to both certificate buyers and developers of renewable capacity, as the price of certificates doesn't fluctuate based on the volume of renewable energy available at a specific time [43].

Time-based Energy Attribute Certificates (T-EACs) offer a potential solution. These more granular equivalents to traditional EACs (e.g., REGOs) contain additional information – most notably, they track when the electricity was generated at a sub-hourly level.

The market could work in much the same way as traditional EACs, with consumers purchasing certificates to negate the emissions from their energy consumption. However, they would overcome many of the issues with the purchasing of unbundled REGOs highlighted in earlier sections, as they would create effective demand signals for the type of renewable and flexibility capacity that is needed to meet a given customer's demand.

EnergyTag published a whitepaper in 2022 proposing a market framework for more granular certificates and Google is one of the first to be piloting a T-EAC-based approach to energy tracking. [44] [45]. Corporates procuring T-EACs can support the uptake of more granular energy tracking and in turn demonstrate more robust claims of emissions reductions through market-based mechanisms.

According to the IEA, more accurately tracking the origin of renewable electricity will be important in the production of fuels such as green hydrogen, which is expected to have a significant role to play in a decarbonised UK electricity system [15] [27]. The government's recent consultation on a UK Low Carbon Hydrogen Standard would require temporal matching at a 30-minute resolution [46]. T-EACs can help to ensure that the electricity used to create green hydrogen is zero carbon.

What role can energy suppliers play?

Most parties engaging in hourly or sub-hourly matching approaches currently are large, global corporations, whose approach to procuring energy typically involves very high volumes secured primarily through direct Power Purchase Agreements (PPAs). This is not typical of most customers in the UK real estate market, most of whom procure their energy as a tariff from an energy supplier.

This does not mean that typical consumers cannot demand or benefit from time-matched products. In fact, many energy suppliers have a strong opportunity to engage in time-matching due to the fact that they supply a large number of customers, which provides a more consistent, diversified demand profile, and they own or contract a broad range of generating and flexibility assets.

Procurement routes guaranteeing a carbon-free energy performance through active matching are still rare and only accessible to a very small fraction of the market. This may change quickly, however, if the demand for such products grows and the electricity markets evolve to better value more granular matching.

As a first step, suppliers can begin to track the percentage of their overall supply they are able to match at an hourly/sub-hourly level with renewable assets under their control. With specific customers, they can also explore what proportion of time-matched supply they can offer them based on their specific demand profile.

If suppliers are only time-matching a small number of their customers, they are likely to be able to achieve relatively good levels, as they have the ability to allocate the generation from their renewable assets serving all customers to those with time-matched tariffs as a priority, leaving other customers with the rest of the supplier's mix. This could result in the same potential accounting issues of 'greening' one tariff at the expense of 'browning' another discussed earlier in the 'Additionality' section.

However, as discussed, hourly or sub-hourly matching sends price signals for specific renewable types and other supporting technologies. If the supplier uses the 'green premium' on the tariff to invest in those technologies, so they can offer time-matched tariffs to more customers, this demonstrates additionality, results in emissions reductions, and contributes wider value to the energy system.

BENEFITS OF TIME-MATCHED PRODUCTS

Engaging in any sort of time-matched product in the current market should contribute positively to system transition and help build market maturity by:

- sending demand signals to suppliers for higher information resolution, quality, and transparency;
- differentiating the relative value of the range of types of renewable generation, storage, and supporting infrastructure needed to fully and resiliently decarbonise the electricity system;
- creating a market environment which can more easily transition to trading time-based renewable certificates in future.

What does good look like?

Time-matching is in its infancy, but has great potential to support more rapid, fair, and cost-effective electricity system decarbonisation. With the right market levers and consumer demand, the availability of time-matched products may increase quickly.

Given the immaturity of time-matched approaches and the lack of availability of necessary data to support them in some instances, consumers' focus should be on how to begin engaging and supporting the development and availability of time-matched products.

The **study from TU Berlin** referenced earlier, that suggests time-matching of around 60 per cent can be achieved with no active engagement for a customer in the European electricity system, also concludes that achieving matching of 90 per cent is possible with only a small cost premium compared to annual matching approaches (though, this comparative scenario does include a high proportion of PPA-supplied electricity). [42]. It also states that costs for achieving matching of above 95 per cent rise rapidly. These data provide useful thresholds that have informed the approach to rating a strategy's performance against the principle of 'time-matched', described in Report 3.

OTHER CONSIDERATIONS

Location

The potential issues with cross-border/energy system trading of renewable energy have already been noted. However, the location of renewable generation within an electricity system is a factor of increasing relevance when delivering system decarbonisation and resilience.

As well as the importance of temporal signals outlined in the 'Time-matched' section, the UK Government recognises the need for locational price signals in driving the electricity system transition in the UK [6]. Their Review of Electricity Market Arrangements (REMA) notes that this is due to the fact that renewable assets are likely to be located at the extremities of the network, and this can lead to physical constraints which can prevent the supply infrastructure from being able to meet demand, even if the renewable electricity is available. Locational price signals would encourage development of renewable generation, storage, and other flexibility assets at locations which minimise overall system costs.

Whether locational marginal pricing – where the cost of electricity on the wholesale market reflects the marginal cost of meeting demand specific to that location – is the right way forwards is still up for debate. The UK Energy Research Centre summarises that there are arguments both for and against its implementation in the UK electricity system [44].

As well as including more granular temporal information, updated renewable certificates could include locational information about where the electricity was produced. However, unlike time-matching, location-matching does not demonstrate the clear benefit in emissions reductions for consumers. In addition, locating assets for the greatest benefit to the system will be influenced by a much broader range of factors, mostly driven by transmission and distribution network operation. Locationality is therefore not considered a priority principle of good quality procurement at present, but may evolve to be so in future.

GEOGRAPHIC IMBALANCE OF SUPPLY AND DEMAND IN THE UK

In times of peak renewable output, the supply is rarely located where the majority of the demand is concentrated. Moving wind power from the North of Scotland, where most of the UK's wind power is located, to the South, where most of the demand occurs, requires substantial infrastructure. In times of peak wind output, the cables are simply not large enough to transmit all the power to where it is needed, and this results in a curtailment of the output from Scotland's wind farms, reducing the overall output from the UK's wind generators by 6% – a substantial amount of wasted energy. In 2021, the cost of turning off the UK's wind turbines rose to £500m, wasting 2.3TWh of zero carbon energy [47].

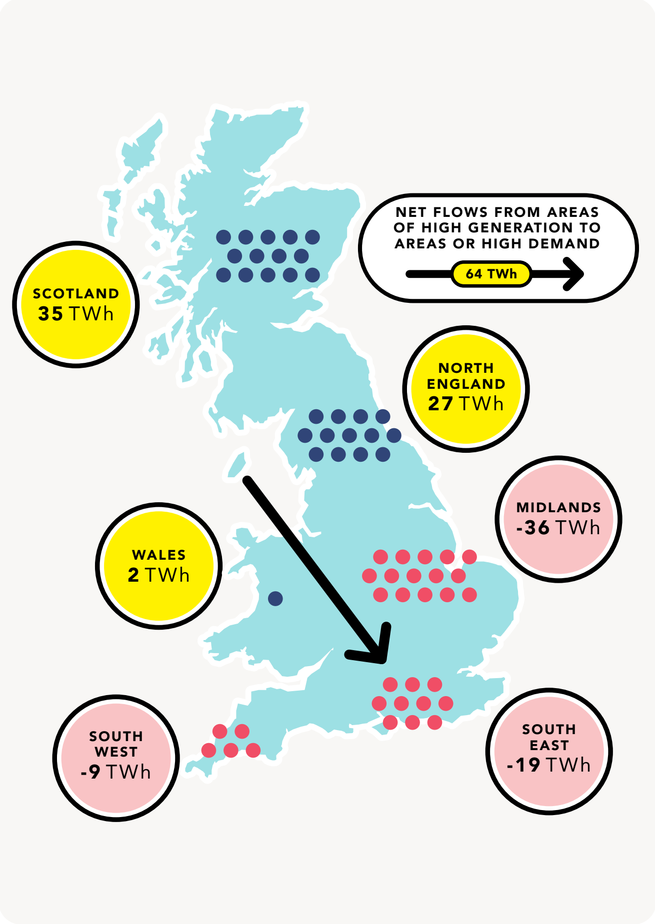


FIGURE 8:
Net regional renewable electricity generation and demand in the UK.
Source: National Grid Future Energy Scenarios (FES) 2022 [15].

Onsite generation and flexibility

The importance of matching renewable energy to demand at an hourly resolution or better, and supporting the deployment of grid-scale storage and other flexibility solutions in decarbonising the UK electricity system, is evident. But in addition to pursuing good quality energy procurement, buildings have a further role to play in enabling a resilient, zero carbon grid.

Onsite generation provides demonstrable emissions reductions and additionality, and rapid proliferation of rooftop solar PV is anticipated to be required to decarbonise the system. The higher the proportion of any onsite generation that is consumed on site, rather than exported, the greater the benefit to the grid. Any locally-generated electricity that is used on site can effectively be considered as time-matched (demand is being met by renewable supply at a granular level) and can contribute to the overall time-matched percentage (CFE score).

As well as self-consumed onsite generation, other demand flexibility can reduce the amount of electricity imported (e.g., by storing electricity generated from onsite solar PV), or help shift when that demand on the grid occurs to times of high renewable output and low carbon intensity (through energy storage or other systems that can manage demand). Both of these minimise the carbon content of the electricity being consumed.

Examples of tariffs where suppliers use price signals to help moderate demand to better match the available supply of renewables already exist in the market. In future, it's possible that suppliers could also send carbon signals to customers, for whom emissions reductions may be a more important driver than energy cost. In fact, due to the marginal cost of gas setting the electricity price on the wholesale market, in most cases, the lowest cost electricity will also be the lowest carbon, so corporates can realise both cost and carbon savings through engaging in demand flexibility.

The IEA recognises this and notes the potential for such demand response technologies to '**enable more cost-effective integration of variable renewables**' into the wider system, highlighting that hourly matching approaches drive corporates to pursue demand response where annual matching does not [27]. EnergyUnlocked highlight in their report '**The Hidden Carbon Economy**' that the benefits of flexibility are not confined to carbon emissions reduced (i.e., using lower carbon electricity) but also carbon avoided, where flexing demand reduces the marginal generation on the grid at peak times, further reducing overall emissions [49].

WIDER BENEFITS OF DEMAND FLEXIBILITY

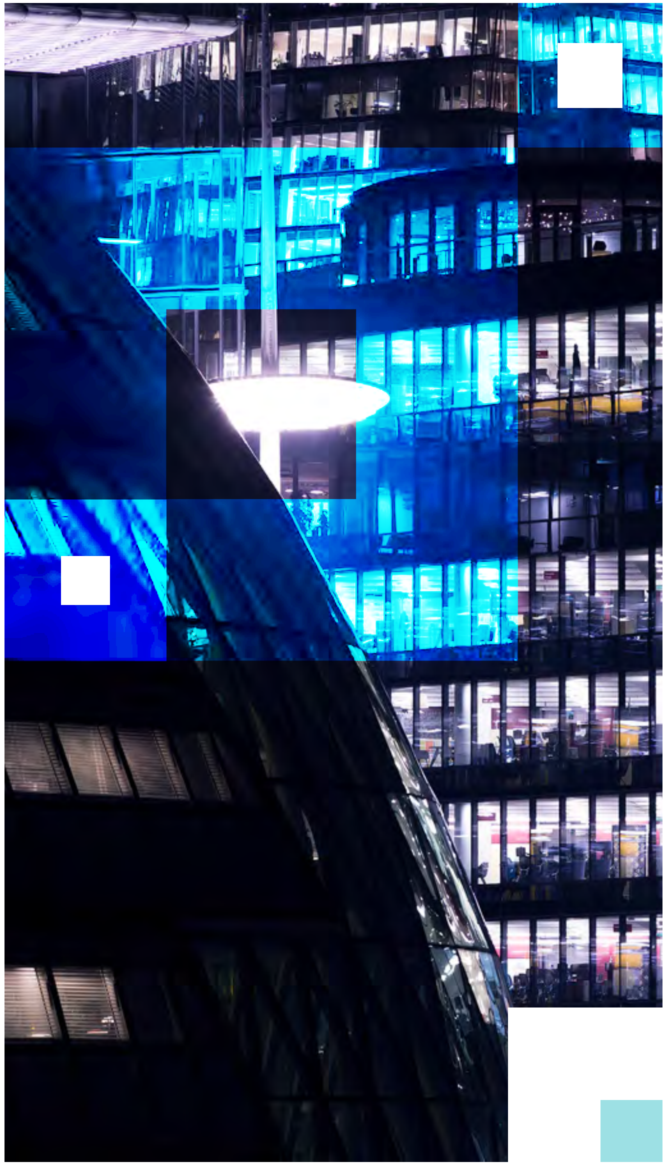
Demand-side flexibility also has broader potential benefits to the consumer than reducing carbon, capitalising on preferential electricity pricing, and supporting wider system transition and resilience. Many areas on the UK electricity network are already constrained, and in order for new demand to be introduced onto the system, additional network capacity is often required. Lead times for this can stretch into the decades and this can be a significant barrier to new development projects. However, if sufficient flexibility can be demonstrated to enable peak demand management and shifting, local distribution network operators may permit development sooner and also reduce typically substantial reinforcement costs.

For a new development, the potential benefits of demand-side flexibility and onsite generation can therefore be summarised as the 'Three Cs': cost, carbon, and capacity. Each development project, and the stakeholders who are involved in delivering and operating it, will give unique weight to each of the Three Cs based on its characteristics and context, but it is useful to consider the interdependencies between all three factors together to ensure an optimal outcome.

Interestingly, the EU has even gone as far as to recently redefine a '**zero emission building**' as one that has 'a very high energy performance, which contributes to the optimisation of the energy system through demand-side flexibility' [50].

To be aligned with net zero carbon goals and drive electricity system decarbonisation, buildings must, therefore, seek to maximise the amount of onsite generating capacity and embed technologies that allow them to maximise the amount of any generated electricity that is consumed onsite, as well as enabling them to flex their demand in response to carbon and price signals from the grid.

Whilst onsite generation and flexibility are not strictly related to the principles defining high quality renewable procurement, the operation of buildings has an equally important role to play in decarbonising the grid and onsite measures and offsite procurement must therefore work in harmony to support the energy transition.



SECTION 4.3
CARBON ACCOUNTING

Carbon accounting describes the process of calculating the greenhouse gas emissions associated with an action. In the context of electricity consumption, this is typically determining the carbon emissions resulting from the consumption of the electricity that a building or organisation consumes.

For electricity, accurately determining the emissions impact of consumption can be challenging for a number of reasons. This section summarises the various sources of emissions from the electricity system, the different approaches to accounting for these emissions, and considerations of how these should be applied in the context of the built environment.

SOURCES OF EMISSIONS FROM ELECTRICITY

Emissions result from the production and consumption of electricity from a number of sources. These are summarised in the Table 2 opposite.

TABLE 2:
Summary of the sources of emissions from electricity consumption.

GENERATION	Emissions from the process of generating the electricity. For example, the emissions produced when burning gas or coal to generate electricity using a turbine. A carbon intensity of generation, in kilograms of CO_2 equivalent per kilowatt hour of electricity produced (kgCO_2e/kWh), can typically be determined for each generator. Modern combined cycle natural gas turbines typically produce around 0.354 kgCO2e/kWh, whereas wind and solar are zero emissions at the point of generation [51]. The combination of all generation sources feeding into the grid at any one time results in an overall carbon intensity of generation for the electricity. The annual average carbon intensity is published by the government each year (0.193kgCO_2e/kWh for 2022) [52]. The carbon intensity at a half-hourly resolution is also available from carbonintensity.org.uk [38].	**SCOPE 2**
TRANSMISSION AND DISTRIBUTION	Whilst significant emissions are not directly produced by the transmission and distribution of electricity over the system, this process does result in losses, typically through heat lost through the wires, transformers, and substations. Losses in the UK system accounted for approximately 9% of all electricity production in 2021 [53]. Alongside the average annual emissions factor for electricity generation, the government also publishes the emissions associated with the losses for each kWh of electricity transported to the consumer over the grid – this was 0.018 kgCO2e/kWh for 2022 [52].	**SCOPE 3**
EXTRACTION, PROCESSING, AND TRANSPORT OF FUEL (UPSTREAM OR 'WELL-TO-TANK')	Before the gas, coal, oil, or other fuel is used to generate electricity, it must be extracted, processed, and transported to the generator, all of which result in carbon emissions. These so-called 'well to tank' (WTT) or upstream emissions are also published as a factor by the government, and equate to over 25 per cent of the emissions resulting from electricity generation, transmission, and distribution.	**SCOPE 3**
EMBODIED CARBON OF ELECTRICAL INFRASTRUCTURE	Much as with constructing a new building, creating new generating capacity and the supporting infrastructure has an embodied impact. Whilst zero emissions at the point of generation, the embodied carbon of solar panels is not insignificant. In 2020, work by Etude estimated the embodied carbon of building level solar PV panels to be around 0.020 kgCO_2e/kWh – though this is just a fraction of the equivalent emissions from generating electricity using even the best gas turbines at under 6 per cent [54]. Grid-scale solar farms are likely to perform even more favourably from an embodied carbon perspective.	**NOT TYPICALLY INCLUDED IN COMPANY REPORTING**
OTHER	Other sources of emissions, such as the operation and maintenance of generators and the system infrastructure, are also present.	**NOT TYPICALLY INCLUDED IN COMPANY REPORTING**

THE GREENHOUSE GAS (GHG) PROTOCOL

Most stakeholders in the corporate real estate market will be familiar, to some level, with the GHG Protocol and its requirements to report GHG emissions from corporate operations, including any real assets.

This subsection is not intended as a comprehensive summary of the GHG Protocol, for which extensive literature is already available, but to provide a brief overview of Scope 1, Scope 2, and Scope 3 emissions for context.

GHG PROTOCOL EMISSIONS SCOPES

SCOPE 1 emissions are direct emissions from sources that are controlled or owned by an organisation. This includes any onsite combustion, e.g., from gas boilers for heating, and from company vehicles.

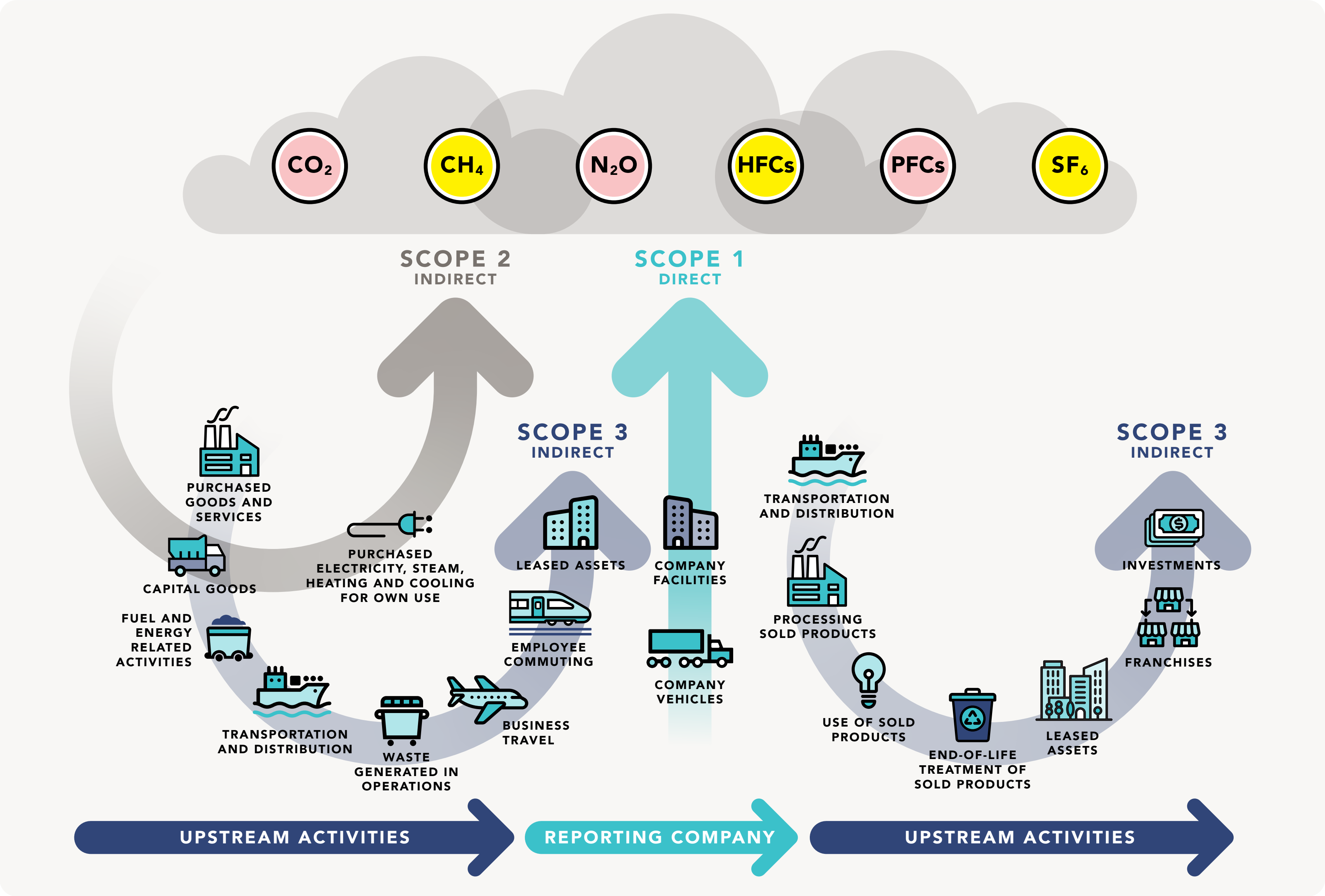
SCOPE 2 emissions are indirect emissions that result from the purchase of electricity, heat, or steam that is generated offsite. Considering electricity procurement, only the emissions associated with the generation of the electricity are included in Scope 2 reporting. Transmission and distribution losses are accounted for under Scope 3.

SCOPE 3 emissions are indirect emissions from sources that aren't owned or controlled by an organisation, but that they indirectly affect in their value chain. As well as transmission and distribution losses associated with electricity consumption, organisations should calculate and report the upstream or well-to-tank (WTT emissions). The embodied carbon and other sources of emissions resulting from the construction, operation, and maintenance of electricity of electrical infrastructure are not typically counted under an organisation's Scope 3 emissions.

The three scopes are illustrated above, taken from the World Resources Institute (WRI)/World Business Council For Sustainable Development.

Further guidance on Scope 3 reporting of emissions associated with fuel- or energy-related activities is also available [55]. This outlines that, for upstream emissions, either an average or supplier-specific approach to carbon accounting can be used. Availability of robust supplier-specific data for upstream emissions is unlikely to be available, so in most cases, grid average information – such as that provided by the UK Government in their '**Conversion factors for company reporting**' – should be used. Supplier-specific information for Scope 2 reporting may be available, and this is discussed in the next section [52].

FIGURE 9:
Illustration of the GHG Protocol's Scope 1, Scope 2, and Scope 3 emissions. Source: World Resources Institute [56].



CARBON ACCOUNTING APPROACHES

Location-based and market-based

There are two key approaches for accounting for emissions from electricity consumption. These are location-based and market-based.

The location-based method calculates emissions using the average emissions intensity of the entire system from which electricity is consumed, accounting for all the sources of generation feeding the grid. This emissions factor can be determined on an annual basis, as is used for national greenhouse gas reporting, or at a higher resolution (e.g., monthly, hourly, or half-hourly).

The UK Government publishes location-based emissions factors for use on an annual basis [52], while carbonintensity.org.uk – backed by National Grid ESO – publishes half-hourly location-based factors for more granular emissions accounting [38].

The market-based method reflects the GHG emissions associated with the procurement choices a consumer makes regarding its electricity supplier or products. The GHG Protocol identifies a hierarchy of different types of qualifying contractual instruments from which emission factors can be derived.

MECHANISMS FOR DETERMINING MARKET-BASED EMISSIONS FACTORS

Provided they meet the Scope 2 Quality Criteria, the following mechanisms can be used to determine the market-based emissions factors for electricity consumed:

- Energy attribute certificates, e.g., REGOs – the zero emissions associated with renewable electricity generation as verified by a certificate.
- Power Purchase Agreements with energy generators – the emissions intensity at the point of generation associated with a specific generator.
- Supplier or product-specific information from energy suppliers – the emissions intensity of a supplier or supplier's tariff based on their supply mix.

ROLE OF REGOS IN CARBON ACCOUNTING

In the case of the UK market, which implements a certificate-based renewables market, REGOs provide the primary mechanism through which the 'zero emissions' benefit of renewable electricity is typically claimed under a market-based approach. For renewable PPAs, the generator supplies the REGOs associated with the power and for green tariffs, the supplier secures sufficient REGOs to cover the entirety of the supplied volume, as a minimum.

Put simply, in the UK, if a consumer can demonstrate their electricity consumption is entirely matched with REGOs – either by procuring a green tariff, engaging in a PPA with a renewable generator where the power is supplied alongside the certificates from that generator, or by purchasing unbundled REGOs – they can claim zero Scope 2 emissions for the electricity consumed under a market-based approach.

Residual emissions

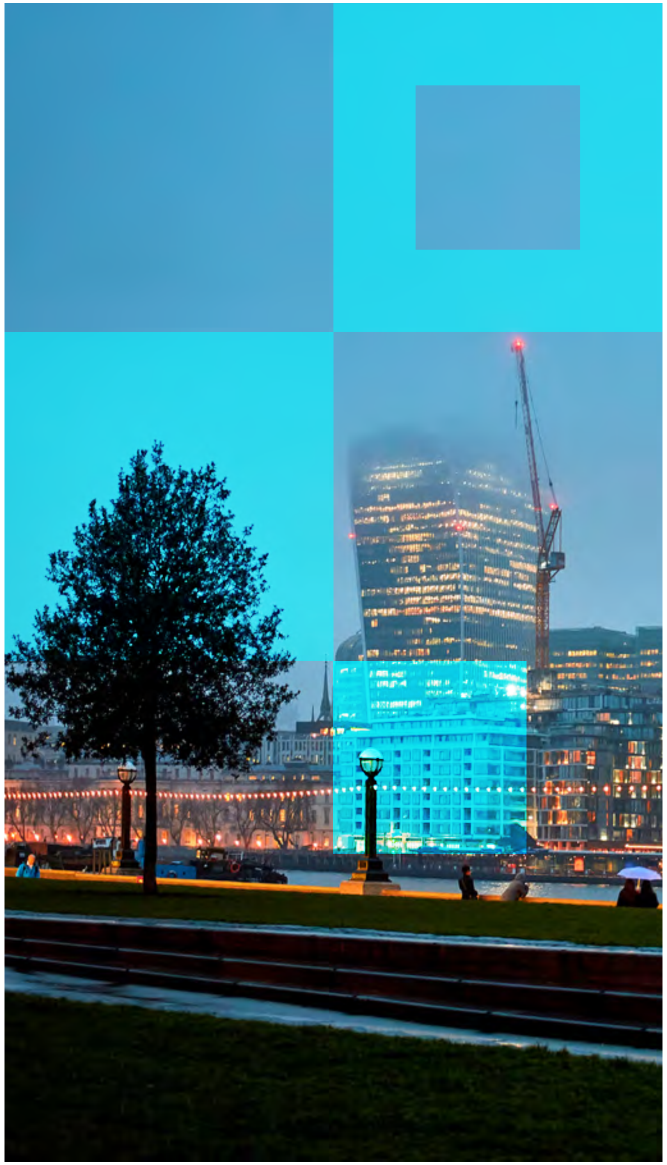
The market-based approach allows consumers to claim the benefit of their procurement strategy in their emissions reporting and, in theory, support and send demand signals for renewable generation. However, as outlined in Section 4.2, in a system where some consumers calculate their emissions using a location-based approach and some use a market-based approach, there is a risk that the zero emissions of renewable electricity is double counted.

To prevent this double counting, an emissions factor for the residual mix is required – i.e., the energy mix once all generation claimed through market-based approaches (in the UK, through REGOs) is removed from the overall national average. This residual emission factor is what UK consumers should use to report under the market-based method if they have chosen not to purchase renewable electricity via PPAs, green tariffs, or unbundled REGOs, and do not have any other supplier-specific data.

WHERE TO FIND THE RESIDUAL EMISSIONS FACTOR

BEIS publishes the residual fuel mix annually – in 2022 the residual fuel mix consisted of just 2.7 per cent renewable energy, compared to the **UK grid-average** (i.e., location-based) of over 50 per cent [15]. To date, BEIS does not publish the associated emission factor for the residual fuel mix. Organisations would need to obtain this elsewhere, such as via the Association of Issuing Bodies (AIB), which publishes annual **figures for Great Britain and a figure for Northern Ireland and Ireland combined** [57]. For comparison, the 2021 residual factors for GB and NI/Ireland were 0.352 $kgCO_2e/kWh$ and 0.570 $kgCO_2e/kWh$ respectively. The location-based grid average for the UK was 0.193 $kgCO_2e/kWh$.

Due to the risks of double counting under a market-based approach, the GHG Protocol recommends a dual-reporting approach, where emissions are calculated and reported using both location-based and market-based methodologies.



Marginal emissions

Location-based carbon accounting approaches are generally based on average emissions factors, i.e., the emissions associated with electricity consumption are calculated based on the average carbon intensity of all generation feeding the grid. Whilst this is sound when footprinting emissions at a system level, it does not necessarily accurately reflect the impact of a given action/intervention at the asset level.

The 'marginal emissions factor' describes the emissions impact of a small change in demand on the electricity system, such as a reduction in electricity consumption due to improved energy efficiency or an increase in onsite generation. This is different to the grid average due to the fact that small changes in demand on the system do not increase or decrease the output from all generators feeding the grid equally.

For example, the system cannot spontaneously create more wind or sun to generate more renewable electricity if a small increase in demand is introduced to the system. Instead, dispatchable generation like gas and coal turbines have to increase their output. The carbon intensity of that 'marginal' generation is higher than the grid average, so the emissions impact of that increase in demand is higher than would be calculated using the average carbon intensity. Similarly, any reduction in demand on the grid or increase in exported electricity does not cause a reduction in other wind and solar power supplying the grid. Instead, fossil fuel generators will typically reduce their output. This means that the emissions benefit of demand reduction or an increase onsite generation is relatively higher.

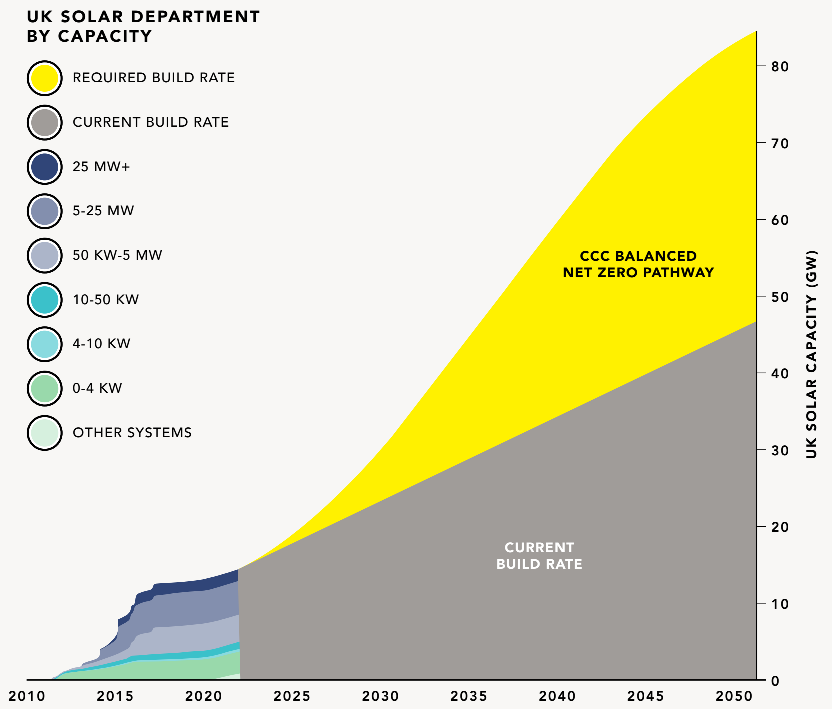


FIGURE 10:
UK historic and required build rate of solar PV to meet Net Zero.
Source: Etude [54].

DOES SOLAR PV DEMONSTRATE AN OPERATIONAL CARBON PAYBACK ANYMORE?

Due to the fact that the average carbon intensity of grid electricity has reduced substantially in recent years and is projected to continue reducing, the argument is often made that solar PV no longer demonstrates an operational 'payback' (i.e., the operational emissions it reduces don't outweigh its embodied carbon). However, this is a false equivalency and is a potentially dangerous attitude given the fact that we are currently falling well short of the necessary pace of solar deployment to achieve net zero (see Figure 10), even given a substantial increase in build rates in the last two years.

We need additional renewable capacity to both displace existing fossil fuel generators and meet the new demand that will be introduced through the electrification of heat and transport. So, whilst the emissions savings from solar PV would be calculated to be low initially and continue reducing using current grid factor projections, the carbon consequences of not deploying that additional generation would be substantially higher.

WHERE TO FIND THE MARGINAL EMISSIONS FACTOR

The UK Government publishes annual marginal emissions factors between now and 2050, projected based on their energy systems modelling [58]. In 2022, the reported 'long-run marginal' factor is around 0.260kgCO_2e/kWh compared to a grid average of 0.155kgCO_2e/kWh – this means the marginal emissions resulting from any small changes in demand are around 70 per cent more than would be calculated using grid average approach. Please note, these emissions factors do not fully align with those published annually for GHG reporting, but should broadly reflect the difference between the average and marginal impact.

As with the grid average factor, the marginal emissions intensity also varies throughout the days and months. In periods where renewable output is high, there may be very low levels of fossil fuel generation feeding the grid, and any additional output from onsite solar PV may be of less value to the system. There is currently no source of reliable hourly/sub-hourly marginal emissions intensity for the UK grid.

Regional differences

The issues caused by the mismatch between where renewable supply and demand are located, such as curtailment of wind power, have been discussed. This mismatch means that the marginal emissions benefit of additional generation or demand reduction in some areas of the country will be different to others. However, the information to accurately account for this relative benefit is not widely available.

In addition to half-hourly national carbon intensity data, National Grid ESO also publishes regional factors [38]. However, carbon accounting using these factors is not currently accepted under most reporting frameworks.

Carbon accounting principles to support the electricity system transition

The v1 guidance presented a third approach to support net zero carbon building claims in line with the Framework Definition. However, in anticipation of the UK Net Zero Carbon Buildings Standard, which will provide the carbon accounting methodology for buildings wishing to claim net zero carbon, this updated guidance does not describe any explicit carbon accounting methodology that should be used for those procuring electricity in the built environment. Instead, it identifies the limitations in current accounting approaches and explores how these can be evolved to better support the energy transition.

As well as the noted challenges with market-based approaches, the current resolution of most carbon accounting approaches does not reflect the variability of a renewable-led electricity system, nor does it value the supporting solutions that enable a resilient, decarbonised grid, such as demand flexibility and storage.

Hourly/sub-hourly location-based

As discussed, the carbon intensity of the UK grid varies constantly, as a result of the changing demand on the system and availability of renewable electricity to meet that demand. The carbon intensity during times of peak demand and low renewable output, when more fossil fuels are required to supply consumers, is higher than times where renewable output is high and there is reduced demand on the system. This means that electricity consumed during peak times results in higher emissions, but current annual accounting approaches – which use an annual average carbon intensity for electricity – do not account for this variation. In turn, there is no accounting incentive for a consumer to manage their demand in response to the availability of renewable electricity at any given time. Intermittent renewables will form the majority component of the net zero carbon electricity system in future, and it is therefore essential that buildings respond flexibly to the availability of the renewable electricity from those variable generators.

With GHG emissions becoming a greater decision-making factor for many corporates' operations, establishing a carbon accounting framework that reflects the impact of electricity consumption at a much higher resolution is critical. As has been established, this requires consideration of electricity supply and demand at an hourly-level or finer.

Location-based emissions factors at a half-hourly resolution have been available from carbonintensity.org.uk since 2019. This National Grid ESO API provides both historical carbon intensity data for the UK grid on an half-hourly basis as well as the forecast intensity for the next 96 hours. Provided electricity consumption data at a half-hourly resolution is available, the carbon emissions of a building or organisation can be calculated using a location-based approach for each hour of the year. In addition, the forecast carbon intensity can be used to inform near future operation of a building's systems, onsite generation, and storage to minimise the carbon intensity of the electricity it consumes from the grid. However, it should be noted that the half-hourly factors only reflect the carbon intensity of generation, and appropriate transmission and distribution losses should be included to account for the impact of electricity consumption.

Hourly/sub-hourly location-based

As well as hourly/sub-hourly location-based approaches, more granular market-based approaches are emerging. In the absence of time-based renewable energy certificates, market-based approaches rely on higher resolution information being provided from a consumer's energy supplier. As discussed in the previous section, this is the basis for establishing the percentage of a customer's energy consumption that is matched in real-time with renewable energy supply. Under the 'Time-matched' metrics provided in Report 3, market-based carbon intensities at an hourly/sub-hourly resolution are included. The supplier can provide these for their overall supply or an individual product, which enables the carbon emissions from electricity consumption to be calculated at an hourly level or better, specific to the supplier or product a customer has chosen, rather than using the half-hourly location-based factors published by National Grid ESO.

Until a market framework for trading hourly/sub-hourly renewable certificates is established, this is the most straightforward way that consumers can claim the benefit of any demand-side flexibility they are implementing in their carbon accounting under a market-based approach (i.e., reflecting their choice of supplier). The World Research Institute (WRI) has recently concluded consulting on a potential update to its Scope 2 reporting guidance, a primary consideration of which is the role more granular market-based accounting of the emissions associated with electricity consumption has to play in accurately reflecting the impact of electricity procurement and driving the energy transition.

In the absence of hourly/sub-hourly certificates, annual REGOs can be used for more granular market-based accounting, but in a different way to time-bound certificates, where a certificate would correspond to a unit of energy generated during a specific 15-minute, half-hourly, or hourly period. Instead, the 1 megawatt hour of zero emission power from an annual REGO can be 'spread' across the output profile of its generator over the year. This requires engagement with the specific generator from where the REGO is sourced to secure the hourly/sub-hourly generation data for the previous year. Whilst somewhat cumbersome, this does enable a temporal value to be assigned to generation from a renewable generator trading on the wholesale market, and a supplier can use this approach to achieve higher levels of time-matching, even for the power they procure from generators they don't own or directly contract with. Until time-based certificates are available, this can help to create price signals for the types of renewable generation that are most valuable to the system.

Summary of key carbon accounting approaches

Table 3 overleaf summarises the different location-based, market-based, annual, and hourly/sub-hourly approaches to carbon accounting that can be implemented. To reiterate, this guidance does not provide recommendations on carbon accounting for buildings or organisations and defers to the upcoming [early 2024] UK Net Zero Carbon Buildings Standard and potential GHG Protocol Scope 2 reporting guidance update for this. This section is intended as an education piece, to describe and summarise the nuances between the different approaches.

However, it is possible to conclude that, in order to most accurately reflect the emissions associated with buildings, send demand signals for the types of renewables and supporting technologies that are most valuable to the system, and reward demand-side flexibility, transitioning from an annual to an hourly (or finer) resolution for carbon accounting is critical.

SUMMARY OF CARBON ACCOUNTING APPROACHES

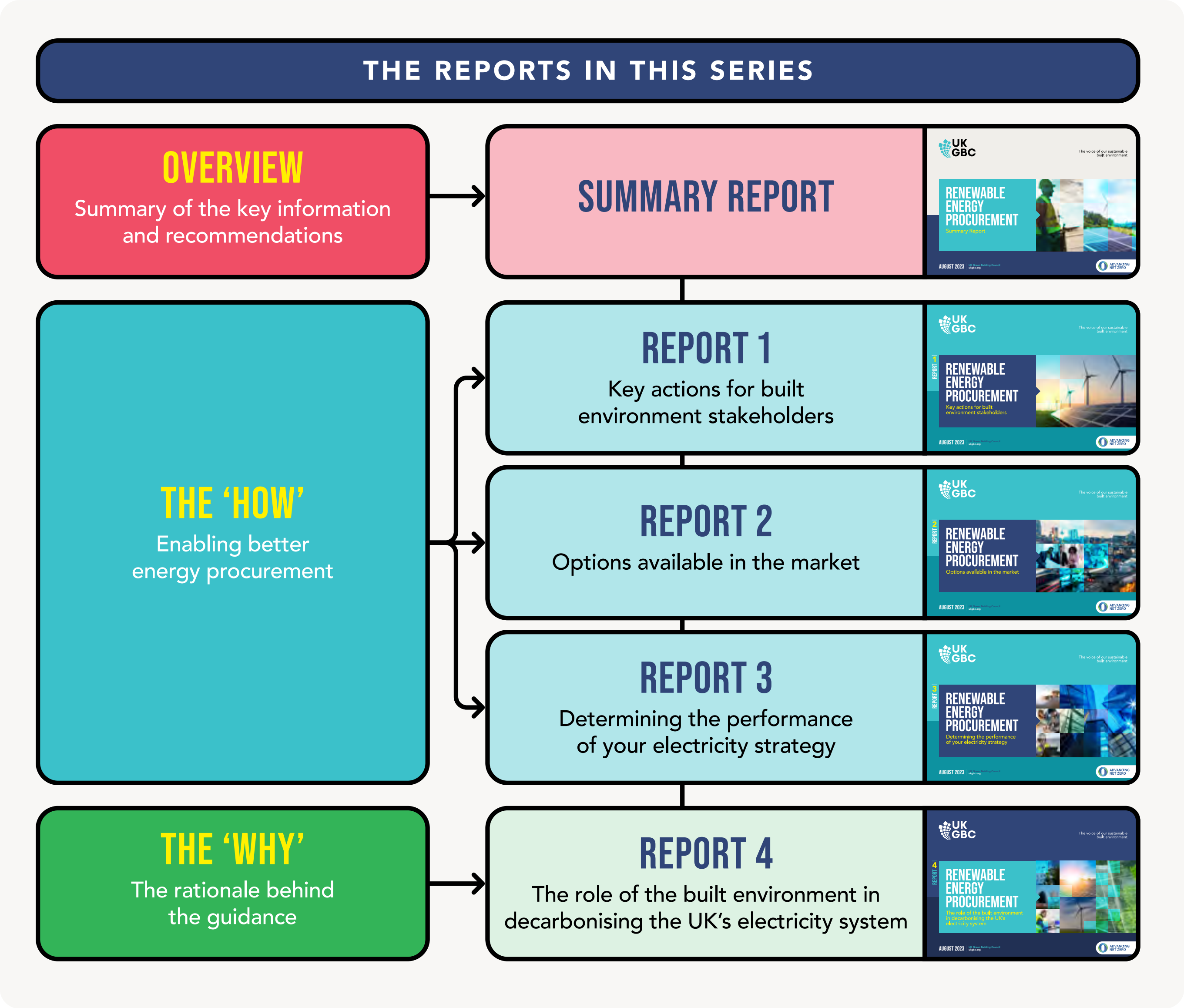
TABLE 3: Summary of carbon accounting approaches for electricity consumption.

		ANNUAL	HOURLY/SUB-HOURLY
		■ Does not value demand-side flexibility ■ Does not accurately reflect the benefits of onsite generation	■ Reflects the benefit of demand-side flexibility ■ More accurately reflects the benefit of any onsite generation
LOCATION-BASED	■ Uses average carbon factors based on the grid's generation mix ■ Does not value any procurement decisions	■ Uses an emissions factor based on the annual grid mix – this can reflect the grid as a whole, or regional networks ■ Simplest accounting approach with lowest data requirements	■ Uses an emissions factor based on the hourly/sub-hourly grid mix – this can reflect the grid as a whole, or regional networks ■ Requires energy consumption data at an hourly resolution or better
MARKET-BASED	■ Uses supplier-specific information ■ Values a customer's procurement strategy	■ Uses annual data from suppliers ■ In the UK, any consumption matched with REGOs can claim zero emissions ■ Emissions associated with any consumption not matched by REGOs should use the residual grid factor ■ Can result in double counting of zero emissions from REGOs ■ Without additionality, REGOs do not contribute to the energy transition or a net reduction in emissions ■ REGOs do not include T&D losses so these should be calculated and accounted for under Scope 3	■ Uses hourly/sub-hourly data from suppliers ■ Requires energy consumption data at an hourly resolution or better ■ A market for granular renewable certificates (e.g., hourly/sub-hourly REGOs) does not currently exist ■ Unbundled annual REGOs can be used for hourly/sub-hourly matching if the zero emissions power is 'spread' over the annual generation profile of the source generator ■ Until a granular renewable certificate market is operational in the UK, hourly/sub-hourly carbon carbon intensity data based on the supplier's or supplier's product's mix should be used for carbon accounting

SECTION 4.4
SUMMARY

This report explains the current UK electricity system and the role of buildings – and those who design, build, own and operate them – in supporting its decarbonisation. It introduces and provides the rationale behind the three updated principles for quality renewable electricity procurement, describes the various sources of emissions from electricity consumption, and summarises the range of carbon accounting approaches available.

This report provides the foundational information which has informed the guidance and tools provided in reports 1 to 3 to support built environment stakeholders in making better, more informed procurement decisions.



THE REPORTS IN THIS SERIES

OVERVIEW
Summary of the key information and recommendations

SUMMARY REPORT

THE 'HOW'
Enabling better energy procurement

REPORT 1
Key actions for built environment stakeholders

REPORT 2
Options available in the market

REPORT 3
Determining the performance of your electricity strategy

THE 'WHY'
The rationale behind the guidance

REPORT 4
The role of the built environment in decarbonising the UK's electricity system

GLOSSARY

TERM	DESCRIPTION
24/7 CARBON-FREE ENERGY (24/7 CFE)	Describes energy consumption where 100% of demand is matched with carbon-free supply at an hourly resolution or better.
ADDITIONALITY	Additionality describes the situation where an action results in an activity or intervention that otherwise would not have occurred had the action not taken place (i.e., additional relative to business-as-usual). In the context of procuring renewable electricity, additionality is achieved where greenhouse gas emissions reductions/removals occur as a result of new or repowered generating capacity that would not have happened in the absence of engaging in a given procurement route.
ANNUAL-MATCHING	The process by which electricity supply or consumption is matched with renewable power on an annual basis. This can be done by procuring Energy Attribute Certificates (EACs) only or by procuring the renewable power directly from a generator.
BEHIND THE METER	Describes anything that happens on the energy user's side of the meter (i.e., directly within the control of the asset).
BIOENERGY CARBON CAPTURE AND STORAGE (BECCS)	Electricity generation that is produced using biofuels where the resultant CO_2 is captured and stored long term, resulting in net negative carbon emissions.
BIOFUELS/BIOMASS	A fuel that is derived from biological/organic matter.
BLUE HYDROGEN	Hydrogen that is created by reforming natural gas and capturing the resultant CO_2.
BUNDLED POWER/ BUNDLED REGOS	Renewable electricity where the power is sold/procured together with its associated Energy Attribute Certificates (EACs).
CARBON CAPTURE, UTILISATION, AND STORAGE (CCUS)	A technology via which CO_2 resulting from a process is captured and used for other process or stored long term.
CARBON FACTOR	A measure of the emissions intensity of a process or fuel.
CARBON-FREE ENERGY/ ELECTRICITY	A term used to describe zero emissions sources of energy/ electricity generation. This includes renewables and nuclear power.
CARBON-FREE ENERGY/ ELECTRICITY (CFE) SCORE	A score between 1 and 100 reflecting the percentage of an energy consumer's demand that is matched with carbon-free supply at an hourly resolution or better, over the course of a year.
CLEAN ENERGY SOURCES	Energy sources that are zero carbon but not renewable.
CARBON DIOXIDE EQUIVALENT (CO_2E)	CO_2e or Carbon Dioxide Equivalent is a unit used to equivalate the emissions of other greenhouse gases (GHGs) to emissions of carbon dioxide (see Global Warming Potential). It also allows the impact of activities that result in the emissions of a variety of different GHGs to be described by a single number.
CARBON EMISSIONS	In the context of sustainability, Carbon Emissions is used as a collective term to describe the emissions of any GHGs.
CARBON SEQUESTRATION	Carbon Sequestration is the process by which carbon dioxide is removed from the atmosphere and stored within a material.
CLIMATE CHANGE	Climate Change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas.
CONTRACTS FOR DIFFERENCE (CFD)	A long-term contractual agreement between a low carbon electricity generator and the UK Government which guarantees a "Strike Price" for all electricity generated, where the difference between the market price and strike price is either paid to the generator by the government or paid back to the government by the generator.
CURTAILED/ CURTAILMENT	Describes a situation where the output from variable renewable generators (such as wind turbines) is reduced in times where supply exceeds demand or the transmission infrastructure has insufficient capacity to accommodate the energy flows.

TERM	DESCRIPTION
DECARBONISATION	Decarbonisation is the process of reducing the net amount of Greenhouse Gas (GHG) emissions released to the atmosphere.
DISTRIBUTION NETWORKS	The electricity networks that manage the flow of electricity from the national transmission network to end customers.
DISTRIBUTION NETWORK OPERATOR (DNO)	A licenced company that that manages the operation of a distribution network.
DISTRIBUTION SYSTEM OPERATOR (DSO)	An evolution of a Distribution Network Operator (DNO) which is necessitated by the more complex flows and management of electricity within the distribution networks.
EMBODIED CARBON	Embodied Carbon or Life Cycle Embodied Carbon emissions of a product are the total GHG emissions and removals associated with its manufacture, transport, installation, maintenance, and end of life treatment.
ENERGY ATTRIBUTE CERTIFICATE (EAC)	A certificate that provides information about the environmental attributes of one megawatt hour (MWh) of electricity. REGOs are the EACs used in the UK.
FLEXIBILITY PROVIDER/ FLEXIBILITY SERVICES PROVIDER (FSP)	An owner of assets, or an aggregator managing multiple assets, that can provide flexibility services by making temporary changes to the way they consume, generate, or store electricity when requested, to ensure continuity of supply.
GENERATOR	The operator of an asset that can generate electricity.
GREENHOUSE GAS (GHG)	Greenhouse Gases (GHG) are constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds.
GHG PROTOCOL	GHG Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

TERM	DESCRIPTION
GLOBAL WARMING POTENTIAL (GWP)	Some GHGs have a substantially higher GWP than carbon dioxide, meaning the same quantity of emissions has a greater impact to global heating. For example, methane's GWP is 25, meaning 1 tonne of methane trap 25x more heat than 1 tonne of carbon dioxide.
GREEN GAS	A gaseous fuel created by processing organic matter by bacteria.
GREEN HYDROGEN	Hydrogen that is created by electrolysing water using renewable electricity.
GREEN TARIFF	A term used to describe a range of energy products offered by suppliers that, as a minimum, have been fully matched with Energy Attribute Certificates (EACs).
GUARANTEES OF ORIGIN (GOS)	The Energy Attribute Certificate (EAC) scheme used in central Europe, closely related to the UK REGO scheme.
HYDROGEN	A gaseous fuel that combusts to produce water.
IN FRONT OF THE METER	Describes anything that happens on the energy system side of the consumer's meter (i.e., not in directly control of an asset).
INTERMITTENT RENEWABLE GENERATION	Renewable electricity generators that depend on variable renewable energy sources, such as wind and solar.
IPCC	The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.
LIQUID AIR ENERGY STORAGE	A form of energy storage where air is compressed into a liquid form and stored in insulated containers. When needed, the liquid air is evaporated and this energy is used to generate electricity, typically through a turbine.
LITHIUM-ION BATTERY	A form of electrical energy storage which uses the reversible reduction of lithium ions in the material to store electricity.
LOCATIONAL MARGINAL PRICING	A way for wholesale electricity prices to reflect the value of the energy at different locations, accounting for the patterns of load, generation, and the physical limits of the transmission system.

TERM	DESCRIPTION
LOCATION-BASED CARBON ACCOUNTING	A methodology for calculating carbon emissions based on the carbon intensity of the local grid area where the electricity usage takes place.
MARGINAL EMISSIONS FACTOR	A measure of the emissions caused by a small change in demand on the system, reflecting the fact such changes in demand do not increase or decrease the demand for all generation types equally.
MARGINAL PRICING	In the context of electricity procurement, marginal pricing is an approach to pricing electricity that sets the price of all electricity based on the cost of meeting the marginal demand (i.e., the final bit of demand on the system).
MARKET-BASED ACCOUNTING	A methodology for calculating carbon emissions based on the specific procurement decisions made by an electricity customer (e.g., claiming the benefit of Energy Attribute Certificates).
NATIONAL GRID ELECTRICITY SYSTEM OPERATOR (ESO)	The licenced company responsible for the management of the GB electricity system's transmission network.
NET ZERO	Net Zero is where all related Greenhouse Gas (GHG) emissions have been reduced in line with a science-based target which aligns with what has been determined to be necessary to stand a reasonable chance of limiting the global temperature increase to 1.5˚C above pre-industrial levels as a minimum. These residual emissions are subsequently responsibly offset to achieve a sum total of zero emissions.
OPERATIONAL CARBON	Operational Carbon are the GHG emissions arising from all energy consumed by a product in-use, over the product's whole life cycle.
PEAK DEMAND	The time of greatest overall energy demand. This can be measured at an asset-level or a system-level.
POWER PURCHASE AGREEMENT (PPA)	A contractual arrangement for power between a generator and a supplier or consumer.
RENEWABLE CERTIFICATES	A general term for Energy Attribute Certificates (EACs).

TERM	DESCRIPTION
RENEWABLE ELECTRICITY GUARANTEE OF ORIGIN CERTIFICATES (REGOS)	The Energy Attribute Certificate (EAC) scheme used in the UK.
RENEWABLE ENERGY CERTIFICATES (RECS)	The Energy Attribute Certificate (EAC) scheme used in the USA and Canada.
RENEWABLE ENERGY	Energy derived from natural sources that are replenished at a higher rate than they are consumed.
RENEWABLE GENERATION	A general term for any electricity generated using renewable sources of energy.
RESIDUAL EMISSIONS FACTOR	A measure of the emissions intensity of electricity from a given system after all electricity 'claimed' via Energy Attribute Certificates (EACs) has been removed from the mix (i.e., the emissions intensity of the residual grid mix).
RESIDUAL GRID MIX	The mix of generation supplying the system after all electricity 'claimed' via Energy Attribute Certificates (EACs) has been removed from the mix.
RETAIL MARKET	The market through which energy customers procure energy from a supplier.
SCOPE 1	Direct emissions from sources that are controlled or owned by an organisation. This includes any onsite combustion (e.g., from gas boilers for heating, and from company vehicles).
SCOPE 2	Indirect emissions that result from the purchase of electricity, heat, or steam that is generated offsite.
SCOPE 3	Indirect emissions from sources that aren't owned or controlled by an organisation, but that they indirectly affect in their value chain.
SELF-OWNED GENERATION	Electricity generating capacity that is owned and operated directly by the referenced party. This could be energy suppliers or building owners.
SUB-HOURLY	At a resolution of less than one hour.
SUBSIDISED GENERATION	Electricity generation that is financially supported by government or other schemes, such as the Contracts for Difference (CfDs).

TERM	DESCRIPTION
SUPPLIERS	Companies that procure energy and supply energy to customers on the retail market.
TARIFFS	The price at which energy is sold by a supplier to a customer.
TIME-BASED ENERGY ATTRIBUTE CERTIFICATES (T-EACS)	Energy Attribute Certificates (EACs) that include the time of generation at an hourly resolution or better.
TIME-MATCHED	Electricity demand that is matched with renewable supply at an hourly resolution or better.
TOTAL GENERATION MIX	The mix of all generation types supplying the system over a given time period.
TRANSMISSION NETWORK	The high voltage system for the transmission of power from large-scale generators to the distribution networks.
UNBUNDLED POWER	Renewable electricity that is sold without the associated Energy Attribute Certificates (EACs).
UNBUNDLED REGOS	Energy Attribute Certificates (EACs) that are sold separately to their associated power.
UNSUBSIDISED GENERATION	Generation that is not financially supported by government or other schemes, such as the Contracts for Difference (CfDs).
WASTE INCINERATION	A process where household waste is incinerated to boil water which is subsequently passed through a turbine to generate electricity.
WHOLE LIFE CARBON	Whole Life Carbon emissions are the sum total of all the associated GHG emissions and removals, for the embodied, operational and disposal of a product through its whole life cycle.
WHOLESALE MARKET	The general term for the market on which electricity is traded by generators and suppliers.
ZERO CARBON	Zero Carbon is where there are no related Greenhouse Gas (GHG) emissions.

REFERENCES

[1] **National Grid ESO,** "Electricity Markets Explained." Online.

[2] **UK Government,** "Energy Trends: UK Electricity." Online.

[3] **UCL,** "Electricity prices dictated by gas producers who provide less than half of UK electricity." Online.

[4] **Department for Business, Energy and Industrial Strategy,** "The Energy White Paper Powering our Net Zero Future." 14 December 2020.Online.

[5] **Climate Change Comittee,** "Delivering a reliable decarbonised power system." March 2023. Online.

[6] **Department for Energy Security & Net Zero,** "Review of electricity market arrangements." 18 July 2022. Online.

[7] **National Audit Office,** "Decarbonising the power sector." 1 March 2023. Online.

[8] **Climate Change Committee,** "2022 Progress Report to Parliament." 29 June 2022. Online.

[9] **United Nations,** "What is renewable energy?" Online.

[10] **Our World in Data,** "Electricity production in the United Kingdom." Online.

[11] **Department for Business, Energy & Industrial Strategy,** "UK energy in brief 2022." 28 July 2022. Online.

[12] **Department of Energy & Climate Change,** "UK energy in brief 2012." 26 July 2012. Online.

[13] **Department for Energy Security and Net Zero,** "Net Zero Strategy: Build Back Greener." 19 October 2021. Online.

[14] **Climate Change Committee,** "The Sixth Carbon Budget Electricity generation." 9 December 2020. Online.

[15] **Future Energy Scenarios,** "Future Energy Scenarios." Online.

[16] **European Parliament,** "Taxonomy: MEPs do not object to inclusion of gas and nuclear activities." 6 July 2022. Online.

[17] **HM Treasury,** "Spring Budget 2023." 21 March 2023. Online.

[18] **Department for Energy Security and Net Zero,** "Hinkley Point C." 29 September 2016. [Online].

[19] **Department for Energy Security and Net Zero,** "Contracts for Difference (CfD) Allocation Round 4: results." 7 July 202. [Online].

[20] **Imperial College London,** "Climate and Environment at Imperial." 29 October 2014. Online.

[21] **Environment Agency,** "Waste management for England 2014." 2 October 2015. Online.

[22] **B. Johnke,** "Emissions from Waste Incineration." Online.

[23] **United States Environmental Protection Agency,** "Energy Recovery from the Combustion of Municipal Solid Waste (MSW)." Online.

[24] **Department for Energy Security and Net Zero,** "Greenhouse gas reporting: conversion factors 2022." 22 June 2022. Online.

[25] **HM Goverment,** "The Electricity (Guarantees of Origin of Electricity Produced from Renewable Energy Sources) Regulations 2003." Online.

[26] Renewable Exchange,
"REGO Index update."
November 2022. Online.

[27] International Energy Agency,
"Advancing Decarbonisation Through Clean Electricity Procurement."
November 2022. Online

[28] Ofgem,
"Ofgem Renewables and CHP Register."
Online.

[29] Uswitch,
"Uswitch Green Accreditation."
Online.

[30] National Grid,
"How much of the UK's energy is renewable?"
Online.

[31] Carbon Footprint,
"International Electricity Factors."
2023. Online.

[32] Department for Energy Security and Net Zero,
"Contracts for Difference."
14 December 2022. Online.

[33] Trading Economics,
"United Kingdom Electricity Price."
Online.

[34] Energy and Climate Intelligence Unit,
"Latest round of renewables would be paying back £7bn under current prices, over £100 off bills."
7 July 2022. Online.

[35] Low Carbon Contracts Company,
"Contracts for Difference."
Online.

[36] Climate Change Committee,
"Corporate Procurement of Renewable Energy – Implications and Considerations."
9 December 2020. Online.

[37] European Comission,
"Questions and Answers on the EU Delegated Acts on Renewable Hydrogen."
Online.

[38] Carbon Intensity,
"Carbon Intensity API."
Online.

[39] United Nations,
"24/7 Carbon-free Energy Compact."
Online.

[40] Google,
"Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights."
Online.

[41] Eurelecric,
"Enabling 24/7 Carbon-Free Energy Solutions."
Online.

[42] I. Riepin and T. Brown,
"System-level impacts of 24/7 carbon-free electricity procurement in Europe."
11 October 2022. Online.

[43] ENTSO-E,
"Views on a Future-Proof Market Design for Guarantees of Origin."
20 July 2022. Online.

[44] EnergyTag,
"Granular Certificate Scheme Standard."
Online.

[45] Google Cloud,
"Timely progress towards around-the-clock carbon-free energy."
15 March 2022. Online.

[46] Department for Energy Security and Net Zero,
"UK Low Carbon Hydrogen Standard: emissions reporting and sustainability criteria."
8 April 2022. Online.

[47] Drax,
"Cost of turning off UK wind farms reached record high in 2021."
Online.

[48] UKERC,
"Exploring the implications of locational marginal pricing of electricity."
4 October 2022. Online.

[49] Energy Unlocked,
"The Carbon Flex Project."
Online.

[50] European Parliament,
"European Parliament."
Online.

[51] UK Parilament,
"Fossil Fuelled Power Stations: Carbon Emissions and Nitrogen Oxides."
26 November 2015. Online.

[52] Department for Energy Security and Net Zero,
"Government conversion factors for company reporting of greenhouse gas emissions."
1 May 2013. Online.

[53] Statistica,
"Electricity lost in transmission in the United Kingdom (UK) in selected years from1970 to 2021."
Online.

[54] Etude,
"The (low) embodied carbon of solar PV."
Online.

[55] Greenhouse Gas Protocol,
"Category 3: Fuel- and Energy-Related Activities Not Included in Scope 1 or Scope 2."
Online.

[56] Greenhouse Gas Protocol,
"Corporate Value Chain (Scope 3) Accounting and Reporting Standard."
September 2011. Online.

[57] Association of Issuing Bodies,
"European Residual Mix."
Online.

[58] Department for Energy Security and Net Zero,
"Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal."
15 October 2012. Online.

[59] FlexiDAO,
"What Is 24/7 Carbon-free Energy."
15th February 2023.

The voice of our sustainable
built environment

UK GREEN BUILDING COUNCIL
THE BUILDING CENTRE
26 STORE STREET
LONDON WC1E 7BT

INFO@UKGBC.ORG

UK Green Building Council
ukgbc.org

ADVANCING
NET ZERO

COMPANY REGISTRATION NUMBER 01029239
CHARITY REGISTRATION NUMBER 1135153