Technical design note

Project name	27675 Slough Trading Estate Simplified Planning Zone		
Design note title	Energy (Electricity) Usage in the Data Centre Sector		
Document reference	TN01		
Author	C Jones		
Revision	02		
Date	24 June 2024	Approved	☐

1. Purpose of this note

The purpose of this technical note is to explain how electricity is used and procured in the Data Centre sector and what role the National Grid plays in the distribution of electricity.

2. What is the National Grid?

The National Grid is a high voltage distribution network that connects electrical generation sources to large capacity demand customers and District Network Operators. The National Grid is not an electricity generator.

2.1 History

Historically, each city or town had a local electrical power station which was configured at low voltage. The power station on the Slough Trading Estate is an example of this.

In the late 1920's / early 1930's it was realised that local power stations were a major cause of air pollution in cities. The solution was to create a country wide distribution system connected to a number of large power stations sited close to the coal fields in the midlands and north of the UK minimising air pollution in population centres. The government set up the Central Electricity Generating Board (CEGB) to manage and operate the power stations and the National Grid to distribute this power.

Electrical power from each power station is synchronised at 50Hz and the voltage increased to either 275 or 400kV for transmission, minimising electrical losses. The voltage is then decreased to either 66 or 132kV for each customer connecting.

During the 1980's the CEGB and National Grid were privatised. National Grid now forms two main elements the Energy Supply Organisation (ESO) and National Grid Energy Transmission (NGET).

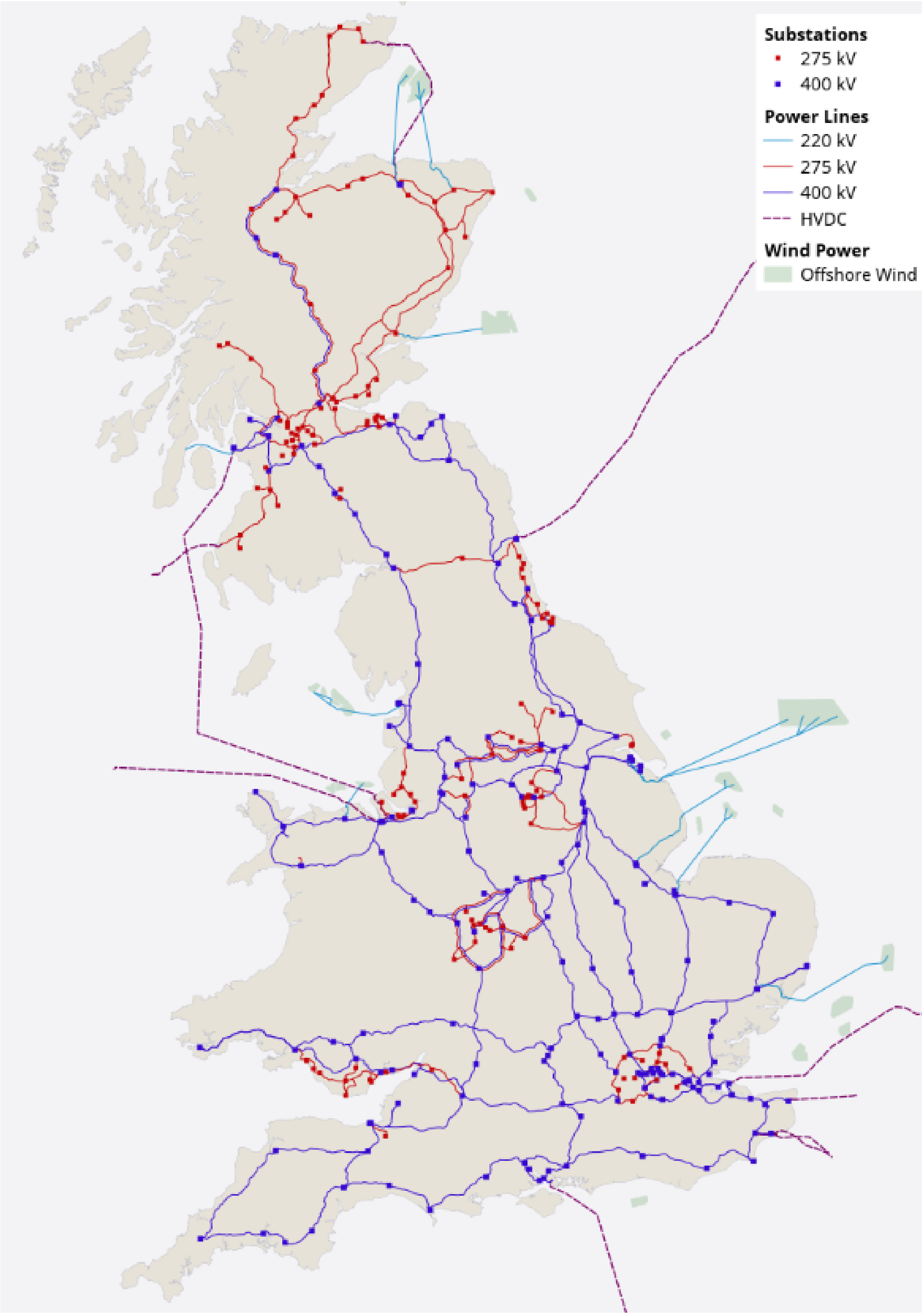

Figure 1 - The National Grid 275 and 400kV Network

2.2 Operational Model

National Grid pays for the operation and maintenance of the grid by charging generators and customers to connect and transmit power across their network. These are called Transmission Network Use of System (TNUoS) charges. The TNUoS charges are regulated by OGEM and are the same for all customers connecting to National Grid infrastructure, irrespective to whether they are connecting to new or existing infrastructure.

The National Grid network is responsible for transmission capacity, but actual generation capacity is provided by the generators who connect.

As discussed in section 2.1, historically these generators operated coal power stations. Over time, the electrical generation sector has evolved, with nuclear and gas fired power stations added. In the past 10 years there has been a significant increase in renewable generation added to the network (see Figure 3. This can also be evidenced by the National Grid ESO carbon Intensity dashboard. The UK grid is proposed to be fully 'green' by 2035 (Uk Government grid decarbonisation roadmap , 2021)

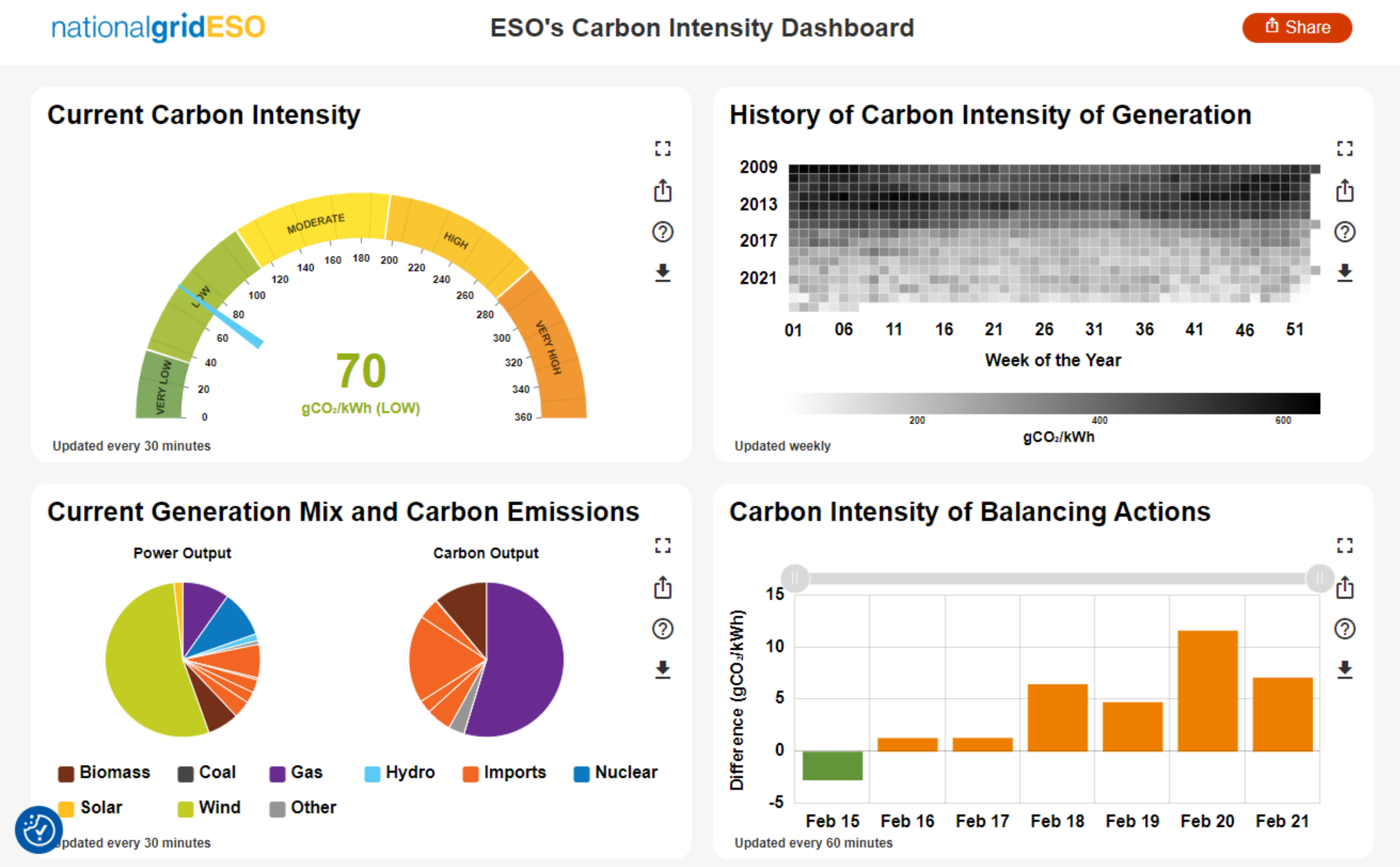

Figure 2 NG ESO Carbon Intensity dashboard

- The top left cell of the dashboard indicates the current carbon intensity of the energy on the grid at that moment of time (12/03/2024). The lower the gCO_2 /kWh value the better.
- The bottom left cell shows the mix of the energy being generated.

- The top right cell shows the carbon intensity of the generated energy of the grid per week from 1st January 2009. The darker the colour the greater the carbon intensity. At a glance it can be seen that the carbon intensity of the electricity is consistently falling and is tracking towards the 2035 target.
- The bottom right cell shows the carbon intensity of energy imported to the UK from continental Europe. Values are updated every 30/60 minutes.

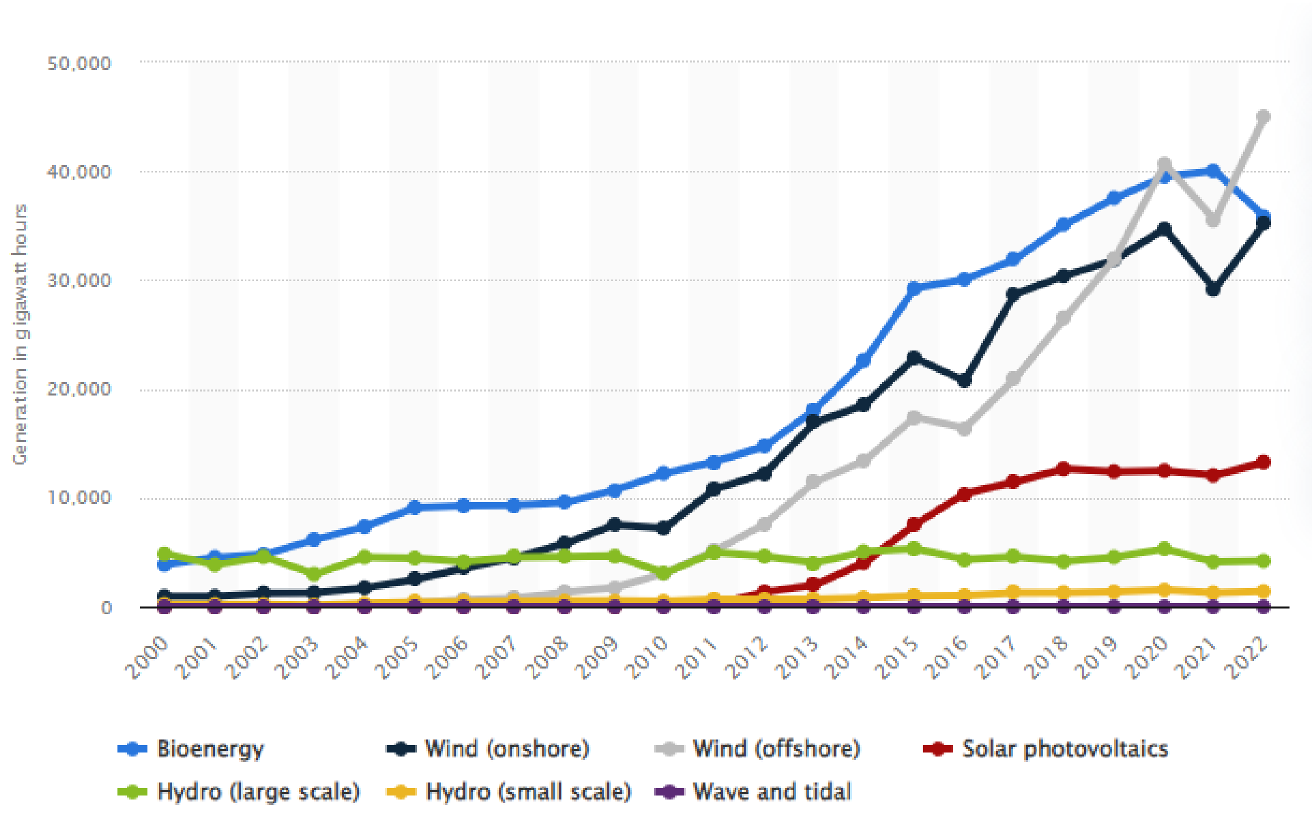

Figure 3 The increase in renewable generation in the UK between 2000 and 2022 (Gigawatt Hours)

2.3 National Grid Reinforcement

The National Grid is a privately owned business. Therefore, any reinforcement works need to be funded by future TNUoS charges. The way the sector operates is reactive, with new capacity only largely being created when requested, which naturally results in delays to the capacity being available. This fact has become more apparent in the move to a zero-carbon grid with more electrical demand being requested and large amounts of renewable generation being connected simultaneously. This additional capacity has created, and will continue to create, connection queues and delays in capacity being delivered.

Due to the size of National Grid reinforcement projects, which are often above 100MW and costing several £100m's; a single connection request does not typically trigger a reinforcement project. This can lead to severe bottlenecks when there is large demand for new connections, with only a significant number typically triggering a National Grid reinforcement project.

New applicants wishing to connect to the National Grid have to provide securities to underwrite the reinforcement works that support their required capacity. As the cost of National Grid reinforcement works can often exceed £100M+, only very large applications (such as Data centres) can afford to securitise the required reinforcement works.

There is often a misconception that Data centres use all available electrical capacity in a region and inhibit the development of other projects. However, the converse is often true; the size of their requested connections often triggers the need for National Grid reinforcements which otherwise would not have been delivered for a considerable time. . When reinforcing, this has the effect of providing additional capacity into the network which can be used by District Network Operators (DNO's) to supply smaller sites locally - thus, creating greater ability for other connections to come forward.

An example, is the creation of a new, 1,400MW Grid Supply Point in Iver (known as the Uxbridge Moor Grid Supply Point) that is being driven by Data centre demand, but is also providing connections for DNO's who will provide power for developments in the local Slough / Iver / Hayes areas.

The current goal of attempting to create a fully decarbonised grid by 2035 is currently driving a significant amount of investment in new infrastructure as renewable generation is located in different locations to traditional generation. This goal is currently on track with significant amounts on renewable generation and storage due to be delivered over the next 10 years.

Since the deregulation of the industry in the 1990's the reactive approach to reinforcement has been workable. However, with the drive to net zero, a more proactive, power master planning approach is required to ensure capacity is available in the areas that it is needed; this policy change will have to be driven by OFGEM and central government.

2.4 Power Purchase Agreements

Large consumers of electricity can use the National Grid to transmit their own (or others) green generated electricity. A number of large Data centre operators are actively developing or purchasing certified renewable generation capacity so that it can be deployed at their sites. To do this, Data centre operators often agree Power Purchase Agreements with renewable generators, however, these agreements are often made at a country-wide or global level. Securing renewable Power Purchase Agreements means that a Data centre operator is able to fully audit their use of renewable electricity.

There is a finite amount of certified renewable energy available at any given time. The Data centre sector is a major driver in the development and deployment of certified renewable energy schemes that help reduce the carbon intensity of the UK grid, however, it is not yet possible to guarantee that certified renewable energy is always available in every location at any point in time.

3. Energy use in Data Centres

3.1 Growth in the Data centre sector

As can be seen in Figure 4, whilst internet traffic and the Data centre sector has grown significantly since 2010; energy consumption has not increased. There are three primary reasons for this fact:-

1. Servers have become much more energy efficient
2. Data centres have become much more energy efficient utilising higher data hall temperatures and increased use of 'free cooling' and improved efficiency of UPS technology
3. The relocation of data equipment from historic server rooms / small Data centres to modern, efficient Data centres. Figure 5 shows that as the use of traditional data centres / server rooms has declined, these have been replaced by Cloud and Hyperscale facilities.

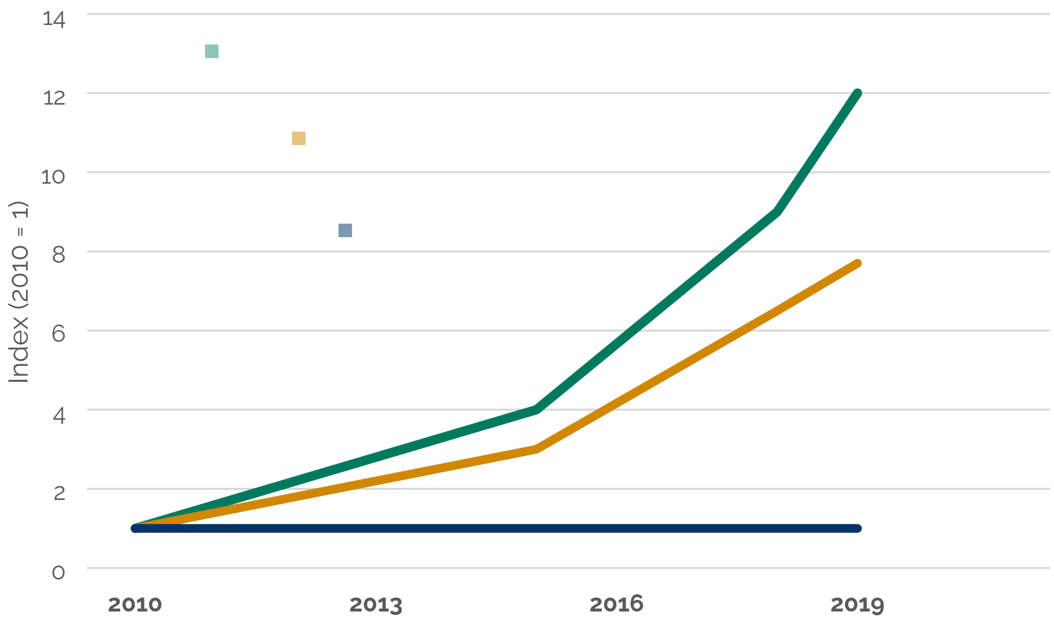

Figure 4 Data centre Energy consumption

Source: International Energy Agency: Data centres and Transmission Networks: Analysis

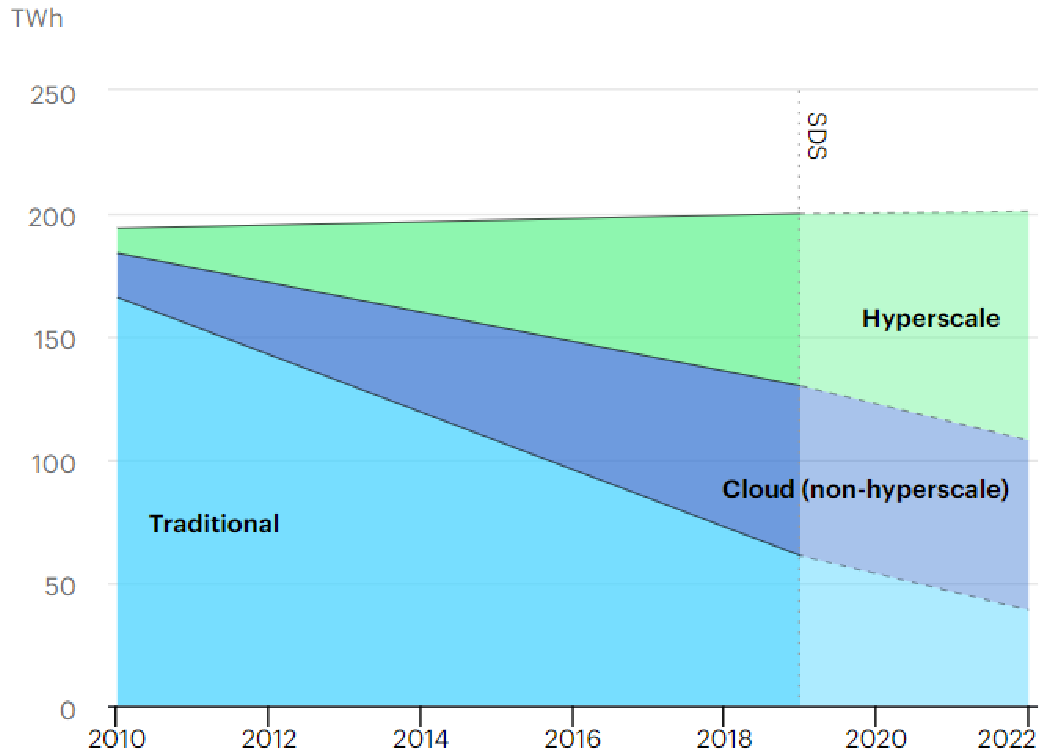

Figure 5 Energy consumption of Data centres by type.

Source: Energy consumption of Data centre by type, IEA

The growth in internet traffic is forecasted to keep increasing and is an essential part of daily life. The construction of new highly efficient Data Centres is the only way to keep energy demands as low as possible.

Increasing Data centre efficiency, is a significant driver in the 'flatlining' of energy consumption while both data traffic and workload are increasing.

3.2 Renewable energy consumption.

As discussed in section 2, the National Grid does not generate electricity, only transmits electricity generated by others. Data centre developers and their tenants are able to purchase energy from a 'Shipper'. A Shipper is a company that arranges for and charges the consumer for the transmission of electricity from the generator to the consumer across transmission and distribution networks. Examples of domestic scale shippers being EON, Octopus Energy etc.

A proportion of the cost of each Mega Watt Hour (MWh) of energy is paid by the shipper to the distribution system operators. These costs are paid to the network operators to pay for the construction and maintenance of the electricity networks.

Wherever available, Data centre operators will either commit to purchase certified renewable energy or will generate and consume renewable energy themselves via a Power Purchase Agreement (PPA). A PPA is a payment mechanism which (as discussed above) allows a Data centre developer who owns or purchases certified renewable energy from a generator remote from the Data centre site to use the transmission and distribution network to 'transmit' that energy to the Data centre. The 4 largest global Data centre operators have contracted almost 50GW; equal to the generation capacity of Sweden; which has significantly accelerated the deployment of renewable energy generation globally.

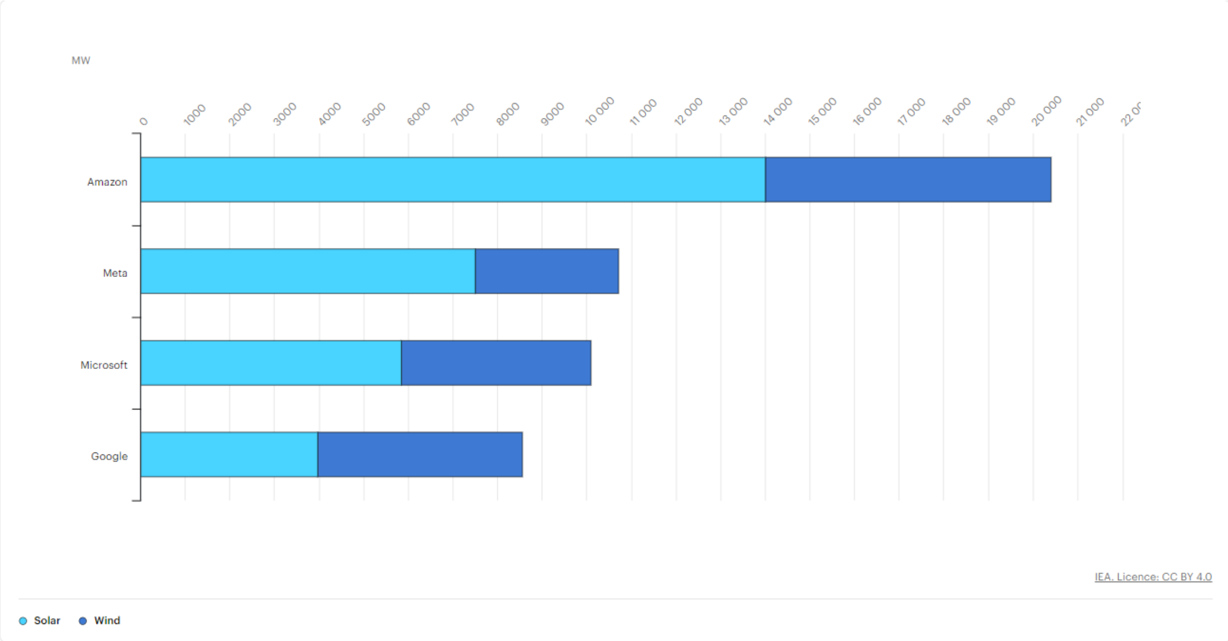

Figure 6 - Top corporate off-takers of renewable energy power purchase agreements 2010-2022 (MW)

4. Data Centre Waste Heat

As a by-product of processing data, Data centres produce low grade heat. This is typically rejected via local heat rejection equipment to atmosphere within each Data centre.

There are a number of examples worldwide of Data centre waste heat being reused. As an example, the Old Oak and Park Royal Development Corporation (OPDC) in the UK is currently working to develop a waste heat district heating network from Data centres in the Park Royal area using central government seed funding and a private sector operator.

The aim of the OPDC's scheme is to collect waste heat from each Data centre via an ambient loop, which is then elevated in temperature via heat pumps to supply local housing and other development types.

An additional advantage to the recovery and reuse of waste heat is that the energy consumption of the Data centre is also reduced as its heat rejection is not required to operate when heat is recovered.

Figure 7 Carrier water to water heat pump designed for recovering waste heat from Data Centres.

Hydrock

Ideally, any district heat network would be integrated into new developments; as retrofitting into existing developments is costly and disruptive.

Older properties are also less energy efficient than newly built properties and unless a simultaneous programme of energy efficiency works to each property is also carried out, the capacity of the heat network would have to be significantly increased. It is noted in the recently issued draft Air Quality Action Plan 2024-2028 that Slough Borough Council are considering working with a commercial partner to utilise this waste heat to reduce emissions from dwellings.

The commercial partner would have to provide a significant amount of capital to create the heat network. Ideally the heat network would supply new developments as the infrastructure can be installed at the same time. As new buildings are significantly better insulated than older buildings the overall demand of the heat network would be smaller.

Retrofitting older buildings to be more energy efficient and the installation of the district heating pipework and heat interface units is disruptive and costly and will need to commercial partnership to operate over several decades in order to create a return on investment.

Any new data centres developed on the Slough Trading Estate can be designed to provide a connection to a future district heating network. This would typically consist of a space allowance in the chilled water return pipework to install a heat network plate exchanger and a route from the Data centre to the highway boundary to allow the waste heat to be delivered to a (future) heat network.

The existing hot steam distribution network within the Slough Trading Estate is extremely old and the condition and specification of the pipework would not be suitable to use as part of any future district heat network.

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