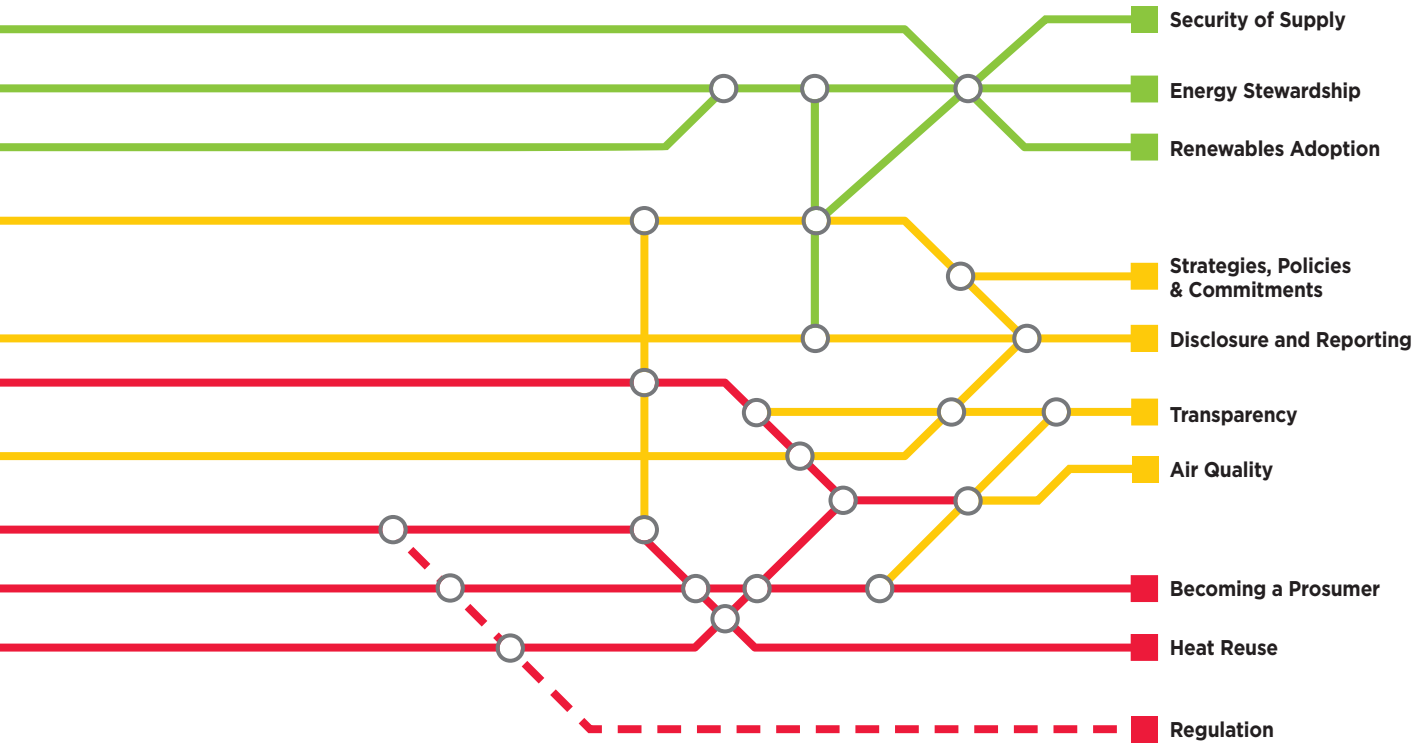
techUK

UK Data Centre Sector
Energy Routemap

November 2019

Contents

Data centre sector energy route map at a glance



I. Executive summary

The UK's challenging net zero carbon targets must be achieved without compromising security of supply or rendering UK energy consumers uncompetitive. Success depends on everyone playing their part. Data centres are electro intensive and the UK's commercial sector consumes 2.89TWh of power a year. The sector is a large electricity consumer with stable, predictable demand and significant embedded capacity and for these and other reasons is well placed to help support the transition away from an economy dependent on combustion and towards one based on renewables.

Data centres too must balance resilience, affordability and sustainability and this routemap sets out how the sector can address these challenges whilst contributing to the UK's low carbon future. Actions are identified that can improve our chances of success in ten priority areas. These are:

1. **Develop relevant corporate strategies, policies and commitments**
2. **Ensure continuity of supply and prepare adequately for supply perturbations**
3. **Demonstrate best practice in energy efficiency, adopting appropriate standards and metrics**
4. **Commit to 100 per cent renewable power well before 2050**
5. **Reduce reliance on grid and become an energy prosumer**
6. **Measure and report energy use**
7. **Help customers understand and act on energy consumption**
8. **Make better use of waste heat**
9. **Minimise air quality impacts**
10. **Work with regulators to help make policy fit for purpose**

The sector is performing well in key priority areas such as security of supply, adoption of renewables, energy stewardship, reporting energy use and customer transparency. Progress is slower in other areas, such as playing a more dynamic role in the electricity market, where projects are mainly at R&D or pilot stage. Success is elusive in the reuse of waste heat and using embedded capacity to facilitate a more distributed grid. Barriers include risk aversion, contractual arrangements, lack of infrastructure and consumption of resource by unproductive compliance activity.

UK operators are also severely challenged by high energy costs that render them uncompetitive compared to counterparts overseas. Significant shortcomings are identified in energy related policies, which fail to drive activity to where it can be performed most efficiently, miss major opportunities for energy saving, are poorly targeted and impose burdens without delivering policy outcomes.

Actions are identified for operators in terms of leadership, best practice, reporting, transparency and technology deployment. Actions for government relate to correcting policy failures, implementing the recommendations of the Helm Review, realigning support mechanisms and reinstating the Climate Change Agreement.

We have not included net reduction targets – yet – because we expect sector energy demand to grow incrementally as the digital agenda is implemented, economic activity is increasingly digitised and policy priorities like smart grid, intelligent transport and superfast broadband are rolled out, all of which will deliver net carbon reductions and improve energy productivity across the wider economy.

This is the first sector energy routemap for data centres and it will be part of an ongoing process. In the next iteration we will report on progress and expand our focus to accommodate our supply chain and embedded energy. For the moment, however, we have plenty to get on with.

II. Introduction

UK Government has set challenging carbon reduction targets and enshrined them in legislation. Our 2008 commitment to reduce UK emissions by 80 per cent by 2050 has been upgraded to net zero emissions by the same date. At the same time we need to ensure security of supply: our electricity grid is one of the most reliable in the world and must remain so. Government must also control the cost of this transition by financing it in ways that do not make UK businesses uncompetitive or increase fuel poverty. The 2017 Green Growth Strategy provides the template for these fundamental changes.

Data centres, along with telecommunications networks, provide the core digital infrastructure that supports our modern internet economy. There are over 200 commercial data centres in the UK and at least the same number again of in-house facilities supporting corporate IT functions. The UK data centre sector is a real success story, is globally important, underpins a fast-growing internet economy worth £225bn and provides the technical infrastructure for financial services, aerospace, transport, healthcare, retail and utilities. Each new data centre contributes between £397m and £436m GVA per year to the UK economy[1].

Data centres are electro-intensive and the UK's commercial sector consumes 2.89TWh of energy a year, around 0.8 per cent of our UK electricity supply and about 0.3 per cent of primary energy[2]. This figure approximately doubles when we include enterprise data centres (operated in-house by organisations like banks, retailers, local authorities and universities). We have to estimate this because enterprise data centre energy use is captured within corporate reporting and not accounted for separately.

Data centre operators too, must balance their energy priorities. These are:

- Resilience: – a secure, high quality power supply to ensure continuity of service.
- Competitiveness: a level playing field for power pricing,
- Sustainability: Access to renewable power and a high level of operational efficiency

Data centres are part of the larger energy ecosystem and operators, collectively and individually, have a duty to help the UK meet its net zero targets. The data centre sector, a large energy user with consistent and predictable demand, high embedded capacity, and a strong appetite for renewable power could, over time, enable greater adoption of intermittent renewables and a more distributed grid. Moreover, with the right expertise and policies in place, data centres could make a significant contribution to investment in additional renewable generating capacity, and with the deployment of emerging fuel cell and battery storage technologies, could be important energy prosumers in a smarter grid. The sector is not yet fulfilling this role, and there is much to do to make it happen.

This energy routemap explores ten target areas: strategy and policy, security of supply, energy stewardship, renewables, becoming a prosumer, reporting, transparency, heat reuse, air quality and regulation. In each case we assess progress and briefly discuss barriers, enablers and future potential, then we identify actions we can take that might accelerate positive outcomes. By and large, commercial operators do not own the ICT that is housed within their facilities. Therefore this routemap is targeted at infrastructure. We also do not explore energy associated with supply chain or embedded assets: we plan to address these in a subsequent iteration.

This routemap is not intended to be a finished article: it is a work in progress. It helps us establish where we are now and sets out routes to achieve our energy objectives and contribute to our national obligations. As new opportunities and barriers emerge, we will reassess our options.

III. Target areas and objectives: Summary

1. Strategies, policies and targets

Data centre operators should develop clear energy strategies and make ambitious climate change commitments.

2. Security of supply

Data centres need a secure and stable supply of electricity. The sector must be prepared for a range of temporary supply issues.

3. Energy stewardship

The sector must demonstrate best practice in energy efficiency, comply with relevant standards and measure progress using robust performance metrics.

4. Renewables adoption

The sector must commit to renewable power for its energy needs. Operators should be implementing strategies to reach 100 per cent well before 2050.

5. Becoming an energy prosumer

The sector needs to find ways to reduce overall reliance on the grid and become a more dynamic player in the energy market.

6. Disclosure and reporting

Data centres should measure and report energy consumption robustly and consistently in order to monitor progress and identify trends.

7. Transparency

Data centre operators must help customers understand the energy impacts of their digital activities.

8. Heat reuse

The sector should make better use of its waste heat.

9. Air quality

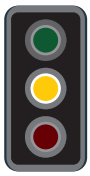
Operators should adopt practices that minimise air quality impacts from standby generators

10. Regulation

The sector will work with regulators to help make policy fit for purpose.

IV. Target areas: Review of progress

This section explores each of our target areas in more detail, assesses progress and suggests actions.



1. Strategies, policies and commitments

Data centre operators must develop clear energy strategies and make ambitious climate change commitments.

All energy intensive organisations should develop and implement an energy strategy or routemap, that covers resilience, efficiency and emissions, and the data centre sector is no exception. Technology moves quickly and this means that predictions about the way we use energy can soon be rendered meaningless but that does not obviate the need for ambitious commitments – although it may change the way we achieve them or the time it takes to do so.

Data centre operators, large and small, commercial (colocation) and in-house (enterprise), private and public sector need to establish baselines, set themselves targets and monitor progress. They should also consider commitments to public disclosure and customer transparency. Priorities should be aligned to relevant UN Sustainable Development Goals, primarily numbers 7 (relating to affordable and clean energy) and 13, (climate action). Commitments should be aligned to relevant Science Based Target methodologies[3].

How are we doing?

Individual operators have implemented comprehensive strategies to procure energy securely and cost effectively and have set themselves ambitious targets to improve efficiency and carbon productivity and increase dependence on renewables. In addition, commercial operators in the UK have collectively committed to improve operational efficiency through the CCA (Climate Change Agreement): there is a sector level target to reduce PUE by 15 per cent by 2020[4].

Corporate strategies

Equinix, a large data centre operator, sets out clear targets in its corporate sustainability report, aligns priorities with UN Sustainable Development Goals and reports regularly on progress.

Digital Realty's 2018 Environment, Social and Governance Report includes clear targets, aligned to UN Sustainable Development Goals, and information on progress to date.

BT, a telecoms provider operating a fleet of data centres, has taken a leadership position with targets in place since 1992. Their climate action journey includes a 3:1 Net Good goal, applies science based targets and aims for net zero by 2045.

Memset, an SME operator, was the first carbon neutral data centre in the UK and publishes environmental policies and credentials.

In addition, large enterprise organisations like BT and IBM with major data centre assets have well-established and leading-edge climate change programmes.

However, the picture is not consistent across the industry and many operators can learn from their counterparts or adapt an industry template.

Sector level actions:

- Develop a template for corporate energy strategy
- Showcase Best in Class energy policies and strategies

2. Security of supply

Data centres need a secure and stable supply of electricity. The sector must be prepared for a range of temporary supply issues.

Data centres are electro-intensive and are usually only located where there is sufficient grid supply[5] . Operators tend to lock this in through power provisioning agreements so that they can accommodate future growth. As well as being large power users, they need that supply to be uninterrupted and stable, because electronic equipment cannot handle outages longer than about 8 milliseconds. ICT is also very sensitive to variations in frequency.

The sector works to international, peer-reviewed "availability" standards[6] and operators compete on the basis of business continuity and resilience. UPS (uninterruptible power supplies) ensure that the flow of electricity to the equipment is constant and at the right frequency. To ensure continuous operation in the event of interruptions in grid power, data centre operators may be connected to more than one substation and usually install emergency generating capacity. In case of power fluctuation or failure, banks of batteries provide instantaneous backup and diesel generators are used for longer term outages. In reality, they are rarely used.

Climate change resilience is very relevant to security of supply: flooding could disrupt electricity supply but could also prevent tankers from making deliveries. These and other physical risks have to be evaluated and managed.

How are we doing?

Operators are well prepared for disruption to electricity supply, which is always high on the risk register with special contractual arrangements, multiple lines of defence and plenty of built-in redundancy. Operators are also exploring new software– and network-based approaches to resilience.

The development of bespoke design and operational standards is remarkably advanced for such a young industry[7], and adoption rates are also high. A monitoring and reporting scheme for incidents DCIRN (Data Centre Incident Reporting Network) provides an industry-wide platform for operators to share information on outages and improve resilience.

The sector also monitors emerging risks, such as the impact of Brexit on security of supply, reports formally to government on its readiness for climate change risks, and is updating relevant operational standards to ensure that emerging risks are handled systematically.

Sector level actions:

- Showcase Best in Class approaches to resilience
- Continue to report formally on sector readiness for climate change risks
- Monitor and report perturbations in supply, incidents involving stability of grid power

Relevant publications

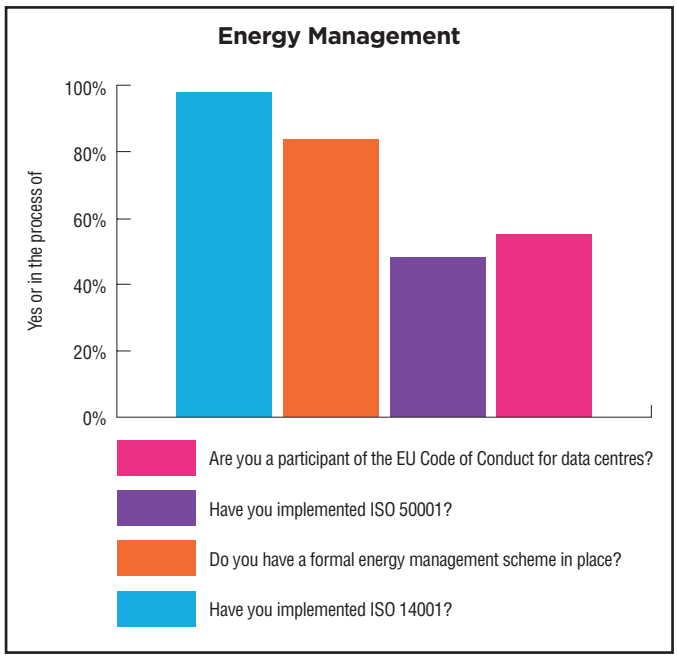
- **Climate change adaptation:** report to DEFRA under the Adaptation Reporting Power: http://www.techuk.org/images/ICT_ARP_response_to_DEFRA_2016.pdf
- **Energy Security of Supply Post Brexit:** https://www.techuk.org/insights/news/item/15034-energy-security-of-supply-in-a-no-deal-scenario
- **Data centre resilience to heatwaves:** https://www.techuk.org/insights/news/item/12485-techuk-input-to-environmental-audit-committee-inquiry-into-heatwaves
- **Data centre standards map:** https://www.techuk.org/insights/news/item/14709-mapping-the-data-centre-standards-landscape

3. Energy stewardship

The sector must demonstrate best practice in energy efficiency, comply with relevant standards and measure progress using robust performance metrics.

Data centres are energy intensive but that does not mean they are inefficient. Energy represents the largest operational cost for data centre operators, who are therefore strongly focused on using less of it if they are to remain competitive in a highly commoditised marketplace.

Energy efficiency in data centres is achieved through a combination of approaches. Firstly, efficiency needs to be a priority at the design stage so energy productivity, and the flexibility to accommodate new technological developments, are built in from the start. Then, when a site is up and running, a multitude of operational measures can be applied. However, it is not just a case of buying and installing the best equipment and then sitting back - these complex environments need sophisticated systems-level management to optimise performance. Some operators also apply a strategic approach to their data centre assets, concentrating those activities needing high resilience (which is very resource intensive) into just one or two facilities.



There are multiple, sector-specific design and operational standards relating to energy efficiency (such as the EN 50600 series), plus best practice tools and guides like the European Code of Conduct for Energy Efficiency in Data Centres. Operators can also refer to a wide range of relevant performance metrics. However, there is no single metric against which data centre performance can be measured, reflecting the variety of business models and functions. This rules out a one-size-fits-all solution.

How are we doing?

The sector is performing well. Energy and sustainability standards and best practice tools are well developed and widely adopted, as are relevant performance metrics.

The chart above reflects the adoption of measures by CCA participants by the end of Target Period 2. We anticipate that engagement will have increased since then. Almost all operators had adopted ISO14001, and more than 50 per cent were signatories to the EU Code of Conduct, though anecdotal evidence suggests that informal adoption of the freely available best practices is almost universal.

Energy conservation also continues to dominate conference agendas and networking events and there is strong R&D activity in areas like cooling and battery storage.

At operational level, commercial operators measure energy consumption and monitor PUE consistently and robustly through the CCA (Climate Change Agreement). This has driven more open customer-supplier dialogue which in turn is helping to address the kind of split incentives that have historically occurred in landlord-lessee scenarios. The CCA's carrot and stick approach has been particularly effective in incentivising operators to implement improvements and has improved the business case for investment in efficiency measures. Sector energy use is transparent and reported.

However, there are barriers that prevent or discourage operators from implementing much needed efficiency measures. These include timing, service level agreements, other contractual constraints, physical restrictions or design shortcomings that preclude retrofitting[9]. The nature of the secure and "always-on" environment also presents difficulties. Firstly, there is a trade-off between efficiency and resilience because a highly resilient site must have redundancy (spare capacity) built in. Moreover, implementing major improvements in sites that must run continuously without compromising service tends to be expensive and risky: unlike a road that can be coned down to one lane or closed overnight a data centre cannot be taken offline. The result is incremental rather than step-change improvements.

Enterprise sites are excluded from the CCA and incentives can be weaker, especially if their energy use only represents a small fraction of the overall corporate footprint. There are circumstances, most notably in legacy in-house facilities, where performance is not scrutinised, and in server rooms and distributed IT (not data centres but performing similar functions) where these drivers are absent, where the data centre is not treated as a business unit, where energy use is not monitored and where investment may not be forthcoming for improvements. Reports suggest that energy stewardship in this less visible part of the sector lags well behind commercial facilities[10].

Sector level actions

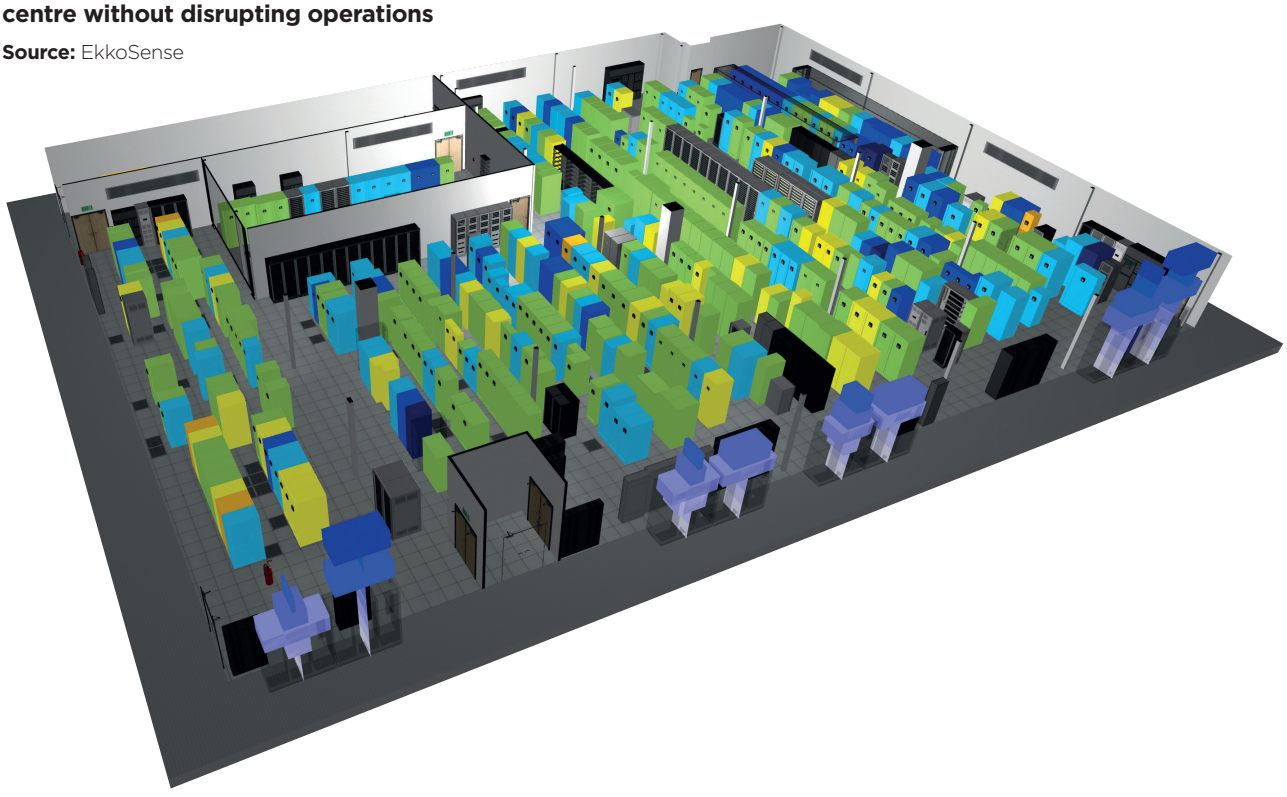
- Continue to support development and adoption of relevant standards and best practices.
- Encourage organisations to treat their in-house data centres as business units, so that operational costs are transparent and performance is monitored.
- Support the consolidation of distributed IT

Relevant publications

- **Data centre standards map:** https://www.techuk.org/insights/news/item/14709-mapping-the-data-centre-standards-landscape
- **Performance Metrics for data centres:** https://www.techuk.org/images/Data_centre_performance_metrics_for_Tiny_Tots.pdf
- **CCA first findings report:** https://www.techuk.org/insights/reports/item/2773-climate-change-agreement-for-data-centres
- **CCA Report against first target:** https://www.techuk.org/images/CCA_First_Target_Report_final.pdf
- **CCA Report of progress against second target:** https://www.techuk.org/images/CCA_Second_Target_Report_04.pdf
- **Data Centres and Power: Fact or Fiction?:** https://www.techuk.org/insights/reports/item/275-data-centres-and-power-fact-or-fiction

Thermal mapping is an approach that can help optimise cooling efficiency in data centre without disrupting operations

Source: EkkoSense



4. Moving to renewables

The sector must commit to renewable power for its energy needs. Operators should be implementing strategies to achieve 100 per cent renewable supply well before 2050.

Although data centres almost exclusively consume electricity and emissions are therefore classified as Scope 2, the sector has an important role to play in carbon reduction through strategic energy purchasing. Large energy users, with stable consumption patterns, data centres can be important anchor customers of renewable power. Operators are already considering their options, individually and collectively. These currently include:

1. Operations near to under-used renewable power sources: some regions, like northern Scandinavia, have plentiful supplies of low carbon energy. Although these locations won't suit all operational models, they should be attractive to large cloud providers among others.

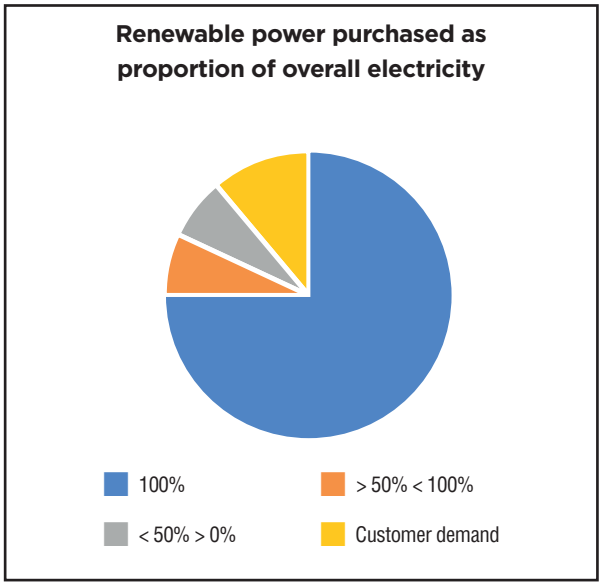
2. Generating power onsite: this is generally restricted to new builds with available land. Retrofitting is likely to be impractical on legacy sites and in urban areas.

3. Using power purchase agreements (PPAs) to stimulate additional renewable generation: PPAs are contracts between customer and generator and stimulate additional renewable capacity by providing long term funding for utility scale renewable projects.

4. Purchasing certified renewables from energy suppliers: Operators without the opportunity to self-generate, or undertake PPAs, can increase their commitment to low carbon energy by purchasing certified renewable power from energy suppliers. Currently in the UK this will not stimulate additional renewable generation because demand for renewables lags behind supply, but it demonstrates the level of commitment, sets an example to other energy users and sends an important signal to the market that demand is growing.

How are we doing?

Large cloud providers have the most freedom to locate their operations close to renewable power sources, and they are doing just that. As a result, we are seeing rapid growth in data centre developments in Scandinavia by operators like Google, Facebook and Apple. In the UK there are several projects underway to locate data centres next to power sources, for example on the Thames at Belvedere using energy from waste, but there are pros and cons to this form of generation. Other approaches to use new sources of renewable power are at development or demonstration stage. One example is the combination of offshore wind with salt caverns, with the latter used for pressurised air so that intermittency can be overcome by a form of pumped storage (but using air instead of water)[11].



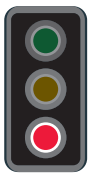
Onsite generation at scale is not yet happening in the UK. Elsewhere, some operators are taking data centres off grid altogether and are developing facilities in tandem with the generating capacity they need, independent of the grid. ETIX Everywhere is developing medium sized data centres together with onsite biomass generation, but deployment has not yet extended to the UK.

There is increasing adoption of Power Purchase Agreements (PPAs) within the industry. Google is leading the field here with 34 agreements in place since 2010 and is the world's largest corporate renewable energy purchaser. We anticipate that these agreements will become more widespread, but this will take time, because PPAs are non-straightforward and require considerable expertise.

In terms of procuring renewables, the ICT sector compares well with other industries[12]. Typically, data centre operators and cloud service providers are actively procuring renewable energy and Greenpeace has been monitoring this with their #ClickClean campaign. A recent survey of UK commercial operators revealed that 76.5 per cent of the electricity they purchased is 100 per cent certified renewable. 6.5 per cent of energy is between 0 and 50 per cent renewable, 7 per cent is between 50 per cent and 99 per cent renewable and 10 per cent is purchased according to customer demand[13].

Sector level actions

- Monitor and report renewables uptake
- Share expertise on PPAs.



5. Becoming an energy prosumer

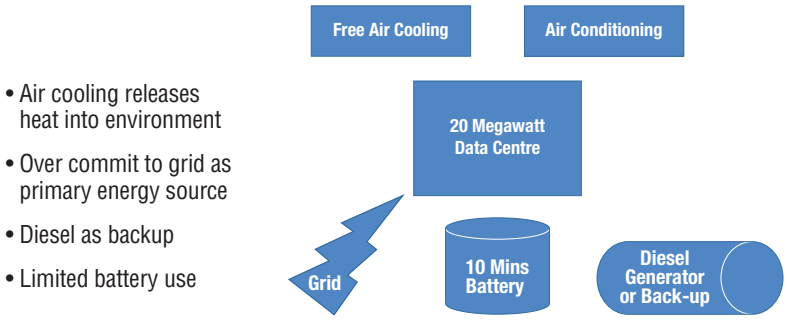
The sector needs to reduce overall reliance on the grid and become a more dynamic player in the energy market.

Deploying embedded capacity

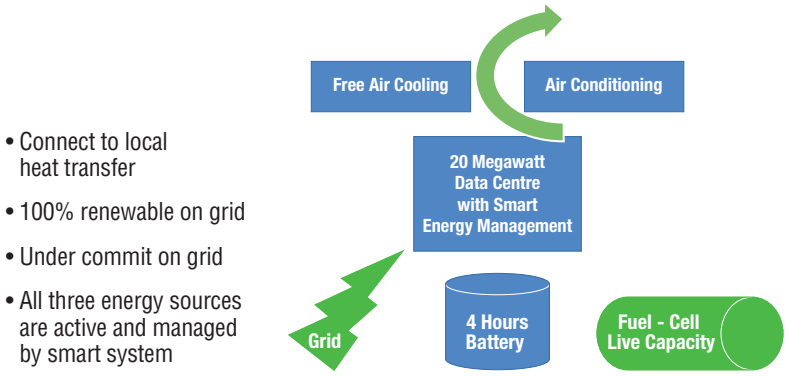
Sectors with embedded generating capacity can potentially support a more distributed pattern of energy supply, allowing greater dependence on intermittent renewable sources in our generating mix without compromising security of supply. Data centres have embedded generating capacity because IT functions cannot tolerate interruptions or fluctuations in electricity supply. This takes the form of battery arrays for instantaneous, short term supply and diesel generating plant that can run continuously if needed. In reality, these generators are hardly ever fired, other than for testing and maintenance.

We estimate very roughly that the sector could have around 2GW of embedded generating capacity in the form of diesel plant. In theory much of this could be deployed under DSR (Demand Side Response) schemes like STOR (Short Term Operating Reserve) to power data centres for short periods when the grid is struggling to meet demand, thus releasing capacity back to the grid. Related approaches like FFR (Fast Frequency Response) respond instantaneously when grid frequency drops. Had more capacity been contracted to provide FFR services, some consequences of the August 9th grid failure might have been mitigated. In practice, all forms of DSR from diesel plant are being ruled out by UK air quality legislation[14]. DSR also tends to be unpopular with most operators, whose customers (often erroneously) perceive it as an unnecessary risk.

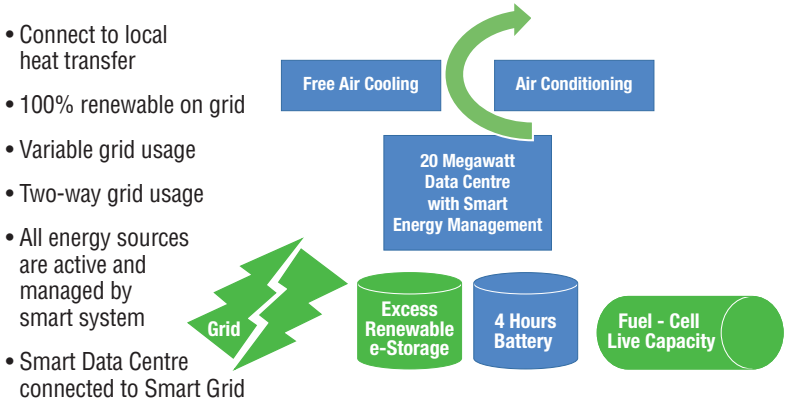
Today – Our Industry is 100% dependent upon grid, diesel backup, heat lost to environment



Tomorrow – 100% renewable from grid, ability to go off-grid, heat recapture



Vision – 100% renewable from grid, storage for grid, buy and sell to grid, heat recapture



New approaches to resilience

Market developments are also encouraging operators to explore new ways to deliver resilience and continuity of service. Emerging data centre business models, like Edge, will be deployed to support the rollout of 5G and will facilitate machine to machine communication. Computing resource for these activities will need to be adjacent to

the customer, rather than consolidated in large, remote facilities. Edge data centres will be very small, distributed around city centre locations and may deliver resilience through network and duplication rather than through redundant generating capacity.

Becoming a prosumer

The current generating model in the UK is monolithic, with almost complete dependence on a highly reliable, centralised electricity grid, where emergency capacity is installed purely to deal with supply shortcomings. However, energy models are changing; supply and demand interactions must become more dynamic. With the right technologies, policies and expertise, data centres can play a significant role in a smart energy landscape.

Advances in battery technology are starting to present data centre operators with new options for emergency supply for longer term outages and in time, there could be more opportunity to make stored capacity available without compromising business continuity. Fuel cell technology is also evolving fast and, together with developments in battery storage, could change the status of data centres from large energy customers to energy prosumer.

The ultimate objective would be to reverse the current market arrangement: instead of 100 per cent dependence on grid power, a data centre could in future supply the majority of its own power requirements, using the grid for top-up[15] or reserve, with potential capacity to export stored energy at times of need.

How are we doing?

Despite significant embedded capacity, it is unlikely that data centres will be able to provide balancing services from their diesel plant due to legislative constraints, unless operators can make the business case to fit abatement, which we expect to be rare. Gas turbines are being introduced on some sites; these emit far lower levels of air pollutants than diesel but uptake is limited. Moreover, opportunities of this kind may diminish as operators seek alternative routes to resilience that do not involve redundant generating capacity. In theory, data centres could also contribute to schemes like DTU (Demand Turn-Up) when the opposite happens, though in practice this is unappealing because it will adversely affect efficiency ratings.

Operators like Digital Realty, Equinix and Microsoft are already trialling fuel cell technology in some facilities. However, data centres are not yet energy prosumers and projects are still in R&D or pilot stage.

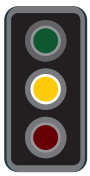
Sector level actions

There are few immediate actions that we can take at sector level, other than:

- Monitor, support and promote the development of alternative emergency (non-diesel) power sources
- Share best practice

Relevant publications

- **Policy conflicts:** http://www.techuk.org/images/techUK_DCC_Com_1606_policy_conflicts.pdf
- **Emergency Generation in Data Centres:** https://www.techuk.org/images/techUK_TechCttee_Briefing_Emergency_Generation_1701.pdf



6. Disclosure and reporting

Data centres should measure and report energy consumption robustly and consistently in order to monitor progress and identify trends.

Energy and carbon are reported by operators in a multitude of different ways: voluntarily through the CDP (Carbon Disclosure Project) or equivalents[16], contractually through the CCA, or by obligation through regulatory measures like EU ETS (EU Emissions Trading Scheme, which captures Scope 1 emissions), ESOS (Energy Saving Opportunities Scheme) and SECR (Streamlined Energy and Carbon Reporting). Data centre business models vary and this tends to make sector-level energy reporting tricky. For commercial (colocation) providers it is relatively straightforward, and the same applies to cloud companies who operate their own facilities. However, organisations like banks, universities, retailers and utility companies run data centres to support their corporate IT functions and although they may report corporate energy and carbon, data centre energy use is rarely segregated. In smaller organisations, these IT functions are sometimes distributed on premises in cupboards and server rooms instead of in data centres. This is a hopelessly inefficient approach to ICT. Moreover, energy use, while significant, is hard to account for.

How are we doing?

The UK's commercial sector reports energy and PUE through the sector CCA, which requires operators to measure and publish energy consumption and PUE. As a result we have detailed, robust, auditable data on sector energy use (currently 2.89TWh in 2018, equating to 0.8 per cent of the electricity generated in the UK). Unfortunately, the CCA was closed to new entrants from the end of 2018, so the dataset will not include new market entrants and will become increasingly incomplete as we approach the end of the scheme, in 2023. Moreover, no successor to the CCA has yet been announced, so it is not clear whether a future scheme will have the capacity for us to report sector- and site-level energy data in the way we do now.

Reporting Energy Use: How are we doing?

Commercial sector:

- ~95 per cent of operators reporting
- ~98 per cent of energy is reported.

There is a tail of smaller operators and new sites, but coverage almost complete.

Enterprise operators: Large companies report emissions and reporting requirements have expanded under SECR. but there is no systematic way to identify the data centre component.

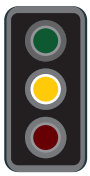
Distributed IT: No data.

Sector level actions:

- Continue to report CCA results
- Encourage enterprise operators with significant data centre estates to segregate data centre power so it can be correctly attributed

Relevant publications

* **CCA Report against first target:** https://www.techuk.org/images/CCA_First_Target_Report_final.pdf
* **CCA Report of progress against second target:** https://www.techuk.org/images/CCA_Second_Target_Report_04.pdf



7. Transparency

Data centre operators need to help customers understand the energy impacts of their digital activities and be transparent about the energy they use on behalf of others.

Accounting for carbon and disclosing sector energy use publicly are challenging enough, but data centre operators and cloud service providers also need to attribute energy and carbon to the services they provide for individual customers. Data centres are business rather than consumer facing, and transparency is important because it enables customer organisations to account for scope 3 emissions arising from their supply chain and outsourced activity.

In the cloud environment, however, individual consumers are often unaware of the energy impact of their online activity because there is no price signal. Freemium and advertorial business models are excellent in terms of driving innovation but tend to obscure individual energy use. Business and public sector customers are increasingly requesting information on the energy and carbon associated with digital activities they outsource to cloud. While cloud adoption is inherently more efficient than traditional approaches, they need data to inform their decision making and ensure they are making sustainable choices. A more detailed appraisal has been the subject of a separate work programme[17].

How are we doing?

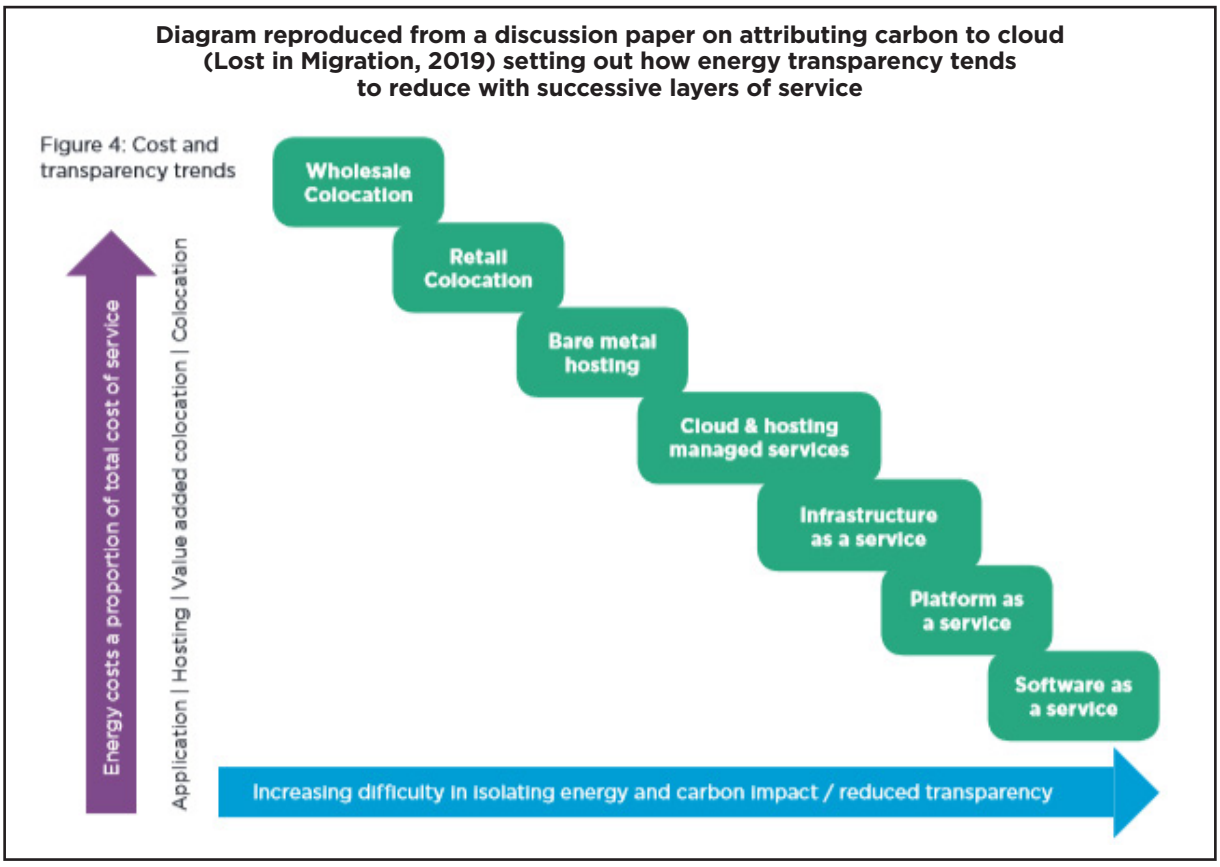
Commercial (colocation) data centres are already transparent in attributing energy: the predominant business model is to recharge energy to customers with an additional factor for the energy overhead of the supporting infrastructure. Customers are therefore incentivised to minimise their energy use and operators compete on the efficiency of the overhead.

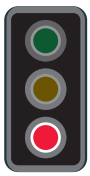
Attributing carbon to a cloud service, however, can be exceptionally challenging, depending on the type of service and the operator's infrastructure and the degree of transparency is mixed, with only a small minority of suppliers providing meaningful, customer-specific data. The sector is working with cloud operators and large customers to improve transparency[18].

Sector level actions

- Continue to identify approaches that can help customers attribute carbon to cloud services
- Showcase best practice in supplier-customer transparency

Diagram reproduced from a discussion paper on attributing carbon to cloud (Lost in Migration, 2019) setting out how energy transparency tends to reduce with successive layers of service





8. Heat reuse

The sector should make better use of waste heat.

The byproduct of computer processing is heat and where large numbers of servers are located together the heat output is considerable. Data centres already export waste heat in parts of Europe with adjacent customers and/or district heating networks. The sector has even adopted a performance metric based on the proportion of waste heat that is reused: ERF or Energy Reuse Factor[19]. The provision of waste heat is frequently a planning requirement and operators duly implement the required infrastructure.

Barriers to data centre heat reuse primarily relate to the quality of the waste heat, the absence of customers and lack of infrastructure. They also include technical difficulty in retrofitting infrastructure, especially where space is constrained, contractual issues like service level agreements, security risks, lack of awareness and recent regulation.

New technologies may help to change this. Immersive cooling, for instance, produces much higher quality heat and while deployment is currently limited, it is likely to become more widespread over time.

How are we doing?

Not well. In the UK successful projects are thin on the ground. Government introduced IHRS (Industrial Heat Reuse Support) to stimulate heat reuse in selected sectors, but the policy design is a poor fit for data centres. We must also remember that producing less waste heat in the first place should remain the overall priority, which could interfere with the viability of heat reuse projects.

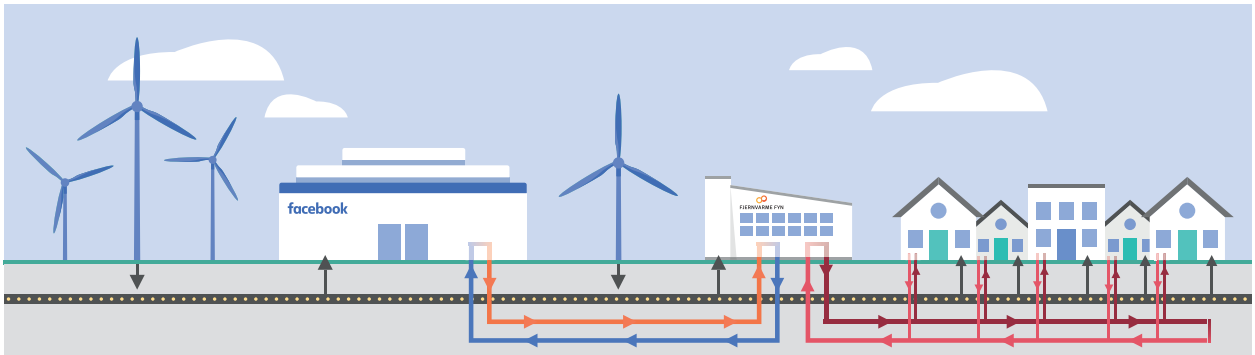
Sector level actions:

- Study successful projects elsewhere and apply those lessons in the UK
- When refitting, consider deploying cooling technologies that enable waste heat to be concentrated rather than dissipated.

Relevant publications

- **Informal Response IHRS Call for Evidence:** https://www.techuk.org/insights/news/item/12072-beis-consultation-on-industrial-heat-recovery-support-programme
- **Briefing note on Heat Networks Regulation:** https://www.techuk.org/insights/news/item/13170-briefing-note-on-heat-network-regulation-for-data-centres

Odense data centre: heat recovery process



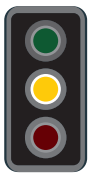
Wind turbines add renewable energy to the electric grid that supplies our data center and powers our servers

Hot air from the servers is directed over water coils to heat water

The warm water from the data center coupled with additional renewable energy is used in a heat pump facility to create hot water for the district heating network

The hot water delivers the heat to the community via the district heating network

Source: https://www.facebook.com/OdenseDataCenter/photos/a.1357162927738930/1357156894406200/?type=3&theater



9. Air quality

Operators should adopt practices that minimise air quality impacts from standby generators

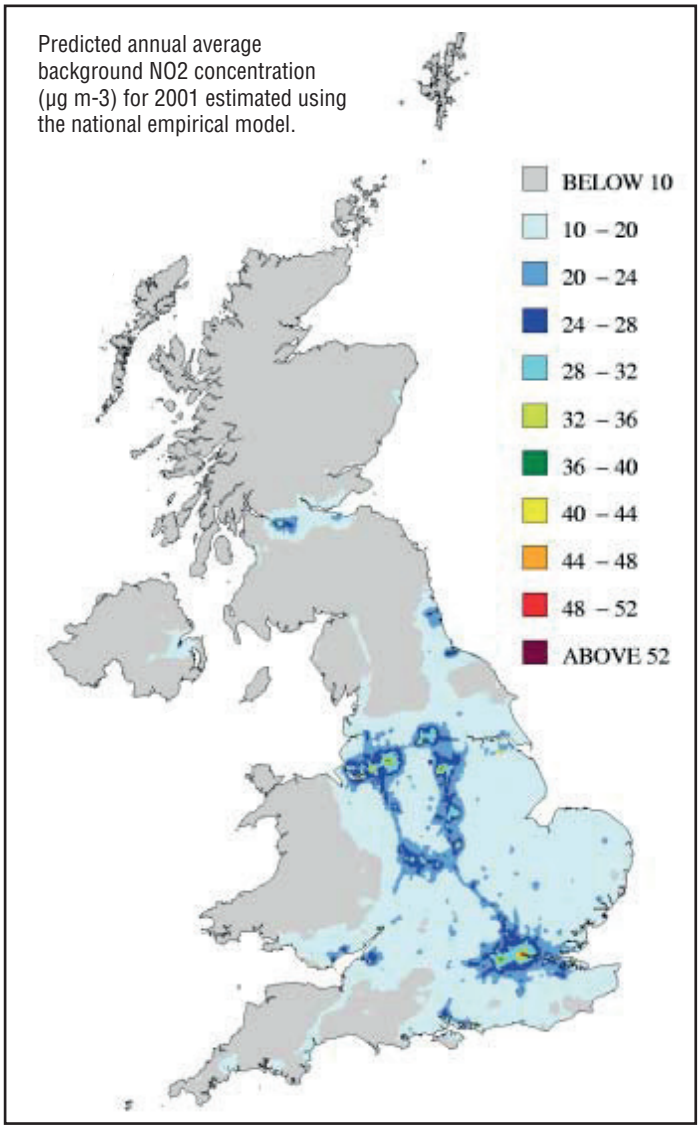
Combustion of fossil fuels does not just give rise to carbon emissions, it also generates pollutants like Oxides of Nitrogen (NOx), Oxides of Sulphur (SOx), Carbon Monoxide (CO) and particulate matter (PM), which cause harm to health. Although impacts are minimal it must form part of our discussion because emergency diesel generating plant can have localised, short-term effects on levels of NOx, SOx, CO and particulates.

Operators with large sites are already obliged under IED (Industrial Emissions Directive), and must meet the conditions of their permits, which are extremely exacting. Smaller plant is now covered by MCPD (the Medium Combustion Plant Directive) and SGC (Specified Generator Controls): new generators must have permits and in time the legislation will extend to existing plant.

There are some data centres that do not have diesel standby, and they either work to lower levels of resilience or they adopt different approaches to continuity of service.

How are we doing?

Variably. Those operators obliged under IED are minimising air quality impacts although the regulation is a very poor fit for data centres: targeted at large combustion plants its application to data centres was unclear and as a result the permitting process has been retrospective in several cases. All facilities must comply with MCPD, SGC and with planning conditions. However, the sector does not have a systematic set of best practices available for smaller operators to refer to. However, smaller operators could take additional steps to minimise impacts, such as staggered test runs, avoiding periods when ambient air quality is poor, identifying sensitive receptors and developing emergency plans. We think that applying practical voluntary measures across the whole sector would be more effective than over-regulating a small number of very large sites.

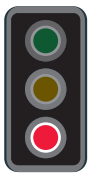


Sector level actions

- Develop air quality guidance for operators not currently obliged under legislative requirements

Relevant publications

- **MCPD and SGC Guidance Notes for Data Centres:** MCPD and SGC Guidance Notes for Data Centres
- **MCPD and SGC Guidance Notes for Data Centres:** Data Centres and Environmental Permitting
- **Generator emissions compliance roadmap (cones of pain):** https://www.techuk.org/images/generator_emissions_roadmap_FINAL.pdf



10. Regulation

The sector will work with regulators to help make policy fit for purpose.

The data centre sector welcomes targets and supports the UK's ambitions to be a global leader in committing to decarbonisation. However, operators would welcome rationalisation and review of the policy landscape. Energy policy has delivered significant carbon reductions at point of generation but at enormous cost to users (see below). Moreover, legislation targeted at energy consumers suffers from a number of shortcomings: instruments designed to improve energy stewardship by and large fail to drive activity to where it can be done most efficiently, and do not address issues at system or process level. Regulatory requirements are often poorly focused, overcomplex and unduly burdensome, and the result is that disproportionate resource is diverted towards demonstrating compliance rather than delivering improvements.

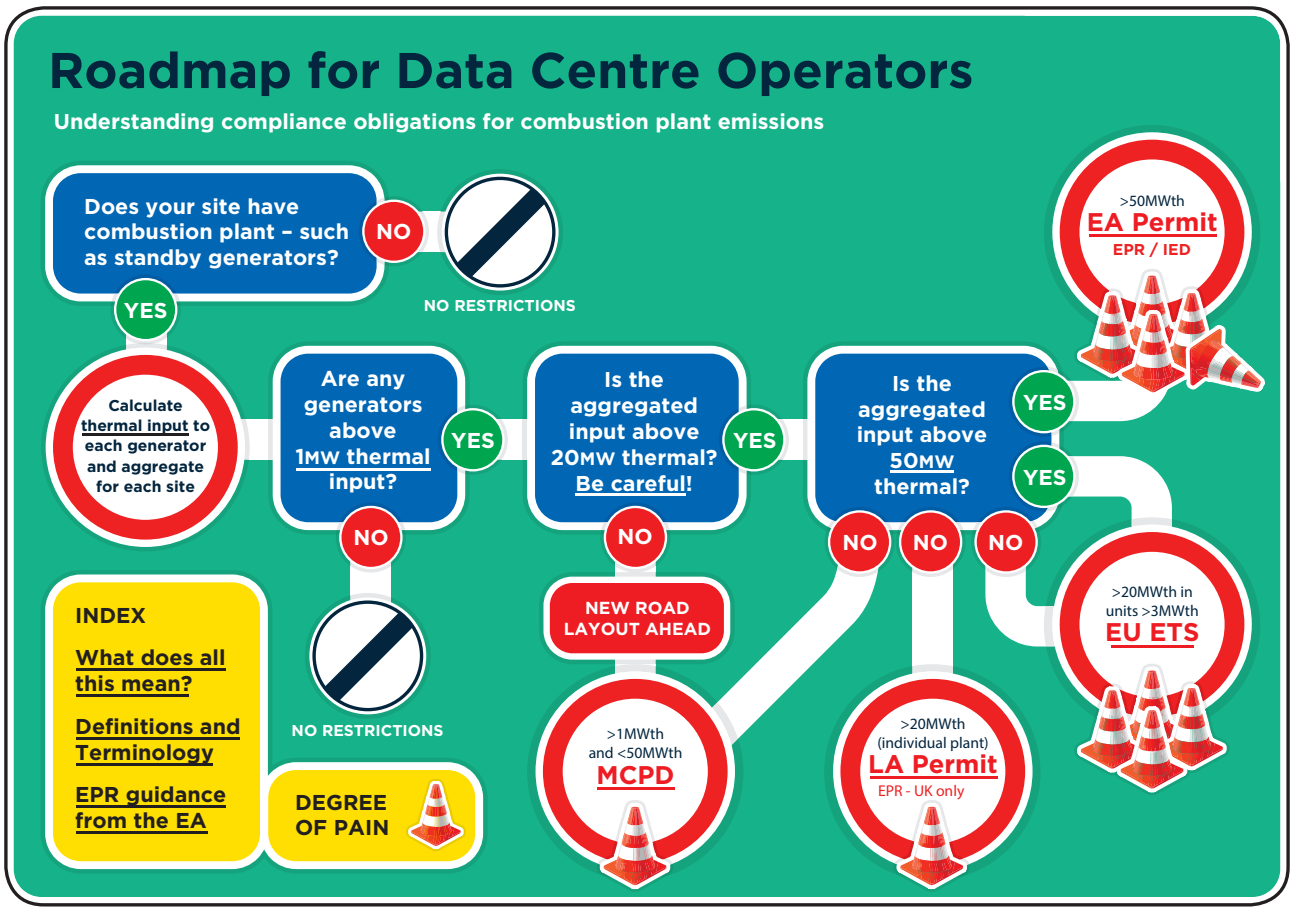
Table 1: Regulatory Requirements

Regulation / Requirement	Shortcomings	Scope	Burden	Outcome
EED - Energy Efficiency Directive Art 8 / ESOS: Requires large organisations to audit energy.	Expensive and adds little value. UK has gold plated implementation.	🟡	🔴	🔴
ETS - EU Emissions Trading Scheme: Cap and trade scheme to reduce scope 1 carbon.	Scope incorrect. Costly and burdensome. Delivers no policy outcome in data centres.	🔴	🔴	🔴
Gasoil Storage Tank Regulations: 110% secondary containment required.	Mostly harmless. Sector compliant, no issues except confusion over terminology.	🟢	🟢	🟢
Heat Network (Metering and Billing) Regs: Requires accurate attribution of heat/ cooling.	Scope incorrectly set. Delivers no policy outcome in a data centre context.	🔴	🟡	🔴
IED – Industrial Emissions Directive (EPR): Controls pollutants from large installations.	Scope incorrect. Very costly and burdensome, negligible policy outcomes.	🔴	🔴	🔴
MCPD & SGC: Impose max levels of NOx, SOx, PM for generators	Prevents DSR /load balancing. More onerously implemented in UK.	🟡	🟡	🔴
MEES - Minimum Energy Efficiency Standard: No leasing with EPC certificate below E.	Scope unclear. Sites already performing above required minimum standard.	🟡	🟢	🟡
SCER: Streamlined Carbon and Energy Reporting: Businesses to report energy.	Scope unclear. Exempts worst performing areas and duplicates requirements.	🔴	🔴	🔴

Table 2: Schemes and Incentives

Scheme / Efficiency Incentive	Assessment	Scope	Burden	Outcome
CCA – Climate Change Agreement: tax concession in return for efficiency gains.	Scope too narrow. Improves efficiency and transparency. Provides energy data.	🟡	🟡	🟢
GPP - Green Public Procurement: (in devt). Sustainable buying criteria for public sector.	Provisions sensible but criteria needed to drive consolidation and right-sizing.	🟢	🟡	🟡
IHRS: Industrial Heat Reuse Support: Aims to overcome barriers to heat reuse.	Scope incorrectly set. Does not overcome key barriers for data centres. Cumbersome.	🔴	🔴	🔴
IETF: Industrial Energy Transformation Fund: £315M fund to help industry decarbonise.	Scope incorrectly set. Fails to target wasteful business models.	🔴	🔴	🔴
STOR / FFDR: encourages large energy users to reduce consumption to relieve grid.	Data centre participation largely ruled out by Specified Generator Controls (qv).	🟢	🟡	🔴

Table 1 lists a selection of regulatory obligations imposed on data centres and assesses their relevance, the burden they impose and the policy outcome they deliver. Table 2 lists a selection of schemes and incentives designed to improve efficiency and assesses their relevance, ease of use and the policy outcome they deliver.



Non-mandatory schemes and incentives also provide a mixed picture. The unusual characteristics of the data centre sector, combined with low awareness within government, mean that most schemes are a poor fit. The best by far is the Climate Change Agreement, but its reach is limited to commercial operators and thus it excludes a large proportion of the sector. It has also been closed to new entrants and its future is uncertain.

How are we doing?

Data centre operators, like everyone else, are subject to policy instruments and must meet their compliance obligations. They take these obligations, and the reputational implications, very seriously. However, operators have a right to expect that energy related regulation will be appropriate, will deliver the required policy outcomes and will not impose disproportionate burdens. This expectation is currently not being met. Over the last decade the sector has done its best to explain shortcomings and propose improvements, but in reality has limited scope to achieve real change. A fundamental change in behaviour is needed among policy makers, who are increasing the complexity of the compliance landscape without necessarily improving effectiveness. There is also an unfortunate tendency to impose regulations on business while exempting their own organisations. The result is complexity and contradiction. New regulations have even been introduced purely to correct previous policy failures[20]. Any operator wanting to understand their obligations now must contract external expertise. This is damaging, costly and unnecessary.

Sector level actions

The sector has alerted policy makers to the shortcomings of instruments and will continue to do so.

V. Energy cost : The elephant in the room

Our ten target areas focus on elements that the sector can, to some degree, control. For this reason, energy costs do not feature in the list above, despite the fact that price is a critical factor for operators. With Brexit approaching and UK energy costs well above those of most competing European markets, Government needs to start sending the right messages to operators and investors. This is escalating into a critical issue for the data centre sector, so energy costs must feature on our Routemap.

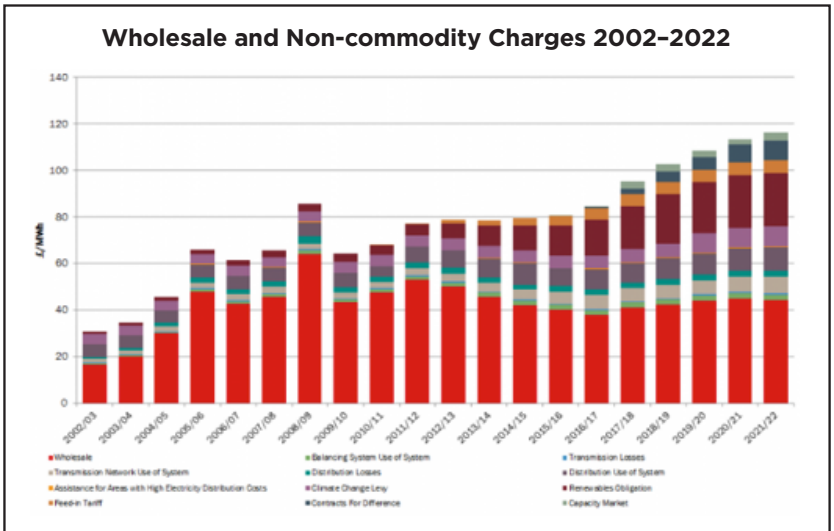


Fig 1: commodity and non- commodity costs in the UK. Source: Utilitywise

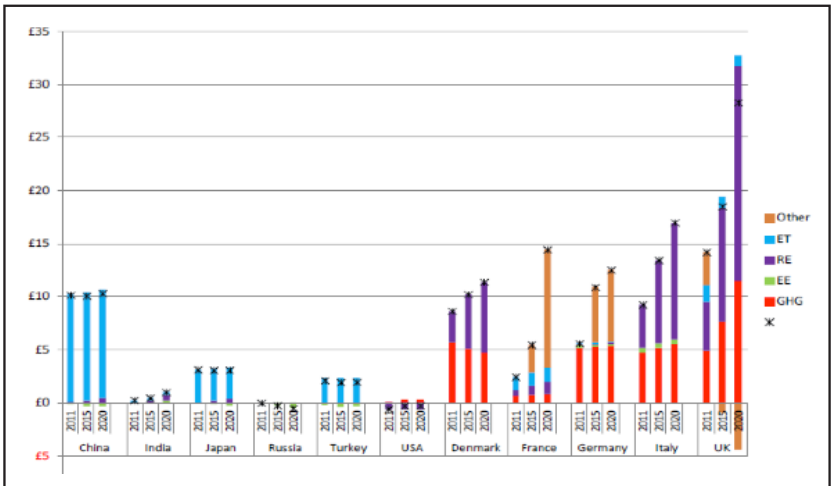


Fig 2: Indicative incremental impacts in 2011, 2015 and 2020 of energy and climate change policies using market forecasts of EUA prices. Source: BEIS

Data centres are energy intensive, compete in a highly commoditised marketplace and handle the most mobile commodity on Earth: digital data. High energy costs render UK operators uncompetitive and erode the UK's attractiveness as a place to locate or expand operations, compared to overseas markets. Urgent reform is needed to create a level playing field. Policy actions that are needed include the following:

- Implement the recommendations of the 2017 Helm Review of energy costs
- Fund energy infrastructure in line with other infrastructure projects
- Honour the 2016 commitment to reduce business energy costs
- Formally recognise data centres as electro-intensive industries
- Deploy price support mechanisms to support growth instead of delaying decline
- Reinstate the sector's Climate Change Agreement

Relevant publications

- **Impact of carbon policies on competitiveness:** http://www.techuk.org/images/techUK_DCC_Com_1703_competitiveness.pdf

VI. Dashboard: priorities, progress, actions

Summary of target areas, actions and progress.

This table summarises the routemap. It places the nine target areas in order of priority, assesses progress to date in each area, and identifies the actions needed by industry and government to improve outcomes. In one case, there are no specific actions in addition to what is already being done. In some, industry needs to step up and in others, policy needs to change. In more tricky target areas, both industry and government must act and even then, we only expect partial success.

Priority	Target category	Where are we now?	Actions required	Target level
1	**Security of supply**	High on risk register, good level of resilience.	**Industry action:** explore alternative routes to resilience.	
2	**Regulation**	Regulation often unfit for purpose, both energy policy and compliance instruments.	**Industry action:** alert regulators to policy shortcomings. **Policy action:** Make policy fit for purpose.	
3	**Energy stewardship**	Commercial and large enterprise leading. Performance variable in small enterprise and distributed IT	**Policy action:** refocus initiatives on problem areas.	
4	**Renewable adoption**	High level of adoption. Poor scope for onsite generation. PPAs limited to a few large operators.	**Industry action:** share best practice.	
5	**Becoming an energy prosumer**	Legislation prevents demand side response. Non-diesel standby rare. Industry needs to move from monolithic to dynamic smart prosumer.	**Policy action:** Address and resolve policy conflicts. Review incentives. **Industry action:** Monitor & encourage new technologies.	
6	**Strategy and policy**	Larger operators leading activity. No systematic strategic approach.	**Industry action:** Develop systematic, sector-level energy strategy.	
7	**Disclosure and reporting**	Large operators leading. Policy currently exempts problem areas.	**Policy action:** Review policy to reduce duplication and refocus on problem areas.	
8	**Transparency**	Data centres are transparent with customers about energy impacts, cloud providers vary.	**Industry action:** help customers understand energy impacts of online activity for their scope 3 reporting.	
9	**Heat reuse**	Few if any successful projects in the UK. Practical & regulatory barriers. Policy a poor fit.	**Policy action**: Review Heat Networks regulation, learn from success/failure. **Industry action:** Revisit as relevant technology emerges.	
10	**Air quality**	Sector complying with requirements. High burdens delivering low outcomes. Policy often cumbersome but ineffective	**Policy action:** Review effectiveness of current measures. **Industry action**: Adopt basic AQM best practices at sector level.	

VII. Recommended actions

Industry actions

Throughout our routemap we have identified potential actions for the sector to take at the bottom of each section. These can be summarised under four types of activity: Leadership, best practice, reporting and technology.

Leadership

- Develop a template for corporate energy strategy
- Encourage enterprise operators with significant estates to report DC power
- Identify approaches that can help customers attribute carbon to cloud services
- Develop air quality guidance for operators not currently obliged under legislative requirements

Best practice

- Showcase “Best in Class” energy policies and strategies
- Showcase “Best in Class” approaches to resilience
- Share expertise on power purchase agreements
- Continue to support development and adoption of relevant standards and best practices.
- Study successful heat reuse projects elsewhere and apply those lessons in the UK

Reporting

- Report power supply incidents
- Continue to report formally on sector readiness for climate change risks
- Monitor and report renewables uptake
- Continue to report CCA results

Technology

- Support deployment of emergency energy sources not reliant on diesel plant
- Explore alternative routes to resilience without resorting to standby power
- When refitting, consider cooling technologies that enable waste heat to be concentrated rather than dissipated

Policy actions

Within the text we have also suggested policy actions that would help data centres achieve their three key objectives of resilience, competitiveness and sustainability. While we think that resilience is relatively well handled at policy level, a number of actions are needed in the other two areas.

Sustainability

- Refocus policy to scrutinise areas of the sector that are performing badly rather than those that are performing well
- Review policies that are creating split incentives or acting as barriers to sustainability
- Ensure that scope is set correctly for policies like EU ETS and IED and enforcement is proportionate
- Review implementation of air quality controls vis-à-vis data centres and consider a more practical but widespread approach
- Upgrade policies that are not fit for purpose
- Drive renewables adoption by creating customer demand
- Drive transparency by creating customer demand for energy data

Energy Costs

- Implement the recommendations of the 2017 Helm Review of energy costs
- Fund energy infrastructure in line with other infrastructure projects
- Honour the 2016 commitment to reduce business energy costs
- Formally recognise data centres as electro-intensive industries
- Deploy price support mechanisms to support growth instead of delaying decline
- Reinstate the sector's Climate Change Agreement

Resilience

- Address obvious policy conflicts such as the inconsistency regarding DSR

VIII. Conclusions

The UK data centre sector is making good progress on its energy priorities, particularly in key areas like security of supply, renewable sourcing and energy stewardship: resilience is a high priority, adoption of low carbon power is good and increasing, operational standards, best practices and performance metrics are applied extensively and appropriately. The commercial sector's energy is publicly reported and customers have insight into their respective energy and carbon impacts.

However, there is room for improvement in many areas. While cloud companies tend to lead the way in renewable sourcing, they can struggle to attribute carbon to individual customers. Although commercial operators and large enterprise providers report carbon publicly, the same cannot be said for smaller in house, public sector and distributed IT, which means that energy data for the sector is incomplete. Distributed IT is notoriously inefficient and consolidating activity into purpose-built facilities reduces energy demand by at least two thirds.

This creates a reputational issue for the commercial sector: Although distributed and in-house IT is diminishing as existing functions are outsourced to colocation or cloud providers, distributed IT energy consumption is unreported, so these reductions are invisible, unlike any increase in activity in the commercial sector, where energy use is audited and reported. While net energy use might be decreasing, there is no way to demonstrate this because we can only see part of the picture.

Overall, we do not expect data centre energy consumption to decrease, because data centres underpin the delivery of so many new policy agendas, business models and consumer offerings. The Digital Agenda, superfast broadband, autonomous vehicles, smart grid, internet of things, will all generate data and their successful delivery will depend on the UK having state-of-the-art digital infrastructure. The same applies to consumer preferences, where a significant proportion of activity has moved online. All these impose demands on the sector and data centres, and ICT at large, must continue to deliver orders of magnitude improvements in energy productivity and efficiency to ensure that the exploding demand for data does not lead to a spike in sector energy consumption.

In addition to corporate and sector-level commitments to renewable generation and efficiency targets, the sector is, in theory, well-positioned to make a positive contribution to the UK's overall low carbon transition. However, a careful balancing act is required and the right technologies, expertise and policy levers need to be in place. Operators will not implement measures that increase risk, or perceived risk, for their customers. The primary function of a data centre is to deliver productivity, security, reliability and efficiency. Generating electricity, other than to ensure continuity of service, is not a data centre's core business.

In other areas things are not going too well. Operators are struggling to use waste heat effectively, primarily due to lack of customers and infrastructure. Data centres are also unlikely to play a productive role in load balancing unless policies change or new technology is rolled out.

Urgent policy action is needed to deliver on the Government's 2016 commitment to reduce energy costs for business. Policymakers have yet to implement any of the recommendations made in the 2017 Helm Review and widespread reform is needed across the broader energy policy landscape. We also need a more coherent regulatory regime for energy and carbon reporting: the current regime exempts those parts of our sector that are most in need of scrutiny: small in-house, public sector and distributed IT.

Carbon taxes and schemes have failed to drive activity to where it can be undertaken most efficiently and instead have penalised those parts of the market that are performing well and are already closely scrutinised. 2018 proposals to improve business energy efficiency failed to distinguish energy efficiency from demand reduction[21] .

Policies to encourage DSR are contradicted by legislative requirements. Air quality legislation imposes heavy burdens but under-delivers on policy outcomes. Scope is also set incorrectly for EU ETS. Incentives for heat reuse do not address the real barriers. The one policy measure that really works, the CCA, excludes an important part of the sector, is now closed to new entrants and has an uncertain future. By and large, compensation measures for energy intensive industries are designed to delay decline rather than support growth. So we all have work to do

Final thoughts

Finally, we need to remember that ICT is a means to an end, not an end in itself. We use digital technology to speed up processes, improve productivity and reduce cost. Data centres consolidate IT functions into purpose-built facilities and by doing so they improve the efficiency and reliability of that ICT. As core infrastructure, therefore, data centres help to ensure that the ICT deployed to deliver efficiency gains throughout the wider economy is itself efficient.

On the other hand we must keep a close eye on areas where there is the potential for net energy growth through new activities, through the creation of new types of demand, and access to new markets. Consumption must be transparent and accountable both to supplier and customer.

Overall, what we really need to know is that the sector is consuming less energy than it is saving in terms of avoided emissions, improved efficiency and dematerialisation. The problem is that this is very difficult to measure. How do we attribute the carbon savings from logistics software that optimises fleet movements, or account for avoided emissions from predictive maintenance? Carbon savings tend to be attributed to the sector that benefits, not the sector that enables them. Broader studies of the impact of ICT on climate change suggest that the balance is net positive[22], but more importantly, that much larger potential savings could be realised from the intelligent application of digital technology.

This is the first attempt at a sector energy routemap and is part of an iterative process. Building energy resilience and sustainability does not happen overnight: it is a journey. So this routemap is a work in progress to help us establish where we are now, where we want to be, and how to get from here to there.

IX. Further reading

Security of supply / resilience

- **Climate change adaptation: report to DEFRA under the Adaptation Reporting Power:** http://www.techuk.org/images/ICT_ARP_response_to_DEFRA_2016.pdf
- **Energy security of supply post Brexit:** https://www.techuk.org/insights/news/item/15034-energy-security-of-supply-in-a-no-deal-scenario
- **Data centre resilience to heatwaves;** https://www.techuk.org/insights/news/item/12485-techuk-input-to-environmental-audit-committee-inquiry-into-heatwaves

Energy stewardship

- **CCA first findings report:** https://www.techuk.org/insights/reports/item/2773-climate-change-agreement-for-data-centres
- **CCA Report against first target:** https://www.techuk.org/images/CCA_First_Target_Report_final.pdf
- **CCA Report of progress against second target:** https://www.techuk.org/images/CCA_Second_Target_Report_04.pdf
- **Data centre standards map:** https://www.techuk.org/insights/news/item/14709-mapping-the-data-centre-standards-landscape
- **Performance metrics for data centres:** https://www.techuk.org/images/Data_centre_performance_metrics_for_Tiny_Tots.pdf
- **Data centres and power: Fact or Fiction?** https://www.techuk.org/insights/reports/item/275-data-centres-and-power-fact-or-fiction

Enabling renewable generation

- **Policy conflicts:** http://www.techuk.org/images/techUK_DCC_Com_1606_policy_conflicts.pdf
- **Emergency generation in data centres:** https://www.techuk.org/images/techUK_TechCttee_Briefing_Emergency_Generation_1701.pdf

Heat reuse

- **Informal response IHRS call for evidence:** https://www.techuk.org/insights/news/item/12072-beis-consultation-on-industrial-heat-recovery-support-programme
- **Briefing note on heat networks regulation:** https://www.techuk.org/insights/news/item/13170-briefing-note-on-heat-network-regulation-for-data-centres

Air quality

MCPD and SGC Guidance Notes for Data Centres:

- **Generator emissions compliance roadmap (cones of pain):** https://www.techuk.org/images/generator_emissions_roadmap_FINAL.pdf
- Data Centres and Environmental Permitting

Energy costs

- **Impact of carbon policies on competitiveness:** http://www.techuk.org/images/techUK_DCC_Com_1703_competitiveness.pdf

Endnotes

1 https://digitalrealty.box.com/s/bserfy44rne36jxupnnnirdcbwdcvp7f

2 Primary energy is the total supply of energy to the UK. Some of this is used to generate electricity and currently around 2.5KWh of primary energy is needed to produce 1KW h of electricity. Only a minority of our primary energy supply is used for electricity generation, the majority is used as fuel or for other forms of direct combustion. Some is used for chemical feedstocks but that is not included in this total because it does not constitute part of our energy supply.

3 The Science-based target initiative is a partnership of CDP, WRI, WWF and UN Global Compact to provide companies with a clearly defined pathway to future-proof growth by specifying how much and how quickly they need to reduce their greenhouse gas emissions.

4 This is amortised among operators who have individual targets depending on baseline performance 15 per cent does not sound very much but these are colocation providers who control only the infrastructure, not the IT.

5 More recently, some data centres are being established "off-grid" with their own power supply or adjacent to a renewable source.

6 Most notably the CENELEC EN 5600 series, developed specifically for data centres.

7 The sector works to both international, peer reviewed availability standards like the EN5600 Series, and proprietary resilience standards like the Uptime Tier system, among others. See also techUK's data centre standards map

8 PUE, or Power Usage Effectiveness is a measure of energy productivity widely applied to data centres. It is the ratio of energy delivered to the IT function divided by energy to the facility. The lower the PUE, the higher the energy productivity.

9 These are dealt with in detail in our regular reports on progress against CCA targets (see further reading)

10 **See Eureca Project findings:** www.dceureca.eu

11 **See:** www.storelectric.com

12 **IRENA:** http://resource-platform.eu/files/knowledge/reports/IRENA-Corporate-sourcing-Market-Industry-trends-June-2018.pdf

13 Desk research conducted by techUK of CCA participants.

14 See: Policy Conflicts and our Briefing Notes on MCPD and SGC

15 Fuel cell technology is only financially viable if the cells are fully utilised, so the approach requires the fuel cells to meet the baseload demand so that they can run continuously, using grid power to top up. The result is likely to be in the region of 80:20 fuel cell to grid power.

16 The vast majority use the GHG Protocol, whose Corporate Accounting and Reporting Standard is the most widely used GHG reporting standard in the world.

17 See techUK's work on Attributing Carbon to the Cloud or contact emma.fryer@techuk.org

18 Between 2017 and 2019 techUK conducted round table discussions with large cloud customers from public and private sector and with carbon footprinting services to identify approaches that could help customers attribute carbon to their outsourced digital activity.

19 See: Data Centre Performance Metrics for Tiny Tots

20 The primary reason that the UK is breaching its NOx thresholds was the increase in diesel vehicles resulting from government policy encouraging drivers to switch from petrol. Specified Generator Controls were introduced purely to "regulate out" diesel generator farms that entered the market through contracts for difference, instead of correcting that policy failure at source.

21 Efficiency and demand reduction are not the same thing – improvements in efficiency are likely lead to an increase in net demand in price-elastic markets – see Jevons Paradox

22 **Publications include GeSI's Smart 2020 and Smart 2030 reports:** http://smarter2030.gesi.org/ **and** https://www.theclimategroup.org/sites/default/files/archive/files/Smart2020Report.pdf

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