Electricity Demand in Net Zero: Lessons from Data Centres

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Background to CERRE Study

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Aims of study:

- Provide regulatory/policy recommendations to frame the evolution of data centres (DCs)
- Discuss legal status of DCs with respect to energy consumption
- Explain what net zero energy policies imply for DCs and energy-intensive industries

This talk:

- Why DCs are interesting
- Net Zero and demand
- Back to DCs

Understanding DC Energy Consumption

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- **DC energy footprint**

  2.7% of Europe's electricity consumption in 2018 (3.2% in 2020)

  Drivers: traffic, computation, storage and infrastructure considerations

  Efficiency improvements have limited demand growth, but may be slowing down

- **Measuring & accounting for Data Centres energy efficiency gains**

  Power Utilisation Effectiveness (PUE) vs. other potential metrics such as DCeP (Data Centre Energy Productivity).

  Potential contributions to flexibility via UPS (Uninterruptible power supply) and on-site backup generation?

  Ongoing transformations: hyperscale (up to 100 MW infeed), cloud, PPAs, net zero commitments

Energy reporting by DC owners poor

Metrics	Proposed By	Discussed in	Utilization level in Environmental/ Sustainability reports of the main players in the industry*:
PUE Power Usage Effectiveness	The Green Grid (2007)	Yuventi and Mehdizadeh (2013) Brady et al. (2013)	90%
DCiE Data Centre infrastructure Productivity	The Green Grid (2007)	The inverse of PUE	0%
CUE Carbon Usage Effectiveness	The Green Grid (2010)	Alger (2013)	10%
WUE Water Usage Effectiveness	The Green Grid (2010)	Mytton (2021)	20%
PPE Power to Performance Effectiveness	Gartner (2009)	Capuccio (2009)	0%
ERF Energy Reuse Factor	The Green Grid (2010)	Wahlroos et al. (2018) Pärssinen et al. (2018)	0%
EER Energy Efficiency Ratio	Standard measure of heat pump efficiency	Ling et al. (2017)	0%
COP Coefficient of Performance	Standard measure of heat pump efficiency	Wahlroos et al. (2017)	0%
DCeP Data Centre Energy Productivity	The Green Grid (2009)	Daim et al. (2009) Sego et al. (2012)	0%

In spite of impressive global commitments:

Amazon is committed to being net zero by 2040 and using 100% renewable energy by 2025, and they have established a $2bn climate fund. Facebook committed to 100% renewable energy and being net zero across scope 1 and 2 emissions by 2020. They aim to be net zero across their scope 3 (supply chain) emissions in 2030. Microsoft are aiming to be carbon negative by 2030 across scope 1, 2 and 3 emissions, 100% renewable energy by 2025 and remove their historical emissions by 2050. They have established a $1bn climate fund.

* 10 Environmental/Sustainability Reports (2020) examined: Apple, Amazon, Microsoft, Google, Facebook, Equinix, Digitial Realty, Cyrus One, Global Switch**, Verizon

** Sustainability Report not available. The company's "Green Bond Framework" was considered.

Drivers of DC energy consumption poorly understood

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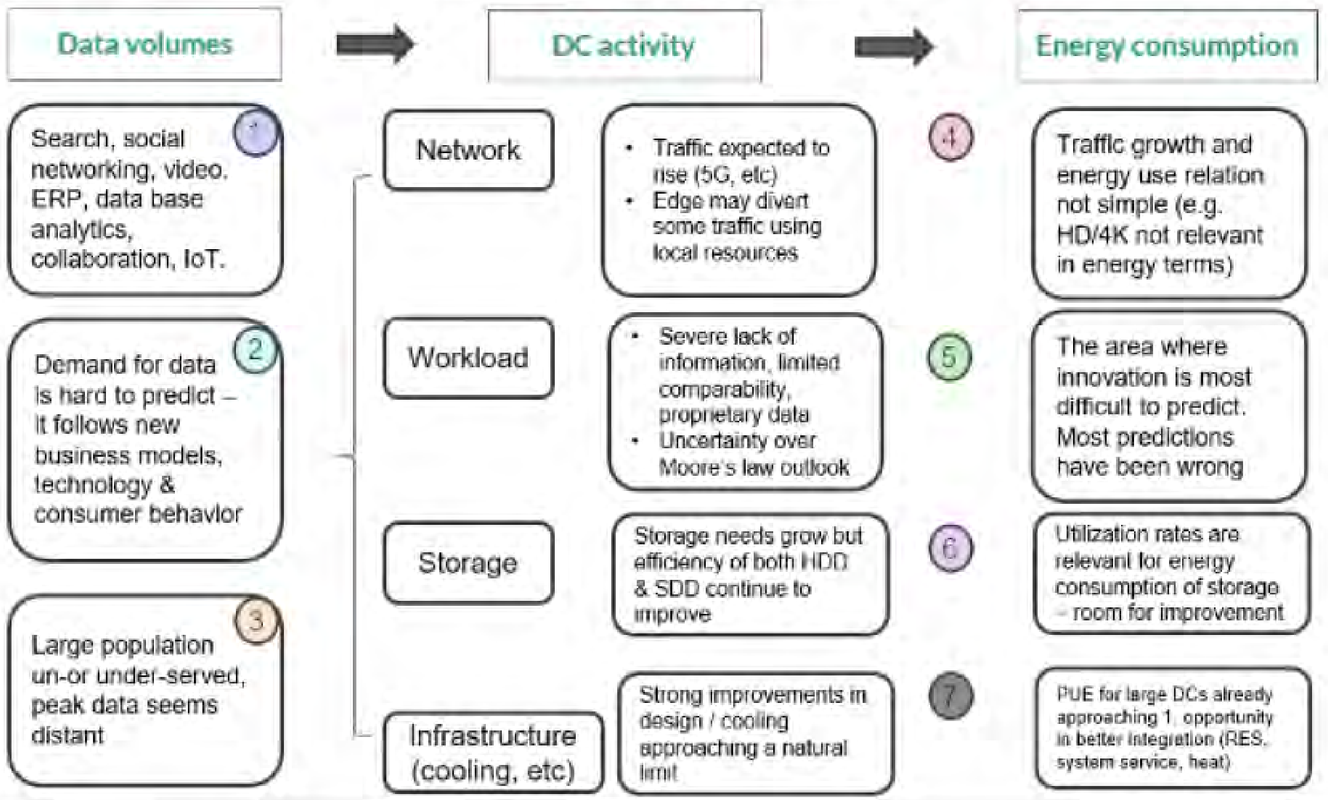
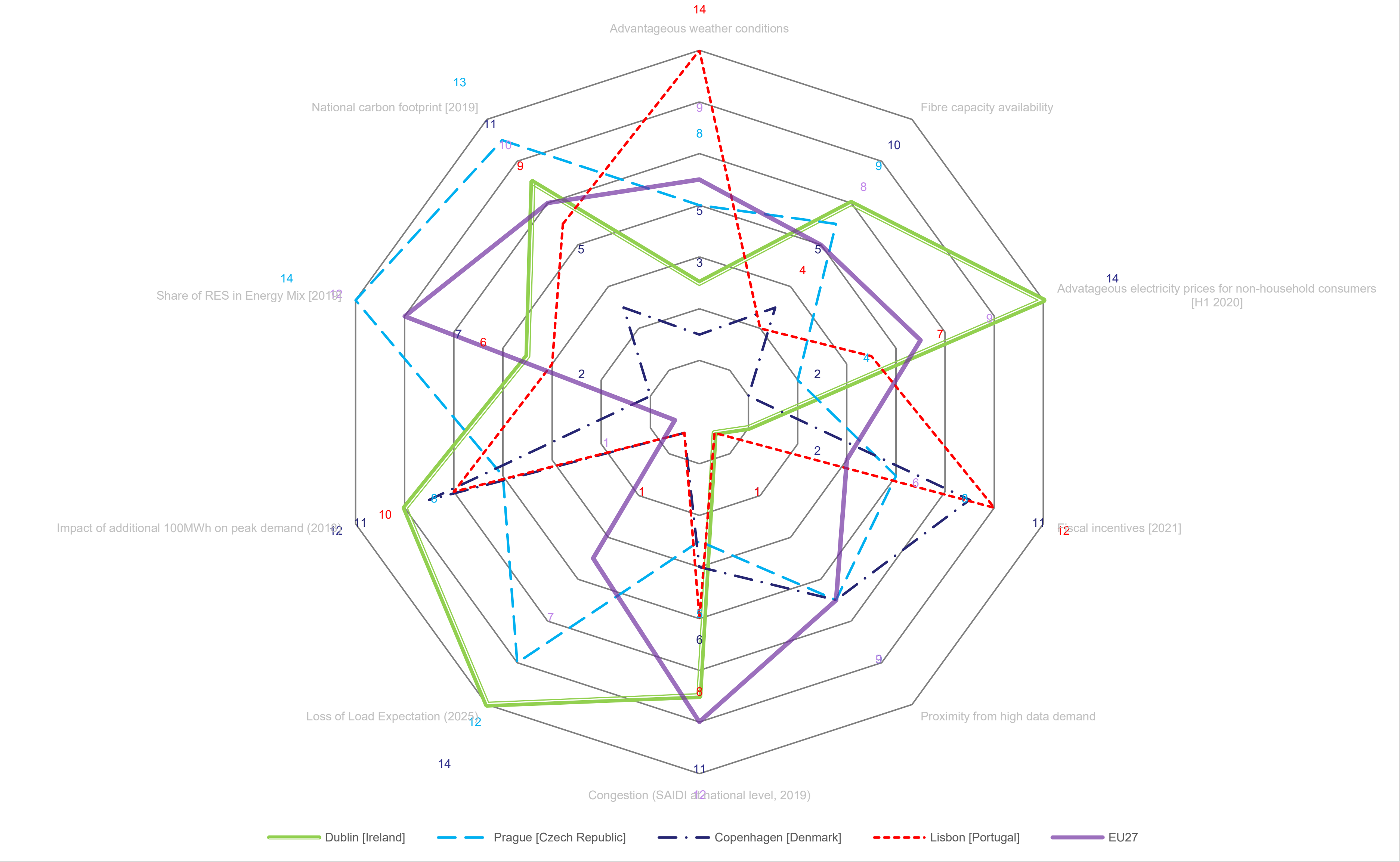
Figure 2: A visual representation of the relationship between demand for data, DC activity and energy consumption



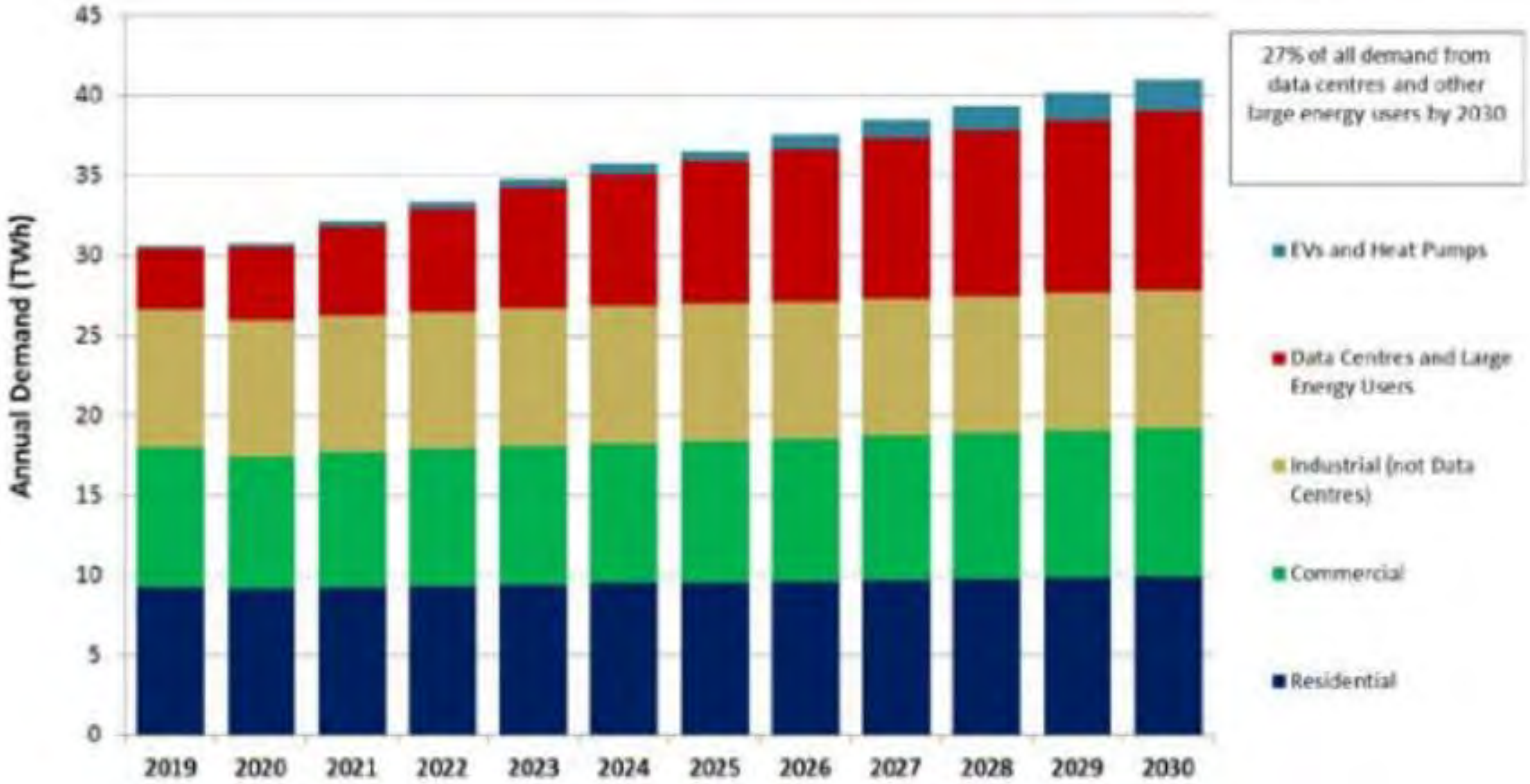
Source: Adapted from Koot and Wijnhoven (2021) and Masanet et al. (2020)
ERP = Enterprise Resource Planning; PUE = Power Usage Effectiveness.

Attractiveness of cities for DCs – Not just about energy



Case study: Demand growth in Ireland driven by DCs

Figure 13: Total electricity requirement forecast for Ireland 2021-2030



Source: EirGrid-SONI, 2021, p. 24.

Key elements of net zero
(see Chyong et al., 2021)

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- Lower energy consumption compared to business as usual

- Final electricity demand will increase
- Electricity will additionally be required for hydrogen, synthetic fuel
- More variable renewable electricity (VRE)
- More investment in electricity grids

- Decarbonising heating via electrification,hydrogen,biomethane,synthetic fuel
- Decarbonising transport via electrification, hydrogen and synthetic fuel

- Higher carbon prices

- More international trade in electricity (not just in Europe and North America)

- Negative emissions required via bio-energy with carbon capture and storage

Implications of net zero for large loads

- It is important to point out that the changes implied by net zero are profound in a 30-year timeframe. Decarbonisation of the European energy system involves reducing carbon by a factor of three relative to the reduction seen in the previous 30 years.
- Every major consumer of energy is going to be affected by the wider net zero impacts on the energy system.
- Net zero is not just about zero carbon sources of electricity. It is also about how increasingly intermittent sources of supply of electrical energy can be matched to demand in real time.
- Large inflexible loads will be under increasing scrutiny in a decarbonising electrical system.
- It is welcome that, for instance, DC owners are taking the initiative in working with the European Commission to support climate neutral DCs via the Climate Neutral Data Centre Pact against this background.

Implications of intermittency of generation

- Net zero implies a much more difficult to manage electricity system than we have now (O'Sullivan et al., 2014).
- Net zero will require substantial upgrading to power grids at the transmission and distribution levels to handle intermittency but also increased peak electrical demands arising from electrification of heating and transport.
- Increased intermittency suggests that there will be pressure towards the introduction of sharper price signals for time of use and location for wholesale electricity and ancillary services (Pollitt and Anaya, 2016).
- And/or it implies more use of control to match supply and demand, and hence incentives to self-supply.
- Sharper longer term and short term price signals differentiated by location within the electricity grid creates threats and opportunities for large loads.

What intermittency means for large loads

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- The threat is that electricity charges will generally be higher for large loads locating close to already congested demand centres. This includes DCs near European capital cities.

- The opportunity is that loads that can respond better to the price signals will face relatively lower average electricity costs.

- Net zero may not result in use of sharper price signals. It could result in more use of quantity rationing and priority ordering of loads. Here loads are disconnected with priority being given to critical infrastructure.

- DCs usually have an uninterruptible power supply (UPS) to protect the equipment from an outage arising from the main grid. This is usually in the form of a battery capable of maintaining the load for a short time. It could also have a generator attached. This UPS and onsite generation could be configured to additionally provide back up power and ancillary services to the grid.

- What seems likely is that any new large load being added to the system will be under increasing pressure and financial incentive to demonstrate their ability to serve their own load and/or provide flexibility to the wider grid.

What about heat decarbonization?

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- Heat decarbonisation presents a significant challenge for Europe.

- Unit heat prices should rise substantially, and hence if waste heat can be captured for use by nearby heat loads.

- The economic viability of local heat schemes should improve, suggesting that heat networks might expand in some places. For commercial buildings, such as DCs, who produce reliable heat in the winter, this may present an opportunity.

- The extent to which governments will be willing to allow prices to rise for heating will be a key political test for net zero.

- Heat network economics are challenging at the best of times with rising energy efficiency (e.g. at DCs) and reductions in the volume requirements for heating raising the unit network capital cost for district heating schemes.

Corporate PPAs on the rise in Europe

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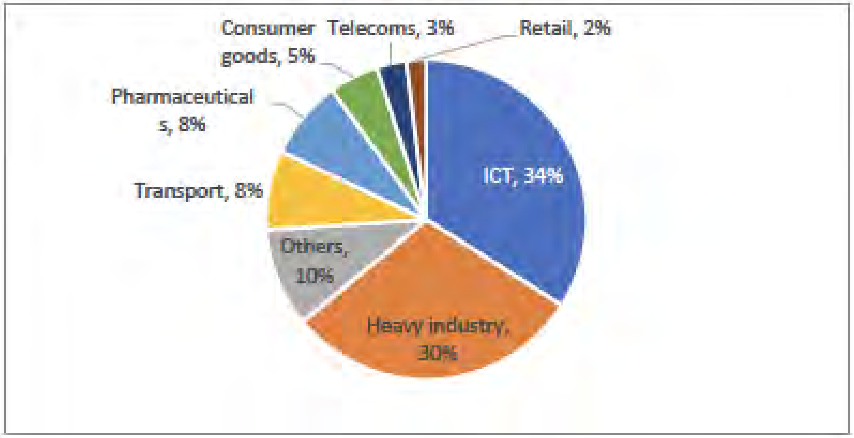
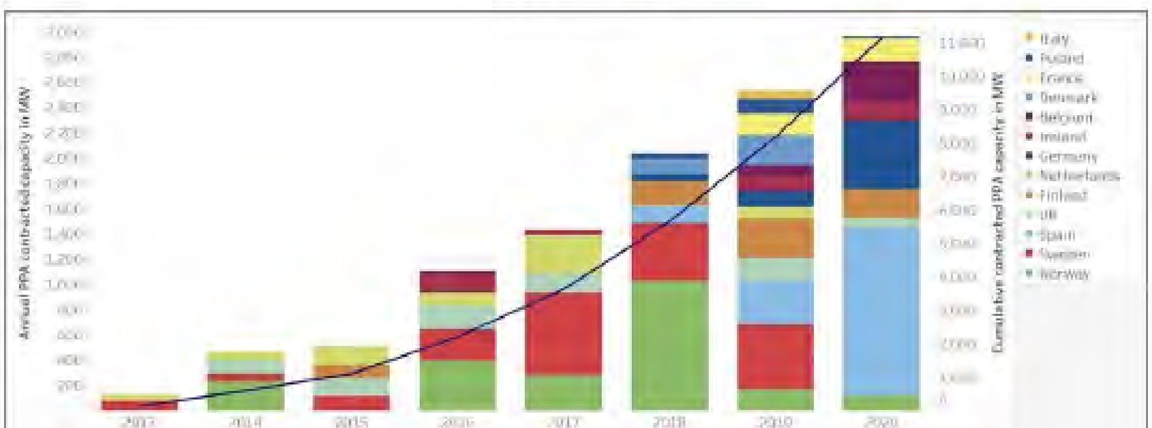
Figure 9: Power purchase agreements in Europe

(a) by sector



(b) by country



Source: RE-Source, 2021.

Can Corporate PPAs help?

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- It is important to point out that the power purchase agreement (PPA) strategy pursued by DC owners can be helpful if it adds additional renewable capacity more cheaply than would have otherwise been the case.

- However corporate PPAs will not on their own ensure the acheivement of levels of low carbon generation required by net zero, these will only be guaranteed by government policy.

- Additional benefits from corporate PPAs can occur if DCs make their sites available for renewables, or if DC owner support is influential in advancing planning applications for new wind and solar facilities.

- Variable renewable electricity (VRE) roll out rates are projected to be very high across Europe. Constraints to the acheivement of very high levels of VRE are unlikely to be contractual. Indeed, in Ireland there are doubts about the ability to deliver much more additional VRE capacity, regardless of new corporate PPAs.

Loads and Energy pricing

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- Net zero will likely significantly raise the unit price of energy. It has to, if relative total energy demand is to fall in line with the modelling (e.g. in Chyong et al., 2021).

- A reduction in relative energy demand of 33% requires an increase of roughly two thirds in the price of energy, at a price elasticity for energy of 0.5, more if income grows or the elasticity is less.

- Rising absolute energy prices and changes in relative energy costs could have profound impacts on the structure of the economy and on the use of data and hence the demand for DCs (and other loads). For instance, long distance travel seems set to be much more expensive under net zero relative to what it is now.

- So even if DC electricity costs rise, rising energy costs seem set to be good for promoting the use of data, for instance in video conferencing as an alternative to travel and in smarter energy systems.

What about loads and actual climate change?

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- We are seeing accumulating evidence that climate change is already causing increased variance in weather patterns. This manifests itself in increased deviation from long run average temperatures.

- Econometric analysis shows that this is not just a problem for agricultural sectors, but for the entire modern economy (Kahn et al., 2019). This is because just-in-time supply chains are badly affected by temperature variations in either direction (both extreme heat or extreme cold).

- DC owners and operators might be one of the sectors that needs to think carefully about this actual impact of climate change (Durairajan et al., 2018). DCs benefit from cooler locations with low long term weather variability in Europe.

- IT demand might be affected by average temperature and increased temperature variance. For instance, demand might rise when energy supply is restricted, due to joint effects (e.g. need to stay at home).

Loads and Locational pricing

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- There is already a trend towards more use of prices to signal location within the electricity system among leading jurisdictions (Pollitt and Anaya, 2016). This has been in spite of the EU attempting to encourage uniform wholesale electricity prices via the extension and deepening of the single market in electricity (and gas).

- It seems likely that new large loads (such as DCs) will need to think more carefully about where they are locating within the electricity grid, and about what impact they might be having on total energy system costs, given that they will bear these in at least proportion to their share of the load.

- The clustering of DCs around electrically congested areas, with emerging VRE supply constraints is something that will either raise electricity costs substantially or result in an increased willingness on the part of local and national governments to prevent new investment going ahead in electrically constrained areas.

Loads and local flexibility

- The more active distribution system operator is something that the European Commission has been seeking to encourage (Pollitt et al., 2021).

- An important issue in a more flexible electricity system is the need for increased visibility and predictability of individual distributed loads and generators.

- Traditionally, the transmission-level system operator has only been able to directly monitor the electrical injections and withdrawals of large generating units and large interruptible loads. There has been much less visibility at lower voltages and still less ability to predict usage patterns with a view to managing a constrained distribution system in real time.

- Over time, we would expect much more monitoring of individual loads consumption profiles and incentives to provide information on drivers of demand and the state of behind the meter batteries and onsite generation. This has implications for DCs, as well as other loads with UPS and onsite generation capability.

Regulatory Issues and proposals facing loads

- Dynamic regulatory approach based on mix of binding/non-binding instruments.
- Prioritise harmonisation of common definitions, obligations and operating rules.
- Carefully assess extended scope proposed under the revision of Critical Infrastructure Directive.
- Further integrate large loads (e.g. DCs) into high-level energy planning processes.
- Ecodesign Directive provides legal basis for further regulation of energy consumption by DCs.
- Streamlining the different initiatives and certification schemes and implementation of E1st principle into legal provisions (EED).
- Public administration to make use of greener DC technology.
- Specific regime for connection to the grid for large loads?

Conclusions

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- Unclear whether there is a specific issue with DC energy demand across Europe – emerging issues around specific cities
- Publicly available data on DC energy demand is woeful. Better metrics of energy performance and underlying drivers of energy consumption need to be in more widespread use
- Opportunity for industry to lead through associations, codes, and information provision.
- Climate neutrality requires flexibility of energy demand at both local and market levels, so corporate global commitments not that helpful.
- Little reason to *negatively* single DCs out in EU law given their need to have UPS and opportunities for back-up generation.
- **However all new large loads may need to face improved locational incentives, requirements for UPS, back-up and contributions to grid flexibility.**

Further Reading

- Banet, C., Pollitt, M., Covatariu, A. and Duma, D. (2021), *Data Centres and the Grid: Greening ICT in Europe.* Brussels: Centre on Regulation in Europe. https://cerre.eu/publications/data-centres-and-the-energy-grid/

- Chyong, C.K., Pollitt, M.G., Reiner, D., Li, C., Aggarwal, D., Ly, R. (2021), *Electricity and Gas Coupling in a Decarbonised Economy,* Brussels: Centre on Regulation in Europe. https://cerre.eu/publications/electricity-gas-sector-coupling-decarbonised-economy/