MORE WATTS FROM LESS CARBON; THE CHALLENGES OF INNOVATING TO ACCOMMODATE THE ENERGY DEMANDS OF DATA CENTRE PROJECTS WITHOUT COMPROMISING NET ZERO

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ABSTRACT

"During a severe drought, when the birds could find very little to drink, a thirsty crow came across a pitcher with a little water at the bottom. But the pitcher was high and had a narrow neck, and no matter how he tried, the water was beyond the reach of its beak. Unable to push the pitcher over, the crow dropped pebbles into the pitcher until the water rose near enough so he could drink."[2]

INTRODUCTION: A UNIVERSAL NEED TO INNOVATE

The convergence of first, economic demand to build more and larger data centres, and second, the political, social and environmental necessity to cut carbon emissions, is driving innovation in the construction and engineering sector at a pace and scale comparable to the first Industrial Revolution.[3] Construction projects in both sectors are attracting massive investment[4] but they have competing demands: the digital economy's insatiable appetite for vast and continuous power conflicts with the push to electrify by replacing fossil fuel generation with more intermittent generation from sources of renewable energy. This dilemma is exacerbated by a backdrop of increasingly volatile global energy markets, aggressive net zero targets, pressure to promote more sustainable development and increasing environmental activism.

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[2] Aesop's Fable, "The Crow and the Pitcher", Fable 390 in the Perry Index.

[3] In 2016, Klaus Schwab, the founder and executive chairman of the World Economic Forum, described the current era of connectivity, advanced analytics, automation and advanced manufacturing technology as the "Fourth Industrial Revolution". Just as steam propelled the original Industrial Revolution (from 1760 to 1840); electricity and automated machinery the second (from 1870 to 1914); computers and digitalisation the third (from the 1950s to the early 2000s); cyberphysical systems and intelligent computers have now ushered in the Fourth Industrial Revolution or "Industry 4.0" or "4IR".

[4] Capital expenditure on digital infrastructure surged after ChatGPT was launched to the public in 2022 and, by the end of 2024, is expected to have surpassed US$400 billion. See "Data center spending skyrockets as cloud building rush accelerates", Ashare, M, *CIO Dive*, 30 September 2024.

For its part, the UK government has recognised the importance of data centres. On 12 September 2024, the UK Technology Secretary announced the government has classed UK data centres as "Critical National Infrastructure" ("CNI"), the first such designation since the Space and Defence sectors gained that status in 2015.[5] CNI designation means the government will setup a "*a dedicated CNI data infrastructure team of senior government officials who will monitor and anticipate potential threats, provide prioritised access to security agencies including the National Cyber Security Centre, and coordinate access to emergency services should an incident occur*".[6] This added protection is likely to come with added burdens for data centre operators, such as implementing heighted cybersecurity protocols, carrying out regular risk assessments and preparing contingency plans.

Similarly, a rare point where Joe Biden and Donald Trump seem to have been aligned was the critical importance of investment in the digital economy for the US. In the closing days of his presidency,[7] Joe Biden issued an executive order aimed at advancing US leadership in AI infrastructure by accelerating the development of hyperscale data centres and clean energy facilities to support AI operations. This proactive approach to building robust AI capabilities domestically in tandem with protecting the environment has continued under the new administration: just two weeks later, President Trump confirmed support for the Stargate Project: a US$500 billion investment over four years to build new AI infrastructure for OpenAI, Softbank, Oracle and MGX[8] (having first revoked a 2023 executive order made by Biden introducing a regulatory framework on AI development).[9] It has been reported that the project could be powered partly by solar energy.[10]

Like the crow in Aesop's fable, engineers are embracing the twin virtues of ingenuity and persistence to find creative solutions for the digital economy and renewables to develop a more symbiotic relationship. This is translating into "first of a kind" solutions being released into the market and established technology being upscaled and/or adapted to perform

[5] See https://www.gov.uk/government/news/data-centres-to-be-given-massive-boost-and-protections-from-cyber-criminals-and-it-blackouts (last accessed 4 March 2025).

[6] https://www.gov.uk/government/news/data-centres-to-be-given-massive-boost-and-protections-from-cyber-criminals-and-it-blackouts (last accessed 4 March 2025).

[7] On 14 January 2025. See https://www.velaw.com/insights/biden-issues-executive-order-to-bolster-ai-infrastructure-in-the-u-s/ (last accessed 4 March 2025).

[8] More recently, it was reported that OpenAI is considering options in 16 states across the US and issued RFPs to develop five to 10 Stargate data centres, each with capacity of 1GW or more: https://www.datacenterdynamics.com/en/news/openai-exploring-stargate-data-center-options-in-16-states/ (last accessed 4 March 2025).

[9] Executive Order dated 23 January 2025: https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/ (last accessed 4 March 2025).

[10] https://www.pv-magazine.com/2025/01/27/trumps-500-billion-ai-datacenter-project-expected-to-be-powered-by-solar/ (last accessed 4 March 2025).

in new environments. It also presents an opportunity for those involved in data centre projects to learn from the expensive lessons of the early offshore wind projects and borrow ideas from other industries where the levels of tolerance for failure are so small that contractual warranties promise continuous operation without any appreciable risk of failure, such as aviation.

The legal issues that data centre projects generate are still emerging. The first publicly reported legal actions relate to issues arising during the project development phase in the form of challenges to planning permission, compliance with increasing regulation and securing tax incentives. But the industry will likely require much more intensive legal intervention to deal with the issues that are only now emerging during the execution and post completion of hyperscale data centre projects. Existing procurement strategies are proving unsatisfactory in that they are failing to provide the contractual tools necessary to overcome the reality of prototypes failing to perform as expected during engineering/factory testing, such that engineers then have to scramble to get them to work in an environment where there is no quick or easy fix, but time is of the essence. The substantial cost and time it takes to resolve these problems is manifested in claims during execution, at least some of which will crystallise into disputes that ultimately will be resolved in legal proceedings.

The legal profession needs to be brave if it is to remain relevant in this evolution. Innovation in construction law must be more than the use of electronic bundles, drones, artificial intelligence and the like. Construction lawyers need to challenge perceived wisdom and proactively seek innovative legal solutions to provide contracts that are fit for the purpose of today's innovative construction projects. In short, lawyers must join Greek philosophers,[11] 19th century economists[12] and modern rock musicians[13] in discovering that "necessity is the mother of invention".

THE DIGITAL ECONOMY'S DEMAND FOR POWER

There are various statistics circulating publicly as to how much energy cloud computing and generative AI already consumes,[14] and it is predicted to grow: McKinsey forecast that generative AI will account for 11 per cent

[11] "*ποιήσει δὲ αὐτήν, ὡς ἔοικεν, ἡ ἡμετέρα χρεία*", Plato's Republic. Translated to "*our need will be the real creator*" by Jowett, B in *Plato's Republic: The Greek Text* (1894).

[12] Boserup, E, *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure* (1865).

[13] The Soul Giants changed its name to the Mothers when it debuted on 10 May 1965, American Mother's Day. However, its record company insisted it rename itself "the Mothers of Invention" because it objected to the insinuation that "Mother" was short for mother***ker.

[14] E.g. cloud computing currently accounts for about 0.5 per cent of the world's energy consumption but is expected to exceed 2 per cent in the coming years. See "What to know about Chat GPT's Impact on Planetary Resources", *Foreign Press Correspondents USA*, 14 June 2024.

of the global energy demand by 2030 (compared with just 3 per cent in 2023); each ChatGPT query is said to consume 2.9 Wh of electricity, nearly 10 times more than a standard Google search engine;[15] and the energy consumption for the computational training of ChatGPT is even higher.[16] It is more difficult to assess with any accuracy the emissions attributable to the digital economy but it is clear that data centres have the potential to generate a substantial carbon footprint at a time when governments are focused on decarbonising power generation.

Notwithstanding concerns about the lack of clear regulatory guidelines and data privacy, most organisations are looking to integrate some artificial intelligence into their operations in the near term, which will lead to increased dependence on continuous access to the underlying data. In this respect, the demands of the digital economy will become analogous to the aviation industry in demanding extremely high levels of performance and redundancy, precisely because the unique nature of the data stored in each data centre elevates the criticality of eliminating the risk and consequences of failure. But the intermittent nature of renewable sources of energy is not conducive to meeting the power needs of this "always on", uninterrupted digital communication system.

Surges in demand arising from extreme weather and cyberattacks are exacerbated by the concentration of data centres in "hubs" or "clusters" along fibre-optic cables routes, overloading local grid infrastructure. The impact of any degradation in the volume or quality of its power supply, let alone an unplanned outage, on a data centre project is usually felt most acutely in indirect or consequential losses. Yet, those are the very losses that construction contracts seek to exclude. Similarly, it is difficult to estimate the losses that are likely to flow from such events at the time the liquidated damages provision is being negotiated. The unique nature of the data that is being stored in a data centre is such that, if a user's access is disrupted by a failure at the data centre within which it is being stored, the user's business is paralysed until the data centre comes back online: absent a backup system, it cannot simply buy the same data from an alternative data centre. Liquidated damages for the contractor not meeting performance guarantees are unlikely to cover the data centre's exposure to claims from its customers.

Construction lawyers need to be proactive in considering innovative – even radical and/or bespoke – solutions with greater focus on risk identification and the types of losses that will be incurred in the event of failures, rather than simply recycle the standard design and build models focused on

[15] Todorovic, I, "ChatGPT consumes enough power in one year to charge over three million electric cars", *Balkan Green Energy News*, 4 September 2024.

[16] It is said to be equivalent to the energy consumption of an American household for more than 700 years. "What to know about Chat GPT's Impact on Planetary Resources", *Foreign Press Correspondents USA*, 14 June 2024.

risk transference and conventional remedies for delays or warranty claims during Defect Liability Periods. For example, might it be better to pursue general damages – perhaps capped but without excluding consequential loss – rather than default to drafting increasingly complicated formulae for liquidated damages (many of which later prove to be unworkable)? Is there scope to imitate the insurance market by adopting a wedding cake structure for consequential loss with layers of liability being attributed to different parties? To what extent might insurance step in?

GRID CONSTRAINTS

Upstream of data centres and downstream of renewables, limited capacity and connectivity to the grid is constraining development of renewable energy and data centres alike as projects compete for extended waiting times to secure connections. The enormous influx of projects seeking grid connections, and the increasing technical complexity of providing them, has created a situation where 2035 connection dates have become commonplace.

To address these problems and alleviate the difficulties of balancing supply and demand, to maintain stability across grids fed by fluctuating renewable power generation, the construction industry is redrawing the global power transmission map. Nationally this involves re-routing and extending the old existing grid infrastructure (radiating from sites of fossil fuel or large-scale nuclear power stations, coal mines and ports for importing oil) to connect renewables in remote (and sometimes offshore) locations. Internationally, there is a growing network of high voltage interconnector projects crossing oceans and borders to allow surplus energy from renewables in one country to make up shortfalls in renewable sources abroad.[17]

The concentration of data centres in "clusters" or "hubs" around fibre optic corridors has forced some governments to take drastic action. Attracted by its proximity to transatlantic fibre optic cables, a cool climate and clean water, there is a hub of over 80 data centres around Dublin, which consumed more than a fifth of Ireland's electricity in 2023. In an effort to counter the risk of overloading the grid, in 2022, the Irish government banned new construction in Greater Dublin (originally set to last until 2028) and, in September 2024, the Minister of Energy demanded data centre owners invest in their own renewable energy and battery storage

[17] See for example the North SEA Link project: at 720 km, it is the world's largest subsea interconnector connecting the electricity systems of the UK and Norway. At times of surplus, it allows Norway to export excess hydro power to the UK, and the UK to export excess wind power to Norway.

facilities. Similar bans had previously been introduced in Amsterdam and Singapore in 2019.[18]

The needs of the digital economy are urgent so data centres must adopt innovative interim solutions to mitigate the weaknesses in the transmission network while it is being overhauled. For example, the need to get into the queue for connections for high voltage transmission lines has driven some developers in the UK to apply for connections without knowing if the project will even go ahead, let alone what their energy demands might be. In an effort to tackle the problem of long waiting times for connections, Ofgem (the UK energy regulator) moved away from its first-come first-served system in November 2023, in order to clear stalled "zombie projects" and fast track others.[19] The rule change gave National Grid the power to introduce strict project development milestones into connection agreements, with powers to terminate if they are not met. However, this has the potential to compound the existing problems of long lead times for key elements in data centre projects and/or derail the logical critical path. The experience of offshore wind projects – where the costs of the marine spread invariably forces non-conforming or incomplete work to be rectified or completed in the more difficult offshore environment rather than lose vessels chartered years in advance – provides a salutary warning: programme constraints designed to ensure delivery and installation of equipment in time to meet National Grid milestones might drive an artificial critical path at the expense of spending time de-risking the project with longer FATs etc.

Another option is for data centres to behave like hermit crabs by repurposing old industrial sites to take advantage of their space, existing grid connections and access to plentiful cooling water.[20] Recent examples include Microsoft's plans to develop data centres on the site of two

[18] In Amsterdam it was driven by a scarcity of space; in Singapore it was driven by concerns about power and the lack of development space. In both cases, although the moratoriums were subsequently lifted, data centres looked to new markets in Europe and South East Asia thereby displacing the clusters. See Gooding, M, "The ongoing impact of Amsterdam's data center moratorium", *Data Center Dynamics*, 22 August 2024.

[19] "Ofgem announces tough new policy to clear 'zombie projects' and cut waiting time for energy grid connection", Press Release on Ofgem website, 13 November 2023 https://www.ofgem.gov.uk/press-release/ofgem-announces-tough-new-policy-clear-zombie-projects-and-cut-waiting-time-energy-grid-connection (last accessed 4 March 2025).

[20] There are innovative cooling technologies that reduce the need for water coming to market but, currently, a relatively standard data centre cooling system can consume about 550,000 gallons of water per day. Engineers initially addressed these challenges by locating projects in cooler climates (such as the Arctic Circle Data centre in Norway) and installing rainwater reclamation systems on data centre roofs. In 2013, Microsoft launched "Project Natick" – an underwater test data centre in which 855 servers were submerged in a sealed container 117 feet below sea level off the coast of Scotland and compared its performance with 135 servers installed in racks of a conventional data centre. See Judge, P, "Project Natick: Microsoft's underwater voyage of discovery" and Moss, S, "Microsoft confirms Project Natick underwater data centre is no more", *Data Center Dynamics*, 5 January 2021 and 17 June 2024, respectively. It even leased a burst of wave energy from the European Marine Energy test centre on Orkney. Only six of the subsea servers (equivalent to 0.7 per cent) failed, whereas eight of the servers on dry land failed (equivalent to 6 per cent). The steady external temperatures of the subsea environment and

decommissioned power stations in northern England; Amazon's proposed campus on the site of the old Birchwood power station in Virginia, US; and Virtus Data Centres planned conversion of a decommissioned solar farm in Berlin and a former wartime munitions factory in the UK into data centre campuses by 2026.[21] As with any brownfield site, the construction contracts will need to look carefully at the allocation of risk for unforeseen ground conditions and responsibility for dealing with contamination.

In *R (Cobalt Data Centre 2 LLP) v Revenue and Customs Commissioners*,[22] the exponential growth in demand that is driving a surge in investment in data centres incentivised one developer to issue a variation that completely changed the project from an industrial unit to three data centres. This led to a surprising situation where the Supreme Court in a tax case issued the leading decision on the scope of a developer's right to vary the works under a JCT "Golden Contract". The original contract provided options for the construction of six different buildings on different sites within an enterprise zone, with the scope of work for each being specified in "great detail" in a series of appendices to the contract. However, three years later and wanting to take advantage of valuable tax incentives for future construction work commissioned within the first 10 years of the enterprise zone, the parties agreed to vary the contract to build a completely different project: three data centres instead of an industrial building and a business park. The central issue turned on whether the agreement to build the data centres could constitute a variation under the original construction contract (and so fall within the initial 10-year period for the enterprise zone) or amounted to a new contract. The Supreme Court held there was an express limit on the developer's unilateral right to issue variations in that it could vary the work "*only to the extent that what is sought to be substituted by the requested Change are still design, quality and quantities of what is substantially the same building (i.e. in this case an industrial unit …)*".[23]

While the facts of that case are extreme, the difficulties of anticipating future capacity needs and building sufficient redundancy to be able to accommodate what will inevitably become bigger, more powerful and more efficient computing power (with commensurate increases in energy demand) in the future suggests the industry will inevitably see major variations to construction contracts for data centre projects, particularly since planning, regulation and grid connectivity have the potential to

the fact that the data centre was filled with inert nitrogen (rather than the reactive oxygen present in conventional data centres) were considered key factors in the success.

[21] Hodgson, C, "Old power stations tapped to house AI data centres", *Financial Times*, 23 August 2024.

[22] (SC) [2024] UKSC 40; [2024] 1 WLR 5213.

[23] At paragraph 116. The Supreme Court went on in paragraph 117 to give a naval example to illustrate its point: "*A shipbuilding contract for the construction of an aircraft carrier may contain a right to alter or modify aspects of its design, quality or quantities. But if the Admiralty decides instead that it wants a nuclear submarine, this will not be a matter of alteration or modification to the design, quality or qualities of the specification of the aircraft carrier. That specification will have to be abandoned and completely replaced.*"

extend the development period and delay data centre projects by five to 10 years. Certainly, the challenge for data centre owners is that "*if they make an investment, by the time it is built, it is already out of date*".[24]

A further alternative has been to turn to new energy sources that avoid transmission through the power grid such as green hydrogen, which is produced by electrolysis using electricity from renewable generation and emits no greenhouse gases during production but, unlike renewable generation and similar to fossil fuel generation, can be activated immediately and does not need to be transported through the grid. In September 2024, Microsoft announced a landmark pilot project to power its Dublin data centre campus with green hydrogen.[25] Similarly, renewable and reusable heat resources that are transferred through pipelines – like geothermal energy, energy from waste and waste heat from data centres themselves – can reduce reliance on the grid.

Finally, advancements in technology make microgrids an attractive option, particularly where data centre clusters are co-located with renewables by allowing data centres to draw on onsite energy sources while effectively balancing power supply and demand to provide a more resilient and sustainable power supply.[26]

ENVIRONMENTAL IMPACT ASSESSMENTS AND JUDICIAL REVIEW

There has been a spate of legal actions from environmentalists seeking to block further data centre developments and associated grid infrastructure in Ireland. So far, the Irish Courts have supported the continued development of data centres as desirable but environmental activists have succeeded in delaying projects by multiple years. For example, in April 2024, after six years of planning, Ireland's independent planning authority upheld a 2022 decision to grant developers permission for a €1.2 billion data centre but the project was almost immediately beset by legal action: eight appeals were lodged against the decision based on alleged failings in its Environmental Impact Assessment (EIA).[27] Notwithstanding the developer's efforts to utilise spare capacity in the grid and access power generated from wind and

[24] Schneider Electric UK citing the Stanford Group. See "The top 9 mistakes in Data Centre Design & Planning": https://www.se.com/uk/en/work/campaign/data-center-design-overview/ (last accessed 4 March 2025).

[25] "Microsoft announces pioneering green hydrogen pilot project with ESB", Microsoft press release on 27 September 2024: https://news.microsoft.com/source/emea/2024/09/microsoft-announces-pioneering-green-hydrogen-pilot-project-with-esb/ (last accessed 4 March 2025).

[26] Shapiro, S, "Why do data centers need microgrids?", June 2023: https://c.ramboll.com/data-centers/article-microgrids#:~:text=The%20ongoing%20climate%20crisis%20poses,storage%20required%20for%20today's%20society (last accessed 4 March 2025).

[27] See various press reports about environmentalists challenging the development of data centre projects: (1) Gooding, M, "Judicial Review could block 200 MW data center campus in County Clare

solar farms in County Clare, a group of environmental activists commenced further judicial review proceedings in June 2024 challenging the legal validity of the local government decision as irrational, arguing it raised important issues of public policy related to climate justice and whether some parts of the economy are "off limits" when assessing compliance with environmental legislation while other parts of society were "expected to shoulder the burden of emissions reductions".[28]

In *Mannix Coyne and Anne Coyne v An Bord Pleanala, Ireland and the Attorney General and Enginenode Ltd*,[29] the Irish Court considered the extent to which the authority's EIA should "*have regard to*" the effectiveness of public policy and environmental legislation. It confirmed the obligation to consider submissions on the effectiveness of policies did not extend to requiring compliance with, or implementation of, government policy.[30] Specifically, there was "*no roving commission to interrogate the success or otherwise of the implementation of Government policy relevant to a decision to be made by it*" because that would "*impose an excessive and potentially sclerotic burden*".[31] The judge rejected criticism of the EIA for failing to attribute the environmental effects of emissions from the generation of grid electricity to the data centre on the basis that they "… *remain elusive, contingent, speculative and incapable of measurement*".[32] However, in considering the scope of European Union's, Guidance on integrating climate change and biodiversity into environmental impact assessment (2013), he warned that while "*it is no error to acknowledge and assess uncertainty and risk as best you reasonably can. Error may well lie in ignoring them.*"[33]

EFFORTS TO OFFSET THE CARBON FOOTPRINT OF DATA CENTRES

Solar panels and wind turbines usually do not generate a sufficient volume of energy, let alone reliable energy, to power a data centre entirely or continuously, but the need to offset at least some of the carbon footprint has driven a more symbiotic relationship as data centres seek to co-locate with renewable sources of energy and technology giants sign long-term

Ireland", *Data Center Dynamics*, 12 April 2024; (2) O'Riordan, E, "Environmentalists bring High Court challenge over plans for €1.2 billion data centre", *The Irish Times*, 11 June 2024; (3) Quinn, J, "An Bord Pleanala won't oppose data centre appeal", *The Clare Champion*, 8 October 2024; (4) "Appeal lodged against two new data centres in Clondalkin, despite local ban", *The Journal*, 1 September 2022.

[28] Submissions filed in Irish High Court proceedings, cited by Ellen O'Riordan in an article entitled "Environmentalists bring High Court challenge over plans for €1.2 billion data centre", published in *The Irish Times*, 11 June 2024.

[29] [2023] IEHC 412.

[30] *Ibid*, paragraph 16.

[31] *Ibid*, paragraph 44.

[32] *Ibid*, paragraphs 210h, 210i(v) and 215.

[33] *Ibid*, paragraph 127.

power purchase agreements ("PPAs") which help finance new renewable projects. For example, Apple signed supply agreements with more than 100 solar and wind projects globally in 2023 and now sources all its electricity from renewables.[34]

Lower construction costs has led to surges in the development of solar facilities in data centre cluster areas in the US.[35] The vast space required by hyperscale data centres itself can also present an opportunity: Facebook's data centre campus in Prineville, Oregon was an early pioneer in using electricity generated from a solar-array on its roof space to provide electricity to the office areas supporting the data centre. Its objective is to have the whole campus at Prineville powered entirely by co-locating with renewables either onsite or nearby by collaborating with solar power companies.[36]

Realising the grid was too weak to handle excess capacity generated from wind turbines in Germany during peak wind hours and that it could not be stored (resulting in windfarms being switched off), WindCores sought to reduce its dependence on the grid by operating small data centres inside the large, mostly empty space of the concrete towers of onshore wind turbines in western Germany.[37] The concept uses the excess electricity generated on site by the wind turbines as its primary source to power the data centres: 92 per cent of the data centres' power comes from the turbines, and the facility is connected to two independent electricity providers to ensure redundancy and uninterrupted operation during low wind periods (or shut down because of extremely high wind). WindCores estimate that the unused electricity generated in Germany during peak wind periods could power a third of all German data centres. It also offers an opportunity to repurpose legacy wind turbines as data centres in the future, when they reach the end of their service life and need to be decommissioned.

[34] Apple's 2024 *Environmental Progress Report* (pages 25 and 26) https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2024.pdf (last accessed 4 March 2025).

[35] North Virginia is the world's biggest data centre market – it has over 25 data centres including bespoke hyperscale data centres for tech giants such as Amazon, Alphabet, Microsoft, etc. Other US data centre clusters co-locating with solar power generation are in Dallas Fort-Worth, Phoenix, Chicago and Silicon Valley. See Ford, N, "Rush for data centres creates US solar hotspots", *Reuters*, 22 February 2024.

[36] For example, Apple was already using two micro-hydro projects to meet the energy needs of its data centre at Prineville but stepped this up so that it was 100 per cent renewably powered by 2017. It: (1) signed a PPA with Cypress Creek Renewables to buy 50 MW of solar power from a 50MW portfolio of six solar arrays in Oregon; (2) established its first wind project – Monatgue Wind Power – and signed a 200 MW PPA; and (3) signed a 56 MW PPA with Solar Start Oregon II PV array. See, Moss, S, "Sun, wind and sea: Apple details data centre renewable energy initiatives", *Data Center Dynamics*, 22 April 2017.

[37] See WindCORES website: https://www.windcores.de/en/colocation/ (last accessed 4 March 2025). See also Moss, S, "WindCores project deploys small data centers inside wind turbines", *Data Centre Dynamics*, 7 November 2018 and "Wind energy for sustainable data centres", 7 December 2023: https://www.en-former.com/en/wind-energy-for-sustainable-data-centres/ (last accessed 4 March 2025). The managing director of WindCores, Fiete Dubberkerke, is reported to have said that each tower could potentially hold server racks up to 150 m high. See Jyothi, A, "This project cuts emissions by putting data centers inside wind turbines", *CNN*, 5 December 2023.

However, in a co-location scenario, how are construction lawyers to draft for the allocation of responsibility and provision of access to remedy defects? If a construction defect in a turbine needs to be rectified, the data centre operator cannot accommodate a long outage even if it is planned. Equally, if the data centre wishes to replace existing VRLA[38] batteries with more efficient lithium-ion batteries which will require enhanced fire protection measures, should the windfarm operator be entitled to delay that work until a planned outage? How will the legal profession unravel the complexities of causation in the event of a failure at the interface between the turbine and the data centre? A more integrated approach to construction will require lawyers to adopt a more integrated approach to the procurement strategy, negotiation of cross-contractual rights and remedies, and may reignite the debate about making provision for multi-party dispute resolution.

UPSCALING AND NEW APPLICATION OF EXISTING TECHNOLOGY

A study almost 50 years ago into the histories of four large metal bridges that failed either during construction or shortly after being brought into service is relevant to data centre projects in the context of the ongoing trend to upscale and depart from established engineering to deliver eco-friendly hyperscale data centres. In the late 1970's, Sibly and Walker[39] noted that while the technical causes of the failures varied,[40] the failures "*happened not because the engineer neglected to provide sufficient strength as prescribed by the accepted design approach but because of the unwitting introduction of a new type of behaviour*". In each case, the engineers had become complacent because the design was founded in established practice and based on extrapolation from past experience and so ignored warning signs. However, over time, the "accepted" design had evolved to incorporate new materials, improve structural efficiency and/or address more challenging requirements and

[38] Valve-regulated lead-acid batteries. There is an ongoing debate as to whether these might be replaced with lithium-ion batteries as a back-up power source for uninterruptible power supply systems. The advantages include the fact that they have a higher energy density; last longer (15 years as opposed to five years); have lower total costs of operation over time; can be fully charged within about two hours; and can operate at higher temperatures. However, they have been associated with fires in data centres in China giving rise to fire safety concerns.

[39] Sibly, P G and Walker, A C, "Structural Accidents and their Causes", *Proceedings of the Institution of Civil Engineers*, Volume 62, Issue 2, May 1977, pp 191–208.

[40] The four bridge failures were: (1) the Dee bridge in 1847 which was a trussed girder bridge that collapsed due to a lateral torsional buckling failure of cast iron beams. The beams were trussed with wrought-iron ties which was thought to provide reserve strength but inadvertently introduced compression and bending loads into the beams; (2) the Tay Bridge in 1879, which was a truss bridge that failed, inter alia, because the design did not account sufficiently for wind load; (3) the Quebec Bridge in 1907, which was a cantilever bridge that failed during construction due to buckling of compression members; and (4) the Tacoma Narrows bridge – affectionately known as Galloping Gertie – in 1940. That was a suspension bridge that collapsed as a result of dynamic win actions.

aesthetic preferences. By the end of that evolution, the basis and assumptions of the "accepted" design had been pushed beyond its limits. Sibly and Walker concluded: "*in early examples of the structural form, a certain factor was of secondary importance with regard to stability or strength. With increasing scale, however, this factor became of primary importance and led to failure.*"

The construction industry is discovering this phenomenon in the next generation wind turbines. The average blade in earlier generations of wind turbines spanned 30–50 m. However, the growing trend for larger turbines means blades now regularly exceed 100 m. In a Whitepaper published in September 2022, Bladena[41] warned of the higher risk of failure because of the changing behaviour of blades when they are upscaled. In particular, higher peeling stresses have been observed when the blade increases in size, reducing the lifetime of the blade.

The English Supreme Court delivered perhaps the most celebrated lesson in the allocation of legal responsibility where established engineering is adapted and applied for a new purpose. In *MT Højgaard v E.on*,[42] the owner and the contractor battled through the courts over who was responsible for an error in a respected international industry standard (DNV-OS-J101) published by Det Norske Veritas. That standard originated out of the experience of grouted connections on offshore oil platforms but was then adapted for use in the smaller diameter/circumference of monopile foundations impacted by more dynamic loads from both wind and sea. By the time an error in the standard was discovered, the standard had been used in 13 offshore windfarms in the North Sea, affecting nearly 1,000 foundations.[43] In short, there was an error in the value of one factor in an equation in the DNV code, which was wrong by a factor of approximately 10. The result of the error was that the axial capacity of the grouted connection in the wind farm foundations designed using the code had been substantially over-estimated. DNV notified the contractor and various others in the industry and revised its code to correct the error. However, as between the owner and the contractor, that left the problem of who was to pay for the very substantial costs of identifying and implementing a scheme of remedial work. The central legal issue concerned conflicting, but typical, contractual performance obligations and warranties spread across different parts of the EPC contract. At first instance,[44] the Technology and Construction Court held the contractor responsible for breaching its "fitness for purpose"

[41] "Risk considerations on upscaling wind turbine blades", *Whitepaper 2 of 3*, September 2022, Bladena https://www.bladena.com (last accessed 4 March 2025).

[42] *MT Højgaard A/S v E.ON Climate and Renewables, UK Robin Rigg East Ltd and Another* (SC) [2017] UKSC 59; [2017] BLR 477.

[43] The failure was traced back to 13.

[44] *MT Højgaard A/S v E.ON Climate and Renewables, UK Robin Rigg East Ltd and Another* (QBD (TCC)) [2014] EWHC 1088 (TCC); [2014] BLR 450.

obligation and a requirement to achieve a 20-year design life. The Court of Appeal overturned this decision[45] before it was subsequently restored in a unanimous decision from the Supreme Court that confirmed apparent conflicts between different contractual obligations could be resolved by applying the higher standard, with all other obligations acting as minimum requirements.

The Supreme Court reasoned that the contractor was, in general, expected to take on the risk where he agreed to work to a design that would render an item incapable of achieving the criteria to which he had agreed. That is likely to be important for data centre projects, since a basic design is often prepared by the client's retained mechanical and electrical consultants, which the client typically then wants the contractor to take over and develop. Contractors will need to be careful not to assume that the designs they have been provided are fit for purpose or that they can avoid responsibility for the consequences of defects in a design they have adopted and developed.

Weaknesses in design, identifiable or not, emanate from human behaviour, but it is the task of lawyers to untangle responsibility and prescribe for the allocation of risk in the event of failure. In circumstances where modern design has led to greater concentrations of specialists within the engineering team, thereby multiplying the potential sources of information that might distort the relative importance of design information, it is likely to become even more difficult to unravel errors in design, let alone allocate the risk. The fact that engineering teams are increasingly managed and controlled remotely, and by human minds or AI that has been trained in the technologies of a previous generation, suggests innovation is likely to produce increasingly unforgiving designs. It is not for contract draftsmen to dictate the importance of returning to first principles such as verifying the accuracy of calculations, careful inspection in the manufacturing process and proper supervision during installation. But if there was more focus on clearly outlining obligations that address the input and expectations of each party with respect to the technology to be used, ownership of that technology and allocation of responsibility for any issues that may arise at every stage in the project cycle, it might mitigate the risk of defective engineering or at least make it easier to identify the cause and allocate responsibility should defects emerge.

[45] *MT Højgaard A/S v E.ON Climate and Renewables, UK Robin Rigg East Ltd and Another* (CA) [2015] EWCA Civ 407; [2015] BLR 431.

WHEN THE "LEADING EDGE" BECOMES THE "BLEEDING EDGE" BY ADOPTING INNOVATIVE SOLUTIONS

Already the industry has seen how "teething problems" with technology manifests in disputes arising from delays, additional costs and/or failures to meet performance guarantees, but these are amplified in data centre projects because of their greater dependence on first of a kind technology and the drive for novel solutions. The problem is exacerbated by a lack of specialists with the necessary expertise to provide the independent analysis required to determine an appropriate remedial scheme or estimate the time and cost of delivering it. As contractors approach the contractual caps on liquidated damages, an owner's contractual right to terminate may become a theoretical remedy: a replacement contractor is unlikely to be able to resolve complications arising out of an innovative concept any quicker or cheaper. Meanwhile, provided the incumbent contractor does nothing that would constitute gross negligence or wilful default (and so risk the validity of its contractual limitations on liability), it can leverage the commercial situation to secure concessions from the owner. Thus, in circumstances where it is difficult to identify a ready solution to the issues that may arise – and so how much it will cost or how long it is likely to take to fix – the conventional mechanisms to regulate underperformance that are habitually included in construction contracts are likely to be unsatisfactory, if not redundant.

Arguably, the problems and disputes that arise from innovative projects are exacerbated by the typical EPC procurement model because it places most of the risk of innovative technology onto the contractor, leading to a claims/disputes-driven project where the technology is "catching up" with the ambition. It is not sufficient to tweak the standard sort of EPC contracts suitable for a warehouse; data centres are specialist projects requiring specific provisions. The need to ensure compliance with performance criteria is paramount; transfer of risk and provision for non-compliance after a failure is likely to be so inadequate as to become of secondary importance. In this respect, data centres might learn from the aviation industry where engineers must try to identify and eradicate the risk of failure altogether or at least minimise it to be able to operate for extended hours without any appreciable risk of failure. The designers and manufacturers of aircraft engines have achieved this by being held to exacting standards and performance specifications, with contractual terms that focus on risk identification and embedding upfront compliance rather than focusing on the allocation of risk and recoverability of losses after there has been non-compliance.

Further, a departure from the traditional risk allocation in EPC – which often drives aggressive pricing to win the job and value engineering to reduce costs, with the unintended consequence of risking compromised quality or functionality – is necessary to prioritise delivery of greater redundancy and impose obligations to notify stakeholders of the early warning signs that the technology might be more difficult to "get to work" than anticipated during engineering. It is imperative to create an environment where all the project stakeholders collaborate to find solutions without the risk of assuming liabilities that the lawyers transferred at the project establishment phase.

Supply chain pressures have reversed the bargaining power in the procurement of long lead-in times for high-demand limited-availability equipment such as transformers, generators, cooling systems and subsea interconnector cables. As the risk of trade wars, tariffs and restrictions on the export of critical technologies grows, it will be essential to allocate procurement risks precisely and with robust contractual language.

Similarly, the differential between the return that the data centre operator stands to make over the life of the asset as compared with the return that the first of a kind technology supplier will receive provides a sound commercial basis for the supplier to push back on more onerous risk allocation and refuse long warranty periods.

As a result, the traditional fixed price EPC model has already been eroded with the increasing introduction of hybrid contracts for key elements of innovative projects: lumpsum engineering and procurement, with cost reimbursable construction. In parallel, the industry is being forced to consider supply chain vulnerabilities at an early stage and then develop a contingency plan and agree strategies to share project risks and successes within reasonable time frames. Again, this might provide renewed impetus for adopting first, a more innovative approach to the identification and mitigation of risks upfront in preference to risk transfer and second, more collaborative contract models and/or relational contracts such as operators developing long-term partnerships with critical equipment and material suppliers (thereby bringing in implied duties of good faith, a novelty under English law).

CONCLUSION

The demand and targets that are driving data centre and renewable projects to innovate so that they not only coexist but also support each other is today's necessity. Both sectors must adapt to a reality that electrical grids are likely to become less reliable – experiencing at least more frequency and voltage disturbances, even if full outages can be avoided – before the infrastructure is upgraded and expanded. As prototypes are rushed into the market, the terms of performance guarantees and the allocation of risk in construction contracts needs to be revisited in the expectation that the new or adapted technology is unlikely to behave as the designers expected and sure knowledge that, if/when it fails, whatever provision might traditionally have been made for the time and cost of identifying and implementing a "fix" is likely to be redundant. Construction lawyers should rise to the challenge by proactively seeking innovative ways to compel better quality of performance from the outset. In parallel, procurement strategies will have to evolve to support the increasingly critical role of data centres in society. Finally, the traditional bipartite approaches to dispute resolution need to be revisited and courts/tribunals empowered to intervene with pre-emptive action to support compliance as issues arise rather than pick over the carcass of performance failures long after the event.