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Towards Net Zero Energy Security: Are we building fast enough?

Engineering Net Zero
In partnership with our planet

ACTION TODAY FOR A NET ZERO TOMORROW.

Contents

Executive Summary

The UK was the first nation to set out the bold greenhouse gas reduction goal of Net Zero carbon emissions by 2050. Plans and strategies published since have translated this goal into increasingly challenging decarbonisation pathways and ambitions. For energy, the first ever Net Zero Strategy brought forward the target further to deliver a fully decarbonised electricity system to 2035, 15 years closer than originally targeted.

Decarbonising power presents a number of challenges. A reduced carbon power system, dominated by intermittent renewables, will be fundamentally different from a fossil-reliant one. Such a system will require an upgraded, larger and 'smart' electrical network, be able to balance fluctuations in power supply for variable and steadily increasing demand. To handle intermittency of supply issues, interconnectors and energy storage solutions of unprecedented scale will be necessary, alongside significant quantities of dispatchable and reliable clean power sources, such as nuclear, hydrogen and gas with carbon capture and storage. Current estimates assume a doubling of generation capacity will be required by 2035. The system will further have to enable demand side reduction on a real time basis. Unsurprisingly, the Net Zero technology portfolio will be more complex, physically larger, of higher risk and more capital-intensive compared to the current system.

The energy trilemma, which demands a balance between cost, security of supply, and sustainability, is ever present. Net zero strategies have traditionally been driven by sustainability and cost, however, as the need for a resilient energy system is becoming more apparent, security of supply issues need to urgently be addressed.

TABLE 1. QUICK COMPARISON – THE 2021 AND 2035 POWER SYSTEMS.

	2021		2035*
INSTALLED CAPACITY	108 GW	+ 132 GW / + 122%	240 GW
ANNUAL POWER DEMAND	334 TWh	+ 194 TWh / + 58%	528 TWh
RETIRED CAPACITY 2021-2035		49 GW	
CAPACITY TO BUILD 2021-2035		181 GW	

* AVERAGE 2035 VALUE ACROSS THE FOUR ENERGY AND EMISSIONS PROJECTIONS SCENARIOS PUBLISHED BY BEIS IN MARCH 2022.

CALCULATING THE BUILD RATE

Atkins' analysis of the UK's revised power decarbonisation target shows a significant impact on the rate at which we need to build new generation capacity – the 'new power capacity build rate'.

To construct sufficient generation to achieve the 2035 target, the UK must achieve an essential new power capacity build rate of 12.2-15.6 GW/year. This is compared to a lower rate of 9-12 GW/year rate to achieve it by 2050, as calculated in our previous research, and a significant increase to the average build rate for the last five years of 3.2 GW/year (see Fig.1).

Our analysis shows that the UK is not on track to deliver the required average new power capacity build rate required to fulfil the 2035 goal. This risk is further amplified when considering security of supply, as intermittent renewables projects are expected to accelerate rapidly whilst strategies for firm power are lagging and deployment of CCS, hydrogen and nuclear has been delayed for years by policy uncertainties. It is clear that coordination between such a wide variety of projects will require novel approaches to planning, optimisation and delivery.

The UK requires an immense energy construction programme to be completed in the next thirteen years to ensure a Net Zero power system is met without sacrificing security of supply and where the cost to consumers is affordable. It is crucial now more than ever that an Energy System Architect is established to assume responsibility for system-wide co-ordination of the UK's approach to achieving decarbonisation targets and ensuring a just and secure energy transition.

LEADING A LOW CARBON FUTURE

1. The New Build Rate

Decarbonising power underpins much of the UK's Net Zero policy. Based on recommendations in the UK's Sixth Carbon Budget, the Net Zero Strategy outlines plans and ambitions for delivering Net Zero by 2050, all largely enabled through high levels of electrification and rapidly decarbonising the UK power grid, potentially reaching zero carbon in 2035, if security of supply can be maintained [1], [2]. BEIS underpinned the Strategy further in 2022 by publishing four future power grid scenarios – with high and low levels of electrification and with and without the use of hydrogen [3].

PROGRESS IN REDUCING EMISSIONS. 2022 REPORT TO PARLIAMENT – CCC

In June 2022 the CCC released their annual report on emissions tracking, concluding that the UK is facing high uncertainty for reaching its longer-term GHG reduction commitments [4].

Assessing the power sector individually, out of the ten indicator areas considered, only three had a benchmark or target against which progress could be measured – offshore wind, onshore wind and solar PV. Others, including nuclear and gas with CCS, had none.

The CCC thus concludes that, while credible plans are in place for over half the emissions reductions for 2035, significant risks remain for delivering the fully decarbonised electricity system ambition.

To estimate the scale of the engineering challenge of delivering this power system, Atkins used the four scenarios and calculated the average required new power capacity build rate between now and 2035. Considering replacement of almost **50 GW** of generation coming to its end of life in the next thirteen years, alongside a circa **50%** increase in demand, we approximate that between 12.2-15.6 GW will need to be built each year to deliver the Government's ambition (with the lower bound reflecting the average of the two lower demand scenarios and the higher bound reflecting the higher scenarios average). The magnitude of the numbers is illustrated against historical build rates in Figure 1.

The power generation build rates required to reach the announced goals are unprecedented, however, we must also consider the supporting infrastructure required to connect and deliver new generation onto the system.

Less prominent in the various published scenarios are the massive improvements in the power grid and distribution networks as capacity expands.

Whereas the most recent CCC progress report to Parliament indicates positive advancements for solar, offshore and onshore wind, it highlights significant risks for delivering almost half of the emissions reductions required for reaching a fully decarbonised electricity supply in 2035. Furthermore, no notable discussion is provided on the additional infrastructure required to solve an already demonstrably strained electrical grid [4].

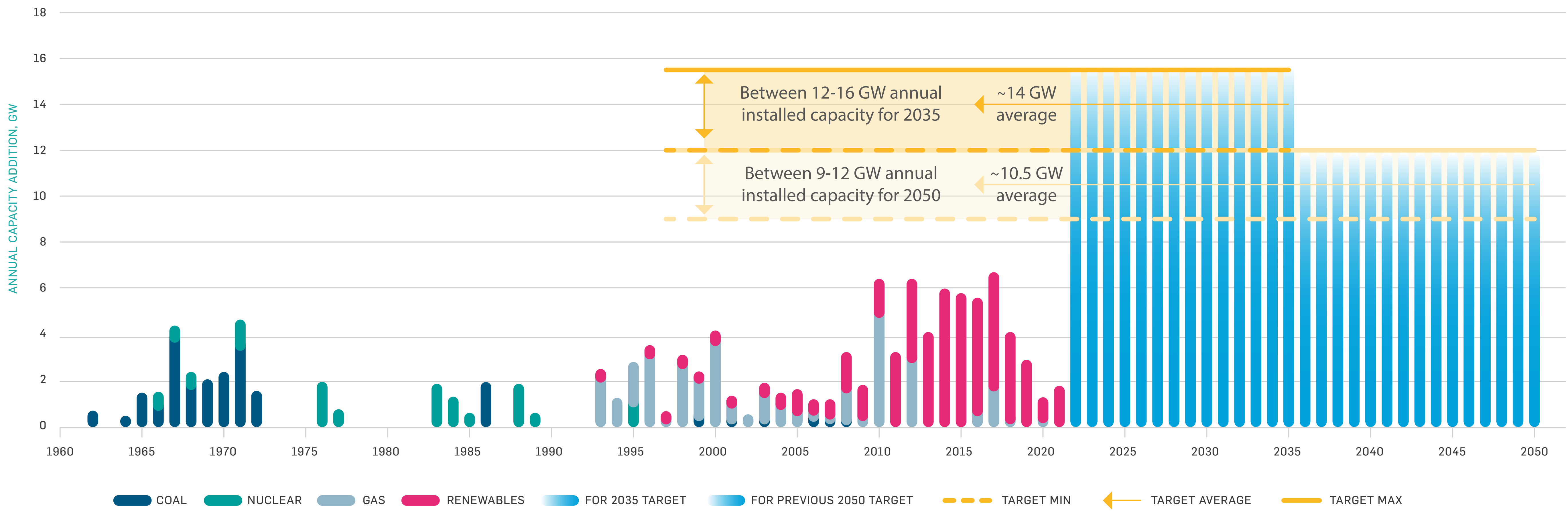

FIGURE 1. REQUIRED BUILD RATES FOR REACHING NEW 2035 TARGET AGAINST 2050 TARGET

PUTTING THE 12.2-15.6 GW/YEAR IN PERSPECTIVE

9-12 GW/year – our previously estimated generation capacity build rate, required for meeting Net Zero targets in 2050 [10] – Figure 1

3.2 GW/year – the average build rate in the last 5 years – at least 4 times less than required for 2035 [5], [6]

6.5 GW/year – the largest ever addition to the grid in a single year (2017) – half the amount which will be required per year by 2035 [5]

12.5 GW – the current generation capacity of the Republic of Ireland – minimum amount required to be built each year, every year until 2035 [17]

159-203 GW – of new build capacity necessary between now and 2035 [3]

2. Security of supply

The energy trilemma is well documented, but it dictates the central challenge facing the energy transition: maintaining a delicate, yet vital, balance between sustainability, cost and security of supply [11].

Geopolitical events over the last year have put the high volatility of internationally traded fossil fuel commodities in the spotlight and demonstrated their immediate effects on energy prices. Still, a less apparent consideration is that of available firm power, and capacity of transmission and distribution infrastructure.

During the extreme heatwave which impacted the country this summer, the system operator was, for a short period of time, forced to pay £9,724 per MWh of electricity to avoid a blackout. The average price for the year to date had been £178 per MWh, a higher cost compared to preceding years [12]. This staggering difference was a result of a perfect storm of events including low output of wind turbine generators, planned maintenance of various thermal power plants, and an electrical grid struggling to supply the high-density demand of the city of London. Such instances clearly illustrate the supply risks associated with highly renewable-dependent power grids and the importance of planning ahead to ensure flexible and low carbon dispatchable sources are available when needed.

The UK is faced with two major challenges to balancing the energy trilemma: – fulfilling sustainability pledges to tackle the longer-term issue of climate change; and ensuring security of supply during a complex system transition whilst in the midst of the shorter-term cost of living crisis. It is vital there is sufficient renewable and nuclear generation capacity to produce the majority of power for a decarbonised system, however, this must be balanced with low-carbon flexible generation that can minimise the risks to ensuring security of supply.

Demand reduction may be used to mitigate temporary system shortfalls but this would impact economic growth if businesses routinely reduce operations. Instead, energy efficiency must become a near-term priority, both through tackling of energy and heat losses in buildings, and through the development and roll-out of smart technology to shift some electrical demand away from peak times.

Alongside this immediate concern, Atkins' build rate analysis shows that the fast-tracking of all infrastructure projects is imperative to keep up with predicted demand growth and decarbonisation goals over the next decade. Taking the necessary actions to create a resilient power grid now will help to reduce energy price volatility in the future, alleviating the economic impact to the general public.

A STRUCTURED APPROACH TO SECURING FUTURE SUPPLY

The balance between affordability, sustainability and supply security should be maintained through committed and robust investment in the national electricity system. To oversee and guide this massive engineering undertaking, an Energy System Architect should be established. The creation of a Future System Operator (FSO), as introduced in the Government's Energy Security Strategy, could provide this role if given the appropriate remits [13]. The FSO would be responsible for operating the electricity transmission system, keeping it balanced minute by minute, 24 hours a day, 365 days per year. Combining the strategic responsibilities of an ESA with the operational responsibilities of the FSO would create a single entity capable of assuming responsibility for overall system planning and operation. The challenge is the orchestration of multiple interrelated, high-value infrastructure projects which need to be planned, delivered and commissioned by multiple private sector operators in the years to come [11]. The FSO would be crucial to ramping up build rates and ensuring affordable, clean and reliable power delivery to satisfy consumer needs alongside decarbonisation targets. As assets planned today will still exist in 2050, the FSO would need to ensure that pursuit of short-term targets does not prejudice the development of an optimal system for the long term. The strategy must facilitate the integration of prevalent market-ready technologies with emerging solutions that will improve longer-term system performance, affordability and security.

ACTION TODAY FOR A NET ZERO TOMORROW.

3. The Net Zero System

3.1. LARGER AND MORE COMPLICATED

In 2035, the UK power system will appear vastly different to the system we use today. Current total connected generation capacity is circa 108 GW, with around 40% formed from fossil fuels [5]. The future power system is expected to comprise of diverse energy generation technologies; however, its configuration is uncertain, with different organisations and academics all coming to different conclusions on the make-up and size. Figure 2 plots scenarios that have been created by experts at BEIS, National Grid ESO, and the Climate Change Committee. These outline what a future connected generation capacity in 2035 could look like, broken down by energy source.

Increased renewables reliance and an increase in overall generation capacity is common across all models, and in all of scenarios developed to date significant build rates will be required to meet projected capacity needs.

For example, BEIS modelling predicts a demand increase of 58% by 2035, with an 122% increase in installed capacity, primarily due to the intermittency of renewable generation (typically wind and solar). Therefore, low carbon firm-power solutions including nuclear, gas with CCS and hydrogen are also required to maintain a secure and stable supply.

TABLE 2. QUICK COMPARISON – THE 2021 AND 2035 POWER SYSTEMS [3].

	2021		2035*
INSTALLED CAPACITY	108 GW	*+ 132 GW / + 122%*	240 GW
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[1] Hydrogen capacity includes low carbon dispatchable energy from other sources.

FIGURE 2. INSTALLED CAPACITY (GW) IN 2035 FROM DIFFERENT SCENARIOS

3.2. CONSTRAINTS TO DEPLOYMENT

Our future grid needs to be optimised and flexible enough to handle exposure to increased costs, supply chain constraints, and technological transformation. As clean technologies rally more support and financial investment, each has a unique combination of constraints to deployment.

An accelerated roll-out of renewable generation is dependent on more efficient planning and consenting processes. Nuclear power requires consistent policy and sufficient skilled personnel and supply chain availability to enable a fleet-like approach that can enable learnings and supply chains to pass seamlessly between projects. Hydrogen will play an important role in industrial processes and energy storage, yet its development must be fast-tracked, and deployment coordinated to identify the right use cases and delivery at scale. Like hydrogen, carbon capture and storage is a possible low-carbon solution to meet power demand, yet it is unlikely to make a significant system-wide impact by 2035 without major market intervention to speed up progress towards large-scale deployment. Energy storage – often regarded as a saviour to 'top-up' missing capacity during peak demand periods – also requires careful planning. Current projects in planning are typically batteries, capable of small-scale, short-term power to maintain system balance, yet longer duration storage from hydro power or hydrogen must also be developed.

Connecting all types of generation and storage to the system depends on the reinforcement and expansion of our transmission and distribution networks. Local electricity networks are already experiencing capacity constraints as embedded generation and battery storage connects to the system, which in turn delays connections for further projects.

The role of the FSO will be vital in ensuring the right infrastructure and technology is built now, and in calculating what is needed for the future.

MARKET MECHANISMS

In recent years deployment of almost all forms of power generation has depended on some form of government assistance or market intervention. Thus, at the strategic level, technology selection is divorced from market forces. An overarching strategy and structured planning are essential to ensure that we are building the right system.

However, we also need the market mechanisms to enable the private sector investments of billions of pounds needed to implement the plan. To deliver this, the Government has initiated a Review of the Electricity Market Arrangements (REMA) [16]. REMA is however not expected to make any real impact until the late 2020s: that is half-way to the 2035 deadline and, in this time, we should have built an additional 80+ GW of generation and associated infrastructure. In the meantime, system architecture is being decided now without an overarching plan.

Creation of an ESA is vital to ensure there is a diverse mix of renewables and low-carbon generation on the network that can maintain security of supply across different demand and generation conditions. Interconnection to other countries can alleviate short-term supply shortfalls but cannot be relied upon when other countries face similar issues. The £9,724 per MWh paid for power from Belgium in July 2022 was necessary to ensure security of supply for the Southeast of England, as demand could not be met by the GB system. Security of supply of a Net Zero power system will be at greater risk as the proportion of intermittent generation increases without significant investments in full system management.

4. Summary – Next Steps

By 2035 there must be significant increases in new generation capacity and in transmission and distribution infrastructure. Our analysis indicates a build rate of 12.2-15.6 GW/year is required, yet we are currently falling far short of the minimum build rate that is essential, not just for decarbonisation, but also for security of supply and affordability. Every year of delay adds further challenge to a task that is already beyond all historical performance.

The required pace must begin immediately and extend beyond 2035: as electrification of heating and transport grows towards 2050, our demand for electricity will increase with it.

To achieve our 2035 goals, we need a system architecture and an execution plan against which we can measure progress. These need to be created as a matter of the utmost urgency.

The Energy Trilemma is an unrelenting and unforgiving challenge. We are already seeing an energy cost crisis beyond anything that has been anticipated and the Government has had to intervene with direct energy subsidies that will cost tens of billions of pounds.

Risk to security of supply has increased, however solving it should not be at the expense of ambitious yet necessary climate goals. Short term actions to address demand reduction and bolster the security of our supply should feed into our longer-term goals of a decarbonised and resilient energy system.

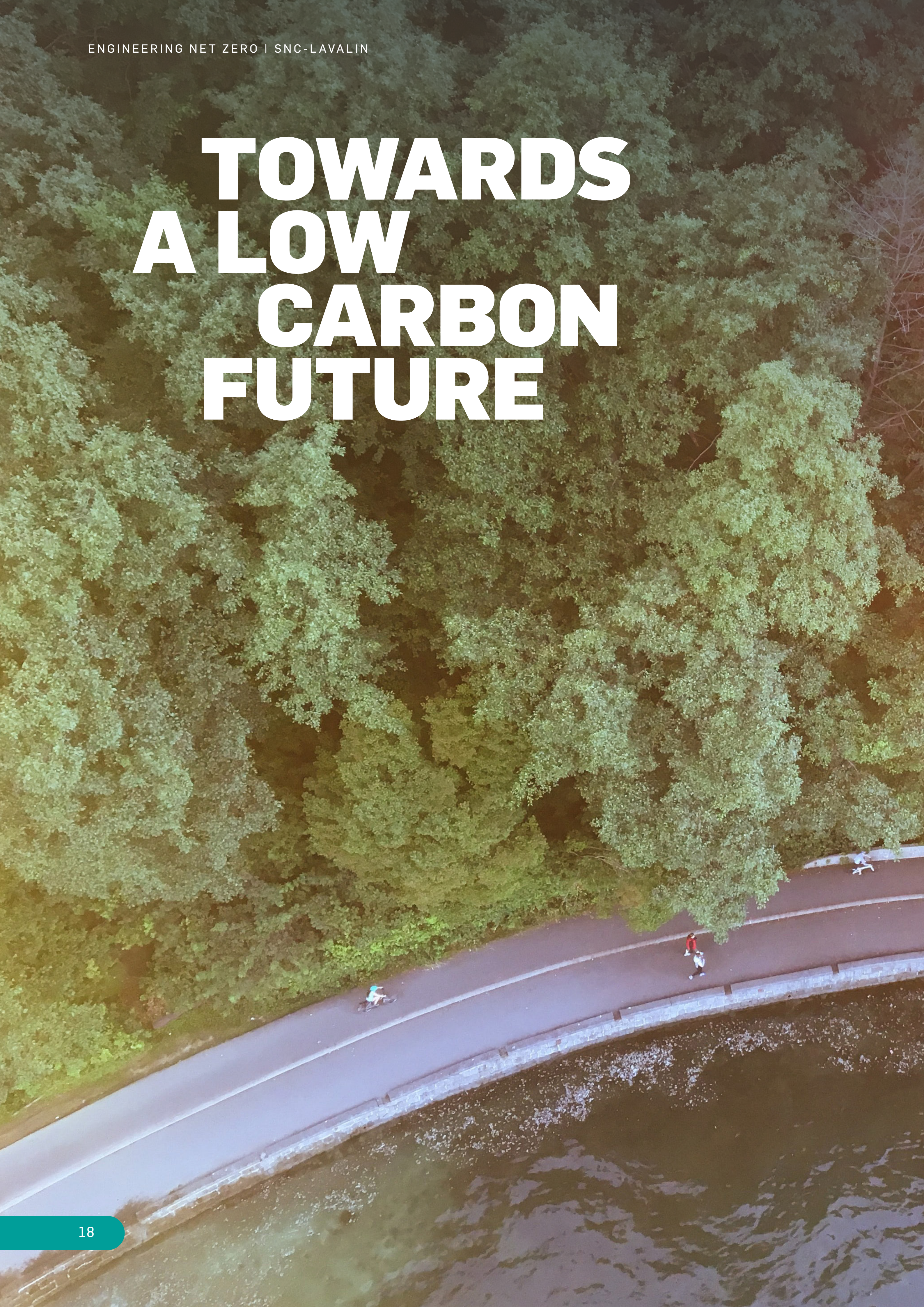
We may not be on course to achieve Net Zero electricity in 2035: further delay will only make things more difficult. With 50% of the UK's current electricity generation forecast to close within the next decade, ramping up the build rate is an urgent priority.

In summary:

- We urgently require a best estimate of the system architecture and pathway to 2035 and the use of existing mechanisms to commit to projects for delivery by this date.
- It is evident that the proposed plan will require building all energy technology infrastructure at a much greater pace than current and will be of value to UK citizens for decades to come, as the assets we rely on today have proved for many decades.
- An Energy System Architect to oversee this national programme is critical – and to marshal our direction of travel as new technologies become commercially viable at scale. The creation of a Future System Operator with the right charter, capability and authority is urgent.

OUR NET ZERO BLUEPRINT FOR THE FUTURE.

TOWARDS A LOW CARBON FUTURE



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