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Engineering Net Zero
Tackling climate risk together

Issue 01 July 2023

Beyond Engineering

Engineering Net Zero

THE FOUNDATIONS OF DECARBONISATION

ACTION TODAY FOR A NET ZERO TOMORROW

Hydrogen is expected to play a substantial role in the transition to a net zero carbon future. However, our nation's power generation fleet is mainly natural gas-powered and a shift to 100% hydrogen-powered electricity would require costly new equipment to be installed. Retrofitting the existing infrastructure to accommodate a blend of hydrogen and natural gas could help accelerate decarbonization goals to reduce greenhouse gas emissions.

Find out about the largest Hydrogen fuel blending demonstration project.

World's Largest Hydrogen Fuel Blending Demonstration SNC-Lavalin (snclavalin.com)

HERE ARE A COLLECTION OF SOME OF OUR LATEST EXPERT OPINIONS ON SOME KEY TOPICS FOR ENGINEERING NET ZERO, SPECIFICALLY AROUND ENERGY TRANSITION / INDUSTRY AND MINING, TO BRING YOU OUR NEW PRINT AND DIGITAL MAGAZINE, BEYOND ENGINEERING.

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Welcome to Beyond Engineering

THE FOUNDATION OF DECARBONISATION

Already, the realities of climate change are being felt across the world. Extreme weather events strike with ever-increasing frequency, from hurricanes and heatwaves to flooding and freezing temperatures. Mitigating the very worst effects of this climate emergency requires rapid decarbonisation of almost every aspect of society, limiting the greenhouse gas emissions that come from industry, transport, energy, the built environment and beyond.

But how do we get to net zero without inadvertently raising emissions further? From the lithium in batteries to the silicon in solar panels, extraction and production of critical minerals will need to increase by up to 450% as we build clean energy infrastructure and technologies at unprecedented rates. Mining accounts for up to 7% of global emissions – sustainable mining methods are vital to accelerate the rate of extraction without pushing this higher.

Further downstream, the production of materials such as steel and cement will also [increase x>] to meet global demand, as new infrastructure is rolled out to deliver low carbon generation, transportation, and infrastructure. Such energy-intensive processes are difficult to decarbonise - yet without this, the manufacture of low carbon technology will create a huge carbon footprint of its own. How do we prioritise the decarbonisation of these essential industries to enable a clean transition to net zero?

In this magazine, we explore this crucial question through pioneering examples fromv across the world, from sustainable cement to net zero mining. But as well as decarbonisation breakthroughs, we also examine the importance of ancillary aspects like planning, data, and decision-making. Only when we harness a project's full complement of disciplines can we make sustained progress towards sustainability.

Therefore, the need for a systems-level plan capable of harmonising these elements is growing. Electrification - of industry, heating, transportation - is the engine powering our path to net zero, and decarbonising power systems is a primary goal around the world. Yet as the articles in this magazine argue, the larger and more complex energy mix of tomorrow will require greater foresight and integration if it is to provide more power without relying on fossil fuels...

The net zero transition will touch every aspect of society, from our built environment to behavioural changes. Such a seismic shift will depend on the delivery of these core areas: decarbonising power, increasing mineral extraction sustainably, and reducing industrial emissions to manufacture green materials. These are the building blocks of net zero: without them, we cannot reach our climate targets. Already, the realities of climate change are being felt; but so too are the solutions.

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A concrete plan

DECARBONISING CONSTRUCTION WITH BETTER CEMENT

In the fight against climate change, the battle to decarbonise the construction industry is one of the hardest. It contributes over 10% of global emissions, but it is also crucial in the continuing development of the dwellings, civil infrastructure, and transport systems that much of the world so desperately needs. One of the biggest decarbonisation opportunities lies in concrete, which has long obstructed the way to sustainable construction. But a new project, Cement 2 Zero, is pioneering a high-quality, durable, and inexpensive form of recycled concrete - and if we can spread adoption, it will be a vital stepping stone to cleaner construction, and a greener future.

As the global economy presses towards a greener future, the construction industry - a significant emitter of greenhouse gases - finds itself at the crunch point. Despite being the backbone of development worldwide, it has struggled to develop and embed low-carbon alternatives. The industry's labyrinthine structures, complex supply chains, and long project timelines present formidable obstacles to swift decarbonisation.

Moreover, the sector's interconnectedness means that isolated attempts at decarbonisation will not suffice. A zero-carbon housing development, for instance, has limited impact if it is not complemented by low-carbon transport options. To truly make a difference, every stakeholder - from contractors and designers to the supply chain - must move in unison towards a greener construction industry.

One of the most pressing areas for decarbonisation in construction is the production of concrete, the world's most popular building material. Cement, a key ingredient in concrete, contributes significantly to global emissions. Every tonne of cement we produce creates an equivalent tonne of carbon dioxide. As construction demands are set to increase with a rising global population, the need for a cleaner concrete production process is more critical than ever. A solution is, however, at hand.

A STUMBLING BLOCK

Concrete is the second most consumed substance in the world after water, and it is one of the construction industry's largest sources of emissions. Yet the industry often overlooks the environmental impact of concrete production, treating it as an infinite resource. Producing concrete is energy-intensive and emits carbon dioxide as a byproduct. Moreover, insufficient attention is paid to the problem of disposing of concrete at the end of its life cycle - and with so much concrete produced, it's a weighty issue.

Cement 2 Zero (C2Z) is an initiative to decarbonise concrete production through recycling existing concrete. By recycling old cement from demolished buildings, we can bypass the emissions-heavy calcination process and reclinker using heat from electric arc furnaces (EAFs) harnessed in steelmaking. The process, called Cambridge Electric Cement (CEC) was initially identified by the UK FIRES group, which promotes resource efficiency in industrial application, and the C2Z demonstration project aims to make the industry more aware of the finite nature of our natural resources and demonstrate the viability of recycled concrete.

PAVING THE WAY FORWARD.

Producing 'Electric Cement', the C2Z development project underscores the need to recycle from existing concrete assets, to spread awareness about reducing consumption, and to demonstrate the structural, regulatory, and economic viability of recycled concrete. Together, this would enable recycled materials to eventually become a primary source of concrete.

CEMENTING CREDENTIALS

The Cement 2 Zero initiative has demonstrated that the chemical composition of recycled material remains robust - much like steel, which is heavily recycled. However, the construction industry imposes stringent specifications on materials, and concrete is no exception. Different categories of concrete and cement are required depending on the application, with differing strength requirements and testing methods. Construction firms, designers, and clients tend to be risk-averse, preferring the tried and tested over the new and innovative.

To overcome these hurdles, the C2Z project team is consciously harnessing collaboration from the start. Bringing together the academic prowess of the University of Cambridge, the testing facilities at the Materials Processing Institute, the manufacturing capabilities of CELSA, and the real-world application knowledge of contractors, designers, and suppliers, C2Z pioneers an end-to-end solution, from research through to deployment. This collective, joined-up approach speeds up the pace of change, targeting not only the technical challenge but also the myriad barriers blocking adoption of recycled concrete.

Scale matters, too. The involvement of Tarmac, a major global supplier, further amplifies the reach and potential impact of C2Z. National Highways has also expressed interest in using a future project to trial the material. Atkins and Balfour Beatty are bringing their collective design and construction expertise to enhance the collaborative nature of the project. It demonstrates how collaboration can disseminate innovation across industry - pioneering faster, more effective change and offering a blueprint for rapid decarbonisation.

PAVING THE WAY FORWARD

The pathway to a low-carbon construction industry is paved with collaboration and leadership. The complexity of the sector, its regulations, and its supply chains necessitates a collective approach, with all stakeholders sharing successful practices and innovations. The widespread use of concrete, coupled with its rigorous specifications and standards, means that successful trials can lead to a swift, industry-wide adoption of sustainable alternatives like C2Z. The opportunity is massive.

But if we're to exploit it, we also need leadership. Just as board-room commitment to sustainability is essential to a company's Net Zero efforts, so too is sector leadership vital to driving and disseminating sustainability across industry. Asset owners are now recognising the value in existing concrete assets and in the ability to recycle and repurpose them - and by exploiting these, we can avoid carbon-intensive manufacturing and its drain on natural resources.

C2Z shows that shared commitment, collaborative cross-sector problem-solving, and enterprising leadership can catalyse solutions and steer the construction industry towards a more sustainable, low-carbon future. We can build the world better - but only by working together.

Mark Connelly

PROFESSIONAL
HEAD OF HIGHWAYS

Navigating to Net Zero

HOW DATA-DRIVEN ROADMAPS CAN ENABLE INDUSTRIAL DECARBONISATION

In the race to decarbonise, data can serve as the fuel. Yet many industrial sites lack a comprehensive understanding of their own energy usage. Absent data capturing where emissions originate often means they are unable to identify on-site inefficiencies. This lack of a clear baseline for decarbonisation hinders efforts, delays decisions, and makes it challenging to develop compelling business cases that attract necessary investment. But when data is properly gathered and applied, it can map the way forward, helping sites identify the most promising avenues to Net Zero, and how best to navigate them.

OF ALL THE OBSTACLES TO INDUSTRIAL DECARBONISATION, ONE IS PARTICULARLY PERVASIVE: A LACK OF DATA.

Many industrial sites struggle to understand their energy use, and therefore their emissions. The absence of comprehensive data on utility, fuel, and electricity requirements across a site, leaves sites without a baseline from which to launch decarbonisation efforts. This impedes progress, delays decision-making, and stymies the formation of compelling business cases necessary to secure investment. So a lack of data, seemingly a discrete and specific issue, can hinder all subsequent efforts towards sustainability.

As regulations tighten and budgets constrict, this approach is not only unsustainable but also detrimental to the bottom line. A dearth of data often leads to unnecessary expense, as sites consume more energy than required due to unidentified losses and inefficiencies. Without data, maintenance is reactive rather than proactive, and therefore inefficient and often more expensive. Sites find themselves in a cycle of increased costs and stagnated improvement. And, without usage data specific to their sites, they cannot calibrate the value of transitioning to cleaner alternatives.

There is a way forward. It starts with understanding the specific energy demands of a site. This baseline allows for an evaluation of the site's entire energy usage, allowing sites to calibrate according to their needs, from equipment sizing to technology selection. The identification of potential efficiencies promotes

a deeper comprehension of the site, and better planning. The result? More appropriate sizing, refined estimates, and more fit-for-purpose facility - all the while propelling us closer to Net Zero.

DATA-DRIVEN DECARBONISATION

Enhancing efficiency begins with establishing each site's energy usage. If sites recognise where energy is consumed, they can identify whether equipment is over or undersized, and where improvements can be made. Better understanding leads to better planning, enabling more accurate estimates that are tailored to the site, yielding efficiencies and credible, evidence-based decisions.

Future forecasting hinges on accurate baselines. Better data leads to more representative and insightful forecasts, enablingW a deeper understanding of the technology required to achieve Net Zero by 2050. With deeper

understanding comes greater confidence, helping sites to make the challenging long-term decisions necessary to transform their businesses.

MAPPING DATA INTO ACTION

Roadmaps provide a clear plan to reach Net Zero goals. They detail different low carbon interventions to reduce carbon emissions, ranging from energy efficiency measures to renewable technologies. With comprehensive data, sites can assess potential revenue from energy export, evaluate the impact of energy efficiency improvements and calculate the amount of hydrogen needed for operation, for example. These Net Zero roadmaps present a spectrum of options, with varying

degrees of carbon reduction and capital associations. With accurate data, the evaluation of the most appropriate technologies becomes far more site-specific, eliminating the need for assumptions and replacing generalities with options tailored to your site's particular situation.

But for sites to enable Net Zero roadmaps, they must first understand their energy use. This requires appropriate metering on-site and proactive monitoring. A robust understanding of the available technologies coupled with solid, site-specific data strengthens the business case, accelerating the transition towards decarbonisation.

TEST DRIVING THE ROADMAPS

The Industry Future Programme (IFP) shows how this approach works in the real world. Atkins was chosen by the UK government's Department of Business,

Energy, and Industrial Strategy to develop Net Zero roadmaps for 15 industrial sites across various sectors. The objective was to provide each site with at least two roadmaps to reaching Net Zero, comprising a variety of low carbon interventions.

LEADING A LOW CARBON FUTURE

The quality and granularity of data varied across sites; some provided minute-by-minute data, while others were only able to supply quarterly data.

The more granular the data, the fewer assumptions were needed, thereby reducing risk. The sites able to provide more detailed data gained a greater number of options - for one site, we were able to provide 6 individual roadmaps.

The IFP demonstrated the potential of Net Zero roadmaps to empower industrial decarbonisation, and how better data enriches the process and improves optioneering. Yet the programme also revealed the need for a joined-up approach, rather than tackling sites individually. Efficiencies could be significantly increased if data were shared across sites or regions, optimising the use of waste streams and resources. One site's waste stream could well be a neighbouring site's key feedstock; without an integrated approach, such opportunities will likely be missed.

To take confident, decisive action, sites need support. They need clarity, certainty, and a sense of direction - no one wants to invest in an alternative energy source that turns out to be a dead end. Yet even with clear, high-level direction from the government, sites must work out how to translate these goals and ambitions into delivery on their site, with all its specificities. This is where Atkins excels. Our multidisciplinary approach means we're able to offer expert assistance throughout the whole life cycle, from initial data discovery and roadmap development to on-site implementation, connecting the overarching ambitions to the individual needs of each particular site.

PATHFINDING PROGRESS

Site-specific solutions matter, but they must be properly integrated with the wider economic, social, and environmental context. Understanding how sites interact with the broader grid is key for demand-side response and increasing operational flexibility. A joined-up approach, considering sites' proximity and shared data, can unlock greater efficiencies.

The road to Net Zero is arduous but essential. Implementing a systems approach is crucial for this journey, and data is the fuel that will expedite the process. Fuelled by data, Net Zero roadmaps ensure we take the best route - propelling us towards a decarbonised future.

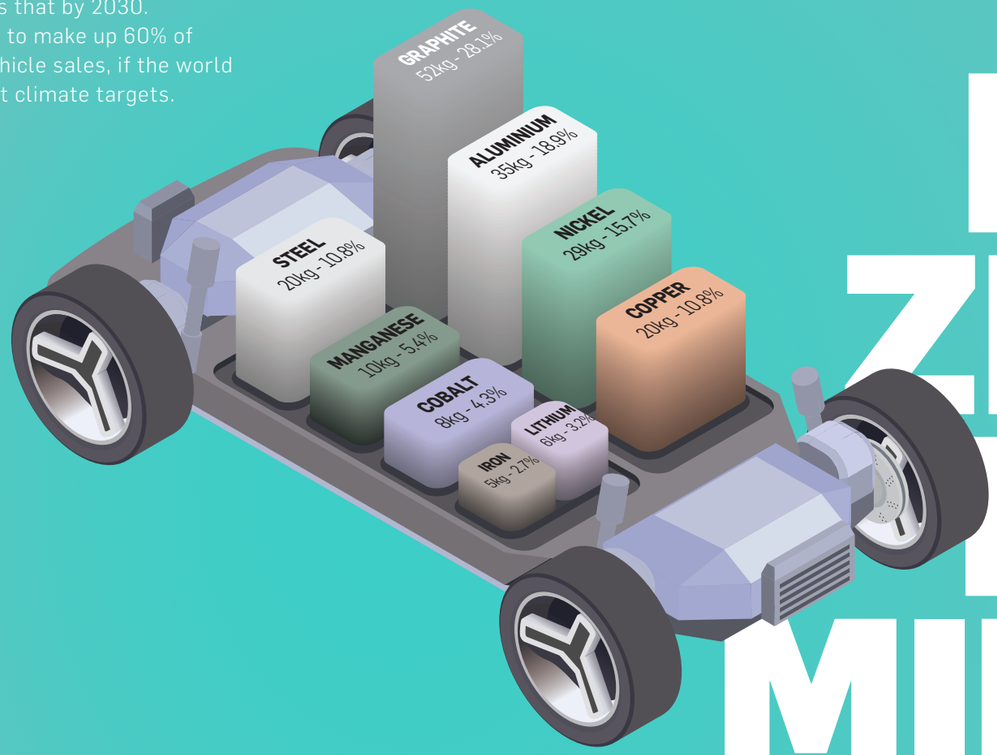
Julie Gilmour

INDUSTRIAL DECARBONISATION LEAD

NET ZERO NEEDS MINING.

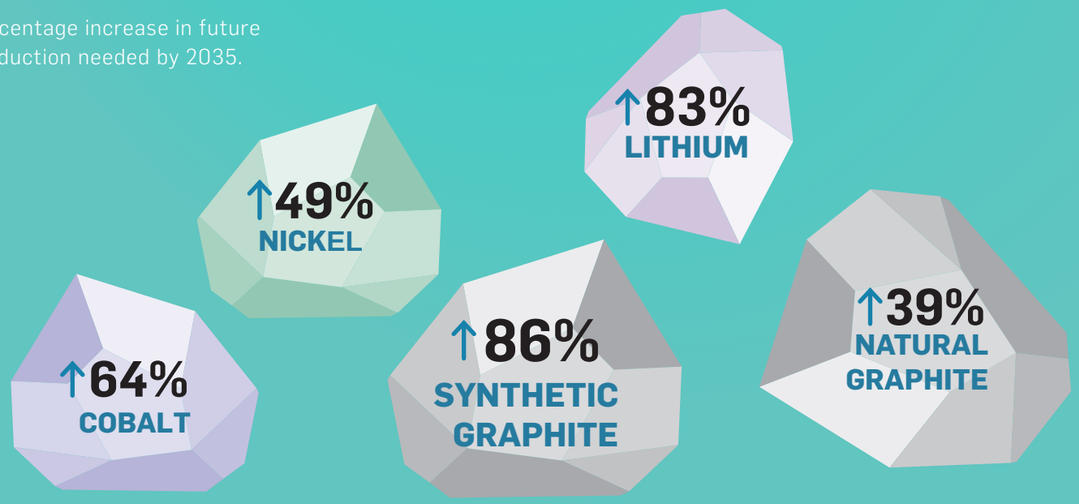
WHAT MINERALS GO INTO AN EV BATTERY?

The International Energy Agency estimates that by 2030. EVs need to make up 60% of global vehicle sales, if the world is to meet climate targets.



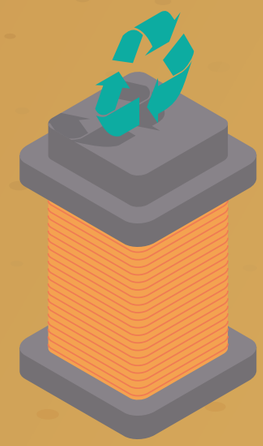
MINERAL PRODUCTION: NOW VS FUTURE?

Percentage increase in future production needed by 2035.



CAN WE INCREASE PRODUCTION WITHOUT INCREASING EMISSIONS

Electrification - Electrifying trucks can reduce 30-80% of GHGs at mines.

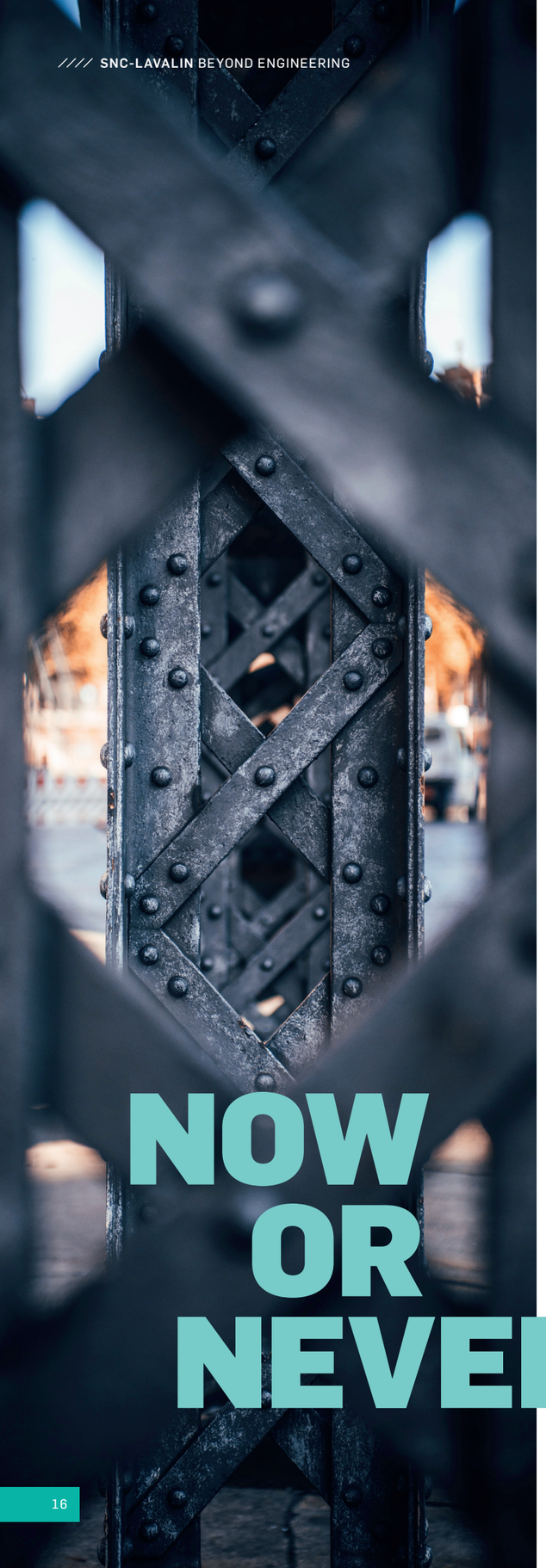


PROCESS IMPROVEMENT

Tailings can be reprocessed for other useful materials such as rare earths.

CLEAN ENERGY

Can be used to power mining sites as a replacement for diesel generators.



INTERNATIONAL COUNCIL FOR MINING AND METALS' 2050 NET ZERO MANDATE

Net Zero ultimately depends on mining. Copper, nickel, graphite, cobalt, lithium and many other metals and minerals are essential for the energy transition. They're needed to make components of everything from solar panels, to wind turbines, to nuclear power generation, to power transmission lines, as well as the construction of sustainable infrastructure - including the batteries needed in Electric Vehicles (EVs). However, as mining activity increases to levels never seen before, to supply this shift to Net Zero, scrutiny of mining's own emissions – responsible for around 4-7% of human-made greenhouse gas (GHG) emissions – is growing.

The sector is now recognising the need to reduce GHG emissions Most notably, members of the International Council for Mining and Metals (ICMM) have committed to the goal of Net Zero, Scope 1 and 2 emissions by 2050 or sooner. The commitment also includes meaningful short and medium term targets, with for example some of the members pledging to reduce operational GHG emissions by 30%, relative to 2020 levels, by 2030.

It's a difficult bind: Net Zero is not possible without mining, and yet mining itself is an energy intensive process of hauling vast quantities of ore and rock, followed by mineral processing – crushing and grinding in particular. Diesel powered generators and vehicles get mines up and running faster than, say, building a connection from the mine site to the grid. Consider that mines are often remote (locations of mineral deposits were fixed billions of years ago, long before the development of modern population centres). So, carbon-intensive processes and power methods have been relied upon heavily in mining. Changing these processes in under 30 years to comply with the ICMM's benchmark, after they've been relied on for many decades longer than that is a complex task.

DIGGING FOR ANSWERS

Truthfully, it's not the ICMM's edict alone that's pushing miners in the direction of greater sustainability. Market forces and expectations alone mean the incentive for change has never been higher. Humanity is projected to mine as much in the next two decades as it has throughout history. Mining's impact- positive or negative- on the natural environment and host communities, will therefore be stronger than it ever has. It's in everyone's interests for that impact to be positive.

Mining need not be inherently unsustainable. Electrification opens up all kinds of possibilities. The global mining industry is collaborating with manufacturers to create electrically powered versions of the 360-tonne haulage trucks that haul rock and ore out of pits. Diesel-powered mining vehicles account for between 30-80% of direct emissions at a typical mine site. With around 28,000 large mine hauling trucks in operation - collectively emitting over 68 million tonnes of CO2 every year according to the ICMM - the impact of electrification will be huge. Indeed, the ICMM has a target for 100% GHG-free surface mining vehicles by 2040. Many large miners are already stepping up, with companies announcing expanded electrified haulage fleets over the next 10 years, and initial deliveries and trials of these vehicles already underway.

Electrification can reshape how mines are conceived and operated. For example, operations can exploit favourable topography, where it exists, to generate renewable power.

If quarries are located at high elevation, with the processing plants further downhill, electrical haulage trucks can charge their batteries on their way downhill while they carry the ore, making use of a regenerative braking system that captures enough energy to power their ascent back uphill to the quarry when they're empty.

CORE PROCESS IMPROVEMENTS

With improvements in the efficiency of mineral processing, we can make further strides towards a cleaner industry. Take the process for concentrating copper ore, in which the average copper ore grade (the proportion, by mass, of copper-bearing mineral in the total mined ore) is now well below 1% as more and more high-grade deposits are mined-out. Traditionally, all of this low-grade ore in the magnitude of thousands of tonnes, is hauled to a processing facility. This consumes a lot of power in both the transport and processing phases. But now, developments in ore sorting technologies mean that the unusable ore can be diverted away from processing, saving energy.

Plus, advancements in crushing ore in-pit and then transporting it to the surface (ideally using electrified power-recovery conveyor belts, where there are downslopes on the route), means that a much smaller mass of material needs to be transported offsite. Efficiencies like these can be unearthed throughout the minerals processing flowchart. It requires looking at standard operating procedures and asking: 'why do we do it this way? Are there better ways to do it?'.

New technologies are enabling us to deliver renewable power to mines and make further progress towards cleaner mining. Intermittent power sources like wind and solar were long deemed unsuitable for mine sites, as their output was vulnerable to changes in weather and daylight. Now, microgrids can be operated with renewable energy, integrating energy storage and generating a steady flow of clean energy built up in times of surplus. This is especially helpful for mines in remote locations that lack a connection to the power grid. Traditionally, those mines have relied upon gas or diesel generators for their electricity.

Hybrid microgrids can ease the transition to renewables: with the main bulk of energy being generated by wind or solar, with diesel used in

a bridging capacity if needed. Energy storage systems can also be deployed alongside microgrids. These systems can be built at speed - some microgrids have been assembled in under a year.

Pumped hydro power storage is particularly promising. Where disused pits and compelling elevation differences are commonplace, this mature technology can be a perfect fit. Pumped hydro power storage is a configuration of two water reservoirs at different elevations that can generate power as water moves down from one to the other, passing through a turbine. It acts as an energy storage technology of sorts: pumping water into an upper reservoir during times of lower electricity demand, and then generating electricity by releasing water into a lower reservoir through the turbine during times of higher power demand.

Employed together or in some combination, each of these practices will move producers closer to the ICMM's 2050 target.

ALL TOGETHER NOW

Innovation is only part of the solution, however. Success depends as much on collaboration and integration as it does on technology itself. No single solution is going to make mining sustainable. If you electrify your fleet, but the electricity comes from a coal-powered station, we're effectively pushing the problem onto someone else. This meets neither the spirit nor the letter of what the ICMM is trying to accomplish for the industry. Instead, changes must be ' interconnected' to be effective.

Nouveau Monde Graphite (NMG) in Quebec, Canada, shows how integrated vertical solutions can compound the benefits of sustainability. Assisted by SNC-Lavalin, NMG is developing a natural graphite operation by harnessing its location, vertical integration, cost structure, and ESG credentials. Its all-electric Phase-2 Matawinie Mine will be powered by clean hydroelectricity, via a connection to Quebec's grid with a dedicated transmission line. It will be the world's first all-electric open-pit mine. With an estimated output of 100,000 t/y over a 26-year period to supply high-purity material for batteries, NVG's Matawinie site is showing what we can achieve in mining sustainability.

REACHING HIGH (OR TUNNELLING LOW) FOR NET ZERO

The investor community funding mining projects, governments, and even potential buyers for metals and minerals in plenty of jurisdictions are far more ESG driven than they used to be. This in turn makes the commercial case for change stronger. Mines that don't put sustainability first may find themselves cut off from swathes of investment. If their projects conflict with a host government's Net Zero targets, they could even have their regulatory permits denied. In the near future, the only commercially viable mines will be those that are net-zero or net-positive.

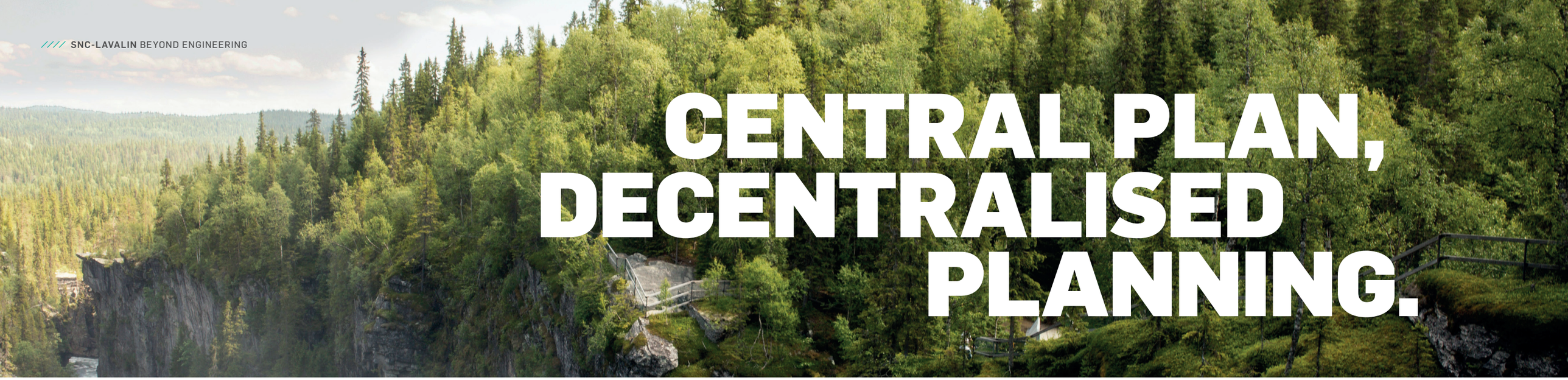
Sustainability is no longer an impediment to profitability, but an accelerator. Reprocessing discarded tailings, using machine learning, digital tools, VR and drone technology, or even turning a decommissioned copper mine pit into a hydropower generating plant, providing clean energy and income for the local community, can tilt the business case to make investments in sustainability favourable. But these solutions must be considered from the start, necessitating early stakeholder engagement, collaboration, and leadership.

As more and more industries come under the purview of society-wide Net Zero targets to which governments are bound, mining will be brought under this remit. Miners today have a unique chance to get ahead of this change, and act with the bigger picture in mind- beyond even the ICMM's goals. Those who act now can sign competitive procurement agreements, establish their supply chains, and reengineer their processes with plenty of lead time. It shouldn't be done just because the ICMM and other industry groups say so. It should be done because it's where stakeholder demands (and in turn, market forces) are going to take the industry in the future anyway.

David Isherwood

VICE-PRESIDENT, SUSTAINABLE MINING CANADA

STRATEGIES AND SOLUTIONS FOR A NET ZERO CARBON FUTURE.



CENTRAL PLAN, DECENTRALISED PLANNING.

WHY COORDINATION IS KEY TO NET ZERO

International agreements, sweeping national commitments, and formidable goals: now that the majority of the global economy is pledged to Net Zero, how do we formulate detailed actionable plans capable of getting us there? Differences between nations, regions, and industries mean that there's no single sequence to decarbonising an economy.
Yet one element must be universally recognised: the need for central plans to be shaped by the ongoing needs of local communities. Otherwise, the short-term actions taken towards decarbonizing the economy risk missing targets, alienating localities, and misaligning outcomes for industry and public alike. So how can plans coordinate global ambitions with local and regional needs?

After decades of dither, it's happening. One after another, nations are announcing bold goals to reach Net Zero emissions. Momentum is building. However, there is no standard solution: every country must find its own way forward. Industry, energy mix, maturity, climate, topography: many factors will influence the equation, and these must be carefully evaluated as plans take shape. Centralised plans coordinating decarbonisation are of little use if they're insufficiently influenced by, and adapted to, each country's individual needs. Similarly, national plans must also be adapted to and incorporated into each region and community's development plans.

Decarbonising the world has far-reaching consequences, and every industry will face uncertainty during the energy transition. Decision-makers need frameworks where the variables affecting their sector's economic health and the viability of their individual businesses are well known. Moreover, scenarios where only certain segments of the economy transition to Net Zero, while other segments are left behind, could lead to unsustainable economic conditions. Rushing ahead without a concerted cross-sector plan is therefore risky, for it could lead to disenfranchisement, inefficiency, and stalling – eroding the public trust and jeopardising our chances of achieving Net Zero by our legally-binding timescales. If we are going to reach Net Zero in time, we need well-coordinated, far-sighted plans that will help translate theory into action, high-level vision into front-line change, and ambitious plans into measurable objectives.

But who decides what to prioritise? Without a planning committee, long-term decisions are likely to be left to a mixture of chance, expediency, and economic conditions. A central plan helps to establish what's being decided, by whom, for what reasons. Yet flexibility is vital. Achieving Net Zero is so complex, and the needs of each region so multifaceted, that a rigid plan could completely miss the mark. Scientific developments, industrial processes, regulations: the consensus on the best path forward is shifting all the time. Meanwhile, the tension between profitability and sustainability, short-term needs and long-term necessities, is constant. Plans must therefore be flexible enough to accommodate developments and local needs as they unfold. Otherwise, the solutions will be too generic, social impact will be marginal, and opportunities to enact lasting change missed.

TIMING IS CRITICAL

Net Zero depends on electrification; electrification upon infrastructure; and infrastructure upon planning. Yet to transition from existing, emissions-intensive electricity generation to carbon-free electricity has two immediate consequences: first, the capacity of the grid must be expanded; and second, the amount of electricity generated must increase. After all, if different sectors are being decarbonised, many of them will switch to electricity. In most cases, the necessary changes to infrastructure are going to be massive.

It is therefore essential to understand the regional development processes. Power system planning, for example, is a lengthy process involving many stakeholders including energy regulators, system operators, as well as various transmission and distribution utilities. Large generation or transmission projects, once identified, often require a decade or more to develop from inception to commissioning. However, utilities may not yet see the full-scale of demand growth that will result from the Net Zero transition, in their respective short-term regional plans. As such, the speed at which power grid projects are identified and deployed is limited. This in turn fuels uncertainty on the industry side

Moreover, renewable energy sources may not be located where they are most needed. A desert of blazing sunshine might be an ideal spot for photovoltaic solar panels, yet few factories are likely to be situated close by. Infrastructure connecting renewable sources to an industrial base must be considered in tandem with the renewable developments, because it could end up determining the viability of the project itself. A centralised plan, encompassing industry, energy mix, and far-sighted needs assessment, guides this process.

Simply put, good timing will be essential. If you build electric infrastructure before sectors are ready to transition, you risk allocating precious resources to capacity that no one is using. On the other hand, if the economy strides towards electrification but the infrastructure is not ready, then this will hinder industry and the pace of growth, causing bottlenecks, delays, and poor return on investment - potentially discouraging businesses.

Instead, industry must be incentivised to move together. But collaboration between distinct, specialised sectors isn't easy to engender. Many are unaccustomed to sharing insights, best practice, and resources, especially when they lack the compatibility to do so.

OUR BLUEPRINT FOR A NET ZERO CARBON FUTURE

By establishing common goals, processes, and rewards, central plans can foster the trust and partnership needed to collaborate, giving businesses the clarity to take action.

DE-RISKING THE TRANSITION

Trade-offs, though, are inevitable. No plan can create perfect harmony between sectors, regions, and industries. In Canada for example, most electrification pathways to Net Zero estimate the need to double or triple the power generation, along with the necessary power grid expansion. However you square it, this will translate into significant costs for the public. Are they willing to pay more just to get the same thing they've come to expect - energy for their homes and businesses?

Moreover, reliability must be guaranteed. Renewables, such as wind or solar, are intermittent and require the robust infrastructure needed for widespread integration, including baseline generation such as hydro or nuclear, energy storage, as well as a modernized transmission and distribution grid. If mismanaged, major changes to the power system operating philosophy could expose the grid to temporary dips in reliability as well as higher bills, which risks turning public opinion against renewable transition.

Central plans focused on incentivisation, collaboration, and impact mitigation are critical to overcome these challenges. Planning should be a process of two-way communication, and centralised plans must remain flexible enough to meet local needs, while moving towards a common goal. In turn, this helps to increase trust, de-risk change, and mitigate the danger of moving too fast or overlooking particular sectors. Regions and communities will need to lead the transition if we are to achieve the end-goals, and local initiatives will need to be orchestrated through central planning.

Data can enable that dialogue. KPI metrics, baseline data, and standards help evidence why decisions are made, maintaining transparency and allowing utilities, industry, and public alike to talk to an accountable central body. But it's a two-way process: regions and communities will also enrich central plans with their own frontline data. High-level national and global statistics aren't enough. We need project data at an operational level to inform and maintain the transition to Net Zero. Data standards, AI, and integrated information management can optimise data sharing, speeding up the identification and optimisation of effective approaches - and spreading them throughout the economy.

A SUSTAINABLE JOURNEY TO NET ZERO

Net Zero isn't just a science problem, it's a coordination problem. Many of the technologies required are already available. Central planning is therefore the only way to generate sustainable, multidisciplinary international action: it achieves consensus, and incentivises partners with long term goals, while communicating priorities to the whole population. But if these plans fail to incorporate the specifics of every industry, region, and community, the risk of ill-fitting outcomes, public discontent, and stranded industries is too high - imperilling our journey to Net Zero.

We need to de-risk both 'first mover' and 'latecomer' alike. In infrastructure, high costs and complexity often mean that the first mover takes the biggest risk - yet if it pays off, they can also find themselves with correspondingly vast rewards. Central plans, informed by local needs, can soften the edges, turning winner-takes-all into all-together-now, sharing risk and reward alike. Net Zero may alter the economic landscape, but it must do so responsibly, so that investment, collaboration, and best practice are genuinely incentivised.

With enough space for local needs, and sufficient flexibility to adapt to the changes along the way, central plans can be both the map to the destination and our vehicle for getting there. That's how we make the unprecedented journey to Net Zero - and that's how we make the journey itself sustainable.

John Chahwan

PORTFOLIO DIRECTOR, POWER GRIDS
CANADA AND INTERNATIONAL

BALANCE OF POWER?

THREE REGIONAL PERSPECTIVES ON THE ENERGY TRANSITION

In the race to decarbonise energy,the underlying resilience and stability of our future energy mix is often underplayed. But rapidly rising demand and a growing dependence on electricity for power threatens to overwhelm grid infrastructure. Together with the intermittency of renewable sources like wind and solar power and availability of resources and capability to deliver low carbon energy projects, the way we manage these risks could make or break our energy transition. There is no single pathway to energy transition – so how are different regions adapting to the new balance of power?

So far in 2023, power cuts and rolling blackouts have struck across the world. From the United States to Pakistan, South Africa to Sri Lanka, developed and developing economies alike are suffering sudden outages or are rationing power to balance supply and demand and cope with unprecedented strain on energy grids. The electrification of transport and heat will push demand further, and growing urban populations and more extreme weather events add further complexities.

Clearly, capacity must increase significantly over the coming decades. But we also face the challenge of balancing the grid. Energy system operatorsundertake roles that influence the mix of generation sources; balancing availability of base load power, peak load management, and managing flexibility. Power generation from fossil fuels has long provided steady base load power, as well as the capability to ramp up and down to meet fluctuations in demand.

Yet renewable sources of power, like solar and wind, are often intermittent. Unless we adapt how we store and manage power, building equivalent volumes of storage and back-up power sources, we will struggle to maintain reliability in the transition to Net Zero.

Overcoming these challenges requires seeing the energy system as a whole, rather than judging the individual merits and drawbacks of specific energy sources. Considering the bigger picture enables the integration of renewables while maintaining reliability, minimising the risk of blackouts and optimising the price of energy for consumers. We must focus on pace of production, resilience, and systems-level plans. Regardless of how it is constituted, any energy mix must be resilient: balancing firm versus intermittent renewables and avoiding over-reliance on any one resource or fuel. System-level plans are necessary to coordinate the transition, determining the required infrastructure and development pathways for each technology and identifying where incentives or market reform are needed, so that the transition is conducted in a coherent, complementary, and consistent manner. And if we're to build generation and supporting infrastructure at the rate necessary to meet Net Zero targets, pace is vital.

Yet each country is unique, with its own challenges and opportunities. No single solution is universally applicable. Climate, economy, politics and natural resources all play a part in each country's path to a net zero energy system. By exploring differing perspectives, however, we can unearth commonalities, showing possibilities for charting a safe, secure, affordable and sustainable course through the energy transition.

MIDDLE EAST: AT THE CROSSROADS

With its abundant fossil fuels, growing economies, and high per-capita energy use, the Middle East offers insights into both the challenges and opportunities on the path to sustainability. Contrary to popular perception, the Middle East's power generation sector does not operate entirely on fossil fuel. The region is emerging as a frontrunner in nuclear and renewable energy solutions, harnessing its ample solar resources. However, gas must play a different role from its current one to deliver the region's transition to a net zero energy system. The Middle East's reduction from its dependence on fossil power generation will serve as a valuable example for the global economy as a whole.

More importantly, the Middle East demonstrates how fossil fuels and their infrastructure can be redeployed more sustainably. Gas-fired power plants, in particular, can play an instrumental role in tomorrow's energy mix. As a cleaner-burning fossil fuel, gas can serve as a transitional energy source, reducing carbon emissions while maintaining supply reliability. Moreover, gas plants can be quickly ramped up or down, providing the grid with the flexibility and back-up as necessary to balance the power demand and supply and accommodate increasing renewable energy power sources. This should however be considered only as a transitional step while other generation is developed. Gas-fired power plants aren't destined to become relics of the fossil fuel era for another reason: they can be decarbonised. Their design can be harnessed to blend low carbon fuels such as hydrogen, ammonia, and biofuels. While blending these fuels into a gas plant's fuel mix presents technical challenges, these are surmountable - and offer an alternative tofitting gas plants with carbon capture and storage technology. Nuclear energy will also be crucial in the Middle East's transition, and the Barakah nuclear power plant in the United Arab Emirates exemplifies this role. As the first commercial nuclear power station in the Arab world, Barakah provides around a quarter of the UAE's electricity, substantially reducing the nation's carbon emissions. Its reliable baseload power can complement renewables. Since 2011, SNCL-Atkins have continuously supported the project, from financing and construction, through to commissioning and operations.

It's a race against time - so we must use all available tools to achieve a sustainable, secure, and affordable energy future.

UNITED KINGDOM: GROWING PAINS

The UK economy is making great strides towards Net Zero, and yet deep-seated structural problems remain. Like many European countries, the UK's reliance upon imported energy has been brutally exposed by the war in Ukraine. In 2022, skyrocketing energy prices contributed to a generational cost-of-living crisis and warnings of blackouts. But thanks to the UK's growing renewable power generation, which now accounts for 40% of its total capacity, for the first time in over a decade the UK was also a net exporter of electricity. Since the mid-2010s, the UK has encouraged investment to expand its offshore wind capacity, contributing to a steady growth in its renewables capacity. However, to maintain progress, the UK must rapidly expand its supporting infrastructure. Many regions must be equipped with the capacity to receive, store, and distribute power from off-shore turbines to areas of high demand. National Grid is commencing a huge programme of work to deploy this infrastructure of pylons, overhead lines, cables

and substations, without which the offshore wind turbines will not be able to deliver their potential.

The government claims that all of the UK's electricity will come from clean sources by 2035, while also estimating a 40-60% rise in electricity demand, driven by an increase in electric vehicles and electric fuel pump heating in homes.Laudable as these ambitions are, they have consequences for Britain's already-straining grid. If all of the UK's 32 million petrol vehicles are converted to electric, the National Grid's infrastructure must be adapted. Solutions like vehicle-to-grid (VTG) charging, a smart charging system that automatically connects car batteries for charging when there is surplus renewable power, can help. But for a decarbonised grid by 2035 - little more than a decade away - we need to have a clearer idea of how this grid will be composed. Our potential of 50 gigawatts of wind is a great start. But even if we build and connect all of this to the grid by 2035, we'll still have a shortfall, and we're yet to clarify which solutions will make up the gap. British businesses and universities are already pathfinding such projects, with many in research or in a concept phase. But we now need to get those projects into delivery - or else veer towards 'the worst of times' scenario.

CANADA: POWERHOUSE POTENTIAL

A growing economy, a young population, and vast natural resources: in the energy transition Canada has some undeniable advantages. Like other countries, though, it's confronted by rising demand. By 2050, Canada's power demand will be two or three times that of today. To exploit its potential, Canada must carefully balance its energy mix. Canada's energy baseload is well-covered. High levels of hydropower and nuclear power plants reduce the need for large-scale, long-term power storage facilities that are often crucial to balancing a decarbonised grid. Canada can also use its hydroelectric power as a long term storage solution. Using excess electricity to pump water up to an elevated reservoir, the water can be stored at higher elevation before electricity is needed and sent back down through the hydroelectric turbines. Short-term storage to meet peaks of demand, though, will be necessary. Perhaps because of its abundant baseload assets, Canada has yet to make significant progress with grid storage in general. So far, batteries have been the preferred solution for short-term storage, helping to manage short spikes of energy demand of around four hours or so. Yet as elsewhere, the grid infrastructure - both transmission and distribution - is ageing. Some of it is half a century old or more. Bottlenecks are already appearing in transmission corridors, which are maxed outalready. With demand set to double or triple, Canada must enhance its grid. One solution lies in how Canada's electricity is managed. Unlike other countries, electricity is managed not at a national level but at a regional level. Differences in provinces abound: some are much more optimised than others, causing regional imbalances. Improving the interconnection between the provinces would even out these inconsistencies, giving grids more flexibility to take on more renewable-generating assets. Wind and solar farms often require a lot of space and tend to be situated further away from points of consumption than traditional power plants. Therefore provinces in Canada will want to be able to share power with their neighbours when the sun is shining or wind is blowing in one place but not the other. But integration must not come at the cost of flexibility. An interruption in one area must remain localised, rather than inadvertently propagated across a vast region. With foresight and planning, Canada can help lead the way to a truly sustainable future.

CURRENT AFFAIRS

The energy transition is daunting;developing complex, critical infrastructure at speed while satisfying rising demand and changing regulations is not straightforward. However, it's also clear that the two essential qualities required; system-level plans to develop a resilient, affordable decarbonised system, and pace to deliver those plans. So much depends on whether these multifaceted challenges can be approached holistically. An 'energy systems architect' capable of orchestrating the energy mix, developing a blueprint for new energy production sources, and balancing supply and demand, can make the difference. With this broader perspective of the bigger picture, regions can reimagine their energy systems intelligently - and create solid foundations for their Net Zero future.

Alastair Perry

VICE PRESIDENT, RENEWABLES, CANADA

David Haboubi

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LEADING INDUSTRY BY EXAMPLE

STEP

Spherical Tokamak for Energy Production (STEP) is a UK Atomic Energy Authority (UKAEA) led programme that will demonstrate the ability to generate net electricity from fusion.

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