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WHITE PAPER / **WHOLE SYSTEM ENERGY MASTER PLANNING**

CREATING A MORE FLEXIBLE ENERGY SYSTEM

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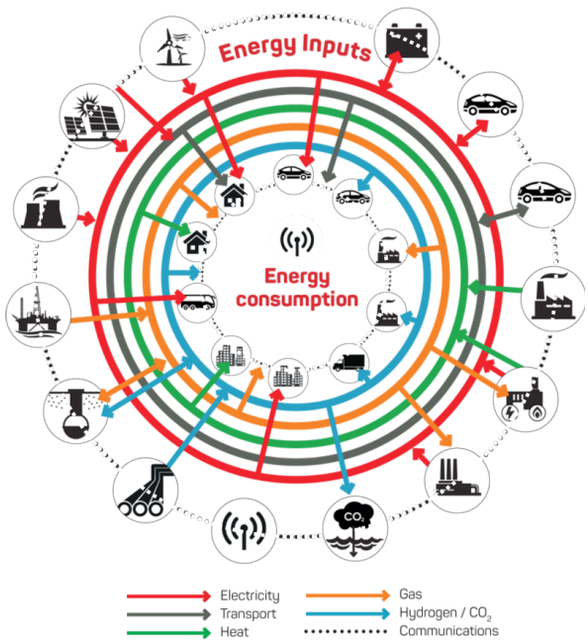
Meeting U.K. carbon emission reduction requirements, and customer requirements related to affordability and reliability, requires a new approach to energy master planning — a whole system approach.

WHOLE SYSTEM APPROACH:

A fully integrated approach to delivering energy services at a district level, which encompasses the supply and demand of all interconnected energy vectors in order to optimise our sustainability, security and affordability performance.



The United Kingdom energy sector is at the precipice of unprecedented change brought on by environmental regulations, evolving consumer demands, new technologies and rising costs that inhibit economic growth. The government's Clean Growth Strategy, Road to Zero Strategy, Industrial Strategy, and the Dieter Helm Cost of Energy Review all seek to chart a path toward meeting environmental and economic objectives, yet all focus on only subsets of the challenge and constituents involved.

The tug and pull between low-cost and low-carbon energy solutions has created uncertainty across the utility industry. There is downward pressure on costs to consumers and decreased consumption, accompanied by an increase in distributed energy resources (DER) and behind-the-meter solutions aiming to use less of the grid — sharing the burden of cost with a smaller constituency. New and emerging industry participants are actively working to solve traditional energy problems in new and creative ways, challenging the existing utility model.

Growing uncertainty is limiting investments in the U.K.'s infrastructure as utilities may no longer be viewed as a low- to no-risk platform for institutional investors. Limited investment hinders the development of clean technologies and network enhancements, which in turn creates greater pressure to improve service and reduce costs. A prime example of this was expressed by Robert Symons, chief executive officer of Western Power Distribution (WPD): "Ofgem's proposal to reopen the RIIO price settlement for electricity networks wiped 20 percent off WPD's stock price."

Albert Einstein once said, "We cannot solve our problems with the same thinking we used when we created them." Solving environmental and economic challenges through energy sector changes also requires new thinking. Our energy systems today are interdependent, yet siloed under various markets, regulations and policies. To solve our energy and associated economic challenges, we must look at challenges and opportunities across our various energy vectors and address them as one.

A whole system approach represents a new framework for designing, retrofitting and/or building smarter infrastructure. It is a fully integrated approach to delivering energy services at a district level, which encompasses the supply and demand of all interconnected energy vectors in order to optimise sustainability, security and affordability performance. The approach erases existing silos and barriers to create an energy system that flexes available capacity across systems; incentivises market participants based on the benefits and services they provide to the system; solves the energy trilemma; and provides substantial economic and societal benefit.

FLEXING CAPACITY ACROSS THE SYSTEM

In today's demanding energy environment, we cannot afford to address energy issues within siloed vectors.

Rather, we must adopt a multi-vector approach that integrates the various systems. Integration would enable the entire system to adapt in real time to flex capacity and load between different vectors and, potentially, use heat and transport as new means for energy storage.

By revisiting the structure of each energy system, we can create a top-down approach for redesigning and reimagining the way the full system is used at a local, regional and national level to achieve:

- Lower carbon emissions through optimised asset and DER usage
- Enhance reliability locally and nationally by solving system challenges locally, where they exist
- Lower costs through cross-vector arbitrage, peer-to-peer trading of available energy services
- Leverage flexibility that is readily available in industrial and commercial estates

The rise of electric vehicles (EV) demonstrates the need for an integrated energy system. In today's fragmented energy market, EVs are feared by electric grid owners and operators. If we flip the perspective, we can acknowledge current risk and seize opportunity to integrate EVs as grid assets through vehicle-to-grid (V2G) technology. Additionally, we can enhance alignment of renewables to consumption, leveraging the interplay between vectors to fill in for intermittency, using readily available technology and by rewarding people for their participation and the benefit they provide to the system.

Of course, technology alone cannot solve our energy challenges. Customers drive innovation, markets and energy demand. The whole system approach focuses on delivering energy services to customers and influencing their engagement and behavior through dynamic pricing models. For example, dynamic pricing for electricity and transport would discourage EV charging during peak electric demand periods while simultaneously enabling V2G technology to support electric load.

Community energy schemes, such as the Chesire Energy Hub's Energy Innovation District, look to bring together large-scale energy users to solve challenges at a local level. This type of programme creates new market opportunities through the aggregation of significant supply and demand; optimise resources; and better meet the collective needs of the community.

STAKEHOLDER ENGAGEMENT AND POLICY SUPPORT

Energy service providers are under immense pressure to deliver better, cleaner and more reliable energy at lower cost. Many regulatory schemes to control costs have the unintended consequence of limiting investment and/or impeding innovation. Limited investment opportunity in the U.K. already is driving investors overseas.

The U.K. needs a strong energy policy that enables industry leaders to integrate systems for greater efficiency, resilience and environmental performance. The government must take a more holistic 'whole systems' approach to energy policy to provide energy security and decarbonisation at least costs to the consumer.

The need for a comprehensive policy was the focus of the Committee on Climate Change's (CCC) report, "An independent assessment of the UK's Clean Growth Strategy: From ambition to action," published in January 2018. The CCC highlighted the need for the British government to "urgently firm up policies and proposals" and provide more detail in its numerous plans in order to achieve required emissions savings.

Lack of a comprehensive policy also affects our energy security, as demonstrated by the natural gas shortage in February 2018, prompting the National Grid to issue a Gas Deficit Warning. Jonathan Marshall, an energy analyst at the Energy and Climate Intelligence Unit, attributed a primary root cause for the shortage to "a failure by successive Governments to map out a secure gas future in the way that they have done so successfully for electricity."

In order to achieve carbon reduction objectives and stimulate economic growth, the government must stop considering electricity in isolation and start thinking about the close interaction between the power sector and other sectors of the economy,

such as heat and transport. Developing a whole system policy requires engaging stakeholders from across all the energy vectors, including:

- Electricity and heat generation asset owners
- Electricity, heat and gas network owners
- End customers and special interest groups
- Government
- Infrastructure regulatory network
- Local entities and partnerships
- Technology innovators

The U.K. is positioned to be the leader in decarbonisation, but we might have reached the 80/20 rule — where the low-hanging fruit have been accomplished by industry. The last 20 percent will be hard and will require us to think differently and more broadly about solving the hardest challenges ahead. We will need immense coordination and collaboration to make this possible.

BARRIERS

Each energy vector is typically regulated under separate government agencies, on different regulatory cycles, and has different funding mechanisms. Disproportionate investment costs exist across vectors for short- and long-term benefits. For example, hydrogen production and carbon dioxide storage have very high capital costs and significant, long-term carbon benefits, whereas existing natural gas-fueled generators have lower capital costs but minimal long-term benefit with regard to achieving carbon budgets.

National policy changes are needed to level the cost of energy and enable a local energy market to operate. We need to think about how to provide price and market signals for participants to openly and actively engage. We need to provide certainty of investment and participation so the clearing price of energy resources is rewarded for those resources' real-time benefit to the networks. Perhaps most importantly, we need to think about the outcomes that we want for the nation as a whole and work backward from there on how to achieve them.
In addition to needing a level playing field for clean energy solutions, industry and government must tap into the growing awareness of the role of consumers in actively managing their energy use and costs.
We also need to consider total energy costs from across all energy vectors and services, rather than individual utility bills. For example, the cost of transportation could rapidly decline as this industry continues down the path of electrification. However, investment and infrastructure upgrades needed across the distribution network to enable mass electrification of transport may unfairly or disproportionately impact customer tariffs.

OPPORTUNITIES

Today, energy prices and network capacity are causing industry and manufacturers to consider the European continent for growth. Reducing energy costs is the burning national platform in the U.K. and a key focus for virtually all stakeholders, across all energy vectors. The whole system approach enables us to create a platform that lowers total energy costs in a manner that attracts and retains industrial development and promotes economic growth. It also enables the nation to position itself as a world leader in carbon reduction.

The rise of electric vehicles (EV) has created a new energy vector that provides a solution and not just a challenge. In today's fragmented energy market, EVs are feared by electric grid owners and operators. If we flip the perspective, we can acknowledge current risk and seize opportunity to integrate EVs as grid assets through V2G technology and/or smart charging solutions.

The technology needed to enable electrification of transport and cross-vector capacity support exists and is, in many cases, already mature. Blockchain solutions can track electrons through a grid system to enable dynamic pricing, cross-vector trading, and new markets and services. Microgrids and DERs can be used to solve micronetwork challenges in real time. Waste heat from industry and combined heat and power (CHP) facilities can be used to generate electricity and steam or heat community buildings. Creating a flexible energy system requires bringing together the market participants, technology and systems to fully understand how each can work together.

The holistic approach is not just understanding how the systems are built under the current regulatory regime, rather how each can be organised to optimise the use of

stranded and/or underutilised assets. Shared solutions exist within the multiple energy vectors; what is lacking is policy and regulations that monetise services and help the end user. By viewing energy systems through the whole system concept, we can drive new policies, business models and economic development.

We must couple the burning platform for lower energy costs in industry with our desire to be industry leaders in carbon reduction. We can't be shy about looking for new ways to do things just because they make us uneasy and uncomfortable. By further aligning our desires with emerging technology, existing assets and capacity, and empowering consumers with actionable intelligence, we will solve traditional problems with new methods.

SOLVING THE ENERGY TRILEMMA

A true whole system approach aligns well with meeting the competing needs of the energy trilemma by recognising the interdependencies and potential synergies of disparate vectors. Optimising these synergies inherently reduces our energy systems' environmental footprint while improving resilience and cost-effectiveness. The following provides high-level examples of how the approach fulfills each need of the trilemma. Fundamentally, there are three major drivers of disruption facing the energy industry as a whole: decentralisation, digitisation and decarbonisation. Each of these drivers has a signifanct role in the energy trilemma and will be critical in solving the toughest industry challenges today.

REDUCING CARBON

The U.K. has already reduced its greenhouse gas emissions by more than 40 percent from 1990 baseline levels. This reduction is largely the result of heavy investments in renewable energy and the phasing out of coal-fueled power generation. To achieve the 80 percent requirement, significant carbon reduction must be achieved in the area of home and business heating. According to the U.K. Department for Business, Energy and Industrial Strategy (BEIS), the heating of homes and businesses accounts for nearly one-third of U.K. emissions.

Hospitals and large industrial facilities typically have CHP facilities that are large enough to provide connected buildings, campuses, and other residential and commercial properties with a sustainable heat supply from already existing assets. If such a service were incentivised, not only would it reduce carbon emissions, it would lower total energy costs for industry and manufacturing.

DECARBONISATION is the ongoing push to cleaner energy sources to reduce carbon emissions and greenhouse gases, improving air quality in our cities. Decarbonisation is driven by policy, consumer behavior, technology and market forces that are within our control.

DECENTRALISATION is about pushing intelligence to the edge of the energy system. This involves connecting smaller-scale, clean, distributed generation sources (including renewables and storage) at the distribution level and closer to demand centers to — when combined with advanced technologies — solve micronetwork challenges in real time.

DIGITISATION is all about the technology and sensors that make up the connected world we live in. The adoption and adaptation of secure, communication-based technologies will be increasingly leveraged in the world of energy to drive efficiency and draw out costs of supply and demand. Digitisation will make us smarter in the lives we lead and how we make decisions about consumption. "[It] will provide the only sure-fire route to decarbonisation," according to Dieter Helm, professor of energy policy at Oxford University.

IMPROVING ENERGY SECURITY

There are regions across the U.K. that could benefit from supplementing the local grid with DERs. Today DERs, particularly energy storage facilities, are largely placed wherever a developer can get access to the grid and a construction site. The whole system approach eliminates the need to build large, stranded assets (reducing costs) while incentivising users based on the network benefit their asset(s) provide.

When local assets — such as CHPs that can be islanded — are integrated for local, real-time control, they can offset lulls in renewable energy production, lower an industrial facility's risk for increased capacity charges, and fundamentally make the grid more resilient.

ENERGY EQUITY AND COST EFFECTIVENESS

The whole system approach addresses energy equity and cost effectiveness by eliminating waste, optimising underutilitised and/or stranded assets, and putting the consumer in control of their energy use. Consumers must become "prosumers" who are engaged and make active decisions using real-time price signals (incentives and disincentives) to manage their energy costs.

A ROAD MAP FOR THE FUTURE

In essence, the whole system approach is about transforming energy utilities from volumetric-based energy suppliers to energy platform providers. Under this model, platform providers serve as an energy "app store" where companies or individuals can create energy services and connect market participants to those services. These interconnected participants will draw on the platform to establish a new set of services and incentives for solving energy problems.

The State of New York has begun implementing similar measures through its "Reforming the Energy Vision" (REV) initiative. In 2016, the New York Public Service Commission approved measures to convert traditional utilities into distribution system platform providers, including utility revenue and ratemaking models that incentivise system efficiency and use of third-party resources, such as DERs.

The proposed whole system approach differs from the New York REV initiative in that it encompasses all energy vectors, rather than just the electric system. Creating an integrated system requires developing a road map that demonstrates value to consumers and provides for significant reduction in carbon emissions.

Key components of the road map:

- The road map and pilot programmes should create a platform for the future and a vision that drives consumer adoption and acceptance. This platform should align with technology, data and policy frameworks to enable future growth and development.
- With regard to technology, the primary objective of the whole system approach is to enable full integration of infrastructure systems over time. To do this, improvements should be based on open protocols and standards-based interfaces.
- The outcome should be lower-cost, affordable energy that leads the world in the way of lowering carbon emissions, backed closely by economic and social development at a community level, where consumers directly benefit from the platform.

Pilot programmes that enable communities to save energy through intelligent and educated consumption, similar to the previously referenced Cheshire Energy Innovation District, are essential to demonstrating benefit, identifying best practices, identifying new markets and reducing barriers. If society can see the benefits and if the barriers to entry are relatively low, then we can be confident that consumers will come en masse and participate at scale.

WHOLE SYSTEM PLANNING

If our ancestors knew what we know now with regard to climate change, the costs of services and the need for reliable energy services, our systems would have been designed differently. Our challenge is modifying our thinking, our infrastructure and our financial models to meet the needs of today and position for future requirements. The whole system approach encourages efficiency by flexing capacity across our energy vectors, making better use of stranded and/or underutilised resources. It engages all stakeholders to create policies that

encourage innovation, enable new markets and services, and place consumers directly in control of their energy use and costs. It effectively addresses the energy trilemma by recognising the interdependencies and synergies of our disparate systems and assets, providing substantial societal and economic benefits in the process.

The energy landscape is changing faster than ever, and the need to position the energy system for the future is growing more urgent. We have the technology and know-how to create a flexible energy system. The time has come to begin creating clear policies, regulations and road maps that guide investments and engagement across our energy infrastructure for the purpose of lowering costs, reducing emissions and facilitating sustainable economic growth.

Collectively, we know that we want a road map that put us at a place in the future where the energy trilemma is solved. That is the only acceptable finish line. The road map should provide for better asset and infrastructure utilisation that drives cost down for consumers; a broad portfolio of renewable assets that enable us to meet our sustainability goals; and the utilization of technology to solve micro energy security challenges. The road map to a flexible energy system is riddled with challenges and barriers, but with that comes great opportunities to change the way we try to solve the trilemma.

BIOGRAPHIES

JONATHAN CHAPMAN, CEng, MICE, MIET, lis the managing director for Burns & McDonnell in the U.K. Jonathan has more than 25 years of experience leading teams in securing and delivering projects in the power, water, telecom and gas sectors. He has been instrumental in enabling businesses to deliver complex solutions to client needs, working on programs valued at £5 billion. Jonathan has a BEng, civil engineering degree, from the University of Bradford and an MBA in engineering management from Loughborough University.

JEFF CASEY, MIET, is the business development director and a senior electrical engineer for Burns & McDonnell in the U.K. Jeff has nearly 10 years of experience in the power and energy industry and has been responsible for helping clients deliver more than $16 billion in energy projects in his career. He relies on his experience as an engineer and project manager to develop innovative and cost-effective solutions to his clients' unique challenges. Jeff has a Bachelor of Science in electrical engineering from the University of Nebraska and is pursuing an MBA from New York University. He is an active member of IEEE, CIGRE and the IET.

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