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WHITE PAPER / **DIGITAL ENGINEERING**

DIGITAL ENGINEERING NEEDED TO REACH U.K. ZERO-CARBON GOALS

BY Brian Palmer

To some, it may appear the 2050 zero-carbon deadline is far off in the future. However, if we are to eliminate all carbon-based sources of energy throughout the U.K., work must begin now on a whole-system approach.

Engineering will be key to success as the U.K. moves towards meeting its zero-carbon goals by 2050, and digital technologies will be at the core of an engineering-led approach. A number of energy assets must be redesigned in order to activate zero-carbon solutions. This design process will require:

- Iteration
- Enhancement
- Value engineering

With the right model, we can optimise energy system design at the outset and then work on the truly challenging components of the larger system. Digital engineering will help achieve success.

The built environment sector is the major source of the total global CO_2 emissions, responsible for approximately 40% worldwide. Carbon emissions are not only released during asset life but also during the manufacture, transportation, construction and demolition; these emissions are referred to as embodied carbon. Capital carbon — emissions during construction, refurbishment and end-of-life treatment of an asset — and operational carbon — emissions produced as a result of operations and maintenance of the asset — each are components of whole life carbon emissions. As asset operations become more efficient, there is increasing significance to reducing whole life carbon.

Thus, it follows that calculating CO_2 emissions associated with electricity is an essential part of Life Cycle Assessment (LCA). However, this is often seen as challenging due to the complex nature of energy systems.

A NEW APPROACH

Let's start with the iterative process. Defined as the computational procedure utilised to replicate a series of operations all aimed at producing progressively better results, digital technologies are the keys to iterative processes necessary to help engineers redesign the electrical grid.

The electrical transmission and distribution system in the U.K. is an engineering marvel. With hundreds of thousands of connection points for wires, cables, substations, transformers and an assortment of other power equipment, all designed to transmit uninterrupted electricity, redesigning the U.K. power system will require repeatable design standards that keep the system among the most reliable in the world.

New demands on the grid are coming from the rapid surge of renewable power sources, along with new electricity loads from electric vehicle charging, two-way power flows and many other demands. Transmission and distribution systems must be designed to operate in many new ways.

A whole life carbon approach needs to be considered for taking projects through their full life cycle, including upfront carbon emissions caused in material production and the construction phase. This approach should also consider use-stage embodied carbon, which are emissions associated with the material and processes required to maintain the assets; operational carbon, which are the emissions associated with energy used to operate the assets; and end-of-life carbon, which are emissions associated with the disposal phase of assets after use.

ENHANCING THE ENGINEERING TOOLKIT

Digital engineering tools range from building information modeling (BIM) systems that already are widely utilised within the construction sector to carbon measuring methodologies like the Inventory for Carbon Energy (ICE) database, the NGET Carbon Interface Tool (CIT) and the RICS whole life carbon assessment. All will enhance and augment engineering technology tools.

The use of Environmental Product Declarations (EPDs) to quantifiably demonstrate the environmental performance of a product, based on data obtained through the LCA, can be fed into BIM systems.

There are already some good benchmarks like the National Grid Electricity Transmission (NGET) CIT that captures a much-needed source of data agreed upon by all parties in the value chain. Integrating the National Grid carbon analysis into BIM models would be a key step in getting everyone tracking the same data. All stakeholders within the energy supply chain are vital to implementation.

The National Grid Wimbledon project was a pioneering use of leveraging BIM within the transmission and distribution sector. It analysed embodied carbon within the BIM model using the CIT, combined with digital engineering tools to produce a £3 million saving by reducing carbon.

Engaging computerised optimisation processes for the design of steel and concrete structures can reduce the embodied carbon further than traditional design methods, by optimising structures to save weight and materials while also reducing costs.

VALUE ENGINEERING

Think of digital engineering as a value chain in which data is provided at multiple points of input. Modeling at the outset in the value chain makes it easier than circling back later and completing this step.

Low carbon design practices — especially those targeting embodied carbon — are most effective as well as most cost-efficient when enacted in the early stages of a project.

Modeling technologies require all participants in the value chain to integrate their data into smart models. A unified approach and agreement on a modeling platform will get everybody tracking the right data. The importance of upfront agreement cannot be overstated.

Developing new best practices will require people to adopt new habits. This will undoubtedly be the most difficult challenge as ingrained habits are hard to break. New processes can be implemented based on technology that can be coded properly, as long as the individuals all along the supply chain agree on the new technology frameworks and everybody tracks the correct data. With everybody in the value chain providing data, modeling at the outset will create an efficient value chain, eliminating the need for later corrections.

With suppliers providing integrated data into smart models, we can reach agreed-upon industry standards for quantifying and classifying carbon impacts of new energy sources as well as all activities related to producing energy. The process of value engineering would start by looking at the highest-impact and lowest-cost options for reducing carbon, all driven by easily understood standards showing the marginal costs of carbon throughout the supply chain.

For example, concrete production, a well-known highly carbon-intense input into the construction supply chain, could be mitigated with replacement materials such as Cemfree, a new concrete material that is already being utilised in some motorway projects as a replacement for ordinary Portland cement (OPC), a material whose production emits an estimated 8%-10% of the world's greenhouse gases. Cemfree is composed of granulated blast-furnace slag mixed with a 5% alkali activator, resulting in a 77% reduction in carbon emissions.

Integrating BIM models with carbon data would create a dashboard look into the carbon impacts of utilising a full range of materials in the supply chain beyond concrete. Quick estimates based on iterative models would point to the areas most ripe for quick improvements. With continual improvements to engineering design models, outcomes begin to improve, creating step change improvements in how we think about carbon in the full range of projects.

In summary, the whole life cycle of engineering design decisions would be impacted. We cannot do this in isolation. The entire supply chain, from raw materials production, component manufacturing, transportation and logistics, engineering design, construction, operations and maintenance to the end game of disposal and recycling at the end of design life would be impacted with an all-new emphasis on digital engineering.

BIOGRAPHY

BRIAN PALMER is a senior civil engineer for Burns & McDonnell, working from a growing office in Birmingham, U.K. He is a specialist in a number of digital and 3D design systems including Civil 3D, Autodesk Revit and Building Information Modeling (BIM) programs. He is currently leading design and modeling efforts for high-voltage electrical substation projects throughout the U.K.

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