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The Road to Zero Emissions in the AEC industry

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Introduction

Currently, the journey to zero emissions in the Architecture, Engineering and Construction (AEC) industry remains a moral imperative. As the climate emergency deepens, construction professionals will come under increasing pressure to decarbonize their operations. Government and multi-national organizations are proposing public policy and regulation, such as the Paris Agreement, that will have local and regional impacts on construction operations as soon as 2021. Current estimates show that 19% of the world's greenhouse gas emissions are from buildings and that 30-50% of every city's GHG emissions come from buildings. Therefore, a smart approach to using building data and processes is critical to achieving a future with zero emissions.

This guide looks at the carbon challenge and how construction operators can play their part in reducing emissions using Building Information Modelling (BIM).

The AEC industry and its role in the CO_2 climate emergency

No matter the source, climate experts agree – global industry presents an existential threat to planet Earth. Left unchecked, they predict greenhouse gas emissions will cause a 2ºC temperature increase that will have devastating consequences for ecosystems, humans, and society[1].

As a result of these studies, the International Panel on Climate Change (IPCC) advised that global greenhouse gas emissions must be reduced by 45% over the next ten years to contain temperature rises with a target of 1.5ºC or lower. Failure to take urgent action could lead to irreversible damage being caused to planet Earth[2].

Although every sector has a role to play in reducing carbon and greenhouse gas emissions, the AEC industry has a proportionally larger responsibility. The United Nations Environment Program reports that the buildings and construction sector accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide (CO_2) emissions in 2018. Just 11% of that figure was generated during the manufacture of building materials[3].

Concerningly, AEC carbon emissions continue to climb, up 2% from 2017 to 2018[4]. This is not entirely unexpected when considering growth in demand for new buildings. The global population living in urban areas is predicted to grow by 1.5 million people every week – or an additional 2.5 billion by 2050. By 2025 we will need an additional 1 billion new homes. And 60% of the homes required by 2050 have yet to be built[5].

Construction cannot stop – indeed, humanity needs more construction urgently. However, every future project must take greenhouse gas emissions into account, both during actual construction and over the lifetime of the building. Already adopted by many city and sub-national governments, the global 'Advancing Zero' project calls for CO_2 emissions in the built environment to be phased out by 2040[6]. Moving forward, carbon reduction efforts will have to address both new construction and existing buildings.

As technologies and concepts mature, Net Zero Energy Building (NZEB) principles can be applied to most types of projects – residential, industrial, and commercial – new build, or retrofit. The building sector will play a pivotal role in achieving Advancing Zero goals. It will also be instrumental in reducing dependence on fossil fuel-derived energy by increasing the use of on-site and off-site renewable energy sources, both during construction and over the lifetime of each building.

Energy efficiency

Although there is some confusion as to the exact definition of NZEB, there is consensus that minimizing energy use through efficient building design is an essential aspect. Increasing overall energy efficiency remains the most cost-effective strategy, while also delivering the greatest returns on investment. Advanced energy analysis tools will allow design teams to optimize and maximize efficiency opportunities in advance, helping to minimize the costs of associated renewable energy projects.

There are plenty of opportunities available to create demand-side efficiencies, including high-performance envelopes, air barrier systems, daylighting, sun control and shading devices, careful selection of windows and glazing, passive solar heating, natural ventilation, and water conservation.

With overall energy demand reduced, energy-efficient equipment like electric lighting controls, high-performance HVAC, and geothermal heat pumps become a more viable source of supply. Energy strategies such as combined heat and power systems, fuel cells, and microturbines can still convert traditional fossil fuels into heat and light, but in a far more efficient way.

Building efficiency into every design will help to achieve NZEB goals.

The road to zero emissions

Although reducing CO_2 emissions on construction sites has both global and local benefits, differing national requirements and energy provisions will greatly affect the efforts of AEC firms. Construction processes will need to be updated and amended to address these local factors, enabling the use of fossil-free and zero-emission technologies and services wherever possible.

In order to meet the demands of the Paris Agreement, there will need to be a greater emphasis on building sustainable urban infrastructure.

What can we do about it?

1. Retire diesel-powered machinery

Diesel remains the primary source of energy for machinery, creating a considerable proportion of the greenhouse gases released during construction. Working with the C40 group of cities, Oslo in Norway estimates that 7% of all CO_2 emissions within their municipal boundaries are created as a result of construction. When averaged out with the other 39 member cities, this could mean as much as 240 MT are being emitted by each city every year[7].

Choosing zero-emission equipment will have an immediate positive effect. As well as reducing CO_2 release, newer construction machinery helps to improve local air quality and reduce noise pollution. As a result, there will be fewer negative health effects in the immediate environs of the project site.

It may be possible to convert existing machinery to biodiesel at minimal additional cost, providing a quick win for carbon reduction efforts. In the future, expect to see increased use of electrical construction machinery that eschews the need for fuel at all. Many will be cable-powered initially, but as battery technology improves (and costs fall), almost every item of machinery will be electrified.

Transportation of materials and waste to and from construction sites is also an ongoing concern. Heavy road vehicles are typically reliant on diesel for fuel, adding to the overall emissions of the project. Battery or hydrogen powered vehicles remain relatively rare in industrial applications, although there are some examples currently in operation. Volvo and Tesla have already announced they are to bring battery electric trucks to market in near future.

Renewable fuels like HVO (hydrogenated vegetable oil), biogas and bioethanol offer a viable alternative to diesel that will help to reduce greenhouse gas emissions. Further reductions may be achieved through improved logistical planning, helping to minimize journeys or to ensure the shortest, most-efficient routes are chosen for every trip.

The construction industry also needs to consider the end-of-life provisions for each structure because construction and demolition generate significant waste. To reduce environmental impact, they will need to select suppliers who develop products that can be recycled after demolition, and who use those recycled materials as the basis for new products.

2. Renewable energy generation

Decreasing fossil fuel use over the lifetime of a property will involve switching to alternative energy sources. Renewables like biomass, geothermal heat, sunlight, water, and wind all offer potential permanent power sources that replenish themselves naturally.

Careful consideration will need to be given to choosing the correct source for each project – solar can only generate power for part of the day for instance. Pairing these sources with energy storage solutions will ensure that power is available around the clock. In reality, buildings will need a combination of renewable and baseload sources (biomass, hydropower, geothermal etc.) to totally displace fossil fuels.

Priority should be given to renewable approaches that are readily available, replicable, and most cost-effective. System maintenance must also be given consideration over time. Lifecycle cost analysis should be used to evaluate the economic merits of various systems over their usable lifetimes[8].

As an enabler of efficiency and sustainability, Hexagon's solutions are used to secure and streamline energy production sites all over the world. One of the more challenging situations is the surveying of windmill constructions at sea, a harsh environment with extreme demands on sub-millimeter precision and safety, not the least during the construction phase.

A combination of Hexagon solutions was used in one such project in the North Sea outside of Netherlands to secure the verticality of windmill piles. Imaging capabilities and metrology software were used to accurately measure location and to monitor accelerations and vibrations through real-time video and data transfer to a remote control room.

This enables the wind farm to operate safely for many years to come, thus increasing its operational time and the output of clean, renewable energy to suppliers in Europe[9].

3. Deploy mains electricity earlier

Increased adoption of electrical vehicles and machinery will require a mains electricity connection at the construction site – often in the early stages as the site is being prepared. Providing a power grid connection will almost certainly extend the project timescales, but those delays are unavoidable. Early planning will also need to consider the provision and location of charging points, ensuring they are properly placed to support operations.

As an early adopter of electrical transportation, Norway serves as a reference for AEC operators elsewhere in the world. One of the most significant challenges to date has been the availability of grid connectivity – in some cases, projects have required grid upgrades in order to proceed[10].

To maintain productivity, AEC operators need to investigate the use of zero-emission equipment (preferably battery or hydrogen-powered) until the electricity grid connection can be established. As the project progresses and a mains connection (natural gas, electric etc.) is established, on-site generation capabilities may exceed the building's energy requirements. Where this happens, excess energy should be fed back into the distribution grid. This surplus can be used to offset excess demand at some later date, helping achieve NZEB – particularly given the current limitations and cost of energy storage technologies.

4. Better power distribution

Smart cities are reliant on sophisticated technology to operate, drawing large amounts of energy in order to keep infrastructure running. Even in the newest cities, most of the energy drawn from the grid still comes from fossil fuel sources, contributing to greenhouse gas (GHG) emissions[11].

Change at the grid level is key to meeting GHG reduction targets and will be driven by the energy supply sector itself. In the near future, we will see the development of smart grids that support the move towards zero-emission renewable energy technologies.

Smart grids are designed to be more economical, reliable, sustainable, and secure. The grid also communicates with the various technologies connected to it, enabling the delivery of a more personalized service to individual customers. The smart city grid is capable of distributing broadband and managing road traffic to optimize performance. By collecting data in real-time, town planners, municipal services, and councils will be better able to manage operations and build for the future.

On an environmental level, a smart grid will manage energy use to reduce carbon and prioritize renewable energy to achieve GHG reduction goals. It will also improve economic efficiency and improve overall power distribution to the city.

5. Production of materials

Traditional industrial development models are quickly becoming dated and ineffective, unable to keep pace with change in other sectors. This has started the Fourth Industrial Revolution as manufacturers embrace emerging technologies - internet of things, artificial intelligence, robotics, additive manufacturing – to help them develop new, viable production techniques.

In order to compete on the world stage, countries (and manufacturers themselves) will need to identify the capabilities, factors, and institutions needed to benefit from these developments. They will then need to facilitate the structural changes that allow them to capitalize. The new technological operating model offers opportunities for early adopters to leapfrog incumbent manufacturers and establish a larger global market share.

6. Supply chain and logistics

Logistics is a significant source of emissions – and probably will be for some time to come. Manufacturers are working hard to develop zero-emission vehicles, but with no viable vessels available yet, attention must be shifted to reducing GHGs in other ways.

Rather than waiting for vehicles to become available, the logistics industry (and its construction customers) must take immediate steps to develop practical, system-level approaches to reducing emissions across supply chains. Initially, this will involve improving the efficiency of operations and fuel use, coupled with supply chain optimization.

Further efficiency gains will come from applying data insights to optimize supply chains across modes. In many markets, 40% of trucks on the road are empty – intelligent planning could be used to consolidate loads and journeys, putting this excess space to use[12].

7. On-site workforce and construction planning

Reaching net-zero in the construction industry is an ambitious – but achievable – goal. However, fully decarbonizing buildings across their whole lifecycle requires a clear policy. Factors to consider include passive building design, material efficiency, low-carbon materials, efficient building envelope measures, and highly efficient lighting and appliances.

Because these issues require industry-wide change, policy needs to be set at both national and local levels, in collaboration with stakeholders in the construction industry: urban planners, architects, developers, investors, construction companies and utility companies. Taking a joined-up approach to decarbonizing buildings will yield significant benefits beyond a reduction in emissions; new opportunities in emerging markets will be worth approximately $24.7 trillion by 2030[13].

With policies defined, construction companies can apply those guidelines to the entire building lifecycle, ensuing net zero throughout.

8. BIM

Specialized Building Information Modelling (BIM) tools have given AEC operators a head-start in terms of data-driven operations and decision-making – particularly in countries like the UK where it has become a contractual obligation when working on government projects[14]. ERP-like functionality improves project planning and execution to deliver cost savings – as well as ensuring emission reduction targets are met.

The global pandemic has changed the way industry works – and highlighted many of the failings of existing processes. Design problems, operational inefficiencies and outdated techniques are all hindering construction efforts – and that's before environmental considerations.

Demand for new buildings, particularly housing, has not fallen – but productivity certainly has. Efforts to prevent viral spread using social distancing have reduced the number of workers permitted on site to just 60% of normal levels[15]. Unsurprisingly, half of all businesses have reported a drop in productivity[16]. Controls on international travel may further exacerbate the productivity shortfall by preventing migrant workers from entering the country.

These limitations and challenges have helped to drive BIM adoption during the lockdown. Unable to meet in person, stakeholders have used digital and virtual environments to keep projects moving forwards.

Having proven its worth, AEC operators will look to integrate smart technologies like AI and big data analytics to enhance and automate the planning and design process. Digital designs can be virtualized, revised, and enhanced then tested to verify viability, cost, impact on the local environment, and to estimate whether the building will meet net zero targets. Accurate, strategic decisions can be taken earlier in the project, speeding up the process. Building out standardized plans will also assist with component manufacture. Accurate pre-specified plans can be produced in mass manufacturing factories which are fast and efficient, and more cost-effective.

How adopting BIM accelerates your journey to zero emissions?

Industries like aerospace, automotive and aviation have undergone a significant paradigm shift in recent years in an effort to improve the quality of service offered to customers. Improving their use of data and technology allows them to increase productivity, reduce waste, and align operations towards shared strategic goals.

The AEC sector remains bound by decades-old processes that increase waste and fragmentation – at odds with the operational agility demanded by modern businesses in other industries. According to MGI's digitization index, the AEC industry ranks last in the USA and second-last in Europe[17].

By centralizing construction project data, AEC firms are able to make more informed strategic decisions. There is also the potential to capture more data from smart sensors automatically, such as power and heating metrics, providing accurate insights into project progress. Better utilization of this data and analytics is particularly important in early project decision making, which has a huge influence on the downstream lifecycle stages[18].

With the right system in place, AEC operators can map out the entire lifecycle – and its CO_2 impact – in the very earliest stages of the pre-planning process. BIM provides a broader and deeper understanding of infrastructure in the larger context of the built and natural environments by integrating information and content. Loaded with the right data, project managers can use real-world traffic data to accurately estimate the environmental impact of traffic on and around the site. They are also better equipped to consider natural factors like flooding that could affect location, orientation, and construction materials used.

More than simply a 3D model, BIM is used to collate all data relating to the project. Similar to the digital twin technology, BIM is used to model every detail of the project during the design phase. The model is then updated throughout the lifespan of each building, even to the point of deconstruction. There is also the potential to deploy smart sensors to capture important metrics, and autonomous solutions capable of acting on that information without manual intervention.

> **"BIM provides a broader and deeper understanding of infrastructure in the larger context of the built and natural environments by integrating information and content"**

With accurate modeling, architects are able to accurately calculate the impact of every phase of construction, including the ability to estimate carbon emitted by machinery and traffic on site. Designers are also able to calculate the lifetime environmental impact of the building and make adjustments that will help them achieve the goal of net zero emissions. With BIM, it is possible to achieve zero emissions for the entire lifespan of each building, not just to the point of construction completion.

Obviously, BIM is not simply a tool for reducing CO_2; the 2019 Geospatial Market in the AEC Industry report notes some significant financial gains too. With BIM it is possible to realize construction workflow efficiency gains of between 10% and 20% for instance, while construction projects complete 14% faster too19. One study published by the University of Florida suggests BIM delivers a 36.7% return on investment[20].

In order to reduce waste (and associated emissions) the AEC industry needs to form stronger, closer partnerships. The ability to work from a central system allows every stakeholder to work from the same data in real-time – and the BIM system is a natural choice to host that data. Because BIM data is passed to the operator of the building after construction, it is a critical point of reference for the various partners involved over the years. The result is a constantly updated record of the carbon footprint generated by each building.

Importantly, sharing BIM data between designers, contractors, and owners allows every party to share knowledge and experience, and to contribute potential improvements. It also allows one to accurately calculate the potential environmental impact of each improvement.

How does Hexagon support BIM in AEC?

There is a persistent industry perception that BIM is only applicable to the largest construction projects. Although BIM can (and is) used to build smart cities, the reality is that centralizing project related data with BIM has the potential to improve every project, even if the system is not used for every phase of the lifecycle.

To this end, Hexagon offers a unique and comprehensive portfolio of sensors, software, and autonomous solutions. These systems have been deployed globally in both urban and production ecosystems. By putting data to work, Hexagon's smart solutions portfolio empowers increasingly autonomous, connected ecosystems – and ongoing reduction of CO_2 emissions.

Hexagon solutions can be deployed to offer BIM capabilities in two key segments:

Smart Buildings and Infrastructure projects that are optimized to reduce rework and build to plan — on time and on budget — while protecting human, environmental and material resources throughout the life of the asset. For heavy construction projects, Hexagon also offers building and surveying capabilities.

Smart Cities and Nations ensure governments, industry, and citizens work together to build safe and vibrant communities that promise the highest quality of life and sustainable economic and environmental vitality. Data can be collected and actioned for a broad range of applications including public safety, utilities, transportation, land management, defense & intelligence, and geospatial content.

With advanced visualization and enterprise integration, Hexagon has the tools and capabilities required to build a customized BIM platform that delivers. To learn more about Hexagon PPM and how we can help your business achieve its ambitious net zero emissions goals, please get in touch.

For further information, please visit our website.

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Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's PPM division empowers its clients to transform unstructured information into a smart digital asset to visualize, build and manage structures and facilities of all complexities, ensuring safe and efficient operation throughout the entire lifecycle.

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