The Why and the What of Digital Twin Building Performance And Sustainability

An Owner's Perspective

A Digital Twin Consortium User Guide

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1 CONTEXT

The Digital Twin Consortium's AECO Tiger Team published a white paper on 17 February 2023 with the title *"*Decarbonizing the Built World: A Call to Action.[1]*"*

The Team started with a vision to "author a series of user guides to assist an owner or occupier-led implementation of the digital twin-related capabilities that are required in supporting overall new or existing building decarbonization throughout the lifecycle.*"*

Through workshops with experts in the field, this was resolved into five questions:

1. Why should we do this? What are the objectives for sustainability, efficiency, resiliency, health, risk mitigation, performance, reliability, accountability? (outcomes)
2. Who are the stakeholders and how should they participate? (who and when)
3. What is the recommended building lifecycle? (requirements/content)
4. How does the project delivery process need to be changed? (physical process)
5. How does the Digital Thread need to be enabled? (virtual process)

So much material was developed that it was decided to publish it separately.

This paper addresses Question 1, "Why should we do this?"

2 INTRODUCTION

The topic of global climate change, decarbonization, net-zero, sustainability and environmental, social and governance + health (ESG+H) has increasingly become commonplace and frequently discussed across company portfolios, both public and private sectors.

Centrica Business Energy Tracker 2022[2] found that energy is a board level concern for 8 out of 10 businesses now. But do senior executives really know what targets they are supposed to hit, and more importantly, do they know how to get there?

A recent Institute of Workplace and Facilities Management survey[3] shows that while companies have strong ambitions, they are lacking the data and knowledge necessary to implement a detailed program to map and reduce their emissions. Their research found that only 35% of firms with net-zero targets believe they have access to all the emissions data they need to track progress. Furthermore, 12% of the firms said they had no baseline figure. If you can't measure it, you can't reduce it. This often paralyzes an organization on the roadmap toward achieving decarbonization and ESG+H commitment goals.

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[1] *https://www.digitaltwinconsortium.org/decarbonizing-the-built-world-a-call-to-action-download-form/*

[2] *https://www.centrica.com/investors/results-centre/annual-report-2022/our-businesses/*

[3] *https://www.iwfm.org.uk/*

There are significant investments being made in this space, but are they investing because they are trying to make a difference or are they investing for publicity? Are they blindly committing to bold actions without really understanding what it takes to achieve them? What about the risk and backlash that comes from not realizing their stated goals? Perhaps it is a combination of the above.

3 CONFRONTING THE DISCONNECT OF THE DIGITAL CHASM

The United Nations Environment Programme's recent Emissions Gap Report 2022[4] concluded "there has been very limited progress in reducing the immense Greenhouse Gas (GHG) emissions gap for 2030."

Typically, many real estate owners resist change, instead favoring short-term profit, stock prices, and company valuation. Prioritizing decarbonization strategies is a big strategy shift, but as with any long-term strategy, there are tradeoffs in the short-term. To build programs for decarbonization, some of the common questions that owners ask to try and resolve these deep voids, for example, include the following:

- How much is decarbonization going to cost me?
- What is the ROI, both investment on facilities as well as occupants?
- Why should I bother now, verses making it someone else's problem to resolve downstream?
- Should the owner or tenant pay the potential cost premium, or both?
- Who's going to validate any of my capital investment and how is it going to impact my operational expenses?
- How does any of this fit into my corporate ESG+H planning, or does it?
- If I do decide to comply with certain ESG+H related metrics, how do I validate that my asset is performing to compliance?

These are all valid questions, but asking the question versus simply implementing roadmaps, using tired repurposed strategies and creating static models to answer those questions are entirely different things.

Let's address just the first of these questions: How much is decarbonization going to cost me? That is not the right question to be asking. Conversely, the question should read "what is it going to cost me if *I do not* invest in decarbonization?" Real Estate is inherently exposed to high climate risk, with the potential risk value estimated at over USD $5 trillion as cited in Beyond The Business Case, a report published by the World Green Building Council.[5]

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[4] *https://www.unep.org/resources/emissions-gap-report-2022*

[5] *https://worldgbc.org/beyond-the-business-case/*

Many owners have set aggressive ESG+H, decarbonization, net-zero and sustainability plans. For example, these targets typically include goal setting such as achieving net-zero by 2030, erasing carbon footprint by 2050,[6] or decarbonizing across global portfolios by region by specific calendar years.

This begs the question of whether owners are being aggressive enough to achieve such targets? More importantly, who is validating that any of the strategies are the right ones to be targeting and how are owners forecasting compliance to those standards? The easy answer – the vast majority are not.

This becomes a considerable opportunity.

Innovations are driven by need and there is a drastic need to intervene in current traditional thinking to introduce and adopt new aggressive strategies to achieve these targets. Building codes and existing ways of financing, planning, designing, constructing and operating buildings need to change.

Code compliance is the bare minimum before a building is considered non-compliant or illegal. It is the lowest benchmark to pass through building departments. This simply is not enough to address the impeding climate change issues at risk and certainly does not follow a consistent decarbonization strategy. Owners need to be proactive to achieve such goals.

4 DESIGN WITH THE END IN MIND: PRESCRIPTIVE VERSUS PERFORMANCE METRICS

As mentioned in the Digital Twin Consortium white paper Decarbonizing The Built World: A Call To Action[7], which accompanies this User Guide, the built environment is held accountable for roughly 41% of global GHG emissions, either through construction material extraction and production or building operations. This is from the initial resources used in materials and installation, but more importantly, in the operational phases due to heating, cooling, lighting and facility maintenance.

According to the IPCC's Climate Change 2022 assessment report, in the United States, the construction and building sector was responsible for 36% of final energy use and 39% of energy and process-related CO_2 emissions in 2018. Of particular interest, steel, concrete and glass alone contributed 11% of this amount.[8]

The building delivery process is set up in a siloed prescriptive approach to planning, design, construction and handover into operations. It is a fragmented system where each stakeholder (e.g. architect, engineer, contractor, operator) is mainly concerned with their own scope and

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[6] *https://www.accenture.com/us-en/insights/sustainability/reaching-net-zero-by-2050*

[7] *https://www.digitaltwinconsortium.org/decarbonizing-the-built-world-a-call-to-action-download-form/*

[8] *https://www.ipcc.ch/report/ar6/wg2/*

their legally binding contracts – it's the short game and typically not considered as part of their business strategy of looking long-term.

This misses the mark of designing with the end in mind entirely. It is a disjointed stakeholder engagement that leads to inefficiencies, lack of design consistency, disconnect with building handover and associated risks where the operational teams simply inherit whatever building is delivered to them without having had the opportunity to bring the operational element into the front of the design process.

A recommended alternative to this traditional approach is deploying the process of the Digital Building Lifecycle (DBL), bringing together enhanced consistency and implementation throughout the asset's useful life and beyond. If the marketplace can bring together all stakeholders at the beginning of a project development to "design with the end in mind", it would set an entirely different perspective of confirming that the performance of the asset is going to be maximized in a meaningful way. This is where leveraging the performance-based digital twin comes into the equation.

A virtual replica of a physical asset, the digital twin provides the foundation of understanding of how an asset will respond and behave like its real-world counterpart. The digital twin delivers data-driven information needed to uncover significant energy, carbon, capital and operational savings throughout an asset's useful lifecycle. An asset could be defined as everything from a piece of mechanical equipment to a building, scaled up to a campus, city masterplan or global portfolio. The digital twin becomes the common vehicle to connect the various phases of an asset throughout the Digital Building Lifecycle.

5 DEFINING THE DIGITAL BUILDING LIFECYCLE

It is fundamental to fully understand the purpose of the Digital Building Lifecycle (DBL) for the purpose of this conversation. The foundational element for activating the DBL is based upon what we reference as the "Three Cs":

1. **Communicate:** The elimination of paper and paper-based systems through digitization allows our communication to be more effective and delivered via users' system of choice. Addressing this legacy issue is referred to as the elimination of yesterday's problems.

2. **Collaborate:** Communication both enables and drives collaboration. Implementing the DBL consolidates that collaboration and drives the need to rethink project delivery frameworks. The process to enable a digital thread to support the DBL is referred to as today's problem.

3. **Correlate:** When all parts are coordinated, process standardization produces clean data that, with context, provides information; and with learning can be transformed into knowledge and applied as competitive advantages. Tomorrow's problems will be solved

through prediction and closed loop analysis. This sets up the vehicle for proactive verses reactive solutioning.

These foundations set up the Common Data Environment (CDE) to establish a shared platform of which all data elements, either historical or simulated, can speak to one another in a meaningful way, connecting components that human intervention alone cannot. The DBL is based upon this principle so there is a lifecycle that provides meaning, intelligence and actionable tasks to create tangible results.

Putting this into practice, the DBL process is essential to confirm building performance successes and ensure on-going improvements can be met. Delivering an asset that is fully connected drives consistency throughout the development of that asset to ensure optimal performance through the Communicate, Collaborate and Correlate data integration phases.

The critical connection of these key points, which we refer to as the digital thread, brings a project's lifecycle together using a common nomenclature, data standardization and cyclical processes in a meaningful, results-driven way. This sets up the framework to deploy a closed-loop analysis for continuous improvement.

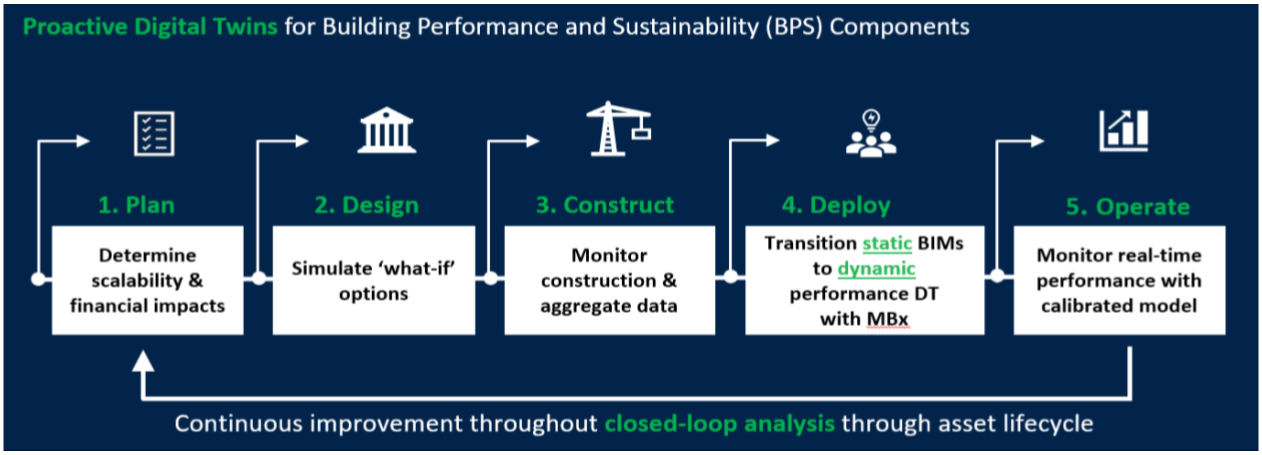


Figure 5-1: Digital Building Lifecycle diagram. *(Source: Gafcon Digital.)*

The DBL illustration in Figure 5-1 shows the connection between the following phases:

1. **Plan:** Creating a digital twin strategy to define goals, determine scalability, roadmap various design and construction options and fully delineate the financial and potential risk impacts, both upstream and downstream. This crucial step should involve all stakeholders but fundamentally should involve finance, design, operations and owner teams.
2. **Design:** Putting the digital twin plan into action during the design phase is key to establishing a baseline using performance based Energy Conservation Measures (ECMs) to simulate various options virtually prior to investment. This step is typically the architects and engineers in a fragmented project delivery process, however, needs to involve the construction, operational and risk teams to account for the project lifecycle.

3. **Construct:** Bringing the intelligence of the planning and design phases into a tangible physical asset by using the virtual asset and digital twin to monitor construction and continually aggregate data to include value engineering exercises, determine likely downstream impacts and forecast ROIs of various construction related tasks. This phase usually only involves the construction teams, subcontractors and commissioning agents but typically misses the involvement of the owner/operator which can lead to mismanaged expectations.

4. **Deploy:** Bridging the connection between any static physical asset and the dynamic digital asset is arguably one of the most critical aspects of using the digital twin to calibrate and conduct model-based commissioning to confirm performance matches design intention with operational compliance. For many, this step is taken lightly and is not fully thought through. This phase deserves additional attention from all project stakeholders to ensure finance, design, construction and operational teams are all aligned. Issues can sometimes become the question of who is responsible for this phase and what is their liability or risk for missing targets or preset commitments.

5. **Operate:** Once the project moves into operation, the built asset will age for the next 50-100+ years suggesting that upon day one, the building will only degrade over time thus performance will erode from its design specification during actual operations. On-going digital twin models and physical asset calibration will need to be addressed on regular intervals to avoid degradation to optimize performance over time.

   Traditionally, many built assets will be handed over into a third-party Integrated Facilities Management (IFM) team who have not even been part of the project development, which immediately sets up a disconnect.

   Alternatively, the facility could be owner-operated with a building management team, however, they have not necessarily been part of the project lifecycle, so they have limited perspective, if any, into ensuring the project is optimized over time. It is critical that this phase continuously validates that the physical asset is aligned with the digital asset with a regular, real-time cadence.

6 IDENTIFYING THE EXTERNAL DRIVERS THAT IMPACT OWNERS AND OCCUPIERS

Buildings have been around for centuries – without the use of digital twins. What have been the most recent developments that are bringing digital twin conversations to the table in a more aggressive sense of urgency? Science targets, data science, financial investments, societal awareness, human impacts, risk mitigation and climate emergency are all strong calls to action for technology such as digital twins to disrupt the industry.

Science proves that our climate is warming, sea levels are rising, ice shelves are melting, GHG impacts are increasing and provides undeniable evidence that our built environment has a significant impact on our aging planet. This movement has led to a greater awareness and acceleration in the understanding of the importance of Building Performance and Sustainability (BPS). We need to proactively decarbonize using real-time dynamic data, not sluggishly react to static data.

Figure 6-1 is an example of a decarbonization roadmap – powered by a physics-based digital twin model – used for a potential owner that has forecasted certain energy conservation measure or ECMs into 2030 and 2050, road mapping several action plans. The model can be used to simulate various ECM options, providing intelligence behind each decision, running associated ROI models, determining which financial scenarios will have the biggest impact and risk assessment measures to prioritize accordingly.

Most importantly, this real-time simulation engine provides a clear path and roadmap for an owner to make informed decisions on when, where and how to implement various ECMs. By using the dynamic digital twin model, a user can play with what-if solutioning and run cost benefit analysis to understand optimal investment strategies.

Additionally, this model can forecast and continually reassess progress to ensure the owner is on the right trajectory. When the model identifies inaccuracies or potential red flags, it provides the data reports for the owner teams to make interventions to recalibrate based upon their priorities to ensure alignment with their decarbonization plan and ensure expectations are realistic and attainable.

This application provides greater confidence that owners are on the right path, gives finance teams greater assurance in investment decisions, de-risks the numbers of variables and gives the "C-suite" science-backed data they can rely on – not simply making empty promises.

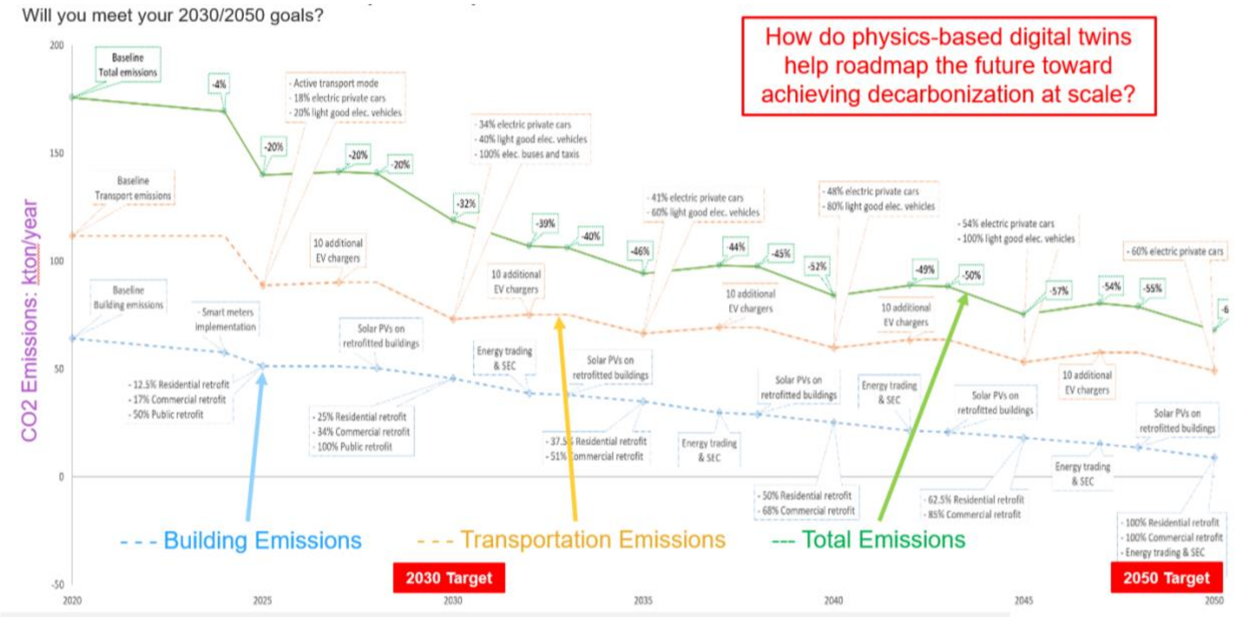


Figure 6-1: Example of a decarbonization roadmap (IES, Ltd.).

7 GREENHOUSE GASES DEFINITIONS AND GROUPINGS

Greenhouse Gas (GHG) has become a very hot topic and through building performance and simulation, the industry is working toward energy efficiency and decarbonization. To understand the fundamental elements of GHG, there are six main types of GHG, carbon dioxide or CO_2 being the most impactful, so for the purposes of this paper we will primarily focus on CO_2.

To better understand the breakdown of GHG scopes and categorization, the following need to be understood:

Scope 1 emissions:

Emission sources that an organization owns or controls directly within their own financial operations. The best example of this would be the usage and burning of fuel in a fleet of vehicles that are gas powered, (*note: electrically powered vehicles would be exempt from this as it would fall into Scope 2 to charge and power those vehicles).

Scope 2 emissions:

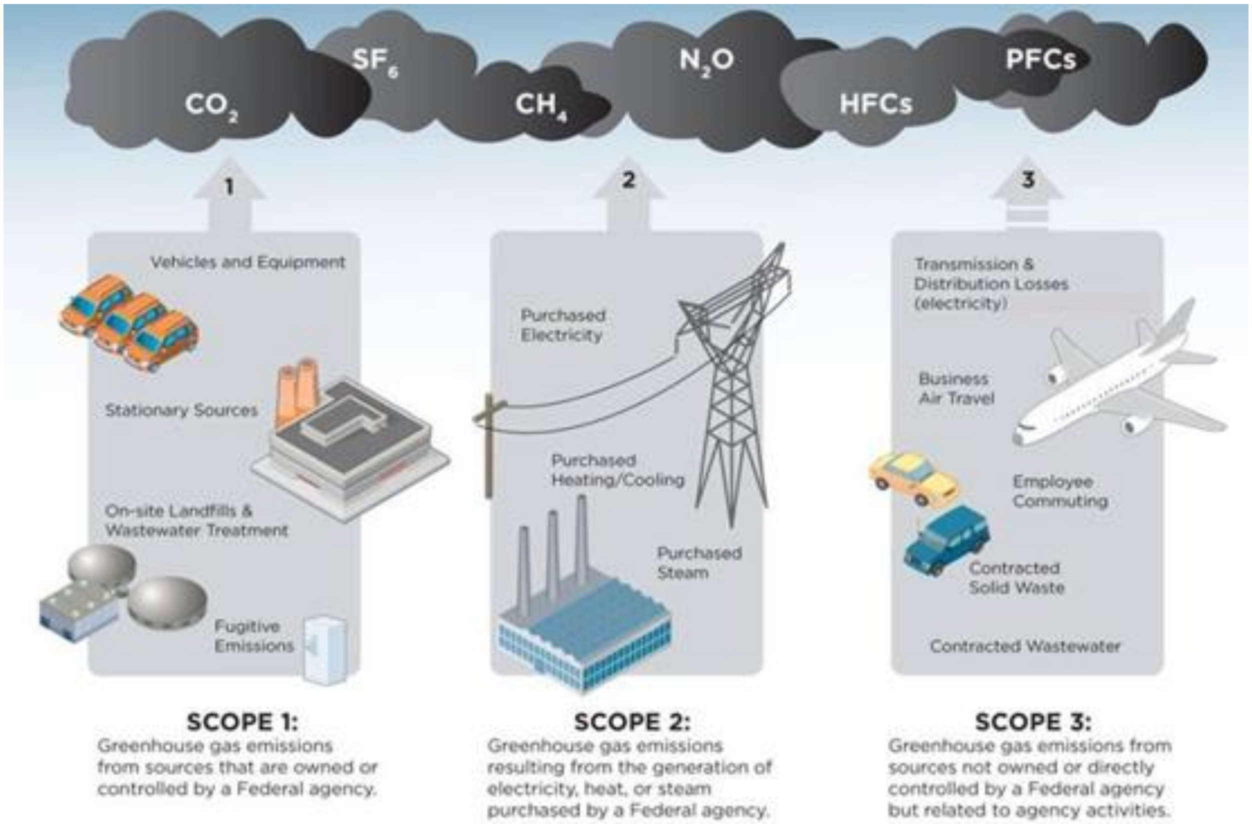
Emissions that a company causes indirectly through the energy it purchases and the GHG it produces along usage patterns. Examples of this would include emissions from the generation of the electricity that you use to operate a facility, including sourcing from power plants, distribution networks and energizing infrastructure.

Scope 3 emissions:

Emissions that are not produced by the company itself. Scope 3 emissions include all sources not within the scope 1 and 2 boundaries and not as the result of activities from assets owned or controlled by them. Scope 3 focuses on key emissions as a root cause that is indirectly responsible for all GHG impacts both up and down its value chain.

This includes the complicated methods of establishing baselines that includes embodied energy, embodied carbon, Lifecycle Analysis (LCA) and total GHG impacts not captured from Scopes 1 and 2 above. An example of this would be the buying, usage and disposal of products from suppliers on a project, or the amount of GHG associated with producing a cubic yard of concrete or steel I-beam.

Figure 7-1 helps visually tell the story of the upstream and downstream impacts of GHG Scopes 1, 2 and 3.



SCOPE 1: Greenhouse gas emissions from sources that are owned or controlled by a Federal agency.

SCOPE 2: Greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency.

SCOPE 3: Greenhouse gas emissions from sources not owned or directly controlled by a Federal agency but related to agency activities.

Figure 7-1: Common sources of Federal GHG emissions.

8 ENERGY CONSUMPTION & EFFICIENCY

Energy is the largest contributor to global GHG impacts. Generation, transmission, distribution and storage are key aspects for determining how best to reduce climate and GHG impacts and therefore encompass the largest area of concern and necessary investments. Reduction and optimization are the primary focus areas. The more energy intense a process, material or program is, the greater the carbon footprint is going to be, resulting in the largest global climate influence as compared to other Key Performance Indicators (KPIs).

Therefore, one of the best strategies is to first reduce energy consumption as much as possible by using the digital twin as a testbed for establishing how the building is going to perform before it is built or retrofitted. By using this strategy, the stakeholders are able to play with a number of variables housed within the digital twin to determine the optimal design solution and invest accordingly. Utilizing such processes drastically reduces the amount of energy inefficiencies, waste and overall consumption. This strategy lowers the requirements needed to offset to become carbon neutral or climate positive.

Renewables

Renewables are a key component to the decarbonization equation. Sources such as solar PV, solar thermal, wind, tidal flux and even nuclear are considered clean sources that generate energy to help electrify the environments we occupy. Energy reduction is typically the first step toward decarbonization, however, the benefits that come from renewable energy sources provide us with the ability to achieve net-zero energy equations to reduce our reliance on dirty energy sources.

This helps offset the GHG impacts that come from operating our built environment. The digital twin can take these sources into consideration and model what types of renewables are most appropriate based on location, where to place them to maximize their utilization, when to rely on them and how best to navigate the overall energy performance equation of an asset. Without leveraging digital twin tools, the process becomes incredibly challenging to succinctly model a holistic solution with all the complex variances of the built environment.

Without appropriate modelling capabilities, there is a significant amount of guesswork that goes into balancing the energy efficiency equation. The performance-based digital twin helps drastically reduce the guesswork to ensure the right decisions are made throughout the DBL and ensure an owner is on track to achieving their ESG+H goals.

9 WATER SOURCING & USAGE

The topic of water can become complicated when it comes to the impacts of building performance and sustainability and greater decarbonization goals. Water is often forgotten when most stakeholders are so focused on energy reduction and the impacts of energy use, generation, transmission and storage. Also, with water being a finite resource, the impacts of climate change, overpopulation, outdated operational controls and aging infrastructure on wastewater increases the need to improve utilization.

To better understand the types of water for this discussion, they are broken down into potable, gray and black water. As a quick example of this, a summary of each is highlighted below:

Potable Water

The type of water that comes from a tap water source typically provided by municipalities distributing clean, drinkable water that meets certain code requirements based on PPM, or parts per million. Different regions of the globe have varied degrees of PPM requirements based on regulation, water sourcing, filtration facilities and mass distribution.

Gray Water

The type of sourcing water that is all the water collected from rainwater collection systems, shower drains and bathroom sinks – not toilets. Gray water has some bacteria, but it can be filtered and reused in gardens or lawns, if designed properly. It can also be used to transport black water as needed to move sewage or other solids through pipelines rather than using fresh potable water sources.

Black Water

This type of water contains human waste, biomedical waste or any other unclean source and is unsafe and not treatable without some sort of chemical filtration and molecular decomposition. This source is traditionally water that is treated by a local municipal waste and sewage treatment facility if on the main grid. For commercial scale buildings in urban areas, potable and gray water sourcing can be used for various applications, however, black water is a direct connection to main city network for processing and disposal.

Let us not forget the impact water has on energy utilization. To process, treat, filter, transport, store, distribute and pump water throughout a grid network, it consumes a vast amount of energy which then dovetails into an owner’s overall decarbonization strategy. Therefore, optimizing water systems and utilization has a major impact on energy use which directly impacts GHG levels.

The digital twin can be connected to the application of water aspects which can be quantified and coordinated at a systemwide level to significantly increase the performance of the built environment in reducing both energy and water metrics simultaneously.

10 WASTE GENERATION

The topic of waste generation is typically addressed by various cities, counties, states or federal requirements. Waste could include all materials that are considered garbage. However, some increasingly strict policies have been put in place that include waste diversion, which have proven to be quite successful. Many municipalities require a blue bin (recyclable products), green bin (compostable, plant materials, biodegradable sources) and black bins (waste that cannot be classified for reuse and typically heads to a traditional landfill)

As part of the DBL, waste can be monitored and traced to lower landfill diversion, monitor compostable materials and streamline the recycling processes. These are KPIs that are part of every international green rating system and are required for reporting and maintaining benchmarks with the goal to improve over time which the digital twin can monitor, track and forecast for data registries.

11 AIR POLLUTION

The quality of air in the built environment has evolved over time. It has increasingly been linked to airborne viruses, human health impacts and quality of our indoor environmental quality. Traditionally urban environments have the poorest performance in this area due to vehicle usage, building exhaust and poor airflow ventilation. This leads to the conversation around air pollutants and acceptable PPM to quantify the airborne particulate density, both for indoor and outdoor environments.

There are certain ASHRAE[9] standards such as 52.2, 55 and 62.1, as well as complimentary ISO requirements that have been implemented throughout the built environment, typically governed by local code authorities. This is directly linked to increased air flow, improved ventilation and advanced air quality. Performance-based digital twins provide the toolkits to measure these PPMs through solutions such as Computation Fluid Dynamics (CFD), air stratification, heating, ventilation and air conditioning (HVAC) zoning models to understand and trace airborne particulates to identify problem areas to mitigate problems related to human health, wellness, thermal comfort and employee productivity.

With the COVID-19 pandemic, indoor air quality (IAQ) has become front and center in relation to the built environment. A digital twin is a perfect tool to leverage and understand where there may be problem zones, poor air circulation, improper pressurization, etc. Many owners or facility managers think that simply replacing an air filter with a higher rated product is all that is necessary to improve the IAQ. However, many people fail to understand that an existing legacy building with aging HVAC infrastructure might not be able to withstand the additional draw of air trespass through thicker filters.

This can lead to complete HVAC equipment overhauls which can present a large, unanticipated capital expenditure impact if not properly modeled. Not only can the digital twin help with understanding the airflow dynamics, but it can also simulate whether existing assets can handle the added pressure on equipment and what that means from an energy consumption perspective and therefore cost impacts. Again, from a holistic perspective, just like water has an energy impact, so does air quality maintenance and distribution.

The DBL and performance-based digital twin can assist in facilitating and identifying problem conditions, energy utilization and run what-if simulations so investments can be made to the right components of a building’s HVAC to plan accordingly and yield the biggest impact.

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[9] *https://www.ashrae.org/technical-resources/standards-and-guidelines*

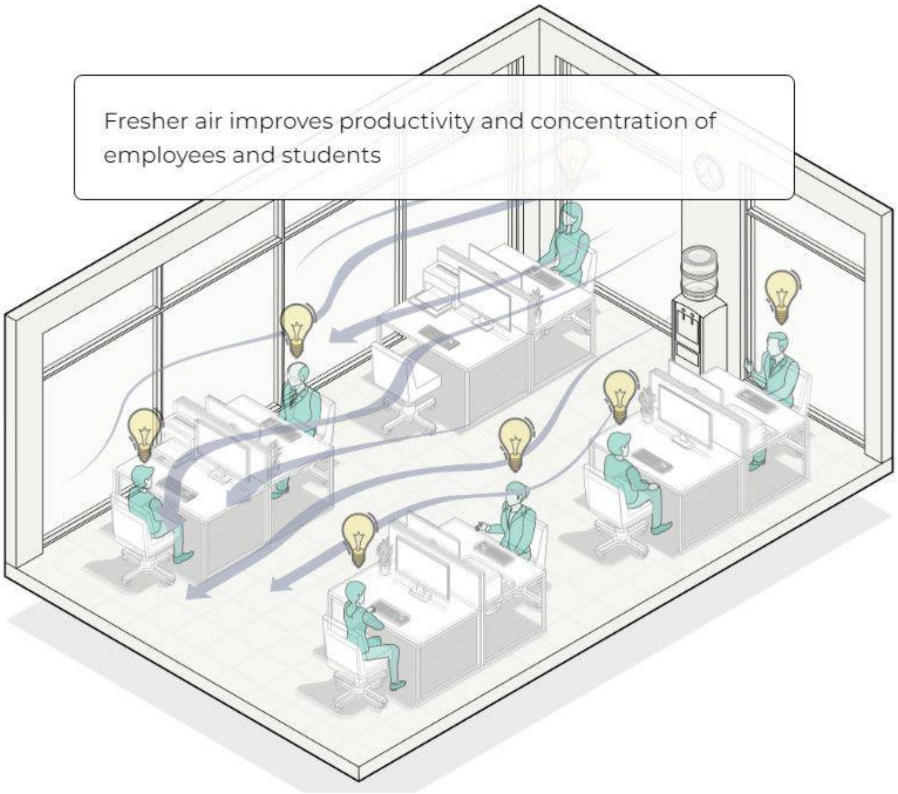

Figure 11-1: Ventilation of fresh air through an office workspace.

12 HUMAN ENGAGEMENT

The built environment is primarily needed for humans to exist and thrive. Yet traditionally the ESG conversation excludes the human aspect. This is where the “H” in ESG+H comes into play.

Too often the industry is so focused on the built environment and improving operations of energy and water that we forget that the primary reason the built environment exists is for human engagement. Every design, construction and operational decision that is made needs to keep the human aspect in mind. Yes, decarbonization is critical to our long-term existence, however, if it is at the expense of humans, then there is a debate on what is more important. That is a topic for another conversation.

In this discussion, the human element comes into play when speaking about leveraging the digital twin and DBL for maximizing performance, spatial environments and optimization for human engagement. This can be achieved through several different strategies using the performance-based digital twin for simulation of airflow as previously mentioned, lighting requirements, access to daylighting, traffic flow, office floorplan layout, etc.

There are many applications woven into the various green building rating systems, such as LEED,[10] WELL[11], and Dr. Joseph Allen's nine basic principles[12] of human optimization, within our built environment. Studies have shown increased productivity, improved human engagement, decreased health related insurance claims and a number of human related KPIs that are directly impacted by our surrounding environments.

What is the role of a digital twin related to humans? Well, much like the industry is aware of terminology around Internet of Things (IoT), the evolution of that has become what is known as Internet of Activity (IoA) and Internet of Behavior (IoB), additional layers of data related to human performance that lives within the digital twin platform. The holistic approach to performance not only weaves in the building performance but now also collects, feeds and instructs on how to design and operate with the human performance in mind.

The concept of the human digital twin is now a topic within the health industries on studying the data coming from the human elements through various portals, such as wearable devices, and shares that data with the Building Management System (BMS) so that the building can respond to the human, not the human responding to the building. This is a relatively new concept that has always been part of static design principles, however, the digital twin can now utilize real-time data from humans as another data source to optimize scenarios and adjust indoor environments accordingly.

The digital twin is the fundamental link to holistic building performance and sustainability, bringing the human into the mix which brings us to the closing of ESG+H principals.

13 CONCLUSION

Within this paper, we looked at the foundational elements necessary to optimize the performance of the built environment to help decarbonize and reduce our impact on the planet. We have discussed the value of leveraging advanced tools like performance-based digital twins as the vehicle to help achieve sustainability goals.

We have addressed the why and the what of a digital twin with the positive impacts it has in optimizing long-term building performance and sustainability. From an owner's perspective the digital twin is the vehicle to roadmap and implement the best possible solutions to lower our impact on the environment and ensure there is a sustainable future for generations to follow.

Subsequent user guides two through five mentioned in the opening of this paper will dive deeper into additional aspects only touched upon in this document. The guides are to be used as standalone references or in progression connecting the larger Digital Building Lifecycle umbrella.

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[10] *https://www.usgbc.org/leed*

[11] *https://www.wellcertified.com/*

[12] *https://9foundations.com/*

14 AUTHORS & LEGAL NOTICE

This document is a work product of the Digital Twin Consortium Building Performance Subgroup, chaired by John Turner (Gafcon Digital).

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