Real estate and environmental performance

Bridging the gap with PropTech

pi labs

Executive Summary

The dawn of the Agricultural Revolution some 11,000 years ago is an early example of humans manipulating our natural environment. In 19th century Britain, communities began attempting to restore the natural environment through reforestation, the commissioning of public green spaces, as well as governmental interventions. Nevertheless, between 2010 and 2020, it is estimated that 4.7 million hectares of net forest area was lost annually around the world. In addition, UNEP estimate that buildings are responsible for 30% of greenhouse gas emissions. Real estate and environmental sustainability are very much intertwined.

In a situation where governments are becoming more stringent on the environmental performance of buildings and other assets, a failure to foresee likely future building codes could lead to premature value write-downs. 'Stranded assets', as they are known, are estimated to risk $5-$16 trillion USD of write-downs globally. We argue that managing environmental performance through ESG (environment, social and governance) scores is limited in efficacy due to the influence of social sustainability and sustainable governance—potentially masking poor environmental performance. PropTech can offer practitioners a solution in this area by generating, aggregating, and contextualising environmental data.

Firms consume economic resources to achieve commercial outcomes. A similar perspective can be applied to a firm's interaction with social and environmental stakeholders, which gives rise to the Triple Bottom Line approach. In real estate, environmental resources can be considered as inputs and outputs. For instance, construction consumes 55% of raw materials in the UK (inputs) and produces outputs such as greenhouse gas emissions, waste heat, sewage, solid waste, and others. In the case of greenhouse gas emissions, Scopes 1,2, and 3 of a carbon inventory distinguish between emissions directly under a firm's control and those caused indirectly through purchasing energy or participating in a supply chain.

As is the case for financial reporting, data for environmental disclosure is not the same as the data needed for practitioners to manage and reduce negative environmental impacts. Given that business processes impact the environment at different times, we propose a framework including leading, real-time, and lagging indicators. Examples of leading indicators include goal setting and cost budgeting. An example of a real-time indicator is a standard operating procedure of a piece of equipment. Resource footprints such as the amount of energy or water consumed to complete a task or project are examples of lagging indicators. Putting these indicators into action through a continuous improvement approach creates a feedback loop. Real estate firms can make use of PropTech to adopt this framework—particularly with respect to the proliferation of internet of things (IoT) devices and attached software.

Decisions made today will set in motion environmental externalities far beyond 2030. Some decisions, such as structural and land use, will last for decades, if not centuries. Other decisions, such as equipment selection and fit-out renovations, will last for 5 to 15 years. At the same time, managers will be making real-time decisions, whether to streamline a construction process or efficiently operate a building. For each of the three decision durations, this paper examines three common scenarios: (i) developing bare earth, (ii) acquiring a new build, or (iii) acquiring an older, existing building. Cross-cutting technologies across all scenarios include material passports, digital twins, and continuous commissioning. The property industry is ready to improve its environmental performance; technology is now available to measure that performance, and will be increasingly ready to help to improve it.

Contents

Foreword

In 2004, the UN invited financial services groups to develop guidelines on how to better integrate environmental, social and governance issues in asset management and other financial disciplines. Nearly two decades later, ESG has come to the forefront of the corporate consciousness—but there is still a long way to go.

As we know, real estate is the world's largest asset class. This inevitably leads to its significance within the ESG conversation. In the UK, government figures indicate our homes are accountable for around 15 percent of greenhouse gas emissions alone. Once you add commercial, industrial, retail and even agricultural real estate, the ecological impact of our built environment can no longer be ignored.

It is the view of Pi Labs that PropTech is a vital ingredient to solving our global environmental challenges, and our investment philosophy reflects this. We are proud to work with entrepreneurs around the world who are committed to taking real action on some of civilisation's most pressing issues, and this report illustrates some of these entrepreneurs in action.

However, if we are to achieve the commitments made by global leaders, our rate of change will need to accelerate. This means not only investing more in sustainable innovations, but also implementing them and reiterating. This will require partnerships between the innovators and legacy industry heavyweights at a level we haven't seen before.

Faisal Butt

CEO, Pi Labs

Introduction

Since the turn of the millennium, we have seen a growing body of literature addressing the issue of climate change and wider environmental sustainability concerns. Buildings are primary perpetrators of unsustainable environmental practices, accounting for roughly 30% of greenhouse gas emissions.

Often, environmental sustainability is bundled together with social sustainability and sustainable governance, forming the familiar ESG acronym. In this white paper, we argue that ESG frameworks risk masking poor environmental performance. For real estate firms, this issue can be managed by using the growing list of PropTech (property technology) solutions available to them, first to measure, and then to continuously improve, environmental performance.

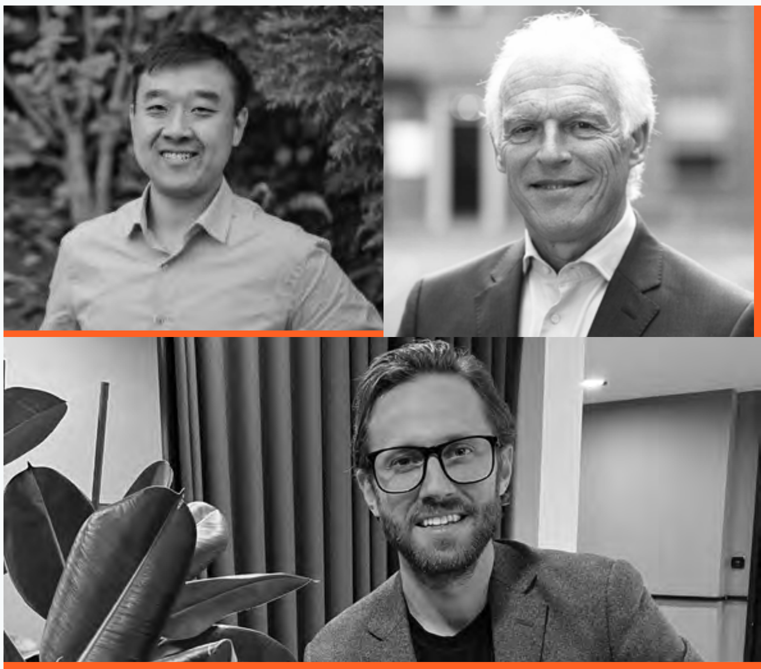
This report is structured into five chapters. In the first, we offer a brief primer on the history of our built environment coming into conflict with our natural environment. In the second, we uncover the challenges facing real estate decision makers when working with ESG data, and we discuss how PropTech businesses have produced tools for measurement and continuous improvement.

In Chapter 3, we look at environmental resources through the lens of familiar accounting and operations frameworks, including the *triple bottom line*, the difference between balance sheet (embedded) carbon and income statement carbon (in use), and seeing environmental performance as part of an input-output process. In Chapter 4 we take this one step further by integrating environmental sustainability and continuous improvement. Here, we offer a feedback loop of 'leading', 'present' and 'lagging' indicators. We develop the idea that improving your environmental footprint is strongly related to cutting out or reducing waste.

In the final chapter, we offer decision makers in real estate some ideas about how they can approach long-, medium- and short-term judgements impacting the environment. Throughout the report, we share examples of how organisations in the Pi Labs ecosystem have successfully offered and/or adopted these approaches, frameworks, and technologies for both the environment and their bottom line.

The real estate sector is one development cycle away from its 2030 net zero carbon goal. The decisions made today will lock in the carbon footprint for the end of the decade. The time to start making carbon neutral decisions is now – and the technology we need is available.

Jimmy Jia, Andrew Baum & Luke Graham



CHAPTER 1:

The path we've been following...

In brief...

1. The built environment's impact on the natural environment goes back much further than the industrial revolution.

2. Early sustainability initiatives in Europe include the prevention of overfishing in medieval times and reforestation in the Victorian era.

3. Each year, we are losing 4.7 million hectares of forest around the globe (more land than Denmark).

4. According to UNEP (2020), buildings are responsible for 30% of global carbon emissions and 40% of energy consumption. Environmental sustainability is very much a real estate matter.

CHAPTER 1: THE PATH WE'VE BEEN FOLLOWING...

1.1: The development of civilisation and the built environment

Throughout history, we humans have had a tumultuous relationship with the natural environment. As far back as oral and written accounts extend, and on every corner of the globe, we optimistically tried to control our environment through ceremonies and rituals. When those failed, survivors turned to migration and innovation—spreading across the world and figuring out new ways of surviving along the way. Then, some 11,000 years ago in the Middle East, humans took the first known steps to domesticating plants and animals as a new means of controlling our environment. The 'Agricultural Revolution', as it came to be known, transformed the diets and behaviours of our species.

As agriculture became more efficient and productive, surpluses emerged, which were then traded in built-up centres such as towns and cities (Taylor, 2012). Thousands of years later, the agricultural era was supplanted by the industrial revolution. The rate of urbanisation accelerated as farm labourers became factory labourers. Construction emerged as a dominant force in many national economies, where it persists to this day. Construction can be partly attributed to innovation, but a related factor is rapid population growth. UN (2018) expects the global population to reach 9.77 billion by 2050, and for all of that growth to take place in our urban settings.

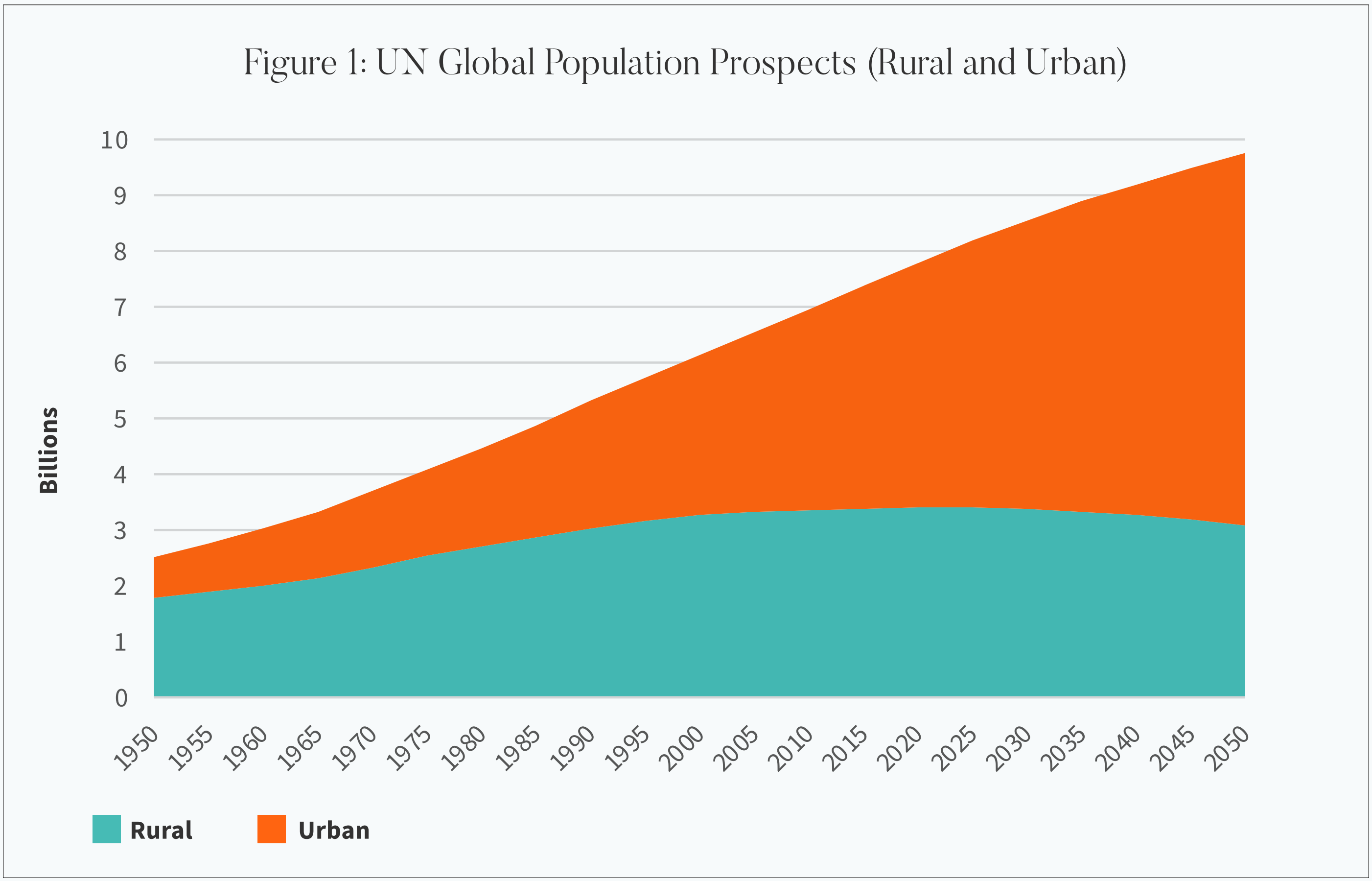


Figure 1: Rural and urban population history and projection 1950-2050 (UN, 2018)

CHAPTER 1: THE PATH WE'VE BEEN FOLLOWING...

1.2: Impacts on the natural environment

The development of humans and our built environment is a fascinating story, but one rife with ecological carnage. Our migration through many parts of the world has been correlated with mass extinctions of other species—from Eurasia to Australasia and the Americas. We cleared land to create settlements, and for personal safety and ease of sustenance. In medieval Europe, we diverted rivers to protect our settlements and power our mills. Species of freshwater fish plummeted, followed by sea fish (Boissoneault, 2019).

By the industrial era, the air of our cities had become unbreathable. In 1952, for instance, London endured 'The Great Smog'. This, alongside other pollution-linked events, led to the Clean Air Acts of 1956 and 1968[1] . Around the mid-20th century, the notion of climate change began to emerge in several thousand pieces of literature each year. By the turn of the century, climate change had become a mainstream issue, and by 2020 it was addressed in more than 6 percent of all published works of that year (see Figure 2).

Figure 2: Annual quantity of published material addressing climate change

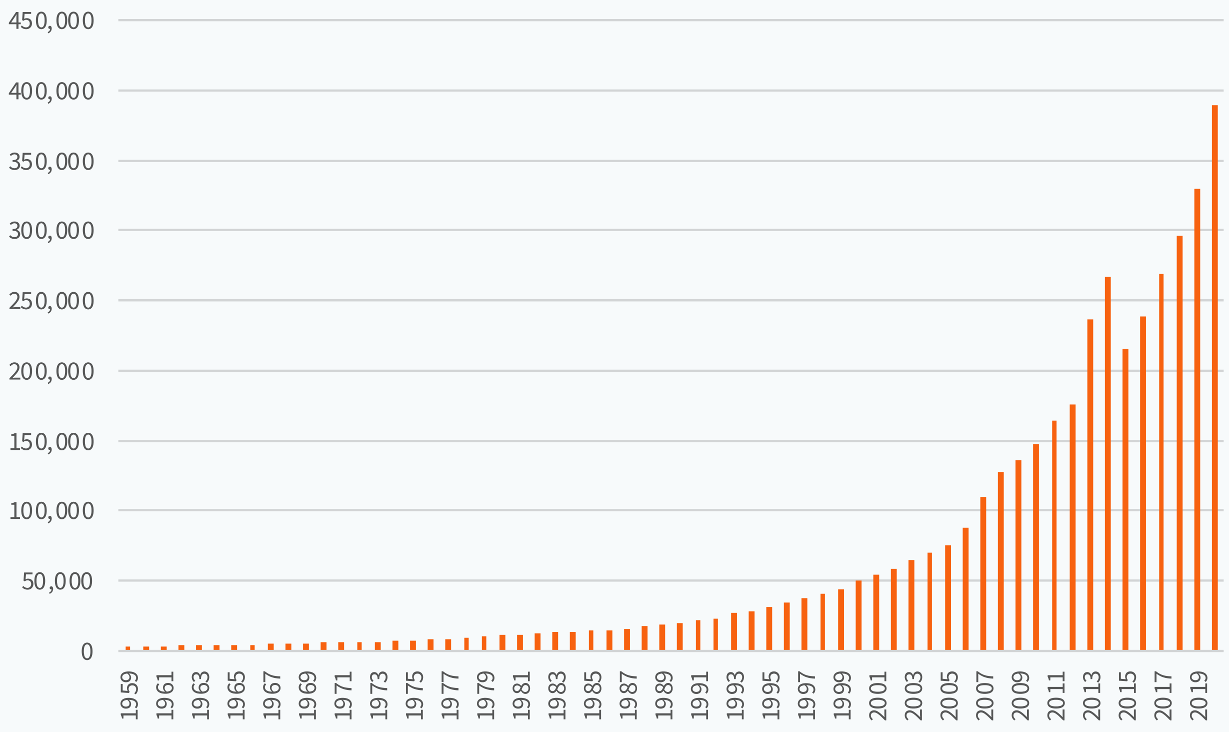


Figure 2: the prevalence of 'climate change' in the literature from 1959 to 2020 (Dimensions, 2021)

CHAPTER 1: THE PATH WE'VE BEEN FOLLOWING...

1.3: Today's environmental challenges for real estate

We have known our built environment is responsible for a large portion of the past, present and future damage to our natural environment since at least the Victorian era. This is when reforestation began in the UK and elsewhere in Europe. However, according to FAO & UNEP (2020), the annual net loss of forest area around the world between 2010 and 2020 was still 4.7 million hectares—equivalent to more than the entire land mass of Denmark (4.2 million hectares). In the case of buildings, UNEP (2016) estimate they are responsible for 30% of global greenhouse gas emissions and 40% of energy consumption. The challenge for real estate and the built environment is that our assets are physical—having a useful life of decades. That means yesterday's decisions are embedded in today's assets, and today's decisions are embedded in tomorrow's assets. Environmental sustainability is very much a real estate matter.

CHAPTER 2:

The gap between decision makers and ESG data

In brief...

1. Decisions made in the built environment today have long term consequences.
2. Due to a changing regulatory landscape, decision makers who aren't accounting for the environment risk building and/or owning stranded assets.
3. Measuring environmental sustainability, social sustainability, and sustainable governance (ESG) together has challenges. Scoring high on S and G could lead to a high ESG score, even if environmental performance is poor.
4. E, S, and G KPIs need to be measured and managed separately.
5. An opportunity exists for PropTech to measure and report ESG performance. The tsunami of available data means that organisation, visualisation and analysis is where value wil be added.

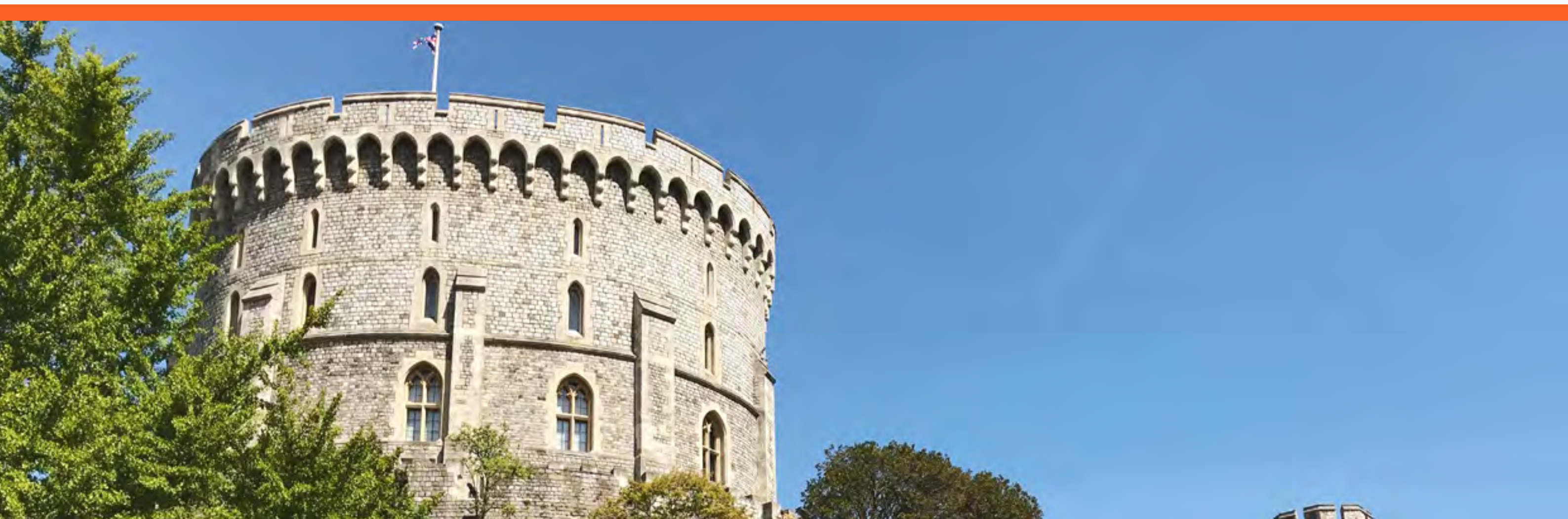
CHAPTER 2: THE GAP BETWEEN DECISION MAKERS AND ESG DATA

2.1: Decision making through the real estate value chain

Real estate investors and developers today are making short-, medium- and long-term choices that are locking in environmental footprints well beyond 2050. Conversely, investors across the real estate spectrum – whether planning a new development on a bare site, operating a highly rated sustainable building, or taking over the operations of an inefficient asset - are constrained by the choices made prior to their involvement of the asset (see Table 1). How can the investors affect the long-term environmental performance of the asset in each of these circumstances?

Table 1: Decision makers and impacted parties in a real estate asset's value chain

Key decision maker	Decision	Impacted party
Government and planning offices	Planning and compliance	Developer and/or builder
Developer and/or builder	Building design and materials	Investor
Investor	Operation and retrofits	Tenants and future investors

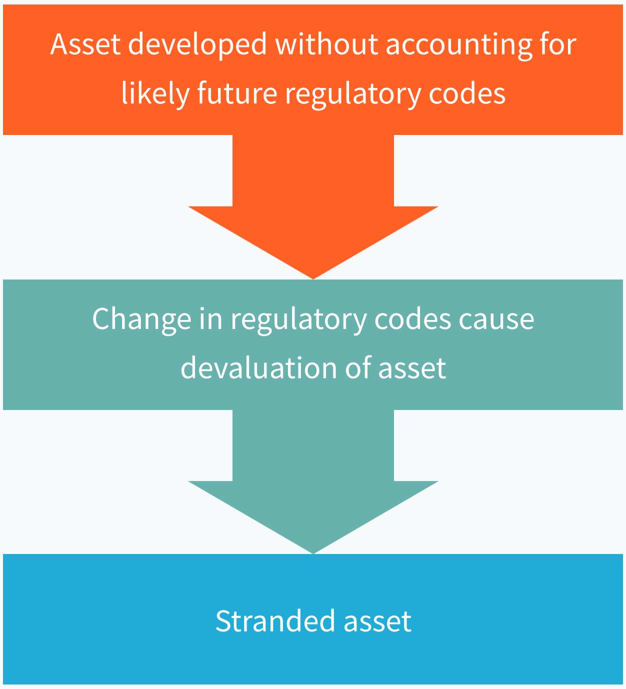


CHAPTER 2: THE GAP BETWEEN DECISION MAKERS AND ESG DATA

2.2: Stranded assets

Buildings that fail to have an appropriate impact on the enviroment run the risk of becoming stranded assets. Stranded assets are a subset of asset impairments caused by climate change risks. For example, fossil-fuel power plants risk suffering from premature write-downs due to the increased stringency of environmental legislation (Buhr, 2017). Real estate is heavily dependent on grid electricity. It is therefore uniquely exposed to upstream stranded asset risks in the power grid. Furthermore, as building energy codes tighten, existing buildings may become devalued if they do not meet those requirements, becoming stranded themselves. One study estimated the real estate sector is exposed to $5 – 16 trillion USD in global asset stranding due to increased stringency in energy codes (Muldoon-Smith & Greenhalgh, 2019).

Figure 3: Failing to account for the environment could result in a stranded asset



CHAPTER 2: THE GAP BETWEEN DECISION MAKERS AND ESG DATA

2.3: Limitations of ESG scores

Some firms disclose their environmental performance as part of a broader sustainability effort—using a combination of environmental, social and governance (ESG) indicators to measure progress. However, ESG scores and ratings aggregate many factors, which brings into question their environmental relevance. For example, an organisation can attain a high ESG score with strong S and G components that overshadow a lack of progress in E (such as decarbonisation efforts). As shown in Figure 4, rating systems also tend to attribute unequal weights to E, S and G attributes—which incentivises participants to prioritise some sustainability initiatives over others. For example, one report found that current corporate sustainability disclosures are skewed towards sustainable governance (such as processes and procedures), rather than actual environmental performance[2]. Another report found that companies are being rewarded in the financial markets for sophistication of reporting[3] rather than progress towards decarbonisation goals. A detailed analysis of ESG in real estate found that E, S and G components had different effects on financial indicators, with S and G creating positive financial returns while E delivered a return discount (Brounen & Marcato, 2018).

Figure 4: ESG weightings of three common rating systems

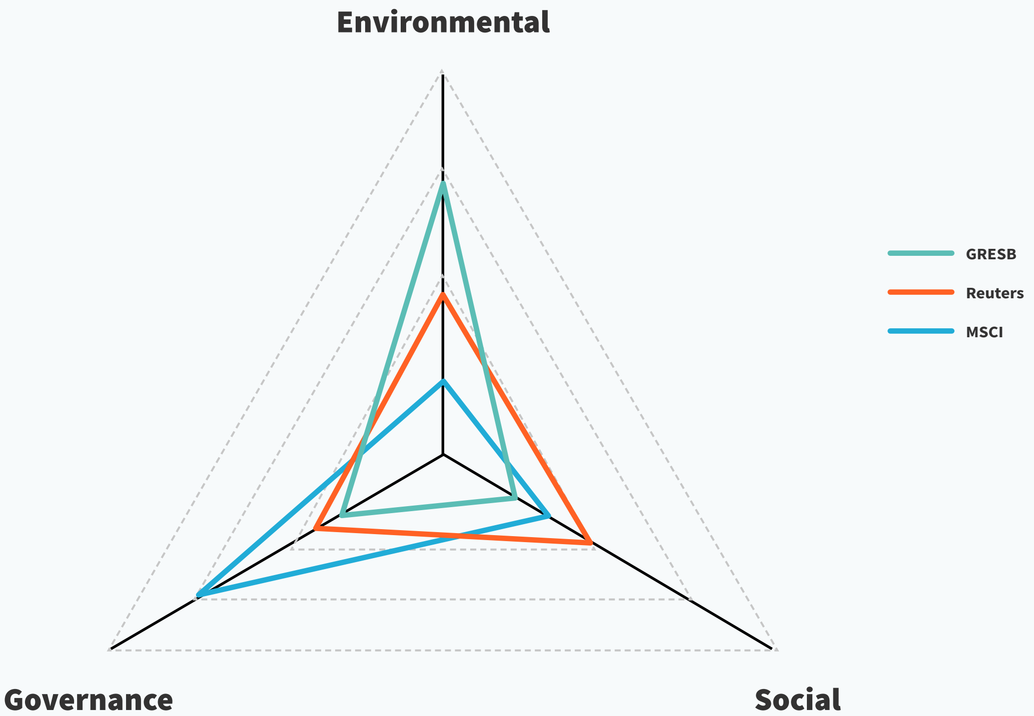


Figure 4 Traditional view of ESG combines a mixture of multiple factors. Further, rating companies will weight E, S, and G components differently. A company can do well overall while excelling on some aspects and lagging on others.

CHAPTER 2: THE GAP BETWEEN DECISION MAKERS AND ESG DATA

2.4: What gets measured gets improved

To decarbonise the real estate sector, one needs to measure carbon. To reduce energy consumption, one needs to measure energy, and so on. Key performance indicators (KPIs) for E, S, and G need to be managed separately using different business processes. Today, management teams of investors, operators, developers and others already use leading and lagging economic indicators to support decision making. Unfortunately, using leading and lagging environmental indicators for decision making is still a nascent field. New technology tools are needed before ESG management systems are as sophisticated as their economic counterparts. This is an area of opportunity for PropTech and the wider innovation ecosystem.

CHAPTER 2: THE GAP BETWEEN DECISION MAKERS AND ESG DATA

2.5: The role of PropTech

Future environmental performance systems will be able to use technology to generate, aggregate, and contextualise data. Already the internet-of-things (IoT) is generating huge quanties of data and billions more devices are forecasted to be deployed in the near future. These data sets exist in pockets, creating opportunities for data aggregators and cloud platform solutions. However, aggregated data creates a new challenge – managers are facing a data tsunami where important signals are buried deep within the noise. Contextualisation will become more critical as managers need to make sense of the data sets. For instance, as described in the following case study, customers will demand enhanced workplace experiences, regardless of how the future develops.

Managers are facing a data tsunami where important signals are buried deep within the noise.

CASE STUDY

Great Portland Estates: Digitisation as a future-proofing strategy

Facing uncertainty

The built environment runs the risk of being left behind in the digital technology revolution – and the challenge is larger than most people realise. It took four years for Facebook to reach 1 billion users[4], six years for 4G technology to reach 1 billion devices[5] and cloud services grew by over 900% in the nine years between 2011 and 2020[6]. Yet each of these trends occurred within the typical 7-to 9-year cycle of a new real estate development, from bare earth to full stabilisation. How should a developer today prepare a real estate product for the future when future demand patterns are uncertain?

This question is a key focus for James Pellatt, Director of Workplace and Innovation at Great Portland Estates plc (GPE). Buildings can be designed to specifications that meet today's strategic goals, environmental targets, and societal preferences. But those may have shifted by the time the product is on the market many years later.

Fortunately, GPE's senior leadership has been forward thinking for many years. GPE started setting sustainability briefs as far back as 2010. In 2018, the leadership asked Pellat to keep GPE ahead of the market by focusing on technology innovations. Three years ago, the challenge was a talent gap of attracting millennials. Today, it is COVID-related uncertainties. Although tenant wants and needs will continue to fundamentally shift, GPE's focus of continuous innovation to enhance the occupier's workplace experience will remain the same.

The trends

Through focus groups and executive workshops, the team identified three main trends that are changing their product. First, big data is coming but the true value has yet to be unlocked by the real estate sector. Second, customers are demanding workspace flexibility, even more so with the proliferation of remote work. Third, climate change is near the top of people's consciousness. Organisations were therefore beginning to feel customer, investor, and employee pressure to do something about it.

GPE's innovation strategy de-risks these three macro trends by preparing the organisation to achieve these goals.

Being involved with Pi Labs has given GPE early access to new emerging technologies that operationalise GPE's targets. This has supported many of GPE's business lines, whether constructing new developments, managing existing properties, or retrofitting low performance buildings.

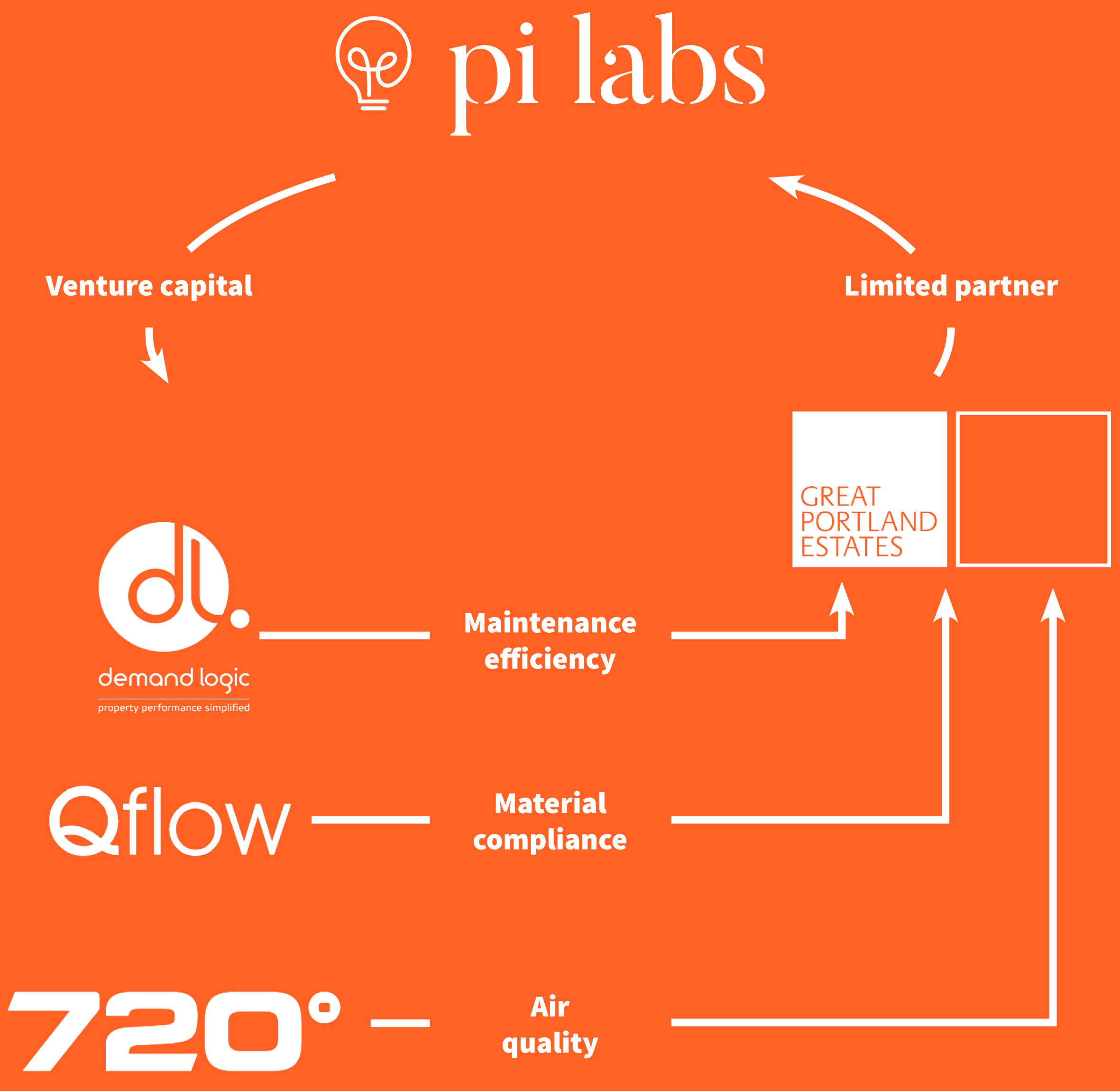
GPE's diversity of projects creates an ideal laboratory ecosystem for real estate innovations. For example, innovative technologies can be piloted in buildings being retrofitted or in short-term tenant leases, generating data and creating a track record. The best of these technologies can then be rolled out in new construction, where it can take upwards of 7 to 9 years for data to be generated and the technology validated.

For example, Demand Logic's solution was well suited for GPE's Hanover Square development[7]. Demand Logic is collecting over 10,000 data sets and flagging inefficiencies in operations for the maintenance and facility staff. Not only is this identifying wasted operations, it is also giving GPE valuable feedback on the seasonality of their building's usage. This can then be compared to the building's design, and future developments can take into consideration actual occupancy demand. Similarly, Qflow, which was piloted on one of GPE's sites, is now being rolled out across the portfolio. Not only will this solution reduce embedded carbon, it will also reduce non-compliance of materials in tenant fit-outs. Finally, the trial of 720 Degree's air quality sensors at GPE's head office in December 2019 resulted in a portfolio-wide deployment of air quality sensors as they help their occupiers return to the workplace.

Facing the future

GPE knows it is only at the beginning of its digital journey. Pellatt's team continues to search and vet technologies, whether implementing digital twins for buildings, supporting continuous improvement, or providing real-time ESG data to staff. Regardless of the environmental initiative – circular economy, materials passport, reducing operational carbon, and so on – the digital strategy is future-proofing GPE.

Figure 5: Closing the innovation adoption loop between PropTech and real estate



CHAPTER 3:

Consuming resources to achieve commercial outcomes

In brief...

1. Traditionally, executives deploy capital in pursuit of profit. Some have adopted the *triple bottom line* approach, accounting for profit, people, and planet.

2. Just like financial capital, real estate firms process environmental resources as both inputs (e.g. energy and materials) and outputs (e.g. carbon emissions and solid waste).

3. Each environmental input has a relationship with the other. Real estate is a major consumer of natural resources. Construction consumes 55% of raw materials in the UK and 72% in the US.

4. Greenhouse gas (GHG) emissions are the most well-known environmental outputs, but real estate professionals also need to consider waste heat, sewage, solid waste (rubbish), hazardous waste and others.

5. GHG emissions are classified by scope, depending on whether you directly caused the emission or whether it was created in your supply chain.

CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.1: The people, planet, and profit motive

Firms consume economic resources to achieve a return on their investment. Generally, firms do their best not to waste these resources. It is therefore common for companies to undertake reviews to reduce inefficient expenses and put capital to work. Some firms have gone a step further by including social and environmental outcomes as part of their vision—accounting for a wider range of organisational inputs and outputs. This can be observed through the popularity of the 'triple bottom line' approach. Introduced by Spreckley (1981), the framework was later refined by John Elkington (1997) and Savitz & Weber (2007). The three 'bottom lines' of social, environmental and economic outcomes (people, planet, profit) can be observed as a sustainability triangle, as shown in Figure 6. A fourth outcome, purpose, rose to prominence in the late-2010s, thereby creating a quadruple bottom line.

Figure 6: The sustainability triangle of a firm's vision

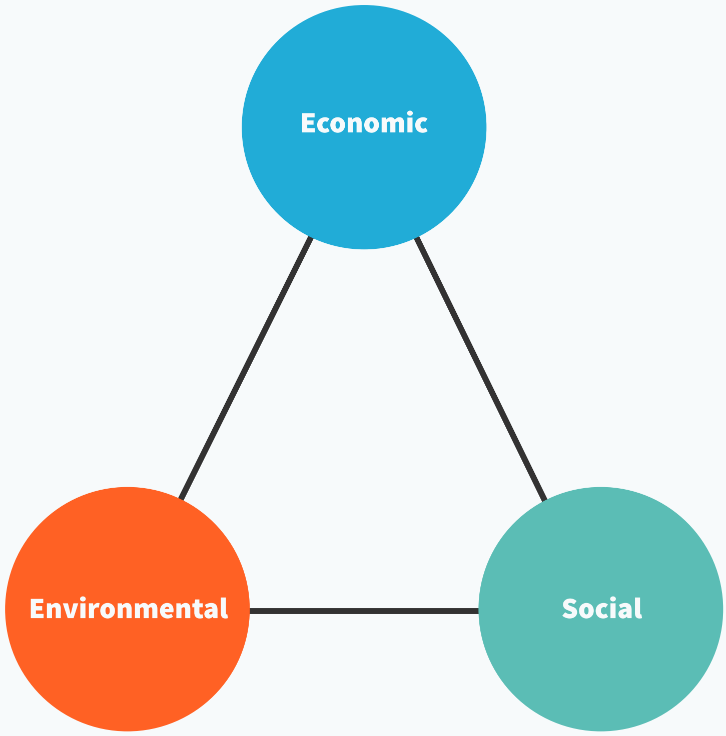


Figure 6 The sustainability triangle. A company must be economically, environmentally, and socially sustainable to continue as a going concern.

CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.2: Planet: consuming resources

Aside from economic resources such as capital, firms also consume environmental resources to achieve their corporate goals (see Figure 7). Without energy, space, or materials, firms will struggle to deliver on their mission. The digital economy, for example, is highly sensitive to power outages. Datacentre downtime can result in lost revenue at $17,244[8] per minute. However, there is a lack of visibility of what the right-sized environmental consumption is. Just as it is unsustainable for a company to endlessly spend itself into negative net profit (even if it's to produce goods), so too is it unsustainable for a company to endlessly consume resources from the natural environment. A reason this occurs is a lack of data and visibility to quantify the waste. Another is a lack of business processes to uncover and reduce it. Better data to support a culture of continuous improvement can help reduce this waste. After all, environmental resources cost money to buy, and any wasted resources will depress economic returns. In the remainder of this chapter, we will look closer at environmental resources as inputs, as well as how they're wasted.

Figure 7: How energy and other resources deliver value

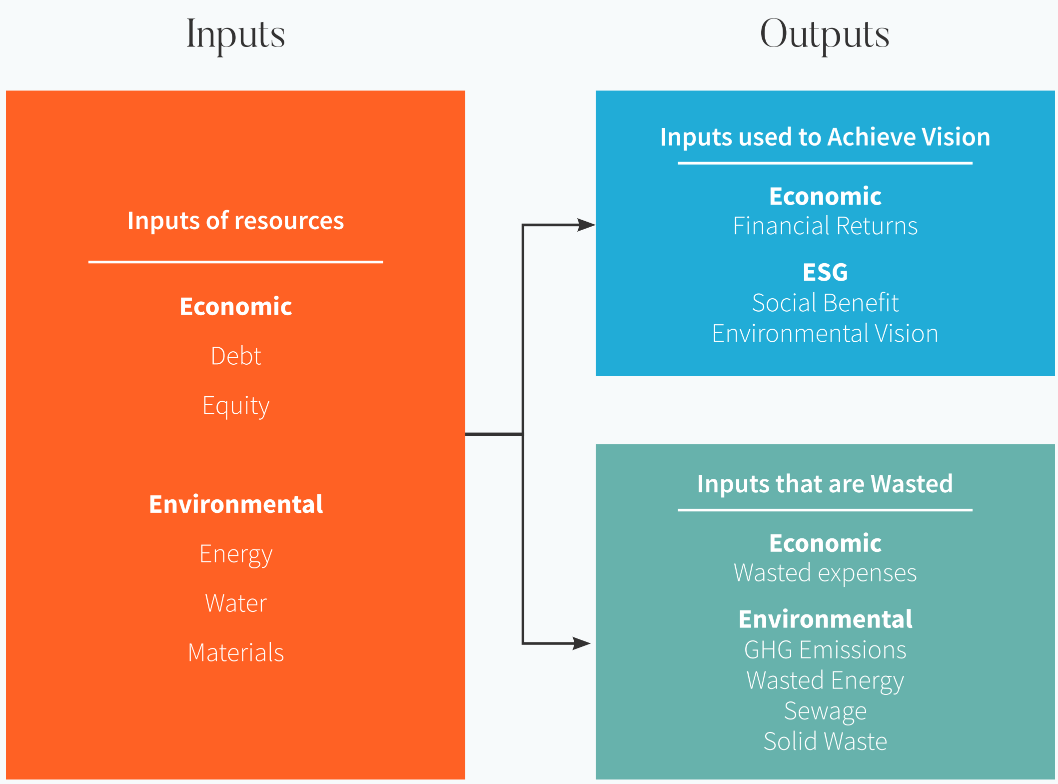


Figure 7 How energy and other resources deliver value. Waste can be considered any resource consumed that was not aligned to a firm's vision

CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.3: Environmental resources as inputs

Energy, water, and materials are the three main environmental inputs into the real estate sector. The resources are intertwined, as depicted in Figure 8. Energy and water intersect in the energy-water nexus. The energy to manufacture steel, cement, and other materials is known as embodied energy while the water consumed to manufacture the materials is known as the water footprint.

Energy

Energy is perhaps the largest environmental input needed to achieve a firm's strategic vision. Energy comes in many forms. Each one of these energy sources can be consumed directly, such as an internal combustion engine in an automobile, or can be converted into electric energy for distribution along the electric grid. The advantage of electric energy is that it allows society to arbitrage the relative costs of fuel supply. In different regions of the world, coal, natural gas, wind and solar can be the lowest-cost resource to provide electricity.

- Fossil fuels (coal, petroleum, natural gas, etc.)
- Kinetic (wind, hydro); chemical (biofuels, hydrogen, nuclear, etc.)
- Photonic (solar)
- Thermal (district heating)

Figure 8: Relationship between input resources

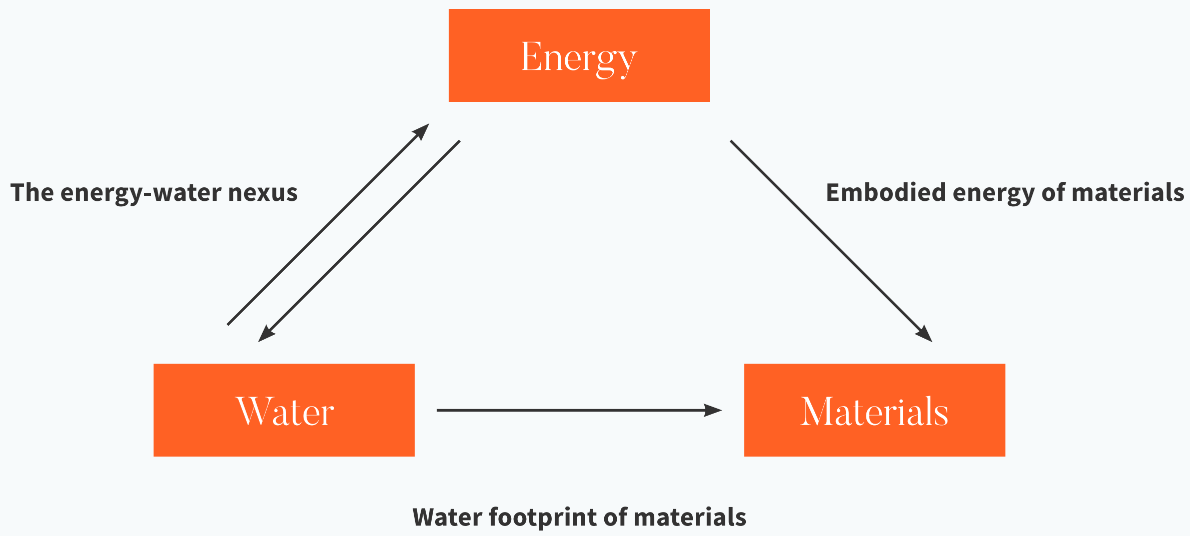


Figure 8 The relationships between input resources. Economic resources are spent to procure each of these environmental resources. n

Water

Water is both a natural resource that is consumed directly, as well as a necessary resource for the running of assets. Fresh water comes in several different forms.

- Blue water = surface or groundwater. This includes water from lakes, rivers, streams, or underground aquifers
- Green water = rainwater. However, rainwater can collect pollutants as it travels through urban streets
- Storm water = rainwater that has collected pollution and particulates
- Potable water = water that has been processed and cleaned to be safe to drink and used in food production
- Process water = that which is used in industrial processes. Within a building, process water is used inside radiators and cooling towers. It is also used for rinsing, spraying, and sometimes irrigation

The energy-water nexus

Water and energy form an inseparable nexus. Thermoelectric power plants require water for power generation, consuming approximately 95 litres per kWh of electricity[9]. Similarly, water requires energy, for treatment into potable water, pumping throughout an office tower, heating for human consumption, and desalination. Further, wastewater requires energy to aerate and treat the water before discharge into the environment.

By some estimates, the UK water sector consumes 4% of the country's energy supply to manage water and wastewater, making it the fourth most energy intensive sector in the country[10]. However, actual energy consumption is dependent on the region. For example, desalination is expected to require nearly 15% of the Middle East's energy supply by 2040[11]. In California, as much as 19% of the state's electricity consumption is already consumed to convey and treat water and wastewater (Copeland & Carter, 2017).

Materials

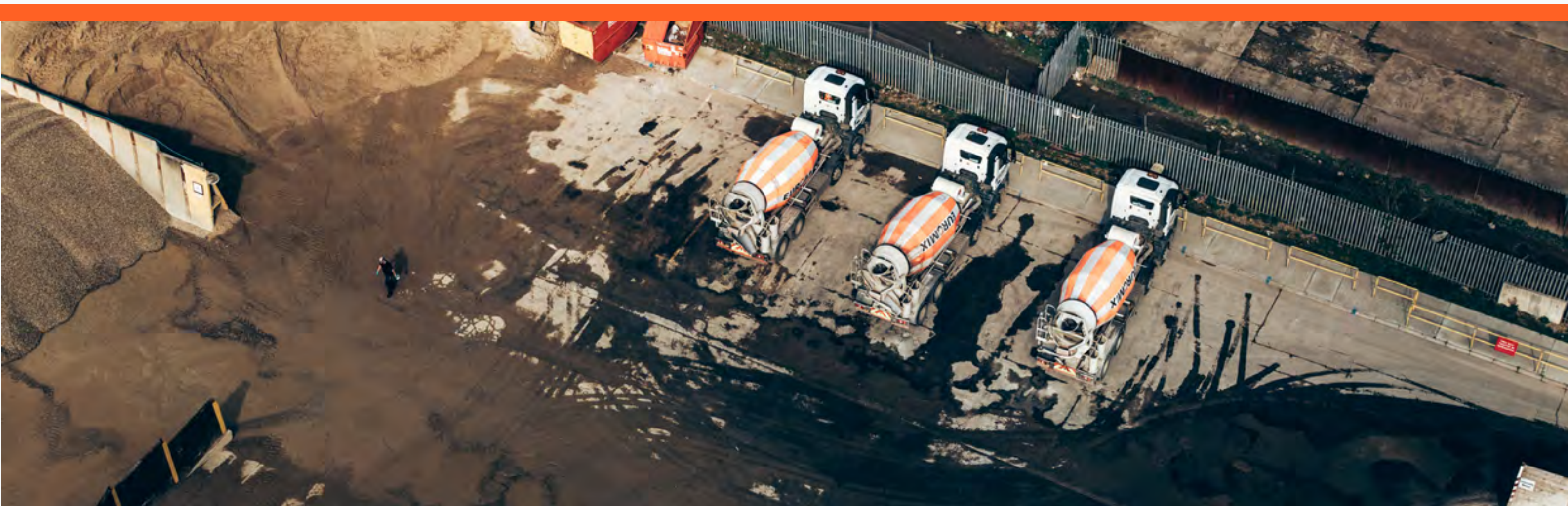
In the UK and the US, the construction industry is the largest consumer of raw materials. Construction consumes approximately 55% of total annual materials in the UK[12] and a whopping 72% in the US (Matos, 2017). For specific materials, construction is the primary consumer of softwood timber at 60% (Moore, 2015) and steel at 50% (OECD, 2010) and major consumers of aluminium and plastics at 26% and 25%, respectively[13].

The water footprint of construction materials

Water is a necessary component of the manufacturing process. Therefore, construction has a water footprint. According to one study, the water footprint of steel ranges from 11.8 litres / kg for unalloyed steel to 76.9 litres / kg for alloyed steel. Portland cement has a water intensity of 2.2 litres / kg (Gerbens-Leense et al., 2018).

Embodied and operational energy

It is useful to distinguish between energy consumed for operations and energy consumed to manufacture raw materials and products. Operational energy is consumed to generate thermal warmth, run data centres, pump water through pipes, among other activities. This energy is consumed immediately. Embodied energy, however, is associated with the manufacturing of a product or material. For example, 8% of global energy is consumed to manufacture steel[14] and 1.5% for aluminium (U.S. DOE, 2007).



CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.4: Wasted Resources

Sewage, rubbish, and heat are interrelated waste streams of environmental resources. Greenhouse gas (GHG) emissions are a primary outcome of energy consumption. At the same time, energy is also consumed to manage waste, whether pumping sewage to the wastewater treatment plant or fuel for bin lorries or garbage trucks. Thus, reducing waste has a multiplier effect on emissions – not only does it save on water and material resources, but it also reduces energy consumed for manufacturing and energy consumed to manage waste.

Operational carbon

Operational carbon refers to the carbon emitted during operations of a building. It is generated as a direct consequence of consuming energy for heating, cooling, lighting, plug loads and other behavioural activities. To reduce operational carbon, one needs to reduce operational energy or fuel shift to a carbon-neutral fuel.

GHG Emissions

The consumption of energy is responsible for approx. 73% of all global GHG emissions. The global warming potential (GWP) is a measure of how much a GHG contributes to global warming (U.S. EPA, 2021). Carbon dioxide (CO_2) is defined as having a GWP of 1. Methane, or CH_4, has a GWP of 25. Some chemicals, such as HFC-23, have a GWP of 14,800! Approximately 74.4% of the GHGs being emitted is CO_2 and 17.3% is methane. Refrigerants make up less that 2% by weight.

Municipal solid waste

Materials that are not consumed or are at the end of their useful life need to be disposed. Approximately 20 to 40% of all waste destined for landfill comes from the real estate sector (Ionaşcu et al., 2020). However, up to 25% of materials can be easily reused and up to 70% of the material can be recycled (Bertino et al., 2021). Three common waste treatment methodologies are repurposing, recycling, and landfilling[17]. The environmental benefit of recycling is enormous. Recycled aluminium requires 95% less energy and 97% less water than to refine it from raw ore. Similarly, recycled steel uses 60% less energy and 86% less water (Jia & Crabtree, 2015).

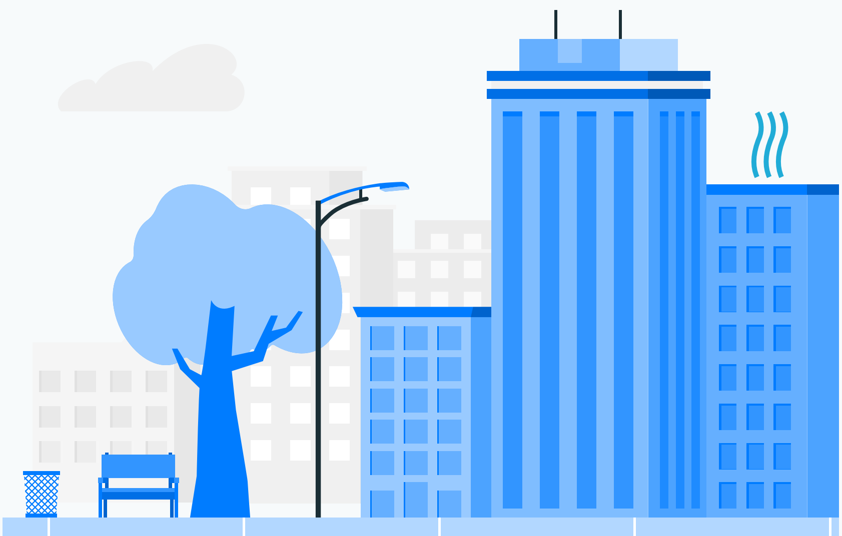


Figure 9: Reduction of energy consumption through recycling

	Aluminum	Steel	Paper	Glass
Reduction in energy use	95%	60%	50%	20%
Reduction in air pollution	95%	85%	74%	20%
Investor	97%	76%	35%	
Reduction in water use		49%	58%	20%

Figure 9 Reduction of energy consumption and other environmental benefits from recycling (Jia & Crabtree, 2015).

Embodied carbon

Embodied carbon is a measure of how much carbon was emitted during the construction of a building or manufacture of a material. Embodied carbon is usually calculated with a life cycle assessment (LCA)[15]. The University of Washington's Embodied Carbon Benchmark Study estimates that, on average, European buildings have an initial embodied carbon of 439 kg-CO_2e per m2 of floorspace.

Wasted heat energy

Heat energy is a by-product of consuming energy. Air conditioners cool down datacentres, auxiliary fans keep laptops from overheating and commercial kitchens need to keep the cooks cool. This excess heat is energy that cannot be consumed for business-generating purposes. The total amount of waste heat is enormous – industrial processes lose anywhere from 20-50% of their energy via heat discharge (BCS, 2008). In the US, that is equivalent to twice the annual energy consumption for the State of California (Jia & Crabtree, 2015).

The waste heat can be recycled to pre-heat or heat other applications. In one innovative example in Seattle, instead of venting the excess heat from the datacentres in the Weston Building Exchange, it is instead piped across the street to heat an office tower owned by Amazon. This recycling of heat avoids the need to generate new electricity, helping keep Seattle green.[16]

Sewage

Wastewater can be a health hazard and needs to be disposed of properly. Wastewater comes in several forms:

Blackwater is hazardous sewage requiring treatment (contains biological material, such as germs and microbes).

Greywater is sewage that does not contain biological materials. Some can be reused in irrigation or toilets (e.g. washing machine waste water).

Stormwater originates from precipitation, but can also contain oils, particulates and other pollution from the urban environment.

CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.5: Other waste

Hazardous waste includes materials that are generally harmful to humans or the environment. It may be contaminated with biological compounds, toxic or radioactive. Hazardous waste cannot be disposed of directly but needs to be chemically neutralised first. Within the EU, approximately 4.4% of all waste is considered hazardous. Common construction-related hazardous[18] waste includes asbestos, batteries, solvents, as well as equipment containing ozone-depleting substances.

An emerging chemical risk is created by per- and poly-fluoroalkyl substances (PFASs), also known as 'forever chemicals' because they resist breaking down in the environment. These chemicals are used in daily products, including food packaging, commercial household products, carpets, paper, clothes, and so on. They have been found in drinking water, as well as living organisms such as fish and humans. Health effect studies of PFASs have reported a variety of outcomes, including some indications that they may be connected to increased cholesterol levels, changes in liver function, and increased risk of kidney failure, among other ailments[19].

Noise pollution is the propagation of sound that impacts human and animal life. It is generated by a variety of machinery, from backup generators, motors, fans, to transportation vehicles, such as automobiles, planes, and trains, to human behaviour, such as loud music. Noise has been attributed to human health issues, such as hypertension, heart disease and stroke (Münzel et al., 2018) and can have adverse effects on children[20]. Ecologically, noise pollution affects wildlife communication and orientation, negatively affecting the richness and abundance of species. (Senzaki et al., 2020).

Light pollution is an excess of artificial light that may be unwanted or inappropriate. It is an umbrella term that can refer to unwanted blinking lights or night-time skyglow that affects astronomic observations. Inappropriate light affects the circadian rhythm of both humans and wildlife. For humans, the light-induced disruption to the circadian clock has been attributed to increased incidents of cancer, eating disorders, and mood disorders (Walker et al., 2020). Within ecology, light pollution threatens nocturnal animals, causes navigation errors and physiological harm. It impacts the predator/prey balance within an ecosystem (Lotzof, n.d.), potentially contributing to a decrease in biodiversity.

CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.6: Carbon inventory: Scope 1, 2, and 3

GHG emissions are generally disclosed in the form of Scope 1, 2, and 3. The advantage of this methodology is that it draws a distinction between emissions under a firm's direct control and those not under direct control, but under the firm's influence. Scope 1 Direct Emissions are those from sources that are owned or controlled by an organisation. This includes those emitted from consuming fuel or released from industrial processes, such as cement manufacturing. Scope 2 Indirect Emissions are those from purchased energy. This could be electricity, steam, heating, and cooling provided by the local utility. Scope 3 Other Indirect Emissions are emissions that occur outside the organisation, including both upstream and downstream in the supply chain. This includes travel and commuting, purchased goods, use of sold products, leased assets, among others (WBCSD & WRI, 2012). Since carbon inventories are reported annually, they have limited usefulness to operational managers making day-to-day decisions.

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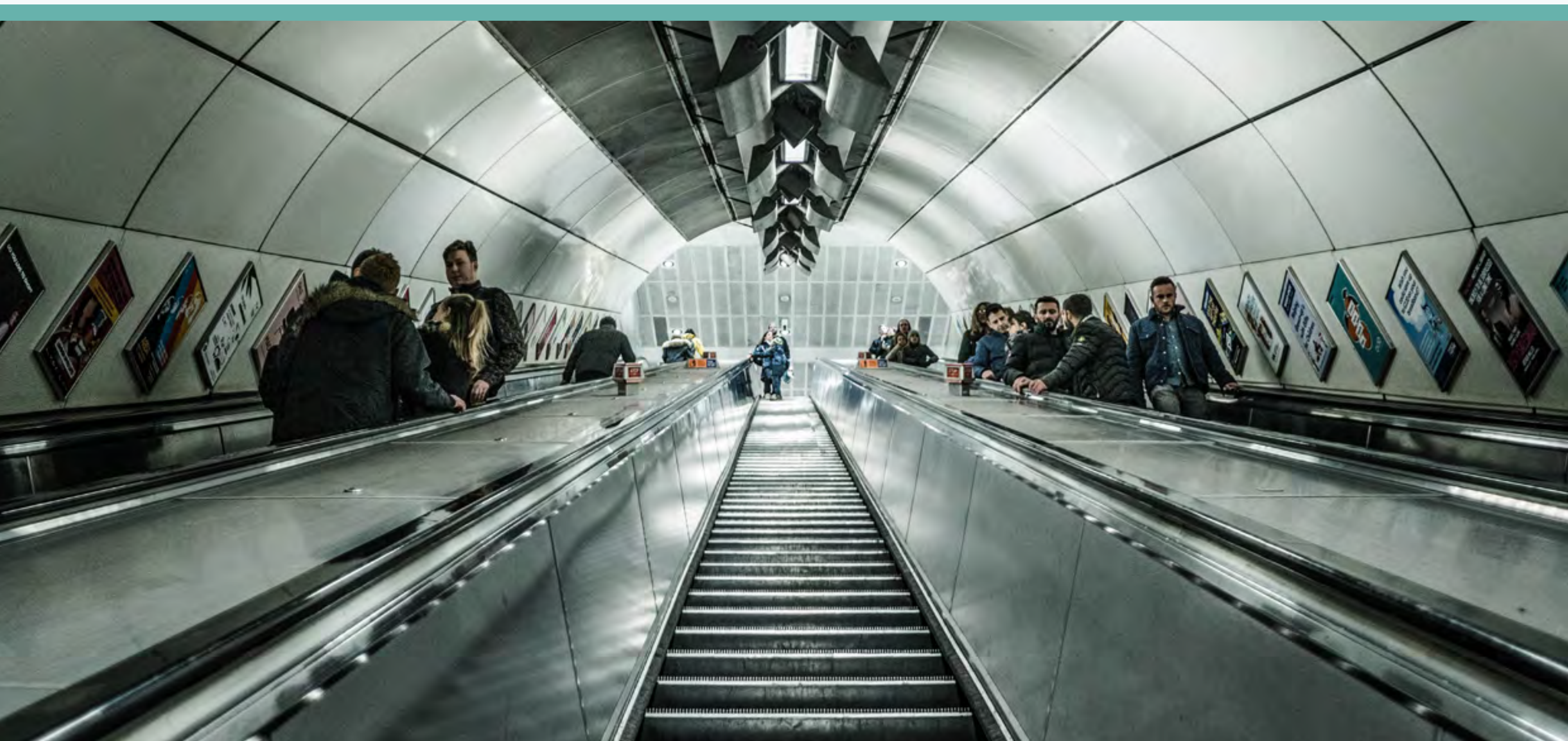
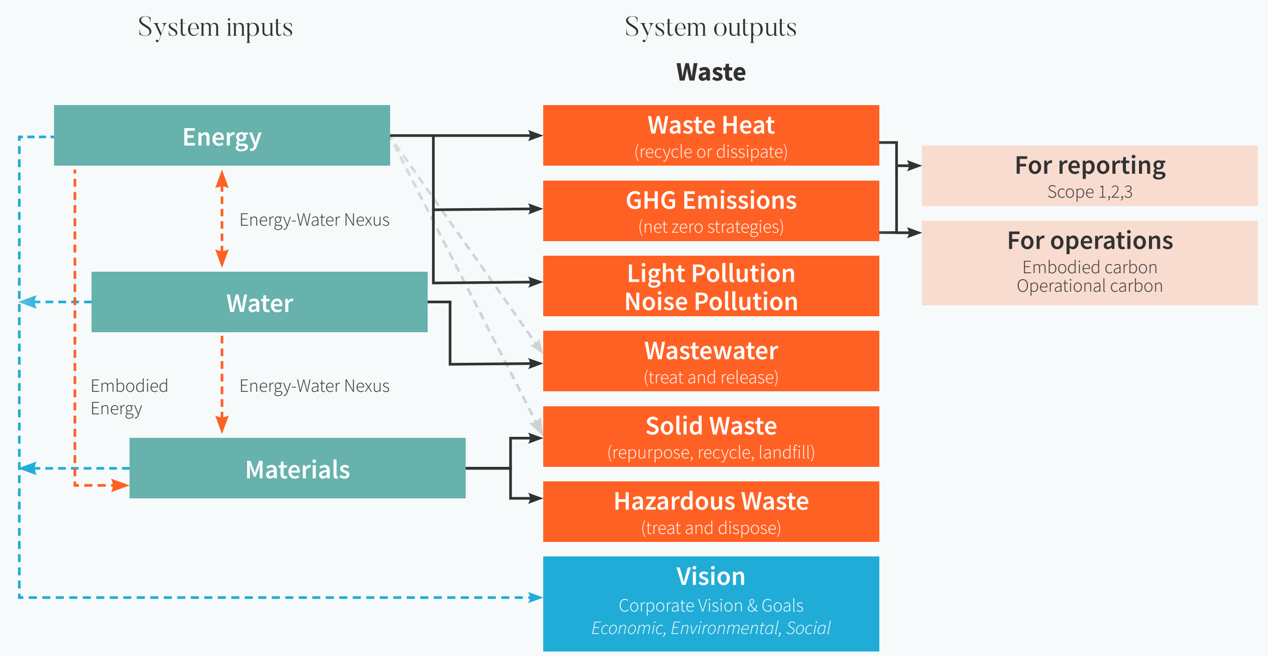


CHAPTER 3: CONSUMING RESOURCES TO ACHIEVE COMMERCIAL OUTCOMES

3.7: Net-zero energy and net-zero carbon

Net-zero energy buildings is a concept that generally describes the interaction between the building and the surrounding grid and energy supply system. There is to be zero balance between exported and delivered energy (Urge-Vorsatz et al., 2020). Net-zero carbon is less well defined for the built environment. Broadly, it means zero carbon emissions netted from activities associated with developing and servicing a building. However, the investment boundary of the carbon related activities is less standardised and can be determined by individual firms (Botten et al., 2020). Figure 10 summarises the relationship of GHG and carbon concepts.

Figure 10: A summary of the relationships between environmental resources



CHAPTER 4:

Environmental sustainability and business operations

In brief...

1. The ESG information your company discloses is not the same as the information you need to improve your environmental footprint. The same is true for financial reporting.

2. Continuous improvement identifies waste in all its forms within an organisation.

3. Waste is more than just rubbish. It includes any resource not being used to create value.

4. By deploying leading, present and lagging indicators, real estate organisations can engage in the continuous improvement of their environmental sustainability initiatives.

5. PropTech solutions facilitate continuous improvement in several ways. Examples include sensors and internet of things (IoT) technologies, among many others.

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.1: Information for disclosure versus information for decision making

Information to help real estate professionals make well-informed internal business decisions is different from the information disclosed to parties outside of the organisation. For example, investors receive corporate financial reports or disclosures that are governed by IFRS and GAAP. However, corporate managers will use activity-based costing, unit cost analysis, marginal analysis, and other managerial accounting techniques to support day-to-day decision making. Today, ESG metrics and standards have focused on the disclosure of data to investors. For example, carbon Scopes 1, 2, and 3 are environmental KPIs used by TCFD, SASB, GRI in investor-facing documentation. There has been less development in making ESG indicators relevant to operational managers.

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.2: Continuous improvement

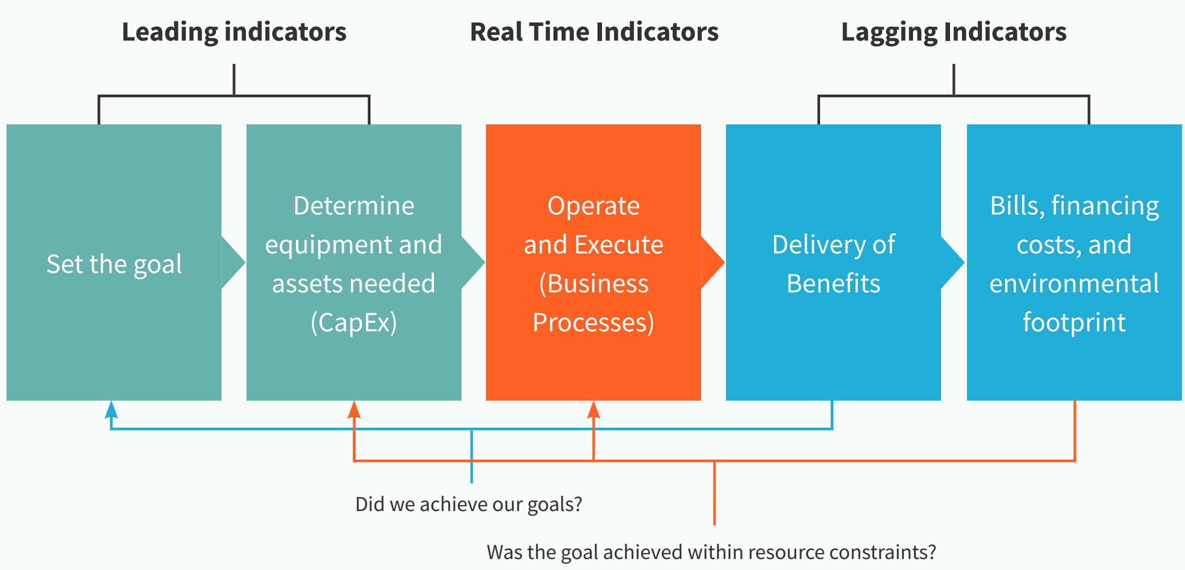
Continuous improvement is a business process that identifies where the waste is hidden within an organisation and creates a system to root it out. It grew out of the field of statistical process control, pioneered by the American statistician W. Edwards Deming. Firmly grounded in data, the method gets people and processes across multiple departments to collaborate with each other to improve quality and satisfy customers. The famous Toyota Production System (TPS) took Deming's innovation one step further. TPS used data to identify and remove waste without sacrificing productivity (Womack et al., 1991).

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.3: Continuous improvement in environmental performance

Regular business processes impact the environment at different times. Thus, environmental indicators can be organised into an operational sequence that is based on a firm's regular decision-making process. Leading indicators include those that give focus and direction, such as vision, or those whose outcomes have a long duration and impact future decisions. Present real time indicators are those that that affect real-time operational processes. Lagging indicators are the resources consumed because of operational processes, or as a necessity to achieve strategic visions. Environmental indicators can therefore be arranged in the following order, as depicted in Figure 11.

Figure 11: A Continuous Improvement View of Environmental Sustainability



Leading indicators

Setting of the vision and goal: Strategic vision is the primary leading indicator that focuses the efforts and attention of corporations. These outcomes can be economic, such as return on investment, yields, or other economic indicators. Environmental goals can be to maintain biodiversity, reduce carbon impact, and so on. Environmental vision setting has overlaps with sustainable governance.

Procuring capital assets: The firm then needs to procure capital assets to fulfil the vision. Assets should only be procured that meet the needs of the strategic vision. Capital asset procurement is an environmental concern, first because assets require energy to build and second because assets consume energy to operate.

Present indicators

Real-time decisions: Operational teams need to make real-time decisions with the assets at their disposal. This includes business processes and workflow management systems, standard operating procedures of equipment, and troubleshooting issues that may arise. Behavioural technologies, such as using occupancy sensors to manage light switches or air quality monitors to manage ventilation, are other examples. Real time decisions are an environmental concern because one optimises real time processes to reduce unnecessary consumption of energy.

Lagging indicators

Delivery of benefits: Firms need to know they delivered the promised benefits set out by the strategic vision. Managers will need to collect data to evaluate against the goals set out earlier in the process. Benefit delivery is a social concern as it is the collection of KPIs that measures value creation.

[E] Resource footprints: Energy, water, materials, and other economic resources are consumed to operationalise the vision. Managers today create financial reports to document monetary resources. Environmental reporting is gaining in popularity with the proliferation of standards.

Feedback loops

[G] Was the vision achieved? It is the role of governance to verify that the goals set out were achieved. Lagging indicators need to be compared to leading indicators to understand effectiveness. If they were not achieved, what processes need to be modified? If the vision was achieved, can further benefits or goals be added?

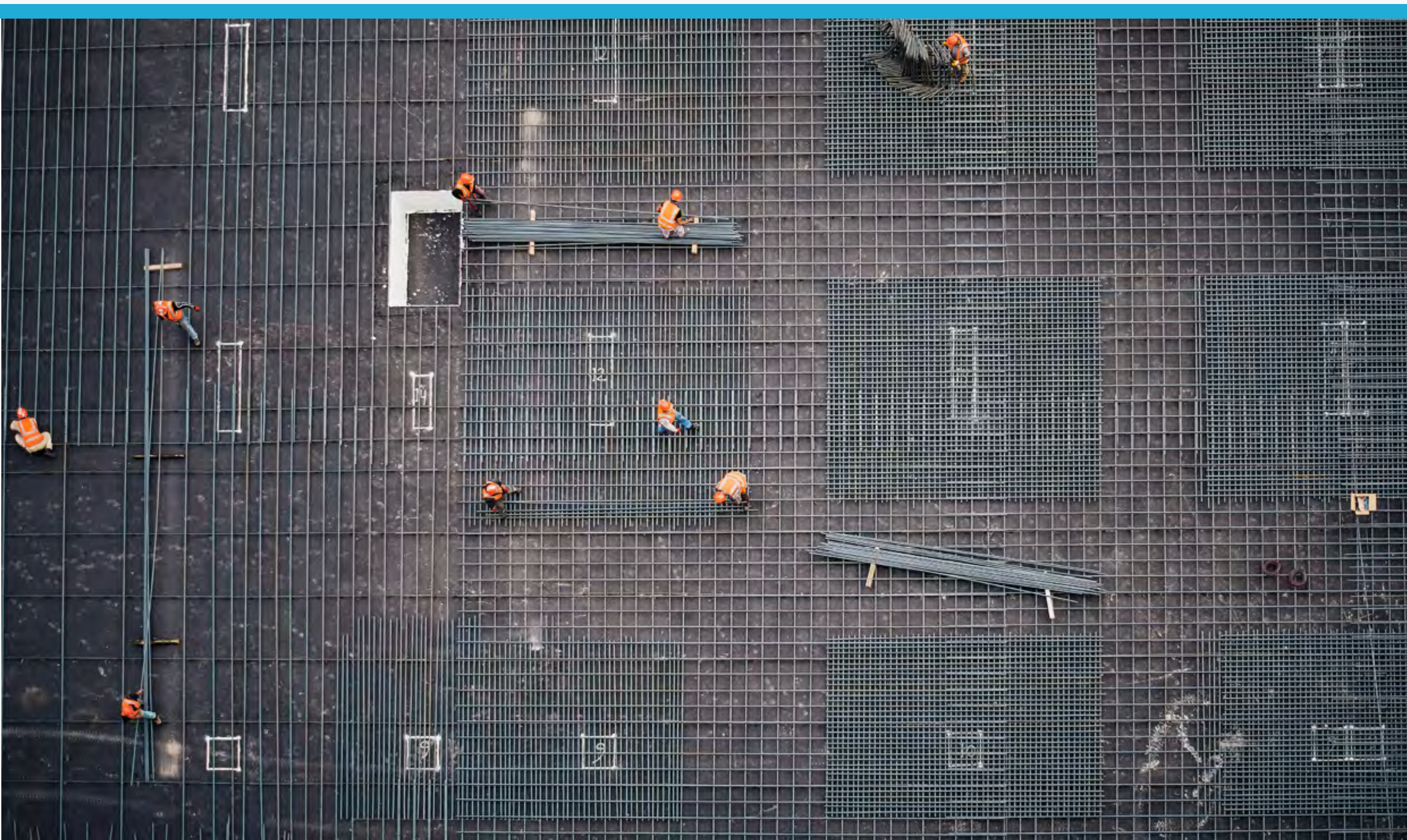
[G] Was the vision achieved within resource constraints? Managers also need to verify that the organisation met resource constraints. Managers are familiar with operating assets within financial budgets. In the future, managers will also need to also operate assets within environmental KPIs. Were capital assets right sized and appropriate for the achievement of the vision? Were the capital assets operated efficiently to generate the right-sized resource consumption?

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.4: Wasting resources

Waste is more than just rubbish, trash, and unused materials to be disposed of. Any resource not being used to create customer value can be considered waste. This includes idle time of employees, unused inventory, over purchasing of inventory that needs to be disposed. There is also cost of waste management, hazardous waste disposal, compliance audits, and so on. Reducing waste is one of the simplest means to improve financial returns and lessen an organisation's environmental footprint.

Waste is more than just rubbish, trash, and unused materials to be disposed of. Any resource not being used to create customer value can be considered waste.



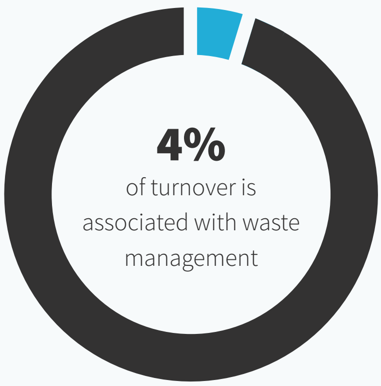
CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.5: Waste in the real estate sector

Waste abounds in the real estate sector. Physical construction waste is the easiest to identify. As much as 30% of the total weight of building materials delivered to a building site are wasted. This is roughly £1.5 billion in unused material delivered to sites. The cost of disposing of waste is also significant. Within the UK, approximately £200 million is spent annually on the Landfill Tax by the construction sector, and roughly 4% of turnover is associated with waste management (Osmani, 2011). Furthermore, recall that materials have both an embodied energy and water footprint as well. Reducing solid waste also reduces embodied energy and water footprint waste.

£200mn

annual spend on the Landfill Tax by the construction sector



CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.6: Energy waste

Energy waste can come from leaving lights and appliances on when no one is there, inefficient equipment, or consuming more energy than necessary. According to the U.S. EPA, approximately 30% of all energy used in commercial buildings is wasted (U.S. DOE, n.d.). This equates to roughly $36 billion annually. In the UK, as much as 36% of energy is lost or wasted (Neill, 2019). Households also waste a lot of energy. According to BEIS (2021) data, 76% of UK households sampled were concerned about climate change. However, most respondents reported leaving the heating on when out of the house for a few hours, as well as engaging in other energy wasting behaviours, as shown in Figure 12.

Figure 12: Prevalence of energy wasting behaviours in UK households

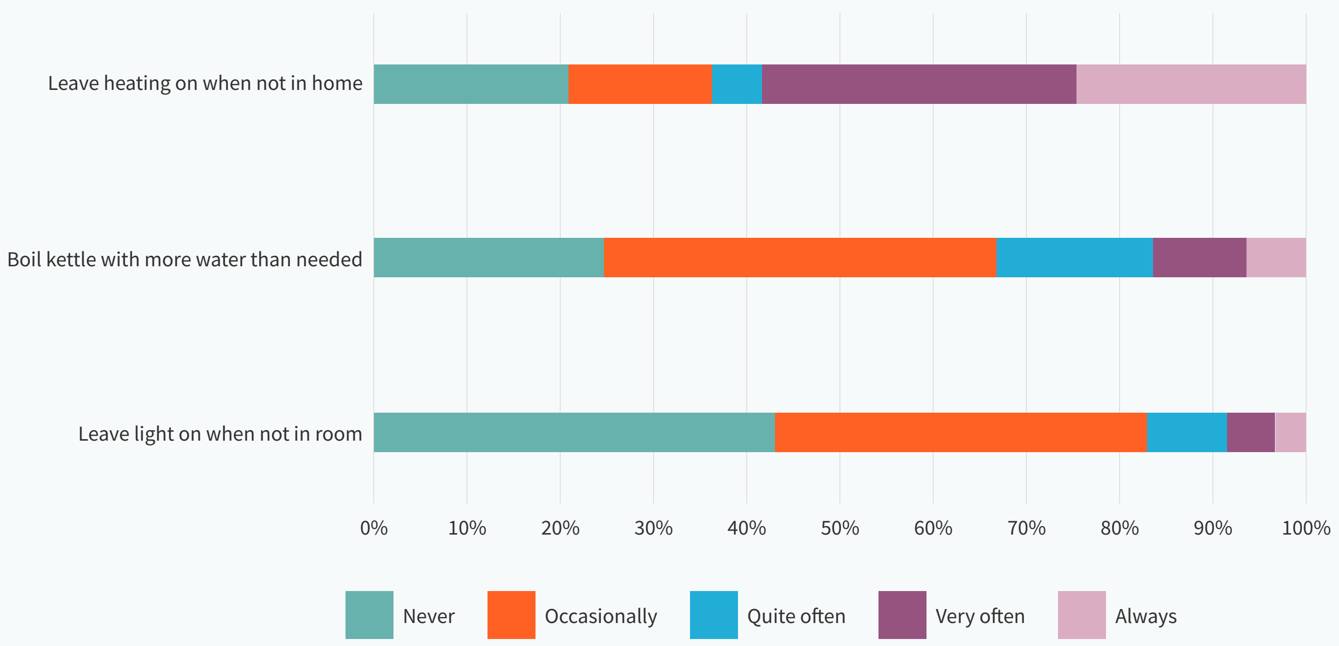


Figure 12 Residential behaviours that waste energy in the UK [21].

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.7: Water waste

The average UK household consumes 143 litres of water per person per day (NAO, 2020). Unless the water evaporates, it needs to be discharged into the wastewater system. The volume of wastewater is harder to estimate, but unsurprisingly, the quantity is also roughly 150 litre / person / day (CBRE, n.d.). Wasted water not only increases the demand for fresh water, but it also wastes energy consumed to treat and transport.

143 litres

is what the average UK household consumes in a day

Wasted water not only increases the demand for fresh water, but it also wastes energy consumed to treat and transport.

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

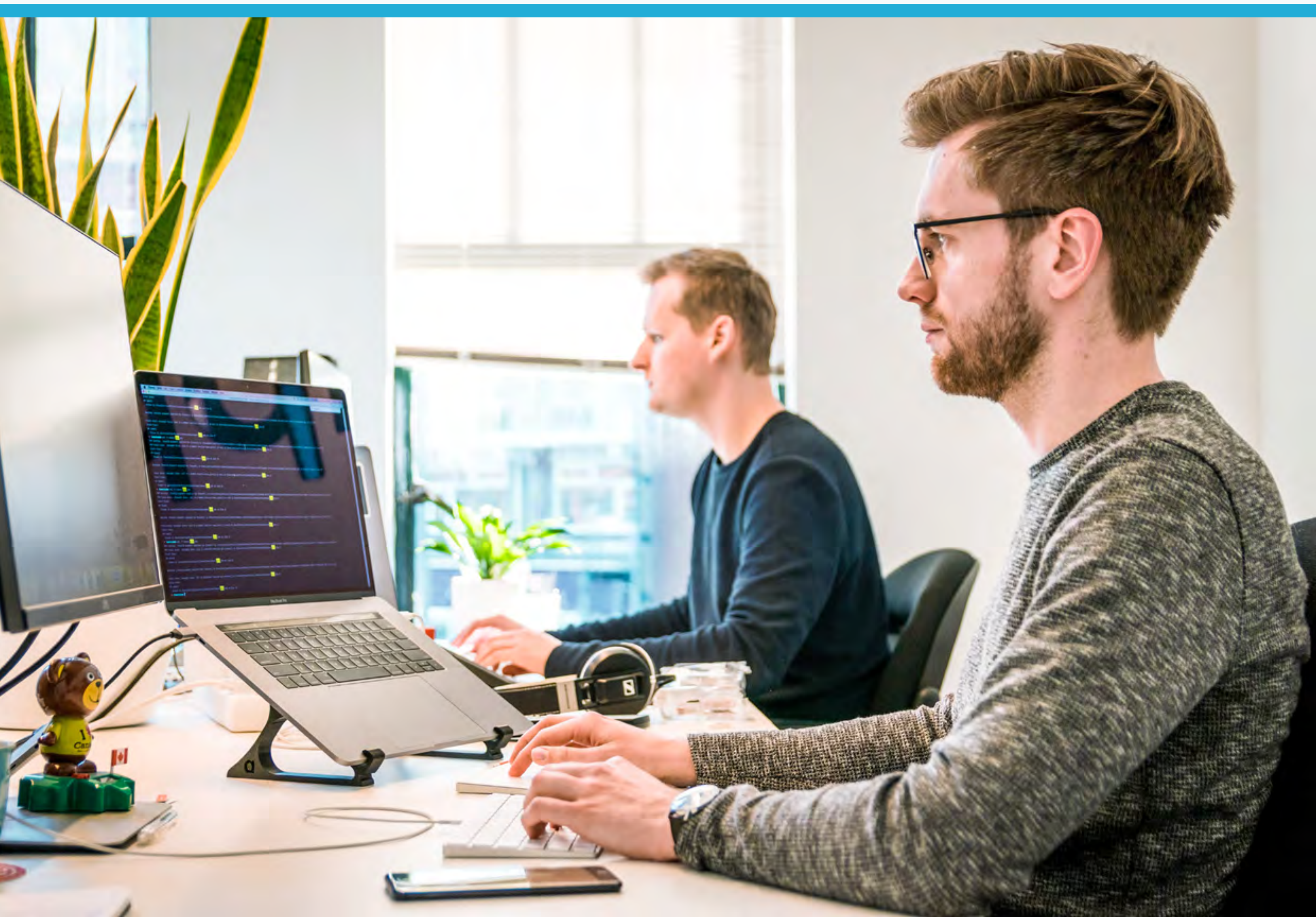
4.8: Operational and behavioural waste

In addition, operational and behavioural waste abounds. As highlighted in the QFlow case study in section 5.1, reducing the effort to audit and inspect materials arriving on site can result in many thousands of pounds of savings. As discussed in the Demand Logic case study in section 5.1, without careful inspection it is not uncommon for buildings to find themselves simultaneously heating and cooling.

CHAPTER 4: ENVIRONMENTAL SUSTAINABILITY AND BUSINESS OPERATIONS

4.9: The role of PropTech

PropTech innovations are increasing the transparency in operational practices, giving managers more control over increasing financial returns and improving environmental resource efficiency. As illustrated by the case of Revcap (next page), there will continue to be an increase in demand for ESG data acquisition and interpretation as sensors get deployed across the entire development phase. The proliferation of IoT devices and other technologies will make it possible to identify and root out environmental waste in the real estate sector, improving returns and creating value.



CASE STUDY

Revcap: Private equity is a data business

The problem

What are we buying? How do we know? These are the questions that Andrew Pettit, Founding Partner of Revcap asks every day. As a private equity real estate fund manager, Revcap raises money from institutional investors and invests it into real estate deals across Northern and Western Europe. They've invested in nearly every property type – from billboards and farms to schools and pubs. Yet one aspect remains constant: Revcap needs historical data to understand the performance potential of any asset. That data needs to be consistent, timely and auditable. PropTech innovations helps fill this data gap.

ESG data is also becoming more important and critical to its business. Although evaluating ESG has been a part of its due diligence process for a long time, it is now a separate investment theme in its latest fund. As a result, consolidating ESG data in a rigorous way has increased in importance. This is easier said than done.

Today, it is COVID-related uncertainties. Although tenant wants and needs will continue to fundamentally shift, GPE's focus of continuous innovation to enhance the occupier's workplace experience will remain the same.

Using PropTech to address the ESG data gap

Revcap is fundamentally a data business. To make financial decisions, Revcap already utilises historical data on yields, rental values, capital values, cost to build, among other KPIs. These are compared to current market forces, such as competing projects, who are the active occupiers in the market, the length of their leases, and so on, to help predict what the potential returns of an asset might be.

ESG scores by themselves fuse together too many attributes to operate against. Environmental attributes alone include energy and water consumption as well as impact footprints of timber, steel, cement and GHG emissions, to name a few. Social and governance factors have their own set of key performance indicators (KPIs). Much of this data already exists but is hidden in pockets across organisations, and innovative PropTech companies are helping reduce the effort to access the data and improve quality control.

The continuous improvement approach to ESG

Revcap already uses continuous improvement methodologies to achieve financial success. The Revcap team is bringing that methodical approach to getting a handle on ESG data as well. The first step is to aggregate the family of ESG data together into a single database to be able to show real improvements to environmental footprint. This is critical to being able to reach its stated net-zero goal by 2030.

The second step is to operationalise, streamline and automate as many of Revcap's internal processes as much as possible. For example, financial and operational software, such as customer relationship management (CRM) software can make employees more effective while reducing errors in data handling. Similarly, once the ESG data is aggregated, automating its data collection and management should reap benefits and allow a proactive approach to achieving its ESG goals.

Lastly, the environmental data needs to be modelled such that there is confidence of correlations between leading and lagging indicators. Meaningful decarbonisation targets can then be set and managed against across the portfolio. Without such clarity, Revcap can only take a policy-based approach to environmental improvement rather than a data-based approach.

Finance as governance

As a fund manager, Revcap's role is to set targets and policies that their assets must achieve. As Pettit noted, "Our job is to make business processes and data analysis more efficient. This improves our decision making." Forward thinking fund managers with a wealth of market relationships such as Revcap are in a unique position to be able to amplify its positive ESG initiatives by disseminating best practices and processes to their diverse joint venture partner and service provider base. There are ample growth opportunities for PropTech businesses to help collect and analyse ESG data in the more opaque and disaggregated real estate markets.

CHAPTER 5:

Decisions for the long, medium and short term

In brief...

1. Decisions made for the long term include sourcing salvaged construction materials; increasing the durability of buildings; as well as creating 'digital twins' and 'material passports'.

2. Decisions made for the medium term include enabling IoT devices to track consumption; installing sensors where needed; and selecting efficient equipment.

3. Decisions made in real time include using IoT devices to deploy 'continuous commissioning'; as well as smart building technologies such as leak detection, energy saving technologies, and fault diagnosis.

Every decision made in the real estate sector today will last for some period of time, constraining future options. For example, the physical structure of a building, such as its thermal insulation, windows, and water management system, could last for many decades if not centuries. The mechanical systems, such as HVAC, boilers, and pumps, are procured and operated based on the needs of the physical structure. These mechanical systems will be replaced every 5-15 years. Finally, tenant and employee behaviour will dictate the daily operational needs that the mechanical system will need to satisfy. Operators will be limited in what they can do by the equipment in place. Thus long-duration decisions will lock-in resource footprints, potentially hampering the ability to achieve net-zero.

This chapter examines the scenarios of three decision cycles – long term (30+ years), medium term (5-15 years), and real-time. Each scenario will discuss approaches, techniques, and technologies to improve environmental attributes, along with brief examples of how investment managers can incorporate sustainability into their decisions.

CHAPTER 5: DECISIONS FOR THE LONG, MEDIUM AND SHORT TERM

5.1: Decisions with long-term (+30 years) duration

As mausoleums, the Pyramids of Giza were built to last forever. 5,000 years later, they are still standing. However, the mean life expectancy of a building built today ranges from 20 years in China to just over 100 years in Europe (Andersson & Andersson, 2019). Design decisions at the beginning of a building's life can dictate the energy, carbon, and water footprints of a property for many years to come.

Embodied energy

As buildings have both embodied and operational energy components, the duration of how long a building is used for matters in its overall resource footprint. As depicted in Figure 13, embodied energy is predominantly consumed during up-front construction while operational energy is consumed year over year. According to one study, it takes only 2-5 years for operational energy to overtake embodied energy as the primary contribution to a building's energy footprint (Ibn-Mohammed et al., 2013). This means that by year 50, only 4-9% of a building's footprint is due to embodied energy in this scenario.

It is misleading to assume embodied energy is therefore less important to manage. First, embodied energy impact is dependent on the lifespan of the structure. Buildings that are demolished and replaced early will have a higher percentage of an embodied energy footprint. Second, it implies that one strategy to reduce embodied energy footprint is to increase the lifespan of the asset. As an example, the Bullitt Center of Seattle was designed and constructed with a 250-year lifespan, rather than a more typical 60-year lifespan. The building needs to be utilised for that period of time in order for the embodied energy footprint to be low at the building's end-of-life.

Operational energy lock-in

The thermal envelope of a building is likely the single most important factor in determining the future energy efficiency of a structure. The Passive House concept increases the insulation of a building such that it simplifies the need for mechanical heating, reducing up to 80% of the ongoing energy need. Thus, upfront design is critical in reducing operational costs. As relayed in the Rice Fergus Miller case study later in this section, the philosophy of 'built for off' resulted in a building that uses mechanical systems for only 30% of the year.

The ability to model energy consumption of a new build is a critical component to achieving long-term sustainability. Pi Labs portfolio company FenestraPro is a design software application that enables architects to design energy-efficient facades for buildings. Architects generally do not know the mechanical requirements of their designs. As a result, their design intents might have poor energy efficiency qualities. This tool gives the ability for architects to converse with engineers to preserve the design intent while optimising for energy.

Figure 13: Total energy of a building over it's lifetime

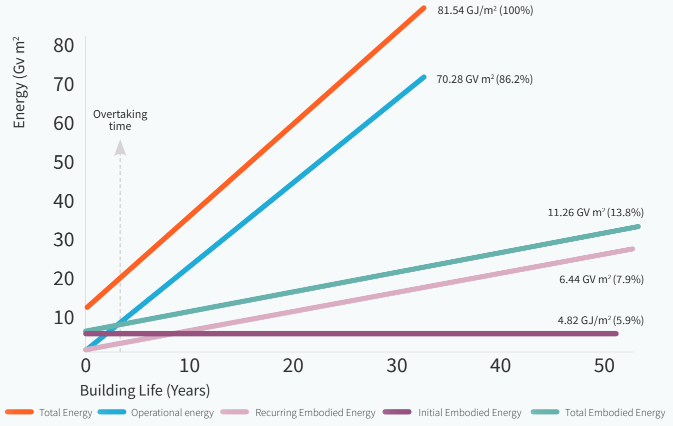


Figure 13 Total energy of a building, including operational, embodied, and recurring energy (Ibn-Mohammed et al., 2013).

One Water

In traditional water management methodology, freshwater is shipped into urban environments, wastewater is shipped out, and stormwater is diverted into rivers. This has become an unsustainable water management paradigm. Figure 14 depicts the difference in water flow for a natural and urban environment. In a natural area, 50% of precipitation infiltrates into the soil and only 10% runs off along the surface into rivers, lakes and streams. However, in an urban environment, due to concrete pavements, merely 15% of precipitation seeps into the ground and 55% is diverted into the waterways (Jiang & McBean, 2021). The paved urban environment is intercepting water that would otherwise seep into the ground. Furthermore, rivers are not meant to handle such an increase in waterflow, increasing the likelihood of flooding as rivers reach capacity.

Natural catchments (Graham et al., 2015) and sponges (Jiang & McBean, 2021) are designed to catch water, giving it time to seep back into the ground. This not only reduces runoff that can create flooding, it also recharges local aquifers, and can create natural habitats for animals, encouraging biodiversity (Graham et al., 2015). For example, The Bullitt Center in Seattle is designed to capture 56,000 gallons of rainwater, of which 61% is returned into the ground, the same percentage as the Douglas Fir forests that used to stand in Seattle[22].

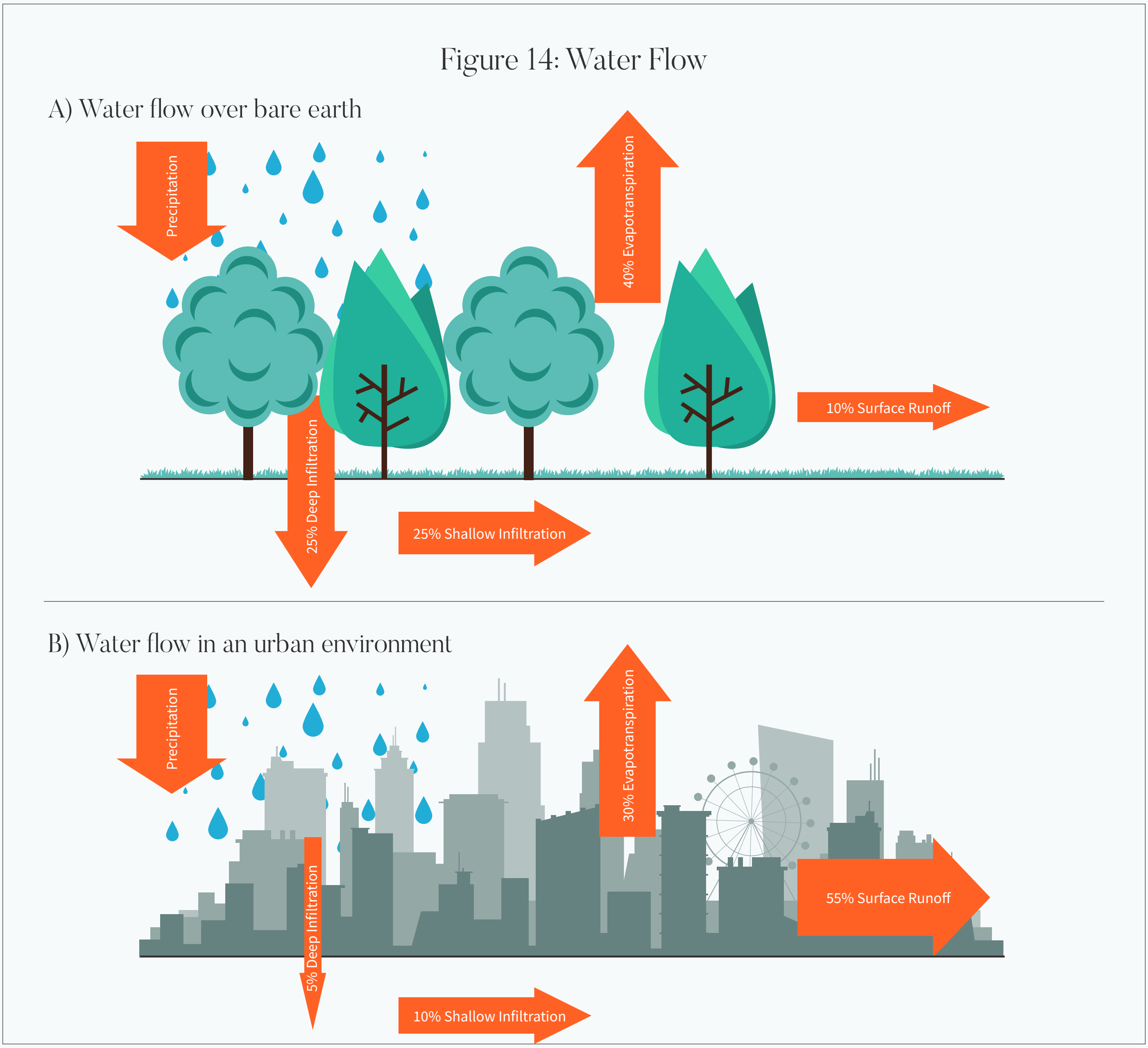


Figure 14 (a) Water flow on bare earth. (b) Water flow in an urban environment (Jiang & McBean, 2021).

Construction materials

A materials passport is a digital report that describes the characteristics of the materials and components in products and systems. This gives direction for present use, recovery and reuse of the material once at the end of its life (Heinrich & Lang, 2019). The intention behind material passports is to encourage the circular economy by diverting end-of-life buildings to new projects rather than to landfills.

Generating a materials passport early in the development process will support the building's end-of-life management. A materials passport interacts between all the stakeholders within the construction value chain, from the project developer on a bare-earth project to a facility manager of a fully stabilised asset. With a materials passport, future managers can make better choices in material recovery, circular product design, and reduce the need for raw materials in future construction projects.

One component of a materials passport is the building information model (BIM). BIMs are digital representations of a building to facilitate design, construction, and operation decisions. BIMs are crucial in construction projects: they enables workers to modify a digital model and examine its systemic effects before implementing a change in real life.

A digital twin is different from BIM in that it also describes how people interact with the building. Although a digital twin is a digital representation of a physical object, the twin is updated with real-time information such that the digital copy resembles the physical world as accurately as possible. Within the built environment, installing IoT devices early in the construction process can help create and maintain digital twin information over the lifetime of the building.

Several organisations have recognised the importance of procurement of materials to meet environmental goals. Each material has its own sustainability certification procedure, such as CARES for steel[23], BES 6001 for concrete[24], FSC[25] and PEFC[26], for wood.

Even with these technologies, construction waste abounds. As mentioned in the Qflow case study later in this section, approximately 14% of all materials delivered to a construction site are wasted. Another Pi Labs portfolio company, Contilio, uses AI and other technologies to track how closely a BIM is followed during the construction phase. This streamlines the verification process, ensuring a building is being constructed properly and preventing wasteful rework.

Considerations for decisions with long-duration impact

For bare earth construction:

- Increase durability: Consider the durability of the project. Longer lifespans project will have a lower embodied energy impact over the duration of the asset's life.
- Decrease operational lock-In: The building envelope will lock-in ongoing resource requirements. Adopt a philosophy of Passive House or Built for Off to reduce ongoing operational footprint.
- Source salvaged materials: The best way to participate in the circular economy is to purchase recycled and reclaimed materials.
- Create digital twins and material passports: A digital copy of the building is just as important to future owners as the physical asset.

After acquisition of a new build:

- Maintain digital twins: Ask for a materials passport, digital twin and energy models of the new construction. Update and maintain these records as changes are made to the asset.

After acquisition of an older, existing build:

- Structural renovations: as with bare earth construction, structural renovations will have durability and operational lock-in considerations.
- Deconstruction: Deconstructing a building maximises the recovery of materials and supports the circular economy. Upwards of 70% of the material can be recycled ore reused in deconstruction projects (Bertino et al., 2021)

CASE STUDY

Rice Fergus Miller: Built for Off

The challenge

"Eating your own dog food" is a term frequently used in the software industry, where companies are required to use their own products that they sell. Companies are therefore incentivised to think like a customer, as employees will be exposed to the same issues customers may face. For Rice Fergus Miller (RFM), an architecture firm, designing their own headquarters gave them a chance to wear their customer's shoes.

RFM is a 40-person firm based in Bremerton, Washington, a small city of 30,000 people just outside of Seattle. They bought an abandoned and dilapidated Sears auto store in downtown Bremerton. Because the structure was so old, they had an opportunity to replace everything, giving them a blank canvas from which to design their new headquarters.

Constructing a cost-effective and functional headquarters took on a new meaning for the RFM team when the three founding partners mortgaged their houses to purchase the building. With no funds available to pay for a green premium, the RFM team set out to build the best permanent headquarters they could within the budget that they could afford. As founding partner Steve Rice said, "Our homes were at stake to afford this place. We needed to make sure it operated at the lowest cost possible so we could get our money back!"

Design principle: Built for off

Buildings are built with the assumption that mechanical systems need to be "on" for normal functionality. RFM took the opposite approach. The headquarters is designed so that it is operating normally when everything is turned off[27]. Equipment and devices are turned on only when it is necessary to return the building to normal operations. Washington State's unique weather pattern helped tremendously. The average outside temperature ranges between 4-21 degrees C (40-70 degrees F), a similar temperature range as is comfortable for people. The mechanical systems are therefore designed to operate only when the internal conditions are outside of this band.

First, the team heavily insulated the structure. Although Bremerton has a temperate climate, the daily temperature swing can be quite significant. Higher insulation increases how much heat can be retained in the walls at night. This delays the need for mechanical heat during the day. The building ended up being so well insulated that it can maintain comfortable internal conditions in the face of a shift of over 11 degrees C (20 degrees F) in outside air temperature.

Second, they separated the ventilation process of providing fresh air from the heating and cooling processes of providing thermal comfort. This way, the two problems could be solved separately. If the outside air temperature was sufficiently warm, fresh air could be piped in or employees could simply open the windows.

Third, the building had five sources of heat that were deployed in sequence. First, the insulation retained heat, providing a strong foundation of thermal comfort. Second, the workstations and computers generated a meaningful amount of heat. Even though the building used LED lights, they still generated a noticeable amount of heat. Fourth, the people and occupants generated body heat. RFM also purposefully built a 3-story tall atrium, extending through their office. At the top of this plenum, they installed a large fan. Since hot air rises, the fan circulates the accumulated warm air at the top of the building down to the ground floor[28]. Only when these options are insufficient do they turn on mechanical heat. As a result of these passive solutions, the active heating system is only used 30% of the year!

The outcome

The facility achieved an energy use intensity (EUI) of 19 kBtu/ft2 in its first year of operations[29]. For comparison, the EUI of an average US office building is 80 kBtu/ft2. The RFM headquarters consumes a quarter of the amount of energy that is typical, saving a huge amount of money for the firm, and for the founders, helping them recoup their costs. For their efforts, the building was awarded LEED Platinum rating in 2012.

Although RFM set out to build well, they ended up building green.

Figure 15: Before Photos

Figure 15 Before photos of RFM headquarters

Figure 16: After Photos

Figure 16 After photos of RFM headquarters, built for off.

CASE STUDY

QFlow: Waste is design gone wrong

The challenge

In the construction phase of a building's lifecycle, waste is design gone wrong. For the principal contractor, developer and other stakeholders, waste can be both a cost risk as well as an environmental compliance risk. With the recent release of the Hackitt Report in the UK, developers are under pressure to ensure that non-compliant raw materials do not creep into their buildings, potentially causing health and safety issues for tenants and occupants.

Waste manifests itself in several forms. Developers frequently have set environmental targets for their new construction. There could be certification requirements for key materials, such as steel, concrete or wood. Further, some developers also require environmental product declaration (EPD)[30] or have adopted ISO14001 standards for environmental management[31]. Not only is time wasted and additional costs incurred to dispose of non-compliant materials, but material already built into the structure may need to be removed. The risk is high enough that principal contractors will employ teams to check and audit the materials arriving on site.

The solution

Qflow's solution helps principal contractors to automate the process of tracking materials they enter and leave the construction site. Customers take photographs of the bill of materials or invoices, and Qflow uses AI and other technologies to digitise the record. The materials attributes can then be compared to the sustainability and other certification criteria, ensuring compliance.

According to Qflow's records, approximately 14% of all key materials they have tracked onto site is non-compliant. Sometimes the supplier makes a mistake and ships the wrong product. Sometimes, a trade contractor makes a substitution without asking for permission when the compliant material is unavailable. Sometimes it's just a simple case of miscommunication. Preventing non-compliant materials from being used saves both time and money.

The benefit

For Canary Wharf Group, who had a stringent requirement of 100% FSC certified timber, the cost savings of automation of materials auditing was £190,000. This was achieved by reducing paper work, but also avoiding the costly mistake of having to remove non-compliant material from their structure[32]. For another principal contractor, the use case was in cost control to verify invoices. Once a construction project is completed, Qflow's data becomes part of the building's Health and Safety record, giving developers perspective on their portfolio and how their delivery partners are performing. This feature was important to another client, who uses Qflow to ensure that the materials used for fit-outs do not release toxic off-gasses and other toxic fumes.

The further opportunity

Brittany Harris, co-founder and CEO, noted, "The construction industry is just at the beginning of unlocking the real power of data." As digital twins become more prevalent, being able to match the physical data with the building information modeling (BIM) data becomes more critical. Qflow has already worked with clients who have day-to-day quality control needs to clients who need a record of the sustainability attributes of the end product. It's the same data that meets all of these use cases. Thus, this single data set Qflow is capturing is set to give exponential returns from the many use cases it addresses.

Qflow co-founders Brittany Harris and Jade Cohen

CHAPTER 5: DECISIONS FOR THE LONG, MEDIUM AND SHORT TERM

5.2: Decisions with medium-term (5 to 15 years) duration

In the 5 to 15-year cycle, tenants will likely change, and most equipment will be replaced. Long-term decisions will constrain the flexibility to redesign and repurpose a space. For example, the size of the mechanical equipment for heating and cooling will be determined by the thermal envelope of the core and shell. Some medium-term decisions will be heavily influenced by tenant preferences. This includes the fit out of the space, the lighting controls and air quality. Others will be common improvements to the building, such as mechanical rooms and electrical equipment. These equipment decisions will constrain the operating procedures of real-time activities.

Materials in fit outs

Fit outs and tenant improvements have similar embodied energy and material flow challenges as in new construction. They are typically smaller construction projects than their new built counterparts, but still involve design, construction and demolition phases. Sustainability can be very much part of the planning and execution[33].

The Responsible Fit-out Toolkit developed by the Better Buildings Partnership gives an overview of sustainable fitout processes[34]. Certification schemes also have specific rating systems for fit outs, such as BREEAM, LEED, SKA, WELL, and FitWel.

Volatile organic compounds (VOC) are emitted by a range of products in the construction process, including paints, cleaning supplies, carpet and other flooring, upholstery, and so on[35]. VOCs may have short- and long-term health effects on tenants who are occupying the space[36]. In the Bullitt Center's construction, the team created a materials red list that identified 14 chemicals that were to be avoided in products procured for the project. As a result of their ban, the team compiled and published a product list of materials and manufacturers that were suitable to use[37].

Pi Labs portfolio company Propster helps developers by streamlining configuration options to show to tenants. Propster maintains a database that includes a list of materials, where they came from, and the life expectancy of the products. This helps tenants procure sustainable and locally sourced materials. Qflow, as highlighted in the case study, has also been used in both new build and fit out construction projects to manage material compliance and waste.

Equipment selection

Mechanical systems selection is both an art and a science. Components such as boilers, chillers, condensers, fans, exchangers, motors, and compressors are integrated into electrical, plumbing, and data infrastructures that span throughout the building. Operators will be required to use the equipment installed, so some forethought into use cases will help support operational efficiency and energy efficiency.

Motors can come in constant and variable varieties. Constant motors only have two settings – on and off. They are unable to vary based on the load needed. Variable motors, on the other hand, can be adjusted to meet occupancy demand patterns. For instance, to serve a floor with cold air, a constant motor will need to run at full capacity regardless of the number of people in the room. A variable motor, meanwhile, could adjust the airflow based on the people in the room. Variable motors use less energy than their constant counterparts. These motors can be found in air handling units, fans, water systems, and so on.

Most equipment today already comes with many sensors and with energy management software. Yet the energy management package is not always purchased alongside the equipment. Equipment with remote monitoring and control software simplifies operational practices as it reduces the amount of time to diagnose and fix a problem.

Fault detection and diagnosis and continuous commissioning outlined in Chapter 5.3, will depend on these software packages being in place.

Water fixtures and other equipment

Water consumption varies greatly depending on end uses. Residential units and hotels use more for showers while sporting venues have a higher toilet water consumption. As shown in Figure 17, domestic / restrooms are usually the largest component of commercial water consumption, followed by mechanical needs of heating and cooling, landscaping and kitchen[38].

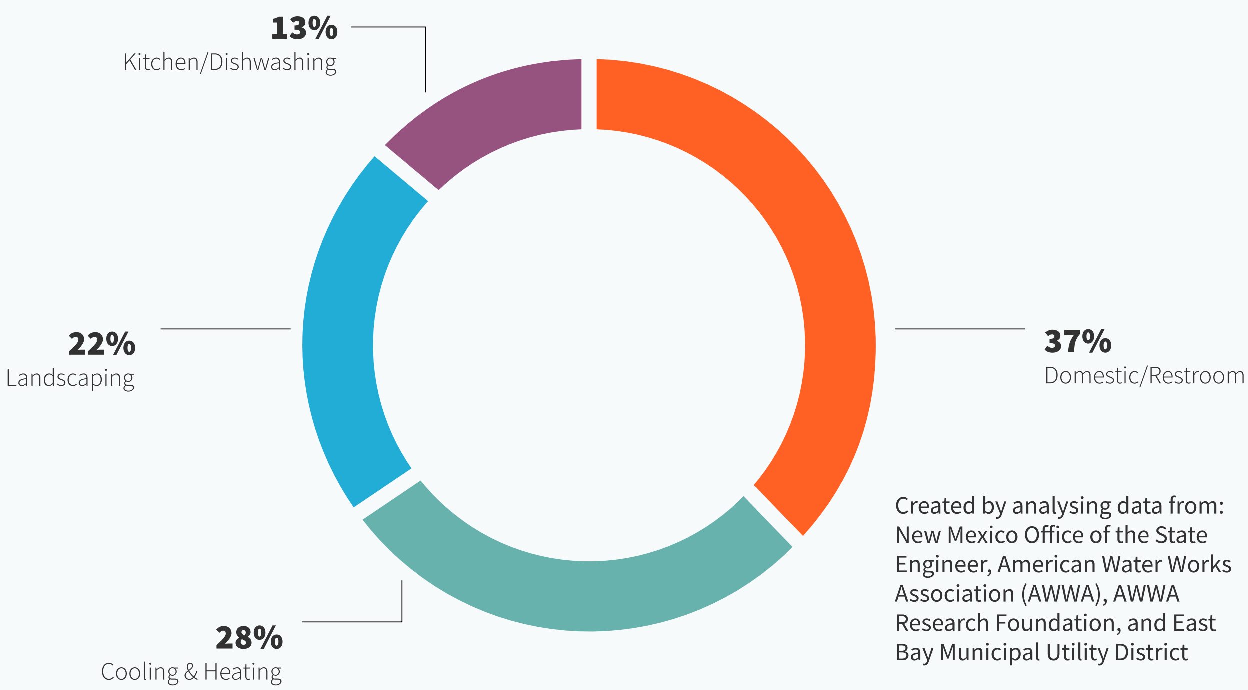
For each end use, fit-for-purpose equipment is available to reduce operational water footprint. Sensor-enabled taps can reduce water usage as well as prevent the taps being left on by accident. Dual-flush toilets and urinals that are fed with rainwater or no-flow urinals can reduce water usage. Replacing potable water with rainwater or greywater whenever possible can also reduce water footprint through reuse and recycling (Allen et al., 2010). For instance, mechanical heating and cooling can be accomplished with rainwater rather than freshwater. The greywater can then be used in the toilets, urinals, or irrigation rather than being discharged in the sewage and septic systems.

Commissioning

It is not uncommon for the energy consumption in a building to increase over time. Buildings evolve over time, as tenants change and as equipment gets replaced. With each change comes an opportunity to improve efficiency, or, as is more often the case, for inefficiencies to creep in. Temperature settings might be overridden and not re-set, mechanical system reconfigured, and new floor layouts might demand new air flow patterns. With thousands of sensors and controls within a building, many small, seemingly inconsequential tweaks can drastically reduce the efficiently of the whole structure.

Commissioning is a process to verify that the building is operating based on the design intent. It is a required step prior to welcoming the first tenants in a new construction. Retrocommissioning is becoming popular in existing buildings as it can identify and reduce energy drift, achieving savings of 13-16% (Crowe et al., 2020). However, at best, retrocommissioning is done once every 5 years, still allowing the building to drift substantially.

Figure 17: End uses of water in office building in the USA



Created by analysing data from: New Mexico Office of the State Engineer, American Water Works Association (AWWA), AWWA Research Foundation, and East Bay Municipal Utility District

Figure 17 End uses of water in office building in the USA [39]

Capital planning

With good maintenance, equipment can last for a long time. However, as equipment comes to end of life, replacements need to be sourced. Doing so proactively could help prevent downtime. With state-of-the-art equipment becoming more energy efficient over time, it is important to stay on top of new developments. Unfortunately, maintenance staff are usually stretched thin, and unable to proactive equipment replacement and capital budgeting needs.

Pi Labs portfolio company Audette helps with this challenge by digitising maintenance records and inventories of equipment. This streamlines and facilitates the capital planning discussions amongst the financial, facilities and sustainability managers who need to ensure retrofit projects meet economic, operational, and environmental performance targets.

Considerations for decisions with medium-duration impact

For bare earth construction:

- **Source efficient centralised equipment:** Although the core and shell can last for many decades, the centralised mechanical systems will need to be replaced. Procuring state-of-the-art efficient systems with monitoring software will enable efficient operations over the lifetime of the equipment.
- **Enable IoT devices:** To support ongoing digital twin initiatives, ensure the building has sensors installed in critical components and broad WIFI to connect the devices. Critical sensors include energy submeters, energy management software, and control software.
- **Submeter the building:** Energy submeters can enable measurement of tenant energy consumption. Submeters are less expensive to install during a new build and more expensive to retrofit.

After acquisition of a new build:

- **Commissioning:** Commissioning will be done prior to the first tenants moving in. Create a culture of continuous commissioning and install sensors where they are missing and needed.
- **Maintain records:** Anecdotally, it takes 5 years for a large building to shake out its systems and run efficiently. Data can be used not only to support the digital twin but also to create best practices for building operations.

After acquisition of an older, existing build:

- **Equipment inventory and capital plan:** Create an inventory of equipment and their expected date for end-of-life. Begin creating a capital plan and sourcing of replacements. Minimise downtime by proactively replacing equipment near end-of-life.
- **Replace any constant motors with variable motors:** Variable motors can be adjusted to meet demand while constant motors only have two settings – on and off – regardless of the number of people in the building.

CASE STUDY

Demand Logic: Make what you have work better

The challenge

How well is your asset performing? And if you believe the building to be performing well, how do you know? These are questions that Mike Darby, CEO and Co-Founder of Demand Logic is used to asking. As a former commissioning engineer, he was tasked with investigating and resetting a building to its designed standard. Buildings are constantly being adjusted as tenants turn over, seasons change, and the building's facilities team changes. With each change, the building's performance might be compromised due to adjusting configurations beyond the expected design of the building or equipment.

A typical building's performance is usually based on a consultant's report or a dashboard. However, rarely do these provide data usefulness at a frequency to make changes should the building be wasting energy and other resources.

The solution

Demand Logic's software platform dives deep into the data resources already available at the building and gives the appropriate details that one needs to make decisions. For the engineer and maintenance team, it's the nuts and bolts of what might need attention, such as a jammed valve in an air conditioner. For the property manager, it is a 28-day trend of how the building has changed.

For an asset manager or a portfolio manager, data usefulness is an aggregated building score based on the building's performance. This performance consists of three KPIs, the first being energy performance. Monitoring energy consumption consistently helps keep it at a minimum, thereby directly impacting the carbon performance of the asset. The second KPI is maintenance effectiveness. As energy consumption is a lagging indicator of behavioural and equipment change, monitoring energy gives a direct indication that something changed and needs investigation. When energy is correlated to the thousands of sensors within a building, it is pretty simple to point out maintenance matters before costly breakdowns occur. The last KPI is occupant satisfaction. As buildings get reoccupied, owners want to know if the space is comfortable for tenants. This includes air quality, ventilation, and other comfort variables.

The result

Wasted resources can be identified in as little as three days. For the 34-storey Walkie-Talkie tower in London, Darby's team is monitoring over 175,000 data points generating 17 million data points daily[40]. At Kings College London, their monitoring has helped save £390,000 per year in energy costs[41].

The ongoing monitoring of a building is just as critical as identifying one-off opportunities. Due to the unique weather patterns in the United Kingdom, it is not uncommon for a building to end up both heating and cooling at the same time. This happens usually due to non-optimal configurations within the building automation system. In one case, a building was consuming over 500 homes' worth of energy in unnecessary cooling and was countering that with over 600 homes' worth of energy in unnecessary heating! Ongoing monitoring can help identify poor behavioural practices early, preventing runaway costs.

The benefit

As Darby puts it, engineering teams are constrained by the buildings they work within. Each building can be run as best as it can, given the physical limitations and equipment within it. Small, quick, and cheap OpEx changes can result in reducing waste and improve the asset's performance. Buildings that aren't environmentally sound are going to become stranded assets in the future. Running buildings as well as they can reduces that risk.

Save energy
Save 10%-30% of energy costs and reduce carbon emissions

Improve maintenance
Reduce maintenance time by up to 30% and improve effectiveness

Increase comfort
Reduce comfort complaints by up to 100% and improve occupant productivity

CHAPTER 5: DECISIONS FOR THE LONG, MEDIUM AND SHORT TERM

5.3 Real-time decision cycles

It has been said that optimising a building's energy consumption by using the utility bills is like driving a car by using the rear-view mirror. Real time data not only needs to be timely, it also has to portray situational awareness to the manager such that he or she can make contextual decisions.

Operators are constrained by the building's existing equipment and structure. While new systems can run well with little effort, an experienced facilities team can make even an old system run as efficiently as a new build.

Procurement policies are critical in supporting the waste management programme as consumables will be disposed of in short periods of time.

Materials procurement and solid waste management

Waste is typically sorted into separate bins for recycling, composting, or landfilling. One challenge is that if the wrong item is placed into a recycling or composting bin, the entire bin will get sent to landfill. One business discovered that placing a sign with photographs of what should go into each bin increased the likelihood that the trash would be properly sorted.

Procurement policies are critical in supporting the waste management programme as consumables will be disposed of in short periods of time. Some best practices of procurement are to buy from recycled or repurposed sources so as to support the circular economy, buy durable so that the product can be used multiple times before being disposed of, and buy recyclable and compostable products, so that the refuse does not end up in landfills.

Figure 18: Common faults identified using FDD technology

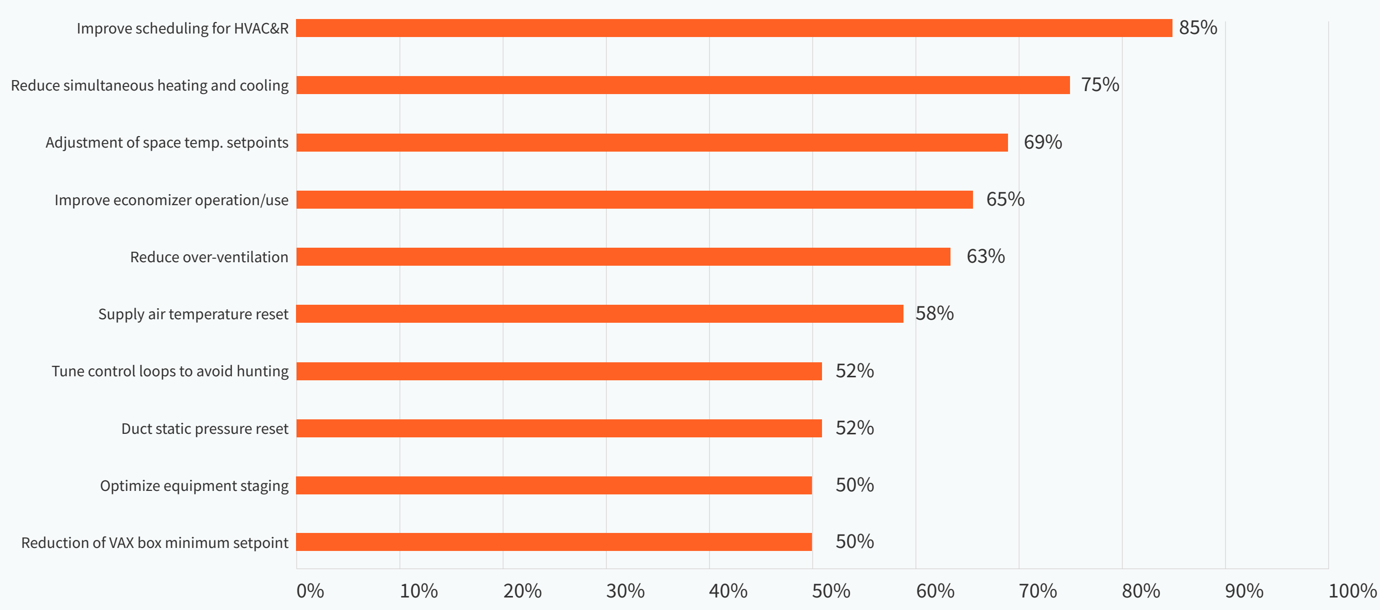


Figure 18 Common faults identified using FDD technology (Lin et al., 2020).

Operational energy and continuous commissioning

Continuous commissioning takes commissioning one step further. Rather than perform commissioning once every 5 years or so, continuous commissioning uses IoT devices, sensors, and controls to monitor for changes and adapt in real time. This keeps the building running based on its design intent and at peak efficiency.

For example, Microsoft's Redmond campus is a small city with 125 buildings. Historically, the facilities team commissioned the building once every five years, resulting in about 20% of their campus being checked out annually. After installing over two million sensors across their campus, collecting 500 million transactions per day, the team can now commission their entire campus once per year. The buildings can get tuned regularly and respond to daily changes. This led to $2 million in savings in the first year alone[42].

Fault detection and diagnosis

Related to continuous commissioning is fault detection and diagnosis (FDD). A fault can be defined as any operations that deviates from normal. This could be due to minor issues such as thermostat resets, to detecting needed repairs before breakdowns occurs. Software and sensors can identify variations in operational conditions, alerting managers that something's amiss. The manager can then investigate further to correct the problem.

In a study of 27 buildings in the U.S., FDD systems had a median cost of $0.12 per square feet, including annual software and labour costs. The FDD systems were able to save $0.27 per square feet in utility costs (Lin et al., 2020).

Pi Labs portfolio companies Demand Logic and Switchee both offer continuous commissioning and FDD benefits. As the two case studies highlight, Demand Logic can easily aggregate thousands of data points in commercial buildings, identifying faults and saving money. Switchee not only saves money both in energy and maintenance bills for social housing, but also improves the communication between landlords and tenants.

Water leaks

Water leaks can cause major damage to the interior and exterior of buildings. According to one estimate, escape of water claims are costing insurers nearly £1 billion each year. Although most people consider water damage as a residential issue, water damage in the commercial sector can be upwards of £1 million per instance, even though occurrences are less frequent than in their residential counterparts[42]. Common causes of water leaks include weather, but also construction practices, workmanship, maintenance, as well as tenant occupancy behaviour and lifestyle[43].

Leak detection software works similarly to FDD software. Sensors can be placed inside water pipes that monitor the flow of water. The data can be captured and analysed for consumption behavioural patterns. When potential leaks are detected, the problem can be isolated with water shut-off valves before water damage becomes an issue.

Rightsizing for behavioural variables

Traditionally, mechanical systems are scheduled to turn on in preparation for employees to arrive and turn off when the last people leave. The proliferation of work-from-home policies has changed the number of people in offices, thereby affecting the system's operating schedule. A more nuanced approach is to use sensors to match system operations to the number of people within a building. As an example, occupancy sensors can decide when lights should be turned on or off.

Air quality monitors can inform when the HVAC system needs to be turned on to provide fresh air. Pi Labs portfolio company *720 Degrees* uses CO2, temperature, humidity, particulate, and other sensors to monitor the health of a work environment. This can reduce complaints while improving productivity, comfort, and the health of the people inside.

Business process improvements

Automation of business processes, workflow management, and record keeping of environmental indicators also have an important impact. For example, Pi Labs portfolio company ConWize helps principal contractors manage tenders for subcontractors. Streamlining and automating the process leads to fewer errors and better oversight. One Utility Bill is a software solution that bundles together utilities, broadband, and media into a single bill. Landlords can then let out flats inclusive of the bills. RESTSolutions helps portfolio managers by automating acquisition of environmental data from real estate assets for sustainability reporting. This removes the need to depend on asset managers and JV partners to submit the data themselves.

Ideas for decisions with real-time impact

For bare earth construction:

- **Create a culture of continuous improvement:** Continuous improvement methodically reduces waste. This could be physical waste due to ordering the wrong supplies, or time wasted, such as inefficiencies in managing subcontractors.
- **Automate processes:** Business processes for construction can be automated and digitised. This can help reduce errors, reduce auditing time to certify compliance, and improving handoff of data to the developer.

After acquisition of both new and older builds:

- **FDD and continuous commissioning solutions:** In existing buildings, it is critical to understand the state of the mechanical systems. FDD will help identify any faults that need to be corrected and continuous commissioning will keep the equipment running well. Invest in IoT sensors if they don't exist to support this initiative.
- **Understand tenant behaviours:** Use occupancy data to understand how tenants are using the asset. This will inform the operations of the building.
- **Maintain digital records for the materials passport:** Changes to the facilities should be reflected in the digital twin and materials passport.

CASE STUDY

Switchee: A human interface for sustainability

The problem

In 2020, Dudley Council committed to reducing carbon emissions in council buildings[44], including in its 21,000 socially rented properties[45]. This created a huge opportunity for Switchee who won the tender to help with their smart thermostat IoT device and analytics platform. As CEO Tom Robins noted, "Many automated thermostat solutions targeted private and high-end residential markets. We felt that this technology should be available to social housing where it is arguably needed more."

As landlords, local government plays an important role in reducing carbon emissions and social housing has its own challenges when it comes to managing energy. For the residents, energy is a larger percentage of their income than national average. A household is considered fuel poor if its disposable income, after housing and energy costs, is below the poverty line. Average households might spend 1-4% of their income on fuel, fuel poor residents might spend upwards of 10-20% of their income on fuel (Jia & Crabtree, 2015). Reducing waste and optimising consumption not only reduces the carbon footprint for the housing sector, but residents also end up with more disposable income.

The solution

Switchee optimises the performance of the boiler system with both hardware and software components. For hardware, Switchee offers smart thermostat, a CO2 monitor for air quality, and an AC clamp to measure energy. The software analyses the trends and matches the boiler operations to meet real-time demand, taking into account external temperature and weather variables.

The results

On the surface, Switchee has been able to achieve a 17% reduction in average bills for residents, but the benefits for social housing owners run deeper.

To a landlord, Switchee offers three value propositions that reduces operating costs:

1. Connectivity: Landlords can gain insights into the properties across the portfolio. Issues with condensation, damp, and mould are connected to internal temperature of a property. Having a smart thermostat can give a steer on whether issues are behavioral or due to the fabric of the building.
2. Control: Remote diagnostics of the boiler system has reduced the number of maintenance trips deployed. The severity of an issue can be determined with remote monitoring and control, thereby sending staff to make visits only when necessary.
3. Communication: Switchee's thermostat has an intentionally large screen with a display for messages. Landlords can communicate with the tenant on basic issues, such as scheduling boiler inspections and maintenance calls. Access to the residents have increased from an average of 25% to 87% with the increased communications. This increases the number of successful visits, thereby reducing operating expenses.

For its work, Switchee has been the recipient of numerous awards, including the 2020 Queen's Award for Enterprise[46], Ashden Award, and 24Housing Innovation of the Year.

The company provides data insights and smart devices to the residential landlord market

Residents save 10% on energy bills
(approximately £150 p.a.)

Landlords get 10% reduction in maintenance costs
(e.g. £464,700 p.a. for a small Housing Association)

Conclusion

Real estate is facing a looming stranded asset risk due to increasing stringency of energy and climate regulations. However, ESG indicators today are not fit for environmentally sustainable real estate. E, S, and G indicators need to be unbundled and separately managed. Operational decision making needs to include leading and lagging indicators so that managers can connect between action and results. Continuous improvement practices require feedback loops of data to enable the reduction of waste and continued enhancement of outcomes.

PropTech is well positioned to fill the ESG data gap. E, S, and G data is not standardised, creating business opportunities for new ventures. The proliferation of sensors and IoT is making it easier to measure and monitor energy, carbon, water, and material flow throughout the development cycle.

However, just optimising today's operations is not enough to achieve a net zero carbon future. Decisions made today may unintentionally lock-in high consumption requirements for the future. The duration of a decision's outcome will affect the environmental impact. Longer-term impacts, such as construction of the core and shell, should focus on thermal envelope considerations. The increase in embodied energy to deliver higher insulation will be offset by lower lifetime operational energy. Medium-term impacts, such as equipment selection, should focus on maximizing efficiency of the device being procured. Real-time decisions should focus on maintaining proper operations, such as continuous commissioning or fault detection systems.

Cross-cutting solutions across long-, medium- and real-time decision making are material passports and digital twins. For developers of new space, new build operators and renovators of existing buildings alike, material passports and digital twins become a collection of all past decisions and modifications made to the physical asset. This greatly enhances the current owner's ability to make wise decisions. Furthermore, continuous commissioning and fault detection and diagnosis software can maintain optimal operating conditions, regardless of the age of the asset.

Although real estate is one of the largest consumers of environmental resources globally, it is promising that there exists a plethora of technologies and practices that can help managers and developers to achieve net-zero carbon. Managers need to start considering and implementing these solutions today if we are to reach net-zero targets by the end of this decade.

Footnotes

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