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Contents

Foreword 3

Introduction 4

Chapter 1
Sector attitudes and understanding 5

Chapter 2
Policy and standards: The sector's view 7

Chapter 3
Perception v Reality 9

Chapter 4
The road to net zero is paved in tech 10

Conclusion 11

Case study
Limerick 12

Foreword

"DIRECT BUILDING CO_2 EMISSIONS NEED TO BE REDUCED BY HALF TO BE ON TRACK TO ACHIEVE NET-ZERO BY 2050"

Astonishingly, buildings account for 40% of carbon emissions worldwide but are often overlooked in decarbonisation and sustainability strategies.

To meet net-zero by 2050 pledges and to limit global temperatures to the crucial 1.5 degrees, we need to bring our built environment to the centre of net-zero strategies. Successfully plugging inefficiency gaps currently prevalent throughout the world's building stock will make a significant and vital difference to overall carbon reduction.

This is not just theory or thought but is being reiterated by industry bodies and their research. According to the IEA GlobalABC report, direct building CO_2 emissions need to be reduced by half to be on track to achieve net-zero by 2050 and the status report for 2021 has set out a triple strategy for decarbonisation: reducing energy demands, decarbonising the power supply and addressing the embodied carbon stored in building materials.

It is clear from our research that mass-optimisation of the built environment is not going to happen without legislative action. More than half (51%) of those working in the sector believe that net-zero by 2050 is unachievable without this kind of action. Positive change in this area is happening, with 18 more countries adopting building energy codes this year and the number of countries with building actions included in their nationally determined contributions (NDCs) increasing by 51% to 136 countries.

However, the built environment sector needs to focus on energy use from actual buildings and not just their energy code ratings as not all buildings that are classed as low energy perform as well as expected. In fact, most don't.

This report aims to bring to light the true implications of buildings on the environment, something that is crucial before we can successfully make reducing their impact a priority and decarbonise the sector. Even within those working in the industry, there is a crippling unawareness. The majority (58%) of built environment professionals think that enough is being done to make buildings more sustainable and 51% believe that construction is the place to make sustainability gains when really buildings use far more energy in operation than construction. Only a fifth (22%) cited operations and energy use as a key sustainability gaining area.

We need widespread use of proper tools to accurately measure building performance from design to operation. Progression in the right direction is happening, something we can attest to as IES's technology has now been used in a million buildings globally, but the move is still too slow. We need to see a rapid uptake of digital technologies that will focus on real-life energy consumption rather than checkbox code more action and legislation focusing on the operational side of buildings to lessen the gap between true sustainability and energy ratings as there is currently a major disconnect.

Introduction

"BUILDINGS NOW ACCOUNT FOR ALMOST 40% OF ALL GLOBAL ENERGY-RELATED EMISSIONS."

The space in which dialogue around sustainability takes place has become increasingly fractious in recent years. Though there is unanimity in the belief that more needs to be done to avert the impending climate crisis, there is discord in how we reach that goal. This is due, in part, to the existence of knowledge gaps as to where the greatest work needs to be completed.

Within conversations dominated by the likes of vehicle emissions, fossil fuel excavation, and deforestation, few are aware that the built environment is one of the most significant contributors to carbon emissions worldwide. Compared to figures collated for 2019, in 2020, CO_2 emissions from building operation increased to an all-time high of around 10 gigatons, or 10 billion metric tons. With the inclusion of carbon output generated from their construction, buildings now account for almost 40% of all global energy-related emissions.

More worrying still, GlobalABC's new Buildings Climate Tracker – which considers measures such as incremental building energy efficiency investment and the share of renewable energy in global buildings – finds that the rate of annual improvement is in decline.

In fact, in order to put the built environment sector on a realistic track to achieving net-zero by 2050, the document states that all stakeholders across the buildings value chain must increase decarbonisation efforts and their impact by a factor of five.

In this report, we summarise findings from the largest ever research project that investigates what leading built environment professionals feel about the current status of sustainability methods and targets. We explore their thoughts on the emerging sustainability themes for the coming decade and how they believe those themes will impact the built environment sector and landscapes of our cities.

The title of our report, *The City of Tomorrow*, is borrowed from Swiss-French architect and urban planner, Le Corbusier, and his seminal work, *The City of Tomorrow and Its Planning*. In it, Le Corbusier articulates concepts and ideas he would implement in his city planning schemes from Algiers to Stockholm.

Recognised today as a work that, quite literally, helped shape our world, The City of Tomorrow and Its Planning describes a European city-scape characterised by a melee of poor design and inadequate housing that sprouted from the makeshift clutter of medieval conurbations.

Almost a century on from The City of Tomorrow and Its Planning first going to print, our modernised cities now face a different challenge; traversing the road to net-zero. Through this report, we hope to provide additional markings that allow that road to be followed to its destination.

Chapter 1
Sector attitudes and understanding

"85% WERE NOT USING SCIENCE BASED TARGETS TO HELP LIMIT GLOBAL TEMPERATURES TO A MAXIMUM INCREASE OF 1.5°C."

Though knowledge is weak, action is strong

It is not possible for any issue to be successfully tackled if knowledge of the issue is lacking. Thus, our research had to begin by asking our respondents how much of the UK's carbon footprint they believe is contributed by the built environment. Only one in five (20%) correctly estimated the contribution to be between 31-40%. In other words, 80% of respondents estimated incorrectly and most believed the contribution to be lower.

To establish whether the sector was responding to the carbon footprint made by built environments, we then asked whether the organisations that respondents work for are actively working towards net zero in their built environment projects or buildings. The results here were more promising, with 79% reporting that it has been on their agenda for at least the last year. Only 5% were taking no action nor had plans to.

Science loses out to standards

When engaged in battle against a crisis as grave as climate change, some action is better than no action. But action grounded in science is likely to deliver the most measurable impact.

Of the various targets, standards, and reporting schemes respondents claimed to be using, 85% were not using science-based targets to help limit global temperatures to a maximum increase of 1.5°C. Instead, they were using a variety of standards and reporting schemes such as Race to Zero and BREEAM/LEED. Though effective when closely adhered to, concern has been raised in some quarters that these standards and schemes can lead to 'greenwashing'.

Chapter 1
Sector attitudes and understanding
(Continued)

"KNOWLEDGE APPEARS TO BE LACKING AS TO THE EXTENT BUILT ENVIRONMENTS CONTRIBUTE TO THE UK'S CARBON FOOTPRINT"

Covid safety supplants sustainability as a priority

It is widely accepted that the development of sustainable cities requires existing buildings to be modified in various ways. This includes being powered by renewable energy sources, retrofitted with various systems and materials that support efficiency, and the use of smart technologies for monitoring energy usage.

We asked respondents which of these they planned to implement into their developments or buildings by 2035. Perhaps unsurprisingly, green measures had lost prominence to post-Covid measures with over half (53%) prioritising the improvement of health, comfort, and ventilation to reduce transmissions.

Usage of sustainability-focused measures was fairly evenly spread among respondents with most switching to renewable or low-carbon energy sources (47%) and using low-embodied carbon construction materials (46%). However, for all the various measures being explored, only (27%) of respondents had any plans to deploy smart technology to monitor real-time energy consumption.

A willingness to do more is being undermined by knowledge gaps

Although knowledge appears to be lacking as to the extent built environments contribute to the UK's carbon footprint, and though measures to drive sustainability are deployed unequally and with little reference to scientific methodology, there is an understanding within the sector that it is an issue that requires more urgent action.

When asked if they currently predict the carbon emissions of buildings prior to construction, 91% of respondents said they did, at least sometimes. However, the EPC methodologies most widely used across the industry for predicting emissions prior to construction are problematic. EPC ratings can differ significantly – up to five times as much - from how much energy a building actually uses when in operation. And yet, the majority (84%) of respondents believed the ratings to be an accurate or at least close to an accurate calculation.

Unfortunately, climate change is driven by real as opposed to predicted emissions and eventually, the industry - at a global level - must converge on a standardised measured performance metric. Reliance on EPC and target emission metrics will not only slow progress towards the goal of net-zero buildings, it could sabotage it altogether.

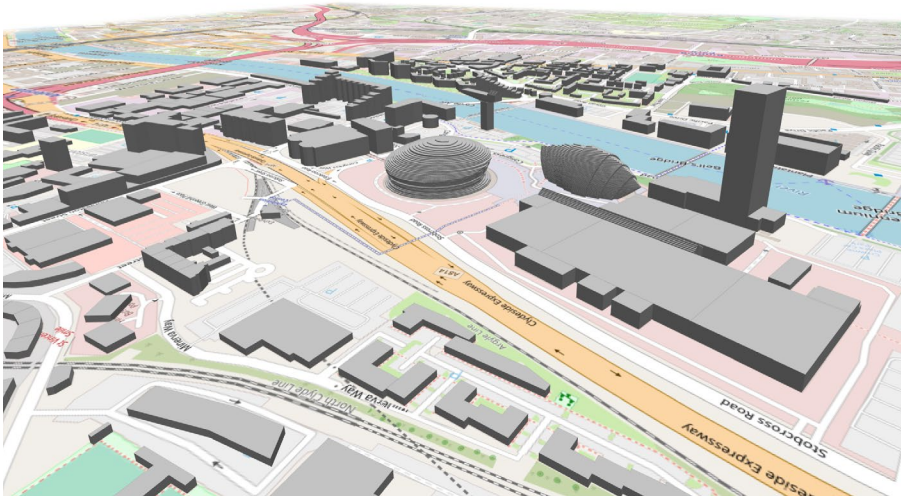
Chapter 1
Sector attitudes and understanding
(Continued)

"THOUGH A RATHER GLOOMY PICTURE, THERE IS CAUSE FOR HOPE."

Advanced modelling approaches give cause for hope

Though a rather gloomy picture, there is cause for hope. More advanced modelling approaches that predict a building's operational performance during design, construction, and occupation are being used. Emerging initiatives such as Design for Performance, developed by the Better Buildings Partnership (BBP) and based on the Australian NABERS system, provide owners and occupiers with a much better understanding of how buildings consume energy on a day-to-day basis. The objective now is to normalise the usage of these initiatives on a much larger scale.

It is widely accepted that radical improvements are needed to boost the energy efficiency of existing buildings if we are to reach net zero but should performance be assessed only by their actual operational energy use? Not quite. EPC grades still have a role when dealing with regulated loads such as heating, ventilation and air-conditioning (HVAC), hot water, and lighting but recognition needs to be given to the fact they are based on assumptions of "standard conditions of use".



Property owners and investors must understand that EPC grades do not allow for poor control and operation – two of the major drivers of the performance gap between design intent and actual outcomes. Indeed, non-domestic building EPC grades and actual annual gas and electricity consumption for the same building show no statistical relationship at all. As such, when it comes to non-domestic buildings, whole building operational energy targets should be the net-zero carbon metric property owners and investors aim for.

With a clearer idea of where the sector is in regard to its attitudes towards and understanding of the measures needed to achieve net zero, we next looked at the role of policy and standards.

Chapter 2: Policy and standards: The sector's view

> "THE SECTOR WISHES TO DO MORE BUT TO DO MORE, THEY NEED GUIDANCE AND ROBUST POLICY."

Carbon offsetting isn't cutting it

An encouraging finding from the research was the 70% of respondents believing the government's target to bring all carbon emissions to net zero by 2050 relies too heavily on the principle of carbon offsetting. This strongly suggests that there is a sector-wide understanding that a 'burn now, pay later' approach to sustainability is an inadequate response. The sector wishes to do more but to do more, they need guidance and robust policy.

The demand for more comprehensive policy was reflected in the feelings shared towards the British government's target to bring all carbon emissions to net zero by 2050. The majority of respondents (51%) believe the target to be achievable but requires further legislation. 9% believe the target not to be ambitious enough and 8% don't believe it to be realistic.

Perhaps the key take-away for policy-makers is that less than a third (31%) of those working within the sector believe net-zero by 2050 is achievable at the current rate.

The sector has an appetite for policy

Currently under analysis, the UK government's Future Buildings Standard consultation outlines a proposal to uplift energy efficiency standards for new non-domestic buildings in 2021.

The intention is to deliver a 27% average reduction in carbon emissions per building compared to existing standards. Generally, respondents were positive about this proposal with 28% reporting that they were working to this standard and 51% believing it to be achievable providing there is additional legislation. These findings add further confirmation that the sector is actively working to meet net zero targets but retains an appetite for more policy.

The Future Buildings Standard consultation stipulates improvements to non-domestic energy modelling methodologies and to standards when work is carried out in existing non-domestic buildings.

Chapter 2: Policy and standards: The sector's view (Continued)

"70% BELIEVED SCOPE 3 EMISSIONS SHOULD BE ROUTINELY INCLUDED IN CARBON CALCULATIONS FOR ALL DEVELOPMENTS AND CONTRACTS"

Voluntary sustainability assessment methods are held in high regard (mostly)

Though voluntary, current sustainability assessment methods such as the Building Research Establishment's Environmental Assessment Method (BREEAM) and the Leadership in Energy and Environmental Design (LEED) are often used in the design, construction, operation, and maintenance of buildings. Our respondents were asked whether they believed such methods to be adequate and able to deliver more sustainable built environments.

Again, responses pointed towards a sector that either appreciates current guidance or appreciates it but feels it could go further. 42% felt BREEAM and LEED were useful and effective while 49% believe both work but can afford to be more stringent. Fewer than one in 10 believed the methods fail to encourage more sustainable outcomes.

Attitudes to Scope 3 reveal genuine sector intent to do more

To complete the section on the sector's view of policies and standards, respondents were finally asked whether they believed Scope 3 emissions should be routinely included in carbon calculations for all developments and contracts.

Scope 3 emissions are those created from assets not owned or controlled by an organisation, but which indirectly impact the value chain. These can include purchased goods and services, employee commutes, waste disposal, investments, and leased assets.

Arguably, the responses to this question most acutely demonstrate the sector's willingness to do more to achieve net zero – 70% believed Scope 3 emissions *should* be routinely included in carbon calculations for all developments and contracts. Only 10% disagreed and a fifth were undecided.

Chapter 3: Perception v Reality

"EMBODIED CARBON ACCOUNTS FOR 10% OF GLOBAL CO_2 EMISSIONS WHEREAS BUILDING OPERATION ACCOUNTS FOR 28%"

The sector speaks

With the sector's understanding of and attitudes towards net zero measures more clearly defined and their opinions on policies and standards recorded, it was then time to explore where respondents themselves felt the greatest sustainability gains could be made.

Over half (51%) believed it to be in the construction process. Given the sector's reliance on steel and cement, two materials among the most carbon-intensive to produce, it is understandable that this is such a prevalent belief. It does, however, point to a major knowledge gap within the industry.

Contrary to what the industry believes, building operation creates more emissions than building construction

Building materials are included in what is termed embodied carbon (EC) emissions and comprise impacts from material extraction, manufacturing, transportation, construction, maintenance, replacement of components, and demolition/deconstruction and disposal. Alongside the construction process itself, EC accounts for 10% of global CO_2 emissions whereas building operation accounts for 28%.

And yet, only 22% of respondents pointed to the operation and energy use of buildings as the area where most sustainability gains can be made. In other words, though the sector affords less significance to the operation and energy use of buildings compared with EC, it contributes more in the way of carbon emissions.

In terms of drivers for the sector's sustainability focus, responses were mixed. Most (39%) reported that general concerns around environmental damage and climate change wielded the most influence with end-user and market demands (21%) coming second.

Despite the sector's appetite for policy - as evidenced in previous questions - less than a fifth of respondents identified policy/legislation as a key driver. With so many respondents believing that currently is not stringent enough, this perhaps should come as little surprise.

Public perception is important, so why the high emissions?

Knowing that built environments account for an average of over half of total city emissions and almost 40% of global energy-related emissions, the question of public perception of an organisation's efforts to be sustainable was raised.

When asked about the importance of their organisation being seen to be engaging in or leading on sustainability matters, 89% of respondents claimed it was either 'very' or 'somewhat' important.

Any surprise elicited by this figure will likely be that it wasn't higher. But if public perception is so important, why isn't the sector doing more? Why are built environments still such a major contributor to carbon emissions? The answers to these questions can be answered partly by the findings provided in our final section.

Chapter 4:
The road to net zero is paved in tech

> "TODAY, DIGITAL TWINS ARE PROVING TO BE A FORMIDABLE INSTRUMENT FOR THE DECARBONISATION OF BUILT ENVIRONMENTS."

The power of Digital Twins

A central reason that built environments have become such heavy emitters of carbon is that those responsible for their design, construction, and management have never had access to reliable and accurate means of measuring their carbon output. It has only been in recent years that the rudimentary tools at the disposal of the sector have been exposed as truly unfit for purpose.

However, as with so many of humanity's most taxing challenges, technology is delivering solutions. Today, Digital Twins are proving to be a formidable instrument for the decarbonisation of built environments.

Scalable from a single building to an entire city, live Digital Twins respond and behave like their real world counterparts. They deliver the data-driven information needed to uncover energy, carbon, capital, and operational savings while accounting for resource use, transport, social, and economic factors.

Awareness of effectiveness is not matched by use

Offering such unprecedented visibility and virtual adaptability of a built environment, we asked our professionals whether they were aware of the role of Digital Twins in establishing and optimising the energy efficiency of an existing or planned development. Their answers went some way to explaining why today's buildings still emit so much carbon.

Just over a third (36%) of respondents were aware of the power of Digital Twins in optimising energy efficiency and claimed to use them regularly. The rest were either aware of their potential but never used them (37%), were unsure (18%), or had no knowledge of the role they could play at all (9%).

Overall, we can see that awareness of the benefits of Digital Twins is good, but the majority of built environment professionals are not using them.

Conclusion

A common accusation levelled at industries responsible for high carbon emissions is that those leading them simply do not care. In this respect, our research should provide encouragement.

To summarise:

- 79% of respondents work for organisations that are currently, actively working towards net zero carbon with their projects or buildings.
- 91% predict the carbon emissions of buildings prior to their construction.
- 88% measure the carbon emissions of the buildings they manage.
- 89% deem it important for their organisation to be seen to be engaging in or leading on sustainability matters

This is a sector that very much cares about playing their part in achieving net zero. Moreover, they are hungry for more stringent policy:

- 70% believe that the government's target to bring all carbon emissions to net zero by 2050 relies too heavily on the principle of carbon offsetting.
- The only criticisms of the proposed 27% reduction in carbon emissions on non-domestic buildings outlined in the government's Future Buildings Standard were that some development types and sectors may find it easier than others (52%), more similar standards need to be applied to older buildings retroactively (17%), or that the plans are not ambitious enough (3%).
- 91% believe BREEAM and LEED to be useful sustainability assessment methods, if not stringent enough.
- 70% believe Scope 3 emissions should be routinely included in carbon calculations for all developments and contracts.

> "THE OBJECTIVE NOW SHOULD BE TO HARNESS THIS SECTOR-WIDE DETERMINATION TO BECOME MORE SUSTAINABLE"

The objective now should be to harness this sector-wide determination to become more sustainable, together with their appetite for policy and direct it in the way of proven, tech-first solutions such as Digital Twins. The awareness is mostly there, the challenge is increasing usage.

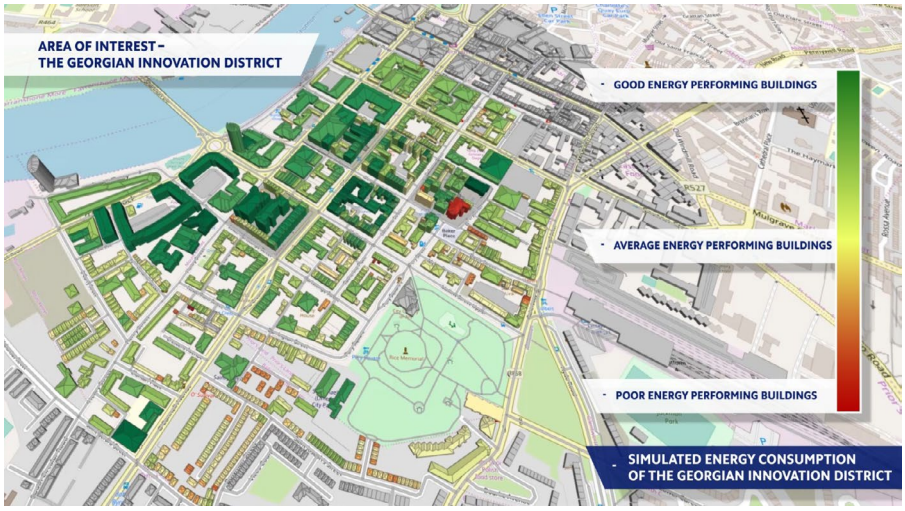
Of course, the only way deployment of technologies like Digital Twins can be increased so that it aligns with awareness is through education. It is incumbent upon all stakeholders, from end-users and built environment professionals, to technology providers and government agencies to articulate the savings that can be leveraged from using these technologies.

When the built environment sector can see the energy, carbon, capital, and operational savings achievable with their own developments, the road to net zero could become much smoother.

Case study: Limerick

Situated in Mid-West Ireland, Limerick is one of two 'Lighthouse Cities' selected by the EU Horizon 2020 +CityxChange project. Their ambition is to achieve a sustainable, zero emissions urban ecosystem and to establish a 100% renewable energy city-region by 2050.

"EACH BUILDING HAD A DIGITAL TWIN CREATED WITH VIRTUAL ENERGY MODELS APPLIED."



Digital Twins are created and analysis begins

IES began by applying their ICL Digital Twin technology to support the creation of a Positive Energy Block (PEB) within Limerick's Georgian Innovation District. The team enriched existing data from Open Street Maps and used other socio-economic data to create an intelligent Community Information Model (iCIM), providing a top-level understanding of the district's CO_2 production and energy consumption/distribution.

A block of five buildings with above average energy efficiency were chosen to test, identify, and group interventions that would aid the transition towards Net-Zero Energy Buildings (NZEB) status. Each building had a Digital Twin created with virtual energy models applied. Where data was limited or absent, IES used their unique physics-based simulation, integrating a Machine Learning algorithm.

Case study: Limerick (Continued)

Simple, low-cost but effective operational measures are identified

By implementing a range of simple operational measures across the five buildings, it was determined that a collective energy saving of 5% could be achieved. This result was skewed somewhat by one of the buildings which had recently become a LEED Gold certified building and thus offered limited savings opportunities. Across the other four buildings, savings of 13% were noted.

IES then assessed a set of shallow retrofit measures, including improvements to building airtightness, upgrades to LED lighting, and new boilers. Applied in conjunction with the operational interventions, these shallow retrofit measures brought the combined savings up to 12%, or 31% when excluding the LEED Gold certified building.

"THE TOTAL CALCULATED SAVINGS AMOUNTED TO 23%, OR 64% WHEN EXCLUDING THE LEED GOLD CERTIFIED BUILDING."

The impact of deeper renovation measures are considered

Measures for historic and conservation buildings were also proposed, including attic insulation, ground floor insulation, and changing gas boilers to air-to-water heat pumps. When added to the other interventions, the total calculated savings amounted to 23%, or 64% when excluding the LEED Gold certified building.

The integration of Renewable Energy Sources (RES) was then applied in the form of photovoltaic panels installed on the collective roof space. Added to the other measures, this translated to a total energy decrease of 34% from external, non-renewable sources. Remaining power demand was then offset by a tidal turbine placed in the nearby river, enabling the block to produce 0.4GWh/year and become a PEB.

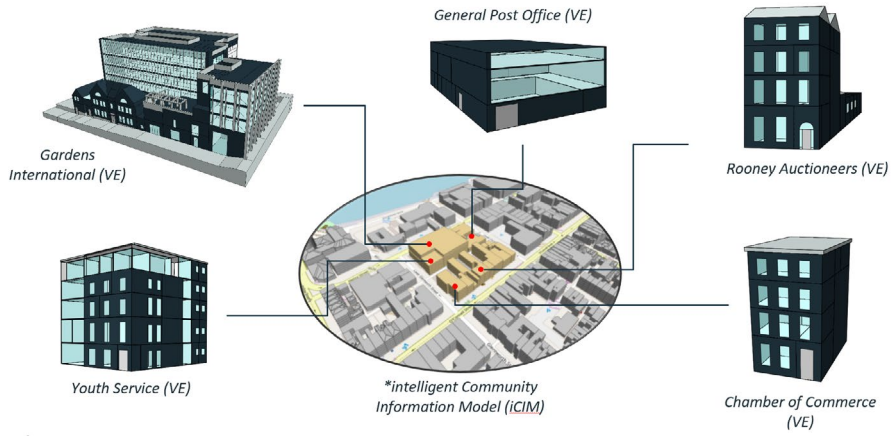
Case study: Limerick (Continued)

> "LIMERICK HAS A GOAL OF BECOMING A POSITIVE ENERGY CITY BY 2050"

Socio-Economic Analysis is added to the picture

Limerick currently has a high vacancy rate in its city centre. A core goal of city planners is to create and reinforce sustainable communities in existing compact urban settlements and incentivise citizens and businesses to occupy these vacant areas. However, as Limerick has a goal of becoming a Positive Energy City by 2050, any decisions had to account for this target and the impact on the city's socio-economics.

To demonstrate how IES ICL technology can support such decisions, analysis was carried out of an urban area (comprising 900+ buildings with approximately 10% full vacancy and significant partial vacancy) within the Limerick Georgian Innovation District. As city planners needed to collect data and insights to better understand the interaction between urban densification and reaching carbon neutrality, two factors along with carbon emissions were analysed - urban repopulation and an increase in jobs.



Following a population rise, IES showed that renovating the buildings to an A-rated standard would generate 450 tons of additional CO_2 emissions over a 30-year period. However, this would be balanced with demand for skilled labourers, leading to an overall 4% increase of jobs within the district. As land vacancies are key drivers for crime within constrained areas, it was also found that renovating the zone would reduce the crime rate by around 5 points.

The analysis provided the city planners with the information needed to ensure any vacant properties could be reoccupied while still developing them to a Zero Energy Standard or integrating them as part of a future PEB. In this way, the socioeconomic targets of increasing jobs while reducing dereliction and vacancy could be achieved, while ensuring the goal of becoming a Positive Energy City by 2050.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