10th May, 2023 – Dublin

CitA SME Digital Acceleration Series: Think Sustainably

Digital Twins

Digital Twins and Energy Modelling for the Decarbonisation of Buildings & Communities

Lorenzo De Donatis, ICL Consultancy Manager

Integrated Environmental Solutions Ltd.

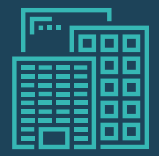
About IES

Home to the largest building physics analytics team in the world

29
Years of building analysis

Apache
World renowned simulation engine

75,000+
Projects per year



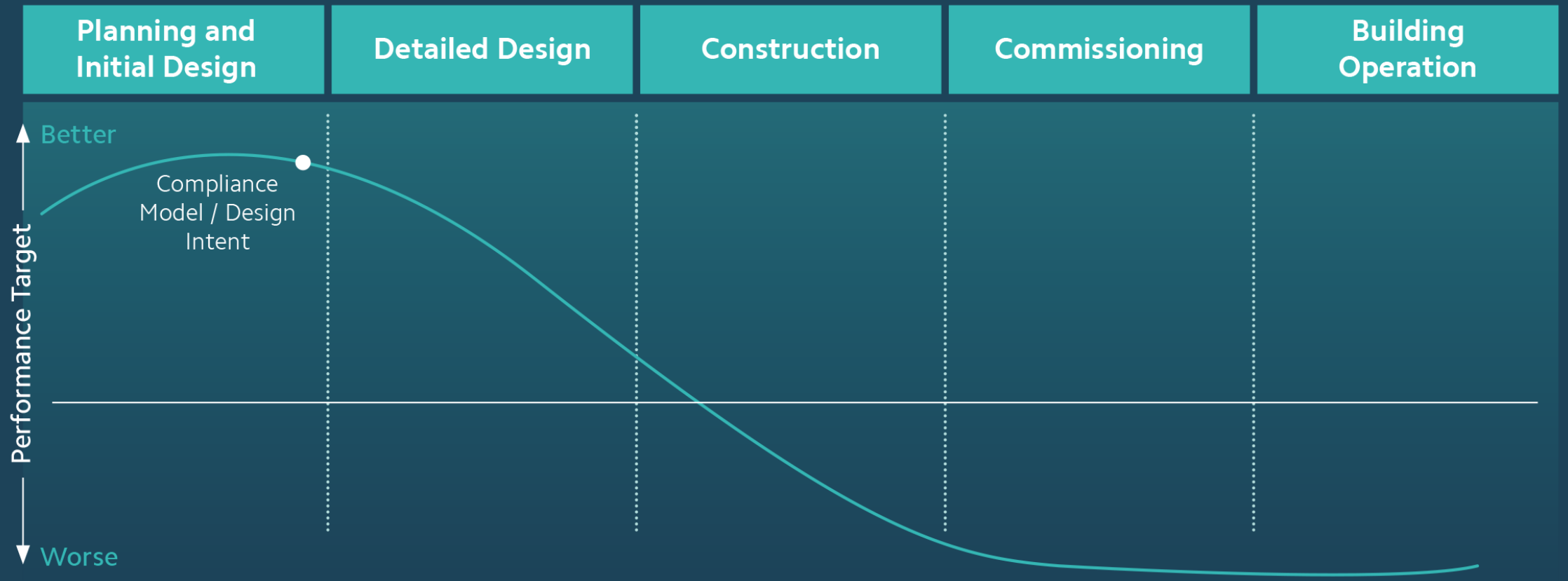
>1,000,000
Buildings

40
Power stations prevented

Our Mission

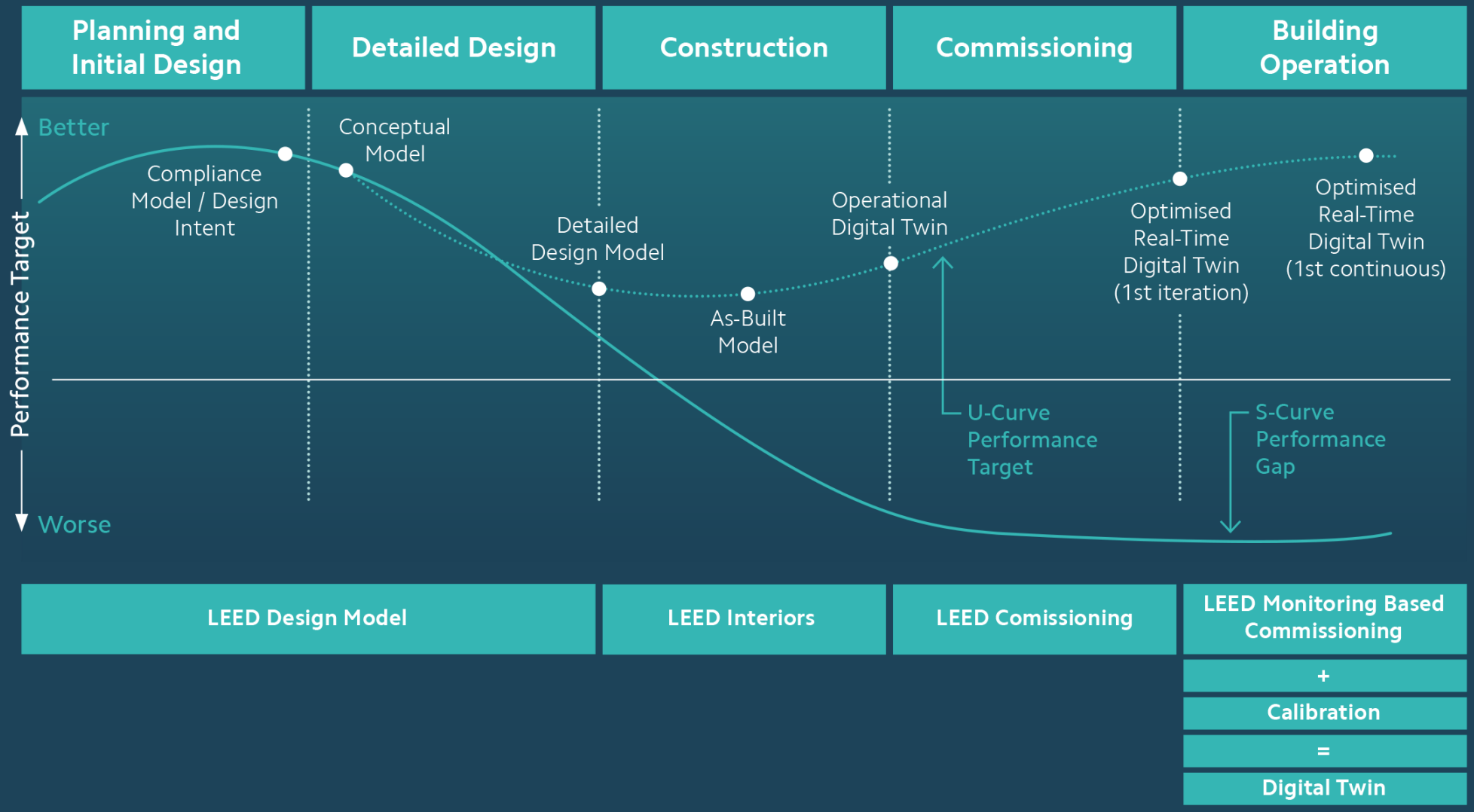
IES believe that every building of every city in the world can be decarbonized. Our purpose is developing the technology to make that happen. Our ultimate aim is to create a built environment that is resource and energy efficient. Eliminating global reliance on fossil fuels while promoting comfort, health and wellbeing, and fairer access to energy for every citizen in the world.

The problem in buildings (the ‘S-Curve’)



Real performance of buildings is very often not aligned with design objectives

The solution (the ‘U-Curve’)



The Best of Physics, Data and AI/ML

Physics Enabled Simulation

- Based on fundamental physics principles
- Simulates the physics of energy & heat flow

Real & Virtual Sensor Data

- IoT & BMS Data from the Real Building
- Virtual Sensor Data from the Simulation

AI & Machine Learning

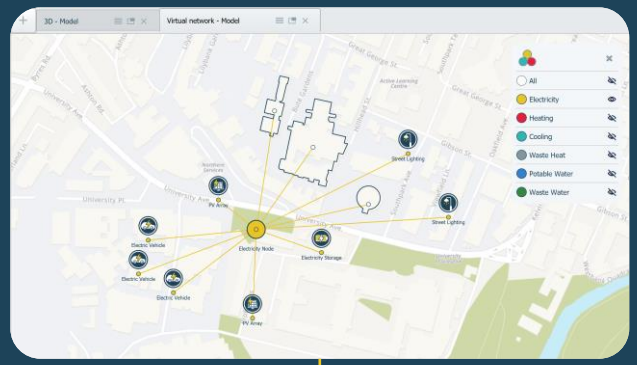
- Enables data driven prediction
- Fills data gaps & checks for anomalies

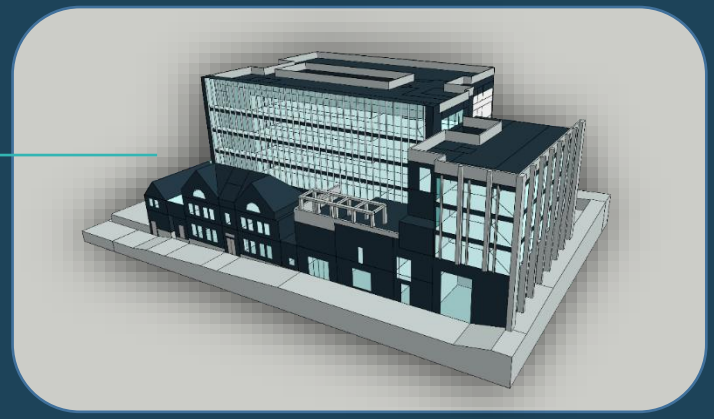
Digital Twin

Leverages the best of both Building Simulation, Sensor Data, AI & Machine Learning

Our Products

Digital Twin solution for decarbonised, healthy and resilient built environments





Who is it for?

Building & Portfolio Owners/Operators

- Monitor and optimise energy performance, running costs, comfort & wellbeing credentials
- Understand what measures are needed to achieve your net zero carbon goals and create a plan

Cities, Public Authorities & Urban Planners

- Create a net-zero roadmap or fossil fuel divestment plan
- Audit current plans to ensure you are on track to meet your goals

Utility & Network Operators

- Design local energy systems (heating, cooling and electricity) taking into account demand from individual buildings
- Explore potential for building integrated renewables, microgeneration or sustainable heating sources

Digital Twins in Action: Case Studies

Building-scale Retrofit Strategies for Decarbonisation

Dublin City Council Case Study – Social Housing

Climate Resilient Housing

Building-scale Retrofit Strategies for Decarbonisation

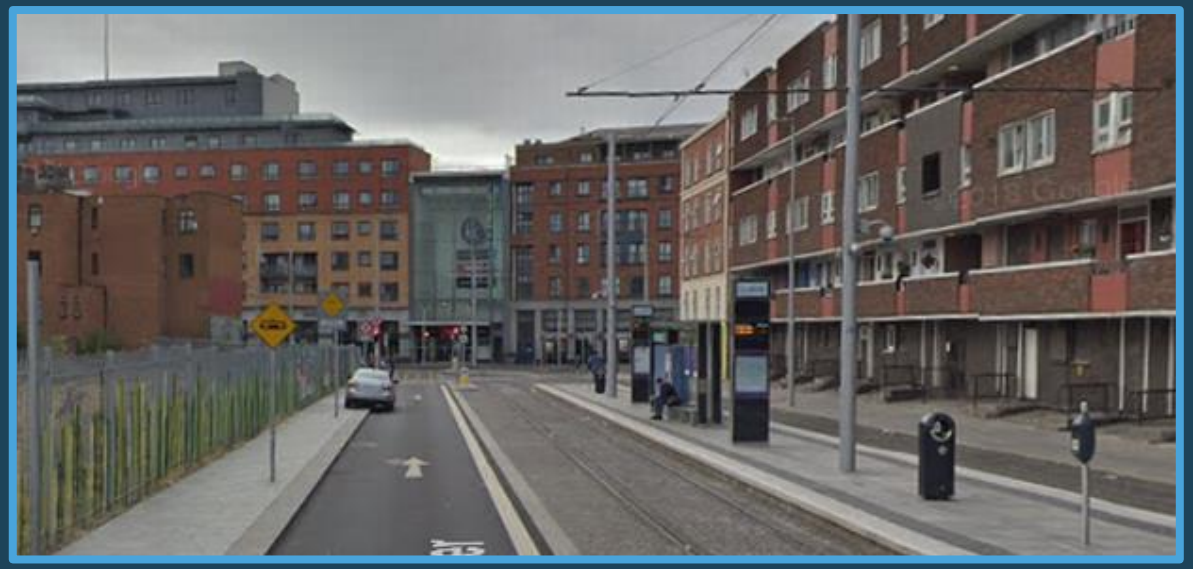
Assess renovation strategies with a number of measures:

- Strategy 1: Shallow Retrofit (30%)

- Strategy 2: Medium Retrofit (60%)

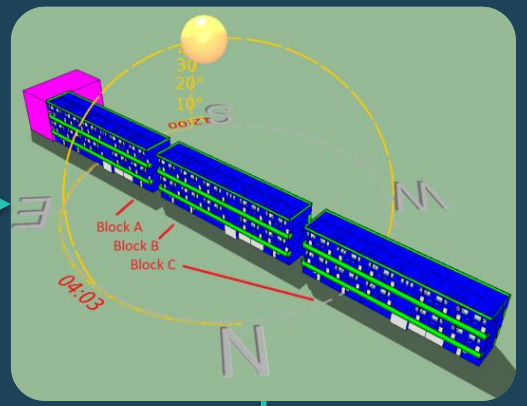
- Strategy 3: Deep Retrofit (90%)

- Strategy 4: Full Renovation (reduce to Core & Shell and rebuild)



Site survey & Energy modelling

A. Site survey



B. Digital Twin (IES VE)

Geometry, constructions, heating/cooling plants, profiles of use, etc.

C1. Energy demand & Op. Carbon (IES VE)

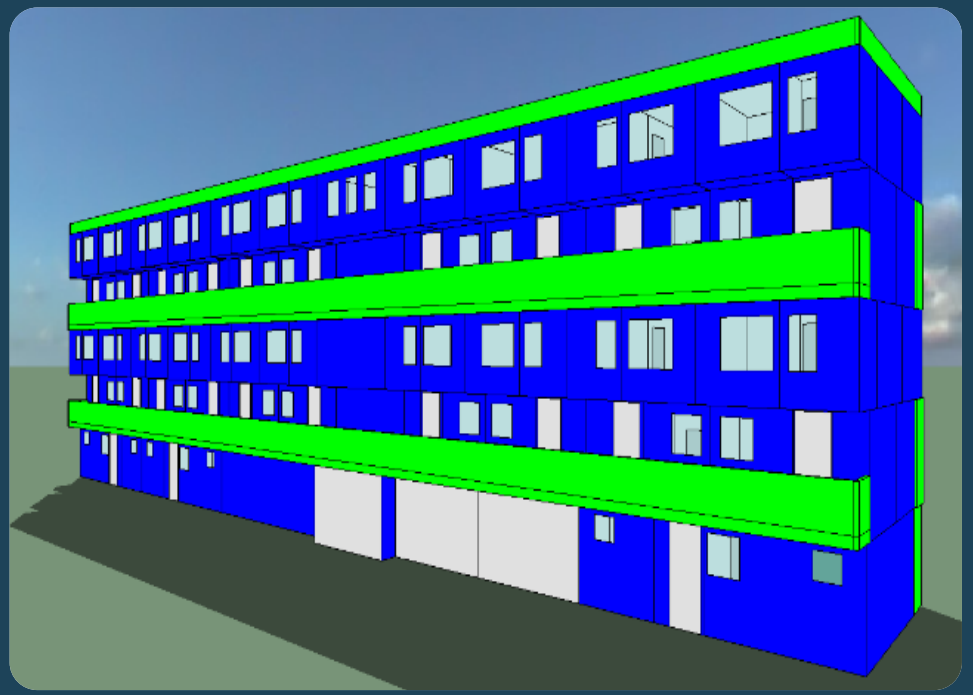
Impact on energy usage and operational carbon of each measure through dynamic, physics-based simulations.

C2. Embodied carbon (OneClickLCA)

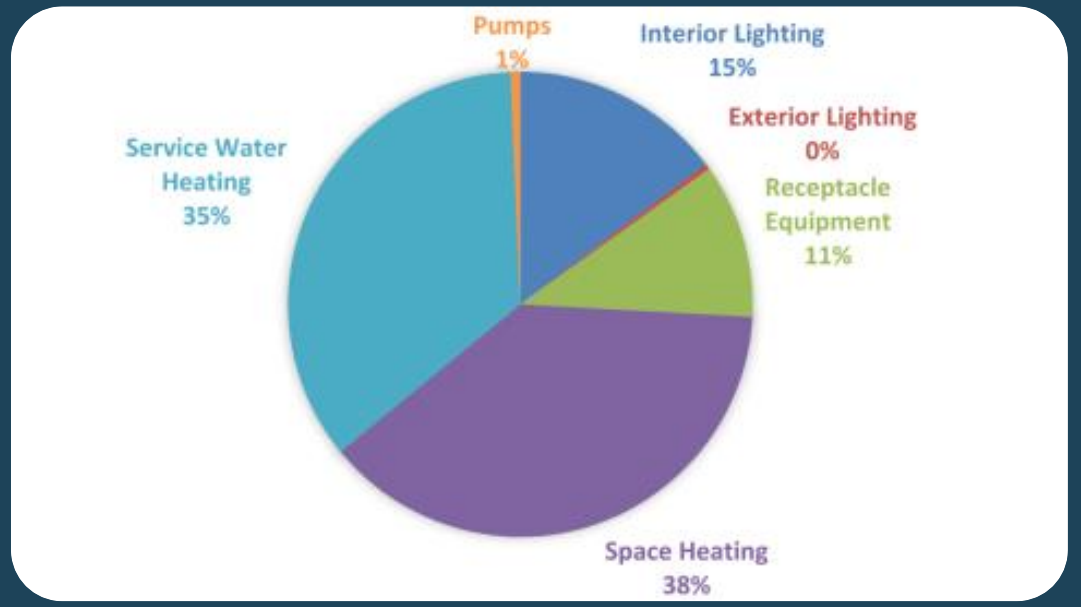
Whole-life cycle impact of the interventions, the integration between the VE and OneClickLCA was used to calculate the embodied carbon associated with each intervention

Operational Energy Consumption

IES have carried out modelling of the residential blocks located on the West side of Dominick Street Lower with the aim of understanding current performance first (i.e. baseline) and then applying renovation strategies

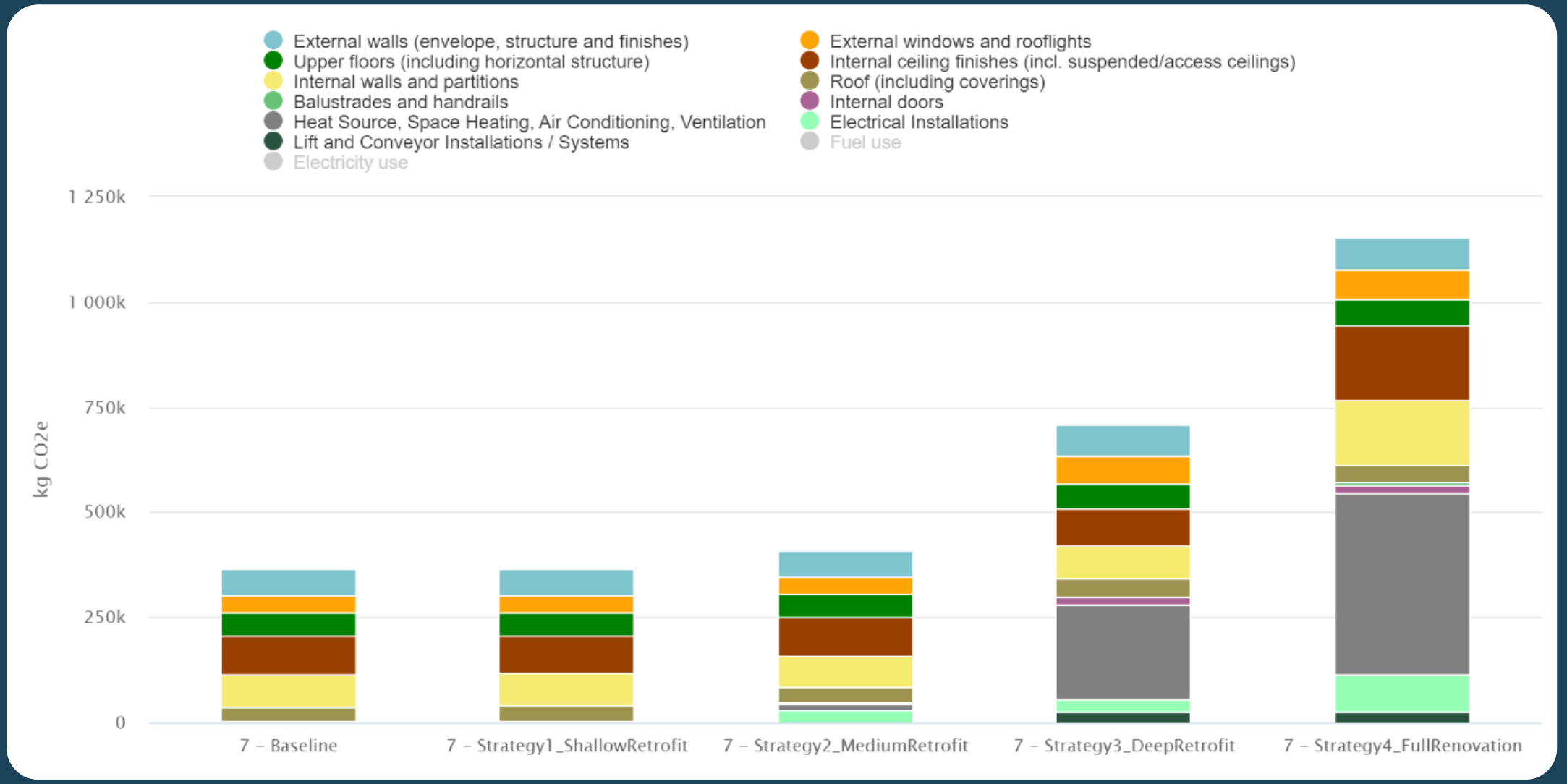


North Elevation

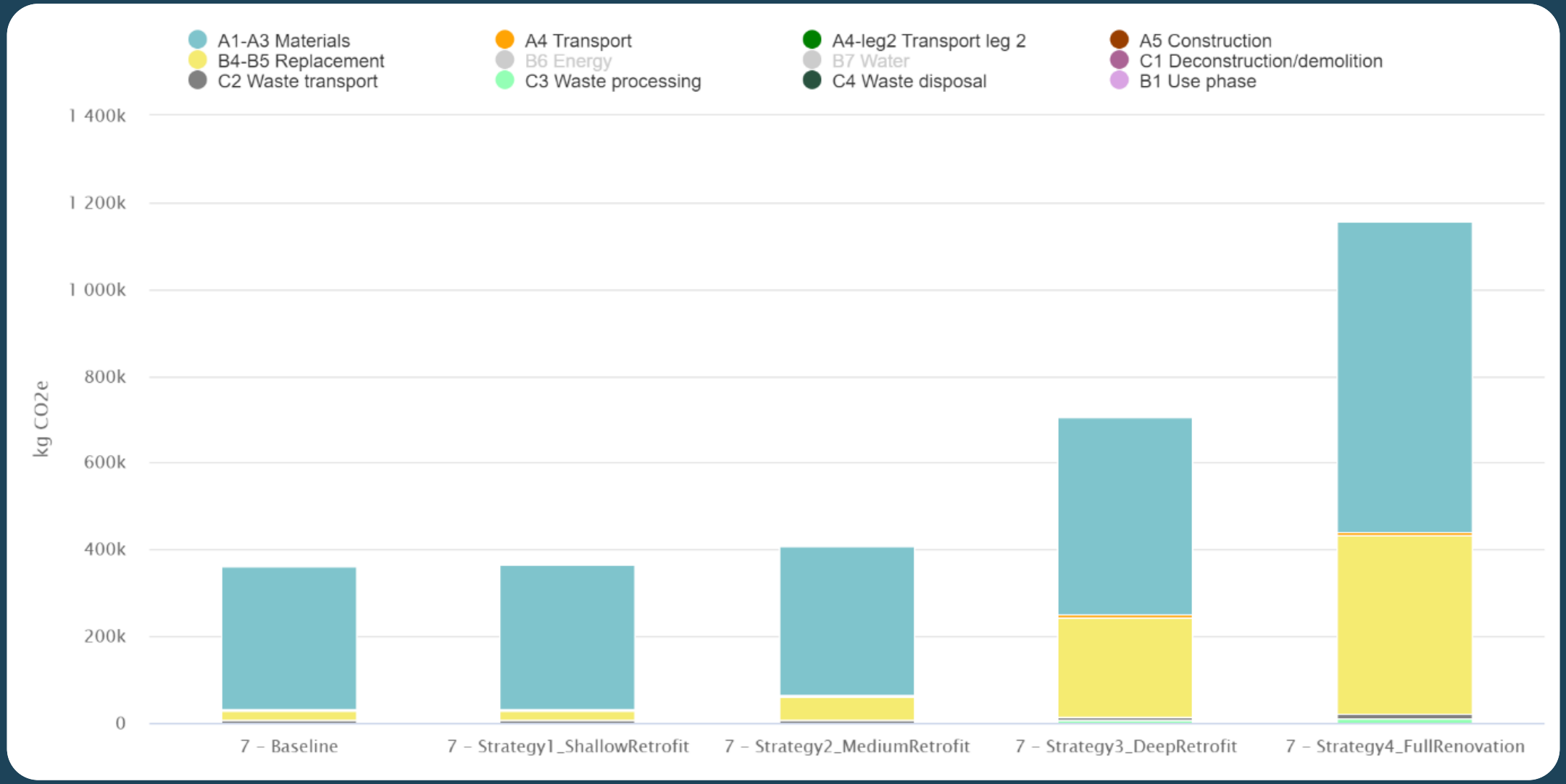


Operational energy breakdown

Embodied Carbon Analysis - Per building element



Embodied Carbon Analysis - Per life cycle stage



Embodied vs. Operational

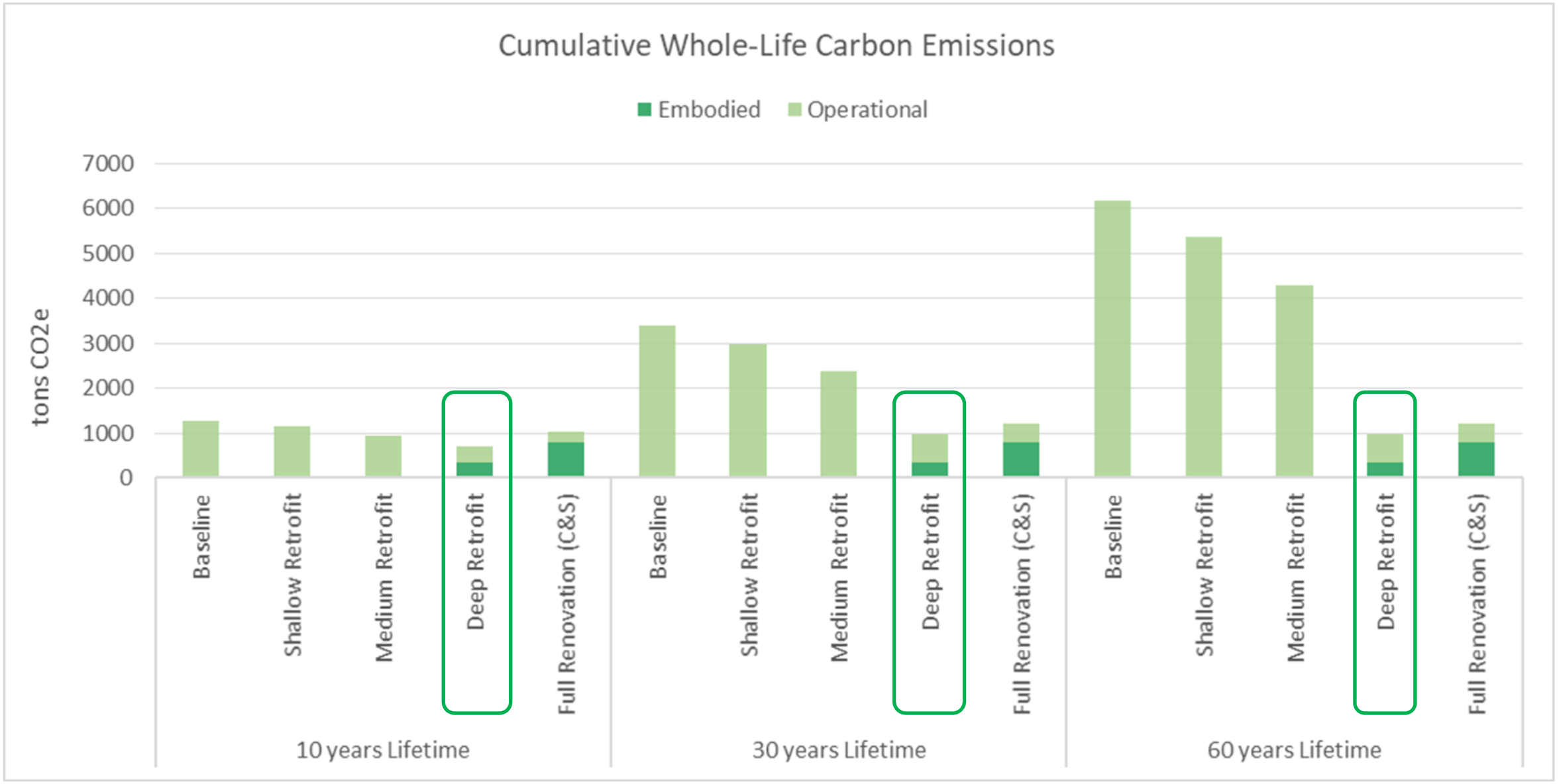
	Annual EUI [kWh/m²]	*Embodied Carbon[1] [tons CO_{2e}]*	*Indicative BER[2]*	*Indicative Cost[3]*
Baseline	380	0	F	0
Shallow R.	338	2	E2	1
Medium R.	263	45	D2	2
Deep R.	105	344	B2	3
Full Renovation	70	792	A3	4

[1]Embodied carbon associated with changes applied to the building only, not to the existing structure

[2]BER Rating estimated based on primary energy use of the building

[3]Indicative costs from low (1) to high (4).

Results


Cumulative Whole-Life Carbon Emissions
Embodied
Operational
tons CO2e
7000
6000
5000
4000
3000
2000
1000
0
Baseline
Shallow Retrofit
Medium Retrofit
Deep Retrofit
Full Renovation (C&S)
Baseline
Shallow Retrofit
Medium Retrofit
Deep Retrofit
Full Renovation (C&S)
Baseline
Shallow Retrofit
Medium Retrofit
Deep Retrofit
Full Renovation (C&S)
10 years Lifetime
30 years Lifetime
60 years Lifetime

Comhairle Cathrach Bhaile Átha Cliath
Dublin City Council

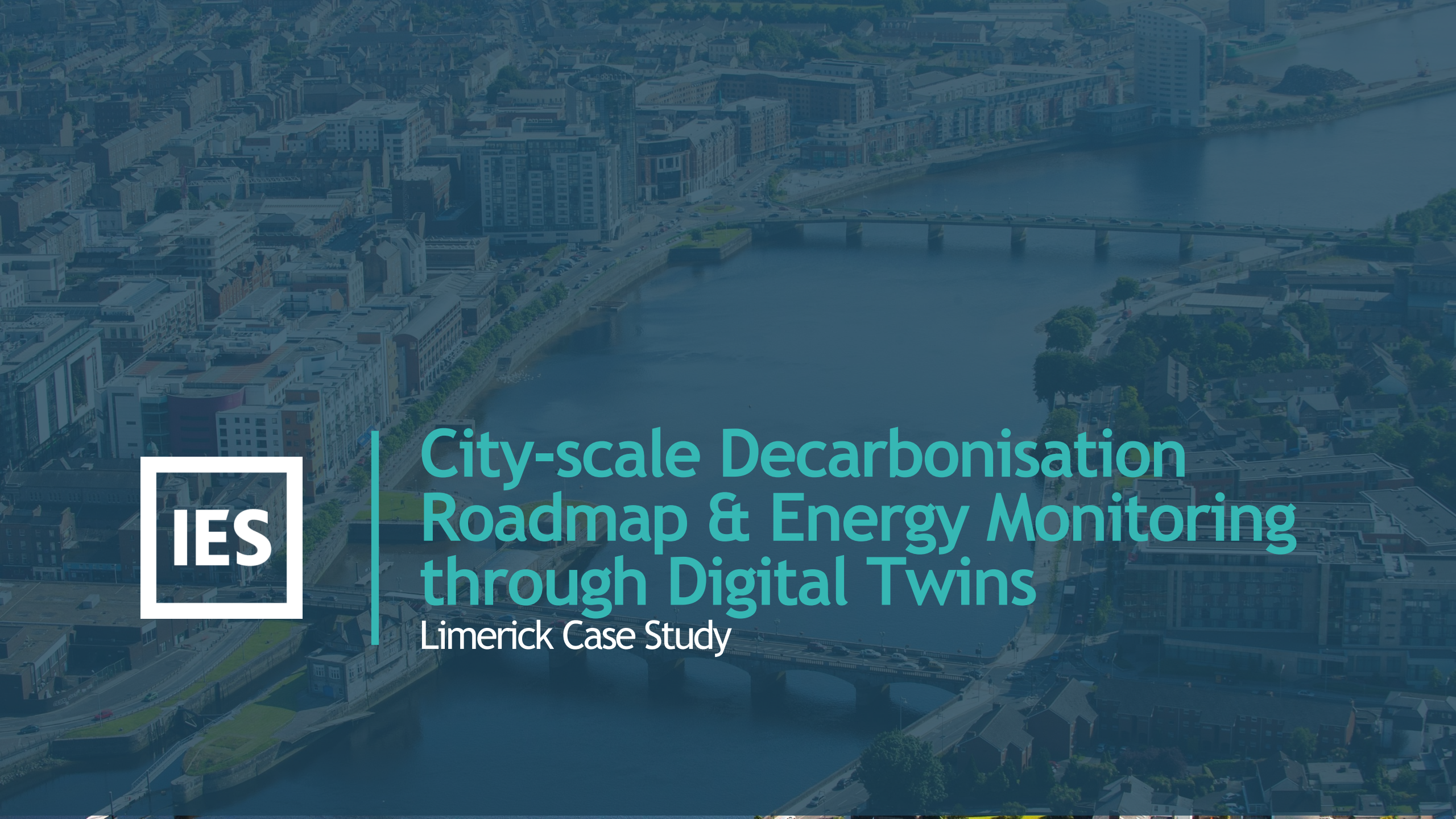
Digital Twins for Climate Resilient Housing

IES

A Digital Twin model of three residential blocks located on the west side of Dominick Street Lower, Dublin, has been created to identify the impact of different renovation strategies to upgrade the buildings, facilitating decision-making and scaling across social housing units. A holistic approach has been followed by considering not only the operational energy savings obtained through each retrofit strategy, but also taking into account the embodied carbon and costs associated with such measures at different life-cycle stages.

Visit the Dublin interactive model

Get Started



City-scale Decarbonisation Roadmap & Energy Monitoring through Digital Twins

Limerick Case Study

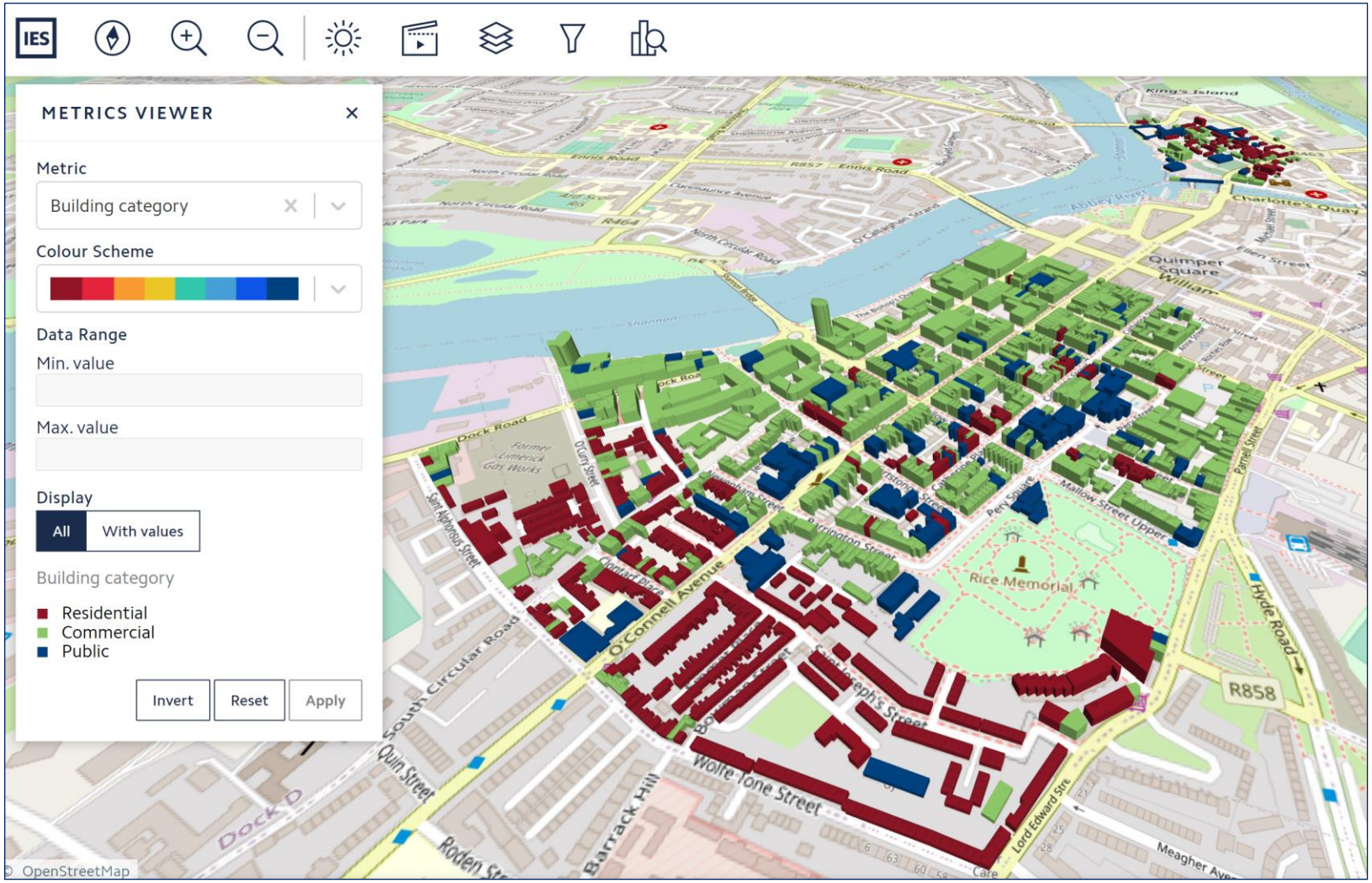
Enabling a Positive Energy City

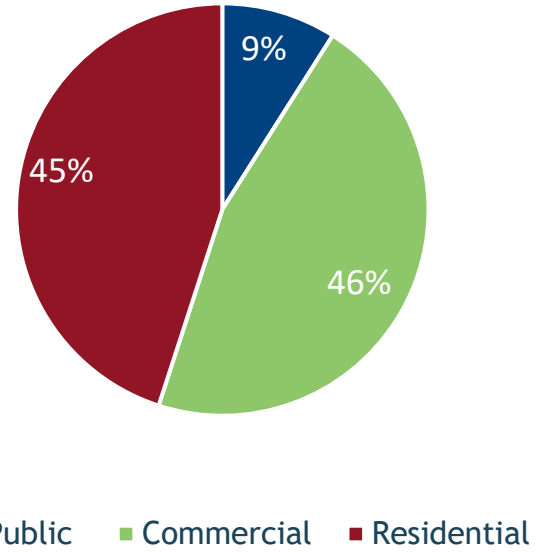
Limerick

Ireland

- Assessment performed through EU2020 R&D funding
- Digital Twin Decarbonisation Roadmap created to plot Limerick performance against their 2050 goals
- City scale Digital Twin for renewables & network analysis, including socio-economic modelling
- **Detailed building level Digital Twins (metered + simulated data) for measurement & verification**
- **Energy monitoring dashboards for building owners and facility managers**

Buildings: Baseline model






Average EUI
350 kWh/m²
270 kWh/m²
METRICS VIEWER
Data Range
Min. value
Max. value
Display
All
With values
Retrofit year
2025
2030
2035
2040
2045
2050
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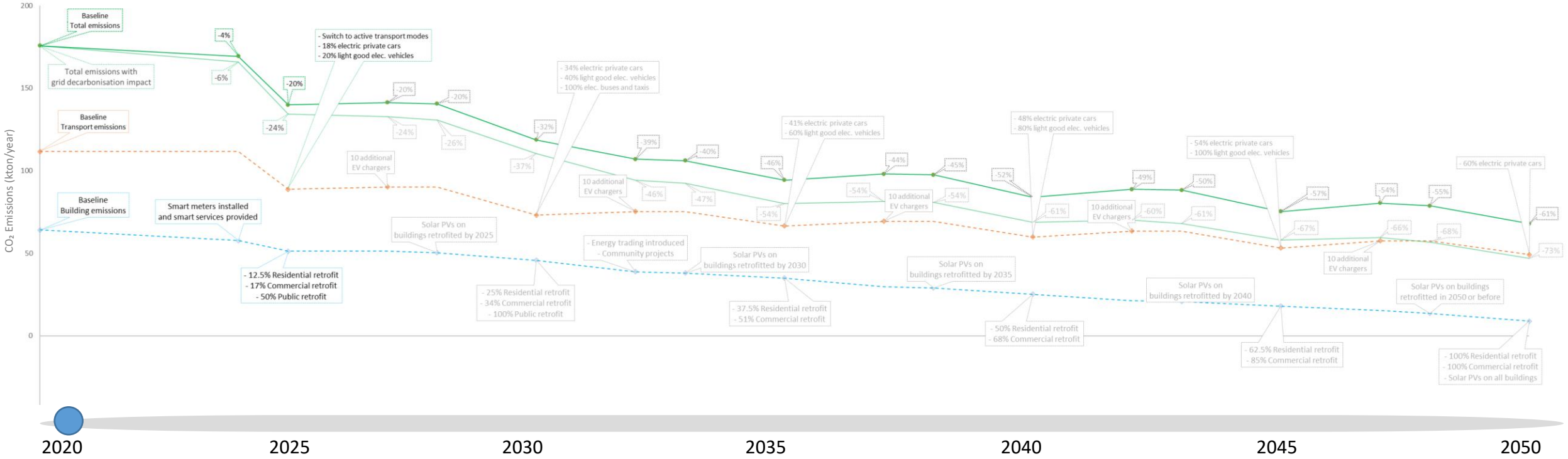
Privacy
+CITYXCHANGE
+CITYXCHANGE


CO2 Emissions (kton/year)
200
150
100
50
0
Baseline
Total emissions
Total emissions with
grid decarbonisation impact
Baseline
Transport emissions
Baseline
Building emissions
Smart meters installed
and smart services provided
- 12.5% Residential retrofit
- 17% Commercial retrofit
- 50% Public retrofit
- Switch to active transport modes
- 18% electric private cars
- 20% light good elec. vehicles
10 additional
EV chargers
Solar PVs on
buildings retrofitted by 2025
- 25% Residential retrofit
- 34% Commercial retrofit
- 100% Public retrofit
- 34% electric private cars
- 40% light good elec. vehicles
- 100% elec. buses and taxis
- Energy trading introduced
- Community projects
Solar PVs on
buildings retrofitted by 2030
- 37.5% Residential retrofit
- 51% Commercial retrofit
- 41% electric private cars
- 60% light good elec. vehicles
Solar PVs on
buildings retrofitted by 2035
- 50% Residential retrofit
- 68% Commercial retrofit
- 48% electric private cars
- 80% light good elec. vehicles
Solar PVs on
buildings retrofitted by 2040
- 62.5% Residential retrofit
- 85% Commercial retrofit
- 54% electric private cars
- 100% light good elec. vehicles
Solar PVs on buildings
retrofitted in 2050 or before
- 100% Residential retrofit
- 100% Commercial retrofit
- Solar PVs on all buildings
- 60% electric private cars
2020
2025
2030
2035
2040
2045
2050


Average EUI
237 kWh/m²
214 kWh/m²
METRICS VIEWER
Data Range
Min. value
Max. value
Display
All
With values
Retrofit year
2025
2030
2035
2040
2045
2050
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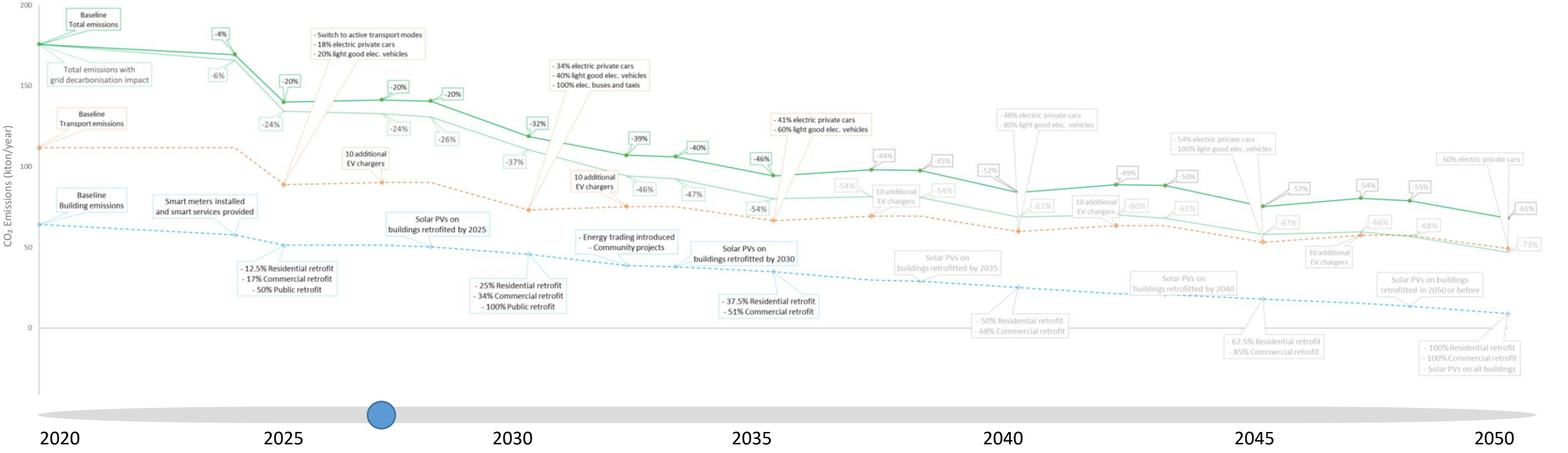
Privacy


CO2 Emissions (kton/year)
200
150
100
50
0
Baseline Total emissions
Total emissions with grid decarbonisation impact
Baseline Transport emissions
Baseline Building emissions
-4%
-6%
-20%
-24%
- Switch to active transport modes
- 18% electric private cars
- 20% light good elec. vehicles
-20%
-24%
-26%
-20%
-20%
-32%
-37%
- 34% electric private cars
- 40% light good elec. vehicles
- 100% elec. buses and taxis
-39%
-40%
-46%
- 41% electric private cars
- 60% light good elec. vehicles
-44%
-45%
-52%
- 48% electric private cars
- 80% light good elec. vehicles
-49%
-50%
- 54% electric private cars
- 100% light good elec. vehicles
-57%
-54%
-55%
- 60% electric private cars
-61%
-73%
10 additional EV chargers
-46%
-47%
-54%
10 additional EV chargers
-54%
-54%
10 additional EV chargers
-61%
-60%
-61%
-67%
-66%
-68%
10 additional EV chargers
Smart meters installed and smart services provided
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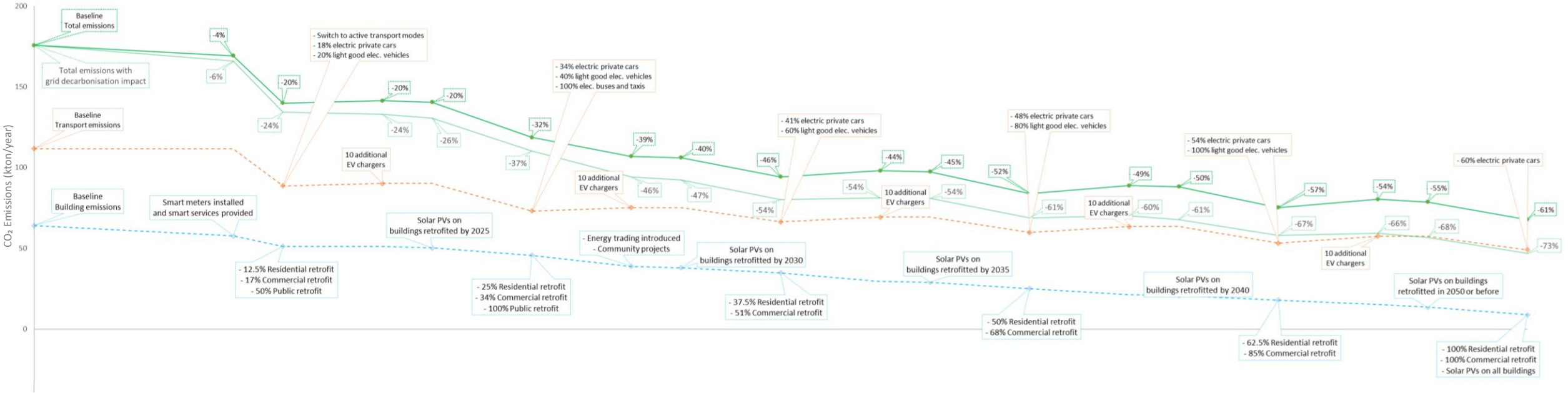
Solar PVs on buildings retrofitted in 2050 or before
- 100% Residential retrofit
- 100% Commercial retrofit
- Solar PVs on all buildings
2020
2025
2030
2035
2040
2045
2050


Average EUI
214 kWh/m²
184 kWh/m²
165 kWh/m²
140 kWh/m²
METRICS VIEWER
Data Range
Min. value
Max. value
Display
All
With values
Retrofit year
2025
2030
2035
2040
2045
2050
© OpenStreetMap
Barrack Hill
Wolfe Tone Street
Rice Memorial
Hyde Road
R858
Terms of Use
Privacy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100
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Total emissions with grid decarbonisation impact
Baseline Transport emissions
Baseline Building emissions
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-20%
-26%
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- 80% light good elec. vehicles
-49%
-60%
-50%
-61%
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- 100% light good elec. vehicles
-57%
-67%
-54%
-66%
-55%
-68%
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- 60% electric private cars
-61%
-73%
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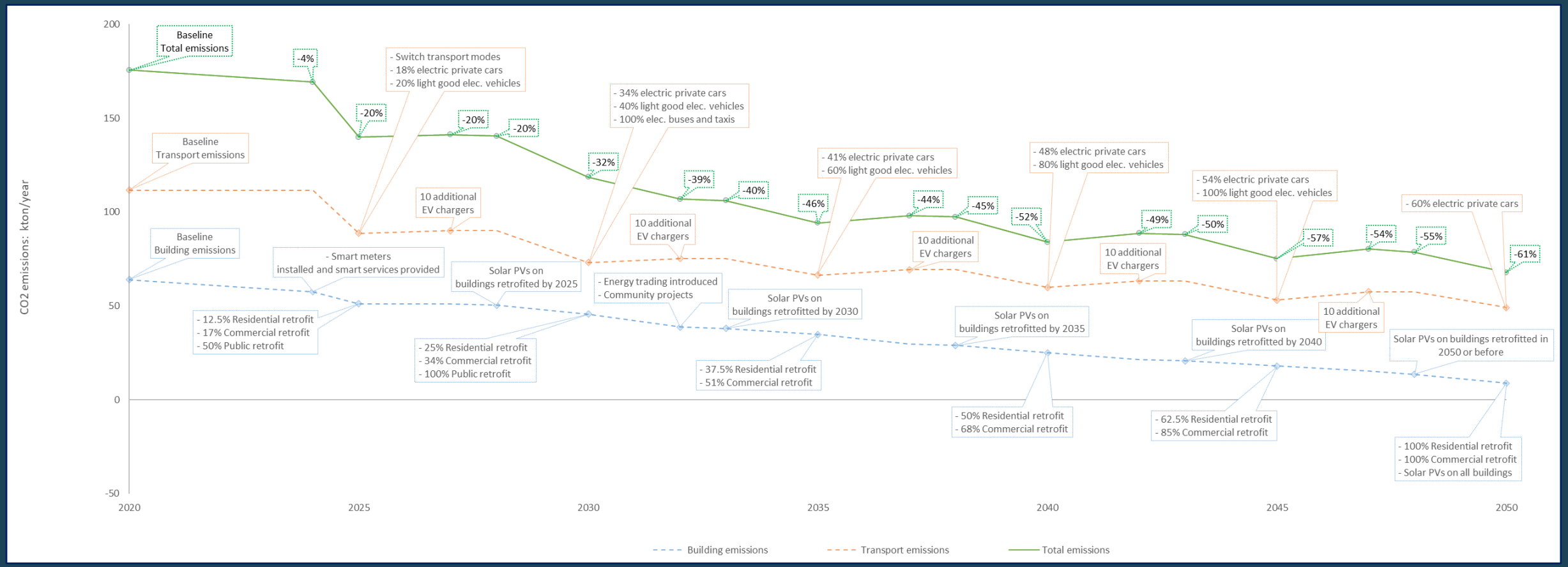
2020
2025
2030
2035
2040
2045
2050

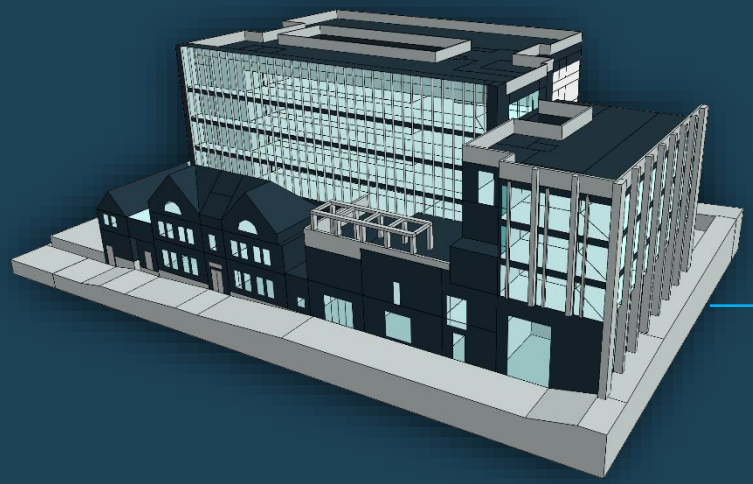
Limerick Decarbonisation Roadmap



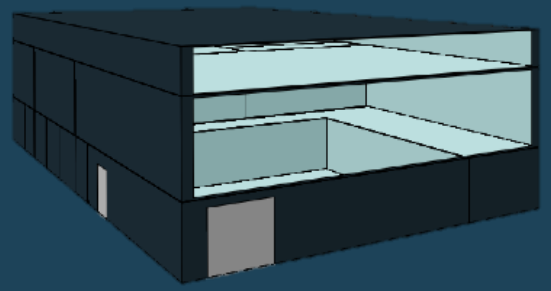
Interactive model link

LCCC website link

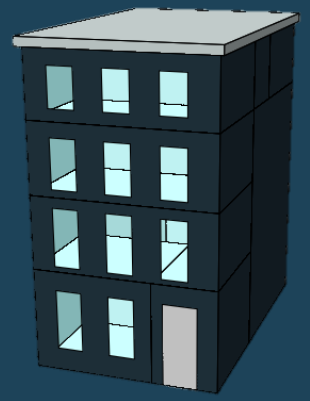
Digital Twin Energy Models



Commercial

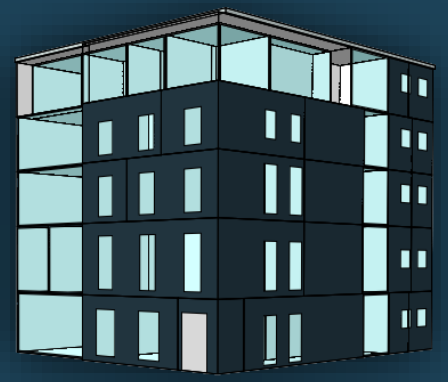


Post Office



Mixed use

intelligent Community Information Model (iCIM)



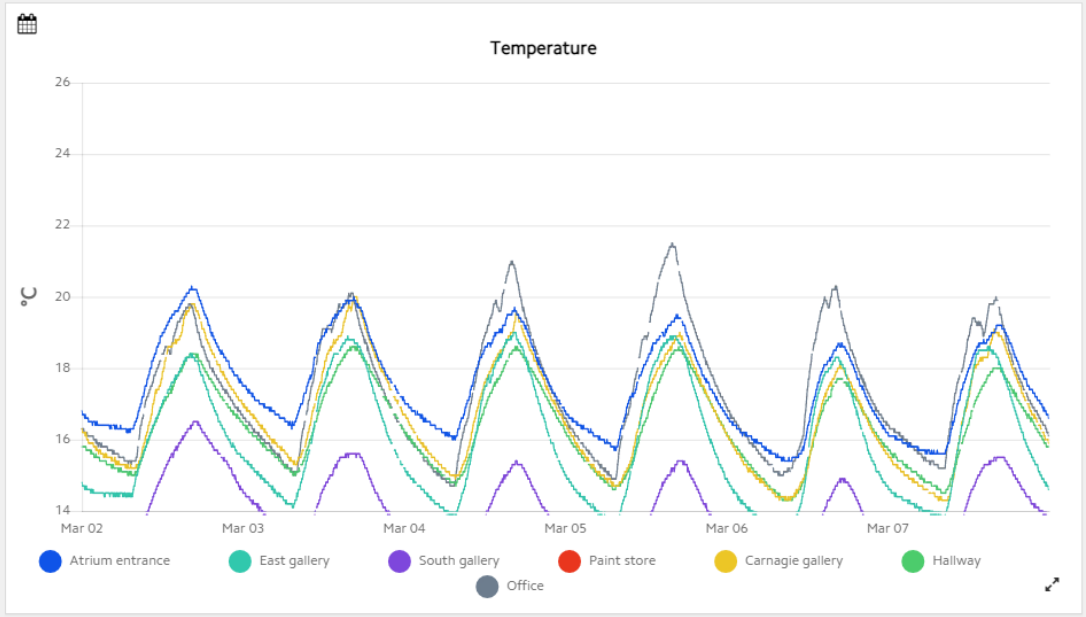
Educational

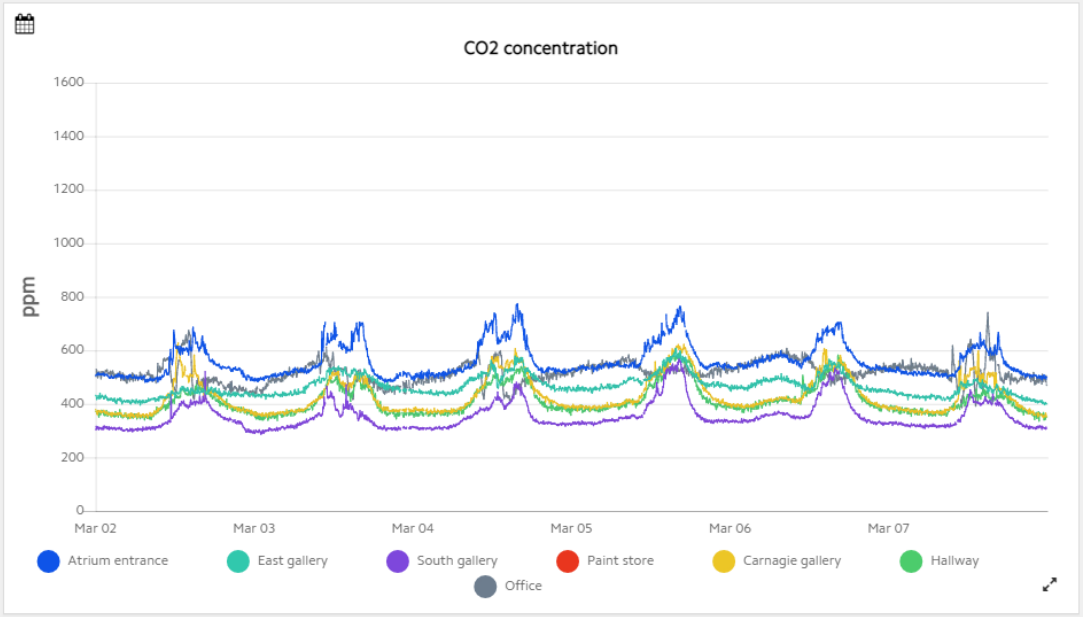
Commercial

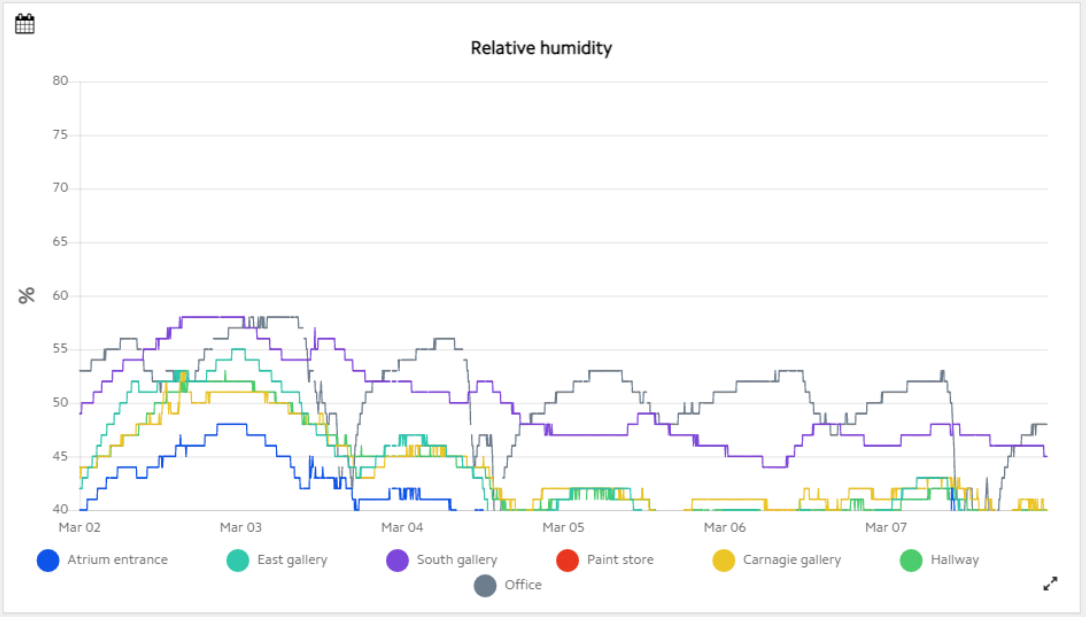
IEQ monitoring | Indoor Environmental Quality Sensors

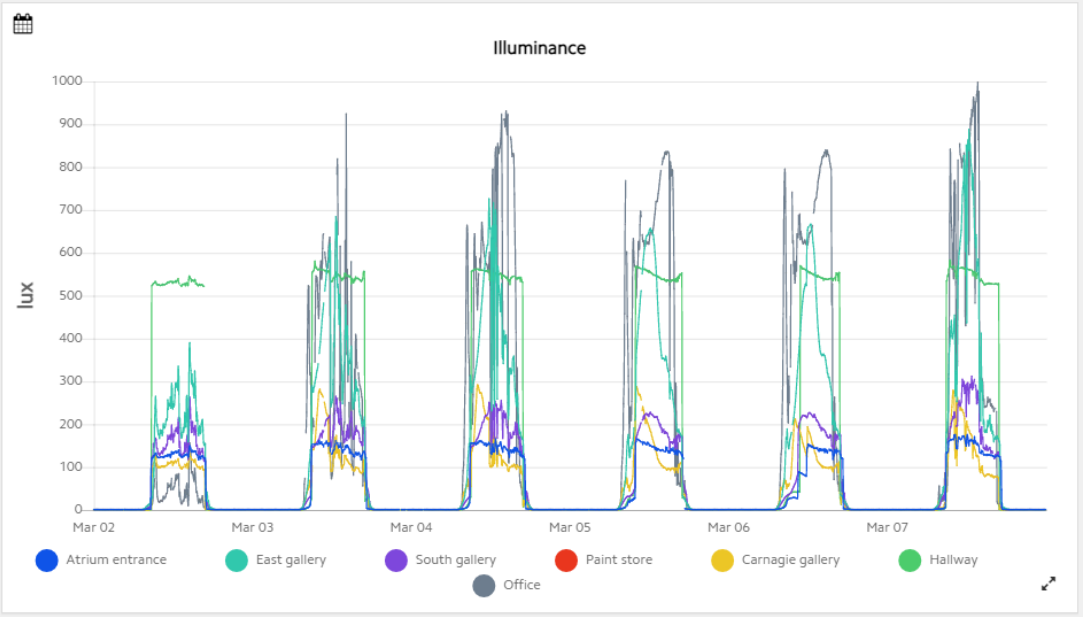
Hello, Lorenzo De Donatis Log off

Auto refresh in : 09:16

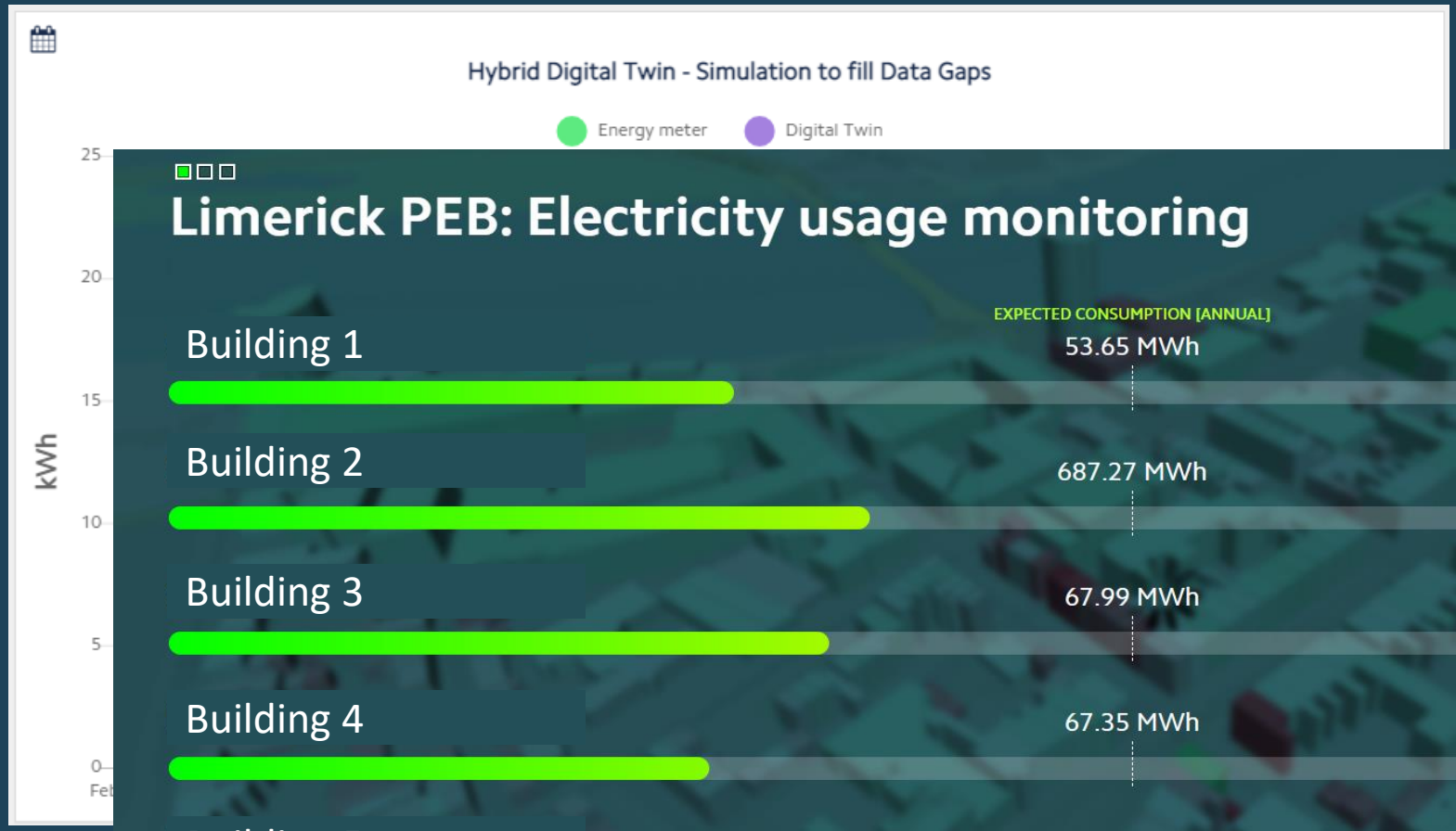


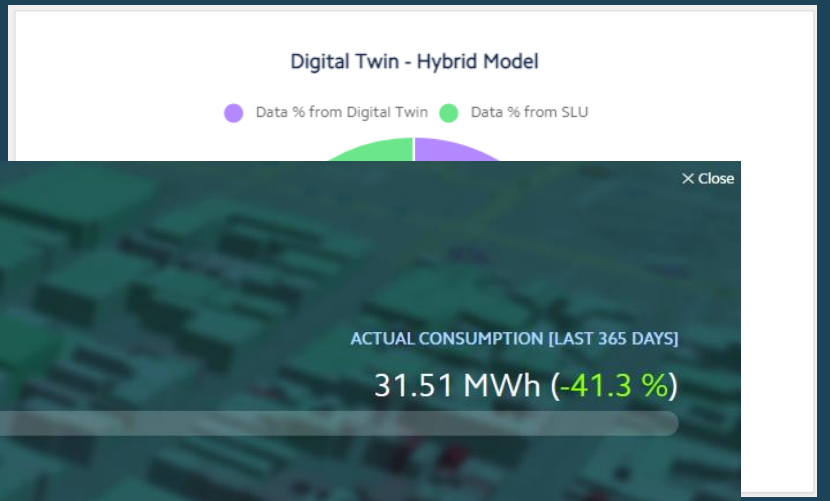






Energy monitoring through Digital Twin





Close

Limerick PEB: Electricity usage monitoring

	EXPECTED CONSUMPTION [ANNUAL]	ACTUAL CONSUMPTION [LAST 365 DAYS]
Building 1	53.65 MWh	31.51 MWh (-41.3 %)
Building 2	687.27 MWh	500.68 MWh (-27.2 %)
Building 3	67.99 MWh	46.68 MWh (-31.4 %)
Building 4	67.35 MWh	37.76 MWh (-43.9 %)
Building 5	97.22 MWh	63.24 MWh (-35.0 %)

Summary

Digital Twins for the Built Environment

- Optimise operation by understanding current and future performance of buildings, communities & networks
- Balance energy, carbon, cost and ESG targets alongside comfort, health & wellbeing needs
- Plan for the future and track progress with net-zero roadmaps & policy targets

Thank you!

Lorenzo De Donatis, ICL Consultancy Manager

Integrated Environmental Solutions Ltd.

Lorenzo.DeDonatis@iesve.com