Low energy retro-fit case study

CIT ZERo2020

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CIT CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Agenda

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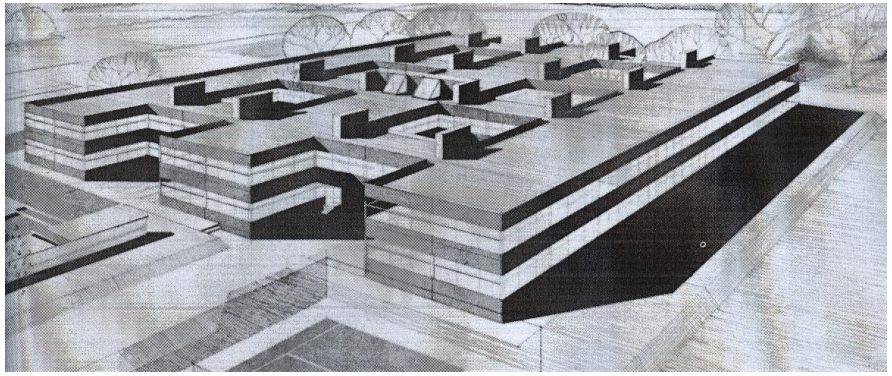
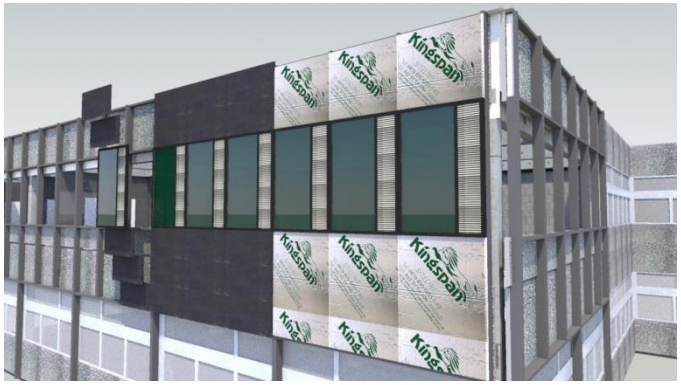
- **ZERo2020 overview**
- **Motivation behind the project**
- **Project build**
- **Performance**
- **Lessons learnt**

ZERo2020 overview

The '**Zero2020' Project** is a project involving extensive refurbishment and upgrade of 3% of an existing 1974 office and teaching space on the Bishopstown Campus of Cork Institute of Technology as a pilot project.





Its mission is to provide a live, monitored testbed environment to explore energy and resource performance through the use of low energy solutions with emphasis on demonstrating nearly zero energy in use operation.

ZERo2020 overview

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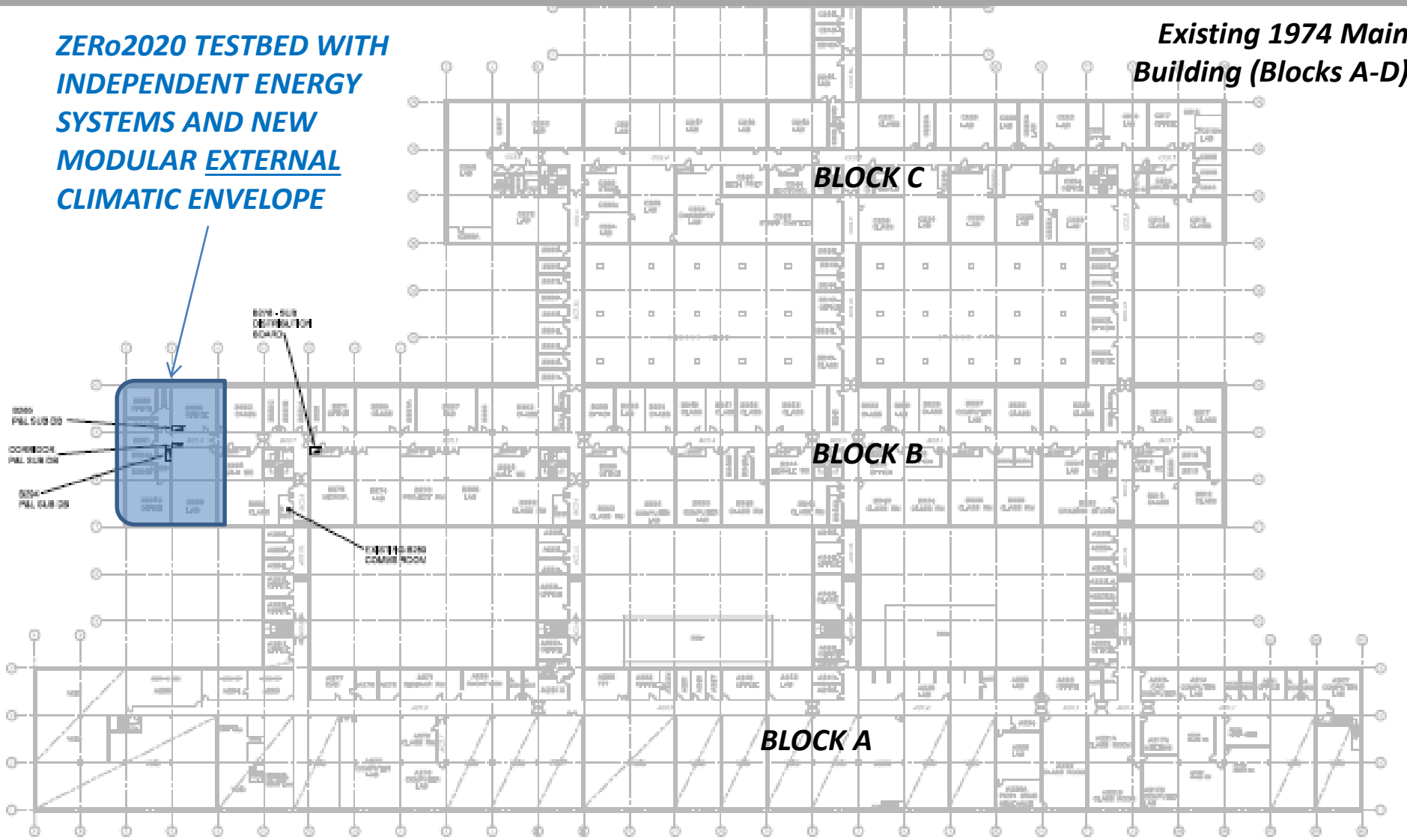
Where on campus is the **ZERo2020** Project?



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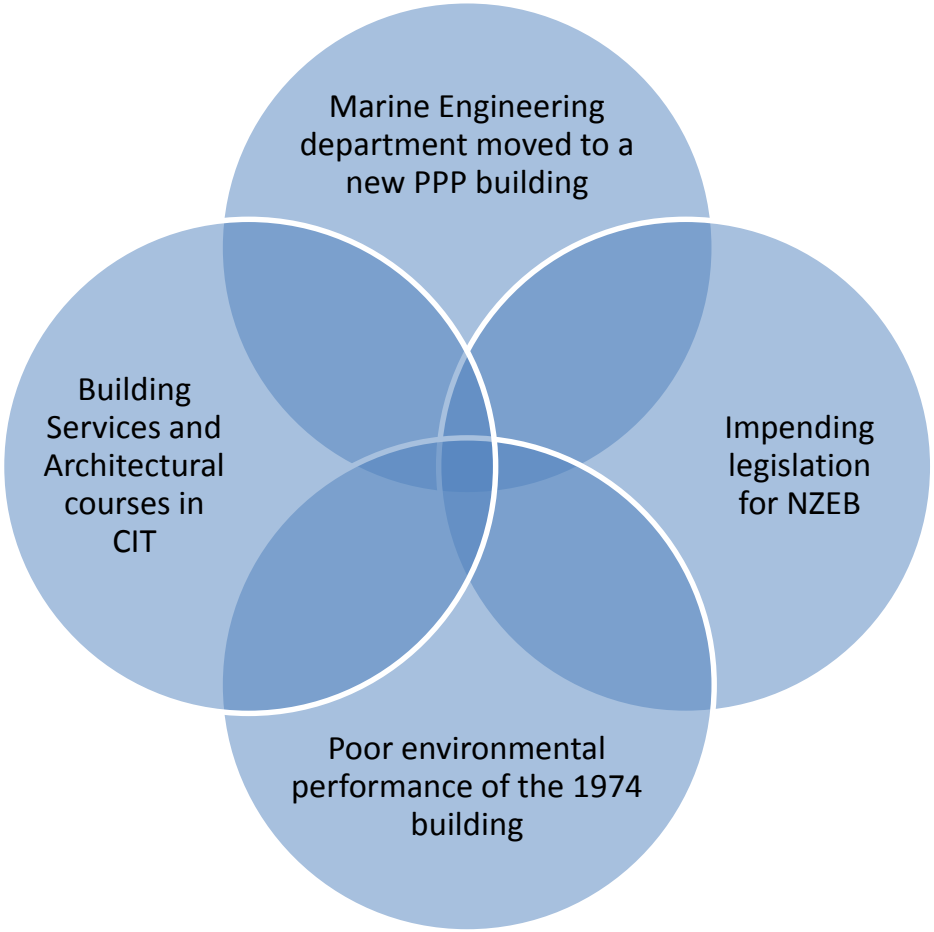
Project motivation



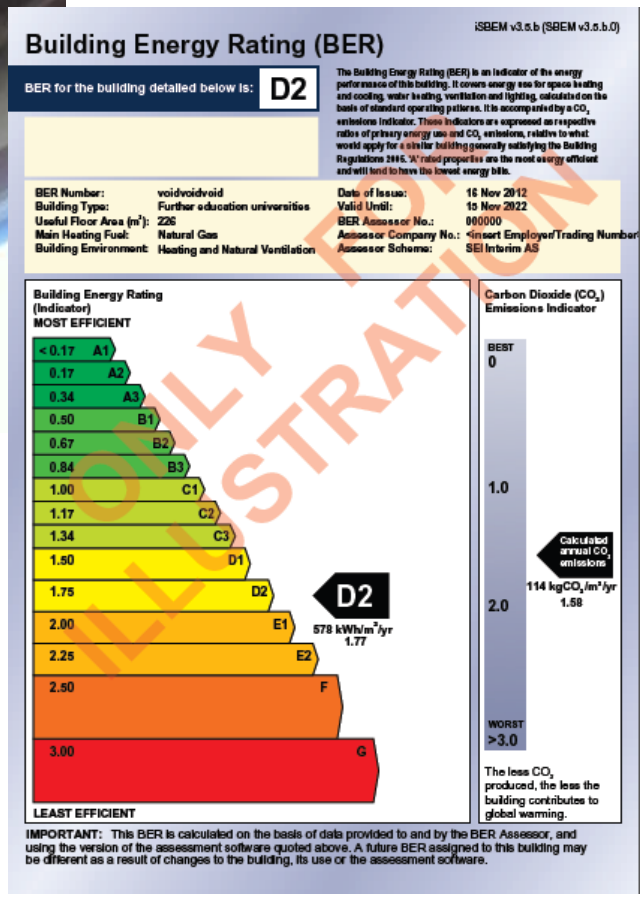
Project motivation

Marine Engineering department moved to a new PPP building

NMCI
National Maritime College of Ireland
Colaiste Náisiúnta Mara na hÉireann

Project motivation

Poor environmental performance of the 1974 building



Project motivation

Building Services and Architectural courses in CIT

Architecture factory CIT

BACHELOR OF ENGINEERING IN BUILDING SERVICES ENGINEERING

Course Code CR 072

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Project motivation

DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 19 May 2010

on the energy performance of buildings

(recast)

Impending legislation for NZEB

REPORT ON THE DEVELOPMENT OF COST OPTIMAL CALCULATIONS AND GAP ANALYSIS FOR BUILDINGS IN IRELAND UNDER DIRECTIVE 2010/31/EU ON THE ENERGY PERFORMANCE OF BUILDINGS (RECAST)

Section 2 –Non Residential

IRELAND

MARCH 2013

Project motivation

- EPBD Recast
  - 19th May 2010 Recast EPBD came into force
  - Overhaul of 2002 EPBD

What are key points of Recast EPBD?

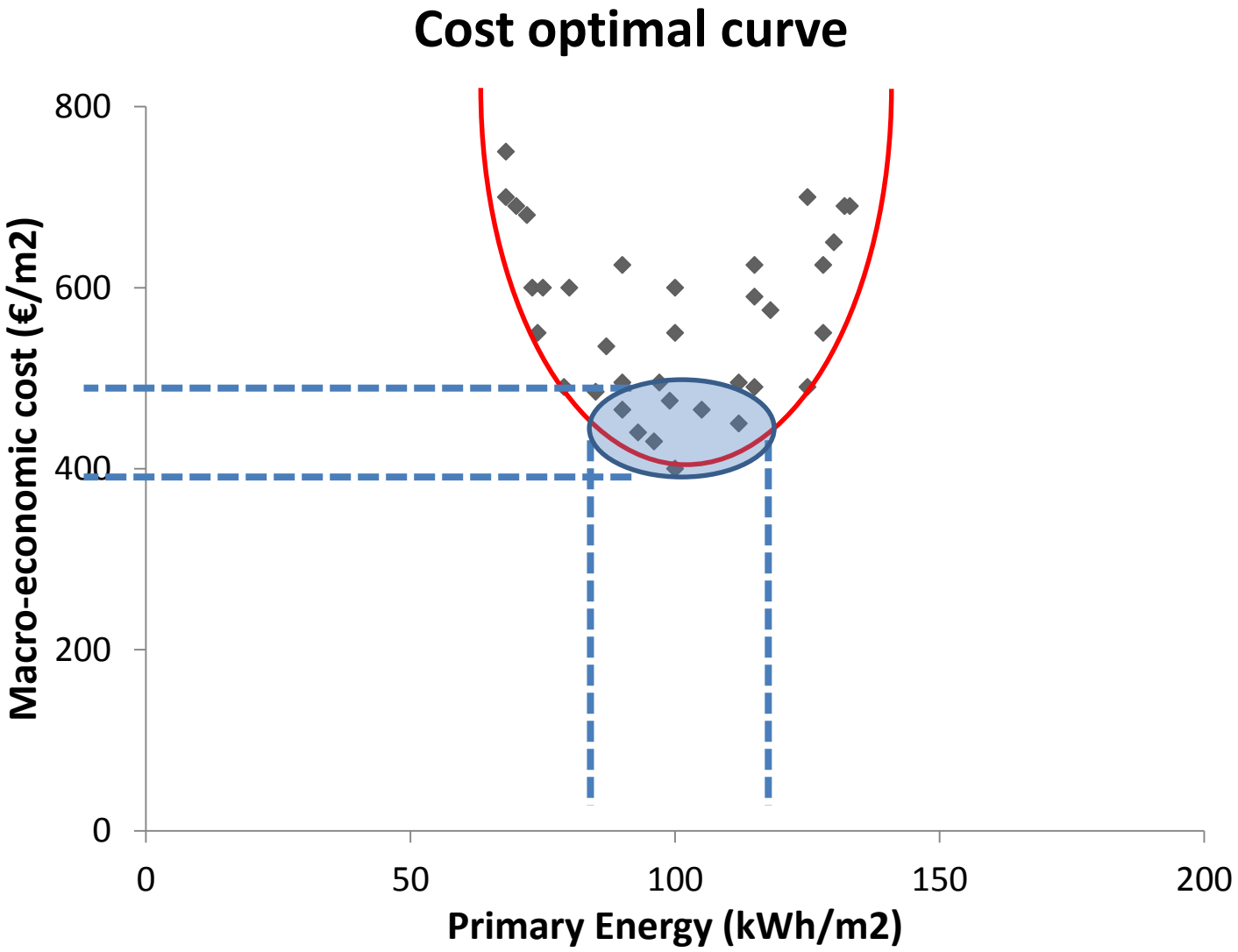
  - Broadly **defines nearly zero energy buildings**
  - Includes general guidance on retrofitted buildings
  - Includes **cost optimal methodology** for first time

Project motivation

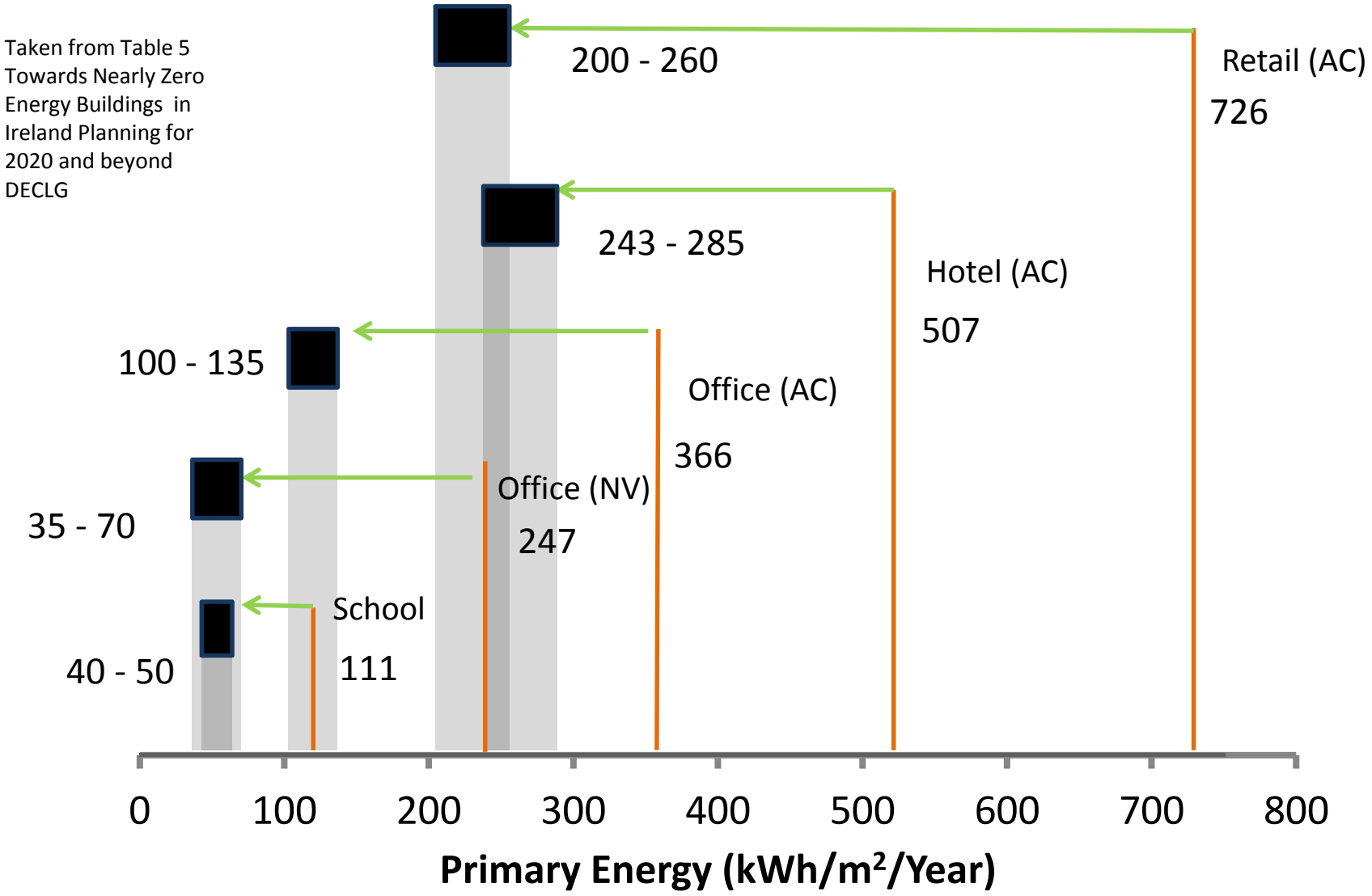
"A **Nearly Zero Energy Building (NZEB)** means a building that has a **very high energy performance**….. The nearly zero or very low amount of energy required should be covered to a **very significant extent by energy from renewable sources**, including energy from renewable sources produced **on-site or nearby**."

EPBD Recast Article 2 Definitions

Project motivation - Cost Optimal Curve



Cost Optimal NZEB New Build



Cost Optimal NZEB Refurb

Option	Cost optimal
Cavity wall U-value	0.3
Other wall U-value	0.2
Roof U-value	0.17
Floor U-value	0.12
Window U-value	1.56
Heating	ASHP
Lighting (lm/W)	62
Chiller (SEER)	5.5
AHU SFP ($W.l^{-1}.s^{-1}$)	1.8

Interpreted from Tables 7.2a to 7.2i Cost Optimal calculations and Gap Analysis for recast EPBD for Non-Residential Buildings, DECLG

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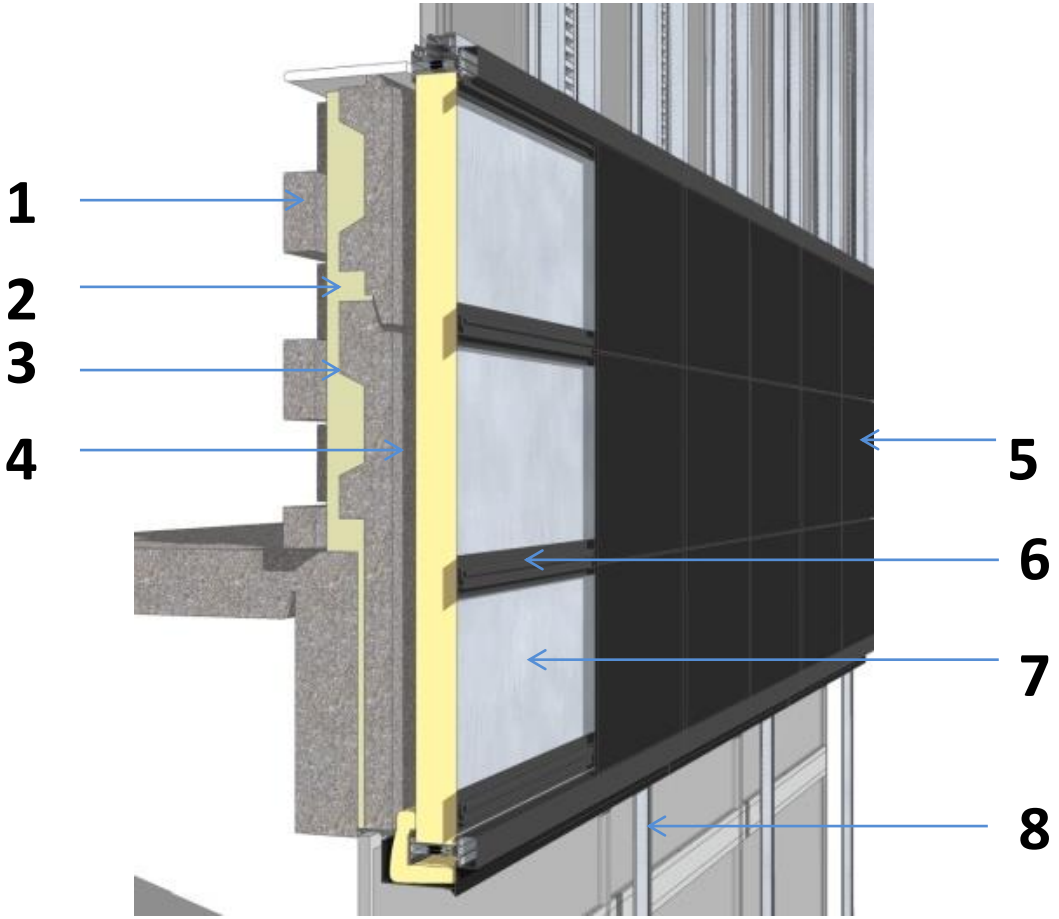
Project build

Project requirements	Solution
Low energy	ASHP connected to radiators, quadruple glazing, interstitial blinds, improved air tightness, heavily insulated
Naturally ventilated	High and low level insulated louvres (Manual & BMS control)
Minimise disruption to existing structure	New envelope wrapped around the existing building
Cannot dislocate staff/students	Flat pack off site build
Live test bed	Heavily instrumented

Project build - wall detail



Layer	Description	Dim (mm)
1	Existing internal block	100
2	BASF Walltite spray foam	86
3	Existing aggregate panel	125
4	Air gap	30
5	Kingspan Benchmark ceramic granite panel	12
6	Kingspan support rail	37
7	Kingspan KS1100 insulated panel	125
8	AMS support mullion	125

Project build - fenestration

Fully integrated factory assembled module

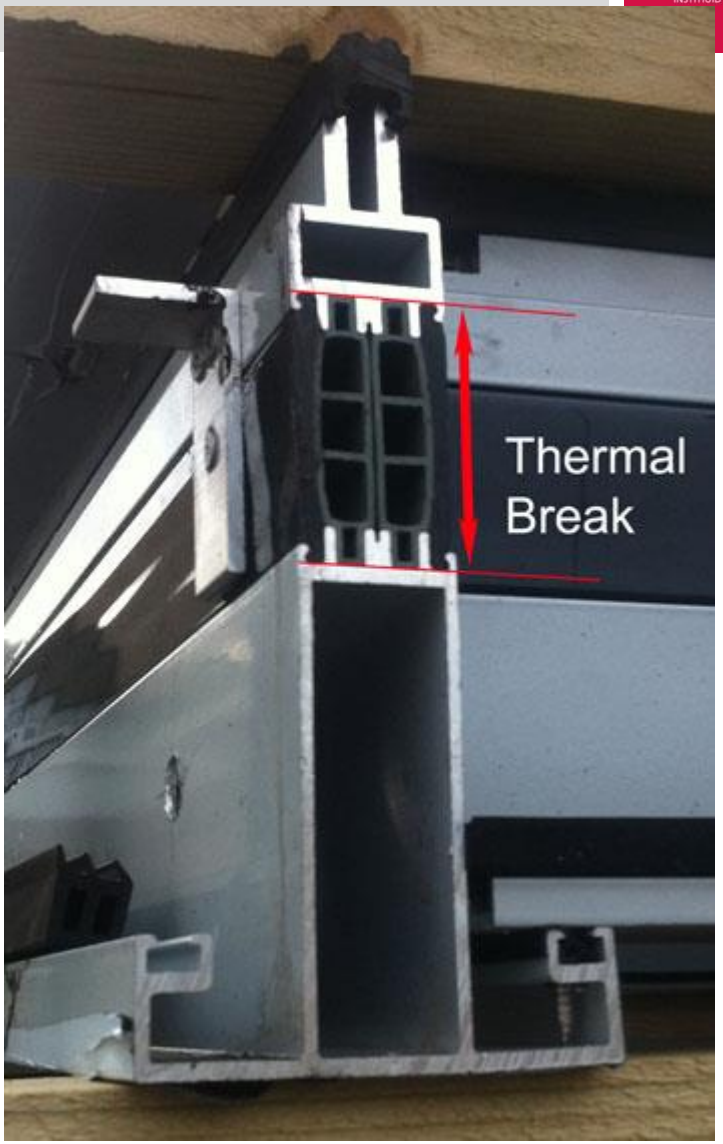
Quadruple glazed unit c/w sealed triple glazed Argon filled system/ manual interstitial blinds / inner clear float pane

Integrated insulated ventilation doors low level occupancy controlled & high level BMS automated

Project build - ventilation module

- Free-running indoor temperature as no HVAC system is used
- The envelope achieved an air permeability of 1.76 $(m^3/hr)/m^2$ at 50Pa building pressure. The existing structure was measured as 14.77 $(m^3/hr)/m^2$

Project build



Project build

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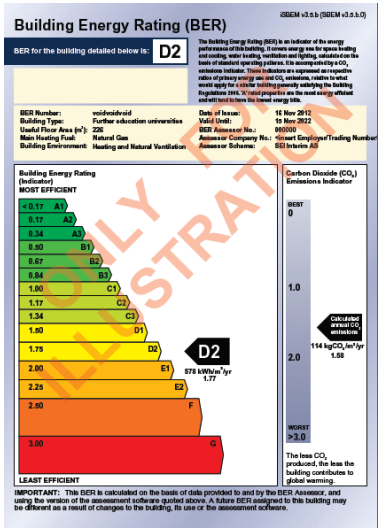
Performance - energy



Performance - energy

	Delivered energy kWh/m²/year	Primary energy kWh/m²/year	CO2 kgCO_2/m²/year
Pre-retrofit	185.0	325.0	69.2
ZERO2020	70	171.5	38.8

Performance - energy

Comparison of CIBSE TM46 Benchmark values to ZERO2020 performance

Category	Name	Total delivered energy kW.h/m^2/year
1	Office	215
17	School	190
18	University	320
	ZERO2020	64*2

*2 64 kW.h/m^2/year is based on 2021 degree days in line with CIBSE TM46

Performance - structure

Refurbished Nat Vent Office EE1

Option	Cost optimal *1	ZERO2020
Cavity wall U-value	0.3	0.09
Roof U-value	0.15	0.09
Floor U-value	0.10	NA
Window U-value	1.8	<1.0
Heating	ASHP	ASHP
Lighting (lm/W)	65	48

*1 Taken from Tables 7.2a to 7.2i Cost Optimal calculations and Gap Analysis for recast EPBD for Non-Residential Buildings

Performance – internal environment

We cannot make a declaration about energy performance in buildings without also making a declaration regarding internal environment and occupant comfort perception

Is the zero2020 internal environment acceptable?

Performance - Occupant Survey

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How satisfied are you with the temperature in your workspace?

Very Satisfied	Satisfied	Somewhat satisfied	Neutral	Somewhat dissatisfied	Dissatisfied	Very dissatisfied
(+3)	(+2)	(+1)	0	(-1)	(-2)	(-3)
66.67%	**22.22%**	**11.11%**	**0%**	**0%**	**0%**	**0%**

How satisfied are you with the following in the building?

Environmental Parameter	Very Satisfied	Satisfied	Somewhat satisfied	Neutral	Somewhat dissatisfied	Dissatisfied	Very dissatisfied
	(+3)	(+2)	(+1)	0	(-1)	(-2)	(-3)
Visual comfort of the lighting	57.14%	28.57%	0%	14.29%	0%	0%	0%
View of external areas	14.29%	57.14%	14.29%	14.29%	0%	0%	0%
Noise	42.86%	42.86%	14.29%	0%	0%	0%	0%
Lighting	66.67%	16.67%	0%	0%	16.67%	0%	0%
Humidity	42.86%	28.57%	0%	28.57%	0%	0%	0%
Health (headaches, astma, alergies)	28.57%	42.86%	0%	14.29%	14.29%	0%	0%
Comfort	**71.43%**	**14.29%**	**0%**	**14.29%**	**0%**	**0%**	**0%**
Air quality - stuffy/stale air, odours	42.86%	28.57%	0%	0%	14.29%	14.29%	0%

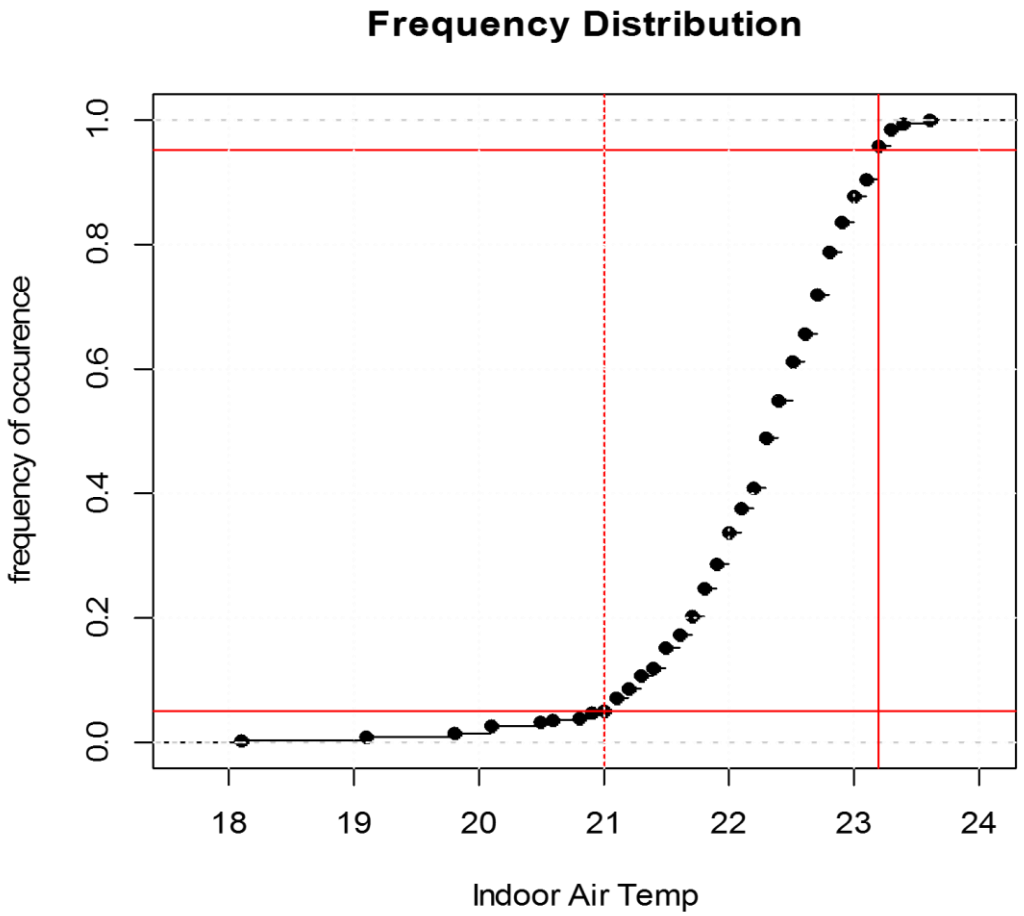
Performance -Winter Env. Performance

5 week period 18th February to 24th March 2013 inclusive

The occupancy schedule 08.00 to 18:00 hours, Monday to Friday inclusive

81% of the time the internal air temperature lies within the 21-23°C comfort range

13% of the time the temperature is in the 23 to 23.5°C range, marginally outside the comfort criteria

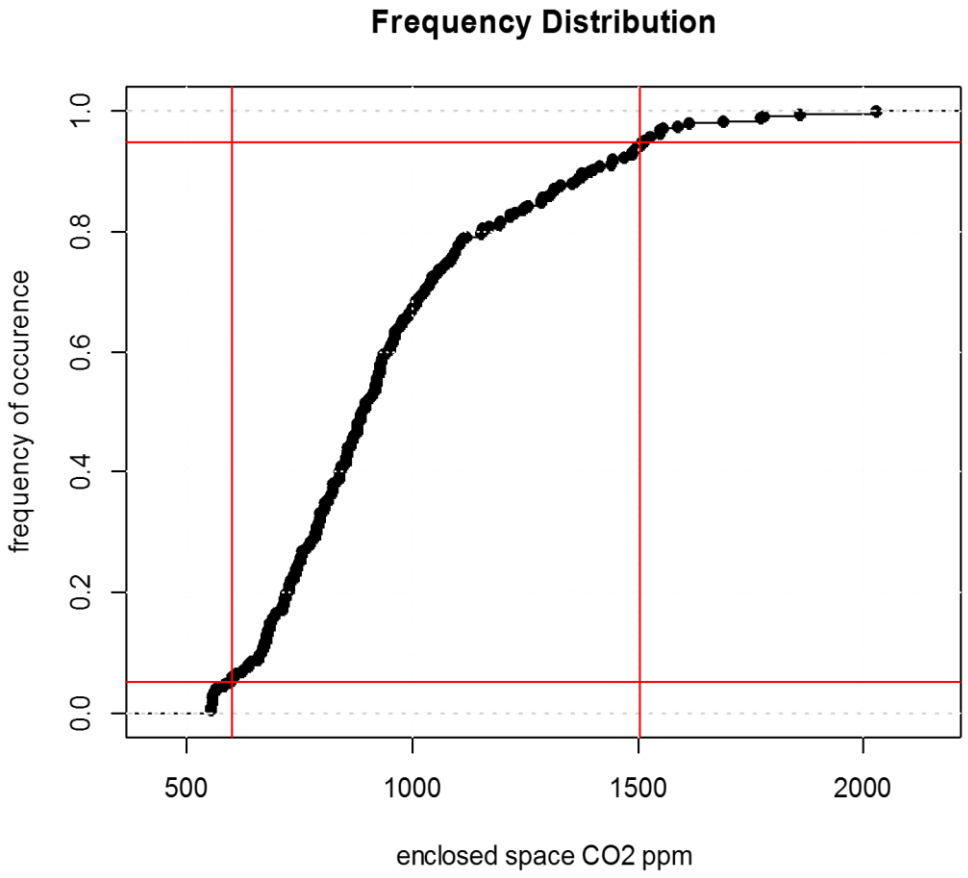


5 week, occupancy hours Cumulative Frequency Distributions for indoor air temperature (red lines show 95 percentile and 5 percentile values)

Performance - IAQ

High air quality, as defined in EN 13779:2007, is achieved 33% of the time and medium air quality 34% of the time

Range of conditions based on 5% confidence intervals is 600 – 1500 ppm. 50th percentile value 850ppm



5 week, occupancy hours Cumulative Frequency Distributions for indoor CO_2 ppm (red lines show 95 percentile and 5 percentile values)

Performance - IAQ

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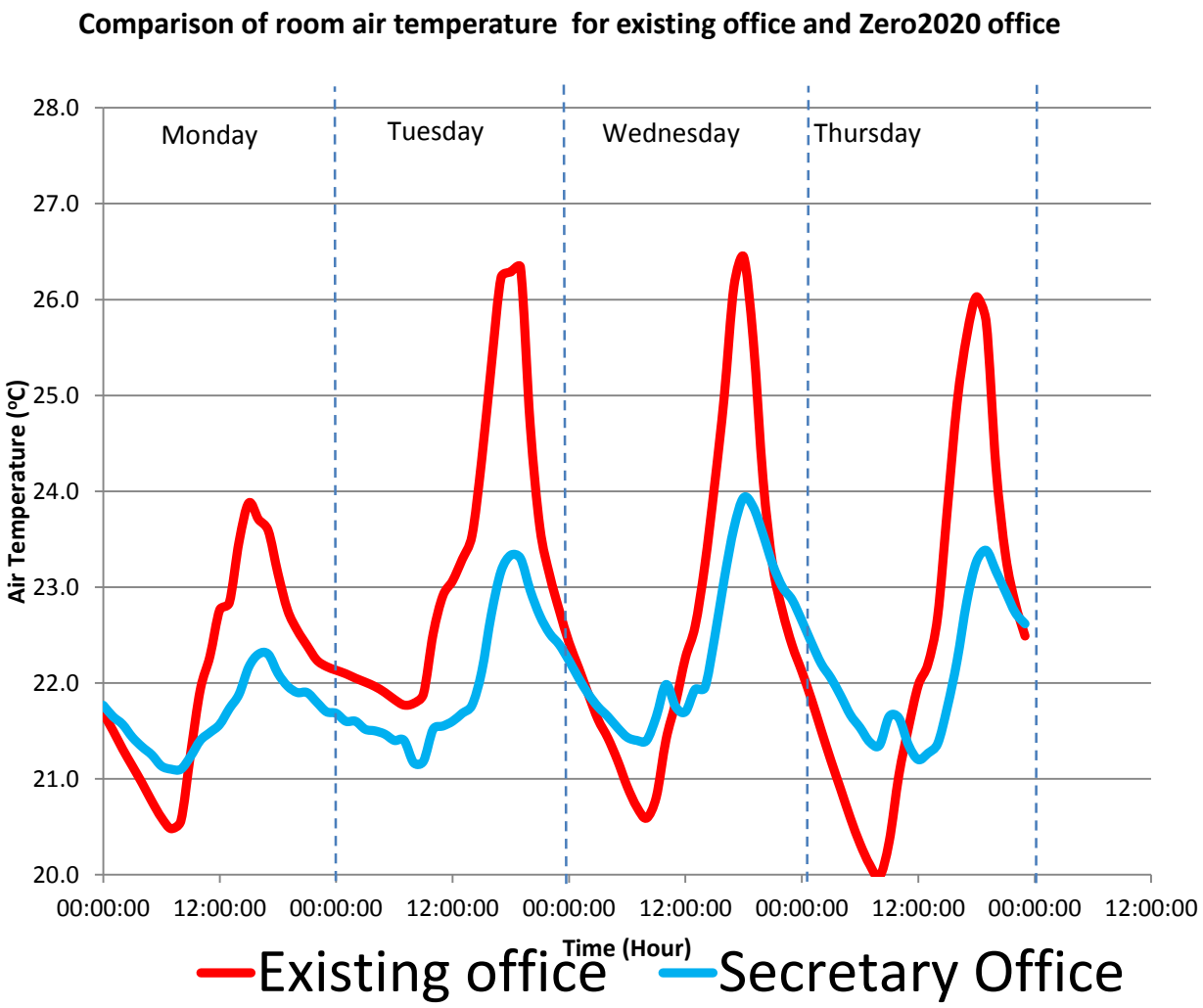
Initial Environmental Data Findings – Sample 3rd - 6th Sept '12



Summary points

- Substantial variation in temperature distribution between pre and post retrofit spaces
- Peak temperature occurring around the same time in both spaces (no major increase in the time lag with new design)
- Conditions uncomfortable in existing space during the occupied period
- Transient effect on conditions over continuous period of warm days
- Temperatures staying above 20°C at all times in both spaces

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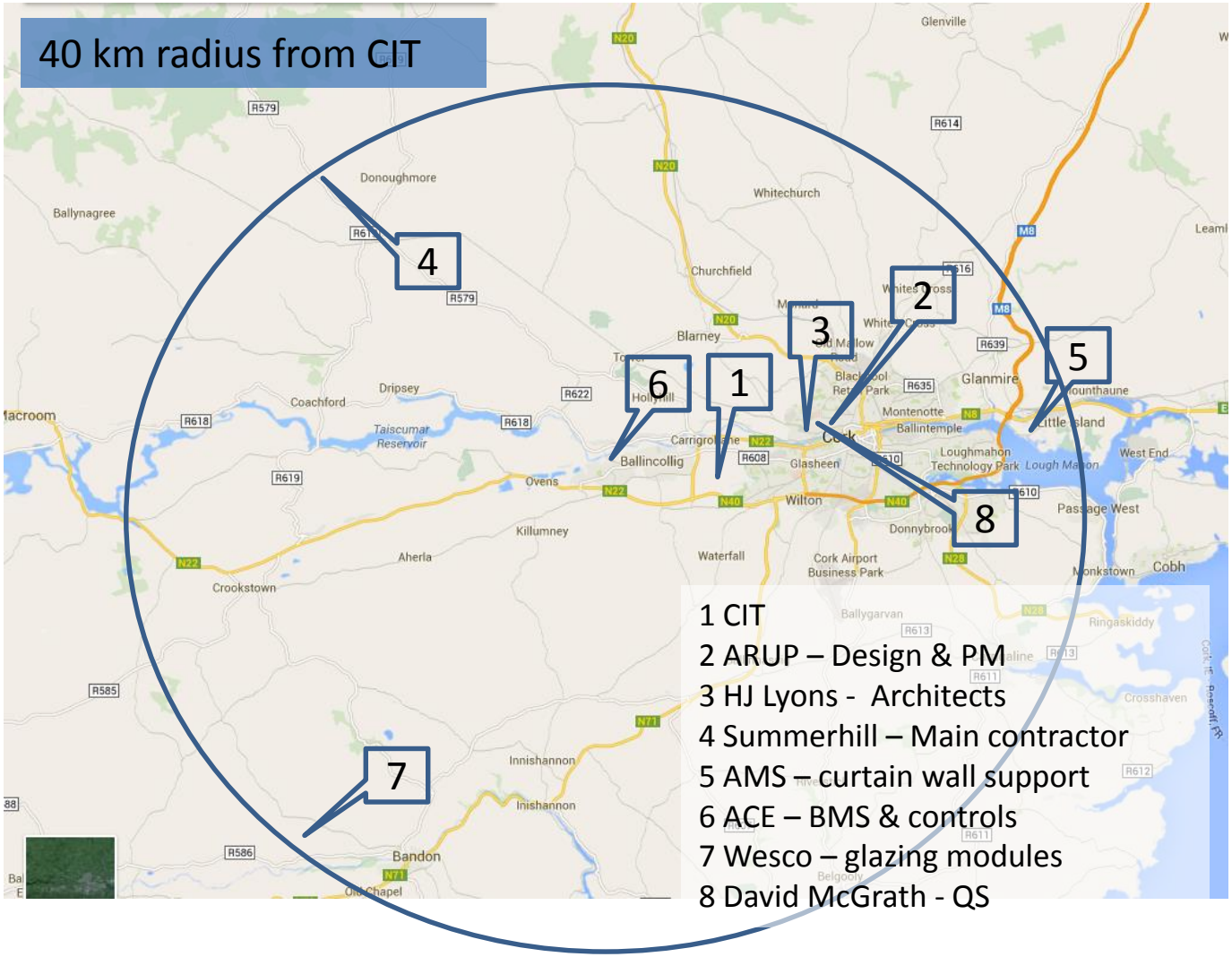
Lessons learnt

- Project requirement :
  - a low energy building that could support our undergraduate in Building Energy Systems and post graduate research
- Project management
  - Building Services consultant appointed as the project designers and managers to emphasise priority on energy reduction
- Good decision ? YES

Lessons learnt

- Localisation was critical for problem solving
  - All parties involved were typically within a 40 km radius of the job
    - Design consultant and project managers, ARUP
    - Architect, HJ Lyons
    - Main contractor, Summerhill construction
    - Controls/BMS, ACE
    - QS, Dave McGrath Associates
  - The only exception was Kingspan

Lessons learnt



Lessons learnt

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- Industry support
  - Enthusiasm from all stakeholders wrt low energy demonstration projects is vital
    - It pushes the boundaries
    - It challenges standard solutions
    - It produces very good build quality
    - Pride in a finished product is a great selling point

Lessons learnt

- Occupant behaviour
  - Natural ventilation under user control will only work with occupant buy-in to the concept
  - Lighting control under user control will only work with occupant buy-in to the concept
  - Motivation for users wears off with time (can be a very short time in some cases!!!!)
  - Positive re-enforcement can have a negative effect! (how do you keep focus on energy reduction before the user gets fed up with reminders?)

Lessons learnt

- Low carbon low energy is not the primary goal
  - The building must be fit for purpose
  - A low carbon, low energy building with poor user satisfaction is a failure
  - Design around the person first

Lessons learnt

- Claims of low carbon, low energy, good thermal environment etc are no good without the data to back them up
  - Meter as much as possible
  - Monitor internal environmental conditions in as many places as possible
  - If it is a refurbishment project can you get in and monitor for a significant period pre-refurbishment in order to establish a baseline

Lessons learnt

- Warning about monitoring!!!
  - Data needs to be analysed, interpreted and reported
  - This needs to be done for a few years post occupancy
  - If you can't finance this resource then there is no point in data-logging!

Thank You…Questions?

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