Toward 2020. Nearly Zero Energy Buildings // CIT ZERo2020

Paul O'Sullivan

Applied Energy Research Group // Process Energy & Transport Engineering

CIT CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Agenda

- **2010 Energy Performance Buildings Directive & Recast**
- NZEB EU Definition, Calculation & System Boundaries
- EPBD Recast Cost Optimal Methodology
- CIT ZERo2020 Overview & performance

EPBD = Energy Performance of Buildings Directive

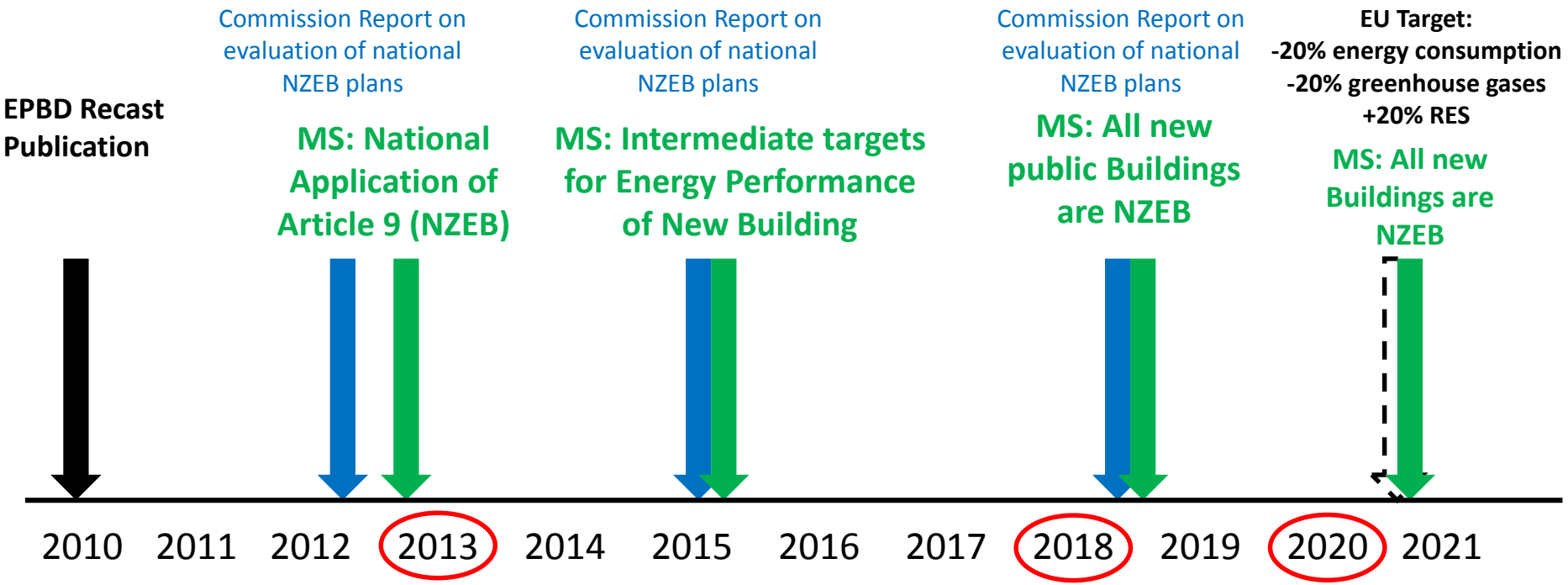
2010 Recast EPBD

- 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
- Doesn't define specific boundaries for calculation

Timeline - NZEB related actions



- **31 December 2018** – Public authorities that own or occupy a new building should set an example by building, buying or renting a nearly zero energy building
- **31 December 2020** – All new building must consume "nearly zero" energy, which will be to a very large extent from Renewable sources

Agenda

- 2010 EPBD & Recast
- **NZEB EU Definition, Calculation & System Boundaries**
- EPBD Recast Cost Optimal Methodology
- CIT ZERo2020 Overview & Performance

EPBD = Energy Performance of Buildings Directive

EU NZEB Definition

"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**."

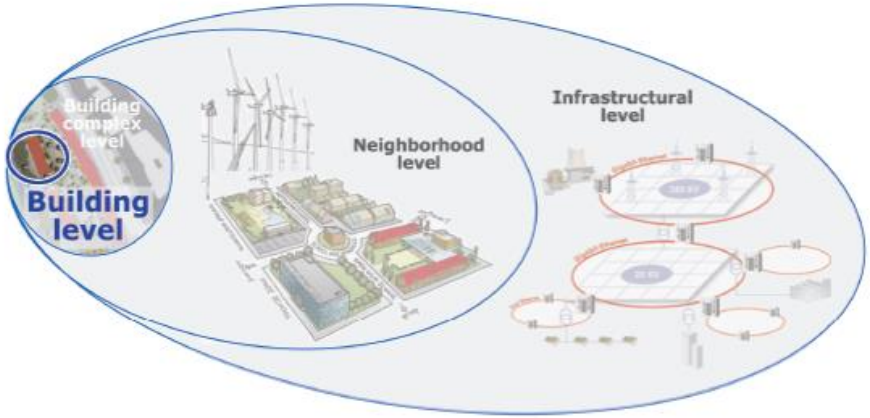
EPBD Recast Article 2 Definitions

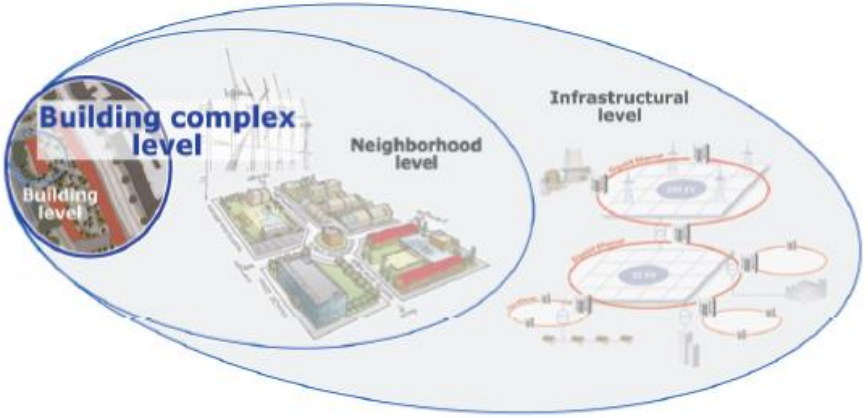
Net Zero Vs. 'Nearly' Zero

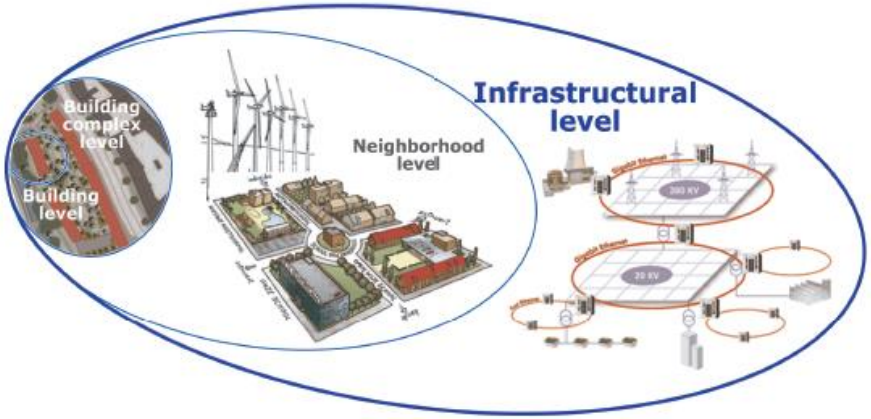
- Net zero energy building has an exact performance of 0 kWh/m^{2}a non renewable primary energy.
- 'Nearly' zero energy subject to national decisions
  - Technically reasonable achievable levels of primary energy use
  - What % of the primary energy is covered by renewable sources
  - Available financial incentives for RE or energy efficiency measures
  - Cost implications and national ambition

NZEB Boundary Definition

Possible Boundaries for Integrating Renewable Energy into NZEB calculations & measurements







NZEB Boundary Definition

- EN15603 defines the aggregation of energy for NZEB purposes
- EN15603 method takes into account the main relevant parameters that affect the performance of a building:
  - the building thermal needs
  - the technical building systems
  - the energy carriers

NZEB Aggregation of Energy

nZEB Boundary Option 1: Building Site

$$E_{us,el} = \left(E_{del,el} - E_{exp,el}\right) + E_{ren,el}$$

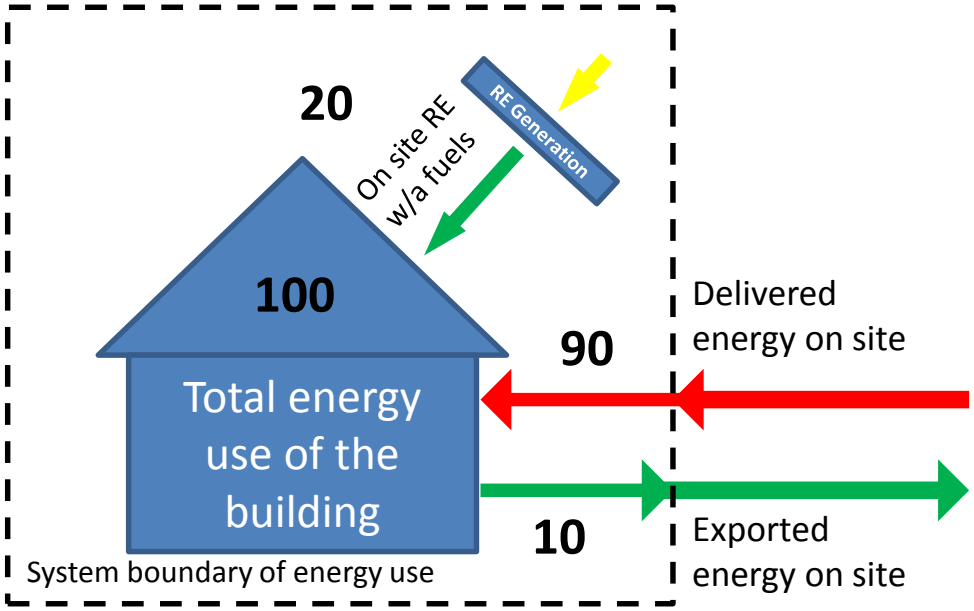
$$E_{us,T} = \left(E_{del,T} - E_{exp,T}\right) + E_{ren,T}$$

E_{us} = Total energy use (kWh/a)

E_{del} = delivered energy on site (kWh/a)

E_{exp} = exported energy on site (kWh/a)

E_{ren} = on site renewable energy (kWh/a)



Building Site = system boundary of delivered and exported energy on site

NZEB Primary Energy Indicator

Calculation of non renewable Primary energy (kWh/a)

$$E_{P,nren} = \sum_i \left(E_{del,i} f_{del,nren,i}\right) - \sum_i \left(E_{exp,i} f_{exp,nren,i}\right)$$

Calculation of Primary energy indicator (kWh/m^{2}a)

$$EP_p = \frac{E_{p,nren}}{A_{net}}$$

Agenda

- 2010 EPBD & Recast
- NZEB EU Definition, Calculation & System Boundaries
- **EPBD Recast Cost Optimal Methodology**
- CIT ZERo2020 Overview & Performance

EPBD = Energy Performance of Buildings Directive

Cost Optimal Levels

Setting of minimum energy performance requirements:

"Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with *a view to achieving cost -optimal levels"*

Article 4 Recast EPBD

Coat Optimal Definition

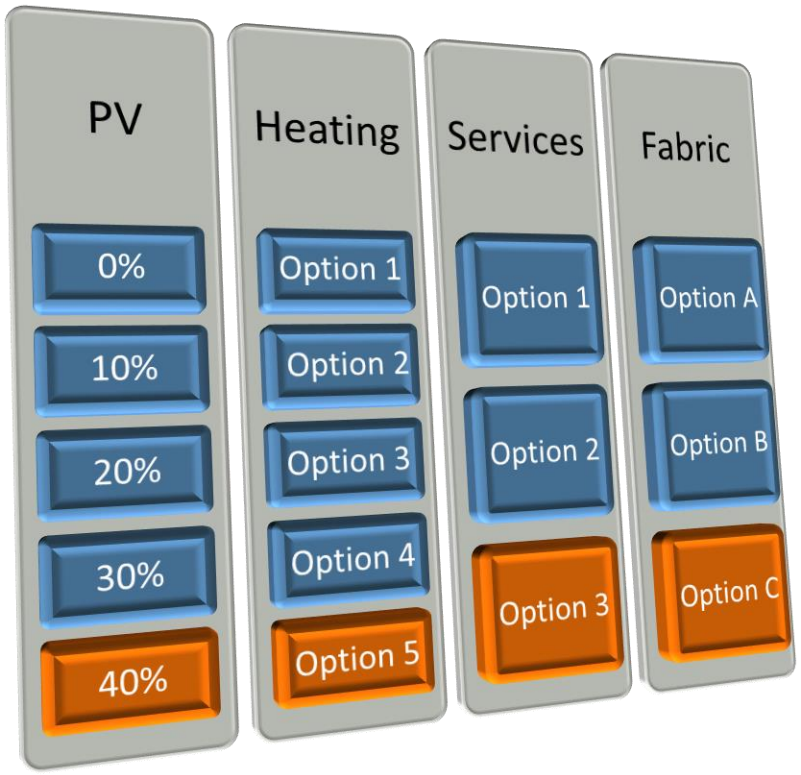
- ‘cost-optimal level’ means the energy performance level which leads to the lowest cost during the estimated economic lifecycle
- the lowest cost is determined taking into account:
  - energy-related investment costs,
  - Maintenance
  - operating costs where applicable
  - and disposal costs

DCELG Parametric Models

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

What do you need for a cost optimal energy model?

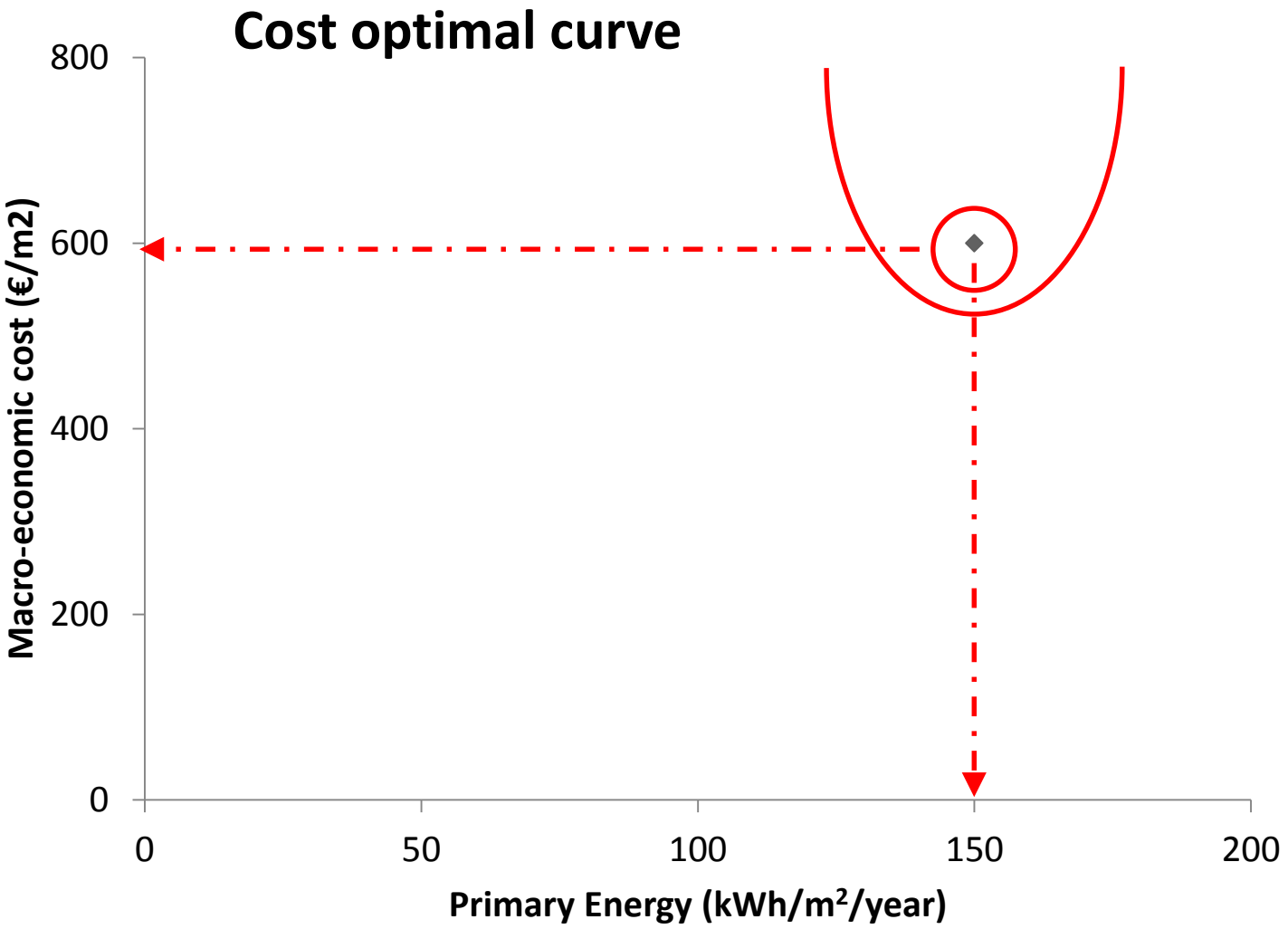
- A generic list of buildings
- A series of packages for each building
- An energy model
- An economic model



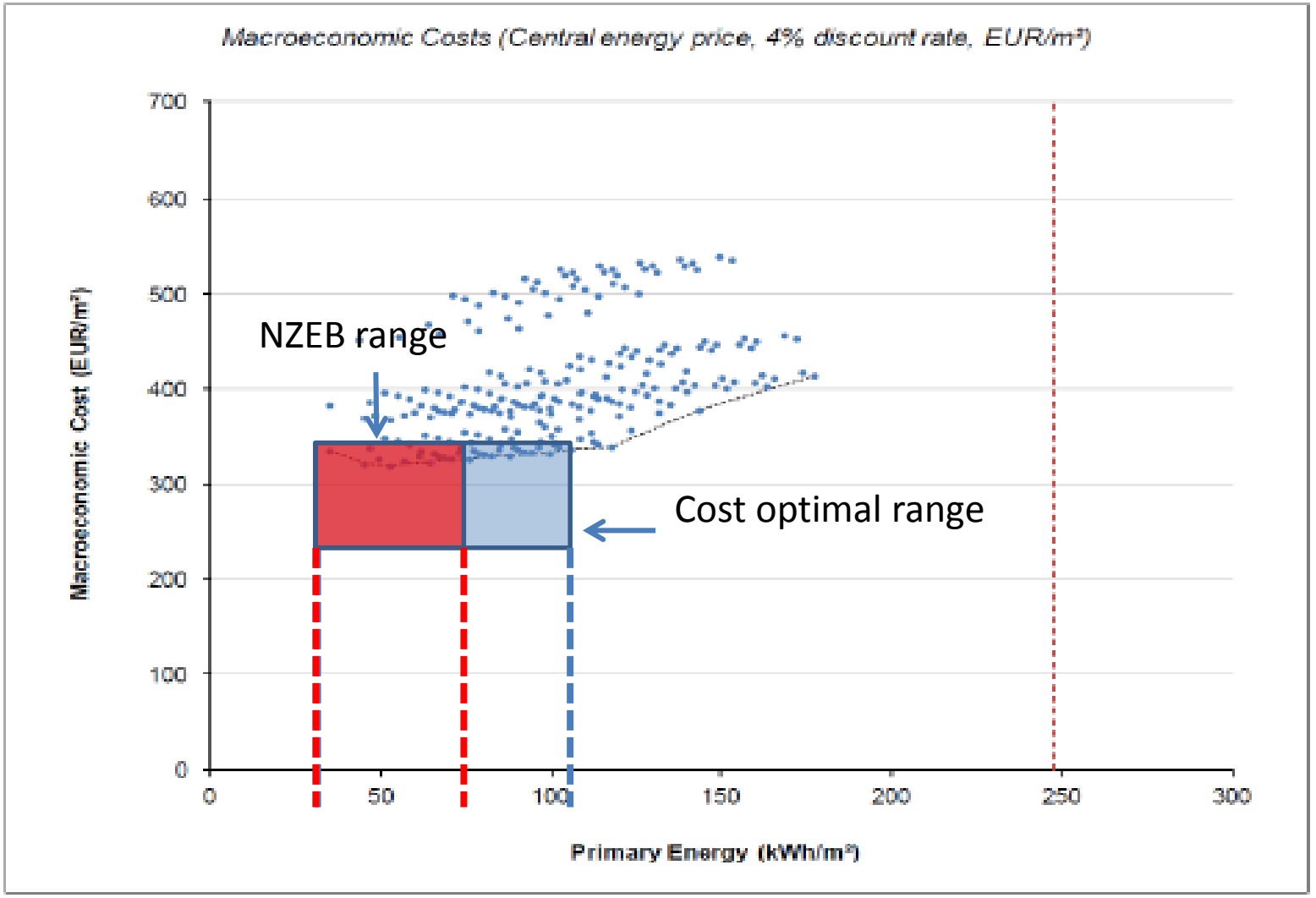
Summary of Irish DCELG Models

- 450 Packages for Offices (AC)

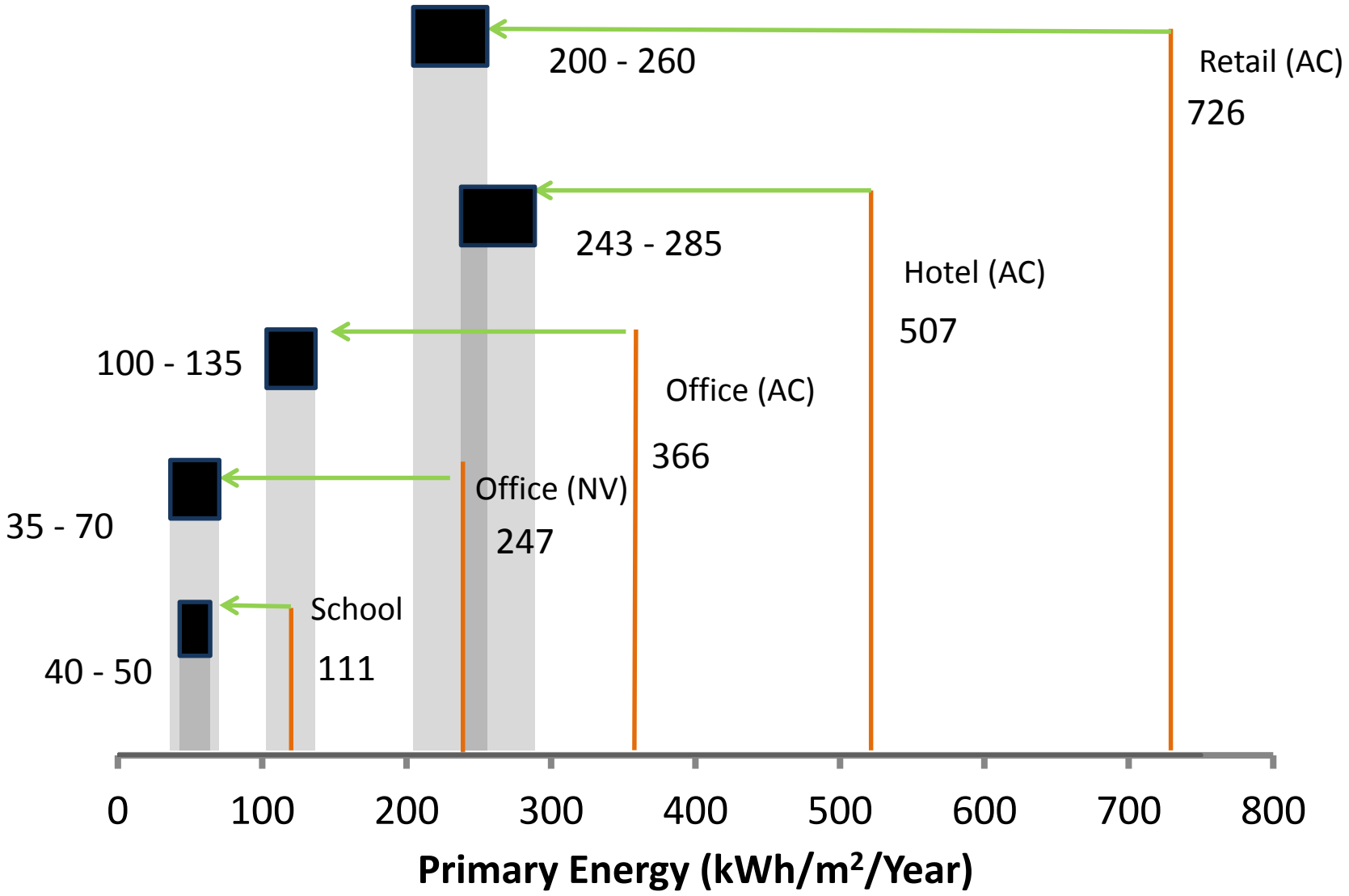
Cost Optimal Curve



Cost Optimal Curve



Cost Optimal NZEB



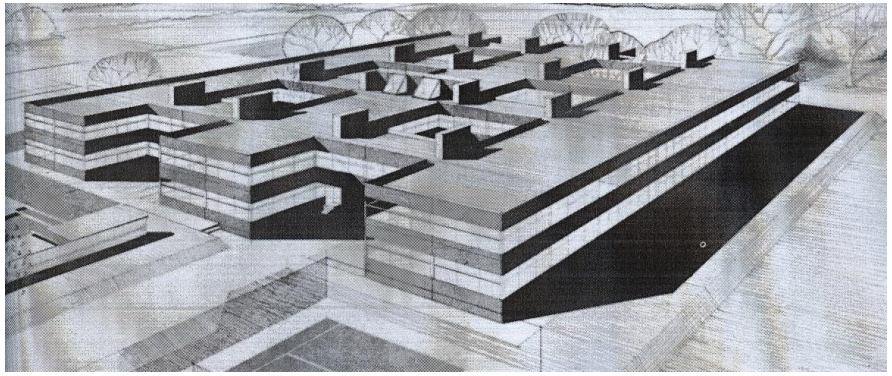
Agenda

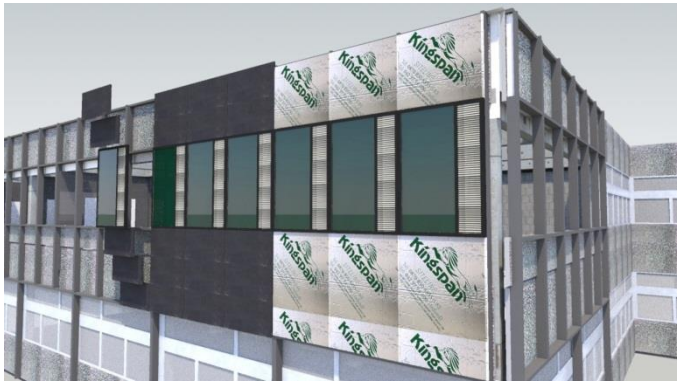
- 2010 EPBD & Recast
- NZEB EU Definition, Calculation & System Boundaries
- EPBD Recast Cost Optimal Methodology
- **CIT ZERo2020 Overview & Performance**

EPBD = Energy Performance of Buildings Directive

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.



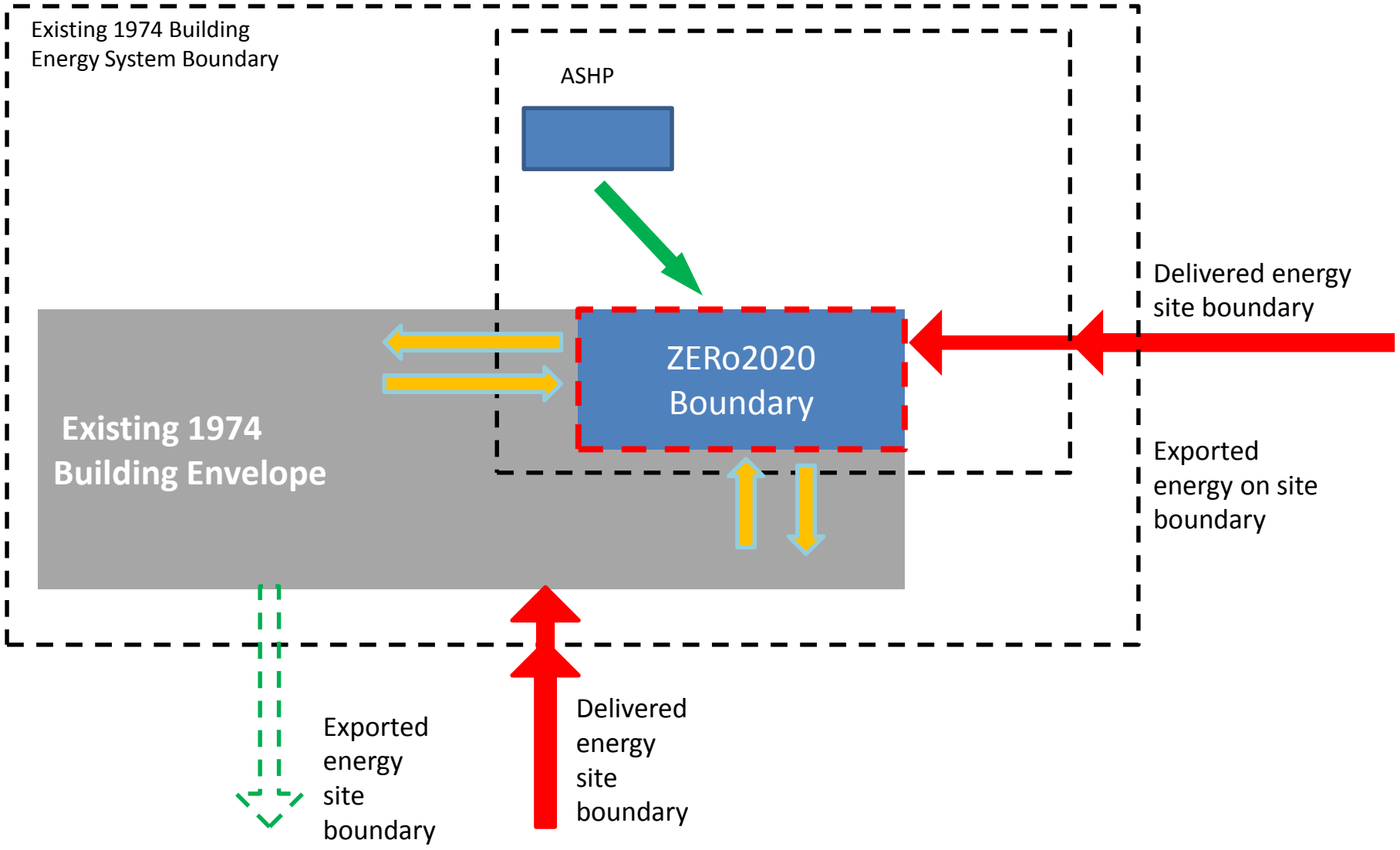


Its mission is to provide a live, monitored testbed environment to explore energy and resource performance through the use of low energy solutions with emphasis on demonstrating nearly zero energy in use operation.

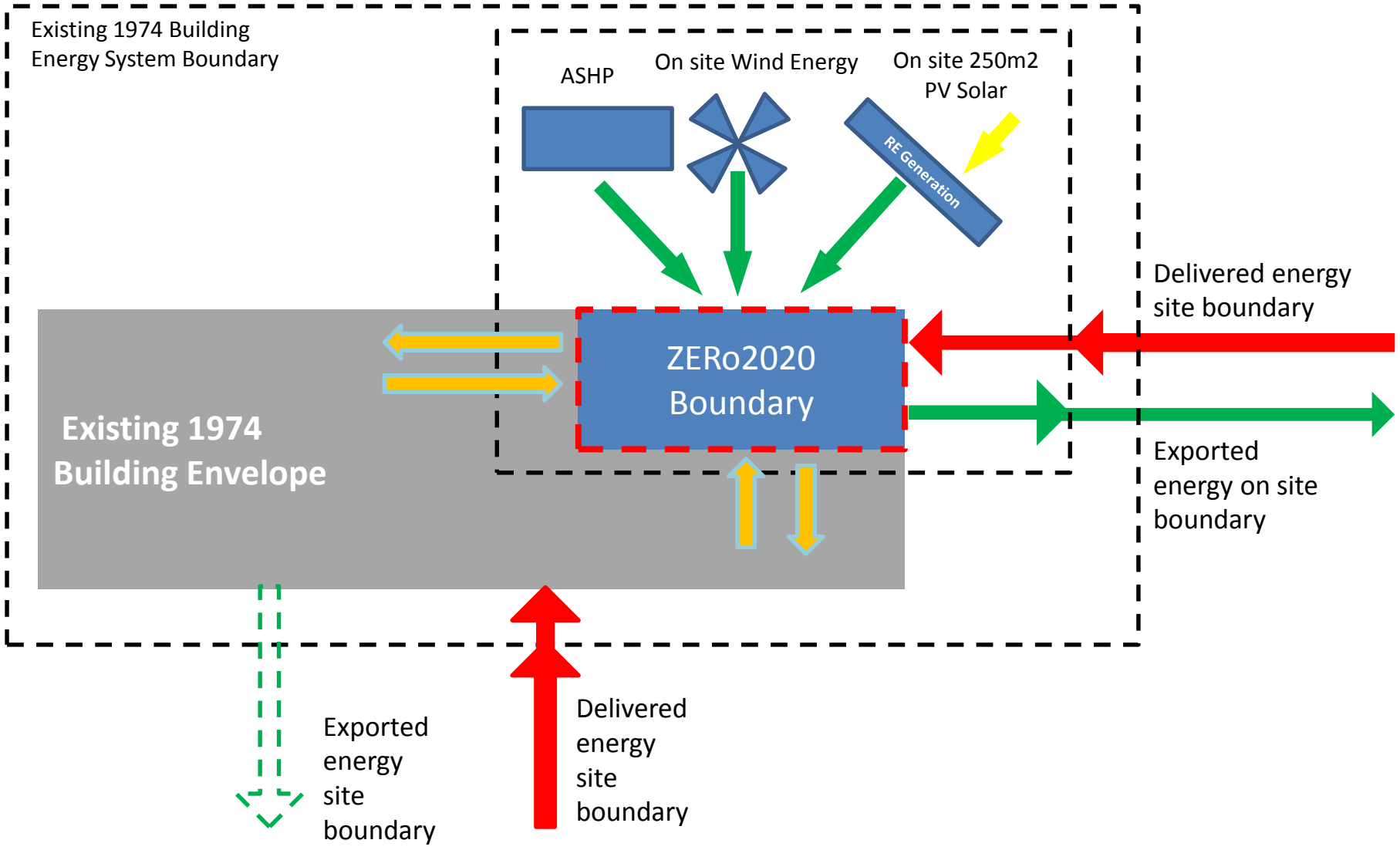
ZERo2020 overview

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

ZERo2020 Boundary



ZERo2020 Boundary



Data Logging System

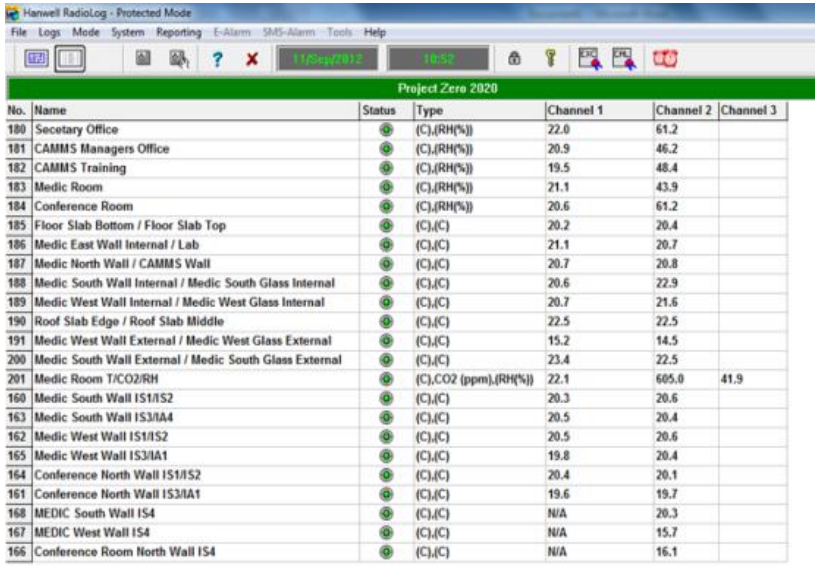
DATA COLLECTION AREAS

1. **Environmental Parameters**
2. **Metering of Energy Data**
3. **Zero2020 Weather Station**

(1.5m+ data-points logged annually)

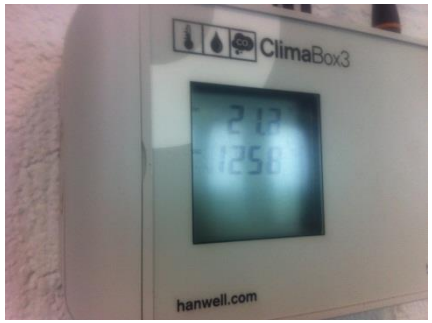
ZERO2020 AS A RETROFIT TESTBED

1. **‘live lab’ approach**
2. **Fully adaptable flexibility with users**
3. **‘plug and play’ capability with systems**
4. **Industry collaboration ‘in use’ testing**



No.	Name	Status	Type	Channel 1	Channel 2	Channel 3
180	Secetary Office		(C),(RH(%))	22.0	61.2	
181	CAMMS Managers Office		(C),(RH(%))	20.9	46.2	
182	CAMMS Training		(C),(RH(%))	19.5	48.4	
183	Medic Room		(C),(RH(%))	21.1	43.9	
184	Conference Room		(C),(RH(%))	20.6	61.2	
185	Floor Slab Bottom / Floor Slab Top		(C),(C)	20.2	20.4	
186	Medic East Wall Internal / Lab		(C),(C)	21.1	20.7	
187	Medic North Wall / CAMMS Wall		(C),(C)	20.7	20.8	
188	Medic South Wall Internal / Medic South Glass Internal		(C),(C)	20.6	22.9	
189	Medic West Wall Internal / Medic West Glass Internal		(C),(C)	20.7	21.6	
190	Roof Slab Edge / Roof Slab Middle		(C),(C)	22.5	22.5	
191	Medic West Wall External / Medic West Glass External		(C),(C)	15.2	14.5	
200	Medic South Wall External / Medic South Glass External		(C),(C)	23.4	22.5	
201	Medic Room T/CO2/RH		(C),CO2 (ppm),(RH(%))	22.1	605.0	41.9
160	Medic South Wall IS1/IS2		(C),(C)	20.3	20.6	
163	Medic South Wall IS3/IA4		(C),(C)	20.5	20.4	
162	Medic West Wall IS1/IS2		(C),(C)	20.5	20.6	
165	Medic West Wall IS3/IA1		(C),(C)	19.8	20.4	
164	Conference North Wall IS1/IS2		(C),(C)	20.4	20.1	
161	Conference North Wall IS3/IA1		(C),(C)	19.6	19.7	
168	MEDIC South Wall IS4		(C),(C)	N/A	20.3	
167	MEDIC West Wall IS4		(C),(C)	N/A	15.7	
166	Conference Room North Wall IS4		(C),(C)	N/A	16.1	

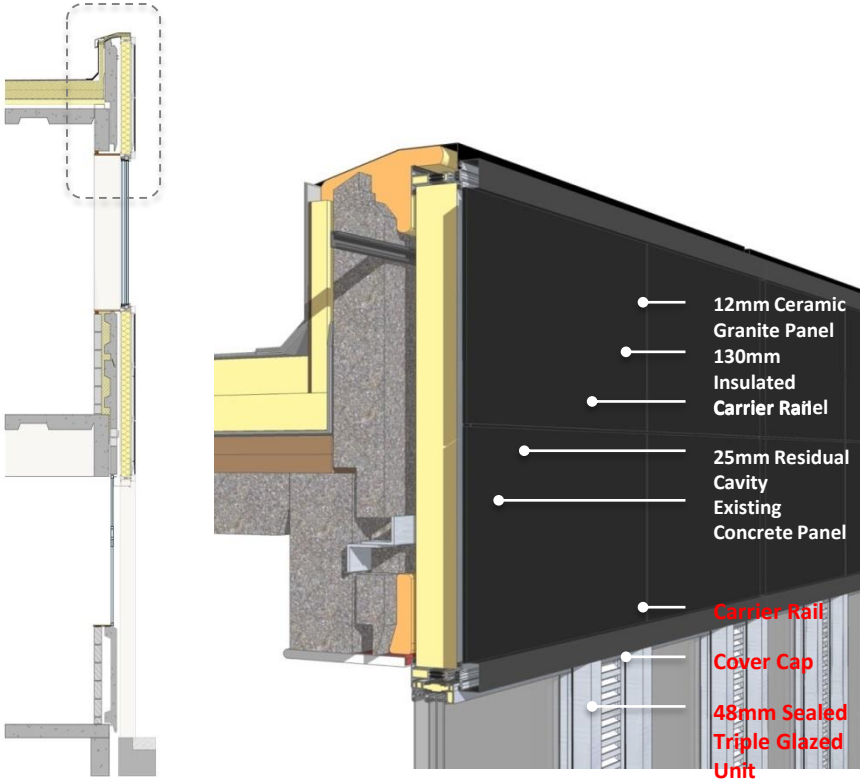
Hanwell data logging system screen dump

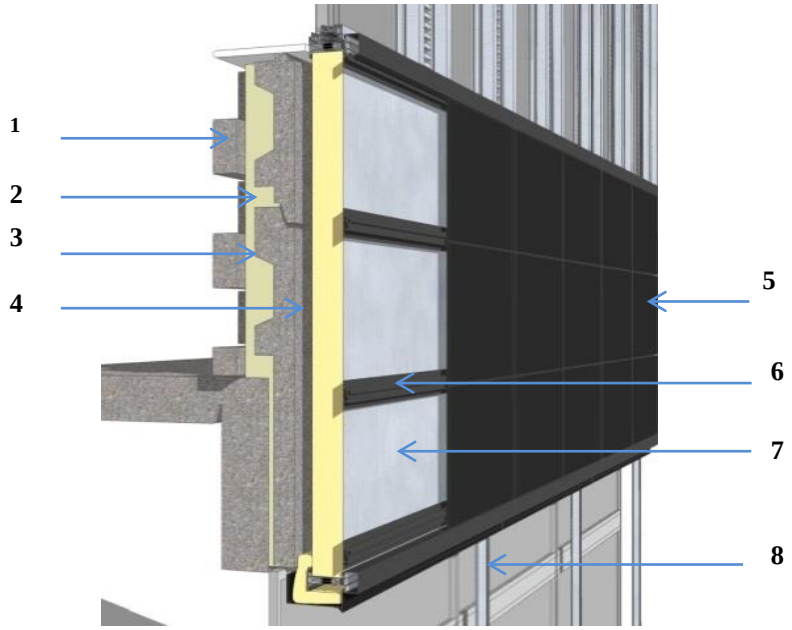


Wireless data loggers

Opaque Wall Detail

Location	ω/φ (W/mK) / h	f (W/mK)	U_{wall} (W/m²K)	$U_{fenestr.}$ (W/m²K)
Control Space	**5.49 / 1.017**	**0.608**	3.633	6.0
Retrofit Space	**5.92 / 0.963**	**0.004**	0.090	0.84





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 $(m^3/hr)/m^2$

Comparison with Cost Optimal

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

Energy Performance

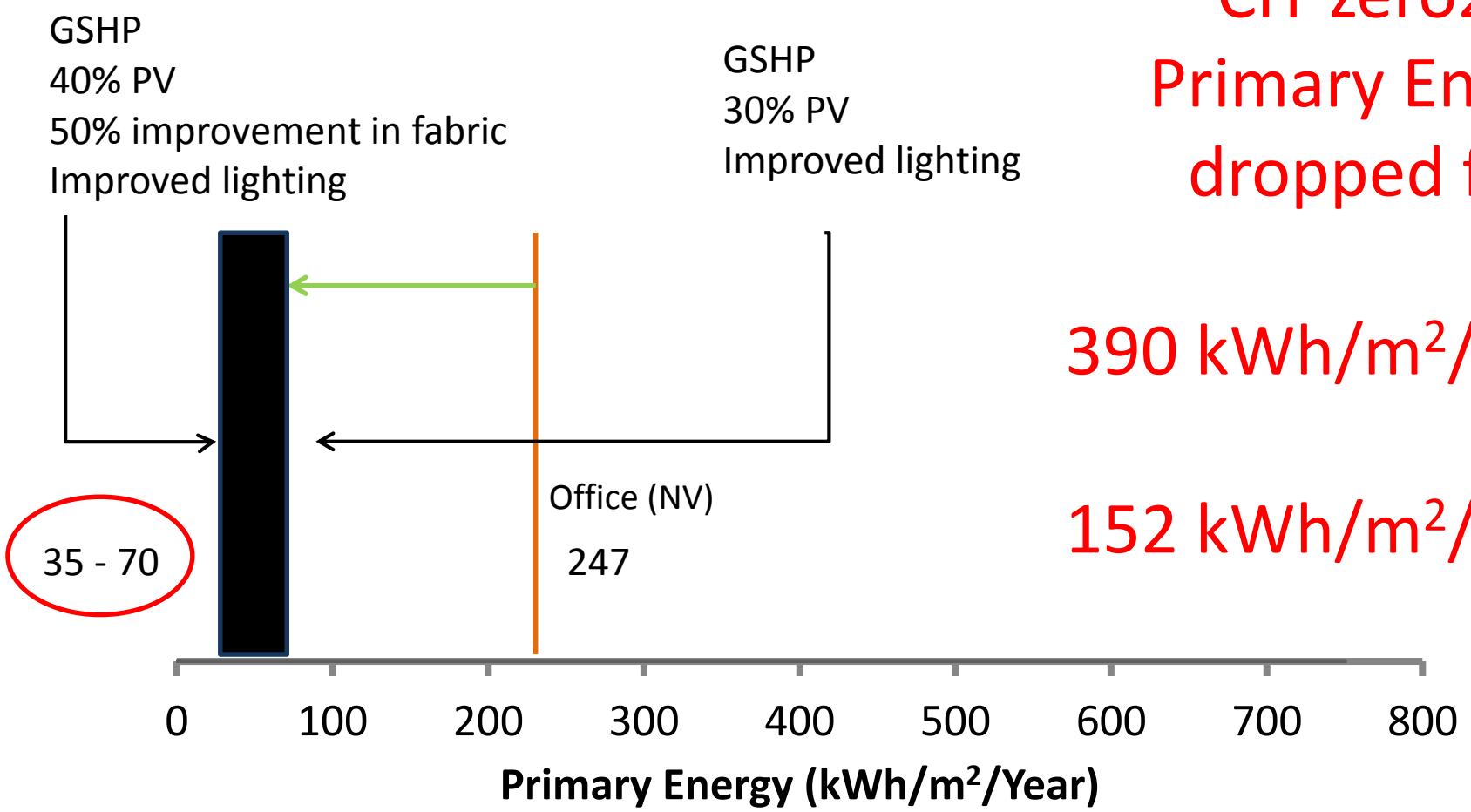
Lighting Primary Energy*	49 kWh/m²a
General services*	89 kWh/m²a
$ASHP_e$ (Heating Energy)*	14 kWh/m²a
Primary Energy Indicator	**152 kWh/m²a**

Focus For Phase 2

Newbuild PassivHaus 25kWh/m²a

**Includes energy conversion weightings for national transmission losses*

Irish NZEB Vs. ZERo2020



CIT zero2020 Primary Energy dropped from

390 kWh/m²/year

to

152 kWh/m²/year

Interpreted from Tables 4.1a to 4.1e Cost Optimal calculations and Gap Analysis for recast EPBD for Non-Residential Buildings and from Table 5 Towards Nearly Zero Energy Buildings in Ireland Planning for 2020 and beyond

ZERo2020 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?

ZERo2020 Occupant Survey

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

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%

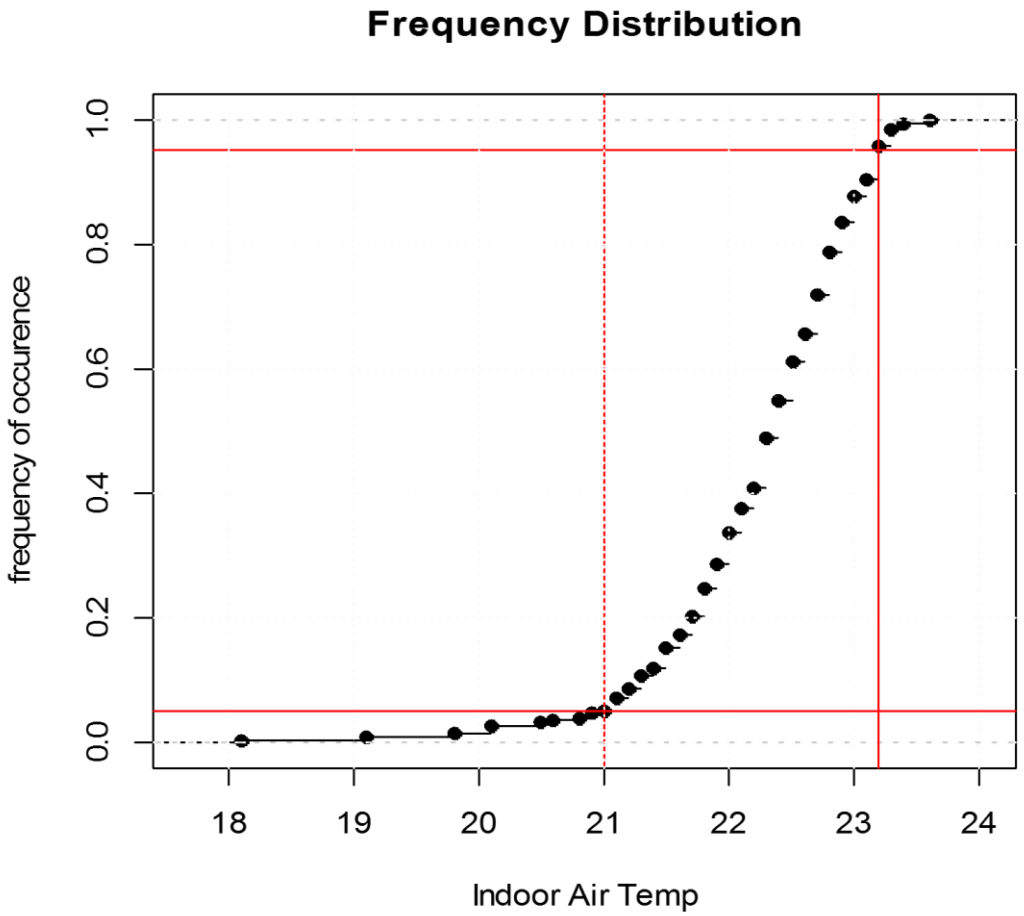
Winter Env. Performance

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

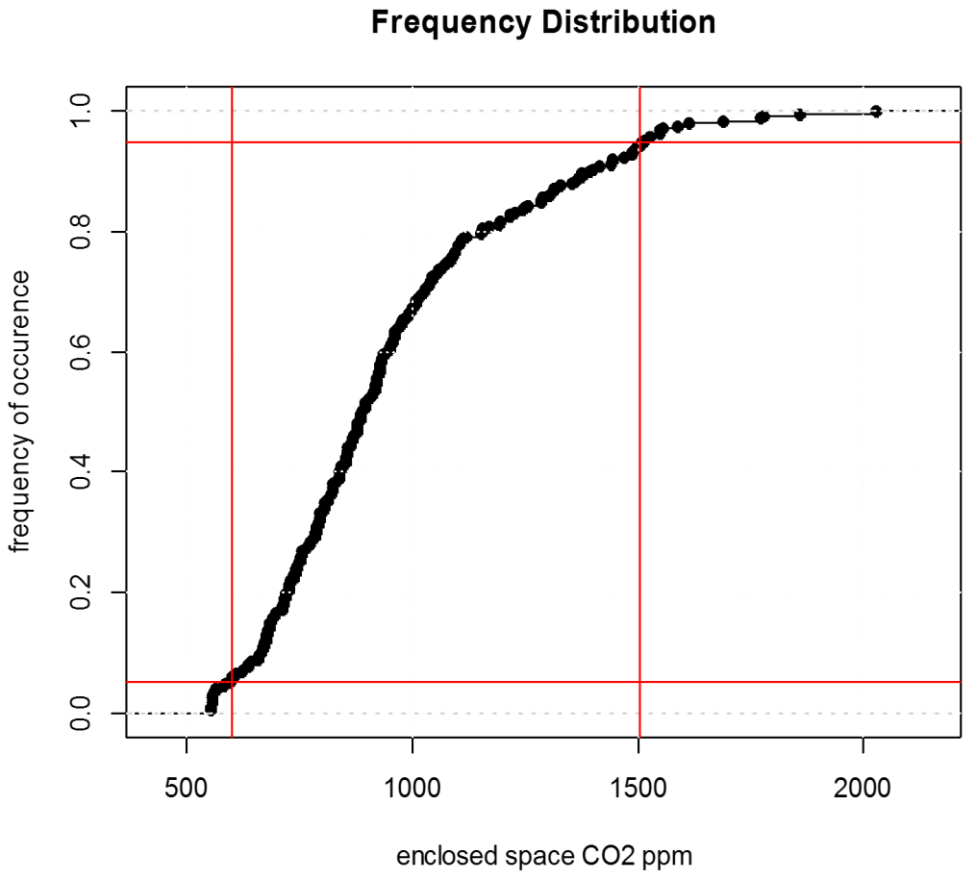


5 week, occupancy hours Cumulative Frequency Distributions for indoor air temperature (red lines show 95 percentile and 5 percentile values)

IAQ Performance

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

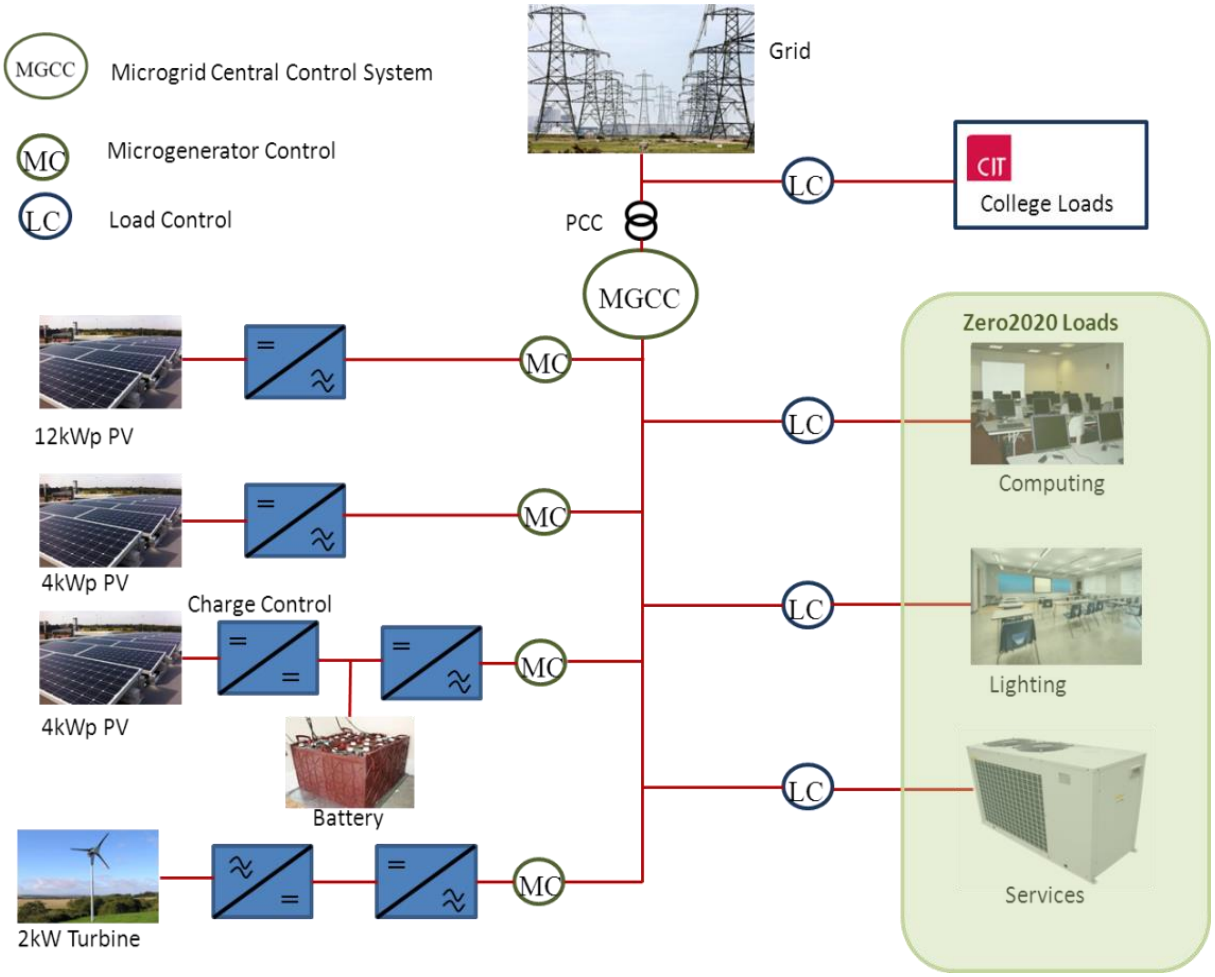
Range of conditions based on 5% confidence intervals is 600 – 1500 ppm. 50th percentile value 850ppm



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

ZERo2020 Phase 2 – RE Int.

PV & Wind Turbine Integration on-going – due for completion End of Nov 2013



Conclusion

- NZEB by 2018 & 2020 – now a key focus
- MS defining their own primary energy indicator
- PEI varies depending on building type
- Convergence of Cost Optimal EP & NZEB definition
- Difficult to achieve NZEB without RE
- Internal Environment key in successful NZEB
- Modular, scalable solutions for retrofit challenge

Thank You…Questions?

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ