http://www.zero2020energy.com/#!home/mainPage

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Aim:

A low energy building retrofit to act as an educational tool for College and Industry

In education, many lecturers teach from textbooks. At CIT we deliver theory but we use demonstration to improve learning outcomes and enhance the learners experience. However if you give the student the ability to participate in his own project or research the experience becomes rich and the learning embedded .

The Zero2020 project has been created to facilitate learning.

Tell me and I will forget,
Show me and I will remember,
Involve me and I will understand

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&
Paul O Sullivan

What is the zero2020 testbed?

- *A net zero energy retrofit testbed*
- *produces as much energy as it consumes.*
- *250m² pilot project upgrade*
- *20,000m² building (A/V ratio 0.23)*

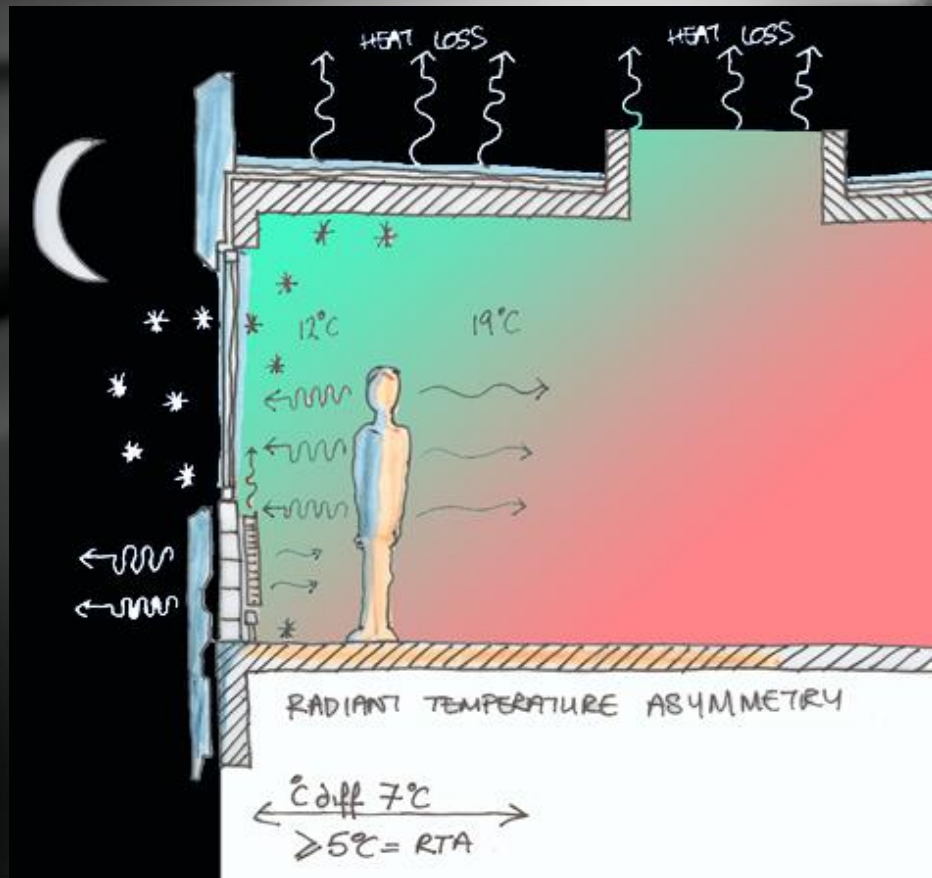
Is it currently net zero energy?

- *No*
- *Limited to fabric & services upgrade,*
- *internal fitout and data metering/logging*
- *12-24 months data logging*
- *renewable energy systems installed*

Is it PassivHaus EnerPhit certified?

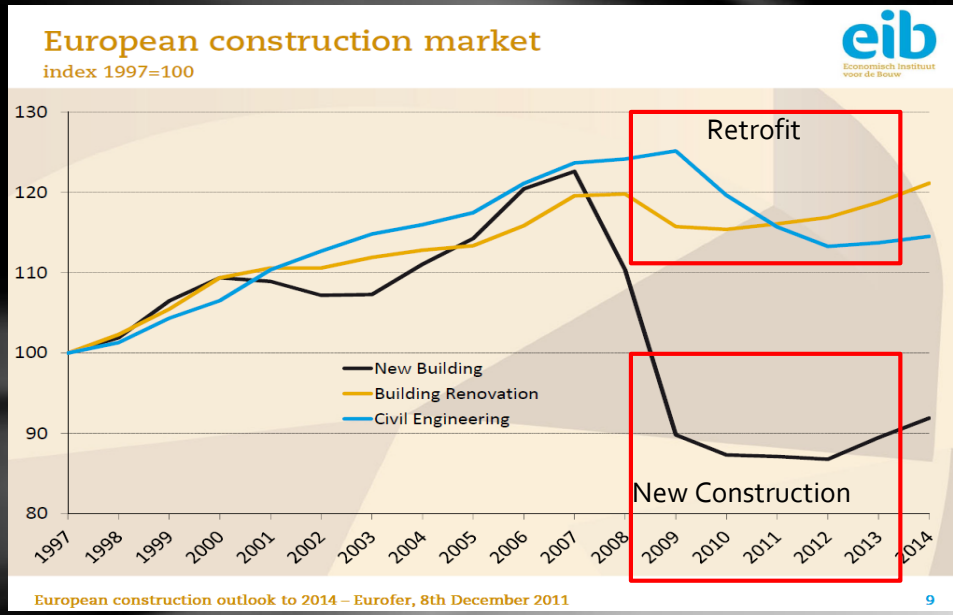
No. the original target was an upgrade to satisfy the CIT masterplan brief. It is very close to EnerPhit standards.

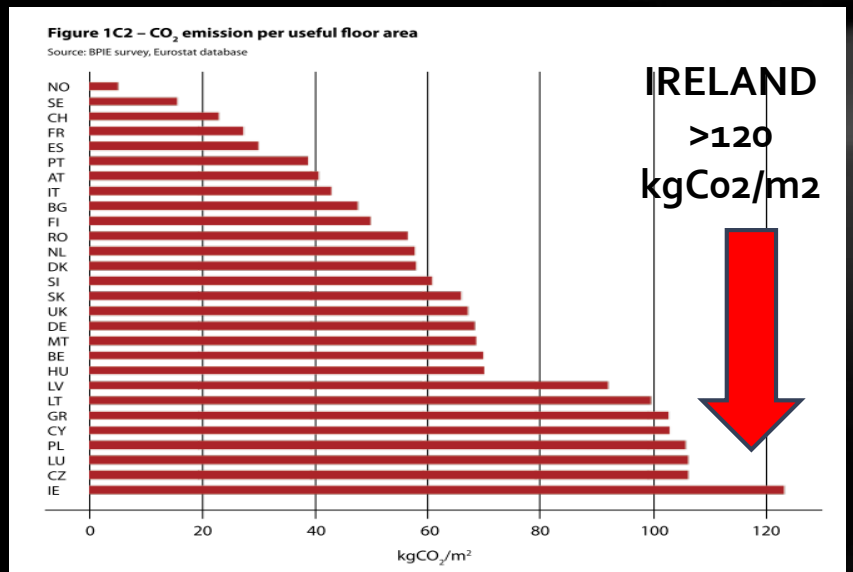
Existing 1974 Building

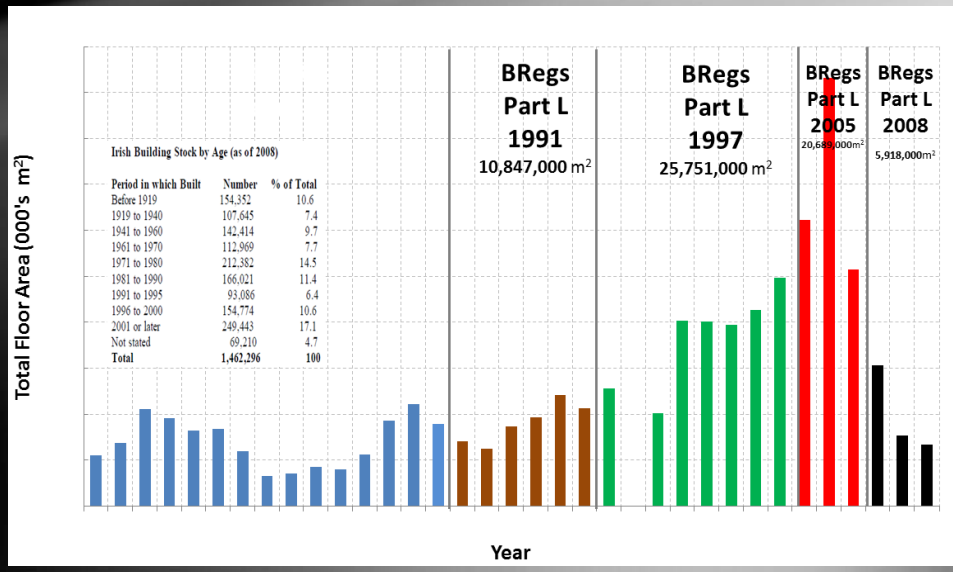


EU & Sector Outlook

- ***EPBD 2010 target to have nZEB public buildings by 2018***
- ***Construction sector has fallen for the 62nd consecutive month-*** Ulster Bank (PMI).
- **Retrofitting expected to be a key growth area-DKM Economic Consultants 2012**
- **76% of new builds go passive or near passive**

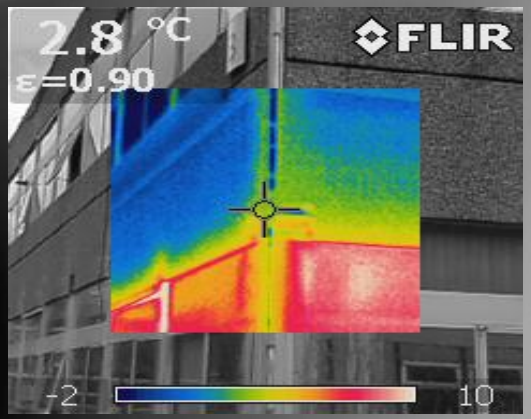






CIT - 1974 Pre Retrofit Space

What do we do in practice?
We finish we leave……



- Existing
- No Temperature Control
- High Air Permeability **14.77** $m^3/h/m^2$
- Un-insulated fabric 2.4 W/m2K
- Summer Overheating
- Poor Ventilation Control
- Recessed T5 manual
- No Energy Monitoring
- Space Heat Demand 95 kWh/m2a

Constraints on execution of the project

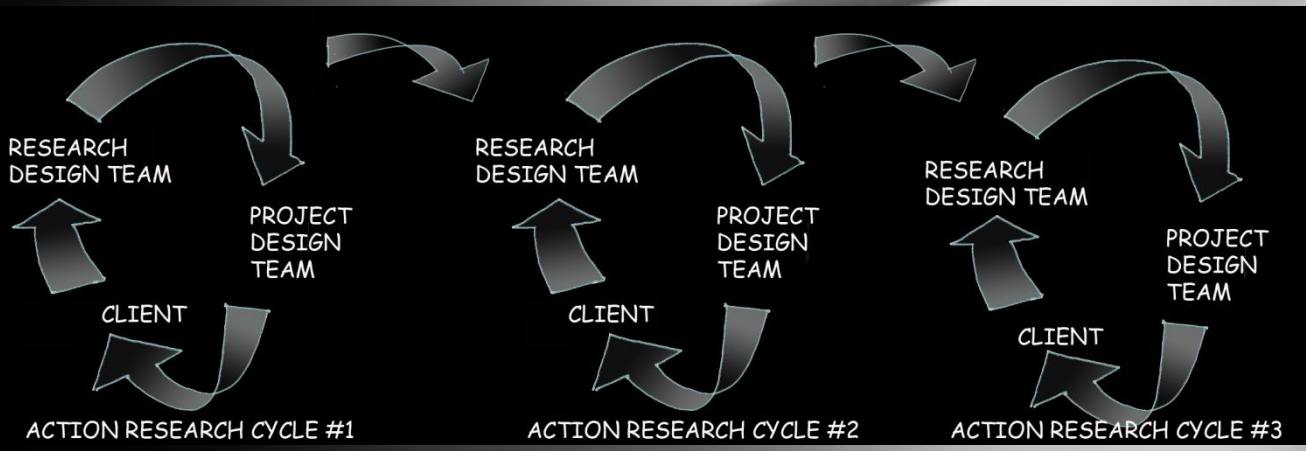
- **Phasing** – academic calender
- **Live construction** – safety, timing
- **Maintenance** –applied renders
- **Occupation** – relocation of users
- **Master plan** – limited aesthetic

Carlow & CIT aesthetic target 2011

CIT Masterplan 2012

Design Process

- Brainstorming – Design *charrette*
- 11/11 – 20/20
- **Project structure:**
- Client
- Research Design Team
- Project Design Team
- Construction Team
- Energy Champions
- & A thorn in the side



So, how do we achieve the target?

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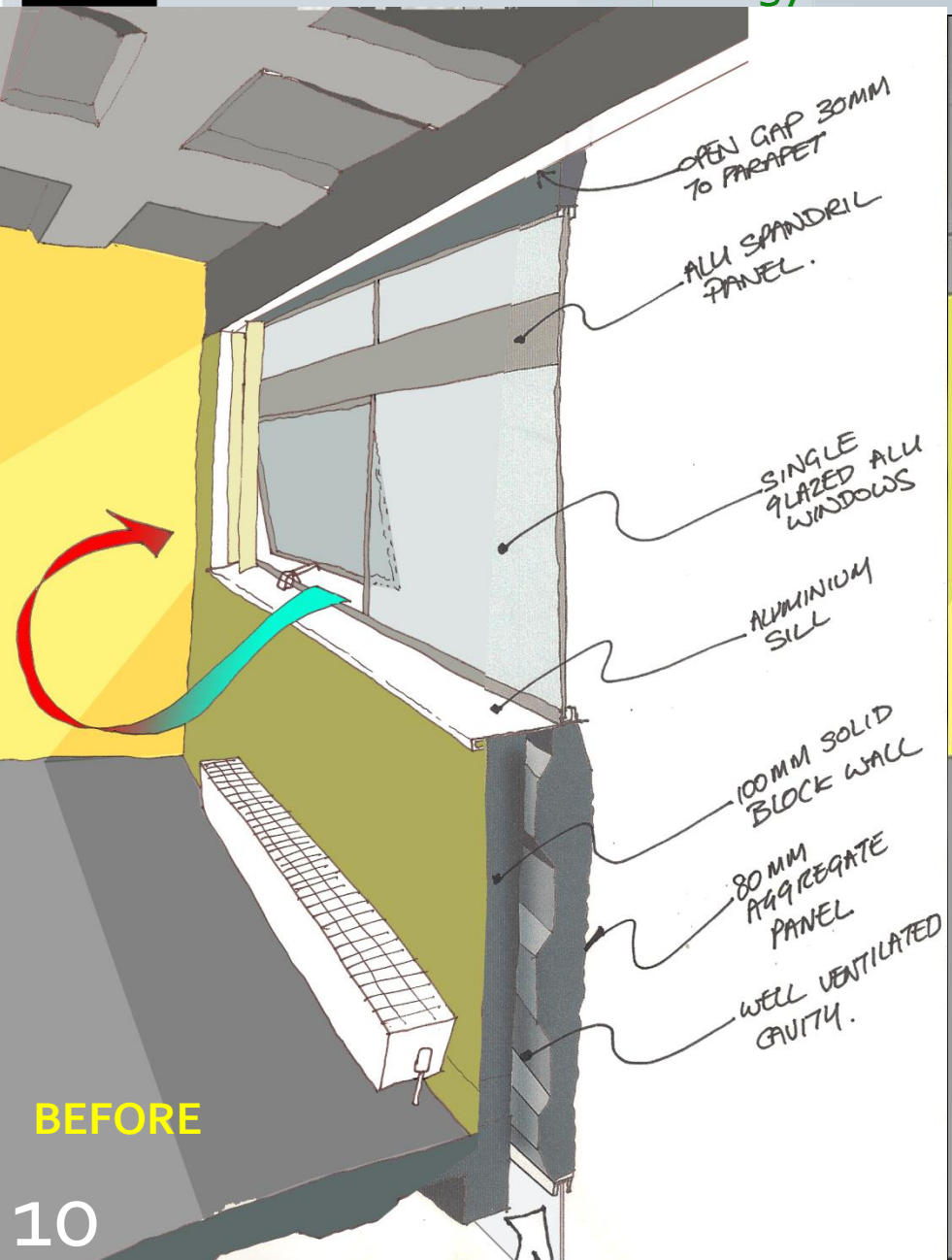
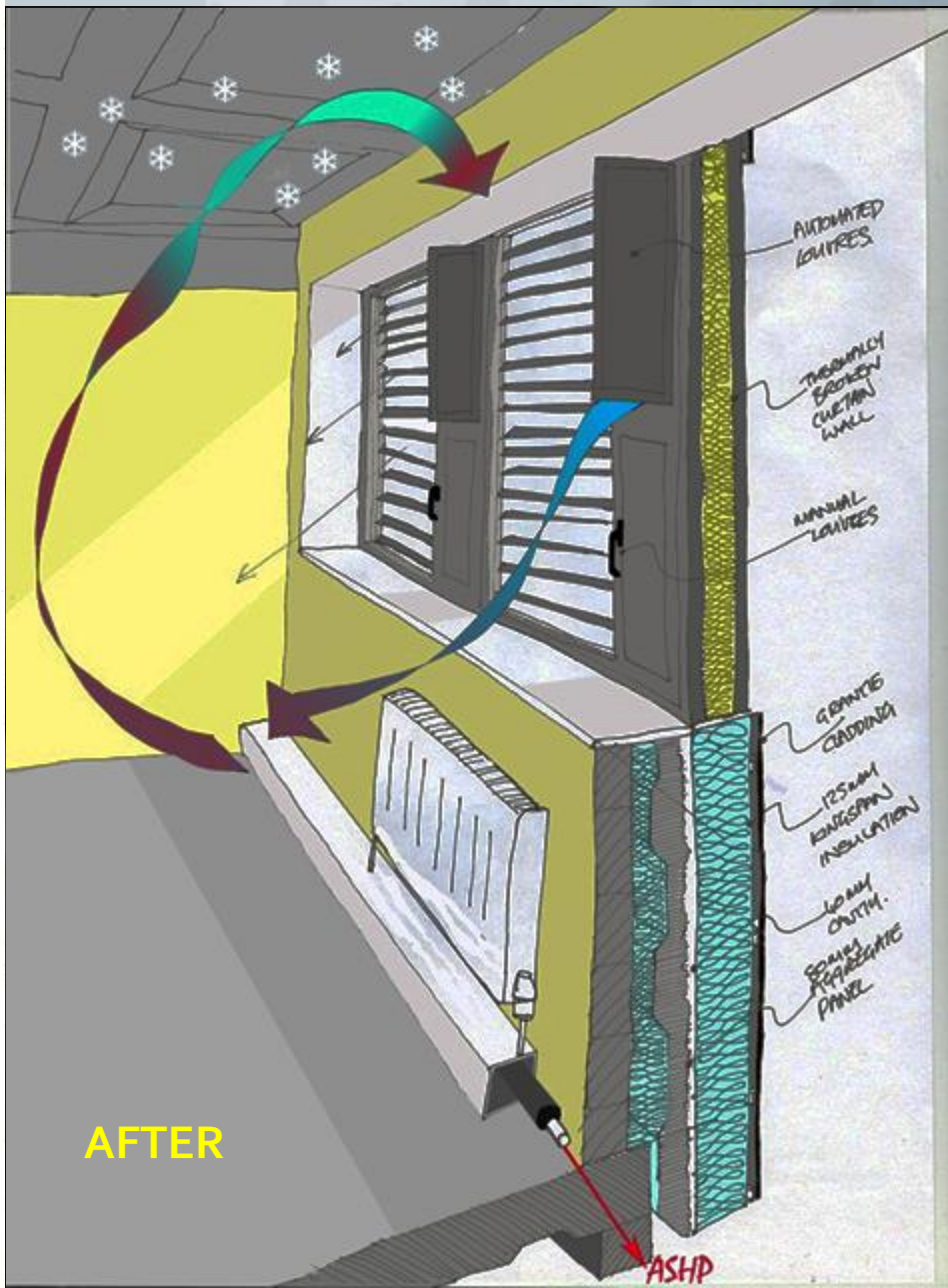


BEFORE



AFTER

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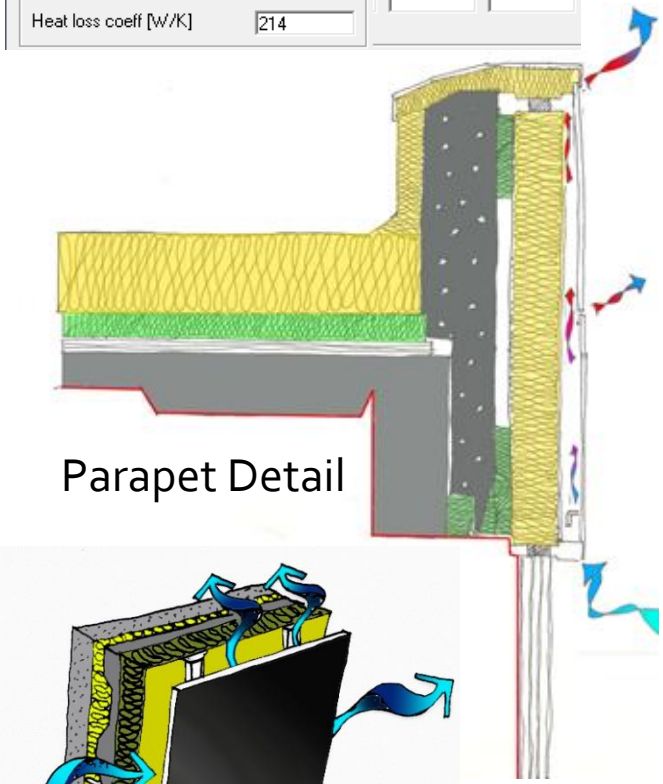
Elements

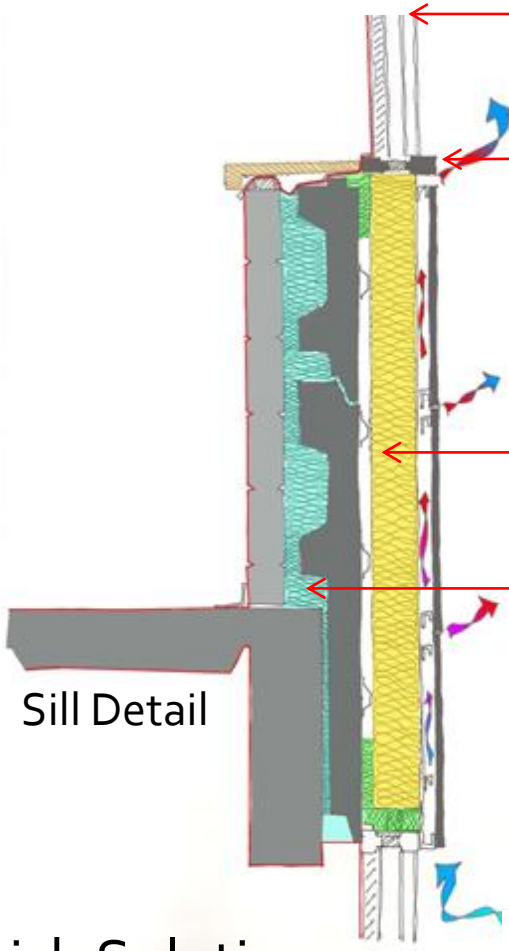
Name	Area [m2]	U-value [W/m2 K]
Roof	233.0	0.09
Main External Wall Upper	65.7	0.17
Main External Wall	88.6	0.10
Windows	162.0	1.03
Main External Wall Ground floor	54.0	0.10

Results for whole building

Average U-value [W/m2 K]	0.36
Envelope area [m2]	603.3
Heat loss coeff [W/K]	214

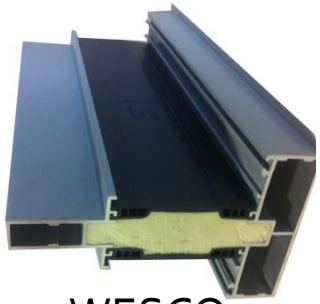


Parapet Detail



Sill Detail

AMS Architectural & Metal Systems



WESCO

Kingspan Insulation

WALLTITE Eco

Curtain Wall-Irish Solution

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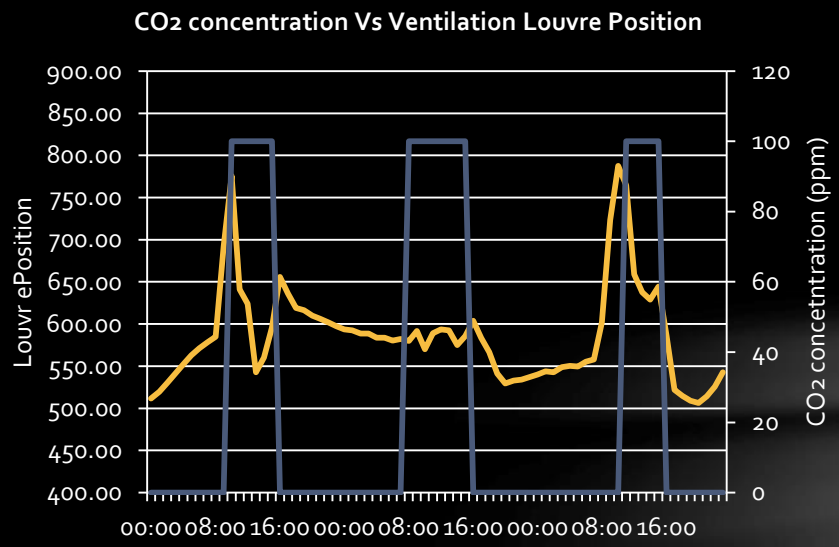
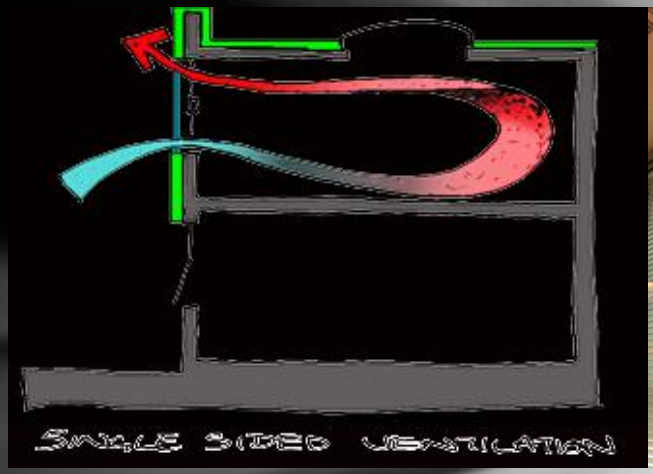
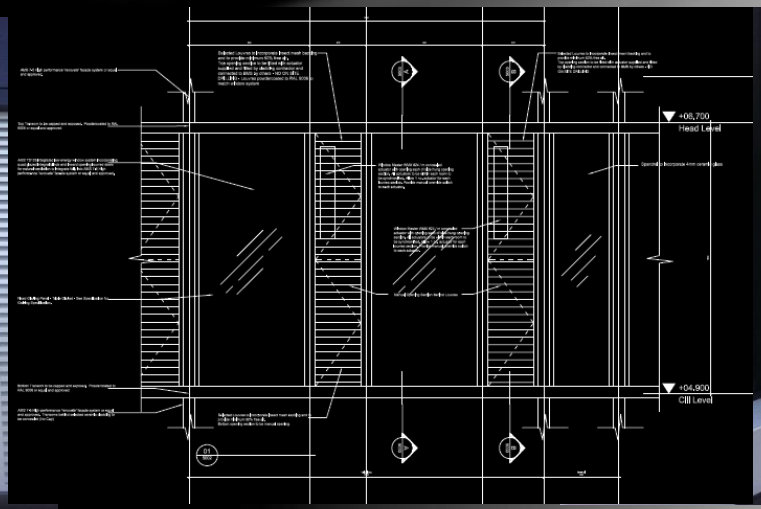
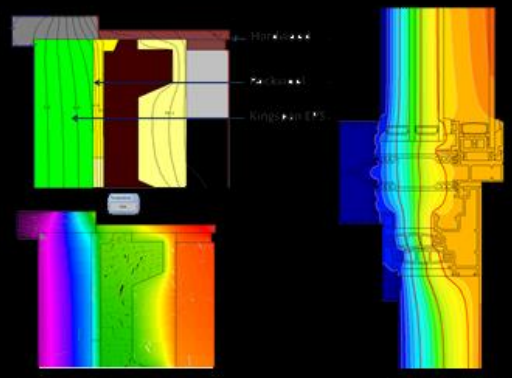




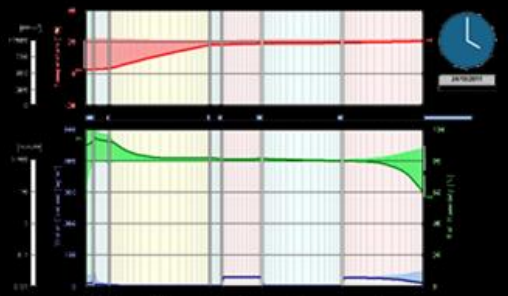


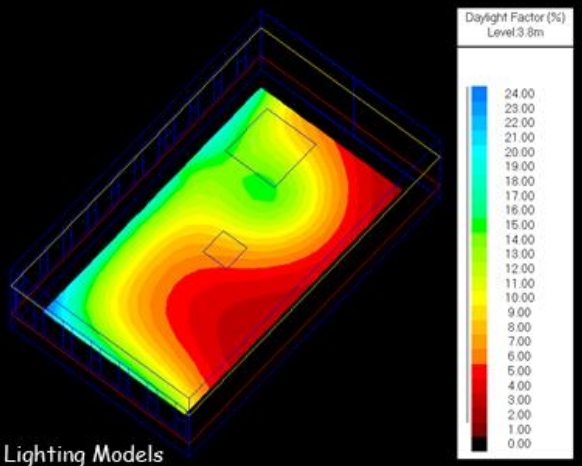
Simulation Testing-Therm 5

- In detail Therm 5 offered the researchers a simulation methodology for testing a variety of details
- Here the sill junction is tested with and without cavity insulation to assess thermal bridge and mould risk
- The simulations were time demanding but critical to the performance.
- The design team feel that further improvements can be found in the future roll out to reduce parapet and roof light thermal bridges in particular
- This challenged the project design team to a greater attention to detail than they had possibly previously encountered.


SILL Detail in Therm

Window Section


WuFi Hygroscopic transfer



IES Lighting Models

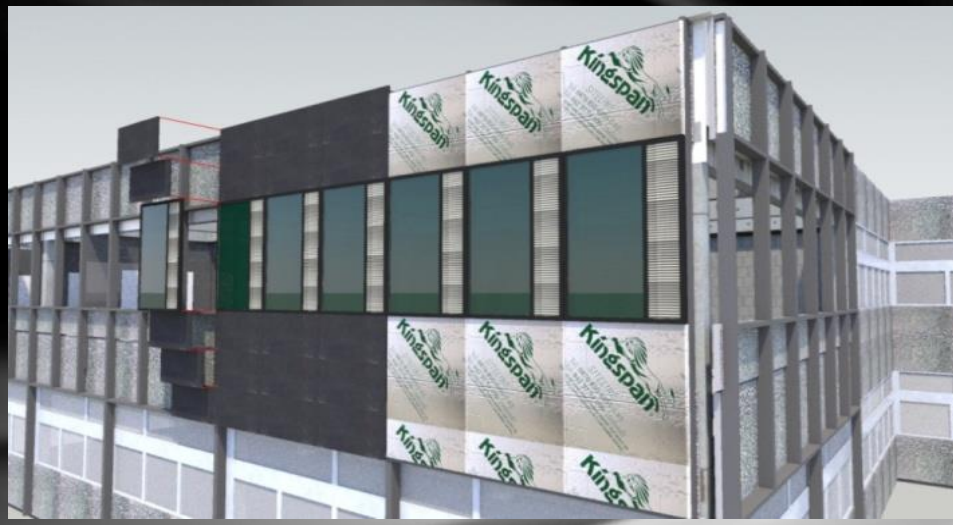
Design Solution

Existing Energy Performance

- Av. U-Value = 2.4 W/m2K
- Air infiltration 14.77 m3/hr/m2
- Glazing ratio 1:3
- Mould Growth
- No thermal Control
- Erratic temperature fluctuations

Design Energy Performance

- Av. U-Value = 0.36w/m2K
- Air infiltration 1.76 m3/hr/m2 @ 50Pa
- Glazing ratio 1:4
- Ug= 0.6w/m2K
- G Factors- 0.61 & 0.34(excluding blinds)
- Co2 average 500-1000ppm



Data available with Education & Research Potential

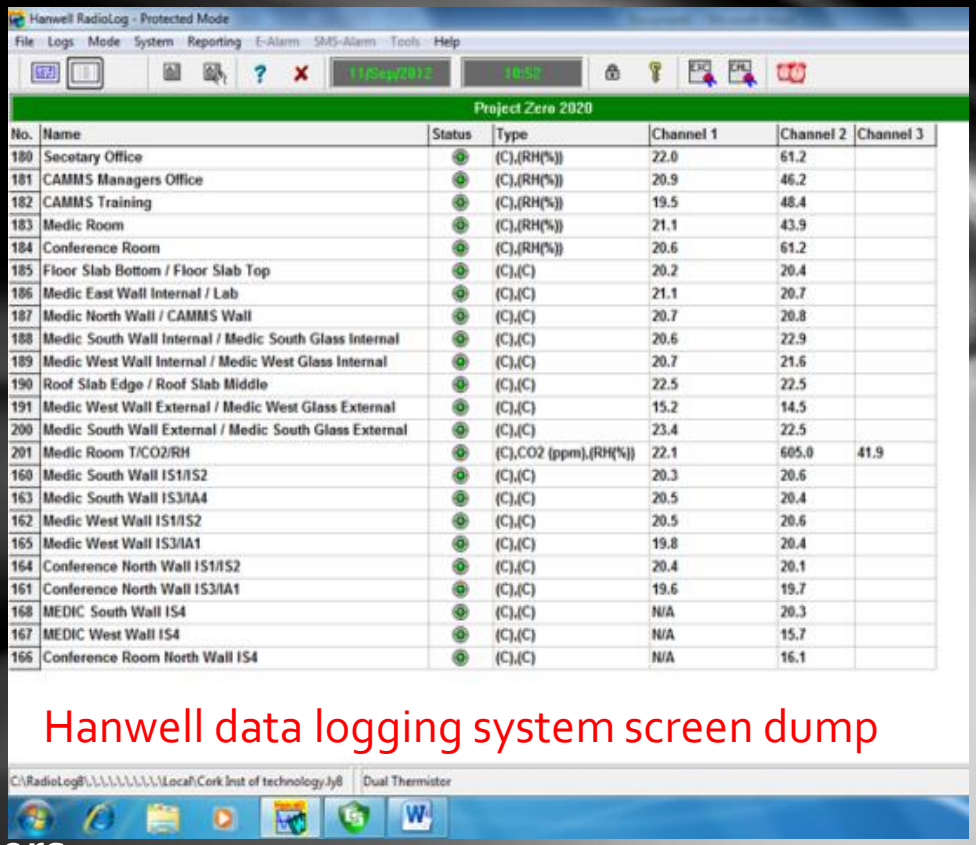
DATA COLLECTION AREAS

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

(1.5m+ data-points logged annually)

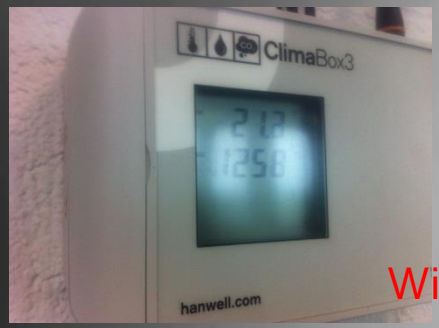
ZERO2020 AS A RETROFIT TESTBED

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

Energy Use Metrics

Calculated Thermal Energy Use

(kWh/m2/yr) @ 20°C setpoint temp

- 235 Existing 1974 Building
- 70 2008 Part L compliance Retrofit
- 24 Zero2020 retrofit

Actual Electrical Energy Use

(kWh/m2/yr) metered values

- 90 Existing 1974 Building
- 55 Existing B-block
- 58 Zero2020 retrofit

Existing Metered Thermal Energy Use

95 kWh/m²/yr (based on 2011)

Electrical energy use data for zero2020 based on 1 week data only and extrapolated.

Thermal energy Values in kWh/m²/yr , delivered energy & estimated based on degree day analysis and building geometries

Electrical energy values in kWh/m²/yr and based on metered energy at CIT and zro2020

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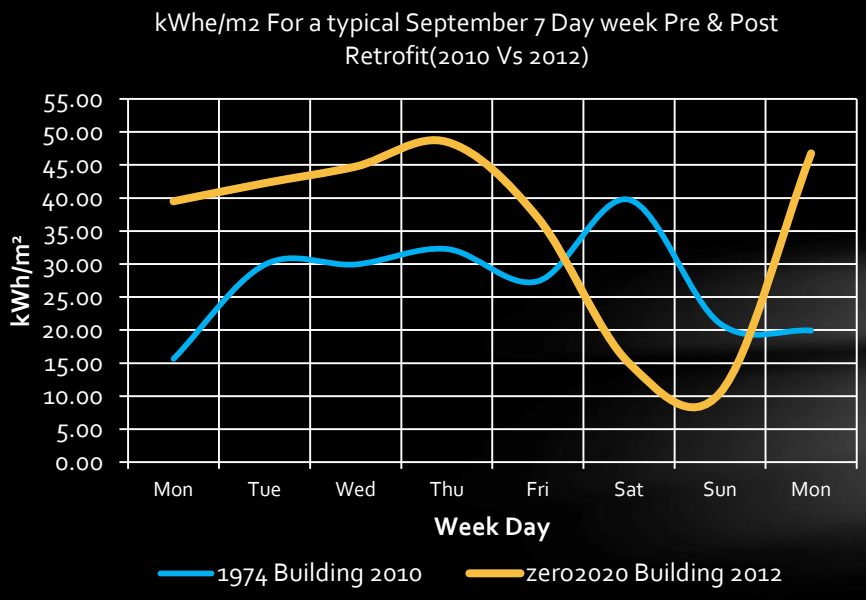
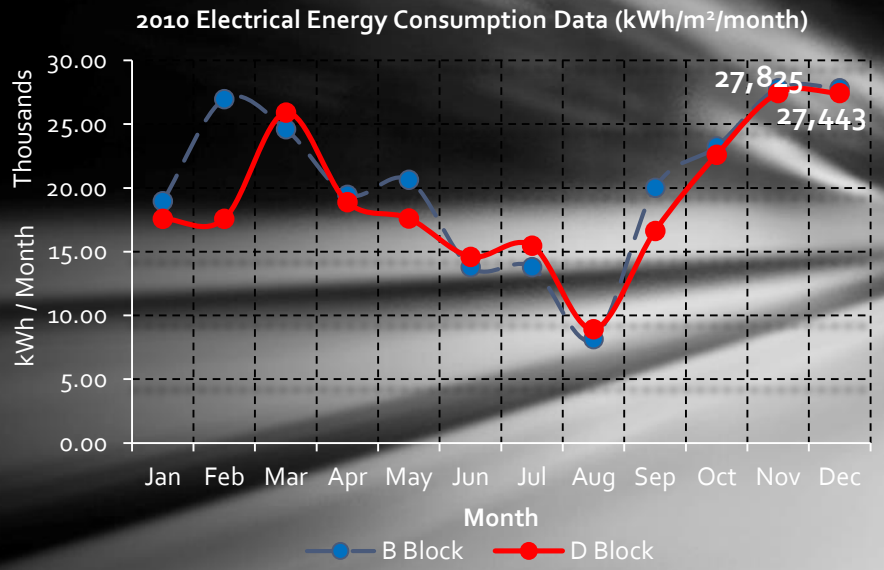
zero2020 Electrical Energy Consumption – Initial Data





Existing Building Statistics 2010

B- Block	**55.31**	**kWh/m2/yr**
C-Block	100.38	kWh/m2/yr
C-Block	139.77	kWh/m2/yr
D-Block	66.40	kWh/m2/yr
Building Ave	90.46	kWh/m2/yr
zero 2020	**58.00**	**kWh/m2/yr**

Dynamic Thermal Characteristics of the structure

PRE RETROFIT		TRANSMITTANCE		ADMITTANCE/CAPACITANCE			Temp DAMPENING	
element	Area	U-Value	UA	Y-Value	AY	time lead	f	time lag/lead
-	(m²)	(W/m²K)	(W/K)	(W/m²K)	W/K	h		h
Ext Wall	4.95	0.88	**4.36**	5.88	**29.11**	1.41	**0.49**	5.38
Ext Window	4.12	6.00	24.72	0	0.00	0.00	0	0.00
Ext Frame	0.98	2	1.95	0	0.00	0.00	0	0
Ext Roof	12.90	1.02	13.09	2.6	33.54	0.96	0.24	6.29

POST RETROFIT		TRANSMITTANCE		ADMITTANCE/CAPACITANCE			Temp DAMPENING	
element	Area	U-Value	UA	Y-Value	AY	time lead	f	time lag/lead
-	(m²)	(W/m²K)	(W/K)	(W/m²K)	W/K	h		h
Ext Wall	4.95	0.15	**0.72**	5.78	**28.61**	1.34	**0.04**	12.78
Ext Louvre	1.35	0.36	0.49	1.09	1.47	0.04	1.00	0.03
Ext Window	2.88	1.00	2.88	0	0.00	0.00	0	0.00
Ext Frame	0.00	2	0.00	0	0.00	0.00	0	0
Ext Roof	12.90	0.11	1.42	2.61	33.67	0.94	0.09	11.29

Admittance is a measure of heat storage capability based on deviation about mean surface temp. **LITTLE CHANGE**

Dampening is a characteristic that represents the ability of the material to reduce the temperature signal amplitude from outside to inside. **SUBSTANTIAL CHANGE**

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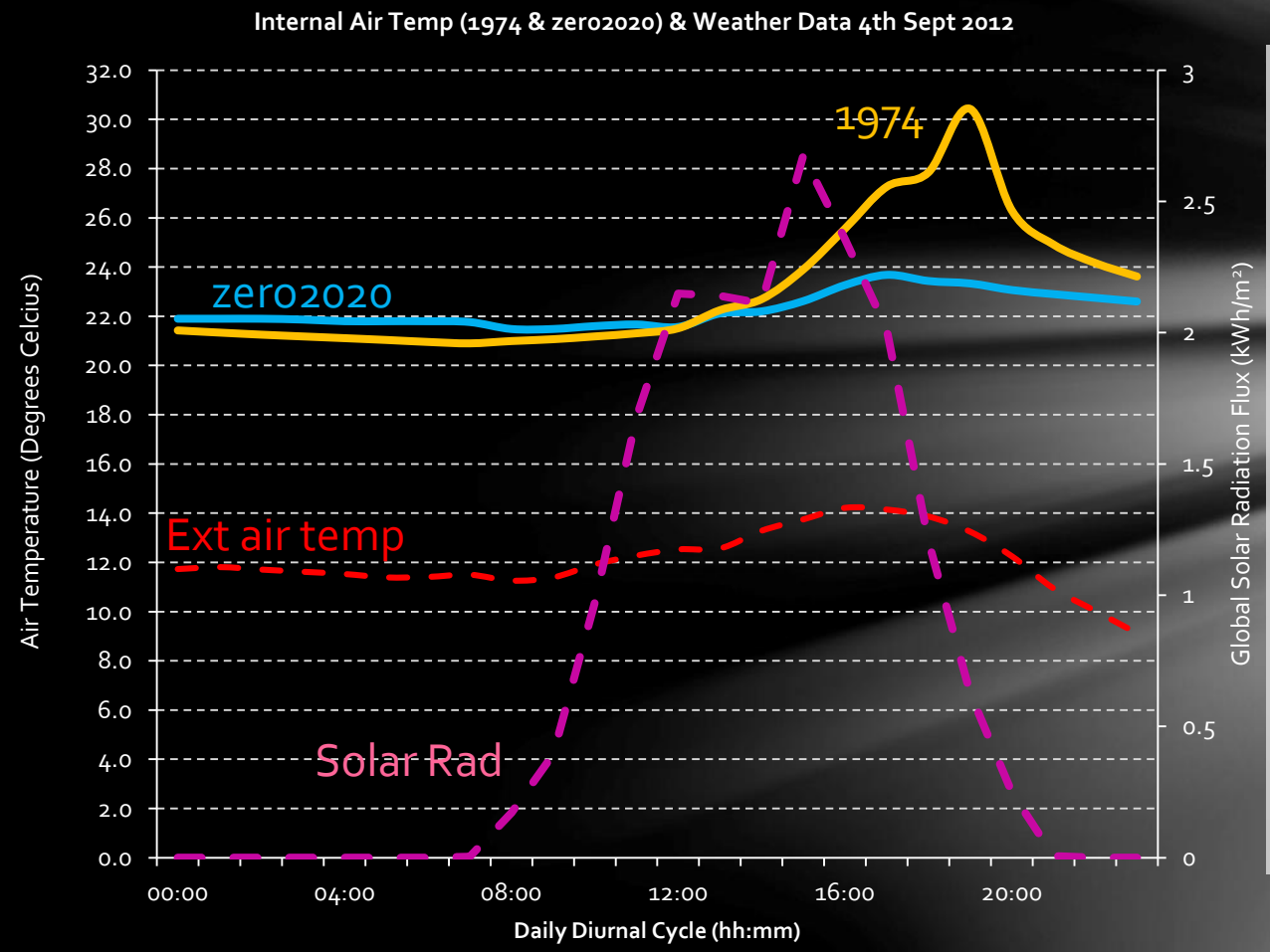
Initial Environmental Data Findings – Sample 24hr cycle (4th Sept '12)



Consider 4th Sept 2012:

- Similar minimum internal T_{air} values both spaces
- 6.9°C difference in maximum diurnal values
- Peak conditions occur outside occupied hours for both spaces
- Peak solar radiation at 15:00 (solar azimuth & altitude)
- Zero2020 diurnal temp deviation about mean = 1.4°C
- 1974 diurnal temp deviation about mean = 7.3°C

zero2020		
T_{air} minimum (diurnal)	21.5°C	8:00
T_{air} maximum (diurnal)	23.7°C	17:00

1974 Space		
T_{air} minimum (diurnal)	20.9°C	7:00
T_{air} maximum (diurnal)	30.4°C	19:00

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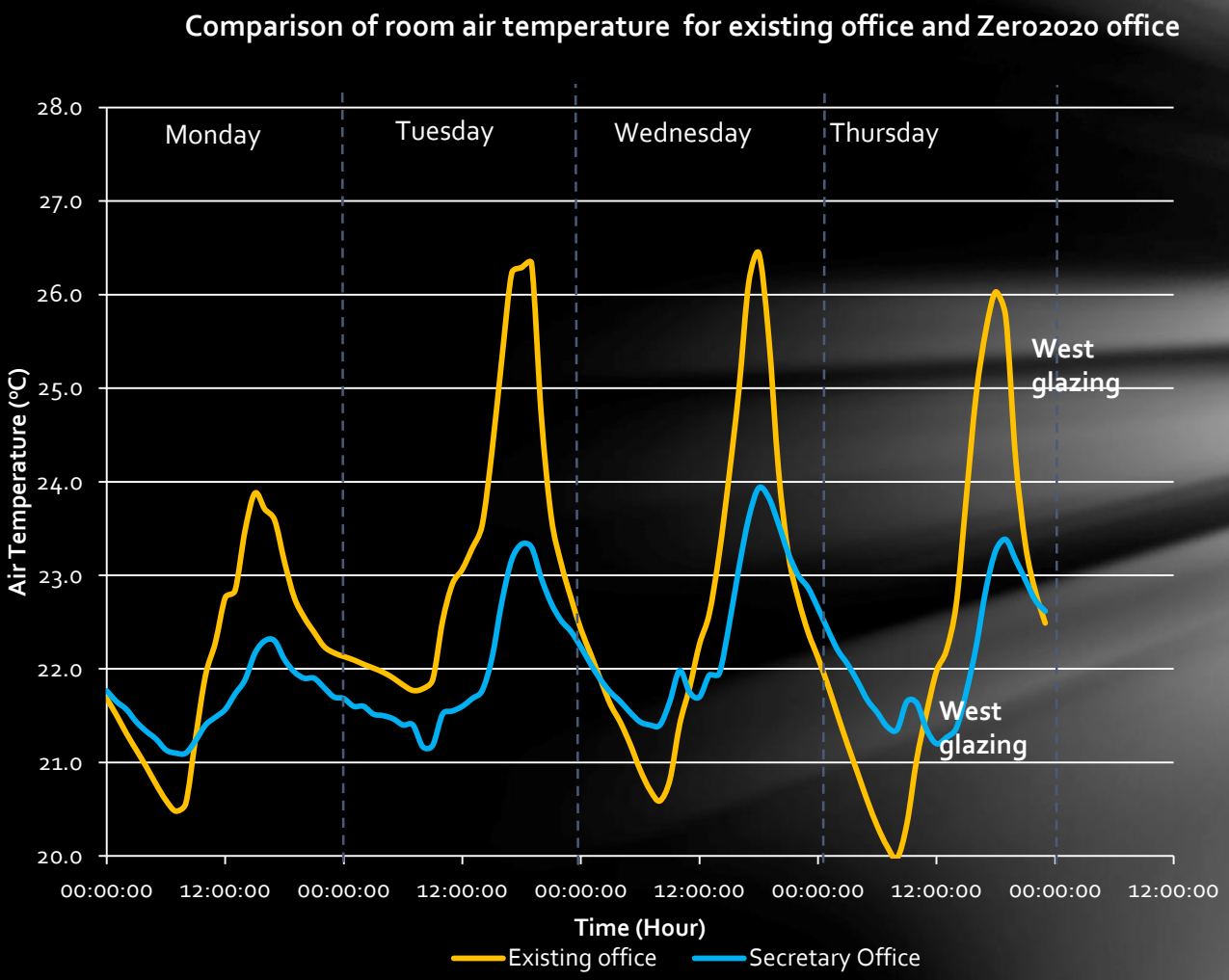
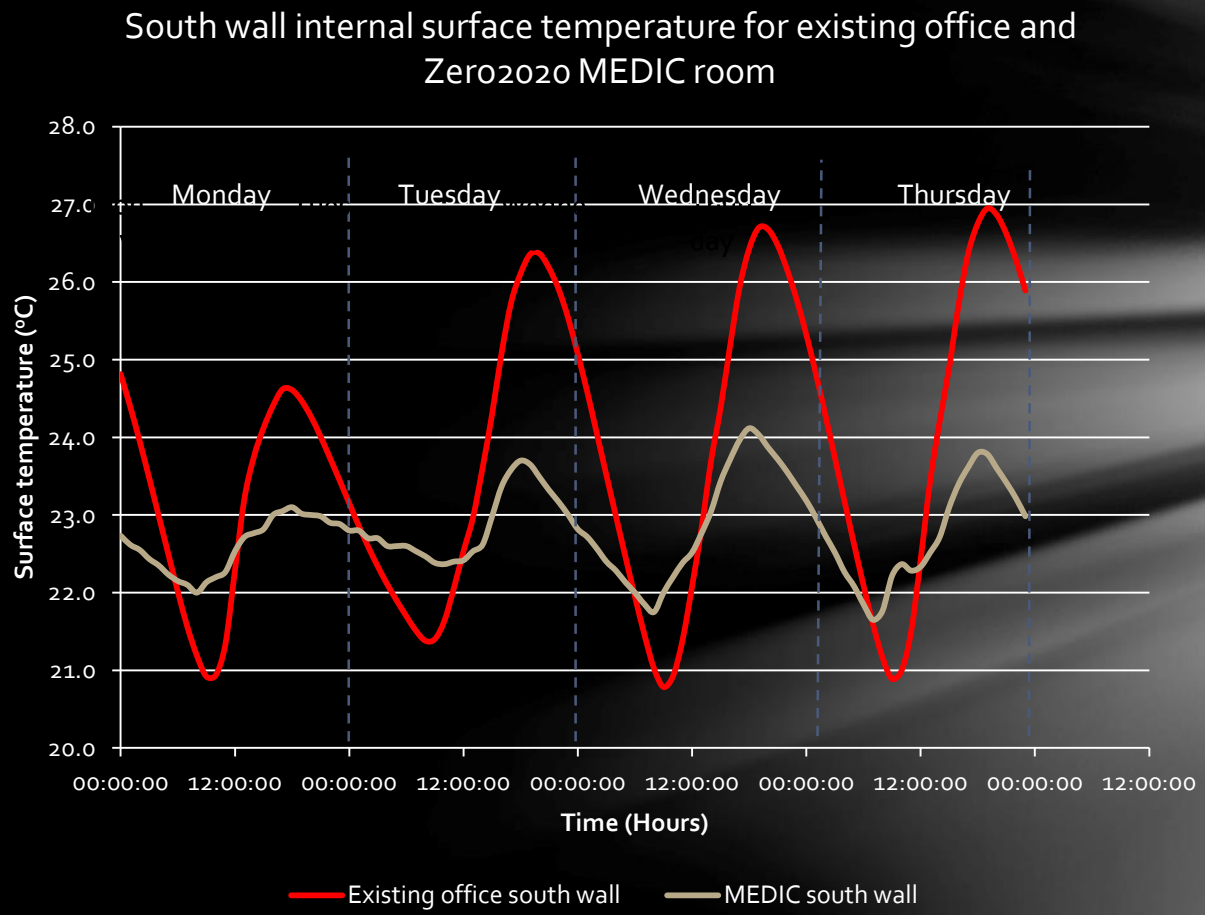
Initial Environmental Data Findings – Sample 3rd - 6th Sept '12)



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

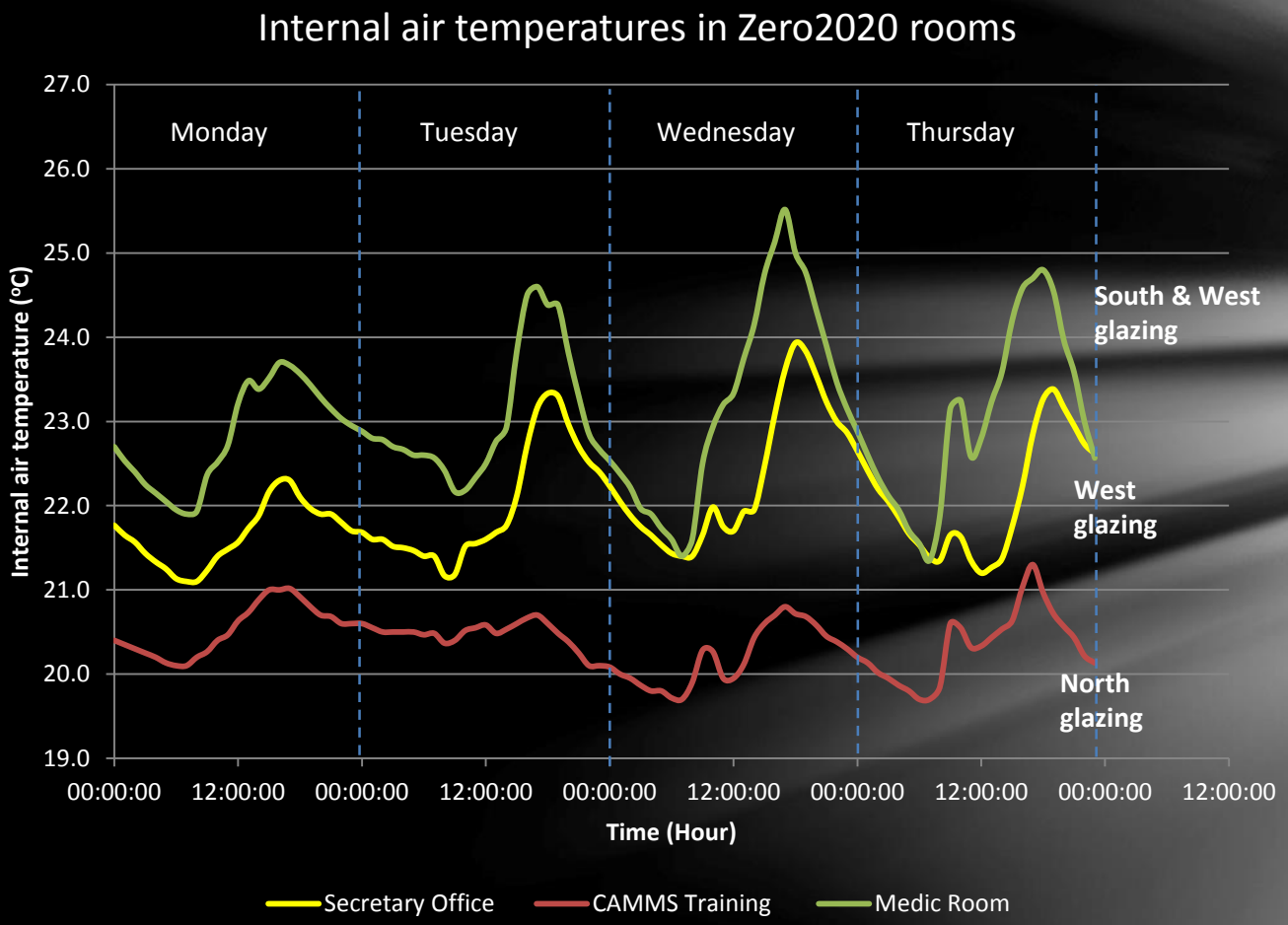
Initial Environmental Data Findings – Sample 3rd - 6th Sept '12)



Summary points

- External surface temperature peaks of 55-60°C (radiation effects very important)
- Evidence of substantial dampening effect in both envelopes – more pronounced in zero2020
- More stable conditions in zero2020 (temp within 2°C)
- Peak internal temperature occurring with time lag
- Analysis of phase shifting necessary in low energy building design

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



Summary points

- Still variations in temperatures throughout retrofit areas
- Generally acceptable conditions for naturally ventilated space
- North facing room more stabilised profile
- Peak temperature after 4 days warm conditions is 25.5°C
- Internal gains have an increased contribution to the temperature profile in highly insulated, airtight buildings
- Peak internal temperatures occur earlier in south & west facing room

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So, How does zero2020 currently compare to EnerPhit?

Criteria	New build	Retrofit
Q_H Specific Space heat demand	max. 15kWh/(m²a)	max. 25kWh/(m²a)
Pressurisation test result n_{50}	max. 0.6h^{-1}	max. 1.0^{-1}
Q_P Entire Specific Primary Energy Demand	max. 120kWh/(m²a)	max. 120kWh/(m²a) +((Q_H −15kWh/(m²a))*1.2)
Frequency of overheating (over 25 degrees)	max. 10%	max. 10%
Water activity of interior surfaces a_w		max. 80%

Building Component	Retrofit criteria
External wall	External insulation U≤ 0.150W/(m²K) Internal insulation U≤ 0.300W/(m²K)
Roof or top floor ceiling	U ≤ 0.120W/(m²K)
Windows	$U_{Winstalled}$ ≤ 0.85W/(m²K) g -1,6W/(m²K) ≤U_g
External door	$U_{D\ installed}$ ≤ 0.80W/(m²K)
Thermal bridges	No linear thermal bridges with Ψ > + 0.01W/(m²K) or punctiform thermal bridges with χ > + 0.04W/(m²K)
Ventilation Electrical efficiency of ventilation system	$\eta_{HR,eff}$ ≥ 75% ≤ 0.45Wh/m³

< 25 kWh/m²/yr

1.6 (m³/h)/m³

< 100 kWh/m²/yr

<1%

<80%

0.10 W/m2K

0.09 W/m2K

0.89 W/m2K

Σ 0.05 W/m2K

'Almost' EnerPhit = 'Almost, Almost' PassivHaus !!!

Next Steps – zero 2020 timeline

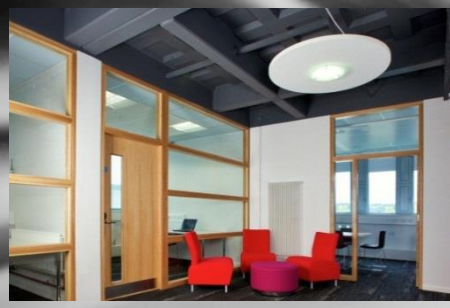
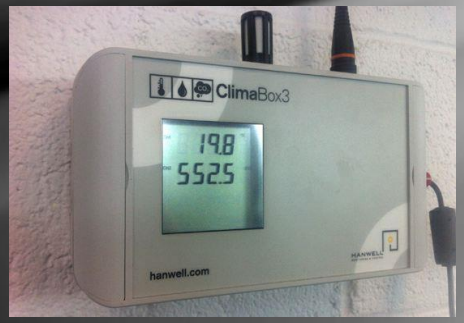
Phase 1 - Post Handover

- Complete process based lessons learned
- Complete interviews of all parties engaged in project
- commence data collection, data mining & analysis
- Commenced data logging and monitoring of existing building comparative space to provide control data

Phase 2 – renewable integration

- Collate Data
- Assess Renewable technologies &
- Supplement
- Further analysis




Lessons Learned

There will be performance gaps

User Behaviour is an important area for uncontrolled energy consumption

Thermal bridging detailing is more important than you think

Inter disciplinary communication can lead to poor performance decisions

Air tightness is critical to energy performance

Post Occupancy Evaluation is critical to continued professional development
More information on:

www.**zero2020energy.ie**