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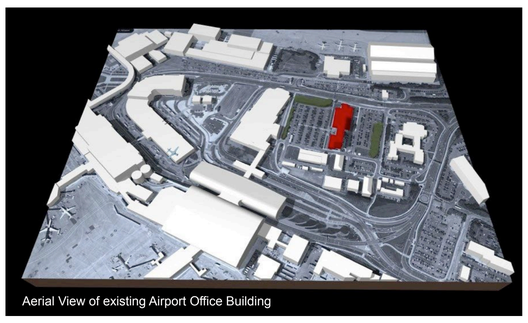
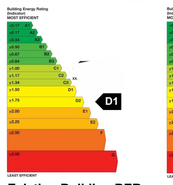
nZEB OFFICE RETROFIT PROJECT

MSc ENERGY RETROFIT TECHNOLOGY DT774b

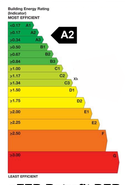
nZEB OFFICE RETROFIT - AER LINGUS H.O.B.



Aerial View of existing Airport Office Building



Existing Building BER



nZEB Retrofit BER

Arising from the Recast European Performance of Buildings Directive 2010/30/EU, from January 1st 2021 every new building in Ireland will have to be designed to near zero energy building standards (nZEB) - meaning buildings with an ultra low energy demand for heating, cooling, ventilation, light and power, and with this residual energy demand being met mainly by on site or nearby Renewable Energy Sources.

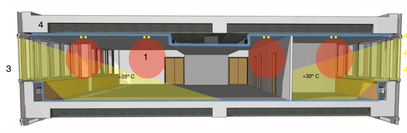
The project investigates a range of low-energy retrofit measures for the upgrade and refurbishment of an existing multi-storey office building to the nZEB standard. The subject building is the old Aer Lingus Head Office Building, located at Dublin Airport, Swords, Co Dublin.

The study was carried out using a range of energy performance analysis tools including Design Builder Dynamic Simulation Software. The study was both an investigation into low-energy building retrofit design, as well as a study of the Dynamic Simulation tool itself.

The focus of the project was to explore *Passive Architectural Solutions* to deliver optimal "load reductions" - By engineering the fundamental form and envelope of the building correctly to exploit passive heating, cooling, ventilation and lighting resources, the greatest reductions in overall energy use can be achieved.

The total Annual Energy Demand for the retrofitted office building has been reduced by over 70%, Annual Space Heating Demand reduced by nearly 90%, and internal comfort conditions for the building maintained without the need for Air Conditioning.

EXISTING BUILDING ENGERY ANALYSIS



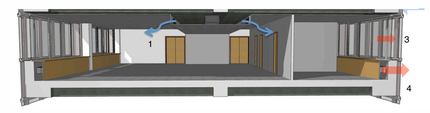
(1) High Electrical Lighting (uncontrolled) & Room Equipment Loads resulting in internal heat gains.

(2) Solar Heat Gains (East/West highly glazed facades without shading / solar control).

(3) Limited scope for Nat Vent cooling (limited opening windows, no cross ventilation or stack effect, low floor-ceiling heights).

(4) Thermal Mass of structure unavailable to help modulate cooling loads.

SUMMER - existing energy performance



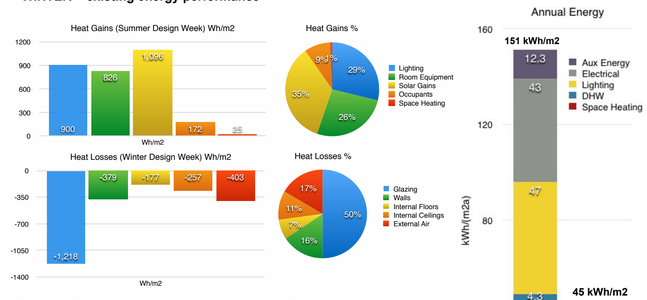
(1) Large Ventilation Heat Losses (Nat Vent & Mech Ventilation without heat recovery).

(2) Infiltration Heat Losses (the building envelope is very leaky).

(3) Glazing Heat losses (Glazing and Frame losses).

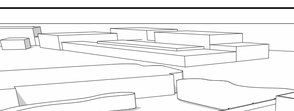
(4) Fabric Heat Losses (very poor fabric U-Values + lots of Linear Thermal Bridging).

WINTER - existing energy performance



Existing Building Simulation Analysis - Heat Gains & Losses

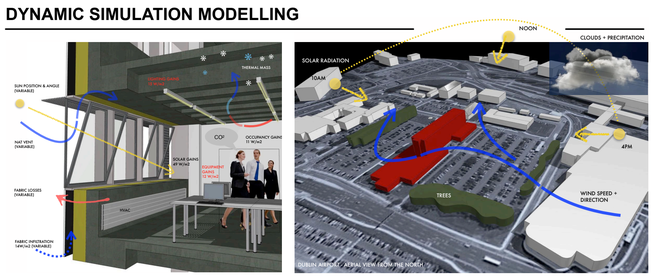
Overheating hours (Summer Design Week)	Hours + 25°C	Hours + 28°C
Office (West)	85.5	29.5
Offices (East)	50	10
TOTAL	**135.5**	**39.5**



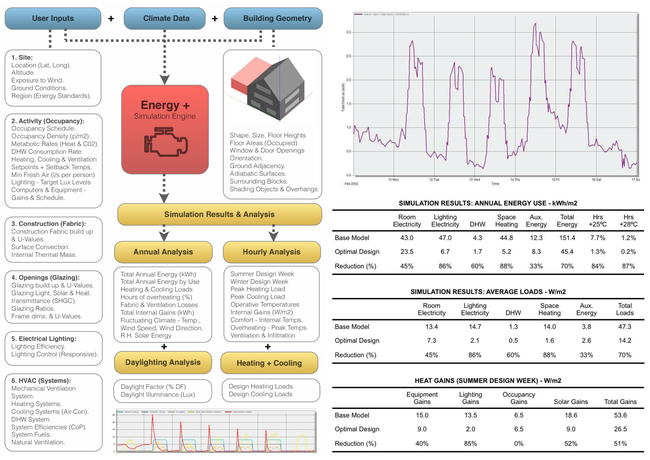
Existing Building Simulation Analysis - Overheating Summer Design Week

Annual Energy Use

DYNAMIC SIMULATION MODELLING



Dynamic Simulation Schematic - Modelling a complex reality



SIMULATION RESULTS: ANNUAL ENERGY USE - kWh/m2

	Room Electricity	Lighting Electricity	DHW	Space Heating	Aux. Energy	Total Energy	Hrs +25°C	Hrs +28°C
Base Model	43.0	47.0	4.3	44.8	12.3	151.4	7.7%	1.2%
Optimal Design	23.5	6.7	1.7	5.2	8.3	45.4	1.3%	0.2%
Reduction (%)	45%	86%	60%	88%	33%	70%	84%	87%

SIMULATION RESULTS: AVERAGE LOADS - W/m2

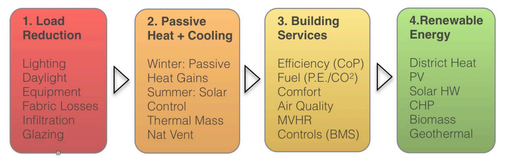
	Room Electricity	Lighting Electricity	DHW	Space Heating	Aux. Energy	Total Loads
Base Model	13.4	14.7	1.3	14.0	3.8	47.3
Optimal Design	7.3	2.1	0.5	1.6	2.6	14.2
Reduction (%)	45%	86%	60%	88%	33%	70%

HEAT GAINS (SUMMER DESIGN WEEK) - W/m2

	Equipment Gains	Lighting Gains	Occupancy Gains	Solar Gains	Total Gains
Base Model	15.0	13.5	6.5	18.6	53.6
Optimal Design	9.0	2.0	6.5	9.0	26.5
Reduction (%)	40%	85%	0%	52%	51%

Dynamic Simulation Inputs & Output results - Ventilation, Annual Energy Use, Loads, & Heat Gains

nZEB RETROFIT STRATEGY

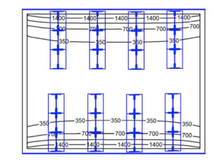


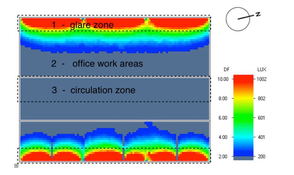
1. FABRIC & GLAZING UPGRADES (PASSIVHAUS ENERPHIT STANDARD):

Fabric Element	Existing	Retrofit
External (Glazed) Wall U-Value	0.83 (W/m2K)	0.10 (W/m2K)
Gable Walls U-Value	1.72 (W/m2K)	0.12 (W/m2K)
Flat Roof U-Value	1.00 (W/m2K)	0.11 (W/m2K)
Ground Floor U-Value	0.77 (W/m2K)	0.12 (W/m2K)
Window U-Value (Ug)	2.40 (W/m2K)	0.75 (W/m2K)
Thermal Bridging Elements	0.98 - 1.81 W/mK	max + 0.01 W/mK
Airtightness (Infiltration Rate)	15 ach-1 @ 50 Pascals	1.0 ach-1 @ 50 Pascals

EnerPHit — Quality Approved Energy Retrofit with Passive House Components — Passive House Institute

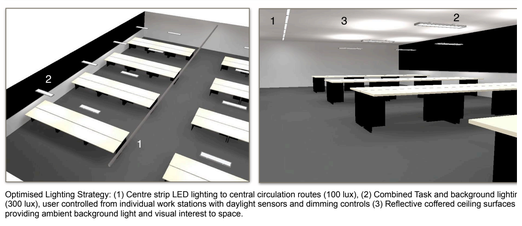
2. OPTIMISED DAYLIGHTING:





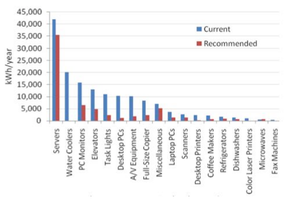
Daylight Strategy: (1) Glare zone (desk work areas set-back from perimeter), (2) Office working areas with good daylight distribution (200-500 lux), (3) Circulation and ancillary spaces to central zone with lower daylighting levels (>200 lux).

3. LOW ENGERY LIGHTING STRATEGY (1.6 W/m2 100 lux):



Optimised Lighting Strategy: (1) Centre strip LED lighting to central circulation routes (100 lux), (2) Combined Task and background lightir (300 lux), user controlled from individual work stations with daylight sensors and dimming controls (3) Reflective coffered ceiling surfaces providing ambient background light and visual interest to space.

4. ROOM EQUIPMENT (PLUG) LOAD REDUCTIONS (7.3 W/m2):



Low energy PCs & equipment

Plug Load Controls (occupancy / time controls)

Reduce "Phantom Loads"

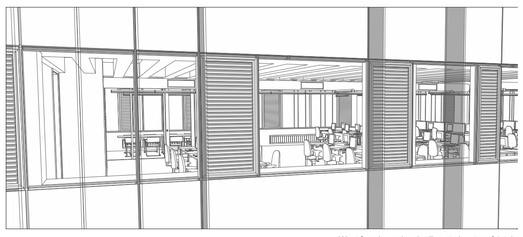
Remote Server Rooms, with localised cooling

Post Occupancy monitoring

45% Reduction in Plug Loads

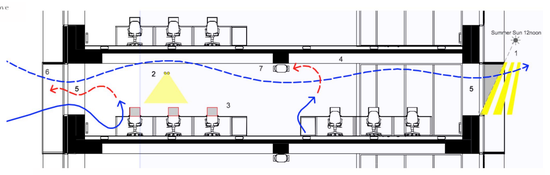
40% reduction in heat gains

5. SOLAR CONTROL (40% GLAZING RATIO + VERTICAL SHADING FINS):



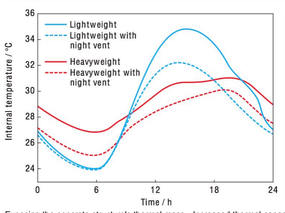
West facade - solar shading study - 4pm 21st Ju

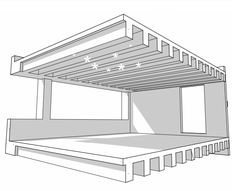
6. PASSIVE COOLING STRATEGY (SUMMER):



(1) Solar gains minimised by external shading, (2) Lighting loads minimised by efficient LED light fittings, with daylight and occupancy responsiveness, (3) Room Equipment heat gains minimised by low energy equipment and "Plug-Load" management, (4) Exposed therma mass modulates cooling loads, (5) Large opening vents provide Summer Ventilation Cooling - automatically opened at night to provide night purge cooling, (6) The mainly open-plan office spaces, and increased floor-ceiling height, allows for cross ventilation as well as localised stack effect. Natural Vent strategies are supplemented if required by the MVHR system (7) operating in bypass mode.

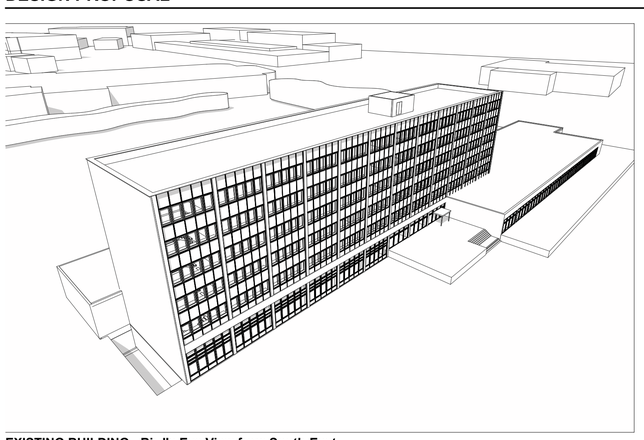
7. UTILISED THERMAL MASS (SUMMER COOLING):





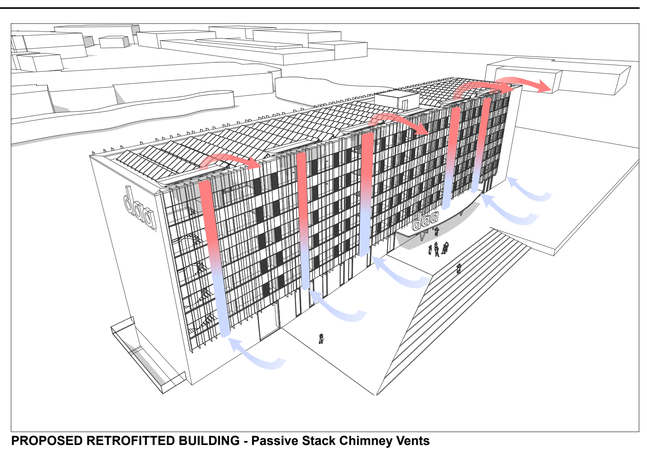
Exposing the concrete structure's thermal mass - Increased thermal capacity combined with Night-Time Purge Ventilation can be used t passively cool the building during Summer, reducing peak internal temperatures by up to 6°C

DESIGN PROPOSAL

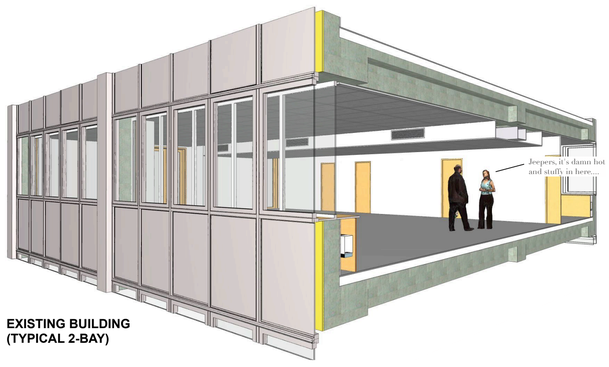


EXISTING BUILDING - Bird's Eye View from South-East

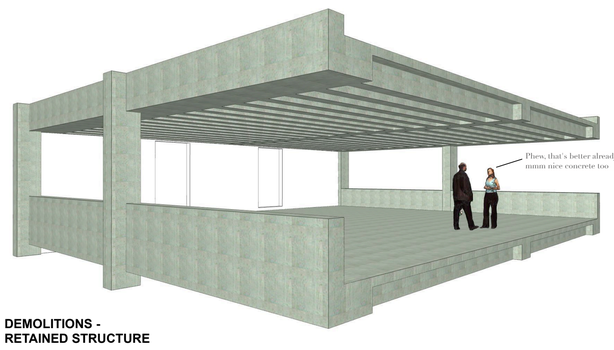
RETAINED STRUCTURES - 750 m3 Concrete & Steel reinforcement = 500 Tonnes of CO2



PROPOSED RETROFITTED BUILDING - Passive Stack Chimney Vents



EXISTING BUILDING (TYPICAL 2-BAY)

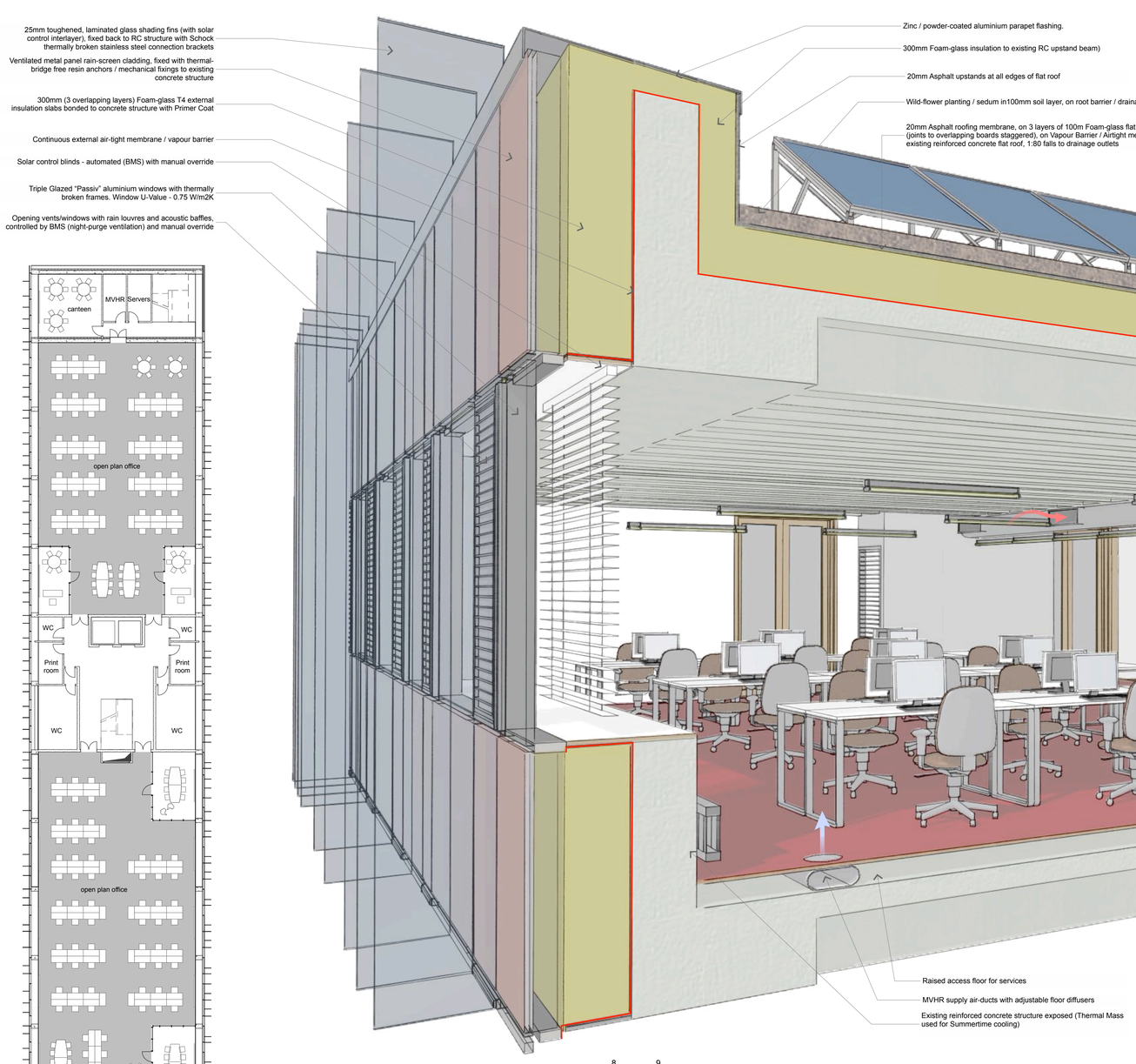


DEMOLITIONS - RETAINED STRUCTURE

RETROFITTED STRUCTURE

RENEWABLE ENERGY (PV ARRAY):

ROOF-MOUNTED PV ARRAY - CALCULATION	
Gross Building Floor Area	6000 m2
PV array area (Roof Mounted)	500 m2
No. of panels - (approx. 1.65m2 per panel)	300
PV output per panel (Sharp NU125E1)	235 W
PV nominal array rating	70.5 kW
Annual PV electrical output	61,000 kWh
Approximate Annual electrical Demand for Building	191,000 kWh
% of Electrical demand met by PV	32%

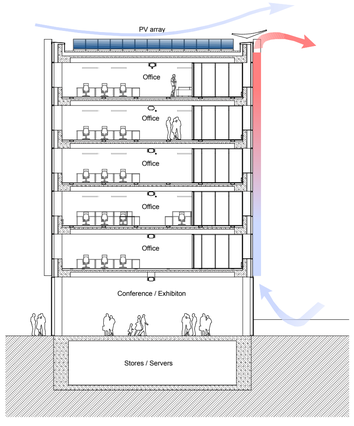


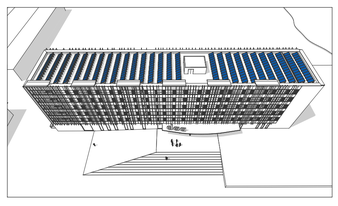
OFFICE FLOOR PLAN 1:250

3D CUTAWAY PLAN OF 3-BAY OFFICE FLOOR

KEY TO 3D FLOOR LAYOUT

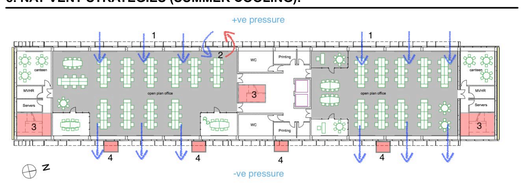
1 - Open-plan offices
2 - Meeting Room.
3 - Lounge Area
4 - Recreation Area
5 - Supply Air Vents in Floor
6 - Internal Passive Stack Chimney (existing riser)
7 - Acoustic Louvres to ventilation chimney
8 - Opening Vents (Night-purge vent controlled by BMS)
9 - Opaque Glass Shading Fins
10 - LTHW convector radiators





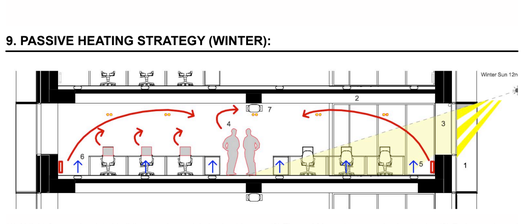
Perspective View From South

8. NAT VENT STRATEGIES (SUMMER COOLING):



Typical Floor Plan - Nat Vent Strategies: (1) Cross ventilation encouraged by open plan offices with opposing opening vents (2) Multiple window openings at high & low levels encourage localised stack effect (3) Stair cores with motorised roof vents utilised as passive stack "chimneys" (4) Ventilation chimneys to west facade.

9. PASSIVE HEATING STRATEGY (WINTER):



(1) Airtight & super-insulated building envelope minimise heat losses, (2) Thermal Mass stores passive heat gains (3) Early morning sol gains, (4) Space Heating is mainly by passive gains from Occupants, Room Equipment, Electrical Lighting, and Solar Gains. (Supplemented when required by low temperature hot water radiators, (6) MVHR system supplies offices with constant fresh air at low lev through the raised floor plenum, warmed via a heat exchanger by the extract air, with CO^2 monitoring and control, (7) Ceiling mounte extract duct extracts return air to MVHR units on each floor.

10. MECHANICAL SERVICES STRATEGY:

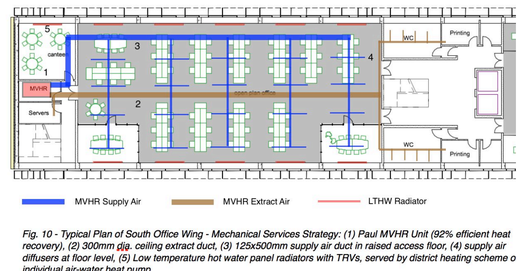


Fig. 10 - Typical Plan of South Office Wing - Mechanical Services Strategy: (1) Paul MVHR Unit (92% efficient heat recovery), (2) 300mm dia. ceiling extract duct, (3) 125x500mm supply air duct in raised access floor, (4) supply air diffusers at floor level, (5) Low temperature hot water panel radiators with TRVs, served by district heating scheme o individual air-water heat pump.