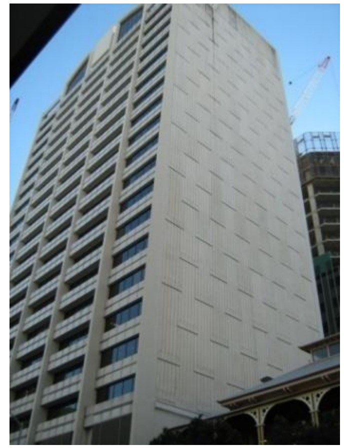
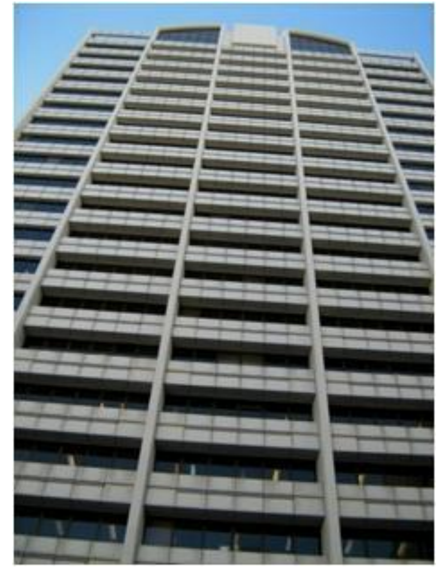
1. INTRODUCTION

160 Ann Street, Brisbane, Australia





PROJECT SUMMARY
- *Year of construction – 1972*

SPECIAL FEATURES
- *Building retrofitting methodology through calibrated building energy modeling, to meet NABERS 4 star rating scheme. Three orders of decisions where developed:*

i. Control of internal loads,
ii. Control of Environmental loads,
iii. HVAC improvements.

ARCHITECTS
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IEA – SHC Task 47
Renovation of Non-Residential Buildings towards Sustainable Standards

2. CONTEXT AND BACKGROUND

BACKGROUND

- *Building is located in the CBD of Brisbane Australia, in a warm sub-tropical climate, approx. 27º S, densely populated with medium to high rise buildings adjacent to Brisbane river.*
- *It is a 23-storey tower with NLA: 15,877m$^{2;}$ 820m^{2} each floor, being internal load dominant.*
- *Whole building energy rating is between 2 – 2.5 stars.*
- *Total energy consumption is 270 Kwh/m2/a*
- *Tenants and HVAC are 126 and 147 KWh/m^{2}.annum*

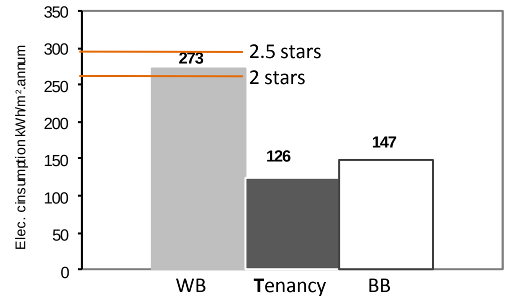
OBJECTIVES OF THE RENOVATION

- *Meet Queensland Emission reduction targets, energy performance improvements to accomplish:*

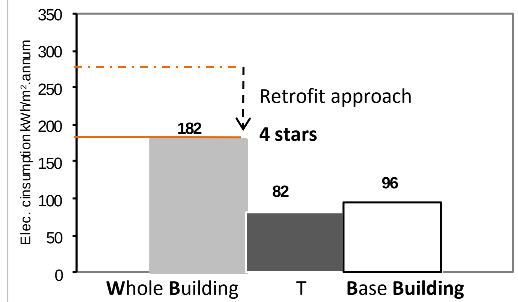
- 4 stars NABERS rating of182 KWh/m2.annum operational energy foot print for the whole building

SUMMARY OF THE RENOVATION

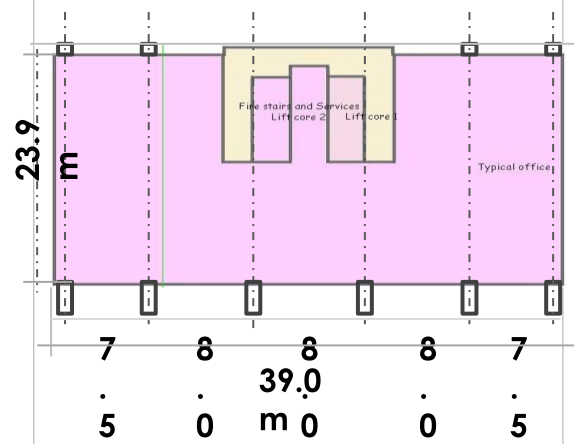
- *Step 1 - Internal load controls – using non-technological & technological strategies*
- *Step 2 - Environmental load controls – using technological strategies*
- *Step 3 - System improvements – using non-technological & Technological strategies to upgrade the HVAC system*



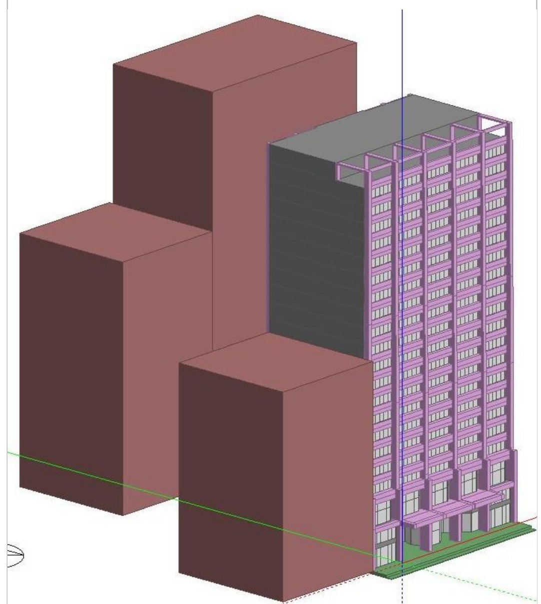
Baseline scenario



Retrofit scenario

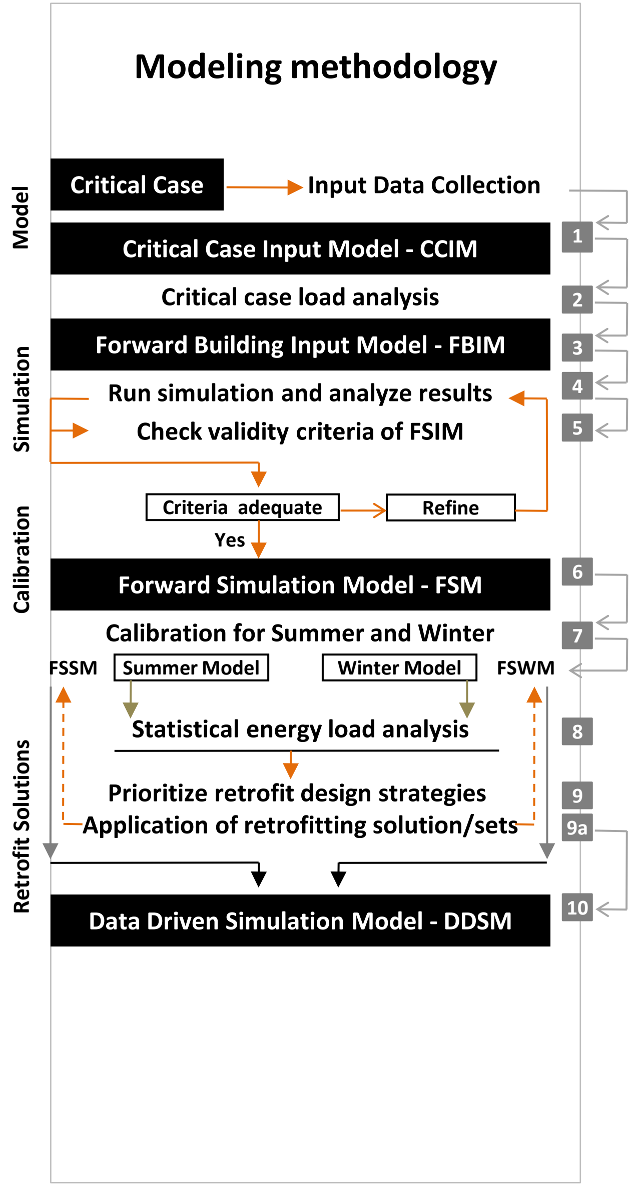


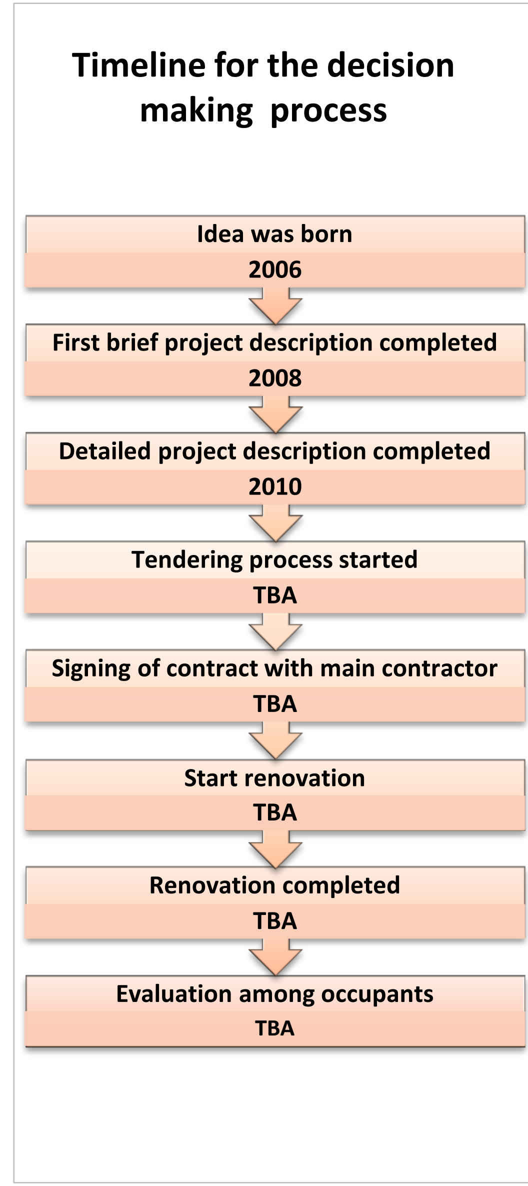
Typical Office floor – Level 4 – Level 21



3. DECISION MAKING PROCESSES

- *Project initiated by Prof. Richard Hyde at University of Queensland under research named “Exploring Synergies with Innovative Green Technologies: Redfining Bioclimatic Principles for Multi Residential Buildings and Offices in Hot and Moderate Cimates”.*
- *This building was considered as a “Critical Case” representing common physical and operational characteristics of typical high rise office buildings in Australia.*
- *Public funding program: ARC (Australia Research Council)*





4. BUILDING ENVELOPE

Roof construction : *U-value:* *2.3W/m^2.K*
Materials . (Interior to exterior)
RCC concrete (existing) *250 mm*
Pure Bitumen (existing) *20 mm*
Total (existing) *285 mm*

Wall construction : *U-value:* *2.7W/m^2.K*
Materials . (Interior to exterior):

Slab construction : *U-value:* *3.0W/m^2.K*
Materials . (Interior to exterior):

Windows : *U-value:* *2.63 W/m^2.K*
Double-glazing (existing)
Clear glass *6 mm*
Cavity with venetian blinds *50 mm*
Bronze tinted glass *6 mm*

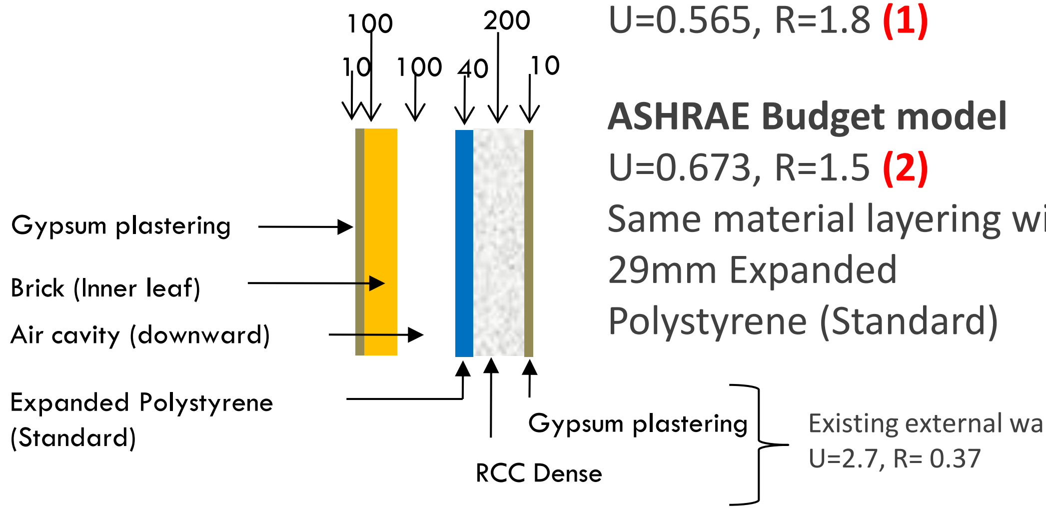
Thermal bridge avoidance:
Airtightness (existing) *1.0ach/h*
Airtightness (new) *0.5ach/h*
0.11ach/h??

Summary of U-values [W/m²K]

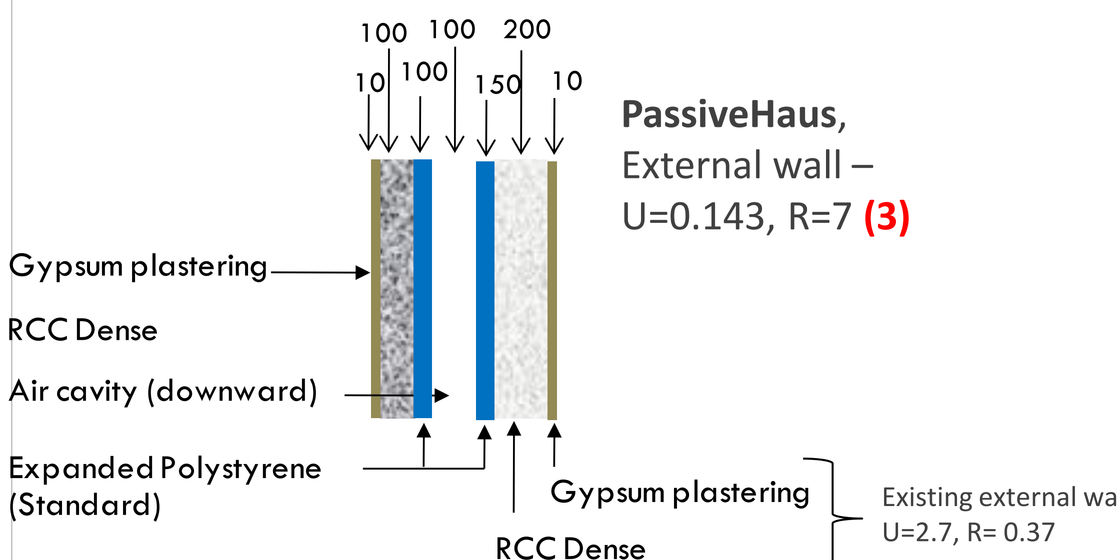
	Before	After (1)	After (3)
Floor/slab	3.0		1.3
Walls	2.7	0.565	0.143
Roof	2.3		0.095
Windows	2.63		0.76

BCA 2009, External wall –
U=0.565, R=1.8 **(1)**

ASHRAE Budget model
U=0.673, R=1.5 **(2)**
Same material layering with 29mm Expanded Polystyrene (Standard)



PassiveHaus,
External wall –
U=0.143, R=7 **(3)**



5. BUILDING SERVICES SYSTEM

OVERALL DESIGN STRATEGY

STEP 1 *(FIRST ORDER)*

Controls to internal heat loads

- *Before (CCIM)* *273 KWh/m^2/a*
- *After* *163 KWh/m^2/a*

LIGHTING SYSTEM

Reduction of power density load

- *Before* *12 W/m^2*
- *After* *9 W/m^2*

STEP 2 *(SECOND ORDER)*

Controls environmental heat loads

- *Before* *163 KWh/m^2/a*
- *After* *155 KWh/m^2/a*

VENTILATION/ INFILTRATION

- *Before* *1.0ach.h*
- *After* *0.5ach.h*

INSULATION (see page 4)

STEP 3

HVAC improvements

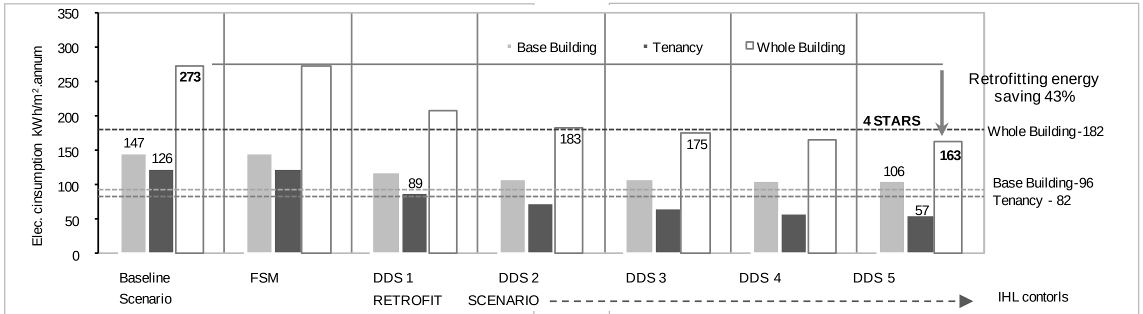
- *Before* *155 KWh/m^2/a*
- *After* *111 KWh/m^2/a*

HVAC SYSTEM

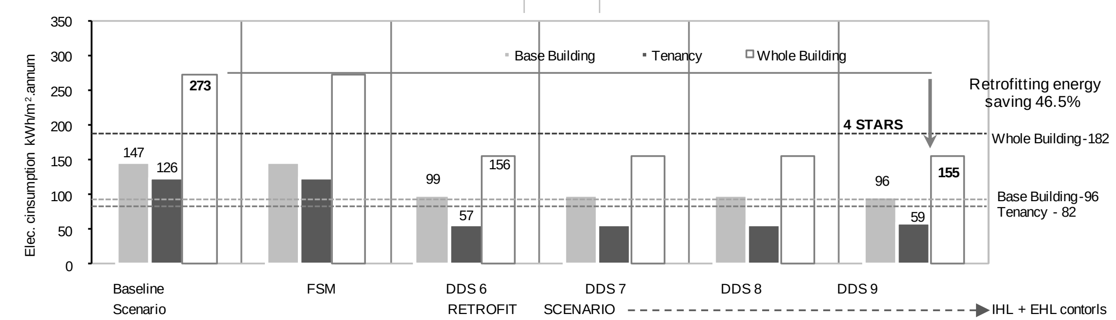
- *Before* *COP 2.5*
- *After* *COP 5.0*

INTERNAL TEMPERATURE SETPOINT

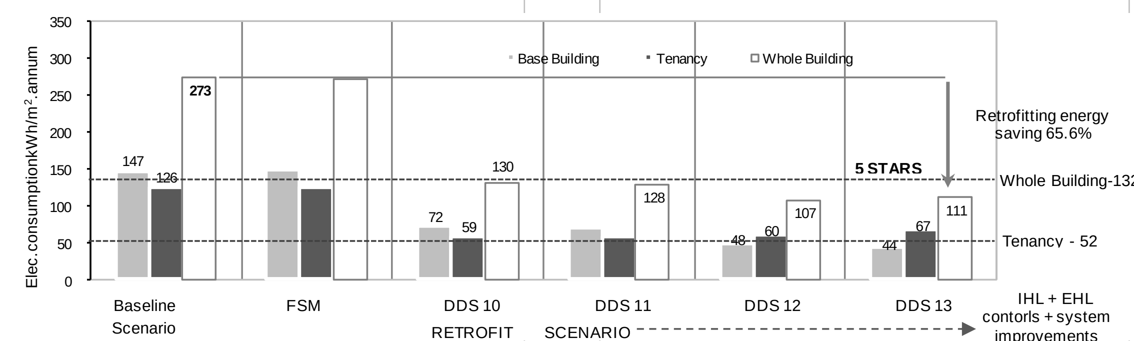
- *Before* *21.5ºC*
- *After* *24ºC*



Step 1



Step 2



Step 3

6. ENERGY PERFORMANCES

Queensland Emission reduction targets

- 4 star energy efficiency rating for commercial buildings by 2010
- Carbon neutral government office buildings by 2020

Retrofit scenarios satisfies the 2010 emission reduction targets

- 1383713 KWh per annum, 87 KWh/m^2.annum
- By 2020 – 3.9% increase in energy usage due to climate change.
- Green Power requirement (Whole building)
    - 1437768 KWh per annum
    - 90 KWh/m2/annum

To achieve near carbon neutral status

- Green power to move from improved energy efficiency status to near carbon neutral status (Step 4)

For internal load control

Using technological and non-technoogical interventions

Scenario	1	FSM + Operational and occupancy profile – for BCA only
Scenario	2	(1) + Efficient appliances (plug loads) – for BCA, PH and ASHRAE
Scenario	3	(02) + Lighting – for BCA, PH and ASHRAE
Scenario	3A	(03) + Daylight linear off sensors for artificial light – for BCA, PH and ASHRAE
Scenario	3B	(03A) + Window blinds operation with solar sensors – for BCA, PH and ASHRAE

For internal load + environmental load control

Using technological interventions

Scenario	4	(03B) + Infiltration – for BCA, PH and ASHRAE
Scenario	5	(04) + Insulation to external walls – for BCA, PH and ASHRAE
Scenario	6	(05) + Insulation to total opaque surfaces – for BCA, PH and ASHRAE
Scenario	7	(06) + Solar transmission control to glazing – for BCA, PH and ASHRAE
Scenario	8	(07) + Efficient HVAC (increased COP 5) – for BCA, PH and ASHRAE (Summer)
Scenario	8A	(08) + Increase of set point temperature by 1 degree C – no heating
Scenario	9	(08A) + Mixed mode HVAC system (winter no heating)
Scenario	10	(10A) + increase of glazing in envelope
Scenario	*11*	*Scenario 11 for climate change effects 2030*
Scenario	12	(11) + Green power, PV Cells – for BCA, PH and ASHRAE

Conceptual thermal behaviour appraisal

7. ENERGY PERFORMANCE

Items that could be covered:

Modeling methodology

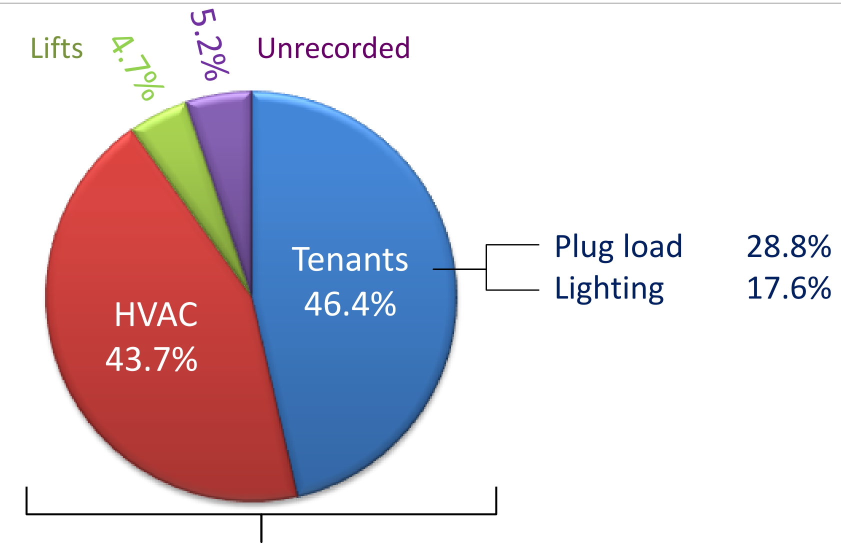
- *input data collection*
- *Model development*
- *Simulation*
- *Calibration*
- *Retrofit solution/sets*

Simulation Program
Dynamic energy simulation software:
- *Design Builder version 2.2.5*
- *G.U.I. for EnergyPlus simulation engine.*

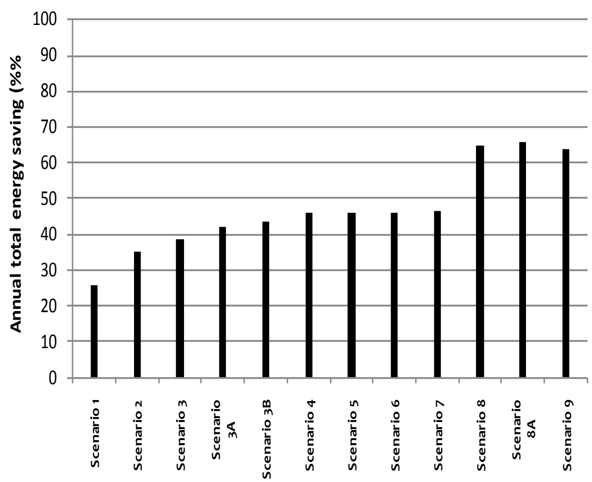
Model development involved the following;
- *Critical Case Input Model – CCIM*
- *Forward Simulation Model - FSM*
- *Model calibration*

Building Design Chracteristics
- *Externalities (building design and microclimate)*
- *Internalities (occupancy, equipment and systems)*

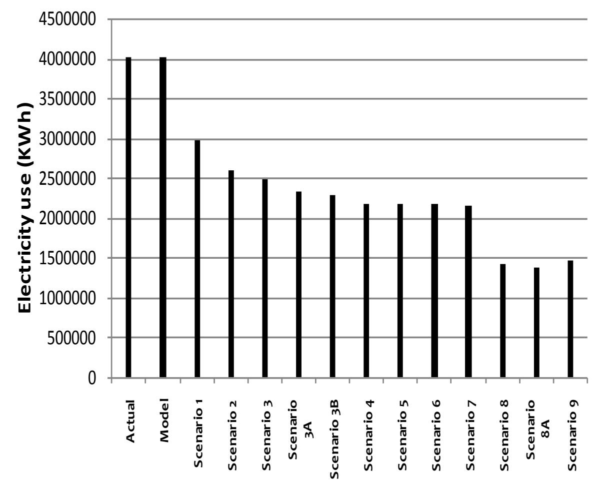
*Both affect the heat load profiles and therefore energy performance were the **AREAS** for retrofitting.*



Operational energy consumption – 61.3% (HVAC + Lighting)



Total energy usage



% of energy saving

8. MORE INFORMATIONS

RENOVATION COSTS

- *Specified for individual energy saving measure and expected pay back time if possible*
- *To achieve a 65% energy cuts in existing buildings, require an economic analysis to justify the retrofitting decisions.*

FINANCING MODEL

- Subsidized loans:
- Grants:
- Interest level: Public disclosure
- Public incentives: Government tenancy require 4.5 star
- ESCO contracts: N/A
- Market conditions:

OTHER INTERESTING ASPECTS

Potential for ecological integration

REFERENCES

Hyde et al, Sustainable Retrofitting, 2012, Chapter 2.4 &2.5

Energy efficiency scenarios that PASS the economic test

SC	Scenario descriptions	Approach 1 Payback (years)	Approach 2 NPV ($)
SC-1	Occupacy and opertional profile of BCA	-	506.681
SC-2	SC-2a Efficient appliances	0,1	967.392
	SC-2b Increase cooling set-point temperature by 1 degree	0,3	187.769
	SC-2c Advance computer managemente systeme	1,1	881.708
SC-3	Infiltration improvements	2,8	15.577
SC-6	Low emission transmission; double glazing	1,4	63.617
SC-7	Efficient Lighting	-	1.645.415
SC-9	Efficient chiller system	0,8	488.163
SC-11	Mixed mode HVAC system with winter no heating	1,7	272.786
SC-10	Mechanical services (Pumps and lifts)	0,5	722.622
SC-12	HVAC Fans & VAV diffuser system	6,2	791.830

Energy efficiency scenarios that FAIL the economic test

SC	Scenario descriptions	Approach 1 Payback (years)	Approach 2 NPV ($)
SC-4	Insulate external walls	44	91.054
SC-5	Insulate total opaque surfaces	2.971	10.264.638
SC-8	SC-8a Daylight linear off sensors	26	12.675
SC-8	SC-8b Window blinds operation with sensors	19	8.691