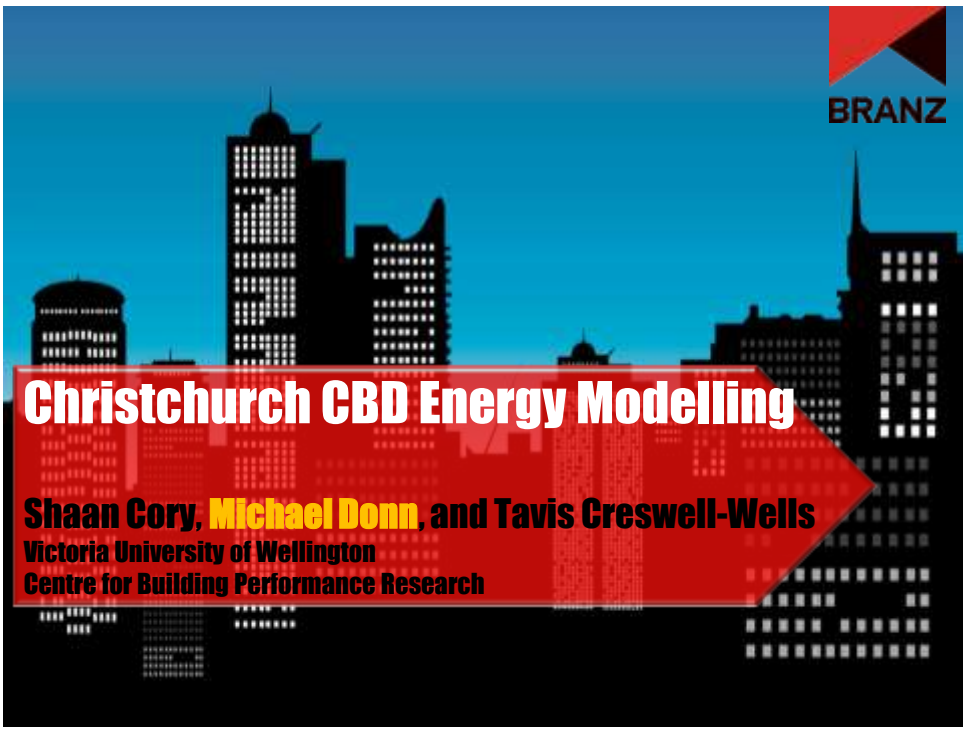

Parameters of our Study

1. **Lessons from international high-performance buildings**
2. **'Optimised' building design:**
   1. T_{vis} and T_{sol}, R-value of all components, shading, WWR and height of glazing, heat storage
3. **Urban design options from CCP:**
   1. Height limit 7 storeys
   2. Sloping South facades over 5 storeys
   3. Permeability = lanes (4m / 10m) or courtyards

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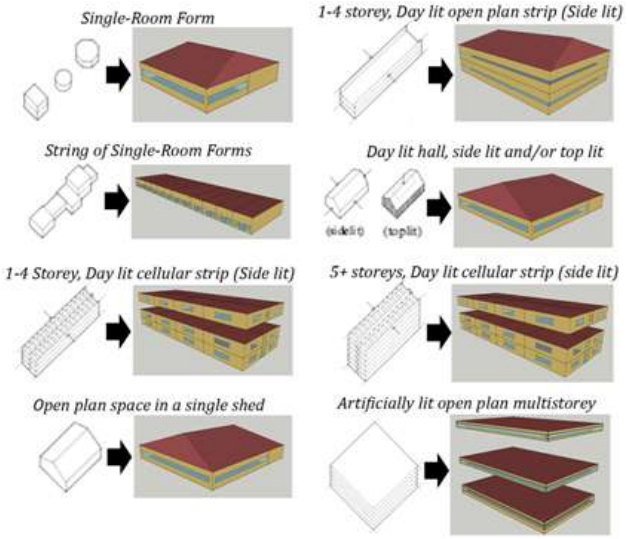
NZ Templates for Energy Modelling



Now: + HVAC systems

Soon: + materials

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Net ZEB: Lessons Learned

- **IDP – essential**
- **Energy Performance must be early goal**
- **Hierarchy when Designing Net ZEBs:**
  - Passive Design → Energy Efficiency Systems → Renewable Energy Solutions
- **Energy end-use: office equipment 50%**
- **Ceiling fans, instead of active cooling**
  - This affected our analysis: assumed 18-27°C comfort band based on their proven 18-30°C comfort band with Natural Ventilation

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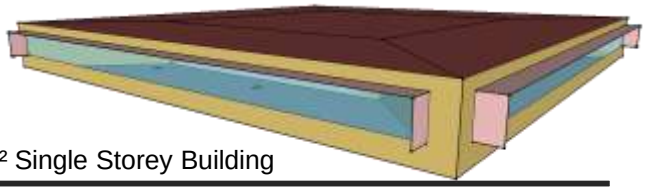
Set of Energy Lowering Solutions

- **Design changes:**
  - Natural Ventilation
  - Electric Light Controls
- **Used BEES Schedules**
- **Optimised parameters:**
  - Solar shading: 0-3m
  - Insulation: R0.1-R12
  - Window to Wall Ratio (WWR 10-90%)
  - Window Height 0.1m Floor/Roof



5 Zone - 1,000m² Single Storey Building

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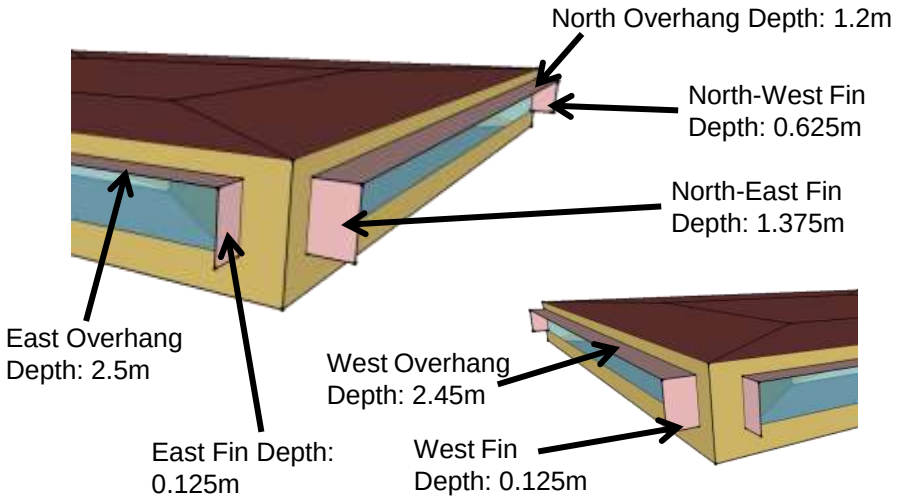
Optimum Shading Parameters



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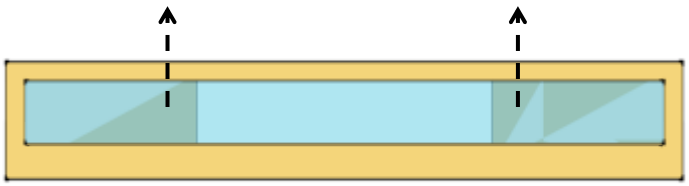
Optimum Window Parameters



WWR: 50%

Window Height: Moves Up 200mm

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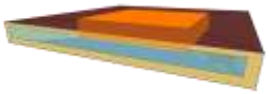
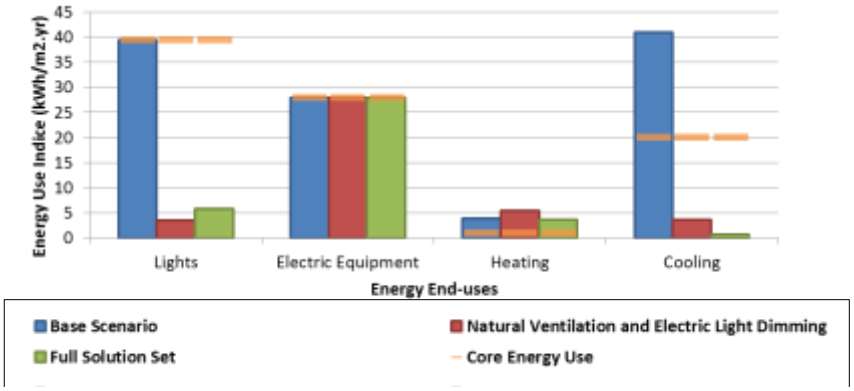
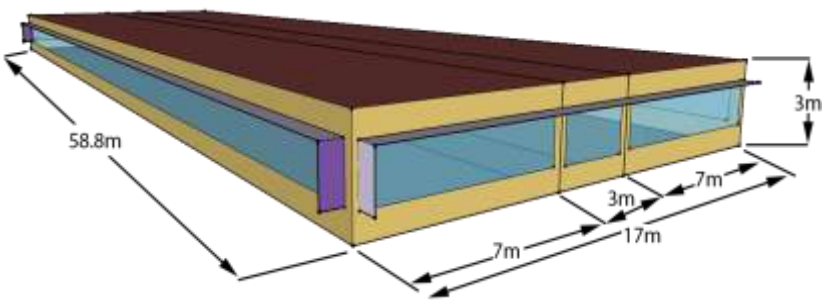
Energy End-use Breakdown & Savings

- **Largest Savings: Cooling and Lighting**
  - Achieved with Natural Ventilation/Free cooling and Electric Light Controls
- **Natural Ventilation and Solar Shading**
  - Elimination of Cooling needs in perimeter
- **Base Scenario**
  - Perimeter Zones use more than Core Zone





Narrow Plan Building



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Summary

- **Cooling almost eliminated in Perimeter**
- **Office Equipment very dominant**
- **Design Principles:**
  - Free cooling and daylight design is crucial – if form is kept narrow for whole building design – almost eliminates mechanical cooling
  - Insulate well – especially the roof AND glazing!
  - WWR same as NZBC of 50%
  - Have high window placement

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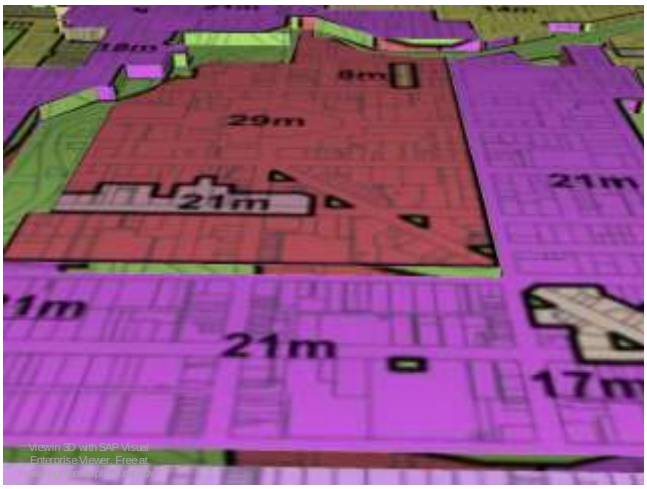
Where to Start?



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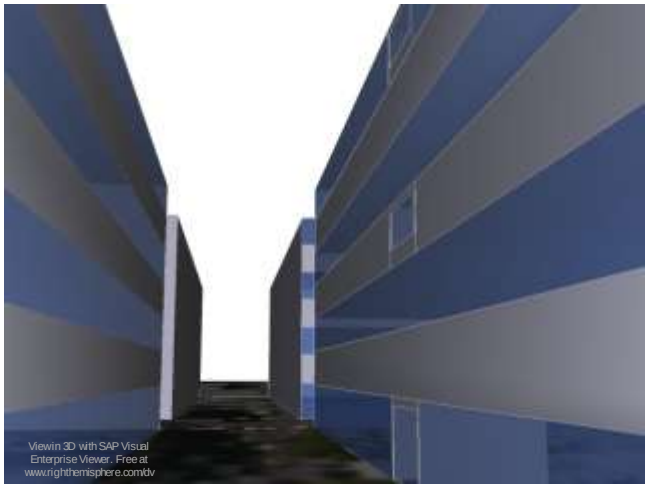
Establishing the Baseline



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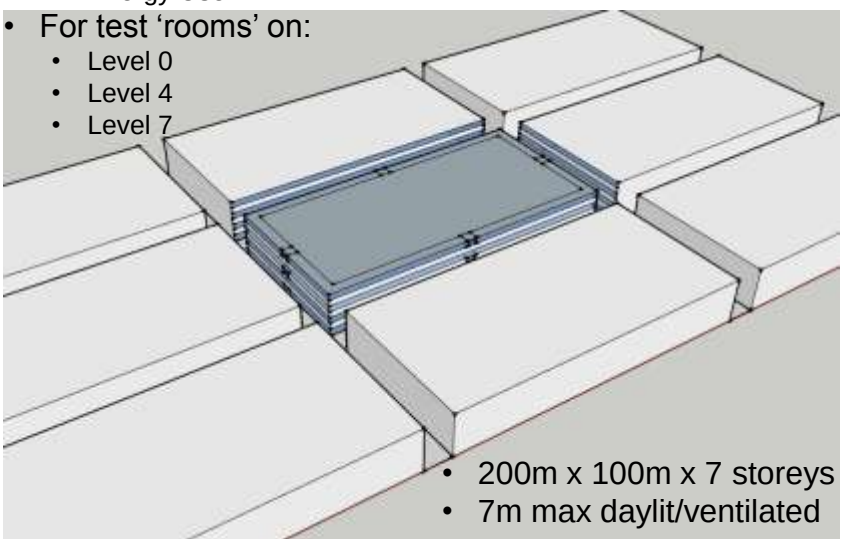
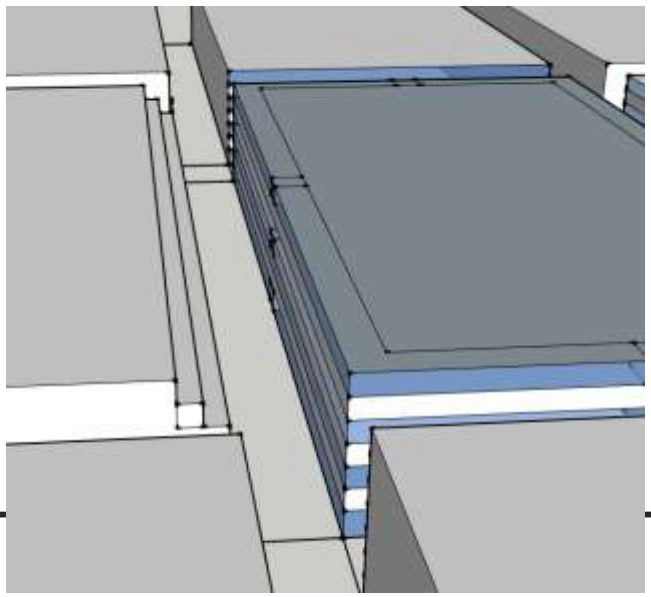
Urban Form Scenarios

- Effect of Urban form on:
  - Daylight
  - Energy Use
- For test ‘rooms’ on:
  - Level 0
  - Level 4
  - Level 7



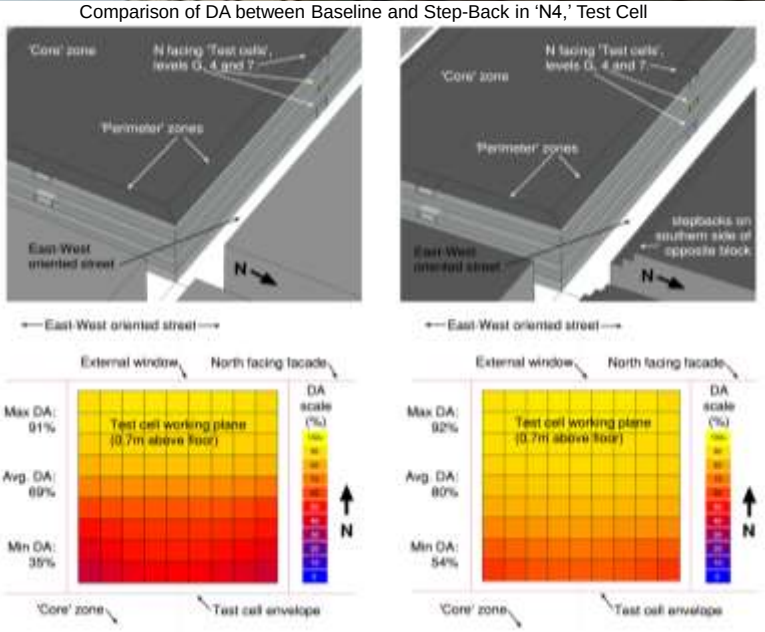
- 200m x 100m x 7 storeys
- 7m max daylit/ventilated

Step-Backs?

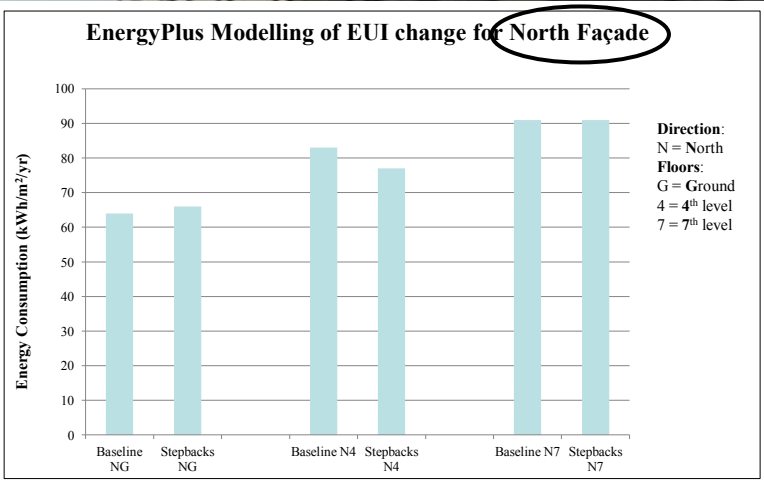


Daylight Autonomy (DA): North - Level 4

Comparison of DA between Baseline and Step-Back in 'N4,' Test Cell



Perimeter Energy Change – Step-Backs



- Step-backs make no difference to top floors
- Biggest improvement apparent on mid-level floors

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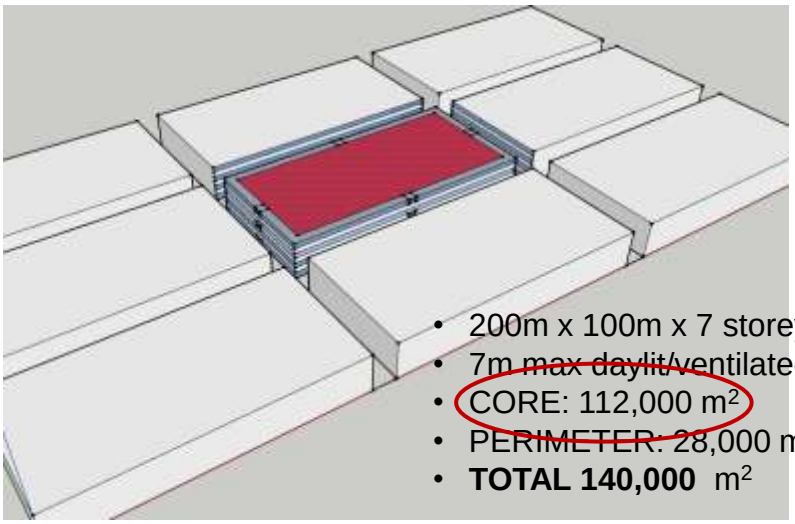
Effect of Step-Backs Overall



- 200m x 100m x 7 storeys
- 7m ~~max daylit/ventilated~~
- CORE: 112,000 m^2
- ~~PERIMETER: 28,000 m^2~~
- **TOTAL 140,000** m^2

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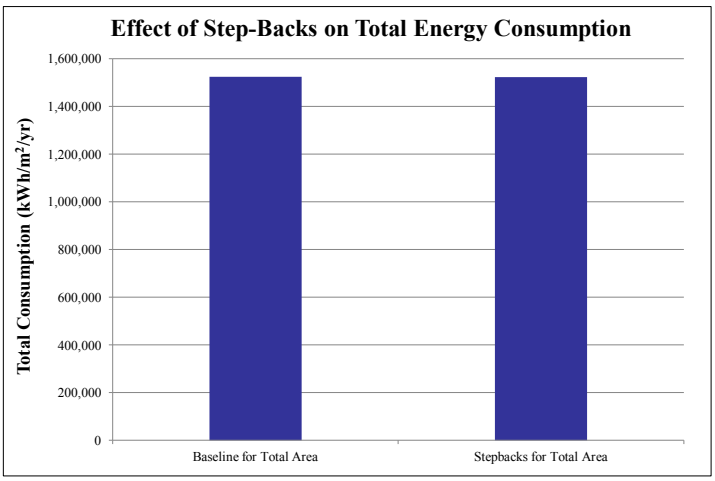
Overall Energy Change: Step-Backs



- Step-Backs make negligible improvement to overall building energy consumption

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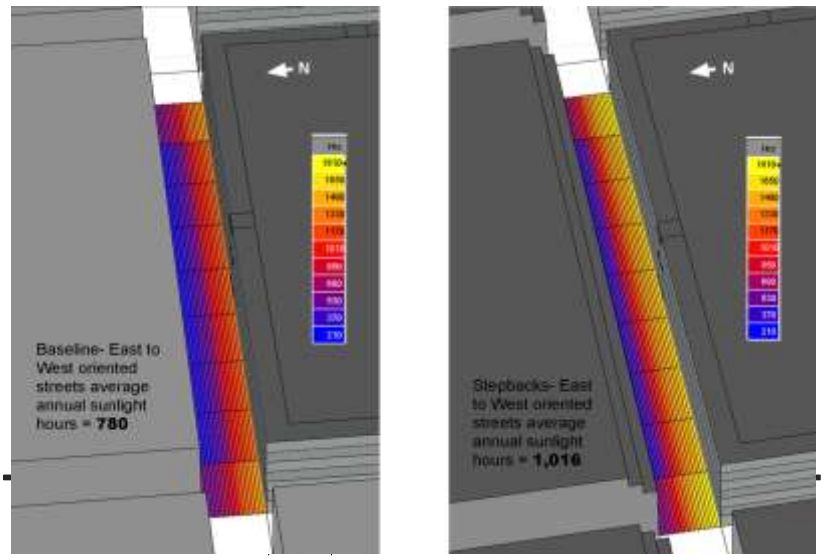
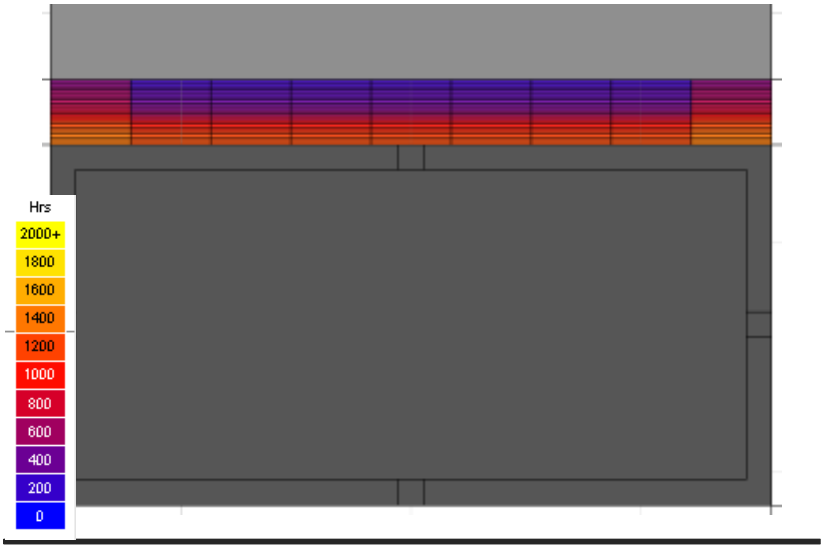
Sunlight in Street: Effect of Step-Backs

- Annual, between 7am and 7pm (4,380 hours total)
- North-South oriented streets not affected (738 up to 778)



Baseline: All Year



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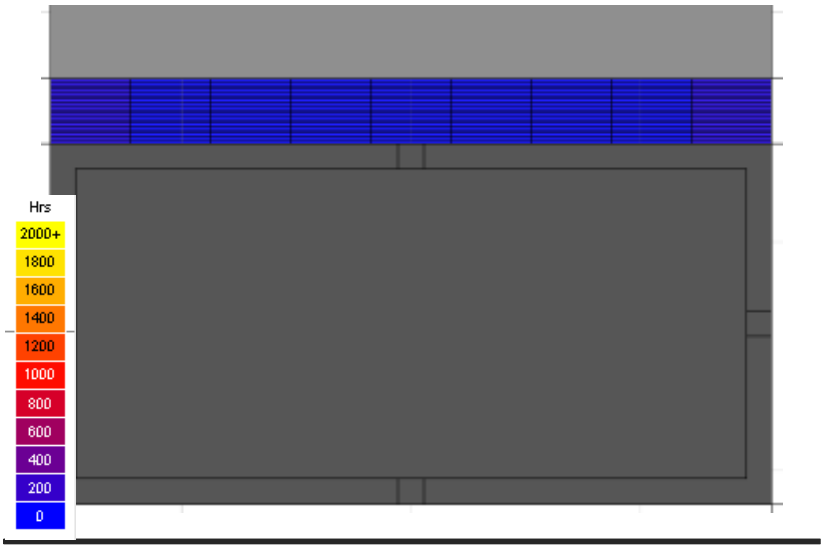
Baseline: Winter



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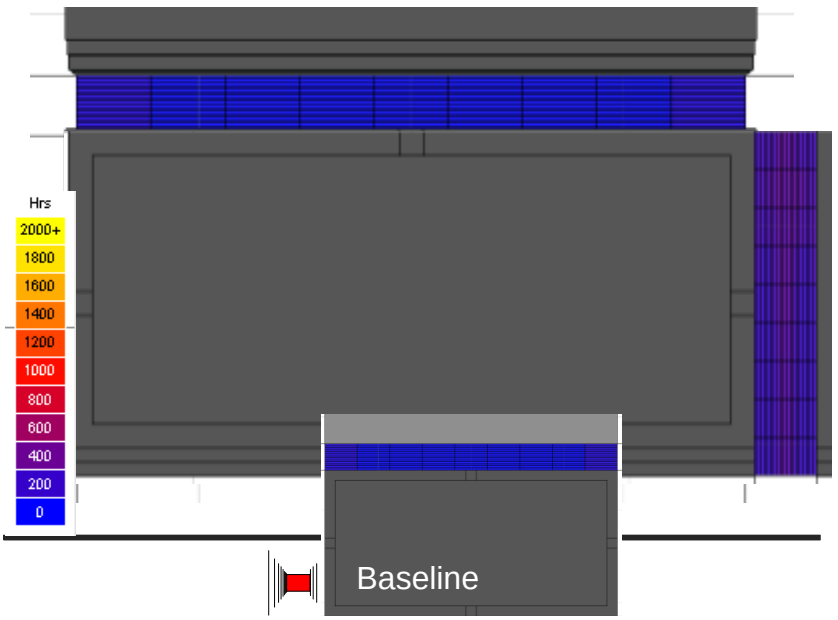
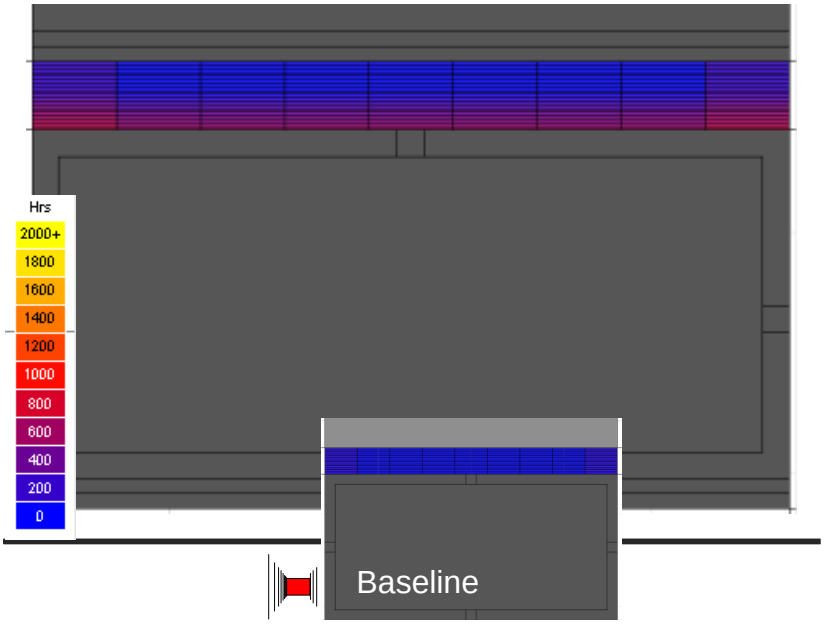
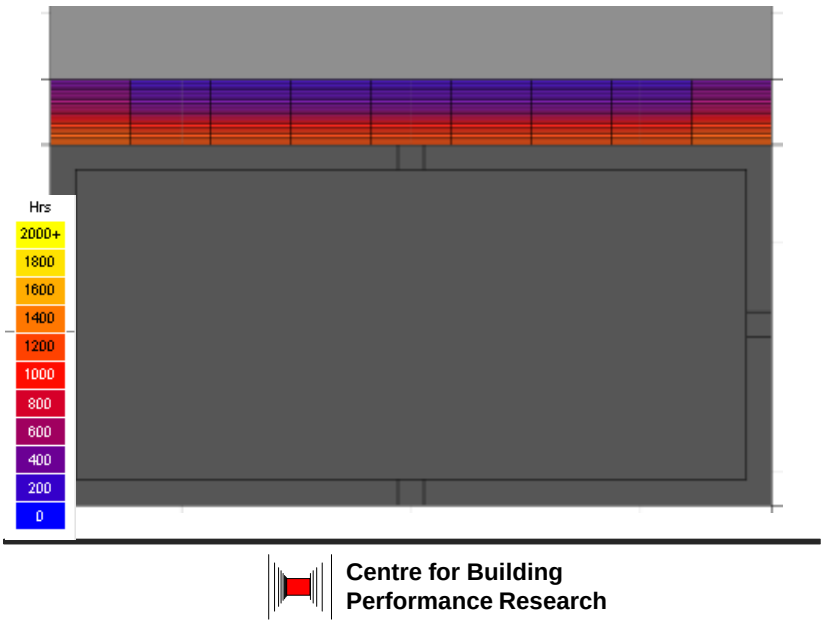
Step-Backs: Winter 7 Storeys



Step-Backs: Winter 4 Storeys



Baseline: Summer



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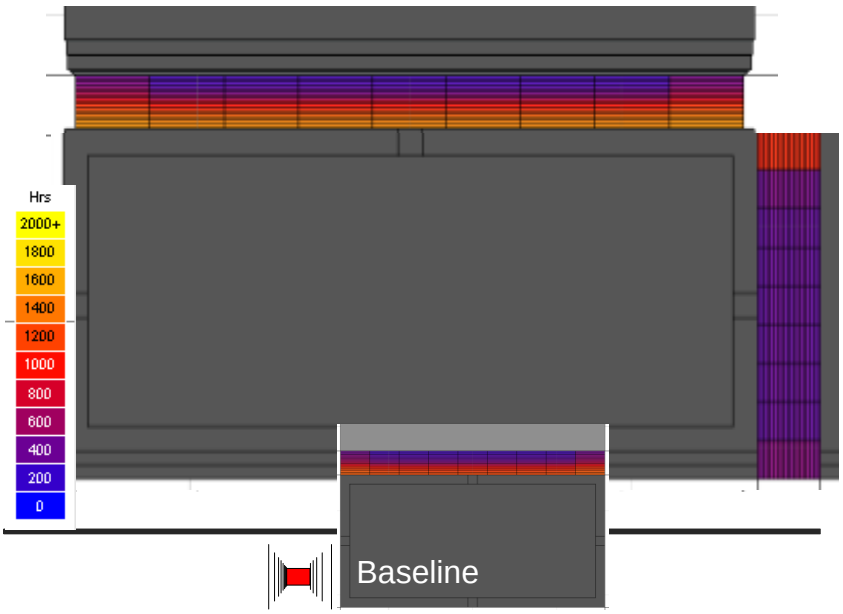
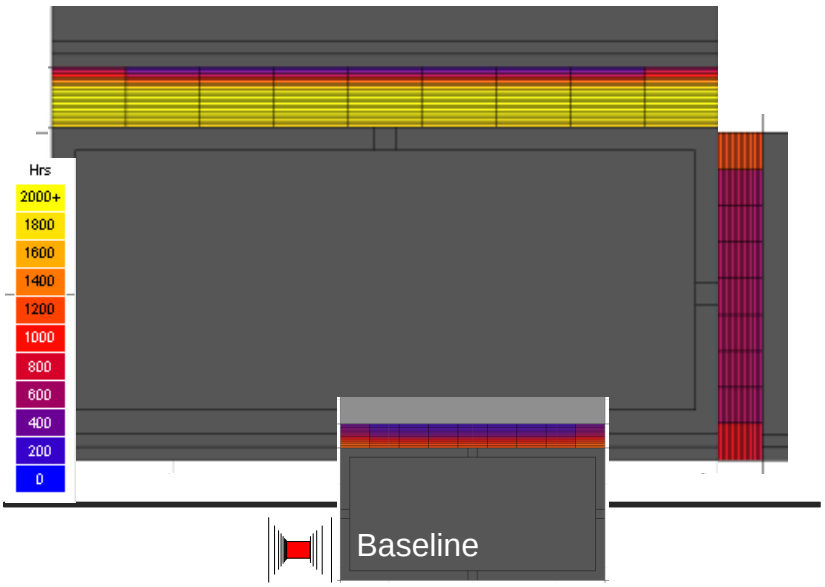
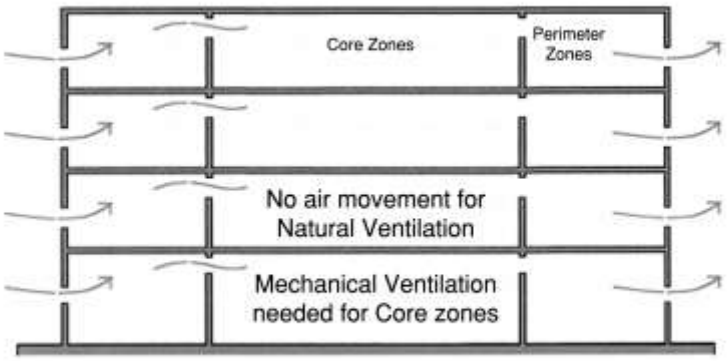
Step-Backs: Summer 7 Storeys



Step-Backs: Summer 4 Storeys



Deep Plan Buildings



Typical Building Cannot Ventilate Naturally

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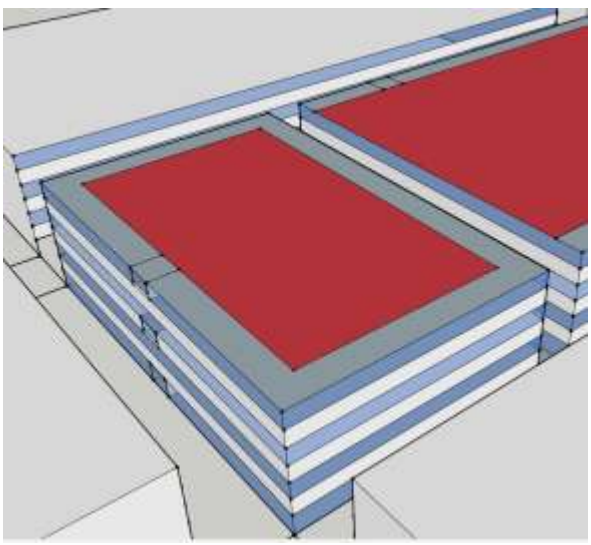
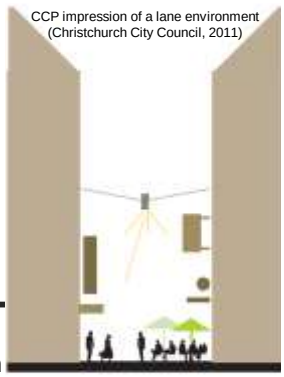
Lanes break up Deep Plan?



- 3 buildings in total
- 65m x 100m x 7 storeys
- 7m max daylit/ventilated
- CORE: 93,000 m^2
- PERIMETER: 44,400 m^2
- **TOTAL 137,400** m^2

CCP impression of a lane environment (Christchurch City Council, 2011)



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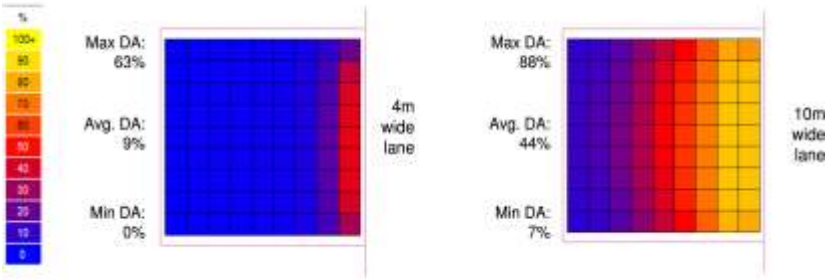
Lane Daylight Autonomy (DA)

Level 4, East and West oriented zones adjacent to lanes



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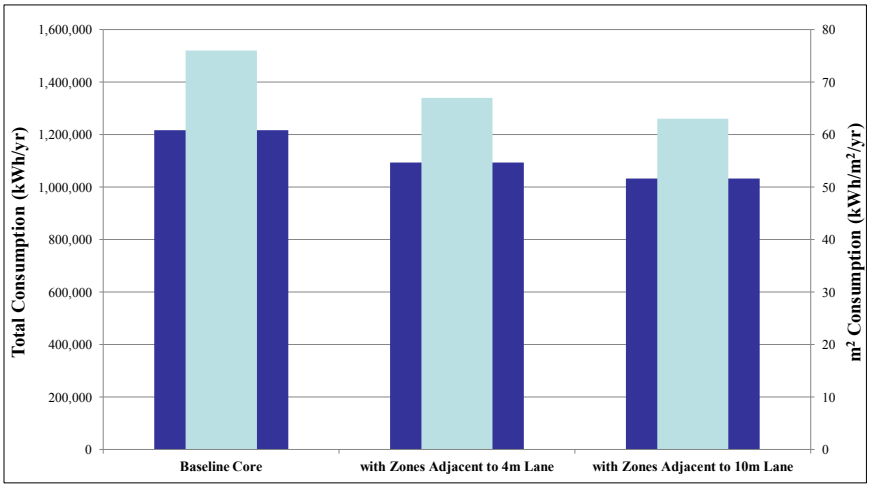
Energy Consumption Change: Lanes



- Despite very poor daylighting, 4m lanes still reduce energy consumption

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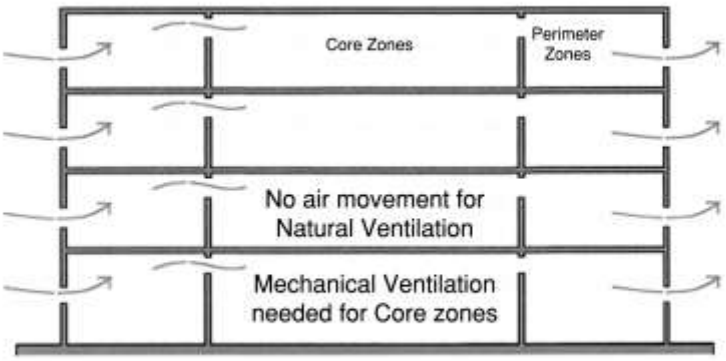
Deep Plan Buildings



Typical Building Cannot Ventilate Naturally

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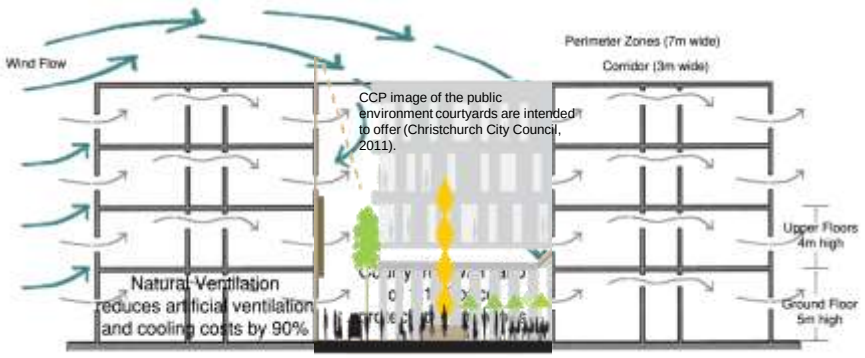
Narrow Plan Buildings

Where: $\frac{Area\ Courtyard}{(Av.\ Height\ Buildings)^2} < 10$ winds 50% reduced

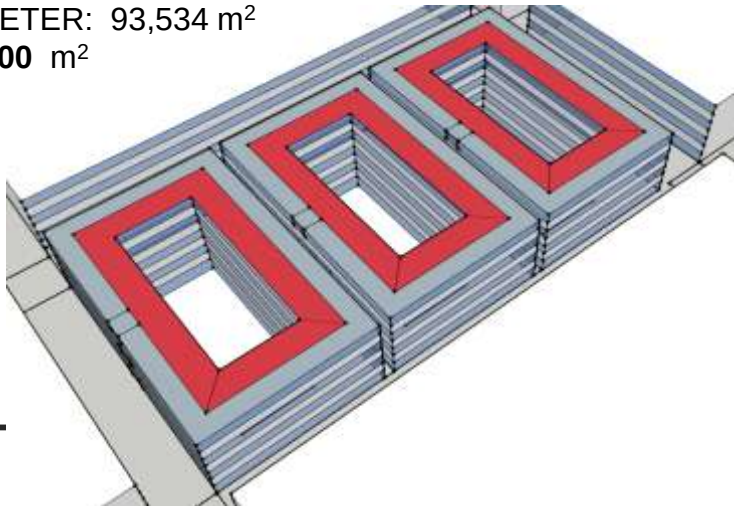
7 storey courtyards: 2.4
4 storey courtyards: 7.1



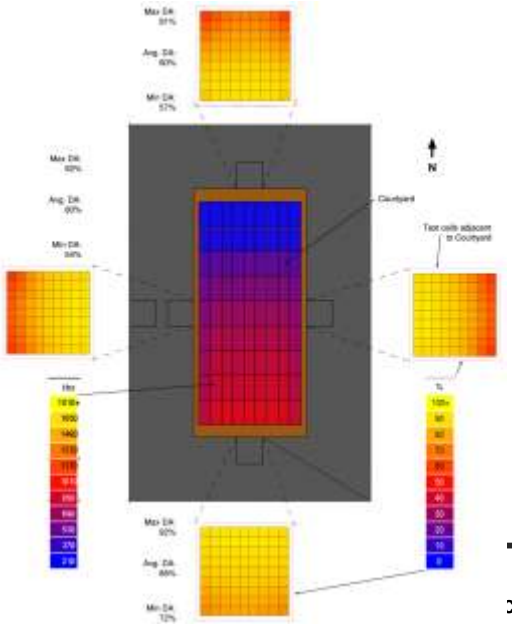
Courtyards for Wind Protection and Natural Ventilation

Courtyards

- 3 buildings
- 65m (62m) x 100m x 7 storeys
- 7m max daylit/ventilated
- Only PERIMETER: 93,534 m^2
- **TOTAL 93,500** m^2



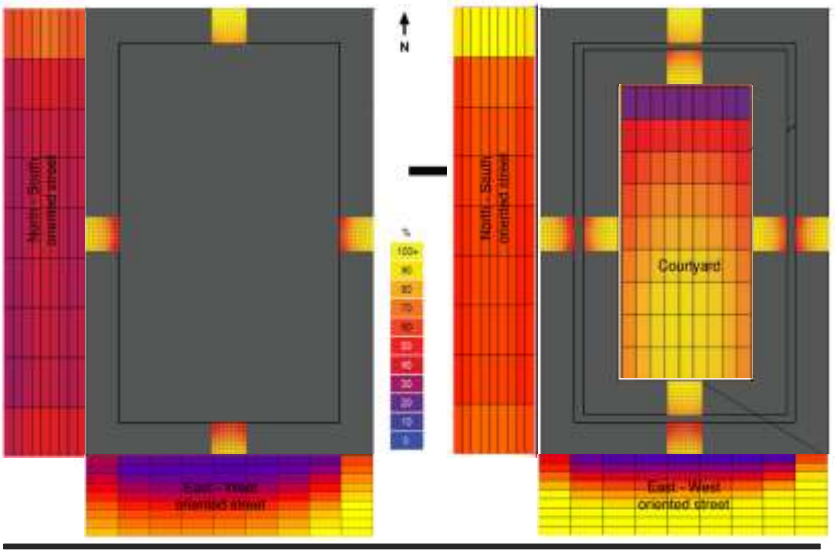
Improved Daylight due to Courtyards



-Very good daylight to zones facing courtyard at mid-height

- Shading becomes an issue at Ground level

Daylight/Sunlight in Streets



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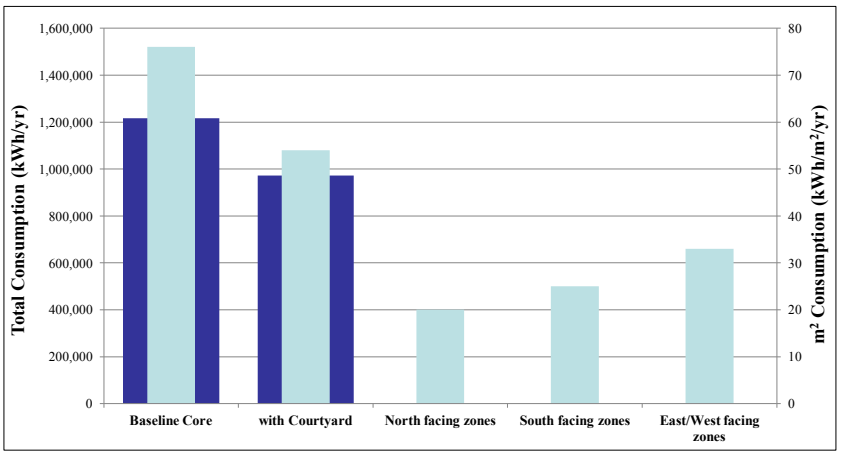
Energy Performance: Courtyards



- All zones adjacent to the courtyard perform very well passively
- Courtyard reduces total consumption by around 20%

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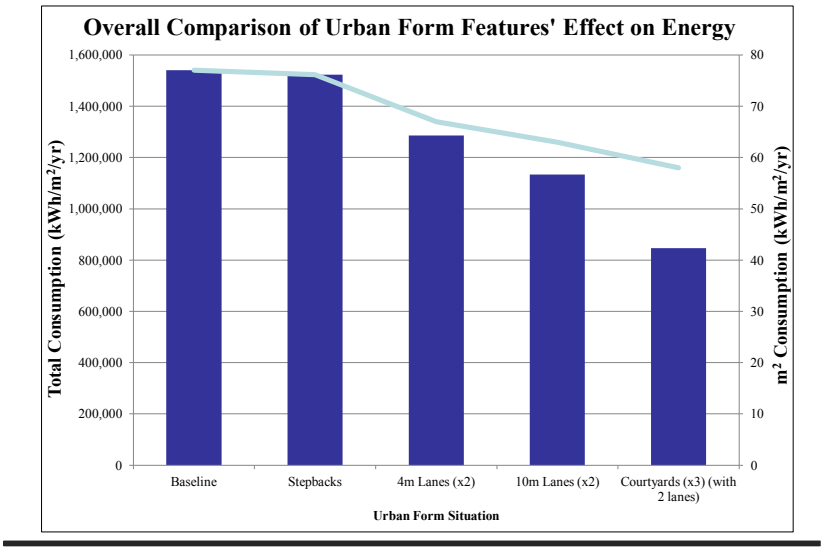
Summary



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Thank You

- To the BEES team for encouragement and assistance
- Tavis and Shaan (and Andrew)
- To you

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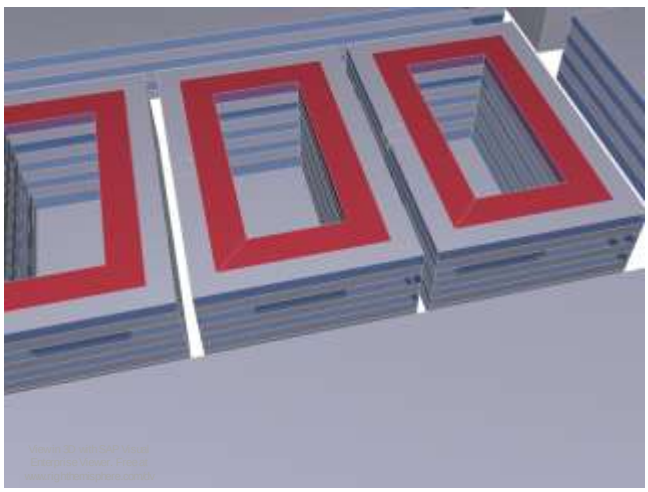

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