Passive & Active Design
CIBSE Building Simulations Group

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Introduction
Passive & Active Design
Introduction

What are the interactions between passive and active design?

In the context of a live project

How does simulation add value to the decision making process?
Definitions – Passive Design

- Insulation
- Air tightness
- Natural light
- Solar gain
- Natural Ventilation

(Basic design elements of a building)
Definitions – Active Design

- Renewables
- Energy saving gadgets
- Sophisticated controls

(Adding things to actively reduce Carbon)
Definitions – The Middle Ground

- Improving efficiency:
  - Boiler efficiency
  - Chiller efficiency
- Heat Recovery
- SFP’s
- Lighting efficacy
- Insulating services
- Power treatment
- CHP

(Building services excluding active design elements)
Low Carbon Design Hierachy

Cost to Implement

Active Elements:
Wind Turbines,
Solar Thermal, Photovoltaic, GSHP & CHP

The Middle Ground:
Services, Metering, Rainwater

Passive:
Form, Fabric

Environmental Benefit
Case Study
Dene School
Main Project
Main Project
Low Carbon Alternative

Existing building retained during construction to avoid additional temporary facilities and associated carbon

Views through

Connections to retained sports hall

Prevailing wind SW

Summer sunrise

Playing fields

Decant to CLASP building during construction

Wind from the coast

Winter sunrise
Low Carbon Alternative
What’s Important?

Classrooms make up 50% of the Carbon
What’s Important?

Breakdown of CO₂ by Energy Use

Heating makes up 50% of the Carbon
Impacts
Passive > Active
Heating

By:
- Increasing insulation
- Reducing air leaks
- Increasing winter solar

We:
- Decrease heating energy by 70%
- Decrease heat loads by 80%
- Introduce a need for Mech Vent
Lighting

By:
- Increasing glazing
- Introducing rooflights
- Improving internal layouts
- Optimising room size

We:
- Double daylight factor to 6.3
- Reduce need for artificial light by 60%
- Introduce a need for sophisticated lighting controls
Lighting

Daylighting Factors for 9.6m x 6m Room

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<th>3.3</th>
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Percentage Glazing

Daylighting Factor

kg of CO2 emitted

CO2 Emissions

Room height (m)

- 8.4 x 7.2 with daylight control
- 8.4 by 7.2 without daylight control
- 9.6 x 6 with daylight control
- 9.6 x 6 without daylight control
Cooling / Ventilation

By:
- Increasing glazing
- Introducing stacks / internal air flows
- Improving shading
- Reducing need for artificial lighting
- Use thermal mass / removing ceilings

We:
- Remove the need for cooling
- Creates a problem how to manage window opening?

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<td>Hours &gt; 28°C</td>
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<td>46</td>
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<td>Hours &gt; 25°C</td>
<td>15</td>
<td>169</td>
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<td>Peak temperature</td>
<td>27</td>
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Impacts
Active > Passive
Integrated Controls

By:
- Daylight sensing
- Temperature, humidity & CO₂ control
- Actuated window vents

We:
- Use more daylight (1,109 hours / 2,646)
- Quantify daylight switching levels (600 Lux)
- Use demand based heating & vent
- Use night purge
- Which requires good stack driven ventilation
Renewables

By:
- Specifying Biomass
- Specifying PV

We:
- Get to zero net annual carbon emissions
- Calculate rough payback using Feed-in & RHI
Utility Modelling

Cumulative Utility Costs Over Time
Including Feed-In Tariff and Renewable Heat Incentive

Cost saving
Payback

Costs for 2006 compliant Dene School
Costs for 2016 compliant Dene School
Our Findings

The Design Path
Its Complicated

DESIGN PATH

CARBON (kg CO₂/yr/m²)

MINIMUM STANDARDS

BRIEF

SITE

FUNCTION

LEGISLATION

SUPPLY CHAIN

PROCUREMENT

24.8

LOW CARBON

SITE

FABRIC

STRUCTURE

INTERNAL

EFFICIENCY

LOW CARBON

Reuse Structure
Location
Orientation
Footprint
Topography
Shading
Form
Usage/Profiling
Climate

Insulation
Leakage
Sustainable materials
Supply & procurement
Thermal mass
Glazing strategy
Partitioning
Floor/ceiling
Waste
Entrances

Efficiency
Sustainable materials
Thermal properties
Supply & procurement
Speed/buildability
Waste

Natural vent
Natural light
Thermal mass
Layout
Shading
Furniture
Finishes
Room dimensions
Environmental performance

Lighting
Heating
Ventilation
Cooling
Electricity
Water
IT
Kitchens
Other equipment
Control
Ancillary systems

Offsite
Biomass
Heat pumps
Solar water
CHP
Wind
PV
Other

7.8
The Design Path

PASSIVE DESIGN STUDIES

DIMENSIONS
- 9.6m long x 6m deep x 2.7m high
- 9.6m long x 6m deep x 3.3m high
- 8.4m long x 7.2m deep x 3.3m high
- 8.4m long x 7.2m deep x 2.7m high

INSULATION
- Minimum insulation
- Super-insulate walls
- Super-insulate floor
- Super-insulate roof
- High performance glazing

THERMAL MASS
- Coupled
- Decoupled
- Lightweight

AIR LEAKAGE
- <10m³/hr/m²
- <5m³/hr/m²
- <2m³/hr/m²
- <1m³/hr/m²

WINDOWS SOUTH
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%

WINDOWS NORTH
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%

SHADING
- Overhang
- Louvres
- Internal
- Improve glazing spec
- Movable

STRUCTURES
- Timber
- Steel
- Concrete
The Design Path
Conclusion
Passive Vs Active

Low Carbon Buildings Need Good Passive Design
The Tools

● Simulation:
  – Adds value to the decision making process
  – Helps identify what is important

● The big decisions are made early on

● Tools need to be simple
  – To be understood
  – For answers in hours not weeks

● Therefore we made our own
Atkins’ Carbon Tools

**Roadmap**
Uses mind-mapping techniques to plan business activities in relation to carbon consequences.

**Relativity**
Creates charts to show the link between carbon determinants and the carbon they produce (or save), and compares scenarios.

**Knowledgebase**
Calculates, analyses and evaluates low-carbon options using a library of verified carbon data.

**Masterplanning**
Identifies, quantifies and visualises the carbon impacts of development masterplans.

**Buildings**
Uses key building factors, services and occupancy parameters to estimate a building’s carbon footprint.

**Atkins Remote Technology (ArT)**
Remotely monitors and controls plant equipment and FM systems to manage a building portfolio’s energy use.

**Traffic Analysis**
Translates existing traffic data into estimates of carbon emissions within a monitored area.

**Travel Behaviours**
Estimates carbon for journeys to a specific location, and produces journey plans to encourage use of low-carbon transport.