More than skin deep – façade design in an era of climate change

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Time is Running Out—UN reports that there is only 12 years left to make radical reductions. NZ committed to become Carbon Neutral by 2050.
13-20% due to built environment in NZ

40% due to built environment globally
The Climate is changing - so must architecture
Performance and Appearance
As Building Professionals we face a choice -

Remake the built environment so that it produces no CO₂ or carry on, business as usual, and live with the consequences.
Develop a 7 point pathway to zero carbon design for all your buildings.
1. Optimize Facade Load Reduction (-10-15%)

2. Maximize Ambient Energy Use (-10-15%)

3. Maximize High Efficiency Equipment and Systems (-10-15%)

4. Engage Sustainable User Behavior (-10-15%)

5. Avoid Fossil Fuel Use (0%)

6. On site renewable energy use (10-30%)

7. Off Site Grid Renewable Energy Supply (70-90%)

Radical Energy Reduction

High performance facade

Mixed mode ventilation and daylighting

Energy efficient HVAC and Lighting

Engagement, Education and Feedback

40-60% Energy Reduction

Carbon Reduction

No Gas, Oil or Coal use

Building Integrated Renewables

90% Renewable Grid Electricity by 2025

Zero Operating Carbon
Developing a pathway to designing a sustainable façade.
Optimising Façade Performance

• What are we trying to achieve – defining a sustainable façade.
• Everyone, Everything, Early.
• Climate Adaptive Design - Looking forward not back.
• Maximizing the passive potential of a façade.
• Digital prototyping and optimization.
• Optimising from the outside in.
• Optimising from the inside out.
• Materials and Embodied energy
Defining a sustainable façade

- Timeless Aesthetics
- Thermal, Visual, and Acoustic Comfort
- Low Energy and Carbon
- Sustainable Facade
- Resilient
- Durable
- Whole Life Costs
- Productive
- Environmentally Friendly

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Avoiding ‘New Facadism’ – ‘Everyone, Everything, Early’

Although upfront building and design costs may represent only a fraction of the building’s life cycle costs, when just 1% of a project’s up-front costs are spent, up to 70% of its life cycle costs may already be committed. That first is critical 1% because as the design adage has it “all the really important mistakes are made on the first day”
“Plan for the future because that’s where you are going to spend the rest of your life”. Mark Twain.

- Testing buildings in a future climate change environment - 2030 and 2090.

Climate adaptive thermal and daylight design
Maximizing the potential for passive control – natural lighting and mixed mode ventilation
Façade – NZ Building Code Minimum Requirements

ENERGY EFFICIENCY
Building Code Clause H1.

- Residential NZS 4218 (higher standard). Double glazed 30% WWR equivalence. WWR % > 50% requires modelling.
- Commercial NZS 4243 (lower standard). Single Glazed 50% WWR equivalence. WWR % > 50% requires modelling.

NATURAL LIGHT
Building Code Clause G7

- Natural light shall provide illuminance of no less than 30 Lux at floor level for 75% of the standard year.
- At least 50% of glazed area provided for natural light to be clear glazed.
- Glazing light transmission of no less than 0.7 in the clear glazed area
Facade Environmental Performance Factors and Typical Ranges

- Reference Building – Code
- Climate zone: 1, 2, or 3 and Exposure
- Thermal Insulation Levels $U_{\text{wall}}$: 0.25 - 0.5
- Window Wall Ratio: 40-100%
- Glass type: Single/Double/Double Low $e$/ Selective Low $e$/ Coatings, inert gas fill and frits. $U_{\text{glass}}$: 1.0 – 6.0 and Shading Coefficient: 0.24 – 1.0
- Frames: Aluminium/Wood – Themally Broken or not
- Shading: External/Internal – Fixed/Moveable/Blinds/Active Facade
- Light Transmission Coefficient: 0.4-0.8
- Ventilation and Air Leakage Rate: less than half the infiltration rate
- Condensation Avoidance: Surface/Interstitial
- Thermal Comfort: Neutral, PMV, Adaptive
- Daylight: Autonomy/spatial Distribution and Glare Probability
- Acoustics: Sound reduction required
Building and Façade Digital Prototyping
From Traditional Parametric Analysis

Limited to 2-3 design variables and a single objectives
20-30 iterations

For example – looking at the effect of window to wall ratio with the objective of minimising energy use

There are limitations to simplify the analysis – i.e. only one type of glass type considered, no shading is considered.

There may be a secondary objective such as minimising the capital cost associated with differing window wall ratios and glass types
To optimising performance by genetic evolutionary algorithms

Design

Build

Environmental Performance

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To multi-objective optimization – survival of the fittest

Up to 10 design variables can be analysed in combination with up to 2 objectives – Thousands of iterations
Scion Hub Façade Optimisation
Scion Hub Building Using Evolutionary Genetic Optimisation Algorithm for Pattern Development of Façade Coatings
Every apartment needed to achieve a minimum 7 star rating. Modelling and the use of dashboards (each bar represents an apartment) enabled us to keep track of the performance of every apartment and to make local changes to the façade as required.
80% of the apartments achieved a higher 8 star rating and 20% achieved the minimum 7 star rating. Façade energy performance forms an important part of the rating with minimum conditional requirements to achieve particular ratings.
New MOE standards for temperature control, indoor air quality and daylighting in New Zealand Schools
Daylight modelling to inform façade glazing design

- Façade design is particularly important as school buildings need to be largely passively controlled.
- Standards Use of climate based modelling
- Encourages integrated design.
- Provides clear performance requirements for the first time.
- Modelling used as early design tool to refine design and to demonstrate compliance.
Materials and Embodied Energy – The challenge after operational energy.
Cutting Carbon: Consider Lower Carbon Materials

- Reinforced concrete, 30 MPa, OPC...
- Carpet, tufted wall-to-wall, 80% wool...
- Post tensioned timber frame...
- Steel, structural, columns and beams
- Timber, soft wood, sawn kiln-dried...
- Aluminium (anodised finish, one side...)
- Insulation, glass wool
- Plasterboard (GIB® standard 10 mm)
- Glass, heat strengthened, low...

<table>
<thead>
<tr>
<th>Materials Manufacture – Product Stage</th>
<th>Demolition &amp; Disposal</th>
<th>Benefits / Loads Beyond Building Life Cycle e.g. recycling</th>
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<tbody>
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<td></td>
<td>kg CO₂ eq. per kg of material</td>
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Engagement Strategies – Buildings that teach - encouraging staff and students to interact better with windows
Artificial Intelligence Control – Self Learning Neural Networks, Genetic Evolutionary Algorithms and Fuzzy Logic Controllers for Intelligent Facades
Thank you for listening.

David Fullbrook