Let the sun shine on Christchurch

Research has assessed the plans to step back upper storeys of buildings and break up city blocks in Christchurch with courtyards and lanes to improve environmental and energy performance.

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THE DRAFT CENTRAL CITY PLAN produced by the Christchurch City Council in response to the earthquakes includes an outline of urban form features such as building height limits, façade step-backs, lanes and courtyards. These were envisaged to increase daylight into the city and create porosity for movement and pockets of community.

Beyond these benefits, these urban forms offer potential for improved environmental and energy performance in buildings.

An investigation of the energy performance and design options for the Christchurch central city has been carried out as part of the BRANZ Building Energy End-use Study (BEES).

Modelling for functionality

The goal in Christchurch was for buildings and city streets to gain greater solar and fresh air access by breaking up city blocks with lanes and courtyards (see Figure 1). This had the potential benefit of allowing buildings to effectively use natural lighting, heating, cooling and ventilation, creating a passively comfortable environment.

The level of improvements likely to result from the Central City Plan's urban form features was estimated using OpenStudio software and simulated in EnergyPlus. Model and simulation parameters

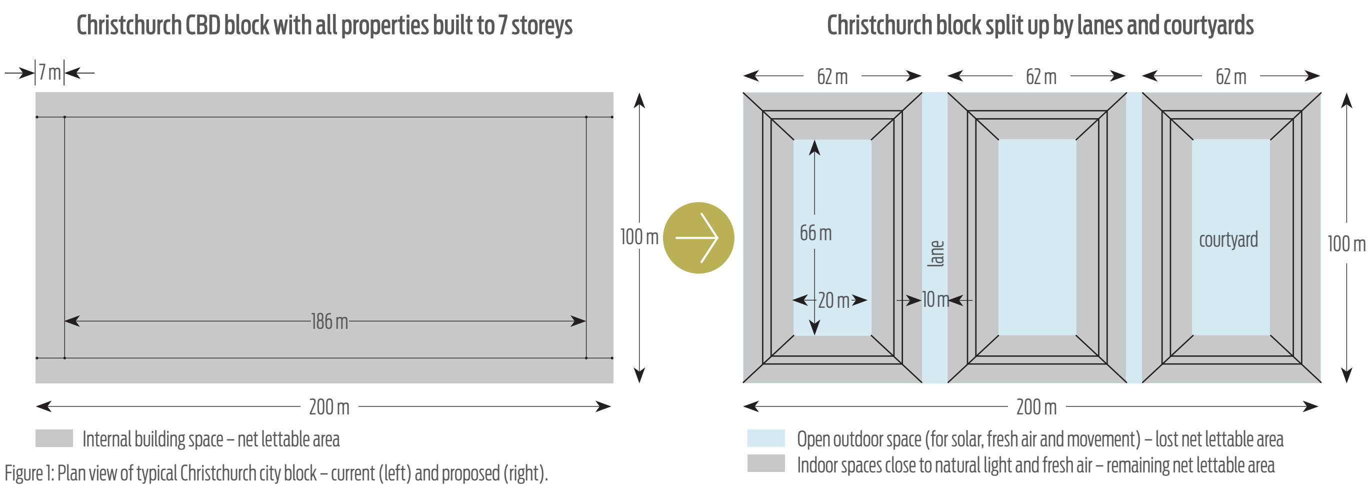

Figure 1: Plan view of typical Christchurch city block – current (left) and proposed (right).

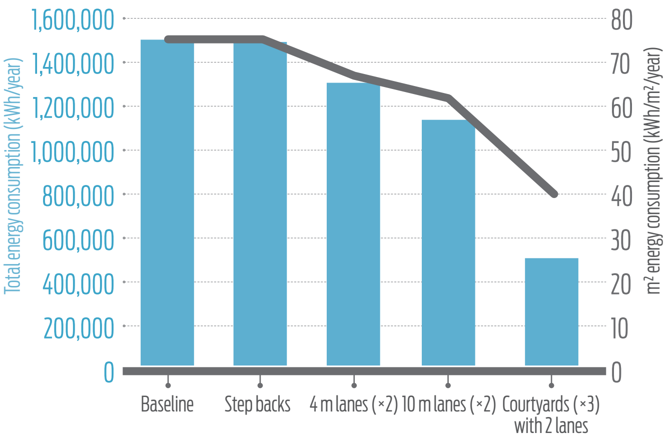

Figure 2: Overall energy consumption for each urban form change against baseline model.

were based on relevant New Zealand standards and BEES data. The performance was compared to a conventional deep-plan model.

Simulations drew on the work reported in the BEES modelling optimisation analysis. The GenOpt optimisation software ran the EnergyPlus simulations on a standard building with multiple combinations of insulation, shading and window size. Each simulation calculated the energy performance for 8,760 hours in a typical Christchurch climate year. This took, on average, 20 minutes per simulation. GenOpt typically ran 500+ simulations to find an optimum Christchurch commercial building.

The energy savings from an optimised building design were added to the saving from daylight to replace electric lighting and openable windows to replace air-conditioning. Achieving these savings requires significant changes to urban form. The impact of lanes and courtyards on potential central city energy use was estimated.

Courtyards cut energy use

Courtyards (three per block) in conjunction with two 10 m wide lanes could deliver a significant reduction in energy - up to 47% per m² less than the deep-plan baseline model if passive cooling was used.

The courtyard plan form in Figure 1 should not be interpreted as a set of three enormous courtyard-shaped buildings but as showing how the many building sites around the block might be developed. The key feature is that they are all 17 m deep at most from window-wall to window-wall, optimising daylight access and encouraging passive cooling.

The courtyard form is a traditional European approach along city streets. It is by no means the only way in which buildings open to air and light might be arrayed in a city grid. The critical dimension (~17 m depth) brings major energy savings and more productive and comfortable building occupants who have improved access to light and air. Occupants also value the views over those from deeper-plan buildings.

Height levels affect street-level sun

Where the city height limit is 29 m (7 storeys), the Central City Plan proposes having the upper 2 storeys step back at a 45° angle.

Results showed only a marginal effect on the energy performance of buildings facing the street and lanes on their own were only marginally better (see Figure 2).

This measure also has a negligible effect on the sun experienced by pedestrians in the streets. The only observable change was experienced during summer, with no increase in solar access to street level during winter.

If the height limit was only 17 m (4 storeys), then stepping back the upper two storeys at 45° would increase street level solar access in winter as well as summer.

The learnings from this BEES study will be used for future optimisation studies on models of the existing building stock in New Zealand.

The CBPR, with support from the New Zealand Green Building Council, will publish this research as a design guide in early 2013.

Key points

- Improved indoor environments are possible through natural (passive) measures, provided buildings are no wider than 17 m.
- Three courtyards per block in conjunction with two 10 m wide lanes could deliver a significant reduction in energy – up to 47% per m² less than the deep-plan baseline model if passive cooling was used.
- Opening up the city centre with courtyards and lanes improves daylight access and natural ventilation and creates useful outdoor spaces.
- Planned façade step-backs are not effective in saving energy or making streets sunnier during winter.