The basic principle of net zero-energy building is that the energy consumed by appliances and space-conditioning equipment is lowered by efficient technologies and offset by clean renewable-energy generation sources, with the overall result of at least zeroing the energy consumption (see Figure 1).

Examples of net zero energy
At least 50 completed buildings around the globe are being monitored in an International Energy Agency (IEA) net zero research project. These are all new building designs.

Far more challenging, and yet potentially far more rewarding, is the application of this principle to existing buildings. The potential to negate one of the main global energy consumers – buildings – is what makes net zero-energy building an attractive concept. Refurbishing existing buildings to net zero-energy buildings means addressing the immediate need for energy efficiency.

Over the past year, research has been done at Victoria University to develop a methodology to analyse the potential for refurbishing the entire commercial building stock in New Zealand to be net zero energy. The methodology tests whether it is possible to achieve a net zero-energy commercial building stock regardless of the various building locations, ages, uses, sizes and surrounding site contexts.

Thermal simulation and BEES
To carry out the research, the existing building stock is modelled using thermal simulation building models. There are approximately 50,000 non-residential buildings within New Zealand, with a total floor area of 48.3 million m². Templates of typical non-residential buildings have been developed based on generic New Zealand building information and will be refined using information and data gathered in the Building Energy End-use Study (BEES). BEES is collecting information from and monitoring a wide range of non-residential buildings to gain a better understanding of energy use in New Zealand buildings (see page 54).

The template models are a simplified version of real New Zealand commercial buildings where there are preloaded building sizes, constructions, internal equipment, occupancy, equipment, people schedules and heating and cooling equipment. Figure 2 shows the template models applied to a real city block.

This model was developed in order to test the modelling and simulation issues in an understandable situation. The model shown at the bottom of Figure 2 is a representation of the EnergyPlus thermal performance simulation software model where roof materials are red, walls are yellow, glazed surfaces are blue and external shading purple.

The research will model typical buildings in typical city blocks rather than actual buildings, but the template models are calibrated using real energy consumption data from buildings that were monitored in the BEES study.

Figure 3 compares a template thermal simulation model of a real building against actual energy data monitored in the real building. The template model has results that are within a recommended range of acceptable tolerance for accuracy. The acceptable range is +/−10% of the real monthly energy consumption.
With the existing commercial building models made and calibrated, the next stage is to refurbish them to be net zero energy.

**Net zero-energy refurbishment**

As well as using the BEES information, this research is also part of an IEA research project on net zero-energy buildings. By participating in the IEA project, the research gains access to measured data and design descriptions for 50 existing net zero-energy buildings. These buildings use state-of-the-art design and technological approaches.

Figure 4 is an initial look at possible net zero-energy building techniques that could be used in the New Zealand refurbishment project. The graph displays the design approaches used in the 50 existing net zero-energy buildings in three basic climate types around the world and highlights the main passive design solutions, energy-efficient technologies and renewable energy generation approaches in these buildings.

Most of these net zero-energy buildings use on-site generation, efficient space-conditioning, advanced glazing and advanced envelope measures. Advanced glazing systems are not merely insulating glazing units, but window systems that balance winter heating by sun and summer shading to protect against potential glare from daylight. Advanced envelope measures are typically opaque elements that are super-insulated, such as vacuum insulation panels or walls that incorporate substantial amounts of thermal storage and insulation.

**The future of net zero energy**

A trial on a single building in Wellington has demonstrated that it is feasible to convert at least some existing buildings to net zero energy in Wellington. To take this example and generalise about converting all New Zealand’s commercial buildings to net zero energy requires a broadening of focus beyond the building boundary.

To accomplish this, the net zero-energy definition needs to be for net zero-energy cities and communities. This allows buildings to use the synergies of the electricity grid balance times of oversupply and undersupply of electricity in each individual building.

It will require the analysis to examine not just the energy performance of typical buildings but all the aspects of building placement within a city or community – connection to an electricity grid that is partially renewable, overshadowing in city centres and the relative importance of big energy-intensive buildings versus multiple small buildings.

**Figure 4: Net zero-energy lowering and producing techniques.**

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**Figure 3: Comparison of template simulation results against real energy data (from Cory, Gates and Donn, 2011).**

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**Figure 4: Net zero-energy lowering and producing techniques.**