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The power of suburbia

New research suggests installing photovoltaics on roofs and driving electric cars could transform low-density suburbia from a high-energy consumer to an energy provider for the city.

IT IS A COMMONLY held belief that a compact city is a more energy-efficient city. In Auckland, like many other cities, this has become enshrined in policy.

Compact housing is believed to have a lower surface to volume ratio and will therefore lose less heat. The low-density urban form of suburbia is also believed to be energy inefficient because of high oil-dependent private transport use.

Looking to the future

At face value, compact houses and urban forms appear to be the solution for a sustainable Auckland. But while these beliefs may be true for now, consider the future when:

- the climate will be warmer
- emerging technologies will replace the internal combustion engine
- harvesting energy from rooftop photovoltaics will be cheaper than the grid.

Should we be designing buildings and cities for the present or for future conditions?

Non-compact vs compact housing

The three significant aspects to energy use and housing are the:

- form of the building
- heating and cooling system
- energy used in the common areas.

Comparing the same size units with the same insulation values, there is very little difference between a unit in the centre of a block of flats or a detached house. In both cases, heat loss is dominated by ventilation and glazing area.

Of greater significance is the problem of cooling, especially with the growing penetration of heat pumps in New Zealand housing. Less-compact housing tends to allow cross-ventilation and remain cool without any mechanical systems. Compact forms can restrict airflow and result in a higher cooling load.

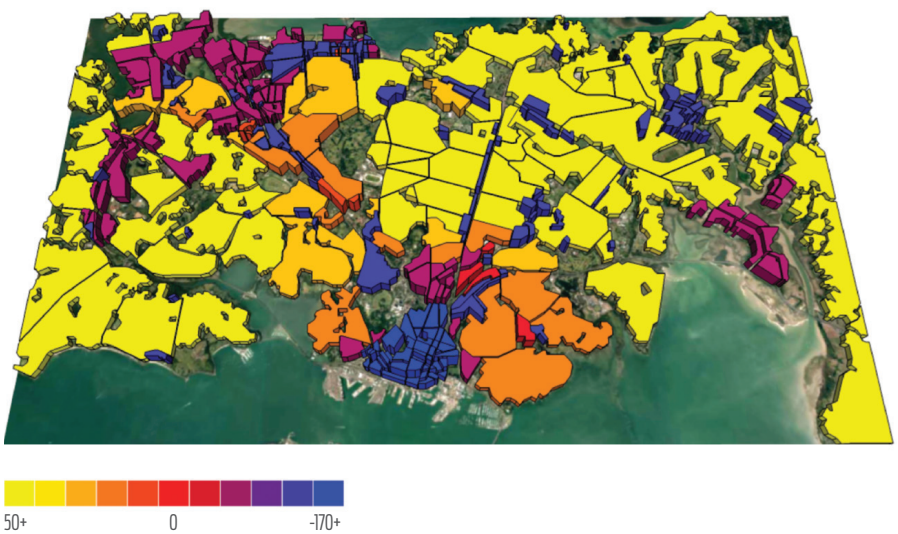

Figure 1: Net metering potential of PVs installed across Auckland. Yellow low-density areas would produce a surplus of energy to household requirements.

Added to this is the energy used in common areas. Detached housing has no common areas, but high and mid-rise housing uses energy for lighting corridors and car parks as well as energy for lifts and additional mechanical air extraction.

A study of energy use in over 3,000 houses of different types in Sydney found that high-rise used more energy than mid-rise, used more than low-rise, used more than townhouses and villas.

Since average temperatures in Auckland will be similar to those currently experienced in Sydney, a warmer climate and more compact built form increases energy use and makes low-density housing forms more energy efficient.

Electric vehicles will be the way to go

The electric vehicle is the logical alternative to the internal combustion engine for light transport in the city.

Both the Energy Efficiency and Conservation Authority (EECA) and the Electricity Authority are predicting that this will become an important mode of transport in the next decade as fuel prices increase and electric vehicle prices decrease with mass production.

Since 90% of all light vehicle urban transport would use less energy in a day than can be stored in the batteries, range is not an issue in a city such as Auckland.

Using the sun to charge cars

Charging electric vehicles could be done from the grid, but with photovoltaics (PVs) now reaching grid-parity for residential electricity users, it will be cheaper to charge cars from PVs on house roofs.

The New Zealand National Travel Profile of 2008 indicated that only 20% of current vehicle use is for commuting in major urban areas. Car sharing for commuting and improved public transport would allow cars to charge during the day so that they are fully charged for other uses.

Looking ahead to a scenario when PVs are prevalent on suburban roofs - even without a feed-in tariff - and electric vehicles have largely replaced the internal combustion engine, what impact will this have on energy and urban form?

Figure 1 shows the net-metering potential of buildings across Auckland with PVs installed at the optimum orientation and tilt.

The blue areas are the high-density compact areas of the city. They consume significantly more electricity than they can collect, while the yellow areas provide net surplus electricity during the day.

The yellow areas are the low-density housing where large roof areas can collect enough energy for their own use in the daytime, all their electric vehicle charging needs and have a surplus that could be fed back into the grid.

Low-density homes power the city

With PVs on suburban roofs and electric vehicles used where public transport is uneconomic, low-density suburbia changes from being a high-energy consumer to become an energy provider for the city.

This changes the current perception of suburbia. Figure 2 shows energy use for travel against density of a city. Superimposed on this is the curve developed from research by Newman and Kenworthy showing how low-density cities are high users of travel energy.

The curve for Auckland when internal combustion engines are used follows the same pattern as Newman and Kenworthy's graph. Using electric vehicles, energy use by transport is significantly reduced. Using electric vehicles charged by PVs, the graph becomes inverted, as the electricity from PVs is more than enough for travel and surplus electricity can be fed into the grid.

As Auckland's climate warms, a compact city plan may not necessarily be energy efficient or low carbon. The synergy between PVs, electrical vehicles and smart grids has an enormous potential for suburbia to reduce the dependence on oil but also transform itself to be a significant renewable energy provider to the city.

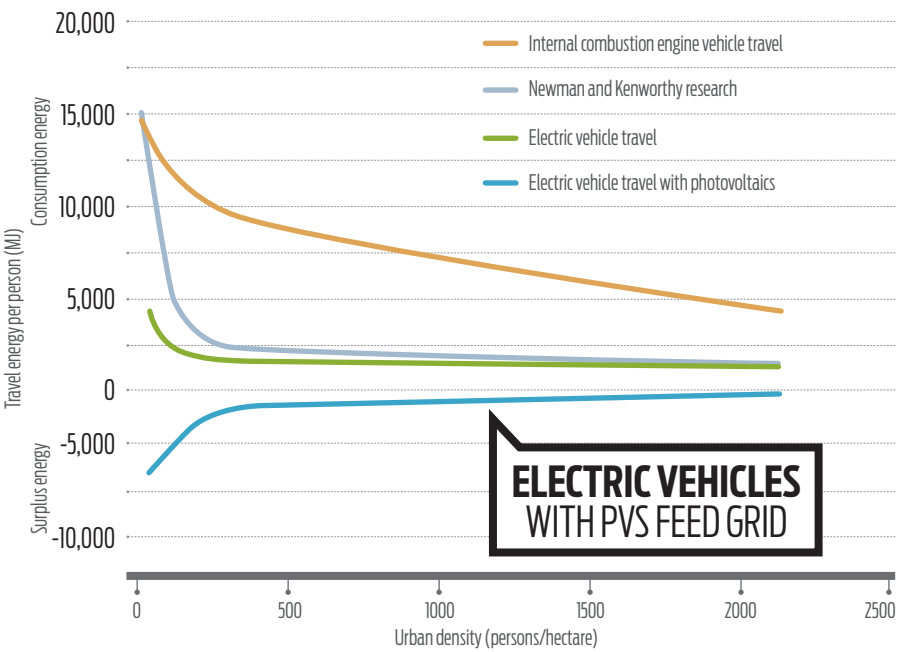

Figure 2: Auckland travel energy comparison with impact from PV energy generation.