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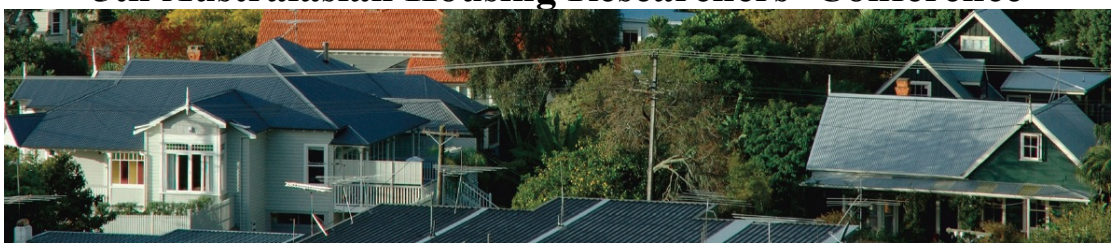

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Sustainable Housing: a Footprint Comparison

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Introduction

The purpose of this paper is to investigate sustainable housing, focusing on two main aspects: affordability and environmental impact. Affordable housing is usually analysed as an issue of social equity and economic benefits, but the environmental aspects of affordable housing have been largely overlooked.

Le Corbusier (Bird 2007) identified the four main modern urban activities: living, working, cultivating mind and body and moving about. For these four functions, housing can be seen as the core connecting each to each. Housing is thus the most basic element in the city. This paper looks at the way in which functional elements related to the daily living and behaviour of urban inhabitants may be combined efficiently. Through examples from Vietnam (VN) and New Zealand (NZ), the paper will show how, potentially, ways of living could improve housing affordability and hence reduce environmental impact. Using the ecological footprint approach, the impact of current patterns of living in NZ and VN is compared. The paper then shows how change in patterns of living would reduce the footprint of New Zealanders in terms of housing and travel.

Housing issues

Housing ownership

In the developed countries, most houses are purchased with the help of borrowed money from a third party, usually from a bank. To make this process more affordable, the idea of shared or joint equity has been proposed. For example, the Auckland regional housing strategy has suggested the occupant might own 75% of the house with the other 25% owned by another party (usually a community sector organisation) (Auckland Regional Council 2003). The Auckland regional affordable housing strategy also states that: "For the purposes of this Strategy, housing is considered to be affordable if households can access suitable and adequate housing by spending a maximum of 30% of their gross income" (Auckland Regional Council 2003).

According to this statement, having a job is the fundamental key to affordable housing. However, the recent economic crisis and rising unemployment rate have tended to eliminate many possibilities for housing affordability within this definition. This definition mainly involves the capacity of households to afford housing and living costs from household income. However, income is not the only factor that measures affordability. Using income alone as the measure might narrow the consideration of other aspects of affordable housing, such as cultural values, housing performance and consumption, the use of space, life style and environmental impacts.

In a poor economy like VN, a country with a population of 85 million people, it is impossible to access suitable housing by spending 30% of household gross income, or by seeking government support. Since the 1990s, self-help is the most common way for achieving housing affordability in VN. Before economic reform in 1986, under the socialist regime, housing production was monopolized by the socialist state and the private sector was prohibited from being involved. Since the ban on private sector activities was revoked, the share of private dwelling ownership has increased from 47.3% in 1989 to 91.5% in 2005 in Hanoi (Ming 2008). Table I below compares the rates of owner-occupation between VN and NZ and shows how they have tended to change over time.

Table I: Comparison of percentage of households living in owner occupied dwellings in NZ and VN in different years

Country	Year	Households Living in Owner Occupied Dwellings
New Zealand[(1)]	1991 2001	73.8% 67.8%
Vietnam[(2)]	1989 2005	47.3% 91.5%

[(1)] - (Statistics NZ 2006)

[(2)] - (Ming 2008)

House size and type

The relationship between house size, house cost and affordability is clear. A larger house costs more to build and also a higher cost for maintaining and operating it.

Declining household size and increasing numbers of one-person households are the typical trends underlying change in settlement patterns in many Western countries including NZ.

Increasing numbers of young people living alone, growth in an older population living alone, rising living standards (for example new constructions usually are larger in size and have more functions) are all factors that have increasingly made housing become unaffordable.

In the case of NZ, the main task is how to match the housing demand (type of household) with the existing dwelling stock (type or size of dwelling). By the end of 1998 70% of NZ homes had spare bedrooms and in only 25% was the number of occupants matched with the number of bedrooms (Cook 1998). Nearly a quarter of households had one to three members living in a dwelling with seven or more rooms (Easton and Smith 2008). The result is the crowding index (number of people per bedroom) was only 0.61 people (Statistics NZ 2001).

In NZ the separate house is the most popular type of dwelling, comprising 81.3% of the stock (Statistics NZ 2001). In particular, the three-bedroom house is the most common size, making up 46.3% of the occupied housing stock (Easton and Smith 2008). For new houses, the average floor area was 205 sq-metres in 2008and this is almost double the size compared to 1973 (110 sq-metres) (Statistics NZ 2008). In 1886, the number of people per dwelling was 5.2and after 100 years this number was 2.8 in 1996 (Cook 1998). It is predicted that household size will continue to fall from 2.6 people in 2006 to 2.4 people in people in 2031. It is also predicted that the number of one-person households will increase from 363,000 in 2006 to 619,000 in 2013 (Bascand 2009). The figure means the proportion of one-person households is projected to increase from 23.4% in 2006 to nearly 30% in 2013.

It seems that change in the construction (either size or type) can hardly catch up with the change in patterns of living. Bigger dwelling size associated with fewer people per dwelling means less sharing and higher housing cost per person, which in turn tends to eliminate housing affordability. The recent report of the House Price Unit in the Department of Prime Minister and Cabinet (2008) suggests that the cost of a 145 sq-metres new dwelling in 2007 is around $247,636 while a 202 sq-metres new dwelling is $292,631. Under current conditions, a household taking up a 20 year mortgage would require a household income of over $118,000 to afford the 202 sq-metres dwelling. A smaller, 100 sq-metres dwelling at prevailing building cost would only require an annual household income of about $70,000 to make mortgage servicing affordable (Department of Prime Minister and Cabinet 2008)

Housing in NZ, as has been shown, is generally large and increasing in size. Housing size is very different in the case of a developing country like VN where the average living area is rather small and people still have a high tolerance of adaptability and flexibility. Before the economic reform (1986), most dwellings had seriously deteriorated after suffering two long wars and the socialist regime. The average floor area of urban housing was extremely low, barely 4 sq-metres per person during the 1970s (Clement and Lancret 2005; p.301).

One common way people in VN help themselves is sharing home-ownership with other family members. A report prepared for Ho Chi Minh City states that: “Most urban dwellers had gotten apartments or land from the estate of their parents. Indeed, in the 1999 Census only 11 thousand households were listed as not owning their urban living place out of 16.7 million people!” (Dapice and Thanh 2008). Although there may be a reduction in privacy, on the other hand, apart from having shelter, there are many benefits of living together. Extended families can economize on household expenses and save money for other purposes, like buying a house in the future or better education for their children. More importantly, sharing is also a good way to save the use of other resources.

Demand for housing and extending living spaces led to a boom in self-building activities during the housing reform period (1990s). Most of the families with land did not have enough money for construction purposes, so they sold part of their land in exchange for the capital for building. Because houses need to have access to the street (not only for the entrance but also for commercial purposes, as described in further detail in the next section), this has formed a new type of dwelling which is an attached/terraced house with a long plan and narrow front. This is the so-called neo-tube house, having a similar typology to the vernacular tubehouse with a width of 3 to 4 metres and depths ranging from 10 to 20 metres (Kien 2008).

Depending on the number of people and functions required, a neo-tube house usually has two, three or four floors. It is an advantageous typology for increasing density and adding functions.

After ten years of housing reform, the average floor area of urban housing has increased significantly to almost 10 sq-metres per person (Ming 2008). Tube houses built in this period have contributed largely to the new housing floor areas in Hanoi and other main cities of VN. This house type has become the most common type of urban housing and has created the main urban fabric and its characteristics.

One way to explain the tube-house phenomenon in VN is that it is a compact, flexible and organic growth structure that has the ability to be renewed and repaired for the required uses. In other words, the tube-house typology is the result of flexibility in ways of living (the non-design factor) rather than flexibility of design. Indeed, the neo-tube house is a modern interpretation of a well understood traditional pattern dating back many centuries, helping to make it acceptable as a pattern for housing development.

Affordable housing is often attempted to be delivered by means of various forms of subsidy. In delivering affordability with equity and independence, there are generally three levels of subsidy to look for: that for construction, that for the people and that for things such as the products they use. Subsidy may not be necessary where people are using systems that deliver the products/needs, they want in the way they want. Hence, what is required is to recognise the value of these existing systems, for example through promoting a culture of sharing. On this basis, it might be better to look at choice of living patterns or social factors first before searching for any design or technical solutions. Once this area is set, then the design will follow. This is not only appropriate for a developing country, but could equally refer to the social housing issues of NZ. In Wellington, for example, there was an agreement in 2007 between the Council and the Government to upgrade all the flats and houses to a good standard for modern living. The Council faces the following challenges: increasing numbers of households assessed as being in housing need that primarily come from one person households, limited types of stock and housing physical access difficulties for an aging population (Wellington City Council 2009).

The aspects of housing and household size discussed above are summarised in Table II.

Table II: Comparison of house size, household size and percentage of one-person households in NZ and VN

Country	Dwelling size m^2	Household size (people)	Square metres per person	% One-person households
New Zealand	197 (1)	2.6 (2)	73 (1)	23.4 (2)
Vietnam (3)	57.24	4.24	14.7	5

(1) - (Easton and Smith 2008)
(2) - (Bascand 2009)
(3) -(Statistics VN 2006)

Sustainable housing:

Space and functions

Changes in ways of living have driven change in settlement patterns. There has been an increasing difference in housing from the past to the modern time. The modern home is not only bigger in size with fewer people occupying it, but also the same people spend less time at home. Home now is the place people come back to after working hours for eating, bathing, watching TV, searching the Internet, sleeping etc. Home now tends to be the place solely of consumption of goods and energy. In the past, the home was smaller and with more family members and people spent more time at home and also more time gathering together for

cooking, gardening, making clothes and other productive activities. The medieval house presents an autonomous model of living in which home and workshop were complementary, where inhabitants lived sustainably in the same houses and worked in the same workshops as their ancestors (Benevolo 1980).

However, life styles and social values have changed significantly since the Industrial Revolution. Furthermore, they are very different according to such aspects as economic levels, cultural attitudes and personal preferences. In a wealthy economy, housing is mainly considered as the place where private activities happen. It is different among the urban poor, where people have to use every capability that they have, so their acceptability is more flexible. In Asian developing countries, housing plays a very important role in community livelihood as the home's function is not only for private living. Its multi functions mix private and public services through inclusion of productive activities (trading, manufacturing products, recreation). This ability of using space in many ways and the lifestyle in Asian countries provides valuable potential for productivity (Kelly 2004). In brief, research into the ways in which the functional elements could be most efficiently combined, accessibility to services (shops and facilities, community, work, school) and design solutions (housing structure, type) are an interlinked part of housing criteria. Design or planning can satisfy these requirements; alternatively the space can be defined or altered by the users' attitudes in order to create convenience.

The tube-house of Hanoi

The case of mixed-use urban housing in VN given below may be very different from the view of Western standards, in which housing is mainly considered as the place where private activities happen. But it might be useful to look at the idea of using living space productively and how the space can be defined or altered by the users to suit their lives.

Originally, the tube-house or so called shop house used to dominate business districts in many Asian cities. In Hanoi, the tube-house was born in the 15th century with the establishment of market towns by traders and craftspeople. The tube-house is a mixed-use model shared between living and working - trading and workshop. The average size of traditional tube houses is about 3 metres in width and 30 to 40 metres in depth, with only one or two storeys. Because shops were taxed by the width of frontage or width of marketing area, they developed into long and narrow houses and storage and living spaces were moved to the rear.

This model of mixed-use between living and trading has been brought into modern times and most dwellings now use the ground floor for commercial purposes. The function of the ground floor is changed according to the change of activities within the day: it is an open space in the day time (for trading purposes) and closed space in the evening (for family life). The ground floor can even be switched to different commercial activities (it can be hired and run by different retailers or family members) within a day. Furniture is used as the tool for changing the function of space. For example, in the early part of the day, people set out implements for serving breakfast or coffee, or lunch at noon. Then during the afternoon the ground floor can become a "mini market" selling vegetables or fruits or maybe open for miscellaneous services. Flexible and resilient are words to describe the retailers and they know very well how to balance their business with the needs of people in the area. At the end of the day, when all family members come back home, they tidy up the implements used for business and rearrange their furniture. Together, they then enjoy family life.

This model of living and trading not only brings jobs and beneficial income for households, but also provides accessible services for many residential areas. More importantly, the space has been used efficiently and most of the time is full of productive activities. Types of activities carried out and occupations of residents are shown in Tables III and IV.

Table III: Mixed-use housing in Hanoi: functions of ground floors in a survey of 230 houses, reproduced from (Hoang and Nishimura 1990; p.50)

Function	Number of houses	Percentage
Living room	30	14.1
Cafeteria	3	1.4
Restaurant	5	2.4
Hair salon	4	1.9
Grocery shop	12	5.6
Office	3	1.4
Dental clinic	1	0.5
Acupuncture clinic	1	0.5
Workshop	8	3.8
Tailor	4	1.9
Embroidery service	3	1.4
Childcare	1	0.5
Meeting room	1	0.5
Tea shop	3	1.2
Clothing shop and miscellaneous services	134	62.9
Total	213	100.0

Table IV: Jobs of the people interviewed in a survey of 70 households, reproduced from (Hoang and Nishimura 1990; p.24)

Occupation	Number of people	Percentage
Craftsman	6	8.5
Entrepreneur	28	40.0
Retired	22	31.5
Government officer	12	17.2
Others	2	2.8
Total	70	100.0

Travel to work and services

This part of the paper will look at the environmental aspect of sustainable, affordable housing in terms of transport use and services for residential areas. There is little point in having affordable and energy saving housing if the residents need to use excessive amounts of energy to access the services they need in their daily lives.

The tendency of NZ cities is low density and sprawl, so usually people have to travel a long distance to work, study and shop. For example, Auckland is "a city built around the car" and Auckland's car ownership is one of the highest in the world (Harre and Atkinson 2007; p. 114 & 115). Private transport use accounts for almost 90% of NZ's total passenger transport energy use (Marth and Sean 2007); and 45.2% of total carbon dioxide emissions is contributed by domestic transport (Mithraratne, Vale et al. 2007; p. 13). The Household Travel Survey in 2006 indicated that travel to work is the largest travel category and also the most dependent on driving and that motor cars were the main means of travel to work for approximately two thirds of the employed population (Statistics NZ 1996-2006; p.1 & 2). Driving for shopping and services has increased significantly during the period 1989/ 1990 to 2006/ 2009; whereas driving for work and social/ recreational purposes has stayed nearly the same (Ministry of Transport NZ 2010; p.8).

If NZ also promoted mixed-use housing models as used in VN, people might not need to drive so frequently to the supermarket or shopping mall to shop. Instead, they would be able

to buy things in local shops run by their neighbours, hence reducing their transport footprint for shopping. Most of the time, the distance between shops and houses would be within 2 km (for detail see Figures 1 and 2). That distance is suitable for car free travel. For daily items and miscellaneous services such as food, shoes/key repair, health club etc. people would not have to go out of their residential areas to shop. Currently 70% of all car travel is for "other" purposes with 30% for "work" and "commuting" (NZTA 2007). The annual distance travelled by a driver is around 11,000km, (Ministry of Transport NZ 2009). The total distance per person for "other" travel is around 6,000 km per year. This suggests that that travel for "other" purposes must be at least 7,700km per year. There are 0.74 vehicles per person in NZ, (Ministry for the Environment 2009) making driven for shopping and similar trips in the "other" category could be reduced by at least 50% there would be a reduction of 3,000km per person per year. For the remaining 3,000 km where the distance is probably less than 5 km, switching to a different mode of transport (bus or scooter) could reduce further the footprint for travelling. This will be discussed below.

The question that then arises is how many New Zealanders would be able to run their own business and work in their own house, so commuting travel to work could be reduced? Like most developed economies, the service sector in NZ is significant, accounting for over two thirds of GDP (72.2% in 2003) and three-quarters of all jobs (NZ Ministry of Foreign Affairs and Trade 2004). There is great potential for promoting local small-scale businesses as well as self-employment in order to enable many more New Zealanders to work at home: "Service industries are expected to be the main source of new job opportunities in coming years. Some 267,000 businesses (approximately 97% of all NZ enterprises) are small to medium enterprises. Approximately 20% of the labour market (or 362,000 people) are self-employed" (Workplace Health Safety Strategies NZ 2005).

Assuming a mixed-use housing model was applied in NZ, many people would be able to run their business at home and work at home for at least part of the time. It can be assumed that the total distance driven for work and commuting of the one working at home would be reduced by 50%, Average car travel is around 11,000km per year (see above) and of this 30% is for work and commuting, meaning that an average person's work related travel is around 2,400km a year. This could then be reduced to 1,200 km a year.

The environmental impact

Scenario

The figures below describe a scenario where travel distance for shopping and other non-work-related trips is reduced by 50%. Similarly, travel for work is also reduced by 50%.

Figure 1: The current separate-function and large-scale model: average distance travelled to work/shops/services ranges from 3 to 10 km.

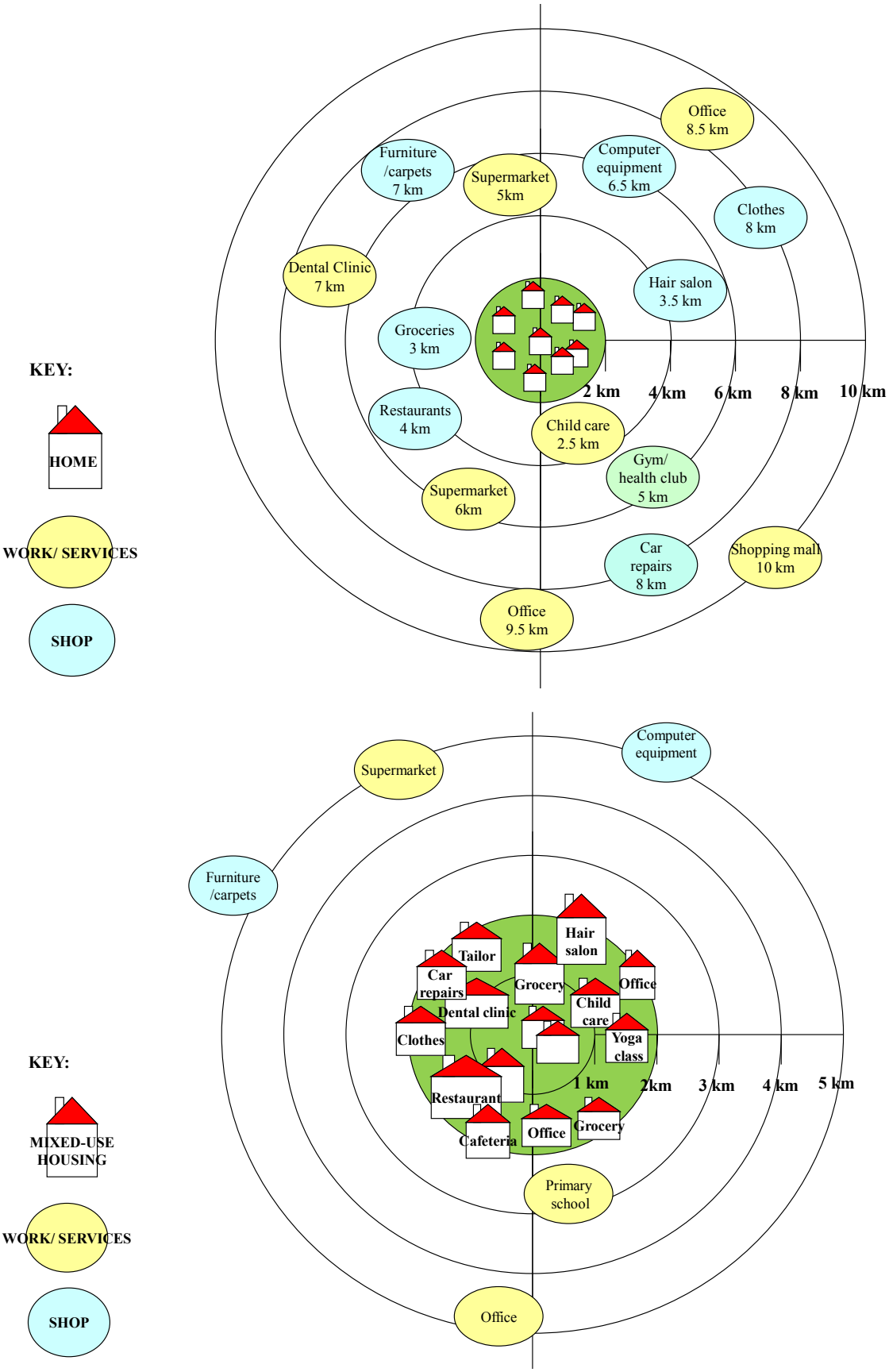

Figure 2: Mixed-use housing model that promotes small businesses and reduces travel distance: Life is more local and average distance travelled to work/shop/services is reduced by 50%. Most of the shops and services are within 2 km of home.

Ecological footprint of travelling to work/shops/services

The average distance travelled per person per year by car to work, shops and services is 8,400 km. If this travelling is done in a car with an overall energy demand of 4.0MJ/km (mid-way between a VW Golf and a Holden Commodore, see (Vale and Vale 2009; p.77), the Ecological Footprint will be 0.34gha/cap/year, assuming a conversion of 100GJ/gha. This could be halved by the travel reductions that would result from the application of mixed-use housing.

Fuel consumption could be reduced further if the use of scooters/small motorcycles became more popular, as in VN. Typical scooter fuel consumptions range from 2 to 4 litres per 100km (Anon undated). "A well cared-for scooter should be able to go about 25,000 miles before it needs a major rebuild. The 50cc two-strokes work harder, so I'd think they should be overhauled by 15,000 miles. I have heard of some Helix's running over 100,000 miles." (Stanley 2009). Assuming the weight of a scooter is 100kg, and it lasts for 40,000 km, its embodied energy will be 100MJ x 100 kg = 10,000MJ/40,000km = 0.25MJ/km. If it achieves a fuel consumption of 3 litres per 100 km, it will use a further 1MJ/km of fuel, giving a total of 1.25MJ/km.

Table V below compares types of settlement and types of vehicle travel based on the assumptions and calculations given above. This is then compared with the footprint of housing in NZ in Table VI.

Table V: Current footprint of car travel per year by a New Zealander and reduction in ecological footprint thereof for car travel and scooter travel, based on different fuels in a mixed-use housing model

Patterns of living	Total distance driven per person per year (km)	Total ecological footprint – vehicle using fossil fuel (gha/cap/year)	Total ecological footprint – battery electric vehicle (gha/cap/year)
Car-based		4.0MJ/km for petrol car	2.0MJ/km* for battery electric car
Current separate-function model, car driving	8,400	0.34	0.17
Mixed-use housing model, car driving	4,200	0.17	0.09
Scooter-based		1.25MJ/km for petrol scooter	0.63MJ/km for electric scooter**
Current separate-function model, scooter driving	8,400	0.10	0.05
Mixed-use housing model, scooter driving	4,200	0.05	0.03

*Based on BYD E6, which uses 21.5 kWh, 77.4 MJ per 100 km.

Green Car Congress (2010) "40 BYD e6-Based Electric Taxis Enter Service in Shenzhen City" 18 May available at http://www.greencarcongress.com/2010/05/byd-20100518.html#tp

**Electric scooter taken as half of petrol scooter, to mirror results for car

Ecological footprint of housing

Table V shows that a greater decrease in transport footprint could be achieved by changing vehicles (from cars to scooters) than by changing housing patterns. It can

also be seen that a change to battery electric cars has the potential to halve the footprint compared to using petrol cars. However, to understand the overall footprint reduction the calculation needs to include the footprint of the dwelling as well as that of transport. NZ houses have increased in size significantly since the 1970s, and occupancy has decreased simultaneously, and this has had an effect on their ecological footprint, as shown in Table VI.

Table VI: NZ – Comparison of the impact of housing per capita over 100 years for two periods 1970-1973 and 2006-2008 (*)

Year	Dwelling size (m^2)	House-hold size (people)	Embod-ied energy at 4.5 GJ m^2 (GJ)	Mainten-ance (GJ)	Opera-ting energy over 100 years (GJ)	Total energy (GJ)	Ecolog-ical footprint of house (gha/year)	Ecolog-ical footprint per capita (gha/year)
1970 – 1973	110	3.6	500	250	4,000	4,750	0.48	0.13
2006 – 2008	197	2.6	900	450	5,000	6,350	0.64	0.24

Table VII: Comparison of housing footprint per capita in NZ and VN (*)

Coun-try	Aver-age house size (sqm)	Aver-age house-hold size (people)	Embod-ied energy at 4.5 GJ/m^2 (GJ)	Main-tenance (GJ)	House annual energy use (MJ) (**)	Total energy use over 100 years (GJ)	Ecolog-ical foot-print of house (gha)	Ecolog-ical foot-print per person (gha)
New Zeal-and	197	2.6	900	450	50,000	6,350	0.64	0.24
Viet-nam	57	4.2	260	130	Low users: 1,770 High users: 15,600	Low users: 567 High users: 1,950	Low users: 0.06 High users: 0.2	Low users: 0.01 High users: 0.05

(*) Details concerning the calculations used to generate Table V, VI and VII can be obtained from the authors.

(**) Most houses in NZ are heated in the winter and not cooled in summer, as the climate is mild. The opposite is true in the case of VN where the winter is mild. Low users refer to families using electric fans for cooling and high users are families using both electric fans and air conditioners.

The various factors of patterns of living, choice of transport mode, house size and occupancy are brought together in Table VIII in an attempt to discover which factors make the most difference to reducing Ecological Footprint.

Table VIII The effect of patterns of living, transport and house size/occupancy on Ecological Footprint

Patterns of living	Total distance driven per person per year (km)	Total ecological footprint – vehicle using fossil fuel (gha/cap/year)	Total ecological footprint – battery electric vehicle (gha/cap/year)
Car-based...		4.0MJ/km for petrol car	2.0MJ/km for battery electric car
		PETROL	ELECTRIC
Current separate-function model, car driving	8,400	0.34	0.17
House (current)		0.24	0.24
TOTAL C1: (separate-function, current house, car-based)		**0.58gha/cap/year** **100%**	**0.41gha/cap/year** **29% reduction**
House (1970s)		0.13	0.13
TOTAL C2: (separate-function, 1970s house, car-based)		**0.47gha/cap/year** **19% reduction**	**0.30gha/cap/year** **48% reduction**
Mixed-use housing model, car driving	4,200	0.17	0.09
TOTAL C3: (mixed-use, current house, car-based)		**0.41gha/cap/year** **29% reduction**	**0.33gha/cap/year** **43% reduction**
TOTAL C4: (mixed-use, 1970s house, car-based)		**0.30gha/cap/year** **48% reduction**	**0.22gha/cap/year** **62% reduction**
Scooter-based...		1.25MJ/km for petrol scooter	0.63MJ/km for electric scooter
Current separate-function model, scooter driving	8,400	0.10	0.05
TOTAL S1: (separate-function, current house, scooter-based)		**0.34gha/cap/year** **41% reduction**	**0.29gha/cap/year** **50% reduction**
TOTAL S2 (separate-function, 1970s house, scooter-based)		**0.23gha/cap/year** **60% reduction**	**0.18gha/cap/year** **69% reduction**

Mixed-use housing model, scooter driving	4,200	0.05	0.03
TOTAL S3: (mixed-use, current house, scooter-based)		**0.29gha/cap/year** **50% reduction**	**0.27gha/cap/year** **53% reduction**
TOTAL S4: (mixed-use, 1970s house, scooter-based)		**0.18gha/cap/year** **69% reduction**	**0.16gha/cap/year** **72% reduction**

Discussion and conclusion

It has been proposed that to make a sustainable society the Ecological Footprint can be no larger than around 1.8gha per person, see (Vale and Vale 2009; p.38). This means a reduction of around 65% in the current footprints of developed countries, including NZ. The results shown in Table VIII reveal that the current footprint of housing for a New Zealander (0.24 gha/cap) is less than the footprint of driving a car. Oil is running out, so in a future of non-fossil fuel living, the results in table VIII show that it would not be a simple task of replacing fossil fuel cars with electric cars and keeping the current patterns of living at the same time. A change to electric cars, while keeping everything else unchanged, would reduce the EF by only 29% (see Total C1 Electric). It seems that technology alone cannot compensate for the environmental impact of changes in life styles, such as the move to much larger houses, unless there are guidelines for sustainable life styles and values to go with the energy innovations. Since the 1970s, the NZ housing footprint has increased by nearly 50% (from about 0.13 to 0.24gha/cap/year, table VI) due to the drop in number of people per household and the increase in the size of houses.

As Table VIII makes clear, the model of mixed-use housing with a more compact life style, combined with more compact vehicles like scooters, could reduce the annual current footprint of housing and transport sufficiently to meet the 65% reduction target. The current separate-function model of residential development is possible only with a return to the housing standards of size and occupancy that were found in the 1970s, combined with electric scooters such as are found widely in China (see Total S2: Electric). The mixed-use model, as found in VN, would allow a greater reduction in footprint when combined with electric transport, but housing size and occupancy still need to be reduced compared to the current NZ situation.

In terms of architecture and design, a broader concept is needed for housing criteria. The issue of housing should not be defined simply as providing shelter; rather, it should be seen as the issue of where it is possible to live. Usually if people cannot afford to live close to where they work or have good urban services, they will live further away. The price of a house could be cheaper but to it must be added the cost for transport and also services and hence the impact on the environment, (measured by Ecological Footprint) is increased.

This paper shows lower ecological footprints come when people use their living spaces productively as well as having flexibility of lifestyle. This means the affordability and longevity aspects of sustainable housing can be interpreted from new angles. Table VII above showed that more sharing – more people in one house – is one key to the light footprints per capita of VN compared to Western countries. The other key in terms of housing is much smaller house area per person. However, to these smaller houses must be added transport that is much closer to what is seen in VN and elsewhere in Asia, the use of small scooters rather than cars.

The future of sustainable housing greatly depends on building sustainable community. The practice of sustainability in Asia and particularly in Hanoi tube houses shows that it requires a high level of acceptance/adaptability and a culture of sharing/community. In some cases, this may reduce privacy and for that reason some might argue this is not acceptable for Western

culture. But actual implementation of co-housing schemes with their different forms of living or settlement in many Western cities shows that it is possible to bring about practice based on changing attitudes and values. Earthsong at Ranui in Auckland is a successful example of sustainable community, being described as a community of 32 houses and units, using renewable energy, and sharing common spaces such as a garden for growing food and kitchen-dining space for sharing meals (Harre and Atkinson 2007). The discussion of the Hanoi tube-house is not intended to imply that the tube-house architecture itself is the sustainable model that should be employed elsewhere; rather, it is suggested that social attitudes such as greater acceptance of sharing or adaptability could provide some new ways to look at the creation of more affordable and sustainable housing.

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