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THE ENVIRONMENTAL IMPACT OF THE WAY RESIDENTIAL PARKING FACILITIES ARE USED IN NEW ZEALAND

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Abstract:

New houses in New Zealand almost doubled in size from 1974-2011 and one feature of this change is the presence of several garages and/or on site carparks. Statistics NZ state that from 1986 to 2013 households with 2 and 3+ cars increased by 34.3% and 83.0% respectively. A questionnaire based survey of 212 New Zealand houses shows an average a 2.7 carparks per house (1.5 cars per household) and that the number of parking facilities increases with house size. This study also shows that 38.6% of these parking facilities are never used for parking cars and many people use garages for other purposes, preferring carports, on-site parking spaces and the road for parking their cars. On a week-based average in this sample people park their cars at home 19.6 hours/day, with almost 50% of this usage between 9pm-6am, and with most parking spaces vacant from 9am-4pm on weekdays. Considering the total number of available carparks for each house, the average time use per parking space is 9.4 hours/day (39% of 24 hours). This paper investigates the environmental impact of these underused residential parking spaces and the alternative uses made of garages.

Key words: New Zealand, House, Parking Facilities, Garage, Large housing, Life Cycle Assessment.

1. Introduction:

Having an integral garage was an aspect of modernism, as the car gradually became an assimilated family member (Gardiner, 2010). To begin with, the carriage house of the very rich became the motor house of the middle classes, often with chauffer's flat above. However, with the loss of servants after World War I, the owner became the driver of the car, and as a result the garage was first built adjacent to the house and then connected to it as an integral part of its architecture (Goodnow, 1928). The flat roofed managers' houses on the 1935 Bata Estate were unusual in having integral garages with a roofed balcony over the street half (Google Earth, 2016). Jensen (2007:158) also suggests it was the larger houses that had integral garages as the roof of the garage gave the opportunity to create a fourth bedroom. For most three bedroom interwar suburban semi-detached houses the garage was a separate structure tucked away behind the house at the end of the garden. For architects, however, the garage was another element in the massing of the house form. The middle class client group of Connell, Ward and Lucas (Sharp, 1994:9) gave this modernist firm many opportunities to experiment with the garage placing, from the 1934 interlocked but attached garages of the Amersham Sun Houses, to the projecting single storey garages of the 1935 Parkwood Houses at Ruislip, to the 1938 fully integrated garage at 66 Frognal, Hampstead (Sharp, 1994:27, 37, 53). Salmond (1986:197) believed that garages were simple

separate buildings added to existing houses when cars first came to New Zealand, stating that "motor cars were expensive to buy and maintain and decent shelter was essential to protect the investment".

According to Quotable Value (QV) (2011), the average floor area of new houses in New Zealand increased from 112.7m^2 in the 1940s to 205.3m^2 in the 2010s. Building consent figures from Statistics NZ (2014a) also show that the average floor area of new houses in New Zealand has almost doubled from 1974 (108.7m^2) to 2011 (191.6m^2). Preliminary studies undertaken as part of this research show that one feature of these larger houses are their double and triple garages, along extra bedrooms, extra living rooms, multiple bathrooms, and specialized rooms, such as a designated study (Khajehzadeh and Vale, 2015a). These studies also found New Zealand houses had carports and hard-standings for parking, usually coupled with the opportunity to park in the road (Khajehzadeh and Vale, 2015a). This all suggests the presence of unused parking facilities in many New Zealand houses.

A study by BRANZ (Page, 2007) indicated double garaging was the most important feature when New Zealanders buy a new house. Based on Statistics New Zealand censuses of 1996, 2000, 2006, and 2013 the percentage of households with no or 1 motor vehicle has continually decreased from 1986 to 2013, while households with 2 and 3 motor vehicles have increased in the same period (Statistics New Zealand, 2002, 2013 and 2014b). The NZ Transport Agency (2013) states there were 2,843,625 cars and 119,307 motorcycles in New Zealand in 2012. These sources (Statistics New Zealand, 2002, 2013 and 2014b) reveal that more than 52.3% of New Zealand households had at least 2 cars in 2013, up from 36.1% in 1986, meaning that the number of families with at least two cars has increased by approximately 45% in 27 years. Having double the cars means double the garages or parking spaces, which leads to more resources going into housing. Turning the land into hard areas for parking cars also affects the storm water system, as the run-off is increased.

How people really use these parking facilities is another unanswered question. While much research in this field has focused on cars and roads, the use of parking facilities in the residential sector has been less investigated. This paper aims to find out the number and types of parking facilities and how people use these in New Zealand houses, and then look at their environmental impact.

2. Methodology:

As a part of a PhD study on the effects of large housing on occupant behaviour and resource use, an online questionnaire survey was undertaken in New Zealand in February-April 2015. The survey was limited to households of single people, couples, and couples with 1 or 2 children living in owner-occupied houses. The survey asked about family members, house features (number and names of rooms), parking facilities (type and number), furniture (type, number and location), number of cars and other vehicles, time use in different rooms of the house (for each family member for 1 day) and time each car was parked in each parking facility/out of home for one day. A preliminary analysis of the house part is published elsewhere (Khajehzadeh and Vale, 2015b) and this paper will focus on the parking aspects of the study. Table 1 presents the number of participants who started the survey and the number/percentage who successfully finished various parts of it.

	House/garage/furniture part	**Time use part**	
	Households/Houses	**Houses**	**Cars**
Number who started the survey	445	445	402
Number/Percentage who finished the survey	212 (47.6%)	201 (45.2%)	316 (78.6%)

Table 1 Number of participating and successful households in various parts of the survey

In the questionnaire survey participants were asked to report the number of cars and boats kept at home. In the time use part of the questionnaire, based on the number of cars at home, a time use diary appeared for each car (car 1, car 2 etc). The survey was set up to ask for time use of up to 6 cars. The questionnaire asked people to report how long they had parked their cars in the various available parking facilities (garages, carports, parking spaces, on the road), along with the time they had used their cars (for shopping, going to work etc.) for one day. The subtotal of these usages had to be 24 hours if not an error message appeared asking the respondent to review his/her answers. Time use data for all cars were then sorted in a SPSS file for further analysis. To find the differences between various aspects of parking facilities with the house/household features, several ANOVA one-way tests were performed in SPSS. Where the ANOVA one-way test showed a significant relationship, a Post HOC analysis using Tukey test was also performed to show the details of the difference.

3. Results:

3.1. Number of available parking facilities and its relationship with house size

Analysis shows that the relevant sample in this study had on average 1 garage, 0.2 carports, 1.5 parking spaces and in total enough space to park 2.7 cars off-road at their houses (Table 2). Garages and parking spaces were the most popular type of parking facility as 66.5% of houses in this sample have at least one garage space and 62.3% at least one parking space. Carports are less popular with only 17.0% of the sample having at least one. Overall 87.7% of the sample have at least 1 private parking facility.

	Garage capacity	Carport capacity	Parking space capacity	Total available spaces for parking cars
Number of sample	212	212	212	212
Mean	1.00	0.22	1.52	2.73
Median	1.00	0.00	1.00	2.00
Std. Deviation	0.85	0.54	1.57	2.10
Minimum	0.00	0.00	0.00	0.00
Maximum	4.00	3.00	7.00	11.00

Table 2 The Mean, Median, Standard Deviation, Minimum and maximum garage, carport and parking space capacity for this study sample

Statistics New Zealand (2014) show that the size of new houses has increased in recent years. There are studies (Khajehzadeh and Vale, 2015) showing that these large houses have new specialized rooms including a play room, games room and study but there is no research looking at how this change in house size has affected the number of garages and other parking facilities. This was investigated here using an ANOVA one-way test and the results are presented in Table 3. These show the number of garage spaces and the total number of available parking spaces of any kind is significantly different by house size at 0.05 level, although the number of carports and parking spaces are not significantly different by house size at 0.05 level (Table 3).

	df	F	Sig.	Result
House size/Total available parking spaces of any type	4,207	4.13	0.003	✓
House size/Total available garage spaces	4,207	6.58	0.000	✓
House size/Total available carport spaces	4,207	0.38	0.821	×
House size/Total available parking spaces	4,207	1.61	0.173	×

Table 3 Results of the ANOVA one-way test for house size and number of different parking facilities

A Further Post HOC analysis using Tukey test indicates that:

• The total available parking spaces (of any kind) in houses with 5 or fewer rooms is significantly less than for houses with 7 (M=-1.45, SD=0.45), 8 (M=-1.55, SD=0.50) and 9-9+ rooms (M=-1.50, SD=0.45). This means that very small houses on average have fewer total parking facilities (Figure 1).

• The total available garage spaces in houses with 5 or fewer rooms is significantly less than for houses with 7 (M=-0.57, SD=0.18), 8 (M=-0.86, SD=0.20) and 9-9+ rooms (M=-0.78, SD=0.18). This means that very small houses on average have fewer garages (Figure 1).

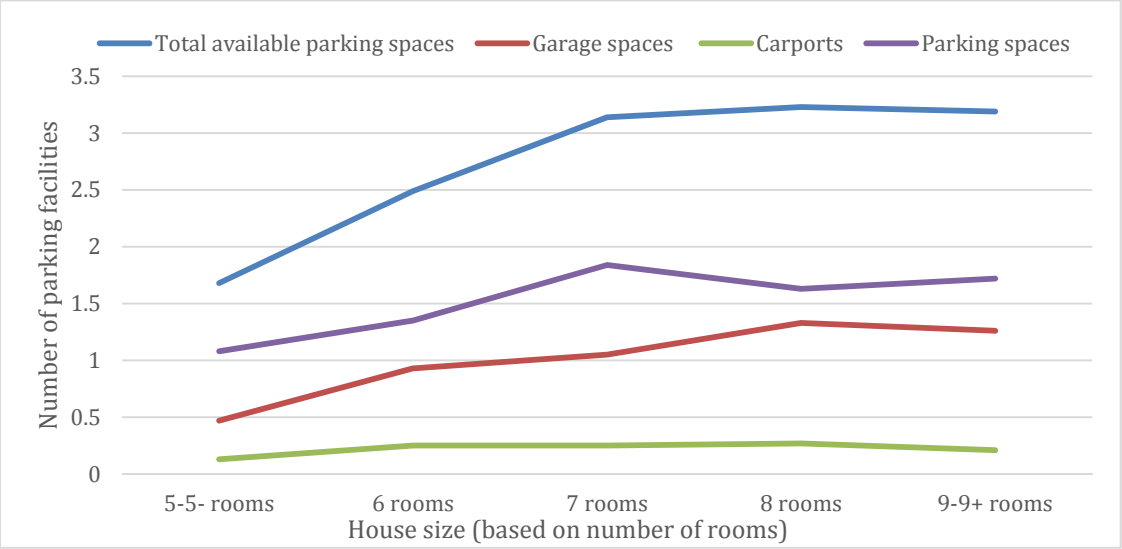

Figure 1 The average number of garages, carports, parking spaces and total parking spaces (of any kind) by house size

3.2. Number of vehicles and its relationship with house/household size

The question arises as to whether residents of these houses have enough cars to park in their 2.7 parking spaces. Analysis shows that on average each household has 1.49 cars, 0.15 motorcycle/scooters, 1.57 bicycles and 0.06 boats (Table 4). Accepting the fact that only cars and boats (subtotal 1.55 cars and boats) are big enough to occupy a parking space, this suggests that on average each New Zealand house has an extra (un-used) space for parking cars and almost half of the available spaces for parking cars are vacant. Of the sample households in this study on average 94.8% have at least 1 private car, 12.7% a motorcycle/scooter, 60.4% a bike and 4.7% a boat.

	Car	Motorcycle/Scooter	Bicycle	Boat
Number in Sample	212	212	212	212
Mean	1.49	0.15	1.57	0.06
Median	1.00	0.00	1.00	0.00
Std. Deviation	0.76	0.43	1.76	0.27
Minimum	0.00	0.00	0.00	0.00
Maximum	5.00	3.00	8.00	2.00

Table 4 The Mean, Median, Standard Deviation, Minimum and maximum number of cars, motorcycles/scooter, bikes and boats per house for this study sample

Results of an ANOVA one-way test indicate that the average number of cars and bikes per household is significantly different for different household types at 0.05 level ((F(3,207)=10.50, p=0.00<0.05) and (F(3,207)=14.45, p=0.00<0.05)). Further analysis indicates that single person households have fewer cars and bikes than couples, couples with one child and couples with two children but do have the most cars/person (Table 5 and Figure 2). Another ANOVA one-way test was also performed and showed that the average number of cars per person is different by household type at 0.05 level ((F(3,207)=19.62, p=0.00<0.05)) but the number of bikes per person is not significantly

different by household type at 0.05 level (F(3,207)=2.30, p=0.08>0.05)). As might be expected households with children have more bikes.

Household type	Cars per household	Bikes per household	Cars per person	Bikes per person
Single persons	1.02	0.93	1.02	0.93
Couples	1.42	1.12	0.71	0.56
Couples with one child	1.71	1.67	0.57	0.56
Couples with two children	1.81	2.93	0.45	0.73

Table 5 The average car/bike ownership per household and per person for four different household types

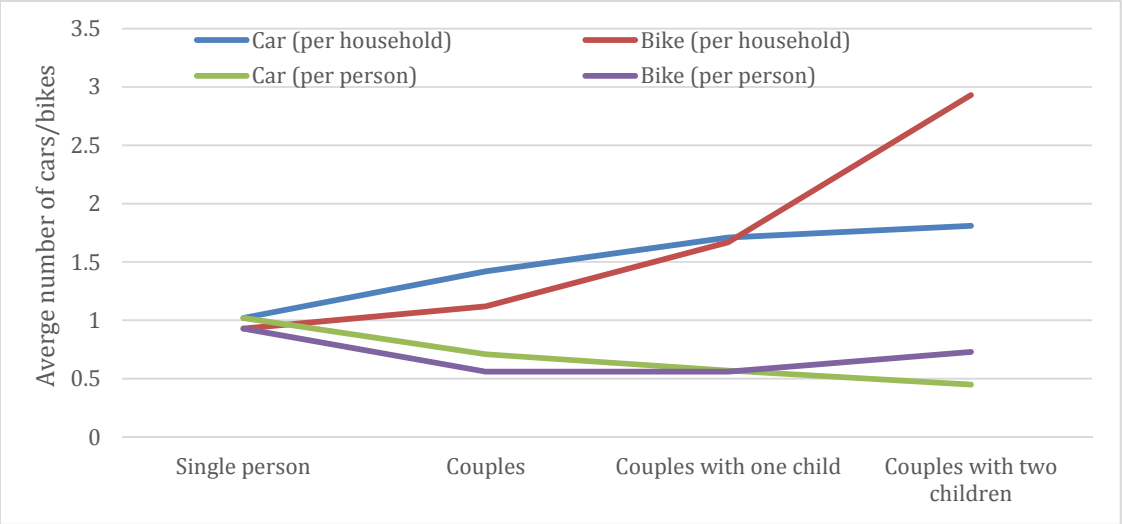

Figure 2 The average car/bike ownership per household and per person for four different household types

In addition Figure 3 shows that the percentage of households with no cars decreases as family size increases and the percentage of households with several cars also increases with family size. Figure 3 shows that while only about one third of couples have 2 cars, more than half the couples with children have 2 cars.

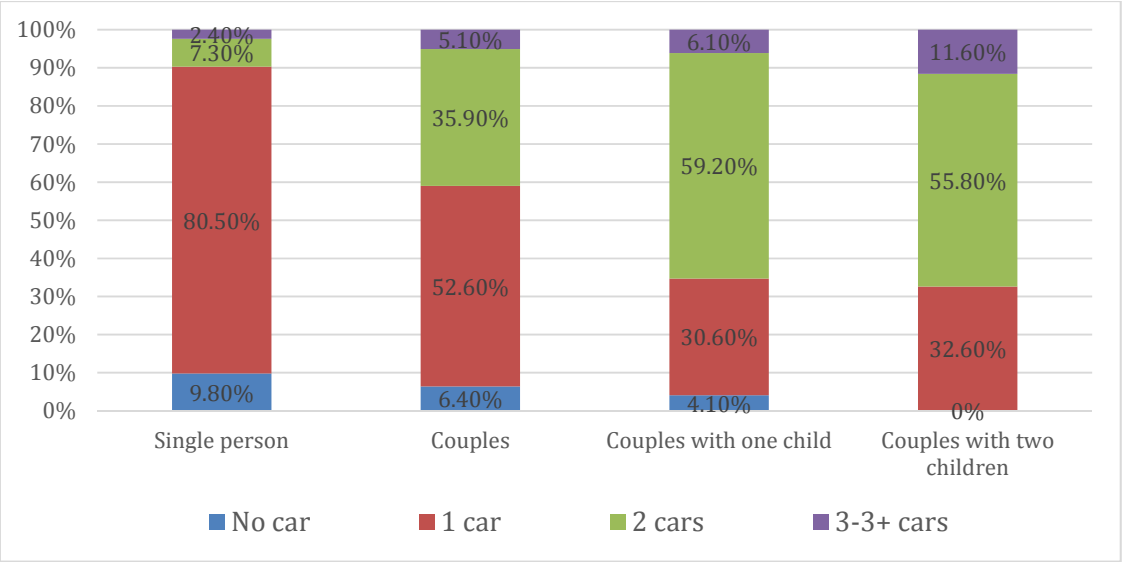

Figure 3 Percentages of households with 0, 1, 2 and 3-3+ cars

Several ANOVA one-way tests were performed to see if larger houses mean more cars, motorcycles/scooters, bikes and boats and Table 6 summarises the results. The number of rooms was selected as an indicator of house size. The results indicate that the average number of cars, motorcycles/scooters and bikes is significantly different by house size at 0.05 level but the average number of boats is not (Table 6 and Figure 4).

	df	F	Sig.	Result
The average number of cars/House size	4,207	4.28	0.002	✓
The average number of bikes/House size	4,207	3.22	0.014	✓
The average number of motorcycles & scooters/House size	4,207	2.76	0.029	✓
The average number of boats/House size	4,207	1.38	0.243	×

Table 6 Results of the ANOVA one-way test for the average number of available cars, motorcycles/scooters, bikes and boats by house size

- According to the results of a further Post HOC test using Tukey HSD the average number of available cars in houses with 5 and fewer rooms is significantly less than houses with 8 (M=-0.54, SD=0.18) and 9 & 9+ rooms (M=-0.48, SD=0.16). The same pattern was seen for houses with 6 rooms as the average number of available cars in these houses is significantly less than houses with 8 (M=-0.48, SD=0.17) and 9 & 9+ rooms (M=-0.43, SD=0.15). This means that small houses on average have 0.5 fewer cars than large houses (see Figure 4).
- According to the results of a further Post HOC test using Tukey HSD the average number of available bikes in houses with 5 and fewer rooms is significantly less than houses with 8 (M=-1.34, SD=0.42) and 9 & 9+ rooms (M=-1.14, SD=0.38). This means that very large houses on average have more bikes than very small houses (see Figure 4).
- The results of a further Post HOC test using Tukey HSD show no significant difference at 0.05 level for the average number of available motorcycles/scooters by house size (see Figure 4).

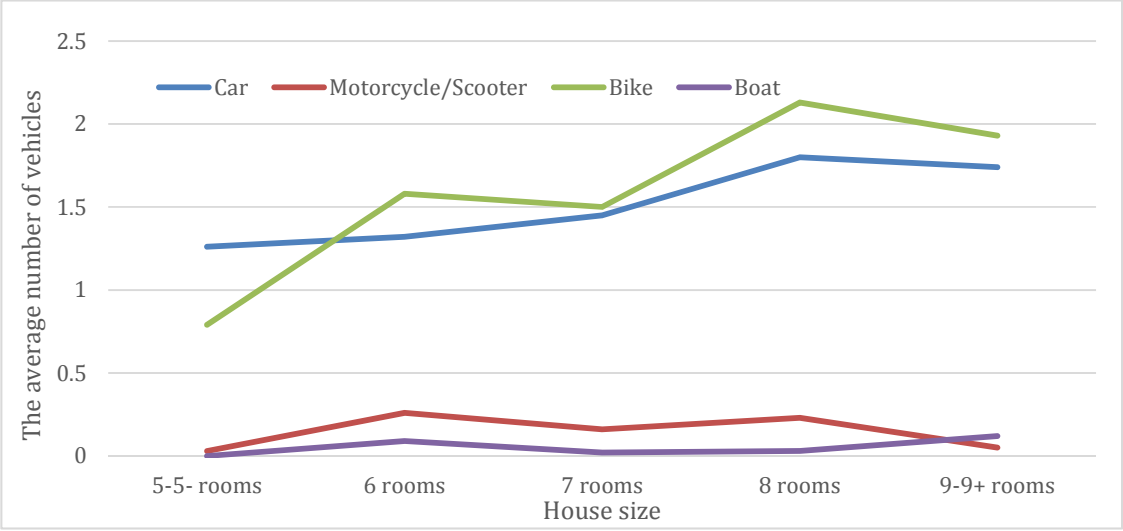

Figure 4 The average number of cars, motorcycles/scooters, bikes and boats by house size

3.3. Time use in parking facilities

Car ownership based on this study is shown in Table 7. Analysis shows that usage of these cars is different. While samples in this study used their cars (either driving or parking somewhere other than at their home) on average 4.4 hours/day this usage differed according to the number of available cars.

Households used their first and second cars much more than other cars and fourth and fifth cars were never used on the survey day.

	Number of samples	Average time Cars are used (Hours)
First car	201	4.73
Second car	97	4.17
Third car	13	2.60
Fourth and fifth cars	5	0.00

Table 7 The average time different cars have been used per day for the first, second, third and fourth/fifth cars available to each household

Results of an earlier pilot study indicated that some households use their garages for purposes other than parking cars (Khajehzadeh and Vale, 2015). This part looks at this in more detail. As all houses did not necessarily have all types of parking facilities, these will be analysed separately for the whole sample.

- *Garages:* The cumulative time for all households in this study for parking their cars in a garage was 2016.5 hours. Given the total available capacity of garages for the whole sample (209) it can be concluded that people with a garage on average parked their cars in these for 9.6 hours/day. As each garage can potentially be used for 24 hours/day, dividing the real usage (2016.5) by the maximum possible usage (5016 hours) and multiplying by 100 gives an efficiency rate for garage use in this sample of 40.2%.
  Efficiency rate = [2016.5 hours ÷ (209 × 24 hours)] × 100 = 40.2%
- *Carports:* In the total sample cars were parked in a carport space for 460.4 hours. Given there were 47 carports in the whole sample people who have a carport on average parked their cars in these for 9.8 hours/day. Following the same method described for garages the efficiency rate of use of carports for this sample is 40.8%.
  Efficiency rate = [460.4 hours ÷ (47 × 24 hours)] × 100 = 40.8%
- *Parking spaces:* In the total sample cars were parked in a parking space for 2437.1 hours. Given there were 322 parking spaces in the whole sample, on average people who have a parking space parked their cars in these for 7.6 hours/day. Following the same method described for garages and carports, the efficiency use rate of parking spaces for this sample is 31.5%.
  Efficiency rate = [2437.1 hours ÷ (322 × 24 hours)] × 100 = 31.5%

In addition to the time use of 9.6 hours/day for garages, 9.8 hours/day for carports and 7.6 hours/day for parking spaces, the average time a car was used (for shopping or going to work etc.) was 4.4 hours/day. Adding average use time for garages and use away from home gives 14 hours/day which is much less than 24 hours. This could either be related to the fact people have multiple parking space choices (i.e. park their cars in a combination of garage, carport, parking space, and on the road) or because many garages are used for other purposes than parking cars. Several questions in the questionnaire will help a better understanding of the usage pattern of garages, as described below.

- What people say: In one of the questions, people were asked where they usually park their cars/boats. The results show 38.6% of households who have a garage say that they park their cars in other parking facilities than their garages. Further analysis shows that 50.6% of people who have a single garage, 21.1% of people with a double garage and 20.0% of people with triple+ garages follow this pattern.
- Human time use in garages: As a part of the occupants' time use of the different rooms of the house, individual household members were also asked to report their time use in a garage if

they used it for a purpose other than parking a car. The results show that 36.6% of the households spent time in the garage for a reason other than parking a car. Considering it is possible there are households who use their garage for something other than parking but not on the survey day, this suggests at least 36.6% of the garage spaces have a double usage (i.e. garage/laundry) or a different usage (i.e. workshop or storage).

Having a large garage could be a reason for a change in the space usage. An independent sample T Test was performed and results showed that the average human time use in double or larger garages is significantly more than that of single garages ($t(91)= 1.81$, $p=0.073<0.1$) at 0.1 level.

- Car time use: The questionnaire asked people to report the time each car was parked in all available parking facilities including garages. An Independent Sample T Test was performed to see if "parking time in garage" per available car/boat is different by garage size. The results show that the "parking time in garage" per available car/boat is not significantly different between single garages and double or larger garages ($t(137)=0.92$, $p=0.36>0.05$). This means that larger garages are not necessarily used for parking more cars.
- Presence of furniture items: A pilot study indicated that many people use their garages for other purposes than parking. A study by Canter and Tagg (1980) suggests the presence of furniture in a space could be an indicator of a human activity happening in that space. The questionnaire asked about the place of furniture and large appliances in the home. Among the possible options, people could select 'garage' as the location of furniture/large appliances. Analysis shows the presence of at least one furniture item/large appliance in 84.8% of garages, although the number of these furniture/large appliance items varies between 1 and 12 (average of 3.1 items).

To find out whether the presence of a furniture item/large appliance means other usage for a garage, an Independent Sample T Test was performed in SPSS. The results indicate that the average number of furniture items/large appliances in garages with reported human time use is significantly higher than garages with no reported human time use ($t(143)= 5.84$, $p=0.00<0.05$). According to the analysis, the average number of furniture items/large appliances in garages with human time use is 4.42 and 2.29 for garages with no human time use.

Having a multi-purpose garage means people use their garages for parking their car and another purpose. Because this could be linked to larger garages, an independent sample T Test was performed and the results showed the average number of furniture items in double or larger garages is significantly more than that of single garages ($t(141)= 3.81$, $p=0.00<0.05$). This means that having a double or triple garage means using at least a part of it for other purposes.

The reason behind having larger garages could be having more cars. An independent sample T Test was performed to investigate this and the results showed that the average number of cars in larger garages is significantly more than in single garages ($t(141)= 2.69$, $p=0.008<0.05$). Figure 5 compares the average number of available cars and furniture items in garages with different capacities. As seen, numbers of both cars and furniture items increase with an increase in garage size although the increase rate is higher for furniture, showing that larger garages are more likely to have multi usages.

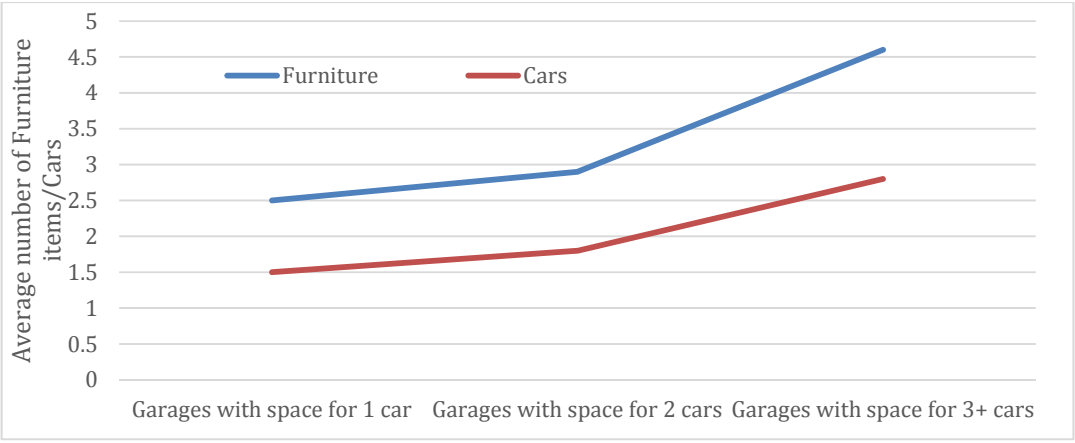

Figure 5 The average number of furniture items/large appliances/cars which are kept/parked in garages according by garage size

3.4. Furniture in garages:

As described, this study shows that many people have furniture items in their garages. Table 7 presents percentages of houses that have at least 1 item of each furniture/large appliance category in their garages (category contents are listed below).

- Laundry appliances: Washing machine, Dryer and Laundry tub
- Exercise equipment: Treadmill, Exercise cycle and Exercise weight machine
- Games equipment: Table tennis table and Pool table
- Kitchen appliances: Fridge/Freezer, Fridge, Bar fridge and Freezer/Chest freezer
- Bedroom furniture: Bedside table/cabinet, Chest of drawers/Dressing table and free standing mirror
- Living room furniture: Chaise longue, Four-seater dining suite, Chair, Chest and Stool
- Outdoor furniture: BBQ, Outdoor dining/Picnic table, Outdoor chair/Couch, Sun lounger/Deck recliner, Outdoor umbrella/Gazebo and Bench
- Children's outdoor playing equipment: Paddling pool
- Gardening equipment: Work bench and Lawn mower
- Study room furniture: Desk, Desk chair and Shelf/book case

	Percentage of houses with at least one furniture/appliance item in their garages	The average number of available items
Laundry appliances	24.8%	2.0
Exercise equipment	6.9%	1.2
Games equipment	2.1%	1.3
Kitchen appliances	29.0%	1.2
Bedroom furniture	2.1%	1.0
Living room furniture	8.3%	2.8
Outdoor furniture	20.0%	1.3
Children outdoor playing equipment	3.4%	1.0
Gardening equipment	61.4%	1.4
Study room furniture	6.2%	1.6

Table 8 Percentage of houses with at least one furniture/large appliance of each category and the average number of available items

According to Table 8 and the type of furniture/large appliances in each category it can be concluded that:

- About 25% of the garages serve as a laundry, combined garage/laundry or as a storage for extra laundry appliances.
- About 7% of the garages serve as a gym, a combined garage/gym or as a storage for extra exercise equipment.
- About 2% of garages serve as a games room, a combined garage/games room or as a storage for extra games appliances.
- Presence of some kitchen appliances (but not stove or microwave) shows that about 29% of garages are used for storing second fridges/freezers but not as a second kitchen or combined garage/kitchen.
- Presence of some bedroom furniture (without any kind of beds) shows that about 2% of garages are used for storing extra bedroom furniture but not as an extra bedroom or a combined garage/bedroom.
- About 8% of the garages serve as extra family rooms, a combined garage/family room or as storage for extra living room furniture.
- Presence of some outdoor furniture shows that about 20% of garages are used for storing outdoor furniture, which could be temporary storage to protect it from the weather.
- Presence of some outdoor children's play equipment shows that about 3% of garages are used for storing this, or as a playroom/garage.
- Presence of some gardening equipment shows that about 61% of garages are used for storing gardening equipment.
- About 6% of the garages serve as a study, a combined garage/study or as a storage for extra study furniture.

Based on the above, it can be concluded that apart from parking cars people use their garages as a laundry, gym, games room, for storage (particularly for outdoor items) and possibly as a playroom or study. In addition, some people use their garages as a workshop, a use which does not necessarily include normal house furniture/appliances, although this could not be verified from this survey.

4. Life-cycle analysis:

This indicative LCA analysis looks at the integral garage and hard standing of the Waitakere NOW Home to see its environmental impact. This sustainable house included an integral garage as part of the floor area of the house for their life-cycle assessment (Collins and Blackmore, 2010). The garage, which contained the laundry appliances, was 24.5m^2, representing 16% of the total building footprint of 149.2m^2 for the three bedroom single storey house (Collins and Blackmore, 2010:49). The garage did not account for any operational energy in the life-cycle, apart from a small amount of electricity used for the washing machine, operational energy being the major component in the energy consumption of the building at 67-75% of total. There is an additional concrete hard standing in front of the garage of approximately 20m^2, which is assumed for this analysis to the 100mm concrete.

Using figures for lightweight construction (Mithraratne et al. 2007) the initial embodied energy of the available parking facilities is 1908 MJ/m^2 at year 0, rising to 2239 after 25 years and 3165 after 50 years. This gives the following embodied energy values of the garage on a pro rata basis (Table 9).

	Embodied/Life Cycle Energy at different life stages			
Component	**0 years**	**25 years**	**50 years**	**100 years**
Garage (MJ)	46,746	54,856	77,545	111,010
Car standing (MJ)	5,304	5,304	5,304	10,608
Total (GJ)	52.1	60.1	82.9	121.6

Table 9 Embodied and life cycle energy of a typical New Zealand garage and car standing based on Mithraratne et al. (2007) figures

Unfortunately the NOW home LCA was no conducted in a compatible way. Using figures from another study (Mithraratne et al. 2007:164) for well insulated houses with a concrete slab, produces the following table for the 124.7m^2 space conditioned part of the house (Table 10), showing the impact of parking facilities as a percentage of the total impact of the building.

	Embodied/Life Cycle Energy at different life stages			
Component	**0 years**	**25 years**	**50 years**	**100 years**
Main house (MJ)	297,922	537,062	848,614	1,409,408
Garage (MJ)	46,746	54,856	77,545	111,010
Car standing (MJ)	5,304	5,304	5,304	10,608
Total (GJ)	350.0	597.2	931.5	1,531.0
Parking % of total	15.0%	10.0%	8.9%	7.9%

Table 10 Embodied and life cycle energy of the main house, garage and car standing of the NOW home based on Mithraratne et al. (2007) figures

In the same way the resources embodied in a normal free standing double garage suggest approximately 4 of these effectively contain the resources of 100m^2 house, assuming such a garage is of normal NZ lightweight construction and measures 7.2 x 6.0 (42 m^2) to give a comfortable side entry (Versatile homes & buildings, 2016). Each double garage also contains on average 3 items of furniture/equipment. This can be added to the impact of the garage over the life of the house, to produce the following table (Table 11).

	Embodied/Life Cycle Energy at different life stages			
Component	**0 years**	**25 years**	**50 years**	**100 years**
Double garage (GJ)	80.0	94.0	133.0	190.0
Stuff (3 items) (GJ)	6.0	11.4	20.4	32.4
Total (GJ)	86.0	105.4	153.4	212.4

Table 11 Embodied and life cycle energy of a typical garage of a 100 m^2 New Zealand house and stuff stored in it

5. Conclusion:

This study shows that a selected sample of New Zealand owner-occupied households on average have 1.5 cars and 2.7 spaces for parking these, meaning that on average more than 1 parking facility is extra and not used for its designed purpose. Households with children are more likely to have 2 or 3 cars although more than 40% of couples in this study had more than 1 car. This study also shows a large positive correlation between large houses and the number of cars, garages and parking spaces. Also, the time use part of this study shows householders do not park their cars in their residential garages for the whole or at least part of the time the car is at home. In addition, many people in this sample use their residential garages for purposes other than parking cars. These include using garages as a laundry, gym, games room, study or as storage for extra furniture/appliances. Larger garages are also more likely to include more furniture items than small ones, suggesting when people buy houses with larger garages they are more likely to use these for reasons other than parking.

The question arises as why should we use energy and resources to build rooms for keeping cars that can be kept outdoors. This study shows that on average garages of NZ houses are vacant for 14.4 hours/day. The results of our pilot study for this project (Khajehzadeh and Vale, 2015a) indicate that a

significant part of this time is between 9 am to 5 pm when most of people are looking for a parking space elsewhere, and possibly in the city centre. Perhaps sharing residential garages and other parking facilities that are left empty in the city centre could lead to more efficient use of the resources going into garages, or perhaps we should simply park cars outdoors at home.

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