Institute of Transport Economics
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Summary:

How to design self-sufficient residential satellites with low car dependency?

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While we know little about how residential satellites should be developed to be self-sufficient and have low car dependency, cities with expected population growth are under pressure to develop new and existing residential satellites. In this study, we found that residential satellites should contain at least 3-5 000 inhabitants if a minimum of retail , such as a grocery store, are to be established. Further, this should be located within 800 meters walking distance (equivalent to approximately 600-650 meters as the crow flies) from the outermost dwellings if the residents are to choose walking as transport mode on their internal trips. Based on this, we calculated that the population density in a residential satellite should be at least 2.3 to 4.5 inhabitants per decare (or 0.23 to 0.45 inhabitants per hectare), depending on the layout and design of the residential satellite.

The aim of this report is to contribute to better knowledge among local decision makers on how residential satellites can and should be developed if the goal is that they should provide a minimum of retail and services, be able to have a good public transport service, as well as high walking shares on internal trips and low car dependency. The retail offered should be sized so that it serves the local market, ie those living in residential satellite or in its immediate vicinity. In these residential satellites, the focus in this report is on a limited retail offer; sufficient to enable the citizens to have short shopping trips, but not so big that it attracts 'outside' customers.

Answer to research questions

To shed some more light on this theme, we first answered three research questions.

i) How many people should reside in a residential satellite for there to be a minimum offer of retail and service?

In interviews with key informants, a consistent statement was that you had to have a customer base of 3 - 5 000 people if they should consider establishing a grocery store. This varies with the geographical scale it is measured by. Only including the residents in the individual satellites is often not enough, as the customer base is also affected by context. This is especially true if the business is located in a spot where many drive past it to and from homes laying outside the residential satellite. Retail stores' attractiveness increases with the presence of others (and different) shops, as customers can make multiple store visits and purchases. Grocery stores are an important 'puller' on other types of retail and service, and they make analyses on the potential customer base for their establishment that other retailers and businesses rely on (such as pharmacies and florists).

ii) What does it take for a residential satellite to get a good public transport service?

Unlike localization decisions on retail and services, public transport service decisions is based on more than just market conditions and profitability. In interviews, key informants explained that they kept an eye on different developments and how this affected the customer base in the city's outskirts. This, in addition to a number of local conditions affects the public transport service. The need for rapid route service and the need to cover different population concentrations must constantly be weighed against each other. Residential satellites with many residents and/or which is located along an established public transport route with high frequency, is thus more likely to be served by a competitive public transport service.

iii) If residents choose walking and/or travelling by public transport, within which maximum distances should the residential satellite be developed?

Based on figures from the National Travel Survey 2013/14, we found that walking is the preferred transport mode when trips are under 800 meters (one way). In our calculations, this corresponds to approximately 600-650 meters as the crow flies. The shorter the journey, the higher the pedestrian share and the lower the car share. As the trip length exceeds 800m (one way), car is the most frequently used means of transport. This applies to all trips, both for work and for leisure. This means that a residential satellite should be developed within a radius of 650 meters as the crow flies, if the aim is to get residents to walk to the nearest retail -and service offer and to the nearest public transport stop.

Design and distances defines land use and density

Based on the answers to the research questions above, we have calculated the density a residential satellite should have for it to be self-sufficient and have low car dependency. The design of various residential satellites is illustrated in terms of land use, inhabitant density and housing density, and based on two different physical layouts (centrally located centre and external centre) and three different distances (5-minute range, 10-minute range and 15-minute range).

Walking distances in a residential satellite is defined by the size of the area. In our calculations, we used three different walking distances; 5 minutes, 10 minutes and 15 minutes. To convert this to walking distance, an average walking speed of 1.42 m/s or 5.1 km/h were used (based on the findings of Browning et al 2006 preferred average walking speed). Further, we calculated the walking distance to be 25-30% longer than as the crow flies distance.

- In the 5-minute range, this corresponds to a radius from the centre at 350 meters as the crow flies, and about 440-455 meters walking distance. One covers on average 426 meters in 5 minutes.
- In the 10-minute range, this corresponds to a radius from the centre at 650 meters as the crow flies, and about 813-845 meters walking distance. One covers on average 852 meters in 10 minutes.
- In the 15-minute range, this corresponds to a radius from the centre of 1 km as the crow flies, and about 1250 to 1300 meters walking distance. One covers on average 1278 meters in 15 minutes.

The two different physical layouts we illustrate is a centrally located centre and an external centre (see Figure E1).

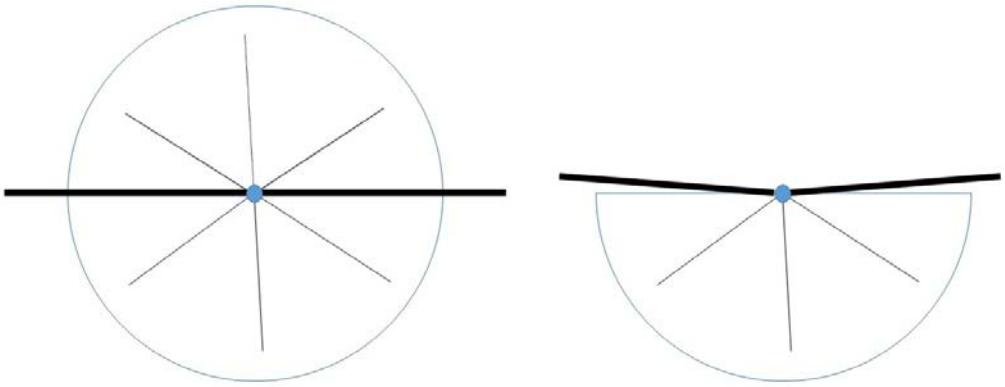

Figure E1: The figures illustrates 'a centrally located centre' (left) and 'an external centre' (right). The blue dot shows the location of retail, service and public transport stops, the black line illustrate the main road passing through/by the residential satellite, and the grey lines illustrate smaller local roads within the satellite.

These are two simplified and theoretically optimal layout designs. When retail, service and public transport stops are located in the middle of the residential satellite, a typical layout when the satellite is developed on both sides of a major road, this is defined as a satellite with *a centrally located centre*. Such a layout means that residents have the shortest average distance to the centre. In a residential satellite with *an external centre*, the location of retail, service and public transport stops occurs at the entrance to the satellite, as this is where the visibility is highest and the point where all or most residents pass when entering the satellite. This is a typical layout when the satellite is developed on one side of a major road. The land use in a satellite with an external centre is simplified to be half the area of a satellite with a centrally located centre, when the radius is equal.

The design of residential satellite affects the public transport service to the area. To increase the chances of a competitive public transport service, any new residential satellites should be located right at or around a main road with an existing, high-frequency public transport route. The public transport stop should be located in or near the main centre of the satellite.

How to design self-sufficient residential satellites with low car dependency?

Given the discussions above, we know that a residential satellite should have about 3-5 000 inhabitants if a minimum of retail and service, such as a grocery store, are to be established. Table E1 summarizes requirements for land use and density for the entire area, in the different residential satellite layouts. The density calculations are based on 3-5 000 inhabitants, which corresponds to between 1 364 and 2 273 housing units (based on an average household size of 2.2 persons). In addition to the housing units, the areas will also accommodate varying physical and social infrastructure (roads, schools, green spaces and parks, retail and service, etc.). The density in the areas regulated for housing will thus be higher.

Tabell E1: Summary table. Calculations based on 3 - 5 000 inhabitants, and 1 364 - 2 273 housing units, based on the entire area, including roads, parks, retail, etc. (for hectares, divide the daa-number by ten).

		5-minute range		**10-minute range**		**15-minute range**	
		Per daa	*Per km²*	*Per daa*	*Per km²*	*Per daa*	*Per km²*
Land use	Centrally located	385 daa	0,4 km²	1327 daa	1,3 km²	3140 daa	3,1 km²
	External	192 daa	0,2 km²	663 daa	0,7 km²	1570 daa	1,6 km²
Inhabitant density	Centrally located	7,8 13	7 799 12 999	2,3 3,8	2 308 3 846	1 1,6	968 1 613
	External	15,6 26,0	15 599 25 998	4,5 7,5	4 286 7 143	1,9 3,2	1 875 3 125
Housing density	Centrally located	3,5 5,9	3 546 5 909	1 1,7	1 049 1 748	0,4 0,7	440 733
	External	7,1 11,8	7 092 11 819	2,1 3,4	1 949 3 247	0,9 1,4	853 1 421

If the aim is to facilitate for a high share of eco-friendly transport to, from and within the residential satellite, the satellite should be developed within a 5-minute range from the centre, or a 10-minute range at the top. Development within of 15-minute range of the centre will likely contribute to a residential satellite with a clearly higher proportion of car use, as many inhabitants will live outside walking range to central service. The table above thus acts as guidance for the type of development (land use, inhabitant density and housing density) that should be chosen, given the goal of self-sufficient residential satellites with the potential for low car dependency.

Consistently, the cases in this study, and probably most other Norwegian residential satellites, do not have a high enough population within a short enough distance from the local centre to have a good retail and service supply and a competitive public transport service within short walking distance for all inhabitants. The density is too low and/or the residential satellite is too sprawled.