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Europe's Vibrant New Low Car(bon) Communities

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Executive Summary

Moving is a time to reevaluate the stuff you own. Boxes of family photos? Coming. That ratty old couch? Not coming. But what if you could leave something even bigger behind? Like your car?

New developments are often associated with sprawl and more driving. But eight communities across Europe demonstrate there is a different model. ITDP Europe investigated these developments and found by using smart urban and transportation planning and design, they have created communities with lower car ownership rates and less driving than nearby developments of comparable sizes and age. As a result these communities have less pollution, greenhouse gas emissions, public health issues and other negative externalities associated with driving.

These new developments use a combination of "push" measures to discourage private car use and "pull" measures to improve the attractiveness of walking, cycling, transit and various forms of shared vehicle use. As the report demonstrates, these measures work, and could be applied in other new developments around the world, particularly in abandoned industrial sites or on other previously developed land.

The eight case study locations are summarized in Table 1.

Eventually these measures should be applied to all urban development, in order to minimize the need for driving and maximize the opportunities for healthier, more sustainable forms of transportation. Therefore ITDP presents these case studies, identifies lessons learned and compares the planning, design and travel demand management techniques used so that others might follow the lead of these eight communities.

Each case study includes background information on the origins of the development and how these best practices were incorporated at early stages of the developments' planning processes, before describing individual measures in more detail. Quantitative data on vehicle ownership, modal split and transport-related emissions are then presented, based on the literature and/or surveys developed by ITDP Europe, followed by a summary of lessons learned and recommendations for further research.

It is worth noting that the most successful "car-free" and largely "parking-free" developments reviewed had well-organized grassroots support for the concept from the outset. Planners and decision makers should look for willing partners as they undertake these

PRINCIPLES FOR SMART URBAN GROWTH

1. Walk: Develop neighborhoods that promote walking
2. Cycle: Prioritize bicycle networks
3. Connect: Create dense networks of streets and paths
4. Transit: Support high-quality transit
5. Mix: Plan for mixed use
6. Densify: Match density with transit capacity
7. Compact: Create compact regions with short commutes
8. Shift: Increase mobility by regulating parking and local road use

Developed by a team of urban design experts including ITDP, Gehl Architects, Nelson Nygraard, and Calthorpe Associates

Table 1: Case study locations

Development	Location	Type	Size (hectares)
Greenwich Millennium Village	London, United Kingdom	Brownfield: mixed use, car-reduced	29
GWL Terrein	Amsterdam, The Netherlands	Brownfield: residential, car-free	6
Hammarby Sjöstad	Stockholm, Sweden	Brownfield: mixed use	160
Houten	Utrecht, The Netherlands	Greenfield "cycling city" of 45,000 people	820
Sihlcity	Zurich, Switzerland	Brownfield: leisure and retail	4
Stellwerk 60	Cologne, Germany	Brownfield: residential, car-free	6
Västra Hamnen	Malmö, Sweden	Brownfield: mixed use	175
Vauban	Freiburg, Germany	Brownfield: mixed use, car-reduced	41

endeavors. And they should foster community participation to build support as the project evolves, and to ensure the endurance of the vision for the development once it is built.

The top lessons learned from these case studies closely align with the Principles for Transport in Urban Life, and are as follows:

1. Develop neighborhoods for walking and prioritize bicycling networks.

The majority of developments in the case studies provide direct, safe and comfortable walking and cycling routes, and plentiful covered cycle parking. They also use a technique called "filtered permability" to make travel by bicycle or foot more direct than by car (Table 2), and locate bicycle parking closer to homes than car parking. This gives walking and cycling a competitive advantage over the car. Some are beginning to use bike sharing to encourage occasional bike use by visitors and residents alike.

These developments are built with pedestrians and cyclists in mind; dense networks of streets allow pedestrians and cyclists to pass, even where cars cannot (filtered permeability). This design is reinforced with low speed limits and traffic calming. By making car use less convenient than other modes, residents are subtly nudged to consider other modes.

2. Provide high-quality transit.

The transport in all of the case study areas is responsive to resident needs, and therefore has high mode share. Stops are within half a kilometer of every home, and service frequencies are at least every 15 minutes. Integration into the regional transit network and long service hours all make riding convenient while low-cost period passes keep it affordable. By optimizing conditions for walking, cycling and transit, living car-free becomes more realistic. Many developments also provide nearby carsharing locations to help residents feel more comfortable giving up their private cars.

3. Create compact regions with short commutes and zone new developments for mixed use.

These case studies also suggest that new developments should be planned as closely as possible to existing job centers and other destinations. This makes investments in transit and cycling networks more efficient and effective. Mixed uses (housing, jobs, leisure facilities, shops, grocery stores, etc.) should be incorporated into new developments at site selection and masterplanning stage, to minimize travel distances, enabling residents to make routine trips on foot or by bicycle, with convenient public transportation offering a realistic alternative to the car.

4. Increase mobility by regulating parking and road use.

In addition to the nudges the urban design of these communities provide, many also use regulations to incentivize and in some cases mandate reduced car use, using a variety of techniques including placing stringent caps on car trip generation and CO_2 emissions and relaxing parking minimums if other criteria to reduce car demand are met. In many of the cases, parking supply has been reduced and the parking that does exist is separated spatially and fiscally from housing units. In some cases the planners have also required developers to fund or build transportation infrastructure and services (including mobility management services) as a condition of site approval. Masterplanning competitions can foster further innovation in both the built environment and transportation planning.

Table 2: Mode share and car ownership rates for study sites and reference areas

Location	*Mode share (proportion of all trips)* by car	by transit	by bicycle	on foot	Cars per 1,000 residents
Greenwich Millennium Village	18%	49%	4%	29%	350
Greenwich District	44%	29%	1%	26%	350
GWL Terrein	6%	14%	50%	30%	190
Amsterdam West	20%	18%	32%	30%	310
Hammarby Sjöstad	21%	52%	9%	18%	210
Stockholm Reference District	35%	50%	7%	8%	n/a
City of Houten	34%	11%	28%	27%	415
City of Zeist (The Netherlands)	46%	11%	29%	14%	530
Sihlcity: visitor trips	30%	70% (transit, cycling, walking combined)			—
Letzipark: visitor trips	n/a	n/a	n/a	n/a	—
Stellwerk 60	21%*	53%*	31%*	29%*	60
Nippes District	61%*	33%*	3%*	3%*	309+
Västra Hamnen	23%	17%	31%	29%	440
City of Malmö	41%	16%	23%	20%	480
Vauban#	16%	19%	64% (bicycle/walking combined)		160
City of Freiburg#	30%	18%	28%	24%	393

* Mode share based on distance traveled
\+ Data for the smaller Nippes Stadtteil
\# Mode share data from 1999/2000 (prior to extension of the tram system to Vauban)

5. Market sustainable transportation.

Many of these developments make ongoing efforts to reinforce their founding vision and to empower residents and visitors to make sustainable travel decisions by offering tailored mobility advice, running marketing and awareness campaigns, and through promotions such as free or discounted transit passes or car-sharing membership for new residents. Ongoing measures to encourage low-emission travel behavior are important to ensure the long-term transport sustainability of residents. Planners should consider whether the developers should be asked to fund these initiatives or if there are ways to create dedicated streams of revenue (e.g. by earmarking a portion of parking fees or outdoor advertising fees/space) to fund them over time.

6. Don't forget the larger policy context.

Transportation policies at the city, regional and national levels play a key role in shaping daily travel behavior and residential locations in the longer-term. Congestion charges, citywide parking management policies, high fuel prices, and high quality transit all influence mode choice, reinforcing site-specific measures such as car-access restrictions, provision of high quality walking and cycling facilities and filtered permeability. All of the case study cities are served by national railroad systems, providing an alternative to the car for longer-distance journeys, thereby complementing measures to discourage car ownership and use in the local area.

A comparative analysis is presented in chapter ten, providing an overview of TDM measures, details of transit provision and urban design features, and a summary of key transport-related sustainability indicators: car ownership, modal split (summarized in Table 2) and transport-related emissions.

In summary, it was found that private car use accounts for less than 35% of all trips made by residents in all of the sites (Stellwerk 60 result inferred from distance-based data), a figure that is generally lower than comparable sites without integrated TDM strategies. Car ownership was found to be no more than 440 vehicles per 1,000 residents in the residential developments, and less than 200 in sites with priced, limited and spatially separated parking: GWL Terrein, Stellwerk 60 and Vauban. These sites generate less than 350 kg of car-related CO_2 per capita per annum, equivalent to savings of around two thirds compared with their reference areas. These figures demonstrate both the efficacy of TDM measures and the importance of building in the right location, close to centers of existing economic and social activity.

Further Research Needs

Further household research should be conducted to update the case studies as necessary and to add to the evidence base justifying the implementation of these policies and practices in Western Europe and in new developments around the globe. Additional quantitative research is required to assess both the demand for car-free living and the financial performance — in terms of rental and property prices — of heavily car-reduced and car-free areas. This would encourage local authorities, planners, investors and developers to be more pro-active in considering this type of development, which has been shown to reduce car dependence and transport-related CO_2 emissions significantly. Many of the lessons learned are replicable or adaptable for implementation elsewhere: the task now is to communicate the successful and transferable policies to politicians, planners and other relevant stakeholders across the world.

CASE STUDY

Greenwich Millennium Village

LONDON, UNITED KINGDOM

Nicole Foletta, ITDP Europe

GMV SITE FACTS

- **Developer:** Greenwich Millennium Village Limited (GMVL)
- **Architect:** Ralph Erskine
- **Population:** 2,300
- **Developed Area:** 20 ha
- **Total Area:** 29 ha
- **Current Density:** 120 persons/ha
- **Projected Density:** 180 persons/ha
- **Current Residential Units:** 1,095
- **Planned Residential Units:** 2,900
- **Construction Began:** 1999
- **Planned Completion:** 2014
- **Distance from City Center:** 9 km
- **Cars:** 350 cars/1,000 residents
- **Parking Spaces/Residence:** 0.8
- **Non-motorized Mode Share:** 32%
- **Public Transport Mode Share:** 49%

BACKGROUND

Greenwich Millennium Village (GMV) is an excellent example of mixed-use, brownfield redevelopment, well-served by transit, with strict parking regulations and a layout that limits through car traffic (Photo 1). While car ownership rates in the development are only marginally better than in the surrounding area, car use is significantly lower.

GMV is located on the Greenwich Peninsula, a 121-hectare brownfield redevelopment site formerly occupied by the town gas works, on the southern banks of the River Thames in southeast London, about 9 kilometers from the London city center. In 1997 English Partnerships[1] committed to transforming the Peninsula, one of the largest development sites in London, into a new residential community. The regeneration project is currently in phase one of a twenty-year build program, which will see 10,000 residential units, leisure and retail facilities, as well as educational and health centers. GMV occupies 29 hectares on the south-eastern side of the Greenwich Peninsula.

The project was the first "Millennium Community" to be identified by English Partnerships and is being developed by Greenwich Millennium Village Limited, a joint venture between Countryside Properties and Taylor Wimpey. The Millennium Communities Programme was launched by English Partnerships alongside the Department for Communities and Local Government to create seven exemplary sustainable communities nationwide. Each of the seven communities is to incorporate high-density housing, green spaces, good transport links, and easy access to shops and recreation facilities, producing quality places where people want to live. In order to ensure that sustainability goals are met, the Millennium Communities Programme has set standards for energy efficiency, water consumption, transport, building defects, recycling and health and safety on site. In line with these goals, the housing at GMV is of modern, environmentally-friendly design, and the development aims to cut primary energy use by 80%, compared to traditional developments of similar size, using low-energy building techniques and renewable energy technologies. Finally the project aims to reduce car dependency by giving priority to cyclists and pedestrians, providing access to high quality public transportation, and restricting and pricing car parking (Photos 2 and 3).

London is one of the largest and most congested cities in Europe, it has also been on the forefront of fighting congestion in part by reducing demand for private car use. While policies like congestion charging have been successful in Inner London, car use remains prevalent in Outer London. Therefore it is important for developments such as GMV, located outside the city center, to implement strategies aimed at reducing car dependency.

GMV is marketed as an experiment in sustainable development. New residents are given a packet of information on sustainable living when they move in. Various studies have shown that residents support the concept and ethos of the village. Further, they appreciate the sustainable design features and enjoy being part of the special community, demonstrating the project's success not only as a sustainable development, but as a liveable community as well (*Cherry and Hodkinson 2009*).

To date, 1,095 homes, a primary school, a health center, an ecology park and a village square with shops have been completed, on 20 hectares (Figure 1). All of the residential units are currently occupied.

The homes completed include a number of live/work units and a wide range of affordable housing. Developers plan to continue expansion of GMV until 2014, including additional housing, retail, and a community center, with a total developed area of 29 hectares for the entire village (*English Partnerships Website*).

PLANNING PROCESS

In 1997, English Partnerships launched a competition to design and build Greenwich Millennium Village, the first community in the Millennium Communities Programme. The competition was won by Greenwich Millennium Village Limited (GMVL), a joint venture between Countryside Properties and Taylor Wimpey. English Partnerships and GMVL signed a Section 106 Agreement (see *Section 106 Agreements* sidebar, p. 11) in which GMVL agreed to build a sustainable mixed-use residential development of 1,400 dwellings

Figure 1: Map of GMV

[1] English Partnerships was a non-departmental public body funded through the Department for Communities and Local Government. It was responsible for land acquisition and assembly and major development projects, alone or in joint partnership with private sector developers. In December 2008 its powers passed to a successor body, the new Homes and Communities Agency.

with 20% designated as affordable housing. For the affordable housing portion of the development, GMVL is working in association with social housing partners Moat Housing. GMVL also agreed to contribute a specified sum for bus improvements in the area and to submit a parking garage management plan.

In return, English Partnerships agreed to fund the Millennium Busway, a bus only lane running through the development, as well as a state of the art integrated school and health center, which opened in 2001 (see Figure 1). English Partnerships also agreed to produce an annual travel monitoring study including analysis of mode split and parking demand of GMV residents in addition to a strategy plan for reducing car use.

Construction of GMV began in 1999 and the first homes were occupied by 2000. Phases 1 and 2 of the building process were completed by 2002, producing 1,095 residential units, a village square with shops, an artificial lake and an ecology park.

In 2006 a new Section 106 Agreement was signed between the Greenwich Peninsula landowners, English Partnerships, and GMVL. This agreement increased the planned development size from 1,400 to 2,900 residential units and increased the required share of affordable housing from 20% to 35%. The agreement laid out the plans for Phases 3 and 4 of the development which will include construction of around 1,800 additional new homes, 15,000 square feet of retail spaces, 70,000 square feet of work space, a community center and a nursery. The planned completion date for Phases 3 and 4 is 2014 (*English Partnerships Website*).

SECTION 106 AGREEMENTS

These agreements refer to Section 106 of the British Parliament's Town and Country Planning Act of 1990, which regulates the development of land in England and Wales. Section 106 permits local authorities and developers to make agreements over the use of land, including planning obligations by the developer to contribute towards sustainable communities and offset the costs of the external effects of the development. Contributions by the developer may include cash, infrastructure investments or provision of services. Examples include provision of new schools, public space, affordable housing, new roads and public transport. Section 106 agreements are legally binding and are linked to the granting of planning permission. Each agreement is different and depends on the unique needs of each community. Some agreements may include measures aimed at reducing transport-related emissions. Transport-related measures that have been included by the Greenwich Council (specifically for the Woolwich Town Centre Development) include: provision of carsharing, controls on parking permits, emission-related parking charges, provision of electric vehicle charging points and use of bio-fuel in delivery vehicles (*Birch 2010*).

KEY POLICY AND DESIGN STRATEGY

The Millennium Communities Programme has recognized reduced car dependency as a key sustainability issue. This is especially apparent in the city of London which has limited room for additional parking spaces and a high level of traffic congestion. Spurred by these concerns, GMV has incorporated several transportation demand management strategies aimed at reducing car dependency and promoting other, more sustainable forms of transport.

Parking

As part of its strategy to reduce car dependency, motor vehicle parking at GMV is restricted and generally located away from individual properties. Parking spaces are only available for 80% of units. Two floors of parking garage are located beneath two of the apartment buildings built during Phase 1. In Phase 2, car parking facilities were separated from apartment units and located at the edge of the development. Overall there are 884 parking spaces in the development.

Further, parking spaces are unbundled from apartment units, so residents who choose to have a parking space must pay for it separately from their residence. Residents don't pay for a specific parking space, but rather for a "right to park," which means they can enter the parking garage and must then search for an available space. Prices per space have gone up since the development was first built, but the current price is 17,500 GBP per parking space (*Marcello Burbante, pers. comm.*).

Only residents who have purchased a space are allowed to park in the garages; visitors are not allowed. Visitors are expected either to park temporarily in the bays on the main roads, which are frequently ticketed by the council, or in the public parking lot next to the North Greenwich transit station located 0.8 kilometers northwest of GMV. However, during school holidays people are informally allowed to park in the school's parking lot. In addition, residents often rent out their spaces to neighbors during the winter holidays by advertising on bulletin boards in the shared spaces. In this way, residents have taken it upon themselves to manage the existing parking supply as efficiently as possible, treating it as a valuable commodity.

Cycling and Pedestrian Infrastructure

On the flip side, GMV strives to promote cycling and walking. A network of cycle and pedestrian routes runs throughout the village and beyond, connecting the development to the surrounding areas. For example, a pedestrian walkway leads from GMV to The O2 Arena, a large sports and music venue located in the Millennium Dome on the northern side of the Greenwich Peninsula. Within GMV, secure bicycle storage facilities are provided for every housing unit and 2–3 bicycle parking spaces are available per unit, including several covered, weather-protective bicycle parking facilities (Photo 4).

Carsharing

Two carsharing vehicles, provided by Streetcar, are located just to the north of GMV (*Streetcar Website*). These vehicles are located in a car bay on John Harrison Way, which boarders GMV. In addition, two Streetcar carsharing vehicles are located in a parking lot off of Tunnel Avenue, about half a kilometer south of GMV. Other than these four

1
Greenwhich Millennium Village

2
North Greenwich Transit Station

The Underground is the most popular mode of transport for GMV residents. The new station was built to allow for larger volumes of passengers and provides direct connection between the Underground and 8 bus routes.

3
Millennium Busway

The Millennium Busway runs from the station through GMV, with two stops located within the village.

4
Bicycle parking

Secure bicycle storage is provided for every housing unit, and 2–3 bike parking spaces are available per unit.

vehicles, no other carsharing vehicles from any other companies are located on Greenwich Peninsula. There seems to be a potential to locate more carsharing vehicles on this site, particularly inside the GMV parking garages themselves.

Urban Design

GMV was designed by masterplanning architect Ralph Erskine to be a modern urban village, incorporating high density residential units with green public spaces and providing opportunities for leisure activities and shopping. Erskine was known for his preference for design with limited through car traffic. He also worked on the Bo01 car-free development in Malmö. In line with these principles, Erskine's vision for GMV was to create a community where the pedestrian has priority over the car.

Street Layout and Design:

Main thoroughfares run along the northwest and southwest borders of the development. Further, two main thoroughfares run through GMV. West Parkside bisects the development, while Southern Way splits off from West Parkside midway through the development and runs southward. A two-lane dedicated busway which starts at North Greenwich station passes through the village along West Parkside, turning onto Southern Way (Figure 1). The busway is separated from car lanes by a green median. The busway is distinguished by its brick-red color. On the south side of the village is a road that leads to the school parking lot. Other than these roads, the development is car-free and priority is given to cyclists and pedestrians.

Public Space Design:

Provision of public spaces was an important component of the design. The village includes an ecology park, a village square and landscaped courtyards. The ecology park, covering 0.2 square kilometers, includes two lakes and a thriving wildlife population. In addition, garden squares are located through-out the residential areas. The design gives priority to the cyclist and pedestrian, providing pedestrian and cycling pathways separated from motor vehicle traffic throughout the village. Furthermore, safety is enhanced through monitoring of transit stops, cycle routes and pedestrian areas by CCTV.

Land Use Planning and Design:

GMV was designed from the beginning as a mixed-use development combining residences, retail, commercial and leisure spaces. Phase 1 of the development consists of blocks of flats 8-10 stories high, surrounding inner courtyards, with two floors of parking garages beneath. The highest buildings are located on the northern side of the development, along the Thames River, to provide more waterfront views. Phase 2 includes a mix of lower rise flats up to six stories and terraced houses situated around public squares with car parking in a separate block at the side of the development. The residential units include a mix of tenure types.

The village square is located near the center of the development, conveniently located within walking distance of residential units so that residents can easily conduct shopping trips and errands by bike or on foot. The uses in the village square include a small grocery store, a pharmacy and several cafes. Overall, the development includes 4,500 square meters of commercial space along with community facilities such as a school and health center (*Countryside Properties Website*).

QUANTITATIVE ANALYSIS

The policy and design measures used by GMV work. GMV has a much higher residential density than the Greenwich District, in which it is located, or London as a whole. And GMV residents are far less likely to use a private car (18%) as compared to their Greenwich neighbors (44%) or Londoners overall (42%). The car ownership rate per resident is also lower for GMV than for London (Table 1).

Table 1: GMV as compared to surrounding area

	GMV	Greenwich	London
Population	2,300	223,000	7,600,000
Area *(ha)*	20*	4,700	170,000
Population density *(persons/ha)*	120	47	45
Residential units	1,095	100,000	3,000,000
Cars per 1000 residents	350	350	370
Car parking spaces / residential unit	0.80	NA	NA
Mode share for all trips			
Car	18%	44%	42%
Public transit	49%	29%	25%
Bicycle	4%	1%	2%
Walking	29%	26%	31%

*current developed area

Rutherfords, 2005; Transport for London, 2009

Car Ownership Rates

Figure 2 provides a comparison of car ownership rate per household for various segments of London. The rate for GMV falls between that of Inner London, where households are generally less car dependent, and that of Outer London, where households are typically more car dependent. The rate for GMV also falls below that for London. These figures demonstrate that many households in GMV choose to live car-free, although the car ownership rate is still not quite as low as it is in Inner London.

Mode Split

However, while car ownership in GMV is higher than for Inner London, car use in GMV appears to be much lower than for other areas of London, even Inner London. As seen in Figure 3, only 18% of trips made by GMV residents are by car, which is much lower than for Greenwich (44%), Inner London (29%), Outer London (51%) and London (43%). The GMV data was collected through a survey of residents conducted to fulfill the requirements for the Section 106 Agreement, and included in the Travel Monitoring Study 2005 Report.

Public transit use is high in GMV, particularly for trips to work. Indeed, the majority of GMV commuters (79%) travel to work by public transit. The breakdown by type of public transport shows that 73% of commuters travel to work by London Underground. This is not surprising given GMV's easy access to the Jubilee Line, connecting the development to central London, and the high cost of driving to central London due to the city's congestion charge. Figure 4 shows that a much larger proportion of GMV residents (79%) commute to work by public transit than Inner London residents (59%), Outer London residents (38%), and overall London residents (46%). Further, the proportion of GMV residents commuting to work by car is very low.

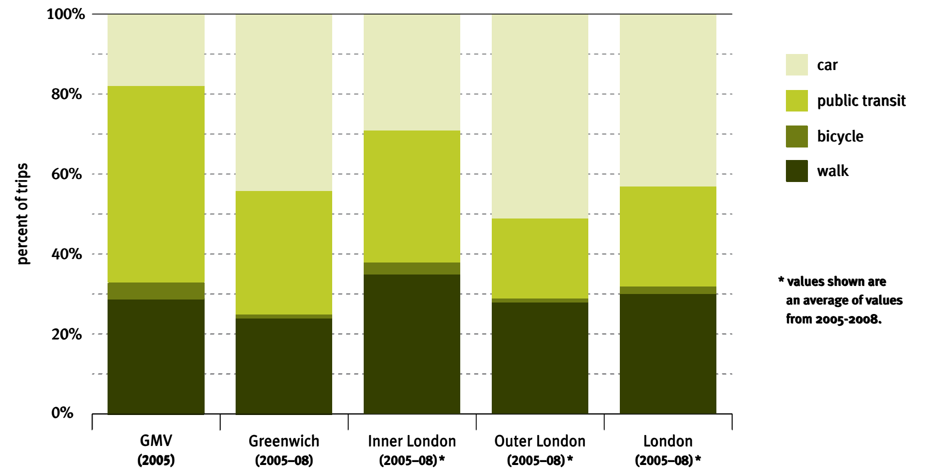
Although a small proportion of GMV residents walk or cycle to work, a much higher number walk or cycle for other trip purposes such as traveling to school and shopping (see Figure 5). Nearly one-third of those who study walk to school, however, almost a quarter drive. These results are likely due to the mix of student types; children are more likely to walk or cycle to school within the village while adults taking classes outside the district might be more likely to drive.

Further, while about half of residents use their car for their main

Figure 2: Car ownership of GMV as compared to surrounding area

Rutherfords, 2005; Transport for London, 2010

Figure 3: Mode split for all trips



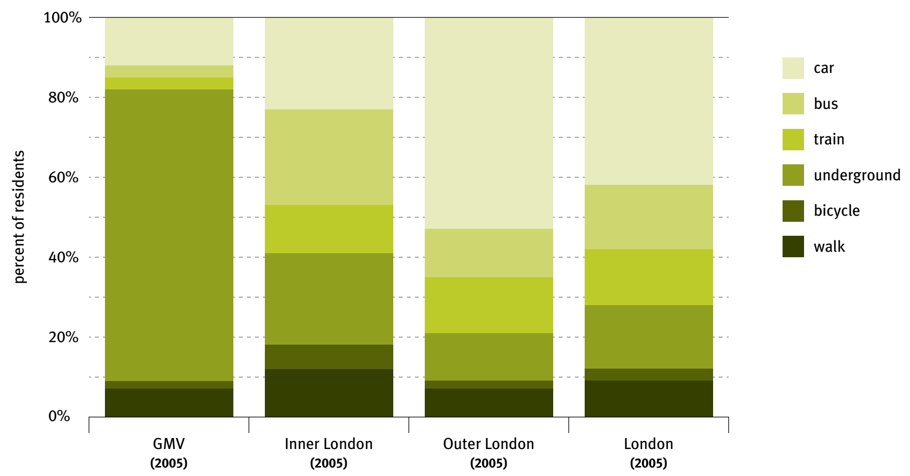
Rutherfords, 2005; Transport for London, 2009 weekly food shopping trip, one-third walk or cycle for this trip. Many may travel to Sainsbury's for this trip, the first low energy food store in Britain, which is located just south of GMV (within one kilometer of most residences). The store is 50% more efficient than a standard supermarket, incorporating use of natural light, high levels of insulation, passive ventilation and under-floor heating systems (*GMV Website*). However, while the supermarket has a focus on energy sustainability, it seems to have overlooked transport sustainability as it caters to the car; the store is located next to an extensive parking lot with more than 300 free to use spaces. The ease of accessible parking might encourage GMV residents to drive to the store rather than cycle or walk. The store is also accessible by bus; however, Figure 5 shows that few residents travel by bus to the grocery store.

Not included in Figure 5 are those who have groceries delivered. The resident survey found that eight percent have groceries delivered to their residence (*Rutherfords 2005*). This reduces the number of trips made by residents, but the effect on carbon footprint of these trips depends on delivery vehicle fuel and scheduling efficiency.

In addition, more than half of residents walk or cycle for other shopping trips. Providing a wide variety of shops in the village makes it more convenient for residents to walk for these trips. The survey of residents was taken in 2005, and the number of shops in the village square has been expanded since that time, so it is likely that a more current survey would show a higher proportion of walking and cycling trips.

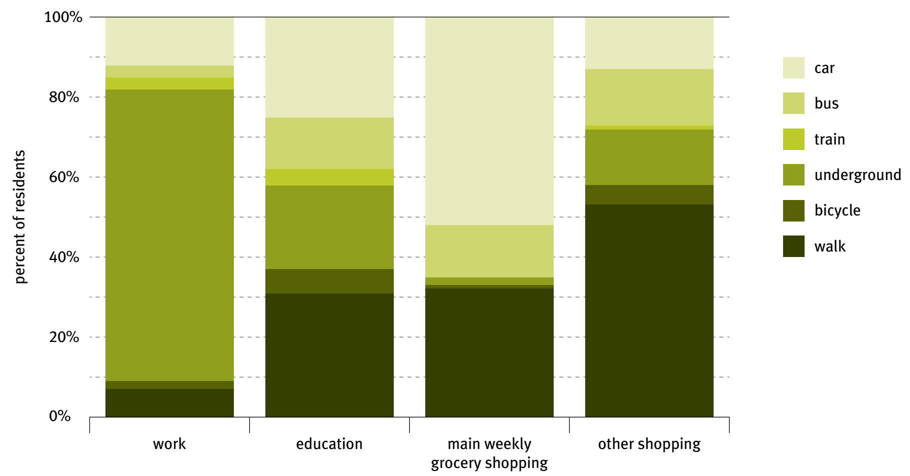
Many live/work units are provided at GMV to encourage residents to work from home, thus reducing the number of commute

Figure 4: Mode of travel to work



Rutherfords, 2005; Transport for London Website

Figure 5: GMV resident mode of travel for various trip types, 2005



Rutherfords, 2005

trips. Several more live/work units are planned as part of Phases 3 and 4. Overall it was found that 7% of GMV residents work from home. This is similar to the proportion for Greenwich (7%) and slightly lower than for Inner London (9%), Outer London (9%), and London (9%) (*Rutherfords 2005*).

The results of this analysis show that the policy and design measures applied in GMV appear to have had a strong influence on reducing car trips made by residents, however potential remains to increase cycling trips, particularly within the development.

LESSONS LEARNED

While GMV residents drive less than their neighbors due to strong policy and design measures, overall car ownership remains higher than some of the other communities we reviewed. This is due in part to the location of GMV, far from central London, which demonstrates the importance of locating new development as close as possible to existing development.

The good news is, GMV's good public transit access, combined with the existence of London's congestion fee, have resulted in an impressive commute mode share of 79% by public transit.

Yet the travel choices of residents within the GMV development could still be improved. About half of residents travel by car for their weekly grocery shopping trip. Increasing the number and diversity of stores located at GMV could encourage more walking and cycling trips within the development as opposed to driving. Eight percent of residents already have groceries delivered; stores could further promote this service to encourage shoppers to leave their cars at home. It is important to ensure that these deliveries are made using sustainable transportation practices.

GMV also provides live/work units. However, at the time of the survey in 2005, the presence of these units did not seem to increase the proportion of residents working from home above that of the surrounding area. Promotion of these units and addition of units in Phases 3 and 4 may encourage more residents to work from home. Home offices have the obvious benefit of reducing commute trips. However, some studies have shown an increase in other trips due to the increased flexibility of the work schedule. This is another reason why it is essential to provide amenities within walking distance of residences in order to encourage residents to walk and cycle for their daily needs rather than traveling outside the development by car to access goods and services. ■

SOURCES

Birch, Carolyn (2010). *Using Section 106 Agreements to Improve Air Quality*, Communities and Local Government, London.

Cherry, Alan and Hodkinson, Richard (2009). *Millennium Homes Revisited*, Ingenia, Issue 41, December 2009. http://www.ingenia.org.uk/ingenia/issues/issue41/Cherry_Hodkinson.pdf

Communication with Kim Smith, Transportation Planning and Strategy Manager, Greenwich Council, May 4, 2010.

Communication with Marcello Burbante, Greenwich Millennium Village Ltd. (GMVL), September 3, 2010.

Coutryside Properties website, http://www.countryside-properties-corporate.com (accessed September 21, 2010).

Department for Communities and Local Government (2004). *Contributing to Sustainable Communities — A New Approach to Planning Obligations*, Eland House, London.

English Partnerships (2007). *Millennium Communities Programme*, London. http://www.urbandesigncompendium.co.uk/public/documents/Mill%20Comms%20May%202007.pdf

English Partnerships website, http://www.englishpartnerships.co.uk/gmv.htm (accessed June 28, 2010).

GMV website, http://www.gmv.gb.com/transport.htm (accessed September 21, 2010).

Rutherfords — Highway & Transport Planning (2005). *Greenwich Millennium Village: Travel Monitoring Study, 2005 Report*, Cambridge.

Streetcar website, http://www.streetcar.co.uk/location.aspx?location=633 (accessed September 21, 2010).

Transport for London (2008). *Central London Congestion Charging: Impacts Monitoring — Sixth Annual Report*, London.

Transport for London (2009). *Travel in London — Key Trends and Developments Report Number 1*, London.

Transport for London (2010). *Travel in London: Report 2*, London.

Transport for London website, http://www.tfl.gov.uk/ (accessed September 21, 2010).

Image credits

Figure 1: http://maps.google.de/maps/ms?hl=en&ie=UTF8&vps=3&jsv=298d&oe=UTF8&msa=0&msid=116478322990710211544.000491ed99cace2d3ecac

Photo 1: Andrew Sparkes, www.pinholedesign.co.uk

Photo 2: Nicole Foletta, ITDP Europe

Photos 3, 4: Frederique Siegel, ITDP Europe

GWL TERREIN SITE FACTS

Developer: Ecoplan Foundation

Architect: Kees Christiaanse

Population: 1,400

Area: 6 ha

Density: 230 persons/ha

Residential Units: 600

Construction Began: 1995

Construction Completed: 1998

Distance from City Center: 3 km

Cars: 190 cars/1,000 residents

Parking Spaces/Residence: 0.20

Non-motorized Mode Share: 80%

Public Transport Mode Share: 14%

Households with Carsharing: 26%

CASE STUDY

GWL Terrein

AMSTERDAM, THE NETHERLANDS

Nicole Foletta, ITDP Europe

BACKGROUND

GWL Terrein is a car-free brownfield redevelopment with limited parking, carsharing provision and good transit access. Non-motorized mode share in the development is much higher than the surrounding area and car use is much lower.

GWL Terrein is located in the famously cycling-friendly city of Amsterdam. The project is in the Amsterdam West District, three kilometers from the city center at the terminus of a tram line and the very edge of the late 19th century city extensions. It makes use of a six hectare site formerly used by the municipal water utility, Gemeente Waterleidingen (GWL), from which it gets its name (Photos 1 and 2). Local residents were involved in the design and development of the project. They wanted to push forward with a new approach to development focused on car-free living, reuse of resources, conservation of energy and water, and community cohesion.

The inner area of the development is car-free and only emergency vehicles are allowed on site. The original residents were asked to sign a non-obligatory declaration of support for the car-free nature of the site. None of the 600 residential units include parking spaces, however, several on-street parking spaces are located along the edge of the development and a limited number of parking permits are available for residents.

GWL Terrein's environmental and social goals make it a unique place to live. The car-free inner area creates a cleaner, safer place for neighbors to interact and children to play. The focus on energy efficient building design and promotion of sustainable transportation helps reduce the carbon footprint of residents. Furthermore, the work of the residential umbrella organization encourages sustainable living and community involvement. It is no surprise that the development consistently receives high satisfaction ratings from residents, which is further underscored by the fact that 62% of residents have lived in the development for more than eight years (*GWL Terrein Website*). Once residents move here they don't seem to want to leave. What began as an idealistic experiment in combining high density housing with green principles appears to have produced a neighborhood its original proponents can be proud of, even ten years later.

PLANNING PROCESS

GWL Terrein occupies the former site of the Municipal Water Company. When the water company decided to move, residents of what was then the Westerpark District (now part of the Amsterdam West District) lobbied for the location to become a residential area, while companies operating nearby wanted the location to be zoned for industrial purposes. The residents won out and in 1989 the Amsterdam city council decided to zone the area for housing. Local residents remained actively involved in the decision process and appealed for a car-free eco-district. This idea was also supported by politicians and the local community center.

In 1993 the basic principles for the site were described in an Urban Planning Schedule of Requirements (SPvE). The site was to be car-free and aimed to discourage car ownership and use by ensuring good public transport, a safe environment for pedestrians and selecting inhabitants who agreed with the ecological principles of the project. Environmental goals also included reduction in water and energy consumption. In addition, it was decided that half of the dwellings would be reserved as renter-occupied, social housing. The other half would be sold, two-thirds of which would be grant-aided owner-occupied dwellings. Furthermore, local residents would have priority in applying for dwellings.

The Westerpark Urban District commissioned two architecture firms to create a conceptual plan for the development based on the Urban Planning Schedule of Requirements. In August 1993 the plan made by architect Kees Christiaanse and landscape designer Adriaan Geuze was chosen by a panel consisting of several inhabitants, representatives of the Westerpark Urban District and the project developer. This panel, along with the architect, then collaborated to create an Urban Plan for the development, which was completed in November 1993. The Environmental Advisory Bureau (BOOM) was also involved in the process to ensure that the environmental aspects of the Urban Planning Schedule of Requirements were upheld.

Given the strict environmental requirements proposed, private investors were not interested in developing the site. Ultimately five housing associations set up the Ecoplan Foundation as a joint venture to coordinate and finance the development. Future inhabitants continued to be involved in the design process. In 1994, five design teams were created, each with an architect and several inhabitants, to design various sections of the development. Construction took place in three phases, starting in 1995 and ending in 1998 (Photos 2 and 3) *(GWL Terrein website)*.

Figure 1: GWL Terrein site map

KEY POLICY AND DESIGN MEASURES

From the start, GWL Terrein had a focus on reduced car usage and sustainable living. These sentiments came from local residents of the Westerpark District and were supported by the local government. Several policy and design strategies have been incorporated into the site to help actualize this ideal. These are described below.

Urban Design

As mentioned, the entire six hectare site of GWL Terrein is car-free. The development consists of 17 buildings along with the renovated pump engine building, which is now home to a café. The buildings are arranged to form a high density perimeter, while the inner areas remain open, including plenty of green public spaces, wide pathways and safe areas for children to play (Photo 4).

Street Layout and Design

Since cars are not allowed on site, no streets pass through the development. Furthermore, signs are posted at various entrance points, stating that no motorized vehicles are allowed on the site (Photo 5). In order to enforce this, the development is raised from street level so that cars do not have access to the inner area (Photo 6). However, ramped access points are located at certain entrances to the development, and sometimes motorized two-wheelers illegally enter the development. Police officers patrol the area to limit these infractions.

Van Hallstraat (Photo 7), an arterial street at the eastern border of GWL Terrein, was traffic-calmed in 1999 with on-street parking removed, speed reduced, sidewalks widened and the tram terminus rebuilt and extended (*Scheurer 2001*). Van Hallstraat also has a brick-colored cycle lane. Near the tram terminus, this cycle lane is bordered by the tram platform and two tram lanes. Beyond the tram lanes are two lanes of traffic, followed by car parking and another cycle lane at the furthest side of the street. For the rest of Van Hallstraat the cycle lane bordering GWL Terrein is protected by a tree-lined median. Beyond this median are two car lanes. At the far side of the street is a lane for car parking and another cycle path. In this way, cycle lanes are protected from moving traffic either by a row of trees, a tram platform, or a strip of parked cars.

Public Space Design

A variety of public spaces are available between the buildings, including public green spaces, children's play areas, shared gardens and mixed use pathways. This is important, since in such a high density development, it is impossible to provide each residential unit with a private yard. Beyond being a more efficient use of space, these shared spaces provide residents with more chances to interact, building their sense of community.

An artificial canal effectively divides the development into two parts. To the north is an urban square surrounded by a nine-story residential building with ground floor retail. To the south the site is more garden-oriented with open green spaces and children's play areas. The children's play areas are located away from the street and have been praised by many families as being safe places where their children can play near home. In addition, several shared garden allotments are provided; which are surrounded by a protective wall of shrubbery. Within these spaces, residents can rent a garden allotment. The gardens give residents another opportunity to interact with neighbors and also provide residents with a sense of ownership for the public spaces.

The area does not have any dedicated cycle lanes, but rather provides wide, mixed use pathways (shared by pedestrians and cyclists). One perspective is that this mix of uses can actually improve safety because both cyclists and pedestrians are more aware of their surroundings, looking out for fellow travelers rather than assuming that paths will be segregated.

Land Use Planning and Design

The site contains a few renovated historical buildings and the GWL water tower, which acts as a landmark of the district, surrounded by blocks of high density housing, designed by five different design teams, but all with a similar color scheme to bring cohesion to the development. One elongated, 186-meter long, high-rise apartment building with nine stories runs along Waterpootweg Street, the eastern border of the development (see Figure 1). Another elongated apartment complex runs along the north and northeastern borders of the site. This building structure helps to create enclosed areas within the development without applying gates or barriers between GWL Terrein and other neighborhoods. To the east, GWL Terrein is open and pathways connect the development to the 19th century neighborhoods. Overall 17 apartment buildings are located on-site. As many dwellings as possible have an entrance at street level and access to either a private ground floor garden, a rooftop garden or an open terrace. Incorporated into these residential buildings are ground floor commercial uses, live/work units, housing for persons with mental disabilities, senior housing and wheelchair accessible housing (Photo 8).

Most of the apartments have 3-4 rooms with an average of 3.44 rooms per home. This is higher than the average for the Westerpark District of 2.64 rooms per home. The average home value is also higher in GWL Terrein. In 2005 the average home value in GWL Terrein was 256,000€ versus 172,000€ for the Westerpark District. The larger size of residential units and higher quality housing are attractive features for families. Furthermore, 55% of residential units are owner-occupied and 45% are renter-occupied. Of the rented units, 60% are social housing.

Several other uses are also located on the site such as the Westerpark Community Center. The water company's pumping station was restored and the old engine room is now home to Café Amsterdam, a popular restaurant which attracts many visitors to the district (Photo 9). The remaining space in the historic pumping station was converted to offices and a gym. Overall, 50 businesses are located at GWL Terrein (many of them home businesses) employing 216 people (*GWL Terrein Website*). The mix of uses provides residents with shopping, entertainment and employment options within their own neighborhood. In addition, several grocery stores, shops, pharmacies and cafes are located in the surrounding neighborhoods so that residents do not have to go far to run their daily errands, which can easily be done by bicycle or walking.

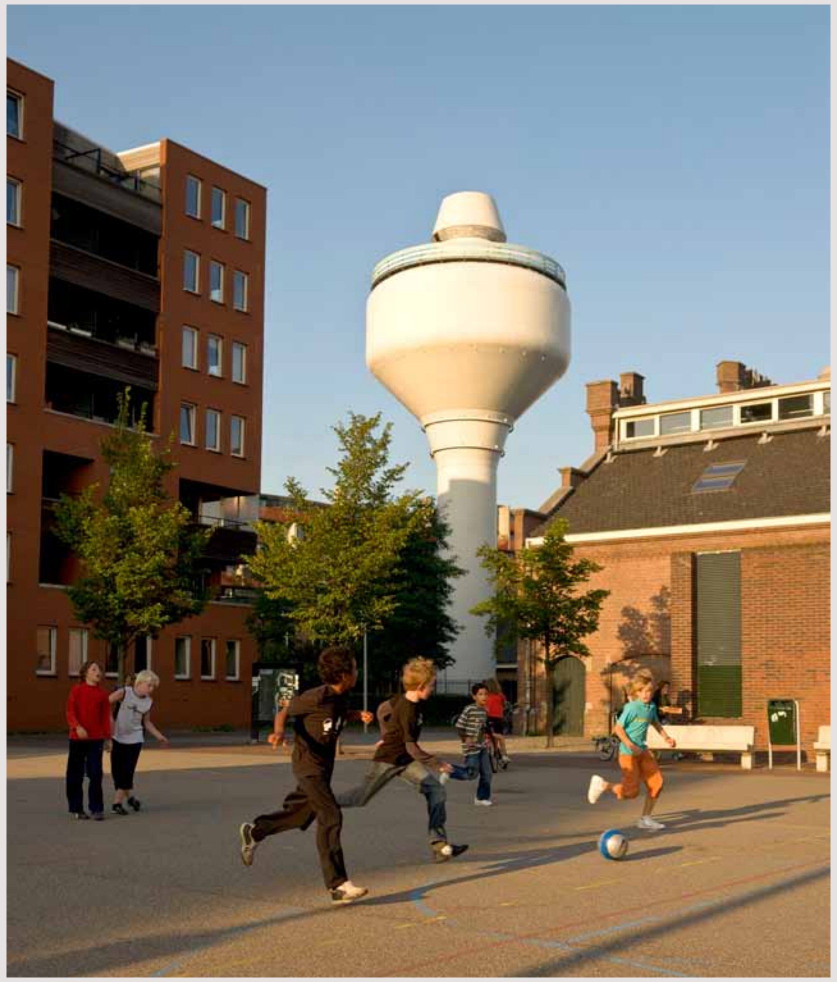
Public Transportation

GWL Terrein is well served by public transportation. Tram line 10 was extended and terminates just outside the development at the Van Halstraat station (Photo 10). The tram lanes are segregated from car

1
GWL Terrein before redevelopment

2
GWL Terrein after redevelopment

3
GWL Terrein development



4
Children playing near GWL Terrein's main landmark, the watertower

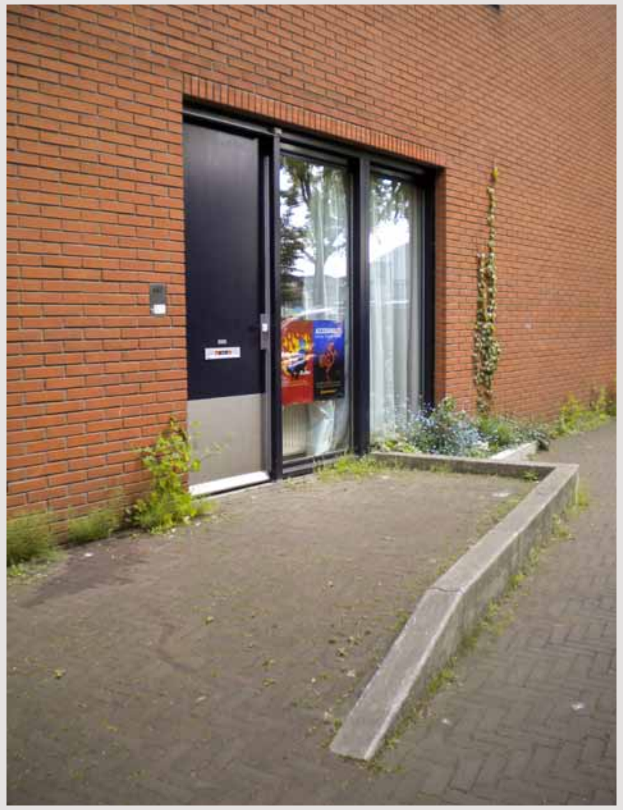
5
No motorized vehicles are allowed in GWL Terrein

6

Bollards and raised curbs prevent motor vehicles from entering.

7
Family cycling on Van Hallstraat

Half of all trips made in GWL Terrein are by bike.



8

Many ground floor units are reserved for seniors and the disabled and have ramped access for wheelchairs.

9
Café Amsterdam

10
Tram 10 at Van Hallstraat Station

traffic lanes which helps to increase tram speeds. The tram runs at 10-minute intervals. In addition, two bus lines serve the development. Bus line 21 provides service to Central Station every 10 minutes. Bus line 60 provides service to Sloterdijk Station every 10 minutes.

A variety of transit ticket types are available for travel within the city of Amsterdam. Public transportation users can buy a one-hour ticket, or daily tickets, good for unlimited travel within Amsterdam by tram, bus or metro. Seasonal passes are also available including weekly, monthly and annual passes. The fares for these passes are zone-based and discounts are available for youth and seniors. All ticket types and passes can be loaded onto the recently implemented OV-chipkaart, a contactless smartcard that must be swiped upon entering and exiting the public transport vehicle or station. In addition, smartcard users may choose to pay based on the distance they travel. The OV-chipkaart can be used on all public transportation throughout the Netherlands, although fares may vary depending on the region. (*GVB Website*)

Parking

Parking for the development is extremely limited. None of the residential units have parking spaces on-site. 129 on-street parking spaces are located on the west side of the district, five of which are reserved for carsharing vehicles and two for persons with disabilities. The remaining 122 spaces, equating to 0.2 spaces per residential unit, are part of the city's public parking supply and are therefore first-come-first-served. The spaces are metered, costing three Euros per hour (versus five Euros per hour for on-street parking in central Amsterdam). Residential parking permits for these spaces cost 16 Euros per month, which is much cheaper than hourly parking, however these permits are extremely limited. Only 110 parking permits, representing 18% of households, are available for GWL Terrein residents and those on the waitlist may wait up to seven years for a permit. Residents of GWL Terrein do not qualify for residential parking permits in the nearby neighborhoods, but some residents have been known to "borrow" parking permits in order to park their cars in the surrounding areas (*GWL Terrein Website*). A 480-space parking lot is located nearby which charges 3 Euros per hour for parking up to a maximum of 30 Euros per day. A variety of parking subscriptions are also available which range from 98 to 295 Euros per month (*QPark Website*).

Carsharing

Five carsharing vehicles are located in the parking spaces on the boarder of the development, belonging to two carsharing organizations: Greenwheels and Diks. Since one of the main goals of the development is to reduce car ownership, provision of carsharing is important to give residents access to a car without having to own one. The vehicles are very popular among residents. Over a quarter of households have a carsharing membership (*ITDP Europe 2010*). Information about the two carsharing companies can be seen in Table 1.

Table 1: Information about carsharing companies in GWL Terrein

	Diks	Greenwheels
Deposit	50 €	225 €
Monthly subscription fee	25 €	Ranges from 5–25 €
Fee per km	0.12 €	0.10 €
Hourly fee	2.75 €	2.50 €
Discounts available	None	Discount with Dutch Railway card (NS card)
Company membership option	No	Yes
Number of cars available at GWL Terrein Location	3	2

http://www.diks.net/autodate-tekst.html, http://www.greenwheels.nl

Table 2: GWL Terrein compared to surrounding areas

	GWL Terrein	Amsterdam West	Amsterdam
Population	1,400	77,510	757,000
Area (ha)	6	990	22,000
Population density (persons/ha)	230	78	34
Number of residential units	600	NA	390,000
Cars per 1,000 residents	190	310	370
Bikes per 1,000 residents	1,300	NA	730
Car parking spaces / residential unit	0.20	NA	0.72
Mode share for all trips			
Car	6%	20%	28%
Public transit	14%	18%	18%
Bicycle	50%	32%	29%
Walking	30%	30%	25%

City of Amsterdam; ITDP Europe, 2010

Development Management and Governance

The umbrella organization Koepelvereniging was created in 1996 to promote the original intentions of the development and to encourage community cohesion. The organization is funded through small fees from residents and the housing associations. Today Koepelvereniging is the one body that unifies the entire development. The organization has a website and a newsletter for residents and holds about six meetings per year to discuss community issues such as safety, maintenance and community events. The organization also employs a concierge, who is available on-site to answer questions from residents, performs minor repairs and enforces the car-free restriction (including keeping delivery vehicles from entering the development). Residents are very involved in the organization and help to plan community events, such as an annual soccer tournament held each June, followed by a community dinner (*GWL Terrein Website*). These efforts help to give residents a sense of community and enhanced focus on the environmental goals of the development.

Car-free Declaration

Initial proponents of the development had hoped to actually ban car ownership among residents, but this was not allowed. As an alternative, Ecoplan asked the initial residents of GWL Terrein to sign a non-obligatory declaration of support for the car-free nature of the site. This declaration did not require residents to live car-free, but informed them of the intention of the development. The declaration reminded residents that GWL Terrein is different from other neighborhoods. Parking in the area is difficult for a reason and sustainable forms of transportation are encouraged. Furthermore, the declaration attempted to provide residents with an enhanced feeling of community and the idea that they were involved in a unique experiment in sustainable living. However, new residents no longer go through Ecoplan. New renters are selected either by one of the five housing associations, which typically do not require a car-free declaration to be signed, or by current owners, who may freely sell their property to anyone they choose. For this reason, the umbrella organization Koepelvereniging has developed a document for new residents, explaining the goals and concepts of the project. The organization also provides advice related to sustainability and car-free living. Therefore, while new residents are no longer asked to state that they agree with the ideals of the project, they are still made aware of the project's original intentions.

QUANTITATIVE ANALYSIS

GWL Terrein is located in one of the world's leading cycling cities. The City of Amsterdam has implemented many policies to encourage cycling and walking and to reduce car use such as improved bicycle infrastructure, extensive bicycle parking facilities, robust police enforcement to prevent bicycle theft, increased bicycle use education to increase bicycle safety, reduced speed limits to improve safety and increased parking prices to reduce car use (*Daniel van Motman, pers. comm.*). However, efforts at GWL Terrein go even further. GWL Terrein residents have a 50% bicycle mode share, compared with the already high 30% in the rest of the city, further reducing the carbon footprint of residents. A comparison of statistics for GWL Terrein, Amsterdam West and the city of Amsterdam can be seen in Table 2.

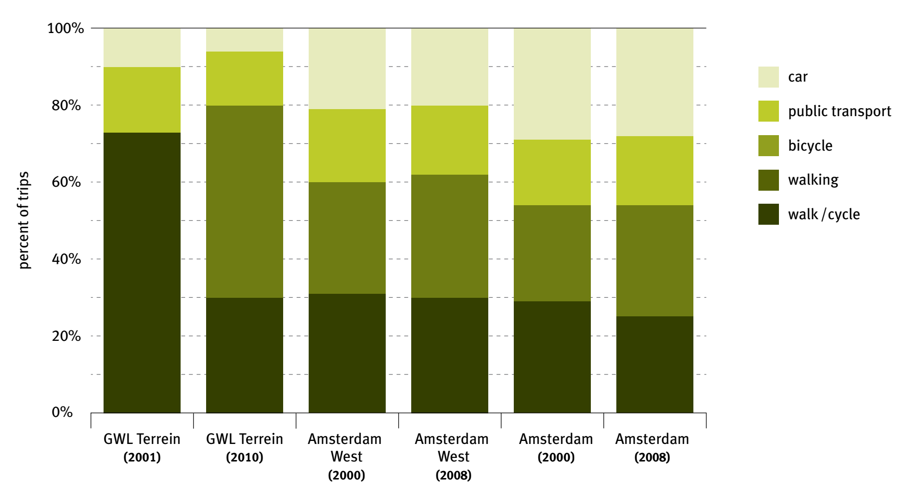
Density

GWL Terrein is about three times as dense as Amsterdam West, the district in which it is located, and more than five times as dense as the city of Amsterdam. It is even more dense than what is required for new growth, or Vinex, locations in the Netherlands (see *Vinex Locations* sidebar, p. 50). Vinex locations are required to have at least 30 homes per hectare, while GWL Terrein has 100 homes per hectare. Higher densities enable more efficient use of resources, which can contribute to reductions in carbon footprint.

Parking

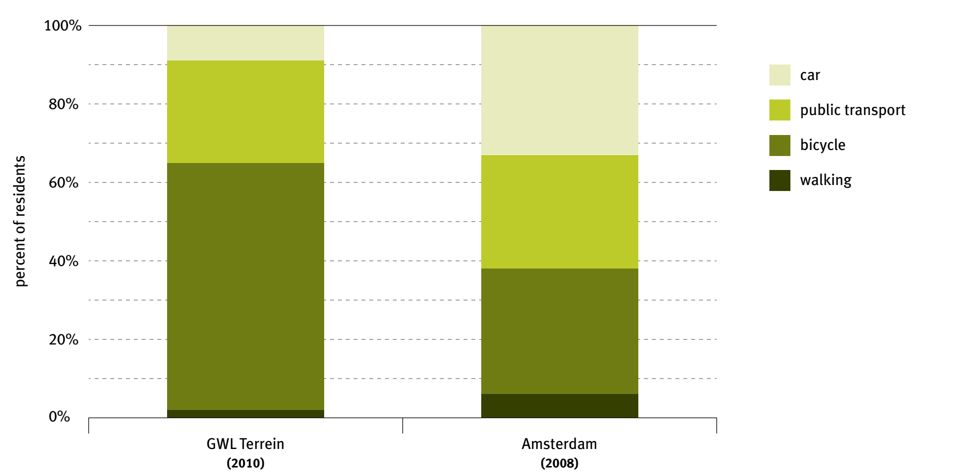
Parking at GWL Terrein is extremely limited with only 0.20 spaces per residential unit, compared to the already low 0,72 spaces in the rest of the city. Reducing the availability of parking spaces contributes to reduced car ownership rate.

Figure 2: Mode of travel for residents as compared to surrounding area



City of Amsterdam, ITDP Europe, 2010; Scheurer, 2001

Figure 3: Mode of travel to work



City of Amsterdam; ITDP Europe, 2010

Car and Bicycle Ownership Rates

In 2001 there were 172 cars per 1,000 residents in GWL Terrein (*Scheurer 2001*). A more recent, internet-based survey of GWL Terrein residents conducted by ITDP Europe in 2010 found that this number is slightly higher today at 190 cars per 1,000 residents (*ITDP Europe 2010*), still far less than the 310 cars per 1,000 residents in Amsterdam West and about half of the 370 cars per 1,000 residents of Amsterdam (*City of Amsterdam*). Furthermore, 15% of households surveyed gave up a car after moving to GWL Terrein. The number of bicycles owned per resident has not changed significantly. The 2001 survey found 1,346 bicycles per 1,000 residents, while the current survey found 1,300 bicycles per 1,000 residents. Indeed, nearly half of all respondents said that there were more than three bicycles owned by their household, and only 2% of respondents said that their household had no bikes (*ITDP Europe 2010*).

Mode Split

These policy and design measures have worked. The survey found that half of all trips taken by GWL Terrein residents are made by bike and 30% are made on foot, while only 6% are made by car (Figure 2). The share of bike trips in GWL Terrein (50%) is much higher than that for Amsterdam West (32%) and Amsterdam (29%). Furthermore, a far smaller share of trips are made by car in GWL Terrein (6%) than in West Amsterdam (20%) or Amsterdam (28%). The total share of non-motorized trips has increased slightly in Amsterdam West between 2000 and 2008 (from 59% to 62%). The share of non-motorized trips has not changed in the city of Amsterdam (54%) during the same time span, however 4% of trips have shifted from walking to cycling. By contrast, the share of non-motorized trips in GWL Terrein has increased 7% between 2001 and 2010 (from 73% to 80%).

It is also interesting to compare the mode split for different types of trips. In GWL Terrein 63% of residents travel to work by bike versus 32% for Amsterdam (Figure 3). Likewise, a smaller percent of GWL Terrein residents travel to work by car (9%) than Amsterdam residents (33%). 94% of GWL Terrein survey respondents said that they do their grocery shopping by bike, 85% conduct other shopping by bike, 93% run service-related errands (banking, doctor visits, etc.) by bike and 94% visit family and friends in Amsterdam by bike (*ITDP Europe 2010*). These statistics overwhelmingly show that cycling is the main mode of transport for residents of GWL Terrein.

While the mode share of public transportation is no higher among GWL Terrein residents than Amsterdam residents, GWL Terrein residents still consider it an important option and most residents use public transit at least once per week. In 2001 it was found that 39% of residents had some sort of periodic public transit pass, although the type of pass varied (*Scheurer 2001*). The 2010 survey found that this number had increased to 46% of residents (*ITDP Europe 2010*). This is even higher than for the city of Amsterdam, where 19% of residents have a periodic transit pass (*City of Amsterdam*).

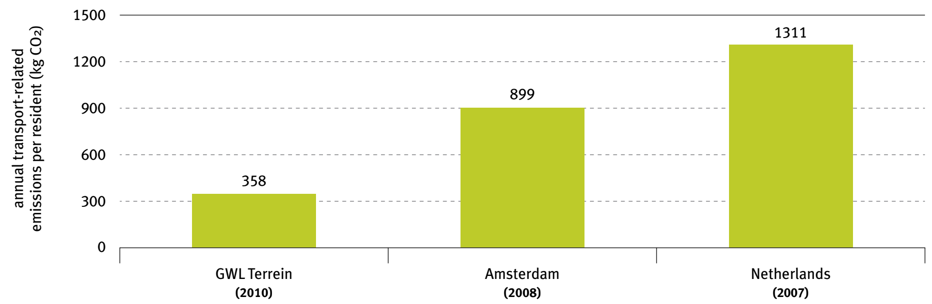
Reduced travel distances also contribute to reduced carbon footprint. GWL's location gives residents easy access to the city center, where many jobs are located. Indeed, 44% of residents travel less than 5 kilometers to work, and only 12% travel 40 kilometers or more. Additionally, more than three-fourths of residents travel less than one kilometer to get to their grocery store (*ITDP Europe 2010*). Having close access to destinations such as work and grocery stores encourages travel by bike and walking and reduces kilometers driven. Therefore, it is not surprising that transport-related emissions of GWL Terrein residents are less than half that of an average Amsterdam resident and one-third that of an average resident of the Netherlands, as seen in Figure 4. These estimates are based on annual kilometers traveled by residents by private and public transportation (for the year indicated), as well as estimates of emissions rates of these vehicles.

LESSONS LEARNED

The GWL Terrein development includes many features that make it unique among neighborhoods in Amsterdam and encourage sustainable living. The context of the surrounding area and city also have a strong impact on the travel behavior of its residents. The extensive network of bicycle paths and efficient public transportation system in the city of Amsterdam allow residents of GWL Terrein to easily travel to other parts of the city using these modes. When non-car-owners were asked to rank the importance of different factors in their decision not to own a car, residents gave higher importance ratings to pull measures such as ease of bicycle and public transport use and lower importance ratings to push measures such as expense of owning a car and limited parking (see Figure 5). Also, GWL Terrein's location close to the city center has an effect on travel distances of residents. Therefore, it would appear that a new development project in a city with a focus on sustainable transportation, especially located near the center of the city, could have more potential for success than one located in a car-focused city or far from the city center.

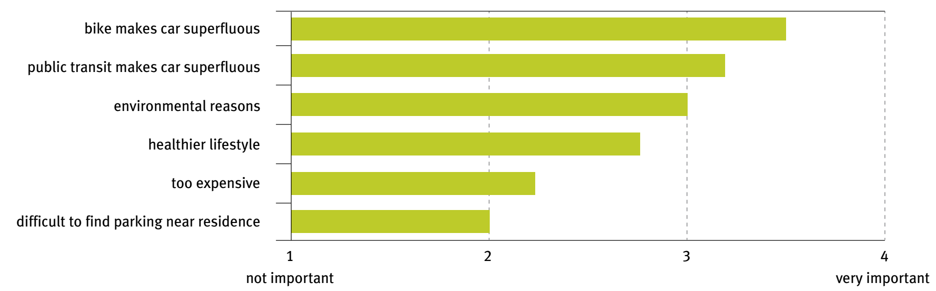
Furthermore, Koepelvereniging, the residents' umbrella organization, seems to be an important catalyst for maintaining resident focus on sustainability, reduced car use and social interaction. It also gives residents a common source to turn to with questions or concerns about the development. Such an organization is recommended for other sites planning to implement a sustainability-focused community.

Figure 4: Average transport-related emissions of residents



Author's elaboration

Figure 5: Importance of various factors on GWL resident decision not to own a car



ITDP Europe, 2010

SOURCES

Communication with Corine Marseille, Koepelvereniging organization, May 2010.

Communication with Daniel van Motman, Department of Traffic Infrastructure and Transport, City of Amsterdam, May 2010.

Communication with Hans Niepoth, City of Amsterdam, June 2010.

GVB Website, http://www.gvb.nl (accessed June 10, 2010).

GWL Terrein Website, http://www.gwl-terrein.nl/?english (accessed June 10, 2010).

ITDP Europe (2010). Interned-based survey of GWL Terrein residents.

QPark Website, http://www.q-park.nl/tabid/657/qparkParkingLocatorvw1094/parkingDetail/ParkingID/613/language/nl-NL/Default.aspx (accessed June 10, 2010)

Scheurer, Jan (2001). *Urban Ecology, Innovations in Housing Policy and the Future of Cities: Towards Sustainability in Neighbourhood Communities*, Thesis: Murdoch University, Perth Western, Australia.

Image credits
Figure 1: Koepelvereniging
Photo 1: Koepelvereniging
Photo 2: Peter Elenbaas
Photos 3, 5–10: Nicole Foletta, ITDP Europe
Photo 4: Giesbert Nijhuis

HAMMARBY SJÖSTAD SITE FACTS

Developer: Multiple*

Architect: Jan Inghe-Hagström#

Population: 17,000

Projected Population: 24,000

Developed Area: 130 ha

Total Area: 160 ha

Current Density: 131 persons/ha

Projected Density: 150 persons/ha

Current Residential Units: 8,000

Projected Residential Units: 11,000

Construction Began: 1999

Planned Completion: 2017

Distance from City Center: 3 km

Cars: 210 cars/1,000 residents

Parking Spaces/Residence: 0.65

Non-motorized Mode Share: 27%

Public Transport Mode Share: 52%

Households with Carsharing: 18%

* Over 30 developers; key developers are JM, Skanska, Family Housing, Swedish Housing, HSB, SKB and Borätt.

\# Jan Inghe-Hagström designed the strategic masterplan. Other architecture firms involved include: White Architects, Nyréns Architect Firm, and Erséus.

CASE STUDY

Hammarby Sjöstad

STOCKHOLM, SWEDEN

Nicole Foletta, ITDP Europe

BACKGROUND

Hammarby Sjöstad is a brownfield redevelopment with mixed uses, carsharing, bikesharing, good transit access and high quality bicycle infrastructure. Car use and transport-related emissions are lower in the development than in comparable reference districts or the city as a whole.

Hammarby Sjöstad is recognized around the globe for having implemented an integrated approach to district planning incorporating sustainable resource use, ecological design and low-carbon transport. The 160 hectare district was built on a former industrial and harbor brownfield area located on the south side of Hammarby Lake, three kilometers south of the Stockholm city center (Photos 1 and 2). The redevelopment has its roots in Stockholm's bid to host the 2004 Olympics. Hammarby Sjöstad was meant to be part of an ecological Olympic Village. Although Stockholm did not win the bid, planning moved forward and construction of the project began in 1999, converting the site from a run-down industrial area into a modern, environmentally sustainable, mixed-use district with good public transit connections. So far, 130 of the total 160 hectares have been developed including 8,000 residential units that now house some 17,000 residents. By 2017 the City anticipates the development will be complete with 11,000 residential units and 24,000 inhabitants (*City of Stockholm Website*).

Hammarby Sjöstad's success can be attributed to strong environmental goals that shaped the development plan, incorporating land use, transportation, building materials, energy, water and sewage, and solid waste. All of the authorities and administrations normally involved in the development process collaborated to create a plan and conceptual approach to the project with a focus on sustainable resource use. The implementation of a holistic environmental profile for a whole district was a new concept when plans began in 1996.

The city imposed strict environmental requirements on buildings, technical installations and the traffic environment. The goal was to halve the environmental impact compared to a typical development built in the 1990's. The goals related to transportation in Hammarby Sjöstad were (*Fränne 2007*):

- 80% of residents' and workers' journeys made by public transport, bike or foot by 2010
- At least 15% of households having carsharing memberships by 2010
- At least 5% of workplaces having carsharing memberships by 2010
- 100% of heavy transportation by vehicles meeting environmental zone requirements

PLANNING PROCESS

The planning and design of this project was made easier because the City had acquired most of the land in Hammarby Sjöstad. The local authority took leadership at every stage from development of the masterplan to construction, spurred on by the City's sustainability program which includes targets for decontamination, use of brownfield land, provision of public transport options in order to discourage car use, energy consumption, water conservation and recycling. In addition, since all planning applications in Stockholm are based on life-cycle cost analysis, it was easier for the development to justify higher initial investments in better performing building design and transportation infrastructure.

The first step in the planning process was the development of the strategic masterplan, led by architect Jan Inghe-Hagström, at the Stockholm City Planning Bureau. The plan is divided into 12 sub-neighborhoods, which are being developed in phases. A process called "parallel sketches" is being used in which the City selects three to four architects/planners in the private sector to draw up detailed proposals

Figure 1: Map of Hammarby Sjöstad

for a sub-neighborhood. The city evaluates each of the sketches and combines the best features to create the agreed upon masterplan.

The city planning and design team then prepares a design code for each sub-neighborhood in partnership with the developers and architects. This design code is included in the development agreement between the developer and the City. The design code is taken through the local authority political process in order to grant planning permission; the code provides an overview of the layout, form, and structure of each block including key landmark buildings, public spaces and pedestrian routes.

In order to provide architectural diversity, and to inspire higher standards of design through competition, a consortium of developers and architects are then invited by the City to develop each plot or individual building within the sub-neighborhood, according to the design code. So far over 30 different developers and more than 30 architects have been identified. Key developers are JM, Skanska, Family Housing, Swedish Housing, HSB, SKB and Borätt (*CABE Website*).

KEY POLICY AND DESIGN MEASURES

The integration of transportation and land use planning was recognized as a key component affecting the sustainability of the project. Expansion of the district has been complemented by transport investments including increased bus service, cycle paths, pedestrian bridges, ferry service, and an extension of the tram line. Development has been focused on a dense settlement structure, concentrated along main transit corridors. In order to discourage car use, parking in the area is limited and is priced. Key policy and design strategies applied are described below.

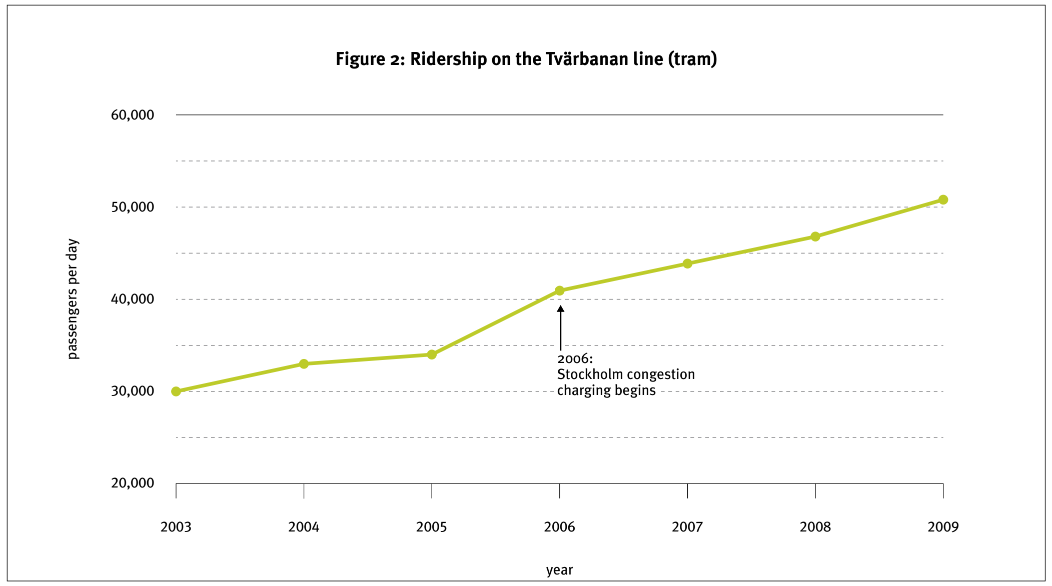
Substantial investments were made in public transport in the area, including an extension of the Tvärbanan tram line (Line 22), which runs through Hammarby Sjöstad with four stops in the district (see Figure 1 and Photo 3). The line operates from 5:30am to 1:00am. This orbital line incorporates several features which enhance quality of service, including level-boarding at stations (Photo 4), which allows easier access to the trains, and message boards providing real-time arrival information of the next trains. In addition to the tram line, two bus routes serve the area.

The tram line serves a whopping one third of all trips made by residents (*Brick 2008*). Figure 2 shows a dramatic growth in ridership on the Tvärbanan line after the introduction of the central Stockholm congestion charge in 2006. Hammarby Sjöstad lies just outside of the central Stockholm congestion zone. This increase in ridership demonstrates the effectiveness of combining push (congestion pricing) and pull (improved transit) methods to shift travelers from cars to more sustainable modes.

The Gullmarsplan Tunnelbanan (metro) station lies just outside the border of Hammarby Sjöstad. This station serves the T17, T18 and T19 (metro) lines and provides direct service to central Stockholm at 7-8 minute frequencies during peak hours. The station also serves as a multi-modal transfer facility with connections to the Tvärbanan tram line and numerous bus lines.

In addition to providing convenient access, fare structure can also help drive public transport use. Public transport tickets in Stockholm County are integrated and zone-based. The same ticket can be used on the bus, tram or metro, improving ease of transfers. Several ticket options are offered from single tickets to annual travelcards, all with both regular and reduced prices. An integrated smartcard called SL Access has recently been implemented. Transit tickets and passes can be loaded onto this smartcard. An SL Business Card is also available for employees of participating companies. Through this program, the employee is given a travelcard at a discounted price, and the cost is deducted from his salary; the employer pays social security contributions. This is a way for companies to encourage employees to use public transport. Another feature aimed to improve ease of ticket purchase is an innovative option which allows passengers to purchase a transit ticket through a text message on a cell phone. The ticket will appear on the cell phone screen and must be shown to the bus operator upon boarding (*SL Website*).

A ferry service was introduced which transports passengers from Hammarby Sjöstad to the Stockholm city center and to



Blomquist, 2010

* data recorded each year on an average winter day

Sodermalm, an island located between Hammarby Sjöstad and the city center (Photo 5). More information about these two ferry lines is summarized in Table 1. Ferry service is run by the city of Stockholm. Bicycles can be taken on board all ferries and ferry terminals are located near bicycle lanes, providing an easy transition between bike and ferry. Studies have suggested that introduction of the ferry service has contributed to an increase in the use of bicycles and walking to/from Hammarby Sjöstad and that as much as 24% of travelers use the ferry for some portion of their trip (*Brick 2008*).

Cycling and Pedestrian Infrastructure

One goal was for Hammarby Sjöstad to be a healthy place for people to live; that offers opportunities for exercise, sports and culture. Numerous bike paths, pedestrian paths and footbridges (Photos 6, 7, 8 and 9; Figure 1) were built to meet this goal. Many of the paths provide an opportunity for scenic strolls along picturesque canals and through a variety of green spaces. The bicycle lanes also enable improved mobility, running along thoroughfares such as Lugnets Allé and Hammarby Allé . Providing safe, accessible bicycle and pedestrian infrastructure is important to both encourage healthy activities, but also to promote use of non-motorized forms of transport.

Bike Sharing

Bike sharing programs are being implemented around the world to make cycling in cities more accessible. These systems are often complemented by investments in bicycle infrastructure, providing safe spaces for users to ride. The bikesharing concept consists of providing public bicycles, available from docking stations spread throughout the city, for the purpose of travel.

The bikesharing program in Stockholm, called Stockholm City Bikes, began in 2006 and is operated by Clear Channel Communications. The company holds similar bikesharing programs in France (Rennes, Caen, Dijon and Perpignan) as well as in Barcelona, Oslo and Milan.

There currently 85 docking stations citywide, and one in Hammarby Sjöstad (Photo 10). At each station, spaces for 9 to 24 bicycles are available. The actual number of bikes available at any time depends on the number currently in use and the bicycle distribution patterns of users. Once the program is fully implemented, there will be 2,500 bicycles at 200 locations throughout Stockholm.

Bike share in Stockholm operates from April to October. Bikes may be picked up between 6:00am and 10:00pm, users can take the bike for up to three hours, after which they must pay a penalty. A membership and rental card are required for use. Two types of cards are available. A seasonal card may be purchased online for 200 SEK (21€) or at a retailer for 250 SEK (26€). A three-day card must be purchased at a retailer and costs 125 SEK (13€) (*City of Stockholm*). There is now an option to add a Stockholm City Bike membership to an SL Access smartcard.

Car Sharing

There are currently 37 low emissions carsharing cars with dedicated parking spaces located in Hammarby Sjöstad, belonging to three different car sharing organizations: Sunfleet Carsharing, Bilpoolen, and CityCarClub. According to a survey of residents in 2010, 18% of households have a carsharing membership (*ITDP Europe 2010*). In 2008, 100 companies located in Hammarby Sjöstad were reported as having a car sharing membership (*City of Stockholm Website*).

Parking

Hammarby Sjöstad has approximately 0.15 on-street parking spaces per household, and an estimated 0.55 spaces per household in public or private garages. The supply of parking is not evenly spread and in some parts of the district the practical parking supply will be much lower. Overall Hammarby Sjöstad has 0.65 parking spaces per household.

On-street parking in Hammarby Sjöstad is regulated in the same way as for the rest of the inner city. There is a charge to park between 9:00am and 5:00pm on weekdays (Photo 11). Evening and night time parking is free. Off-street parking is mainly operated by Stockholm Parkering, the city's parking company, which owns a number of garages and off-street parking lots in Hammarby Sjöstad. Additionally, a number of the housing co-operatives own their own parking and set their own prices for residents and there are also a few private car park operators. Table 2 shows the parking prices for Stockholm Parkering. The prices for off-street parking are comparable to other areas just outside the inner city, but a little lower than typical prices inside the inner city. Typically charging more for on-street parking spaces than for off-street spaces encourages long-term parkers to park off-street and maintains a larger number of on-street spaces available for short-term parkers, who have a faster turnover. Hammarby Sjöstad's parking pricing structure does not follow this strategy and it is recommended to raise on-street parking prices.

Table 1: Summary of Hammarby Sjöstad ferry service

Ferry destination	Travel time to destination	Frequency	Operating months	Hours of operation	Cost
Sodermalm	5 minutes	10–15 minutes	Year round	06:00 to midnight	Free
Nybroviken (Central Stockholm)	25 minutes	1 hour	May 31–October 1	Weekdays: 07:30–17:30 Weekends: 09:30–18:30	Regular fare: 40 SEK (4.3€) Discount fare: 25 SEK (2.7€) Children under 13: free

http://www.ressel.se/index.asp

Table 2: Parking prices in Hammarby Sjöstad

Time period	On-street parking	Off-street outdoor parking	Off-street garage parking
Per hour	15 SEK (1.5€)	12-15 SEK (1.2-1.5€)	20 SEK (2€)
Per day (24hr)	50 SEK (5€)*	60-80 SEK (6-8€)	100 SEK (10€)
Overnight	–	–	60 SEK (6€)
Monthly	700 SEK (73€)*	750 SEK (78€)	1,100–1,500 SEK (110–160€)
Yearly	8,400 v (870€)*	9,000 SEK (940€)	13,200–18,000 SEK (1,370–1,870€)

City of Stockholm, Traffic Administration

*with residential parking permit

Urban Design

The layout of Hammarby Sjöstad was designed to integrate transportation, amenities and public spaces. The spine of the district is a 37.5 meter wide boulevard and transit corridor, which connects key transport nodes and public focal points, and creates a natural focus for activity and commerce (Figure 3).

Street Layout and Design

Two main thoroughfares, Lugnets Allé and Hammarby Allé, run through the district. These streets include tram lines in the middle of the street with boarding platforms on the outside. Beyond the boarding platforms there is one car lane in each direction and outside the car lanes are bicycle lanes followed by parking spaces and then pedestrian walkways. The bike lanes are painted on the street and cars must pass over the bike lane in order to park. Pedestrian priority is given on the main streets, complemented by speed restrictions and frequent zebra crossings. A cross section view demonstrating the layout of Hammarby Allé can be seen in Photo 12.

Public Space Design

A network of varied parks, green spaces, quays, plazas and walkways runs through the district, providing space for outdoor activities. All public spaces are owned and maintained by the city of Stockholm Photo 13).The initial goal for the development was to provide 25 square meters of public green space per apartment unit, for a total of 300,000 square meters in the district. So far a total of 280,000 square meters has been completed. The development also has a goal to provide 15 square meters of private courtyard space per apartment unit. (*City of Stockholm Website*)

Land Use Planning and Design

The general building layout of Hammarby Sjöstad is blocks built around an inner courtyard. The entire development is high density, but with the highest densities focused along the transit corridor, where buildings are 7-8 stories high. The average height of buildings in the district is 18 meters, or 6 stories. Safety on the streets is enhanced by providing a variety of ground floor uses, and facing balconies and front doors onto the street in order to increase "eyes on the street." The architectural style utilizes contemporary sustainability technologies and follows modern architectural principles, maximizing use of daylight and providing views of water and green spaces.

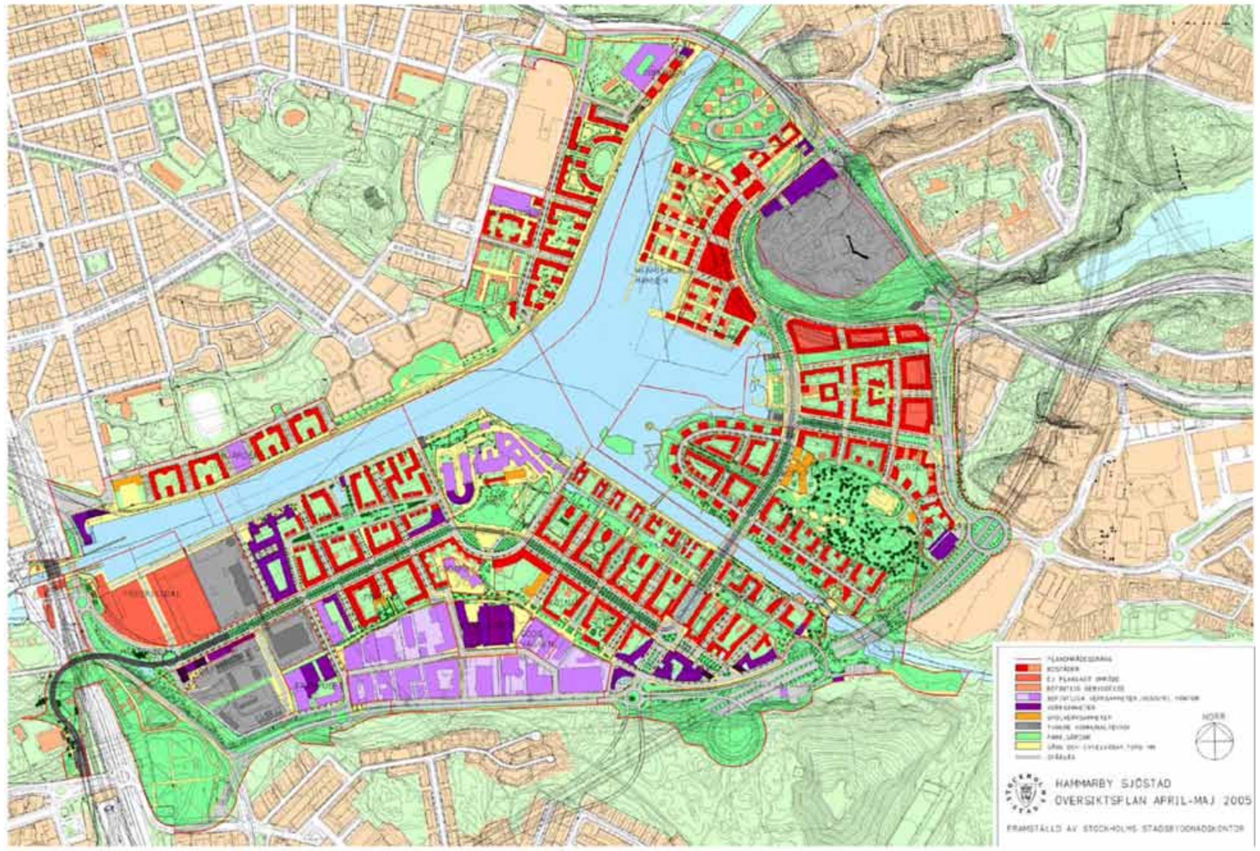


Figure 3: Hammarby Sjöstad Site Map

1
Hammarby Sjöstad before redevelopment

2
Hammarby Sjöstad today

3
Tvarbanan line tram stop

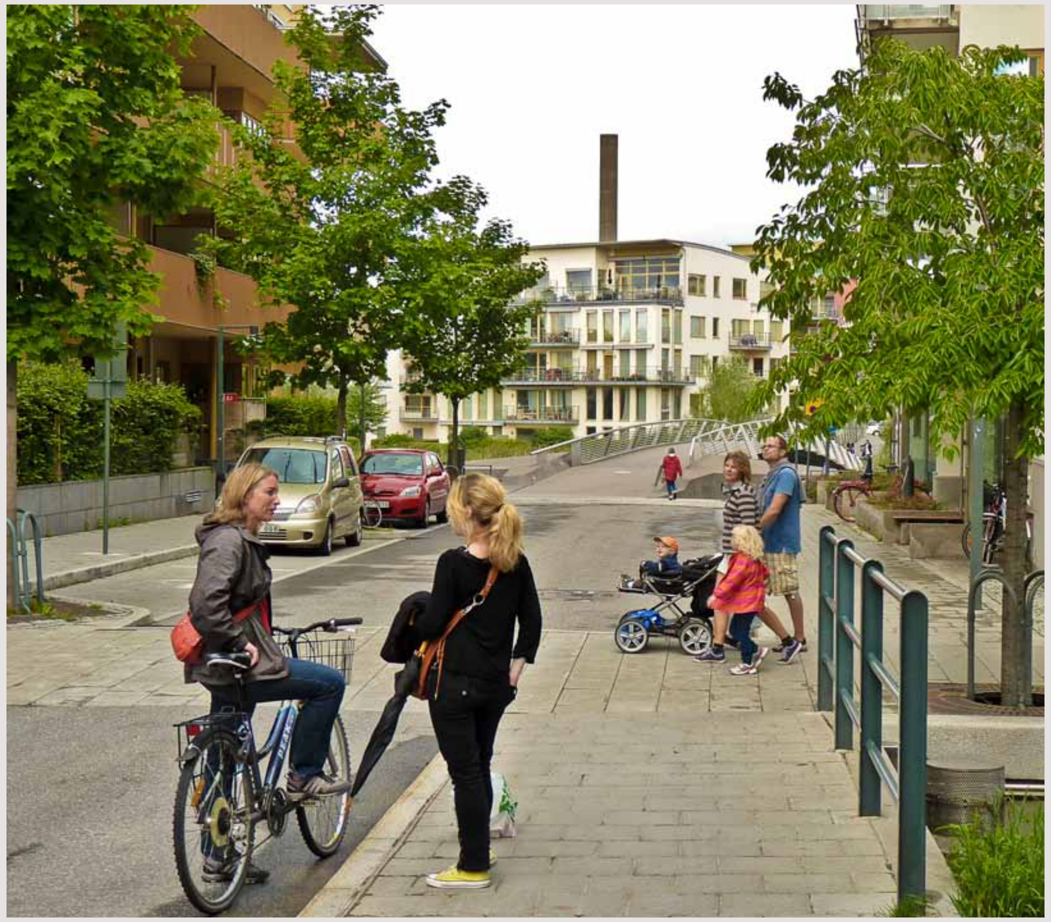
The tram line was extended to serve Hammarby Sjöstad and now carries 33% of trips made by residents there.

4
Level boarding on Tvarbanan tram

Level boarding is one example of the high-quality features of the tram system, which also include long hours of service and real-time arrival information in stations and connections to Metro and bus lines.

5
Ferry terminal

Ferries connect residents to the city center. Bikes are allowed on-board and the ferry terminal is reachable by bikeways.



6
Pedestrian pathways

7
One of Hammarby Sjöstad's many bicycle and pedestrian bridges

8
Canal-side bicycle path

9
Bicycle path separated from motorized traffic

10

One of Stockholm's 85 bikeshare stations is located in Hammarby Sjöstad.

11

Hammarby Sjöstad has .15 on-street parking spaces per household, parking is charged during the day and free at night.

12

Hammarby Allë, one of Hammarby Sjöstad's two main thoroughfares, with center-running tram lines, driving lanes, bike lanes, parking and sidewalks. Pedestrians have priority.

13 plaza in Hammarby Sjöstad

A network of parks, green spaces, quays and walkways runs throughout the development.

14 Hammarby Sjöstad café

Hammarby Sjöstad has over 100 retail units and restaurants as well as office space and some light industrial uses, employing over 5,000 people and providing convenient services for local residents.

STOCKHOLM DISABILITY PROGRAM

In 2004, the Stockholm Local Council adopted the Disability Policy Program whose aim was to make Stockholm the most accessible city in the world by 2010. To reach this goal, the document enlists a series of wide scale measures to be undertaken. In the transportation sector, the program recommends removing all physical barriers that can easily be removed. This includes widening doorways and installing handrails in public transport stations and providing level boarding of transit vehicles. The program also stipulates that all public authorities and private companies need to integrate financing of these measures into their budgets. The goal is to provide better access to disabled persons and, consequently, enhance democracy and social equity among all Stockholmers. Due to its goal of becoming an exemplary district for the future, Hammarby Sjöstad has paid special attention to satisfying these requirements (*City of Stockholm 2005*).

Table 3: Breakdown of residential unit size in Hammarby Sjöstad

	Area (ha)
Studios	9%
1 Bedroom	35%
2 Bedrooms	32%
3 Bedrooms	21%
4 Bedrooms	2%
5+ Bedrooms	< 1%

City of Stockholm

Table 4: Planned breakdown of land uses in Hammarby Sjöstad

	Area (ha)	Percent of Total Area
Residential	90	56%
Public green space	30	19%
Other	40	25%
Total land area	160	100%

City of Stockholm

The residential units include a mix of tenures; 46% of the units are rented and 54% are owned. Most of the apartment units have one or two bedrooms, as seen in Table 3. In addition, the development has 59 apartments with 24-hour care for the elderly, 30 apartment units where assisted residential care is provided and 400 student flats.

The planning department recognized the importance of providing a mix of uses in order to ensure that residents have access to goods and services within walking distance. Therefore, the city initially offered a two-year rent-free subsidy in order to attract commercial operators and to ensure that service provision was established during the early phases of the development (*CABE Website*). This strategy was successful and today the area includes nearly 100 retail units and restaurants as well as office space and light industrial uses, employing over 5,000 people (Photo 14). In addition, at least five food stores are located throughout the development and no one lives more than one kilometer from a grocery store. The mix of uses in Hammarby Sjöstad includes the following institutional uses: twelve pre-schools (for ages 1–5), three primary schools (for ages 6–16), two high schools, a library, a cultural center, a chapel, an environmental center, childcare facilities and healthcare centers. A breakdown of the area of the various land uses can be seen in Table 4. (*City of Stockholm Website*)

QUANTITATIVE COMPARISON

In order to quantify the benefits of the sustainability measures implemented in Hammarby Sjöstad, it is important to look at the development in the context of its location. Hammarby Sjöstad is located in one of the most progressive cities in the world with regard to sustainability. Stockholm is the winner of the European Green Capital city competition for 2010. The city has reduced carbon emissions by 25% per resident since 1990 and has established a target of reducing emissions from today's 4 tonnes of CO_2 per capita to 3 tonnes in 2015. These values are extremely low for developed countries, considering the entire country of Sweden has an average emission rate of 6 tonnes of CO_2 per capita, the average for Europe is 8 tonnes per capita and the average for the United States is 20 tonnes per capita (*EIA*).

The City of Stockholm has recognized the connection between land use planning and transport and has taken many measures to steer development in the direction of a dense settlement structure, complemented by investments in public transportation, cycling and pedestrian infrastructure. Furthermore, the city has successfully implemented a city-center congestion charge.

Density

Hammarby Sjöstad compares favorably with Stockholm, which stacks up extremely favorably against most of the rest of the world. Compared to both the inner city of Stockholm and the City of Stockholm itself, Hammarby Sjöstad has a higher population density, as seen in Table 5. The provision of on-street parking is lower for Hammarby Sjöstad than for the city; however, the provision of off-street parking is higher, bringing the total to 0.65 spaces per residential unit for both Hammarby Sjöstad and the city as a whole.

Car Ownership Rates

We also compared Hammarby Sjöstad to the municipality of Sundbyberg, a five kilometers to the northwest of the Stockholm city

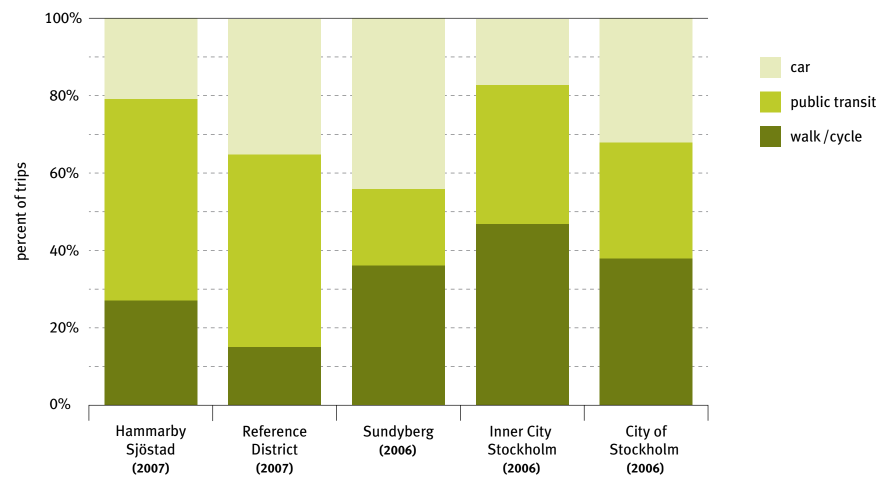
Table 5: Hammarby Sjöstad as compared to nearby and surrounding areas

	Hammarby Sjöstad	Sundbyberg	Inner City Stockholm	City of Stockholm
Population	17,000	37,700	308,900	829,400
Area (ha)	130*	900	3,500	18,700
Population density (persons/ha)	131	42	88	44
Average income (SEK/year)	356,000	272,000	na	293,000
Jobs per resident	0.3	0.5	na	na
Cars per 1000 residents	210	295	na	370
Car parking spaces/residential unit	0.65	na	0.65	0.65
Mode share for all trips				
Car	21%	44%	17%	32%
Public transit	52%	20%	36%	30%
Bicycle/ walking	27%	36%	47%	38%

City of Stockholm; City of Sundbyberg; Blomquist, 2010); ITDP Europe, 2010

*current developed area

Figure 4: Mode of travel for Hammarby Sjöstad compared to reference and surrounding areas



Brick, 2008; Blomquist, 2010

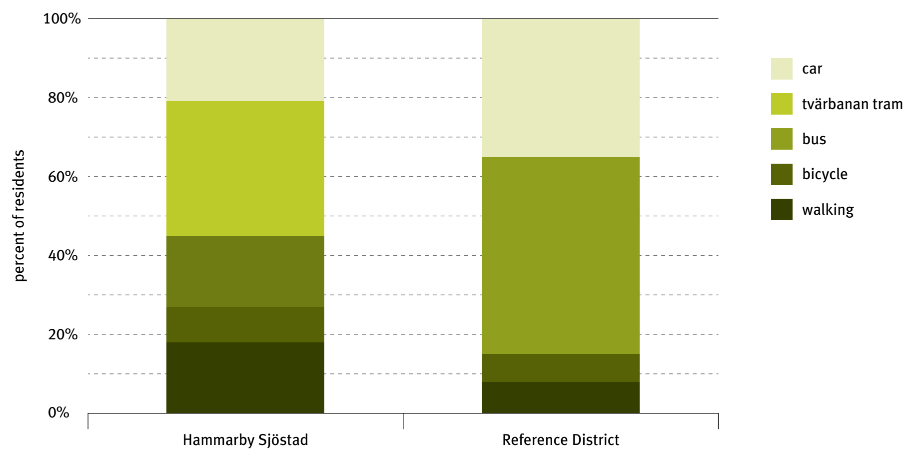
center which also has good public transit availability. Car ownership per resident is quite low in Sundbyberg (295 cars per 1,000 residents) and is even lower in Hammarby Sjöstad (210 cars per 1,000 residents). These values are both smaller than for the City of Stockholm (370 cars per 1,000 residents), which is already low by international standards in developed countries. These and other statistics are summarized in Table 5. In addition, bicycle ownership is quite high in Hammarby Sjöstad at 820 bikes per 1,000 residents (*ITDP Europe 2010*).

Mode Split

The policy and design measures employed in Hammarby Sjöstad have proven effective. Only 21% of trips made by Hammarby Sjöstad residents are by car, while 52% are by public transportation, and 27% by non-motorized modes. The percent of non-motorized trips (27%) is still not quite as high as for those in Sundbyberg (36%), Inner City Stockholm (47%), or the city as a whole (38%), as seen in Figure 4. This may be due to the high concentration of jobs in Sundbyberg and Inner Stockholm, making it possible for residents of these areas to cycle or walk to work nearby. However, compared to a reference district without integrated policy and design measures, Hammarby Sjöstad has a higher percent of trips made by bike (9%) and on foot (18%) than the reference district's share of bike trips (7%) and walking trips (8%), as seen in Figure 5.

In addition, Hammarby Sjöstad has a much higher share of trips made by public transit (52%) than Sundbyberg (20%), Inner City Stockholm (36%) or the city as a whole (30%). This demonstrates that although residents of Sundbyberg walk or bike for more trips than Hammarby Sjöstad residents, for motorized trips, residents of Hammarby Sjöstad choose public transit over the car for a far greater percentage of trips than Sundbyberg residents. The breakdown of mode split for the regions discussed can be seen in Figure 4. Figure 5

Figure 5: Mode of travel (2007)



Brick, 2008

shows a more detailed breakdown of mode split for Hammarby Sjöstad and a reference district. The Hammarby Sjöstad values are generated from surveys of residents. The reference district values are based on a previous overall study of comparable city districts, but have been adapted for Hammarby Sjöstad. (*Brick 2008*)

Furthermore, an internet-based survey of Hammarby Sjöstad residents conducted by ITDP Europe in 2010 asked respondents what mode of transportation they take most often to get to work. It was found that 3% of respondents walk to work, 14% cycle, 78% take public transit and 5% drive, as seen in Figure 6. This shows that residents overwhelmingly prefer to take public transportation to work rather than driving. Stockholm's congestion charge likely has an influence on this decision. In addition, the survey found that 39% of residents live less than 5 km from their place of work, 43% live between 5 and 10 km and 18% live more than 10 km from work. These short commute distances also make it easy to travel to work by non-motorized modes or public transit. The average one-way commute time of residents was found to be 33 minutes. (*ITDP Europe 2010*)

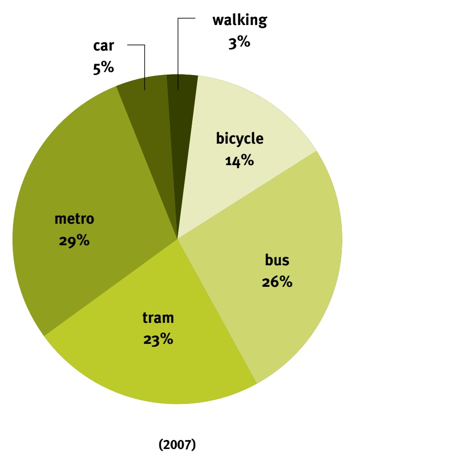
Transport-related Emissions

The low car ownership rate, low car mode share and short commute distances help to reduce the carbon footprint of Hammarby Sjöstad residents. CO_2 emissions per apartment from personal transport by car are more than 50% lower in Hammarby Sjöstad than in the reference district, as seen in Figure 7. These savings alone would yield a reduction of approximately 2,373 tonnes of CO_2 per year (*Brick 2008*).

Moreover, by measuring kilometers traveled per resident per year by both private and public transport, along with estimates of emission rates of vehicles, it is estimated that overall transport-related emissions for residents of Hammarby Sjöstad are less than half that for an average Stockholm resident and less than a third that of an average resident of Sweden, as seen in Figure 8.

The statistics presented in this section quantify some of the many benefits of integrated policy and design measures. These comparisons show that even in a city as ambitious as Stockholm, concentration of integrated policy and design measures in a single district can bring about further reductions in carbon footprint.

Figure 6: Mode of travel to work for Hammarby Sjöstad residents



Author's elaboration

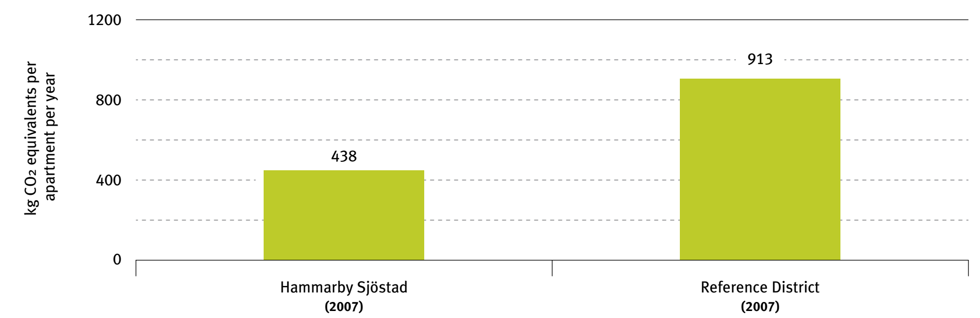
LESSONS LEARNED

A holistic approach to planning, grounded in strong environmental goals can help shape better new developments. These goals should be created as early as possible, making it possible to integrate them into every part of the infrastructure early in the planning process. These goals should be formed in close cooperation with all stakeholders and should include a discussion of possible technical solutions and their potential results within the planned district.

Context is also important to new developments. In Stockholm the availability of high quality transport and a congestion charge has a strong influence on all residents, including those in this new development.

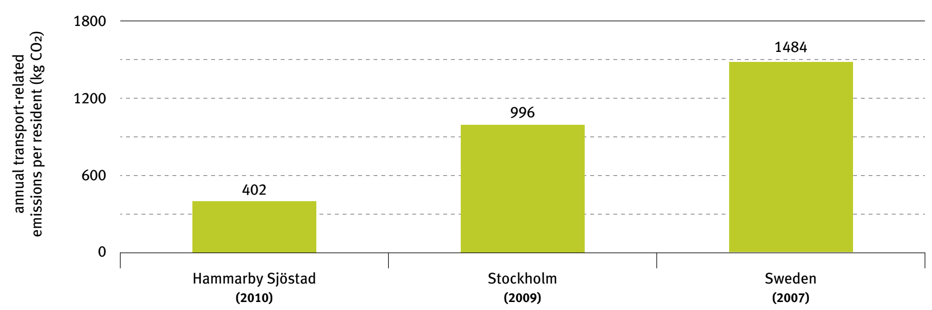
Meeting environmental goals does not end once the development is built. The district plan should include information and incentives to influence the behavior of residents in the long term. Following this line of thought, new urban districts should design an evaluation process with a structure for follow-up with a clearly defined feedback process to ensure continued sustainability of the project. ■

Figure 7: Average car emissions



Brick, 2008

Figure 8: Average transport-related emissions of residents



Author's elaboration

SOURCES

Blomquist, Anna (2010). *Fakta om SL och Lanet 2009*. Stockholm, AB Storstockholms Lokaltrafik.

Brick, Karolina (2008). *Report Summary — Follow Up of Environmental Impact in Hammarby Sjöstad*. Grontmij AB, Stockholm.

CABE website, Hammarby Sjöstad Case Study, http://www.cabe.org.uk/case-studies/hammarby-sjostad/design (accessed July 14, 2010).

City of Stockholm (2005). *Disability Policy Programme for the City of Stockholm: Summarized Version*, Malmö.

City of Stockholm website, http://international.stockholm.se/Press-and-media/Stockholm-stories/Sustainable-City/ (accessed July 14, 2010).

City of Sundbyberg website, http://www.sundbyberg.se/ (accessed July 14, 2010).

Communication with Björn Cederquist, City Planning Department, City of Stockholm, August 2010.

Communication with Daniel Firth, Transport Planner, Stockholm City Traffic Administration, July 2010.

Communication with Malena Karlsson, GlashusEtt — the center for environmental information and communication in Hammarby Sjöstad, July 2010.

EIA, Carbon emissions from consumption of energy, http://www.guardian.co.uk/environment/datablog/2009/dec/07/copenhagen-climate-change-summit-carbon-emissions-data-country-world (accessed July 14, 2010).

Fränne, Lars (2007). *Hammarby Sjöstad — a unique environmental project in Stockholm*. GlashusEtt, Stockholm. http://www.hammarbysjostad.se/inenglish/pdf/HS_miljo_bok_eng_ny.pdf

ITDP Europe (2010), internet-based survey of Hammarby Sjöstad residents.

Ressel website, http://www.ressel.se/index.asp (accessed July 14, 2010).

SL website, http://sl.se/ (accessed July 14, 2010).

Stockholms Stad (2008). *The Stockholm Environment Programme 2008-2011: Overarching goals and priorities.*

Image credits

Figure 1: http://maps.google.de/maps/ms?hl=en&ie=UTF8&vps=3&jsv=298d&oe=UTF8&msa=0&msid=116478322990710211544.000490d42ec5947427b82

Figure 3: http://www.hammarbysjostad.se/

Photo 1: GlashusEtt

Photo 2: Lennart Johansson, Stockholm City Planning Department

Photos 3, 5, 6, 14: Luc Nadal, ITDP

Photos 4, 7: Cathleen Sullivan, UC Berkeley

Photo 8–11: Qian Jiang, ITDP Europe

Photo 12: Google Maps

Photos 13: Simon Field, ITDP Europe

CASE STUDY

Houten

UTRECHT, THE NETHERLANDS

Nicole Foletta, ITDP Europe

HOUTEN SITE FACTS

Architect: Rob Derks

Population: 43,900

Urban Area: 820 ha

Urban Density: 54 persons/ha

Number of Residential Units: 18,400

Distance from Utrecht City Center: 8 km

Cars: 415 cars/1,000 residents

Parking Spaces/Residence: 1.1

Non-motorized Mode Share: 55%

Public Transport Mode Share: 11%

Households with Carsharing: 2%

BACKGROUND

Houten, a city in the province of Utrecht in The Netherlands, is a unique example of an entire city designed and built to prioritize the cyclist and pedestrian. It is a greenfield development with good transit access, high quality bicycle infrastructure, provision of public bikes and carsharing, and application of employer contributions and educational programs to promote cycling. Non-motorized transport use is higher in Houten than in comparable cities while car use is lower.

The city's innovative traffic layout was a departure from the norms of the time when it was developed in 1968 and approved by the city council. The design limited intra-city car use and gave priority to traffic safety for pedestrians and cyclists. Core design features include narrow roads, application of traffic calming measures and separation of bicycle paths from car traffic whenever possible.

The basic layout of the city consists of two train stations, each surrounded by a ring road with a radius of approximately one kilometer. The rest of the city is covered by an extensive, 129 kilometer network of bicycle paths (Photos 1 and 2; Figure 1). There are 31 residential districts, each of which is only accessible to cars via the peripheral ring roads encircling the town. However, the network of paths for cyclists and pedestrians includes a thoroughfare that passes directly through the town center, providing filtered permeability for cyclists and pedestrians. The majority of schools and important buildings are located along this thoroughfare. Due to this design, cycling is the most direct mode of transportation and is often even faster than travel by car.[1]

Houten's innovative design features along with the city's persistent policies to favor cyclists and pedestrians have resulted in numerous measured benefits, including improved cyclist and pedestrian safety, increased activity levels of residents, and reduced use of motorized vehicles. Furthermore, this case study demonstrates that innovative design features are not limited to new districts within a city, but can be applied to new cities as a whole.

PLANNING PROCESS

In 1966 the national government identified Houten, then a small village with a population of about 3,000, as a high growth area and mandated a growth plan be developed to accommodate an eventual population of 100,000. In 1968 Dutch architect Rob Derks offered a plan heavily focused on filtered permeability: a dense network of direct routes for cyclists and a course network of general roads, offering limited city center access to cars (see Filtered Permeability sidebar, p. 49). The city council, which was then made up of civilians and farmers and no politicians, approved Derk's plan, which they believed would provide a more liveable quality to their city. They hired four city advisors (including Rob Derks) with expertise in architecture, city planning and transportation engineering to implement the plan. This combination of technical and planning expertise was key to the success of the development.

In 1974 an agreement was made with the national government to fund the first ring road. Construction began in 1978. Further infrastructure was publicly funded, both through the local government and using grants from the regional and national governments.

In 1994 Houten was again designated as a new growth area under the government's new Vinex Location program (see *Vinex Locations* sidebar, p. 50). Plans were made to construct a second train station, also surrounded by a ring road with bicycle paths and mixed use lanes throughout. This area is referred to as South Houten.

To this day, city policies in Houten have a strong focus on bicycle safety and bicycle rights. The local cyclist union is also very active in advocating for cycling infrastructure and cycling rights.

KEY POLICY AND DESIGN MEASURES

Sustainable transportation is one of the main priorities of the City of Houten. Beyond using urban design to encourage cycling and walking, the city has also applied several other policy measures, the combination of which has had a great impact on travel behavior of its citizens. These are described below.

Bicycle and Pedestrian Infrastructure

As mentioned, the city of Houten has over 129 kilometers of cycle paths, which are colored brick-red. In the city center these paths are completely separated from car traffic (Photo 3), although motorized scooters are allowed to use them. (Dutch law places low-speed scooters in the same category as bicycles, therefore they cannot legally be excluded from using the paths.) In order to improve safety, speed bumps are located on cycle paths throughout the city designed specifically to slow motorized scooters while providing minimal disturbance to cyclists (Photo 4). The entrance to many of the cycle paths are blocked by bollards, so cars are physically unable to enter these pathways. Only in residential areas do bikes share roads with cars, but speeds in these areas are limited and the streets are traffic calmed to maintain safety for pedestrians and cyclists. Furthermore, signs are located on these streets stating that cars are guests on the road and must give priority to cyclists. Bicycle tunnels and bridges have been built under or over the ring roads so that neither bicycle nor car traffic are interrupted (Photo 5). In addition, cycle paths connect Houten to the city of Utrecht where many residents commute for work.

This extensive focus on bicycle infrastructure and bicycle priority above the car on all city streets is unique to the city of Houten. Furthermore, infrastructure costs for Houten are no higher than for any other Vinex location in the Netherlands (*Beaujon 2002; Tiemens 2010*). This focus makes cycling in Houten easier, safer and more convenient than in other cities. Surveys have shown that even those not predisposed to cycling cycle more as a result of living in Houten (*Hilbers 2008*). This demonstrates the strong impact infrastructure can have on travel choices.

One issue encountered is that since so many residents cycle, it can often be difficult to find a bicycle parking spot, especially in high-trafficked areas like the city center (Photo 6). To resolve this issue, the city is currently constructing a staffed bicycle parking facility and bicycle shop under the tracks of the central train station.

Urban Design

Houten's early focus on urban design is a key to the city's current level of transport sustainability. When designing the city, Houten's planning advisors considered how the location of housing and layout of roads and bicycle paths would affect resident travel behavior. They did not neglect the car in their designs, but created a layout that would give priority to cyclists.

[1] http://www.youtube.com/watch?v=p4QT5rvnfSo

Street Layout and Design

The street network in Houten consists of north and south ring roads, each with a radius of about one kilometer (Figure 1). From the ring road there are roads leading to every residence, however, generally there are no direct links between neighborhoods by car. In order to access another neighborhood, drivers must first enter the ring road and then exit again at their destination. Furthermore, even on these residential roads used to access homes, priority is given to cyclists (Photo 7). Other than these mixed-use roads the majority of streets within the city are for cyclists only and cars are restricted from entering. Due to the layout of streets and cycle ways, cyclists have much more direct access to various parts of the city, often resulting in cycling being the fastest mode of travel.

Urban design features were used to mark the transitions from the ring road to the residential areas. By law, drivers are required to slow down when exiting the ring road, which has a speed limit of 90 km/hr, and entering the 30 km/hr residential areas, but these design features help to further ensure safety at ring road exits. First, large buildings are located on either side of the road at these transition points to act as a visual signal to drivers that they are entering the city. Additionally, there is a change in the road from asphalt pavement to bricks and a fork to slow down car speed. Furthermore, no residential street is straight for more than 75 meters, which helps to maintain safe vehicle speeds and heighten driver awareness of the surroundings.

FILTERED PERMEABILITY

Filtered permeability is an urban planning and design technique that allows pedestrians and cyclists to travel through an area more directly than motorists. This makes travel by these modes more convenient and even faster than traveling by car, stimulating mode switching and reducing emissions. This approach may even include strategies to limit or restrict movement by cars.

Filtered permeability applications often include separating pedestrian and cycling paths from roads for motorized vehicles. Houten, for example has built a limited street network for motorized vehicles while providing a more extensive network of car-free paths for pedestrians and cyclists.

As a result, traveling by bike is often more direct and even faster than traveling by car. In addition, pedestrian and cycle paths have been separated from roads for motorized vehicles whenever possible, even at intersections where bicycle bridges or tunnels have been built to keep cycling traffic separate from car traffic.

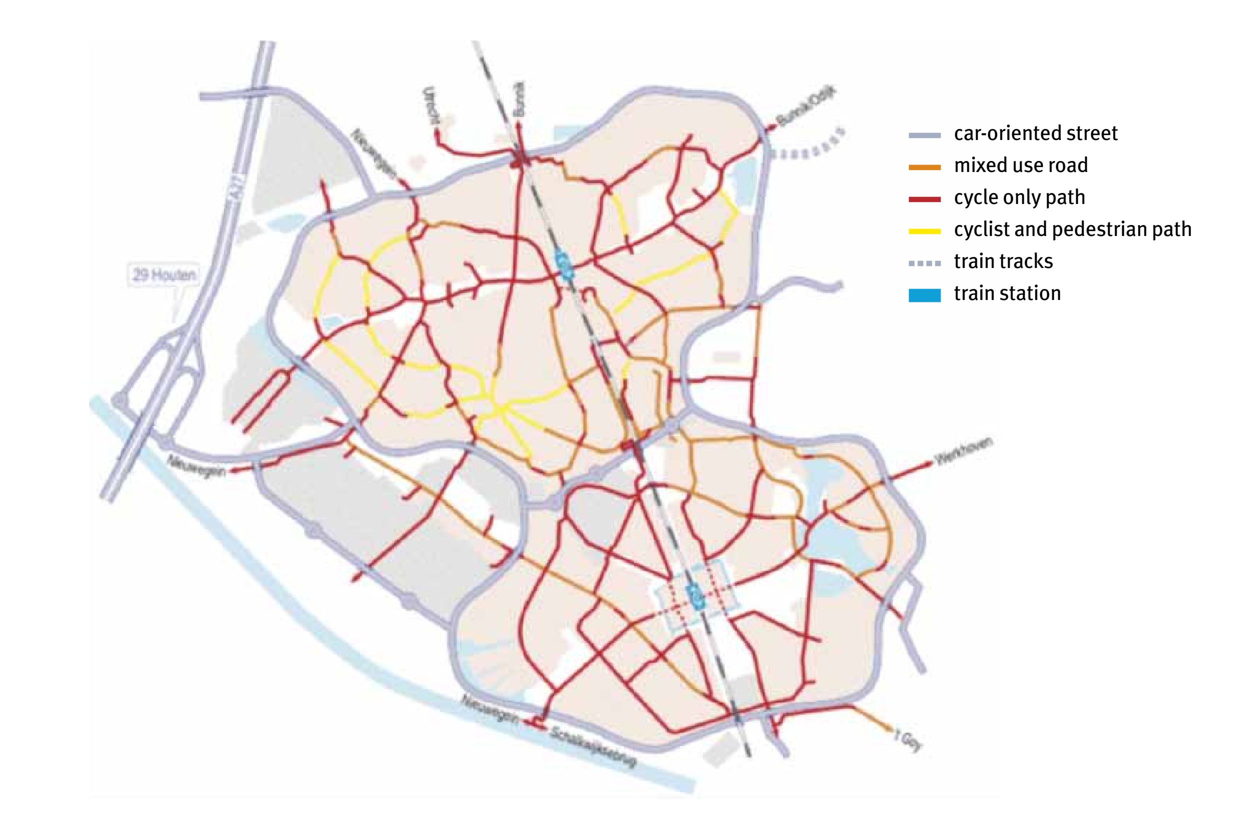


Figure 1: Street Layout of Houten

VINEX LOCATIONS

Vinex Locations are areas in the Netherlands, generally in the outskirts of cities, designated for housing development. The program was created by the Dutch Ministry of Housing in 1993 as an answer to the anticipated housing shortage, mainly due to the high growth rate of the population. More than just an urban-extension program, the Vinex project was intended to metamorphose the shape of the Netherlands. Over a million houses were to be built by 2015, in new neighborhoods fulfilling special conditions. "To fit the requirements of the consumer in the 21st century," special attention was given to quality, sustainability and social equity.

The principles of Vinex housing are:

- **Build cohesive neighborhoods in place of existing urban gaps to reduce the fragmentation of Dutch cities and to protect green areas**
- **Make easily accessible all urban facilities and, in particular, shopping centers in order to increase the potential customer base**
- **Reduce car-dependency by providing easy access to urban facilities by public transport or NMT**
- **Build a viable and social structure that will correspond to all layers of society**

Vinex Locations are required to create growth plans following certain standards. To avoid segregation, 30% of housing is required to be social housing, which is subsidized by the government and meant for low-income households. Additionally, housing must be high density with at least 30 houses per hectare, must conform to market conditions, must maintain the relation between existing and new urban areas and must use sustainable design (*Vinex Location Website*).

Public Space Design

The city of Houten has incorporated many open public spaces and green areas into its design. Next to the central train station is a plaza surrounded by a man-made canal and home to numerous shops and cafes. The plaza is often used for public markets, making it a bustling activity center. A similar plaza with shops and cafes but incorporating a Romanesque theme, is planned for the Houten Castellum station in the south of the city. Many small play areas and parks are located throughout the city so that no one has to go far to find green space. In addition, a small forest complete with cycle paths and play areas for children was created just outside the city. The objective was to create an area near the city, accessible by bicycle or walking, where residents could escape to enjoy nature without having to drive.

Land Use Planning and Design

In the core of each of Houten's rings is a train station, so that no one lives more than two kilometers away from a station. Next to each station is a plaza with shops and other amenities. Housing is arranged "like pedals of a flower" around these central areas (*Beaujon 2002*). This style follows the classic layout of a transit oriented development (TOD), with housing and retail focused around a central transit station, maximizing access for all residents. Furthermore, the majority of schools and important buildings are located along a bicycle thoroughfare, which runs through the center of the city, providing easy access to important destinations by bike.

A business park is located in South Houten close to the border between the two rings, providing many job opportunities to residents. In addition, the historic city center of Houten is located in the southwestern part of the northern ring, which consists of a plaza surrounded by shops and restaurants as well as several historical buildings, including a protestant church that dates back to the 1500's.

Public Transport

As mentioned, Houten has two railway stations, one located in the center of each ring road. Houten Castellum was recently renovated and additional track capacity was added. Every 15 minutes a train takes travelers from Houten Station to the city of Utrecht, with a journey time of 10 minutes. There are also four trains per hour running in the opposite direction, towards the town of Geldermalsen. Houten also has bus connections to Utrecht and other regional centers. The trains and buses make it easy for residents to access Utrecht and other parts of the Netherlands without needing a car.

Train and bus riders in Houten may use the OV-chipkaart, a contactless smartcard that will eventually be used on all public transport in the Netherlands. Introduction of this card simplifies the process of traveling to other parts of the country. The same card can also be used in the GWL Terrein development located in Amsterdam.

Public Bikes

An OV-Fiets (translated as "public transport bicycle") rental station with 35 bikes is located at a staffed bicycle parking facility near Houten's central train station (Photo 8). OV-Fiets started as a pilot project in the Netherlands in 2002 with the aim to integrate bike rental as part of the services offered by the Dutch public transport system. There are now over 160 rental points, mainly located at train stations throughout the Netherlands. The scheme has been designed for frequent users, mainly commuters, to encourage cycle use over motorized transport for the first/ last leg of their journeys between the station and their homes or places of work. Currently 50% of the nation's rail passengers have access to the scheme (*OV-Fiets (NL) 2008*).

OV-Fiets users must register with the system and a Dutch bank account is necessary for the subscription charges. Users can sign up using their existing annual rail season card (much like the Oyster scheme in London) or obtain a membership card. Each individual rental costs €2.85 per 20 hour period up to a maximum of 60 hours. The yearly subscription charge is €9.50. Members may use a bike at any location throughout the Netherlands, but must always return the bike to the station where it was obtained.

The OV-Fiets system differs from bikesharing systems being introduced in many cities, such as Velib in Paris and Stockholm City Bikes, in which short trips are encouraged and users can pick-up and drop-off bikes at numerous locations throughout the city. OV-Fiets, on the other hand, has one charge per 20 hour period, so users often keep the bikes for longer periods of time. Additionally, each bike comes equipped with a lock, making it possible for users to park the bike, for example, at their office during the day, and use

Table 1: Information about carsharing companies in Houten

	Wheels4All	Greenwheels
Deposit	250€	225€
Monthly subscription fee (varies based on subscription type)	Several options: 2.5, 5, 10, 20 or 150€	4,700
Population density *(persons/ha)*	2.5, 5, 10, 20 or 150€	Ranges from:
Fee per km (varies based on subscription type)	0.11 or 0.13€	0.10€
Hourly fee (varies based on subscription type)	0.5, 1.6 or 2.5€	2.50€
Discounts available	No substantial discount available	Discount with Dutch Railway card (NS card)
Company membership option	Yes	Yes
Number of cars available in Houten	14	2

http://www.wheels4all.nl, http://www.greenwheels.nl

Table 2: Houten as compared to nearby and surrounding areas

	Houten	Zeist	Milton Keynes	South Houten	Veldhuizen
Population	43,900	60,400	196,000	18,700	9,350
Urban area *(ha)*	820	2,500	8,900	350	190
Urban density *(persons/ha)*	54	24	22	53	49
Number of residential units	18,400	26,600	NA	5,700	3,500
Cars per 1,000 residents	415	530	NA	449	NA
Mode share					
Car	34%	46%	70%	58%	77%
Public transit	11%	11%	10%	16%	10%
Bicycle	28%	29%	3%	24%	13%
Walking	27%	14%	17%	2%	0%

ITDP Europe, 2010; City of Houten; City of Zeist; Milton Keynes Council, 2009; Hilbers, 2008

the bike throughout the day for trips or errands. The bike must then be brought back to the same station where it was checked-out. Therefore it functions as a hybrid system between bikesharing and bicycle rental.

Carsharing

Two carsharing companies are located in Houten: Greenwheels and Wheels4all. Greenwheels has two carsharing vehicles in Houten, one of which is located near the central station. Wheels4all has fourteen cars located throughout the city. These vehicles provide residents of Houten with access to a car when needed without having to own one. More information about these companies is included in Table 1.

Employer Contributions

In the Netherlands, companies are required to compensate employees for their transport to work. This money is subsidized by the government through tax deductions. Typically employers provide a variety of options that employees can choose between, such as reimbursement for fuel, free parking, transit passes, and even providing money towards the purchase of a new bike. For example, City of Houten employees can purchase a tax deductible bike every three years. The City of Houten goes beyond national policy to restrict companies from offering compensation options related to cars. Companies may only offer transport subsidies related to bikes or public transit, in order to encourage employees to choose these options over commuting by car (*Tiemens 2010*).

Educational Programs

Children are taught from an early age≠ not only about the health benefits of cycling, but also about bicycle safety. Since cycling is a primary mode of transport in Houten, it is essential that residents understand appropriate and safe bicycle use. Starting at an early age Houten's children are given a thorough education in bicycle riding and take a compulsory bicycle exam when they are 10 years old to test their knowledge of hand signals, road rules and riding ability. Children must take this test until they pass (*CylcePress 2003*).

QUANTITATIVE ANALYSIS

In order to quantify the benefits of Houten's unique combination of urban design structure and policy measures, we compared it to Zeist, as a reference point within the Netherlands, and Milton Keynes, England, to demonstrate the difference between bike-oriented and car-oriented urban design (Table 2). Zeist has a similar population to Houten and, like Houten, is located on the outskirts of Utrecht (a

1
Houten

2
Cycle path

Houten has 129 km of cycle tracks, many of which are fully separated from traffic.

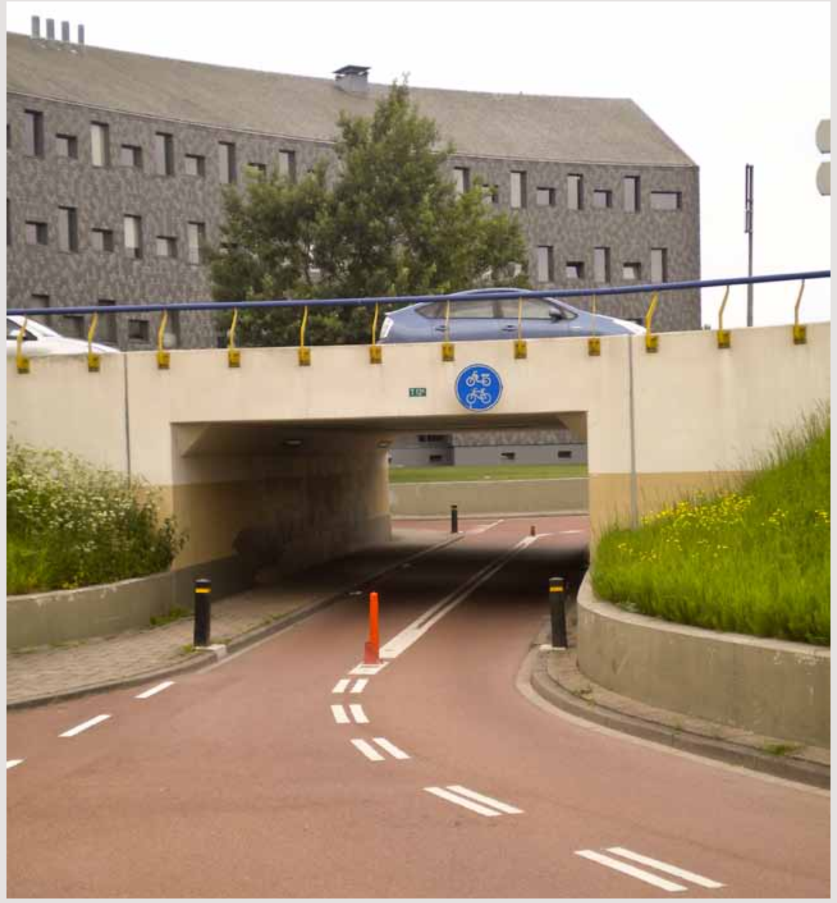
3
A car yields as cyclists cross

4

Speed bumps slow motor scooters which are permitted by Dutch law on cycle paths.

5
Cycle tunnel

Cycle paths cross the ring road, giving both cyclists and motorists safe, uninterrupted travel routes.



6
Bicycle trailer

Children learn about cycling and cycling safety from an early age in Houten and many families travel together via bike.

7
Mixed use street

On residential streets, bikes share space with cars, but as the sign indicates, drivers must give cyclists right-of-way.

8
OV-Fiets bicycles

An OV-Fiets bicycle rental station near Houten's train station is a blend between bikeshare and traditional bike rental, allowing for day-long rentals to encourage passengers to ride to and from the station.

regional center with a population of 307,000). Like many cities in the Netherlands, Zeist has good bicycle and pedestrian infrastructure; however its street network is much more car-oriented than the Houten network. Milton Keynes, like Houten, was designed in the 1960's as a new city; it was the last and largest of the British government's new towns, under the 1946 New Towns Act. The city is located about 80 km northwest of London. Unlike Houten's bicycle and pedestrian focused, dense, urban design, Milton Keynes was designed with the car in mind, focusing on low densities and easy car access on high speed grid roads. In a further attempt to accommodate the car, the parking supply is quite high; as much as 2-3 times higher than what would be expected for a city of its size (*Whiteside 2007*).

Additionally, the area of South Houten is compared to the neighborhood of Veldhuizen, located in the Leidsche Rijn district of the city of Utrecht. Like South Houten, Leidsche Rijn was identified as a high growth area, or Vinex Location (see Vinex Locations sidebar). Both locations were required to follow the same Vinex Location guidelines, including reserving 30% of housing as social housing, providing a density of at least 30 houses per hectare, maintaining the relation between existing and new urban areas and using sustainable design. The neighborhoods in the Leidsche Rijn district were designed individually, each with its own identity. However, the urban designers of Veldhuizen and other neighborhoods of Leidsche Rijn took a different approach to the planners of Houten, placing more focus on cars and therefore providing more parking facilities, more main roads, and improvements to public transit (*Hilbers 2008*). Table 2 provides a summary of statistics for the entire city of Houten (within the two ring roads), the city of Zeist, the city of Milton Keynes, the area of South Houten (within the southern ring road) and the neighborhood of Veldhuizen.

Car and Bicycle Ownership Rates

While the car ownership rate of Houten is not necessarily low (415 cars per 1,000 residents), it is lower than the nearby city of Zeist (530 cars per 1,000 residents). A survey of Milton Keynes residents found that 45% of households have two or more cars (*Milton Keynes Council 2009*). This is higher than for the city of Houten where 36% of households have two or more cars (*ITDP Europe 2010*). The Milton Keynes survey did not collect exact numbers of cars owned per household.

Surveys conducted in both Houten and Milton Keynes asked about the bicycle ownership rates for households. In Houten only 2% of households are without a bicycle while in Milton Keynes 35% of households do not own a bike. The bicycle ownership rate is quite high in Houten at 3.4 bikes per household. The rate is much lower in Milton Keynes at 1.1 bikes per household. This is not surprising given that the Netherlands is known for having a much stronger bicycle culture than England. However, investments in bicycle infrastructure also likely contribute to this difference. The city of Houten has nearly three meters of cycle paths per resident while Milton Keynes has just over one meter of cycle paths per resident. Furthermore, the cycle paths in Houten are direct and are perceived as safe by residents, while the cycle lanes in Milton Keynes are not direct, can be difficult to follow and are perceived by some to be dangerous after dark (*Whiteside 2007*).

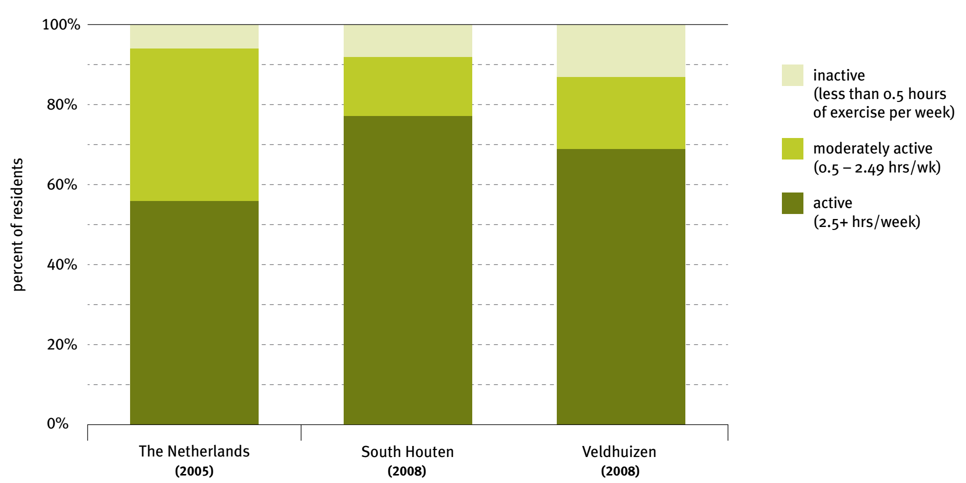
Bicycle Use and Perceptions

Results of a survey conducted by University of Utrecht students shows that people in South Houten are more active, on average, than people in both Veldhuizen and the Netherlands as a whole (Figure 2). Factors contributing to this increased activity are that residents of South Houten more often cycle for daily and weekly errands and also spend more hours per week on recreational cycling (2.3 hours per week for South Houten residents versus 1.4 hours per week for Veldhuizen residents). It would appear that the spatial design structure and extensive cycle network seem to encourage cycling in Houten. This is further supported by survey findings that residents of South Houten are more satisfied with the number of unhindered bike paths and give higher ratings for quality and safety of bike paths (Figure 3). In addition, more than half of survey respondents stated that their bicycle use increased after moving to South Houten (*Hilbers 2008*).

Mode Split

While Houten residents do more recreational cycling than residents in surrounding areas, encouraging more transportational cycling is key to reducing carbon emissions. A survey of South Houten and Veldhuizen residents in 2008 found that more respondents from South Houten (24%) cycle to work than respondents from Veldhuizen (13%), as seen in Figure 4. Furthermore, 14% of respondents from South Houten cycle or walk to a public transportation stop or station and then take public transportation to work versus 9% in Veldhuizen. A far smaller proportion of South Houten residents (58%) travel to work by car than Veldhuizen residents (77%).

Figure 2: Activity level of residents of The Netherlands, South Houten and Veldhuizen



Hilbers, 2008

Surveys of residents of Houten and Milton Keynes found that far more work trips made by Houten residents (31%) are by bike than work trips made by Milton Keynes residents (4%), as seen in Figure 5. In addition, far more commute trips by Milton Keynes residents (73%) are by car than in Houten (53%). This demonstrates that Milton Keynes residents are much more dependent on their cars for work trips than Houten residents.

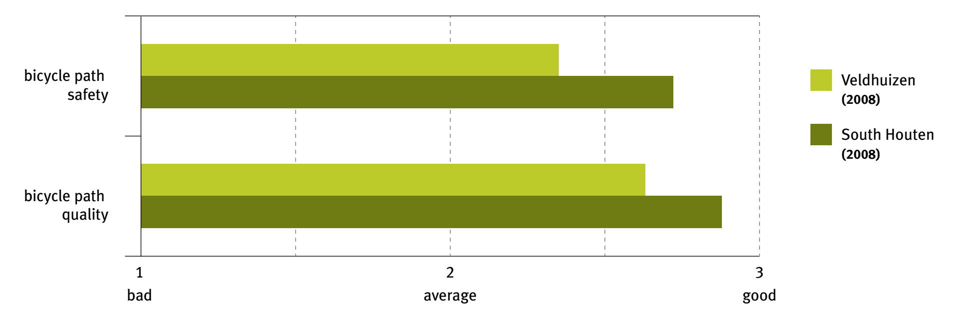
Still, many work trips made by Houten residents are by car, particularly for trips out of the city. However, by far, the most popular mode of travel for trips made within the city is cycling. The majority of Houten residents travel to the grocery store (53%), conduct other shopping (70%), run service related errands like visiting the bank or barber (79%) and visit friends and family in Houten (79%) by bike or on foot, as seen in Figure 6.

Overall, more than half of all trips made by Houten residents (55%) are made by non-motorized modes of travel, which is higher than for the city of Zeist (43%) and Milton Keynes (20%). Further, higher proportions of trips made by Milton Keynes (70%) and Zeist residents (46%) are by car than for the city of Houten (34%), as seen in Figure 7. A further study found that 42% of trips shorter than 7.5 kilometers in Houten are made by bike, and around 21% by foot (*City of Houten Website*). Another study states that car use in Houten is 25% lower than in similar cities (*Beaujon 2002*). All of these studies support the finding that the combination of measures present in Houten have contributed to improved sustainability of travel choices of residents, particularly for trips within the city.

Distance Traveled

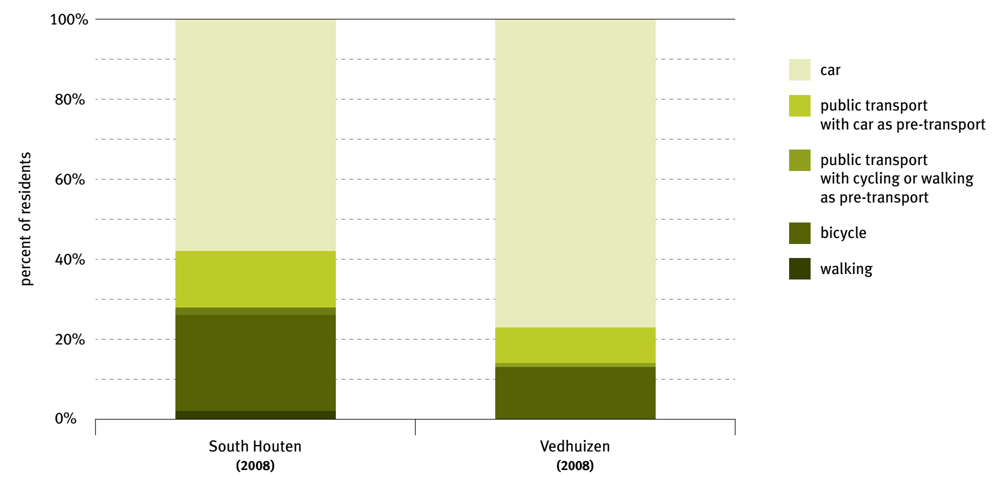
Distance traveled is a key measure for evaluating transport-related emissions. Resident surveys found that residents of South Houten have shorter commute times than residents of Veldhuizen, even while more people commute to work by bike and fewer by car. This suggests that residents of South Houten live closer to work, thus requiring less daily travel, and reducing the carbon footprint of residents (*Hilbers 2008*).

Figure 3: Perceptions of bicycle path quality and safety in South Houten and Veldhuizen



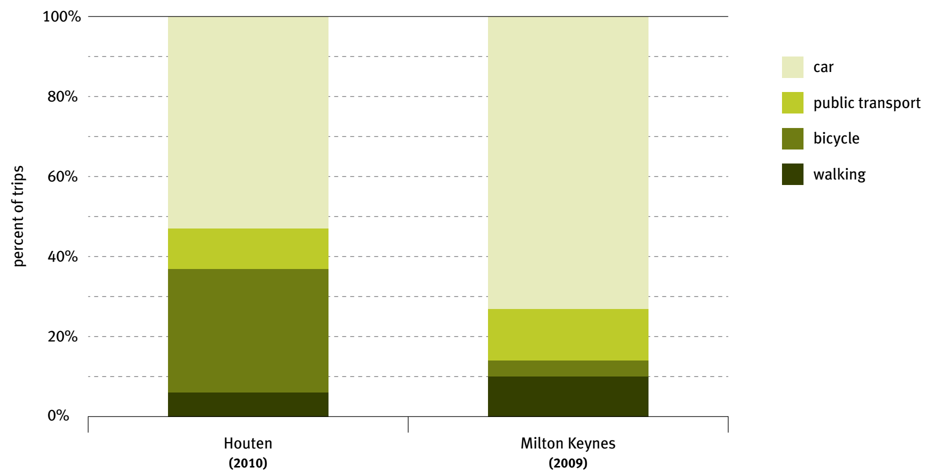
Hilbers, 2008

Figure 4: Mode of transportation to work for South Houten and Veldhuizen residents



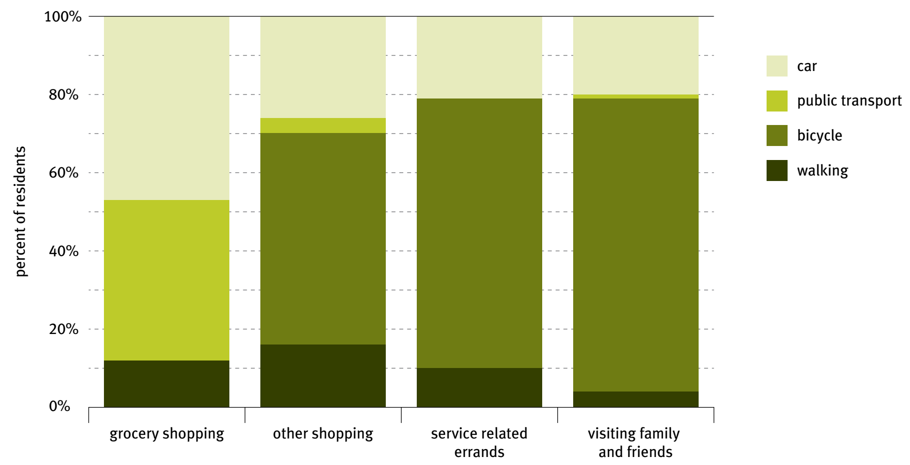
Hilbers, 2008

Figure 5: Mode of travel to work



Hilbers, 2008

Figure 6: Houten residents' mode of travel for various trip types (2010)

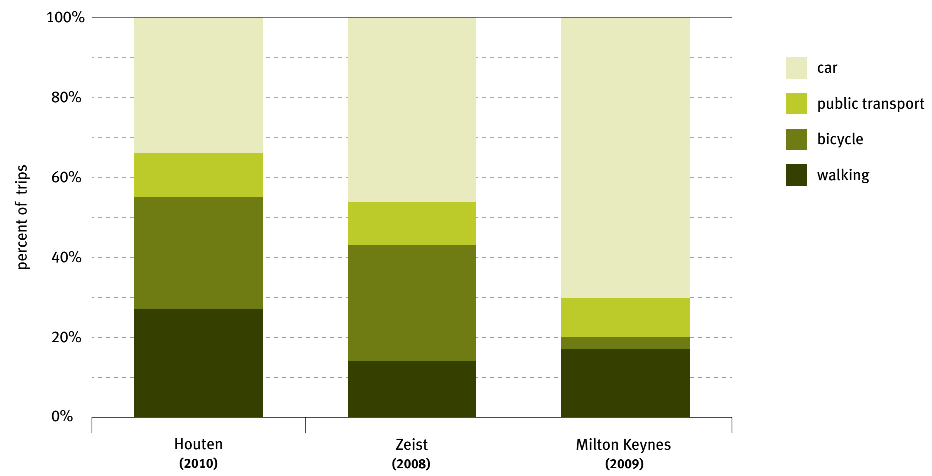


ITDP Europe, 2010

Indeed, surveys of residents throughout the city of Houten found that 21% of residents live within 5 kilometers of their place of work or education, and more than half live within 15 kilometers. However, the finding that almost half of residents live 15 kilometers or more of their place or work corresponds with the finding that 53% of resident commute trips are by car (Figure 5). For longer travel distances, residents are forced to travel by motorized modes since most are not able to cycle or walk such long distances. While Houten has good public transport access, it appears that many residents still choose to travel by car to work, particularly for destinations more than 25 kilometers from home. Increased car travel increases the carbon footprint of residents.

Half of Houten residents travel less than one kilometer to their grocery store, and 18% travel a mere 500 meters or less. The average distance residents travel to a grocery store is 1.2 km (*ITDP Europe 2010*). However, 47% of residents stated that they typically travel to the grocery store by car (Figure 6). Residents might be incentivized to drive to the store based on the low parking rates in parking garages in Houten and the high availability of parking spaces. If parking prices were increased, more residents would likely shift to cycling to the grocery store, since the majority of residents already cycle for most other trip purposes within the city (Figure 6). Indeed, many residents own bike trailers which can be used to carry goods (Photo 6). These trailers, combined with the short distance to a grocery store make shopping trips by bicycle feasible.

Figure 7: Mode split for all trips



ITDP Europe, 2010; Rijkswaterstaat Centre for Transport and Navigation, 2008; Milton Keynes Council, 2009

LESSONS LEARNED

Residents of Houten cycle far more and drive far less than their neighbors, and much less than their counterparts in Milton Keynes, England. However, the city has been so successful at promoting cycling and transit, that now over-crowding has become an issue. Bicycle parking facilities are filled capacity and residents complain about lack of bicycle parking. The city of Houten is aware of this issue and is currently constructing a staffed bicycle parking facility combined with a bicycle shop and bicycle repair services under the tracks of the central train station.

The demand for trains leaving from Houten's central station was also underestimated. As a result, frequency of train service to Houten was increased and the number of tracks on the line from Utrecht to the south via Houten is currently being doubled to four tracks.

An important strategy not applied in Houten is to restrict parking by limiting and pricing parking. There is more than one parking space per residential unit in Houten. As a result, the majority of households own cars and the car ownership rate in the city is fairly high.

In addition, two parking garages are located near the central station. The first two hours are free within these garages, then 1.50 Euros per hour is charged up to a maximum of 9 Euros per day. The shop owners in central Houten subsidize the free hours through their rent. They were worried they would lose business if people had to pay too much for parking (*Tiemens 2010*). However, as shown in Figure 6, most residents of Houten already walk or ride a bike for shopping trips, so parking prices could easily be raised without hurting business. Though most do cycle, the low prices for parking might encourage some residents to drive to the grocery store rather than cycle, even though they live within cycling distance of the store.

Other cities that choose to replicate Houten's model should limit or economically decouple residential parking in order to encourage reduced car ownership. In addition, non-residential parking should be priced in order to encourage residents to use other forms of transportation besides driving to do their shopping. ■

SOURCES

Beaujon, Otto (2002). *Biker's Paradise: Houten*. Bike Europe.

City of Houten website, http://www.houten.nl/over-gemeente-houten/projecten/houten-demarreert/internationaal/ (accessed August 9, 2010).

City of Zeist website, http://www.zeist.nl/ (accessed August 9, 2010).

CyclePress (2003). *Taking a Look at Houten City*, CylcePress, No. 189, May 2003.

Greenwheels website, http://www.greenwheels.nl (accessed August 9, 2010).

Hilbers, Brechtje (2008). *The influence of the spatial planning on bicycle use and health — Comparisons between Houten and Leidsche Rijn*. University of Amsterdam.

ITDP Europe (2010). Internet-based survey of Houten residents, conducted in cooperation with the City of Houten.

Milton Keynes Council (2009). *Milton Keynes Multi-Modal Transport Model — Report of Survey*, Halcrow Group Limited, London.

OV-Fiets (NL) (2008). *Bikeoff Project — Design Against Crime*, http://www.bikeoff.org/design_resource/dr_PDF/schemes_public_Ov_fiets.pdf

Rijkswaterstaat Centre for Transport and Navigation (2008).

Tiemens, Herbert (2010). Interview with Herbert Tiemens, Traffic Planner, City of Houten, May 27, 2010.

Vinex website, http://vinex-locaties.nl (accessed August 9, 2010).

Wheels4all website, http://www.wheels4all.nl (accessed August 9, 2010).

Whiteside, Kevin (2007). MK Transport — Moving with the Times, Urban Design, Issue 104, pp. 27–33.

Image credits

Figure 1: City of Houten
Opening spread photo: Nicole Foletta
Photos 1–6, 8: Nicole Foletta
Photo 7: Simon Field

SIHLCITY SITE FACTS

- **Developer:** Karl Steiner AG
- **Architect:** Theo Hotz Architects
- **Developed Area:** 4 ha
- **Construction Began:** 2003
- **Year Completed:** 2007
- **Number of Businesses:** 97
- **Jobs:** 2,300
- **Visitors per Day:** 19,000
- **Visitor Parking Spaces:** 800
- **Allocated Staff Parking:** 0
- **Transit and NMT Combined Mode Share:** 67%
- **Number of Carsharing Vehicle Available:** 3

CASE STUDY

Sihlcity

ZURICH, SWITZERLAND

Simon Field, ITDP Europe

BACKGROUND

Sihlcity is a new non-residential retail and leisure development located about 2.5 km to the south of Zurich city center (Figure 1). It is considered best practice because parking is heavily restricted, a result of a policy in Zurich to only allow new development in sites that have adequate access to public transit as well as walking and cycling facilities, thereby detering new car trips to destinations that might traditionally attract them. The city uses a "trip access contingent model" to determine what policies will help keep car trips below a certain level. In this case the process suggested a reduction in parking supply, and provided incentives for the imposition of high usage costs. Today only 33% of trips to Sihlcity are made by car.

There are 75 shops, 14 cafés and restaurants, a cinema, church, library, hotel, gym and medical centre, as well as high quality public space at Sihlcity (Photo 1). The heart of the development is a four-story mall accommodating almost all of the retail businesses. The site was previously occupied by a paper mill, ceased operations in 1990. In 2003 the land was bought by the developer Karl Steiner AG, which integrated four of the historic buildings into their plans for a new non-residential quarter, named after the River Sihl bordering the site to the east. In 2008 Sihlcity received a European Shopping Centre Commendation, in recognition of the work of Theo Hotz Architects in blending the old and new, as well as the provision of a variety of businesses and services on the same compact site (*Sihlcity, 2008*).

Large shopping centers are significant trip attractors, and without incentives not to, most people get to them by car. To prevent new traffic congestion and pollution on the routes to Sihlcity, the City and Canton of Zurich invoked planning regulations to restrict car access a) as a condition of initial planning permission, and (b) in the longer-term after opening.

This strategy includes parking management, better public transportation, improvements to infrastructure for cyclists and pedestrians, and the provision of a sustainable home delivery service.

PLANNING PROCESS

According to the Canton of Zurich Structural Plan, "heavily frequented sites"[1] may only be located in areas that satisfy the following accessibility criteria:

- A maximum distance of 300 m to a rail station served by at least one train per hour, or 150 m to a transit stop served by eight or more trams, buses or trolleybuses per hour;
- Sufficient road capacity in the surrounding area for general traffic;
- Proximity to existing pedestrian routes and cycle networks

Having passed this initial screening, the City of Zurich approved the plans for construction of Sihlcity subject to conditions being imposed on the site owner and developer that include:

[1] Defined by the Canton of Zurich as sites that generate more than 3,000 trips per day on more than 100 days of the year.

Figure 1: Transit routes to and from Sihlcity

- Provision of "recreation quality" space within the site (Photo 1);
- Provision of capital and revenue support for the following public transportation improvements: extension of platforms at Saalsporthalle S-Bahn (urban rail) station, with a new pedestrian subway giving access to the site; construction of a subterranean bus station; operation of bus route 89 and an extension to tram route 5 for two years (Photo 2);
- The development must pay for the construction of new access roads and links to the existing bicycle network on three sides of the site;
- Provision of a bicycle-based home delivery service;
- Parking on the site is capped at a maximum of 850 spaces, all of which must be charged for, plus a cap on car trips to the site (access contingent).

The access contingent model is a mechanism to impose limits on the number of trips made to/from a site by private car in a given period, with stiff financial penalties for non-compliance. This provides an incentive for the owner of a new development to make access by alternative means as attractive as possible. The first step is the calculation of the number of parking spaces permitted, based on the following criteria in the City of Zurich's parking regulations:

- Floor area per building category e.g. offices, retail, restaurants;
- A reduction factor based on proximity to the city centre;
- A reduction factor based on transit accessibility level;
- A reduction factor where local NOx limits are exceeded;

In Zurich's central old town district, for example, a blanket reduction factor of 90% applies, i.e. the maximum number of spaces is 10% of the value based on floor space alone. For Sihlcity one parking place was allowed per 110 m² ground floor space, giving a total of 800 spaces.

The "specific trip generation" per space per day, evening period and peak hour is capped under a formula based on the categories of expected visitors. This and estimated price elasticities then inform the level of parking charges (Table 1). The maximum car trip contingent values for Sihlcity are as follows:

- 10,000 trips per day, decreasing to 8,800 by 2012;
- 1,300 trips at night;
- 800 trips per peak hour.

KEY POLICY AND DESIGN MEASURES

A two-fold travel demand management strategy is in place at Sihlcity: high parking costs to "push" visitors and workers out of private cars, reinforced by parking restrictions in the surrounding area, and high quality local and city-wide transit and non-motorized transport infrastructure to "pull" people onto alternatives.

Parking

Parking management discourages trips to Sihlcity by car: spaces are few and expensive. There are 850 spaces in the on-site multi-story car park, of which 50 are allocated to park & ride season ticket holders, but none to Sihlcity workers.

Parking charges are listed on the Sihlcity website and are in Table 1. A stay of up to four hours costs 7 Swiss Francs (CHF), comparable with the 1–2 zones transit day ticket at 8 CHF. However, residents of Zurich can avail themselves of a range of period passes for one or more zones in the Zurich Verkehrsverbund (integrated transportation authority area), a national travel pass (GA card) or national half-fare card, reducing the real and perceived costs of transit significantly[2]. As there are no discounts for those employed on the site, it is prohibitively expensive to commute by car. Table 1 shows that it costs 20 CHF to park at Sihlcity for an eight-hour working day.

[2] Over 400,000 GA cards and 2.27 million half-fare cards were sold in 2009; 35% of the Swiss population own one of these mobility passes. Sources: SBB (2009) and FSO (2010).

Table 1: Sihlcity parking charges

Time (hours)	Daytime rate 08:00–20:00 (CHF)*	Evening rate 20:00–08:00 (CHF)*
< 1	2.50	2.50
1–2	3.50	3.50
2–3	5.00	5.00
3–4	7.00	7.00
4–5	10.00	8.00
5–6	12.00	9.00
6–7	15.00	10.50
7–8	20.00	12.00
8–9	25.00	13.50
9–10	30.00	15.00
10–11	35.00	16.50
11–12	39.00	18.00
12–24	39.00	39.00

Sihlcity

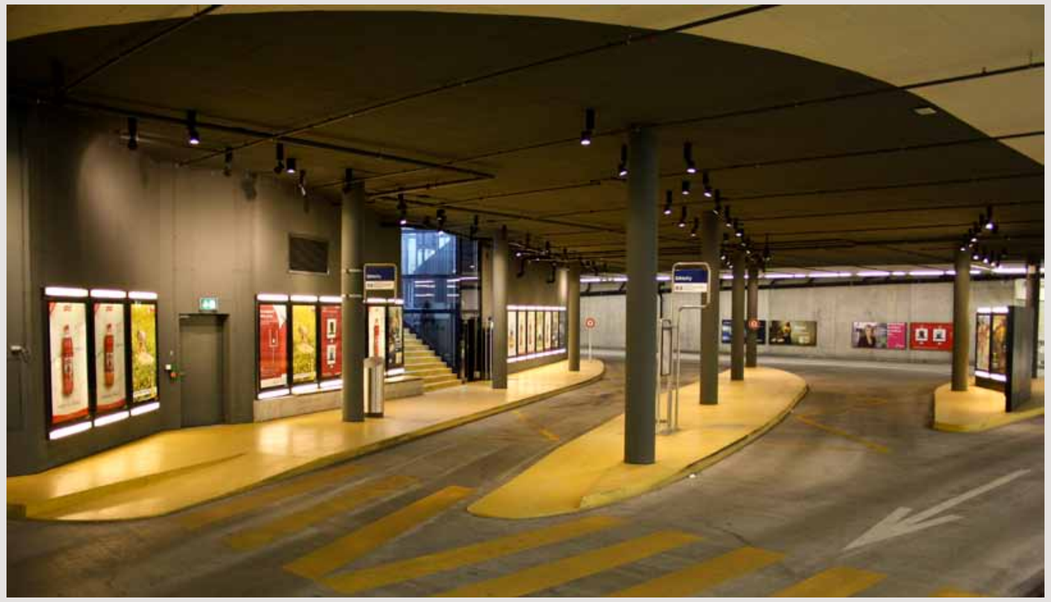
*1 CHF = 0.75 EUR = 0.95 USD

1
Public space in the heart of Sihlcity

The Sihlcity entertainment center has an ample amount of public space, as opposed to surface parking lots that are commonly seen in similar centers in the U.S. and Europe.

2

The site developer paid for the extension of platforms at Saalsporthalle S-Bahn station, adjacent to the Sihlcity mall.



3

Sihlcity underground bus station, with lift and steps to the main square.

4

Prominently displayed public transport departure information in the heart of Sihlcity.

5

The main entrance to Sihlcity from Sihlcity Nord is reserved for cyclist and pedestrians, motorized traffic is prohibited.

6
Bicycle parking next to storage lockers

Customers can store cold groceries while running other errands or take advantage of low-cost delivery service via electric bike.

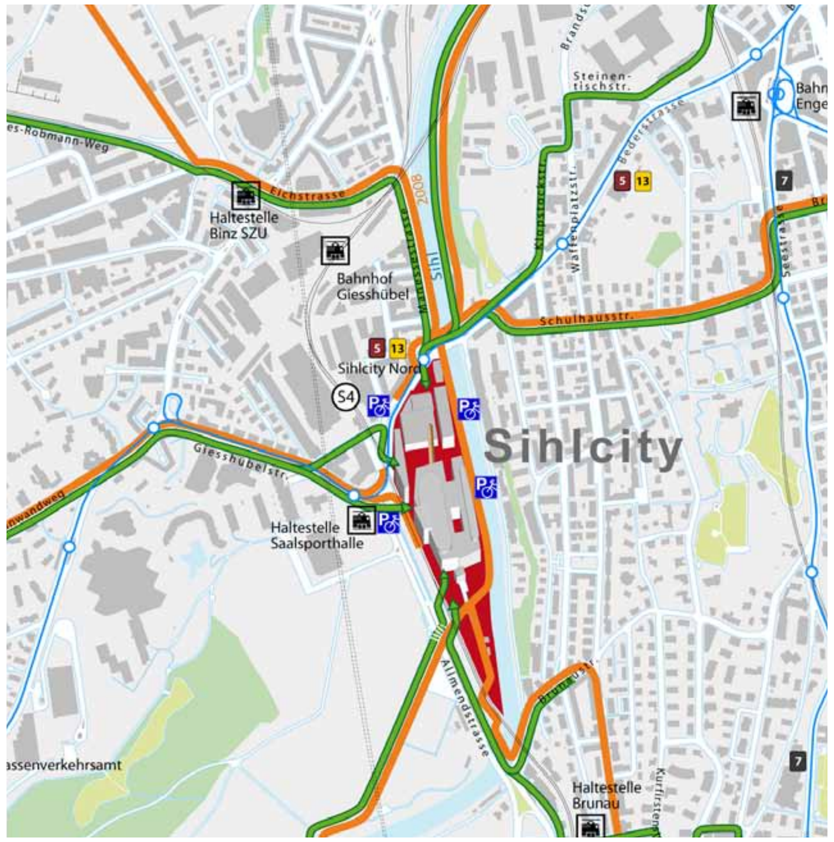


Figure 2: Recommended pedestrian (green) and cycle (orange) routes into Sihlcity

A fine of 50 CHF is payable by vehicle owners attempting to leave without paying the correct fee.

The surrounding area is a controlled parking zone with no on-street parking for non-residents, critical to avoid shoppers or workers from just parking on residential streets and inconveniencing the adjacent community. However, the multi-story car park is directly connected to the mall and the local road network via two new access roads. The A3 motorway from Zurich to Chur can be accessed at a junction 0.5 km to the south of Sihlcity at Brunau. Thus the limited supply and cost of parking is the only policy "stick," with much greater reliance on the "pull" measures described below.

Public Transportation

The area is very well served by transit, with traffic-free access routes to the most heavily used stops. No part of the development is more than 250 m from Sihlcity Nord tram and bus stop, 150 m from the extended platforms at Saalsporthalle station (Photo 2) and 150 m from the site's own underground bus station (Photo 3). The use of step-free, low-floor vehicles is detailed in Table 2.

Transit routes and frequencies are summarized in Figure 1 and Table 2. As in most European cities, a Zurich ZVV single trip ticket allows unlimited changes to reach one's destination, minimizing the inconvenience of interchange. Trams, buses and trains are timed to connect at many hubs, as is the case across much of Switzerland. Printed timetables, maps and fare information are displayed at all stops and in the central public square, with electronic departure boards located on the square and inside the mall (Photo 4).

A comprehensive network of tram and suburban rail (S-Bahn) services form the backbone of Zurich's transit system, complemented by buses and trolleybuses serving lesser-used and orbital routes. Routes, timetables and fares are set by the ZVV Verkehrsverbund (transit agency), which is also responsible for information provision and marketing, allowing full intra- and inter-modal integration across the city region: the slogan "one ticket for everything" is part of the ZVV logo. The municipal operator of the city's tram and bus network, VBZ, has heavily marketed the improved transit service to Sihlcity, focusing on the comfort and frequency of tram routes 5 and 13 with the slogan "changing makes sense."

There are location maps, route maps and timetables at all stations and you can purchase the most popular tickets with coins at most stations. An increasing number of city centre stops have touch-screen machines offering a greater variety of passes and destinations: these accept coins, credit and debit cards, and will eventually replace the coin-only terminals.

Heavily-used stops feature electronic departure boards, some of which can display real-time information. All stops are shown in the online mapping service Google Maps, together with the times of the next two departures per route and links to full timetables on the ZVV website. Real-time next stop and connectional information is announced, and in most cases displayed electronically, in trams, trains and buses.

Zurich has a zonal fare structure, with a range of personal (non-transferable) and transferable monthly and annual passes available for either (a) travel without restriction, or (b) travel at any time outside the hours of 05:00–09:00 on weekdays: the latter cost half the price of the unrestricted versions, starting from 693 CHF, or 519 EUR, for the annual personal pass covering the entire metropolitan area. 75% of Zurich residents possess at least one transit season pass

Table 2: Transit routes to and from Sihlcity

Route	Sihlcity stops served	Details	Mon–Fri peak frequency	Mon–Sat off-peak frequency	Sunday frequency	Step-free vehicles?
Train S4	Saalsporthalle	City radial routet	Mon–Fri peak frequency	20 mins	20 mins	No
Trams 5 and 13	Sihlcity Nord	City radial route	3–4 mins	3–4 mins	10 mins	Some
Trolleybus 33	Sihlcity Nord	City inner orbital route	6.5 mins	7.5 mins	10 mins	Some
Bus 89	Sihlcity (bus station)	City outer orbital route	7.5 mins	15 mins	No service	Yes
Postbuses	Sihlcity / Saalsporthalle	To/from rural hinterland	30 mins	Mostly hourly (no Saturday service)	No service	Yes

Author's elaboration

(*Stadt Zürich, 2007*). Books of six one-day and single-trip tickets are also available. A Junior Travelcard costing 20 CHF per year allows accompanied children up to the age of 16 to travel free. Carsharing membership can be bundled with these options.

Bicycles can be carried on buses, trolleybuses and trams subject to space, and on S-Bahn trains at off-peak times.

The electricity generation mix across Switzerland as a whole is 55% renewable (largely hydro-electric) and 41.1% nuclear[3], while that of the national railway system is 73.5% hydro-electric and 26.5% nuclear. This clearly demonstrates the value of modal shift from the car to electrified transit in particular, as a core element of the Swiss climate change mitigation strategy.

Pedestrian and Cycling Infrastructure

Within the site, the main access route from Sihlcity Nord and the central public square are free of motorized traffic and shared by cyclists and pedestrians (Photo 5). Access from the west is via a new subway under Saalsporthalle station: this and the southern access point are linked to existing cycle paths via newly constructed paths. Access routes for pedestrians and cyclists (Figure 2) are described in a printed leaflet, and were available to download from the Sihlcity website until September 2010.

Bicycle lanes in the surrounding area are either on the road, separated from other traffic by yellow painted lines, or on the pavement (sidewalks), especially at the busy Sihlcity Nord junction. A dedicated traffic-free route runs along the river for approximately one kilometer towards the city centre: detailed printable and audio guides for leisure walks from the city centre are downloadable from the Sihlcity website.

Bicycle use is further encouraged through the provision of 600 covered parking spaces in four locations across the site (Photo 6).

Storage Facilities and Home Deliveries

Many people drive to shopping centers because it is usually the easiest way to transport purchases back home. Sihlcity offers a number of innovative services to encourage the use of sustainable modes by shoppers.

Storage lockers of varying sizes are available on-site, with modest fees of no more than 4 CHF for up to six hours. An innovation demonstrating Sihlcity attention to detail is the provision of lockers chilled to 12°C, ideal for the storage of fresh and dairy produce.

A bicycle-based delivery service for groceries and other small items of up to 40 kg is provided through the community association Züriwerk, which provides opportunities for disabled people in Zurich. Goods, including chilled perishables, can be left with Züriwerk at any time between 09:00 and 20:00, avoiding the need to rent a locker, with the actual delivery taking place at a time of the customer's choosing. The standard price is 8 CHF to any destination within the city. Deliveries averaged fifty per day in 2009, up from twenty in within the first hundred days of opening.

Carsharing

Three carsharing vehicles, including one station wagon[4], are available to rent from the park & ride area of the car park through Mobility Carsharing Switzerland. The annual membership fee is 290 CHF, or 150–190 CHF for holders of national or regional annual transit passes. Members pay between 2.70 and 4.20 CHF per hour, and a distance fee of between 0.25 and 0.92 CHF per km, depending on vehicle type and total distance travelled. Vehicles can be located and reserved online and by telephone. More information, including eco-driving tips, is available on the Mobility Carsharing website.

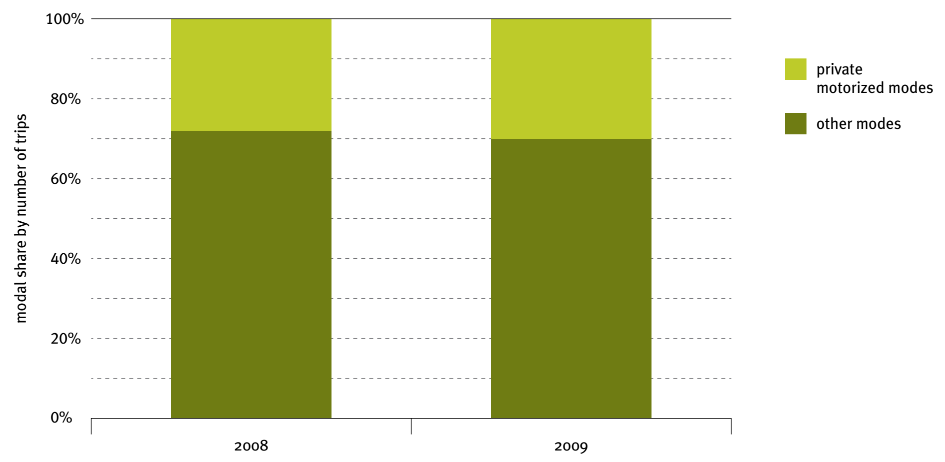
This organization offers cars at 190 sites in the City of Zurich, and at a total of 379 sites in Zurich Canton, putting a large proportion of the population within easy reach of one. Over 10,000 people hold a combined ZVV annual public transportation and Mobility membership pass, for an additional fee of 150 CHF, plus the hire charges outlined above. Interestingly, a separate tariff for infrequent users is also offered: bundled membership is available for only 25 CHF, with users paying an extra 1 CHF per hour when using a vehicle. This discourages frequent use if a reasonable alternative is available.

Unfortunately the cars are not available for one-way hire, requiring users to return them to Sihlcity: this implies additional trip generation rather than substitution. Unsurprisingly, use of these vehicles is low, with 1,040 recorded trips per day from Sihlcity in 2009, equivalent to about three trips per day, or one per vehicle (*Schmid, 2010; pers. comm.*). Alternatively, members can pick up vehicles in their own neighborhood, then drive to Sihlcity and back, although they face the same parking charges as other car users. The marginal effect

[3] 0.005 kg CO_2 / kWh. Source: Ecopassenger (2010).

[4] Estate or combi car.

Figure 3: Mode of travel to Sihlcity



De Tommasi, 2008; De Tommasi, 2009

Table 3: Quantitative comparison of the Sihlcity and Letzipark leisure and retail developments.

Site	Number of shops	Number of restaurants and cafés	Number of parking spaces	Cost of parking for three hours	Distance to tram stop	Distance to rail station
Sihlcity	75	14	850	5 CHF	250 m via traffic-free route	On-site
Letzipark	57	9	1,500	Free	250 m via busy streets	800 m

Author's elaboration

of Sihlcity carsharing vehicles on travel demand might be negligible, or even slightly adverse, but the overall impact of membership on car ownership and vehicle kilometers travelled should be considered when assessing the efficacy of carsharing. Mobility Carsharing Switzerland has 90,000 members, with an estimated 18,000 fewer car movements per day as a result (*Mobility Carsharing Switzerland website, accessed 15 July 2010*).

QUANTITATIVE ANALYSIS

Prior to the opening of Sihlcity, 1,350 people (boarders and alighters) used Sihlcity Nord tram stop per day. This more than doubled to an average of 3,100 per day within the site's first 100 days of business. User surveys estimated that non-car modes accounted for 70% and 67% of visitor trips in 2008 and 2009 respectively, comfortably beating the target of 60% (Figure 3) (*Sihlcity, 2010*). This compares with the national figure of 8–9% of shopping trip stages being made by transit in 2005 (*FSO, 2009*).

These data are not split further into transit vs, cycling or walking, but it is likely that transit dominates: City of Zurich statistics reveal that 64% of all trips involving two or more modes (including walking) include a transit component (*Stadt Zürich Tiefbauamt, 2008*).

The car park has spare spaces on weekdays, but fills to capacity on Saturdays. Car users stay for 2.5 hours on average, paying 5 CHF to do so. Of the daily limit of 8,800 car trips allowed under the trip contingent model, approximately 3,600 were made in 2008. Average car occupancy is 1.6 persons, consistent with the national figure for Switzerland. 30% of visitors used a car in 2009, compared with 38% for all shopping and leisure trips in Switzerland. Although there are no data available, it is highly likely that car use among Sihlcity workers is negligible owing to the lack of free allocated car parking.

An interesting comparison may be made with the Letzipark shopping centre, located 2.5 km to the north-west of Zurich city centre (Table 3).

Unlike Sihlcity, Letzipark is geared towards serving motorists: a petrol station and car dealership are located on-site. Public transportation comprises a radial trolleybus route, an orbital bus route and a local bus feeding the tram system. Access to high quality rail-based public transportation is considerably less convenient than in Sihlcity. More importantly, the Letzipark website (*accessed 26 October 2010*) boasts of 1,500 parking spaces, despite its smaller size, which are free to use for up to three hours. "Women only" bays are located close to the exits, increasing the attractiveness of multi-story car parking at night. The "how to get here" pages of each website are noticeably different: Letzipark's displays information for car users, with a separate link to a transit route planner, whereas Sihlcity's offers more detailed public transportation information alongside transit and car route planners. The walking and cycling map shown in Figure 2 was available on the Sihlcity website (accessed 14 July 2010), but has subsequently been removed.

LESSONS LEARNED

Encouraging the use of sustainable modes for shopping trips is a major challenge, especially when bulky or heavy loads are purchased. Nevertheless, the City of Zurich and Sihlcity have addressed this issue by (a) using the price and limited supply of parking as the key policy tool to deter private car use, and (b) providing improved transit, storage and delivery alternatives that people find convenient to use. This was facilitated through the planning system, including the City's stringent planning regulations for heavily frequented sites: planning permission was conditional on satisfying accessibility planning, maximum parking standards and car trip contingent criteria. This is a model that other cities could adopt as part of their spatial planning strategies and guidance.

The Sihlcity strategy relies on a large proportion of visitors already owning one of the many types of integrated transit pass available (from 1.90 CHF per person per day), since the cost of undiscounted one-day tickets within the city for a family of four (27.20 CHF), plus bicycle-delivery (8 CHF), compares poorly with the 3–4 hour parking fee of 7 CHF, or 7-hour stay for 15 CHF. Although there are fuel and vehicle maintenance costs to consider, these are generally perceived by car users to be negligible in terms of marginal trip costs. The carsharing vehicles on site are a useful back up for car-free visitors who may have made more or heavier purchases than anticipated, but do not contribute to a reduction in motorized vehicle kilometers. A better solution for retail centers might be just increased availability of taxis and the creation of a taxi stand at a central location for customers who are too laden down with packages to take other modes.

The use of non-motorized modes to access Sihlcity is believed to be relatively low. Possible ways to address this are the use of personal travel planning and awareness-raising campaigns on site. Free bicycle trailer hire could also help: this is offered by the British supermarket chain Waitrose and would be simple to integrate into the Züriwerk delivery facility.

Expanding the use of low-floor vehicles on transit routes to/from Sihlcity may help maintain or even expand the already high number of people who use transit to reach the site. Happily, the transit agency has a strategy to convert S-Bahn route S4 by 2014 and eliminate remaining high-floor trolleybuses by the end of 2013 (ZVV, 2008): this will improve accessibility for those laden with shopping bags and using pushchairs, as well as the elderly and disabled. In contrast, the key priority for the tram system is expansion, including the "Glattalbahn" tram network in the north of the city, rather than the replacement of older vehicles or the addition of low-floor centre sections to a further batch of "Tram 2000" vehicles. However, the Swiss Disability Discrimination Act requires that transit buildings and vehicles be fully accessible to the disabled by the end of 2023 (*Federal Office of Transport, 2006*).

In terms of the transferability of the Sihlcity experience, a prerequisite is a comprehensive, frequent, reliable, affordable, clean and comfortable transit system. Simply increasing the cost of parking alone is unlikely to be successful, given the availability of alternative retail and leisure facilities with free or low-cost parking. ■

SOURCES

Cairns S., Sloman, L., Newson, C., Anable, J., Kirkbride, A. and Goodwin, P. (2004). Chapter Eight in *Smarter Choices: Changing the Way We Travel*. Department for Transport, London.

De Tommasi, R. (2008). Heavily Frequented Sites: New Playgrounds for Mobility Management. Presentation at the 2008 ECOMM Conference, London.

De Tommasi, R. (2009). A good example of integration: Sihlcity, Zürich, Switzerland. Online presentation for the EPOMM project "MAX: Successful Travel Awareness Campaigns & Mobility Management Strategies."

Ecopassenger (2010). http://ecopassenger.hafas.de/hafas-res/download/Ecopassenger_Methodology_Report.pdf (accessed 21 July 2010).

Federal Office of Transport (2006). http://www.bav.admin.ch/mobile/01244/01258/index.html?lang=en (accessed 27 October 2010).

FSO (2009). *Mobility and Transport: Pocket Statistics 2009*. Swiss Federal Statistical Office, Neuchâtel.

FSO (2010). http://www.bfs.admin.ch/bfs/portal/en/index/themen/01/01/key.html (accessed 27 October 2010).

Letzipark: http://www.letzipark.ch

Mobility Carsharing Switzerland: http://www.mobility.ch

SBB (2009). http://mct.sbb.ch/mct/en/konzern_kennzahlen (accessed 15 July 2010).

Schmid, S. (2010). E-mail correspondence from Stefan Schmid of Mobility Carsharing, received 27 July 2010.

Sihlcity (developer website): http://www.sihlcity.ch

Sihlcity (2008a). http://www.sihlcity.ch/downloads/medienberichte_de/PR_Shopping%20Center_Award_17_04_08.pdf (accessed 8 June 2010).

Sihlcity (2010). http://www.sihlcity.ch/downloads/medienberichte_de/Medienmitteilung-Geschaeftsjahr_2009.pdf (accessed 14 July 2010).

Stadt Zürich (2007). *Mobilität und Verkehr 5/2007*. Stadt Zürich Statistik, Zürich.

Stadt Zürich (2008). *Wegtypen und Aktivitätsmuster im Verkehrsraum Zürich. Datengrundlage Mikrozensus Verkehrsverhalten 2005*. Stadt Zürich Tiefbauamt, Zürich.

ZVV (2008). Strategie 2011–2014. Zürcher Verkehrsverbund, Zurich. http://www.zvv.ch/export/sites/default/common-images/content-image-gallery/unternehmen-pdfs/ZVV_Strategiebericht_farbig2011-2014.pdf (accessed 27 October 2010).

Image credits

Figures 1, 2: Sihlcity.
Photo 1: Andre Lardon via Flickr
Photos 2–4, 6: Simon Field, ITDP Europe
Photo 5: Sihlcity

We would like to thank Roberto de Tommasi for providing additional information.

CASE STUDY

Stellwerk 60

COLOGNE, GERMANY

Simon Field, ITDP Europe

STELLWERK 60 SITE FACTS

- **Developer and Architect:** Kontrola Treuhand
- **Developed Area:** 4.2 ha
- **Total Area:** 6.1 ha
- **Planned Completion:** 2011
- **Population:** 750
- **Density:** 123 persons / ha
- **Net Housing Density:** 95 units / ha
- **Completed Housing Units:** 320
- **Planned Housing Units:** 400
- **Jobs On-site:** 0
- **Distance from City Center:** 2.5 km
- **Parking Spaces/Residence:** < 0.3
- **Cars:** 60 per 1,000 residents
- **NMT Mode Share:** 26%*
- **Transit Mode Share:** 53%*
- **Households with Carsharing Membership:** 67%
- **Number of Carsharing Vehicles Available:** 17

*by distance travelled

BACKGROUND

Stellwerk 60 is a "car-free" development of 700 homes in the Nippes district of Cologne, a German city of almost 1 million inhabitants. It was chosen for this study as an evolution of the Vauban model, with totally car-free residential streets as well as spatially and fiscally separated parking. Car ownership is 20% of that in the surrounding neighborhood, and per capita transport-related CO_2 emissions are half those of the city as a whole.

Built on the site of a former railway repair works, the genesis of the project was a local citizens' petition calling for a new type of residential area for people wanting to live free from the nuisance of motorized traffic. This led to a master planning competition, with Kontrola Treuhand selected as sole developer to realize the vision of a car-free district on a site close to existing services and transit routes, and within cycling distance of the city center. The development includes a range of home types and tenures, from apartments to town houses, for rent or sale on the open market, offering between 61 and 106 m² of floor space (Figure 1).

On-street parking is prohibited within Stellwerk 60 and on nearby residential streets, and the requirement that all car owners pay for a parking space in a peripheral garage. Non-car owners are required to sign a legal declaration that they will not bring a car to the site or attempt to park it in the surrounding area.

PLANNING PROCESS

Stellwerk 60 residents began with the intention to create a traffic-free community. The project took some time to come to fruition owing to negotiations regarding the unique legal status of Stellwerk 60 as "car-free housing." The project could not get a total exemption to German minimum parking standards, so the developers comprised on an "optically car-free" plan, with a separate garage providing the negotiated minimum of 120 parking spaces for 400 planned housing units, or 0.3 spaces per unit. Special contracts between the developer and the city, and the developer and residents, were drawn up to satisfy the planning authority.

The future provision of car parking within the development is prohibited under a City of Cologne land use plan and building law, and the interior is officially designated as a pedestrian zone.

KEY POLICY AND DESIGN MEASURES

In addition to the absence of parking within the development, and the policy requirement for car-owners to purchase a space in a garage that is physically and financing separated from the residences, there are several measures that make other modes of transportation more attractive.

Urban Design

There is a driving and parking ban for motor vehicles development-wide (all roads marked in yellow in Figure 1), enforced simply through the "limited access" model with physical access restrictions at each of the three entrances (Photo 1). Retractable bollards allow access for the emergency services and municipal vehicles, but general drop-offs and deliveries are not permitted. In addition, at around 2.5 m in width the residential streets are not physically wide enough for parking, unlike those found in the "parking free" streets of Vauban.

Local shopping facilities, a daily farmers market, a primary school, kindergarten and hospital are all available within 600 m of the development, reachable via pleasant residential streets with outdoor cafés (Photo 2). Small play areas within the site, together with an adjacent park, mean that travel is not required to reach recreation and green space.

Figure 1: Stellwerk 60 site plan. Cars may not access the streets marked in yellow.

In addition, home owners and tenants must sign a legal contract to indicate that they agree not to (a) drive motorized vehicles within the development, (b) create parking spaces and (c) park in specified areas in the surrounding district.

These conditions ensure the entire residential area is completely free of moving and parked cars, releasing land for recreational space and significantly reducing the convenience of car ownership.

Parking

State minimum parking standards require that provision be made for vehicle owners. Since there is no parking within the residential area of Stellwerk 60, this problem was addressed by providing a total of 120 spaces in the peripheral car park depicted in Photo 3: 0.2 residents' spaces per unit, plus 0.1 spaces for visitors. This also houses six Cambio Carsharing vehicles. Under the same planning rules, which require a minimum of 0.3 spaces per unit, land adjacent to the car park has been set aside to cater for a possible future upturn in car ownership.

Car owners must purchase a parking space at a cost of 16,000 EUR and pay a maintenance fee of 70–80 EUR per month. The high cost of the parking — set to reflect the true cost of providing such facilities on valuable urban land — are a significant deterrent to car ownership. At the time of writing, a total of 45 car parking spaces (56% of the total for residents) had been sold.

Public Transportation

A dense network of heavy rail routes, the most frequent of which are branded "S-Bahn," and Stadtbahn[1] lines form the backbone of transit provision in Cologne. These routes offer combined S-Bahn and Stadtbahn frequencies of ten minutes and at least every five minutes respectively, to the city center and beyond during the daytime on weekdays (Photo 4). Every home is within 500 m of a stop, with one bus stop located immediately outside the north entrance to the site (Photo 5).

An additional outer-orbital Stadtbahn line provides direct services to key interchange in other parts of the city, removing the need to make lengthy journeys via the city centre. Three bus routes complete the local network, including a popular new route direct to the University. Operating since December 2009, this has been a victim of its own success, as overcrowding threatens to suppress demand. Happily, this is likely to be addressed by increasing the peak frequency in December 2010: it is important that operators or tendering authorities respond quickly, to avoid turning passengers away.

A timetable is provided at every stop, with the majority offering comprehensive maps and fare information. All local stops are unstaffed, but S-Bahn stations feature standard Deutsche Bahn touch-screen ticket machines. Tickets for journeys commencing by bus must be purchased on board, and not all bus stops are equipped with waiting shelters.

All transit services other than the outer-orbital tram offer step-free access, with lifts to station platforms in good working order when a site audit was conducted in March 2010. Bicycles can be carried on transit subject to space and purchase of a separate bike ticket.

Cologne is in the Verkehrsverbund Rhein-Sieg (VRS) integrated public transportation authority area. VRS single trip and period tickets allow unlimited changes to reach one's destination within one or more zones of validity, minimizing the inconvenience of interchange. Within the large Cologne City zone, fares include:

- 20-minute "short trip": 1.60 EUR;
- Transferable monthly season: 66.50 EUR;
- Transferable off-peak (after 09:00) monthly season: 46.40 EUR.

The monthly passes compare very favorably with the monthly maintenance fee of at least 70 EUR for owners of car parking spaces in the Stellwerk 60 garage. VRS has a comprehensive website with timetables, fares, maps and details of how to register for the purchase of single-trip and one-day tickets by mobile phone (HandyTickets). A "mobility guarantee" is offered by VRS: a transit delay of twenty minutes entitles a ticket holder to travel by long-distance express trains or taxi as appropriate, with a full refund of additional rail fares incurred, or up to 20 EUR in the case of taxi fares. This provides additional reassurance to intending transit users.

Google Maps includes Cologne U-Bahn and S-Bahn stations, but no timetable data or any bus information at the present time.

Pedestrian and Cycling Infrastructure

A shared cycle and pedestrian path is provided from the south-west entrance to Nippes S-Bahn station. Local streets are one-way and/or traffic-calmed with humps, street furniture or by narrowing, encouraging the use of non-motorized modes for local journeys, and many of the former permit contra-flow cycling, maximizing convenience for cyclists.

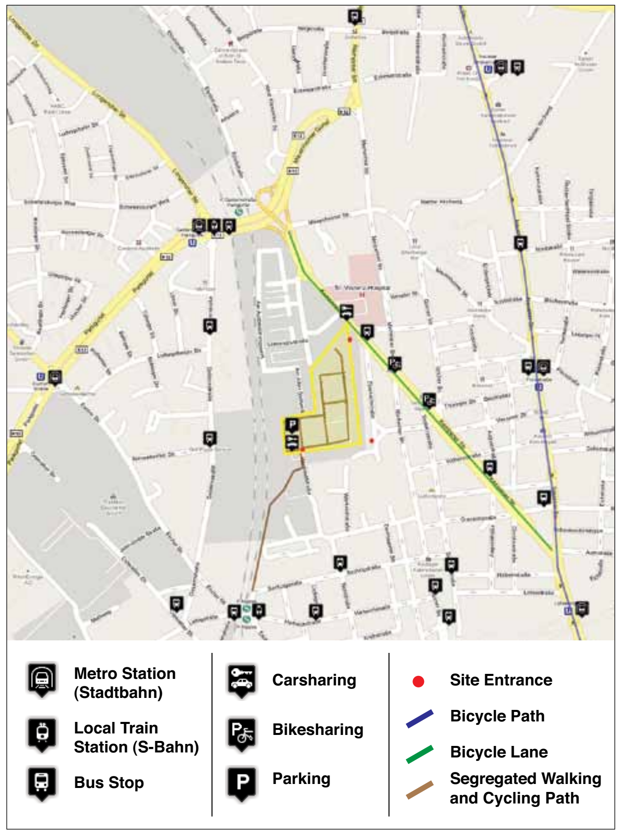


Figure 2: Map of the area surrounding Stellwerk 60

[1] In Cologne these are light rail routes in tunnel in the central area, where underground stations are branded "U-Bahn," with a mix of segregated and on-street surface running elsewhere. The vehicles closely resemble conventional trams. Stadtbahn is the generic term for this type of system.

1
Southwest entrance to Stellwerk 60

Cars are restricted with retractable bollards, which can allow emergency vehicle access when necessary.

2

A public square on the walking route to the shopping area on Neusser Straße.

3

The Stellwerk 60 parking garage is located at the edge of the development, making driving less convenient. Space in the foreground is reserved for future expansion if needed.

4

Every household in Stellwerk 60 is within 500 m of a transit stop. Trains have daytime frequencies of between 5-10 minutes, making transit extremely convenient.

5
Sechzigstraße bus stop

Street narrowing serves as an effective traffic-calming feature.

6
Cycle parking outside row houses

7
A Cambio carsharing station

Three vehicles were used within the course of a 15-minute site survey.

8
Delivery vehicles

All motorized traffic is banned from Stellwerk 60, including delivery vehicles, so the development offers free "rental" of human-powered cargo vehicles for residents to haul in goods.

9

Advertising for the most recently completed apartments: "Rental of exclusive living space / dreams! Car-free living area – Stellwerk 60."

Roads within Stellwerk 60 are for the exclusive use of cyclists and pedestrians. An average of one cycle parking space is provided per 30 m^2 of residential floor space, and the vast majority of this is provided in the form of parking cellars easily accessed by ramps. Each row house has three racks (Photo 6).

Covered bicycle parking is available at S-Bahn and Stadtbahn stations, although the short distances from Stellwerk 60 are easily walkable. The city center is around 10–12 minutes away by bicycle, along direct routes with a mixture of on-road cycle lanes and paths shared with pedestrians (Figure 2).

Carsharing

Sixteen Cambio Carsharing vehicles are available on-site, split between the general car park and ten spaces adjacent to the north-east entrance to the development (Photo 7). These include small and medium-sized cars, as well as small and transit-sized vans. Membership fees are waived for residents, with discounted usage fees: these vary by frequency of rental, distance traveled and vehicle class.[2]

Interestingly, the rival carsharing firm Flinkster has a single vehicle stationed adjacent to the main car park. Unlike Cambio, it aims for the image-conscious market by offering an Alfa-Romeo sports car, albeit one with a relatively modest 1.4 liter engine. Market differentiation is likely to be important in broadening the appeal of carsharing.

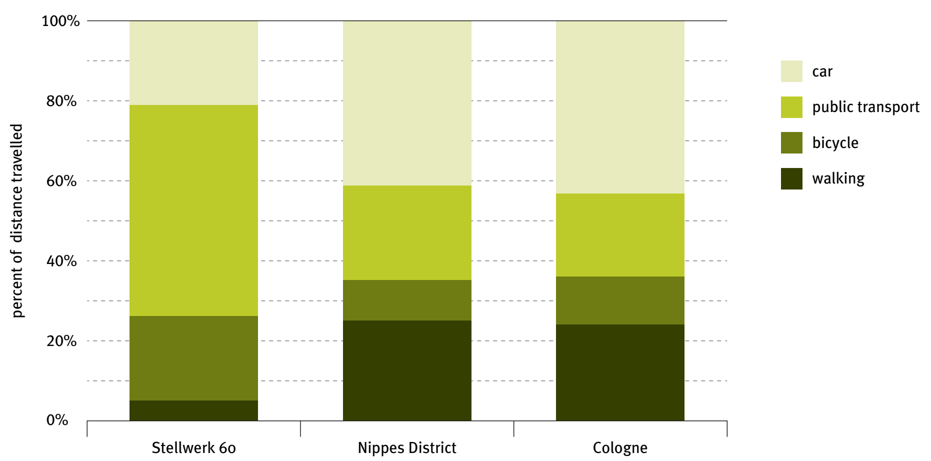
Deliveries

As previously mentioned, there are very few exceptions to the no-access rule for motorized vehicles, presenting quite a challenge for the delivery of heavy and bulky goods. To address this problem, a "mobility center" located close to the south-west entrance to the site has a range of human-powered trolleys and trailers (Photo 8) for free rental by residents. This service is paid for by the developer on an ongoing basis. Thus the last leg of every delivery is extremely low-carbon, and the safe and noise-free nature of Stellwerk 60 is maintained.

Home deliveries of beer and other drinks are made by a supplier once a week, under a special contract granting access to the development by motorized van, in return for the waiving of delivery fees normally payable by customer. This service is slowly increasing in popularity. Thus far this is the only example of residents accepting a compromise in the zero-tolerance approach towards motor vehicle access.

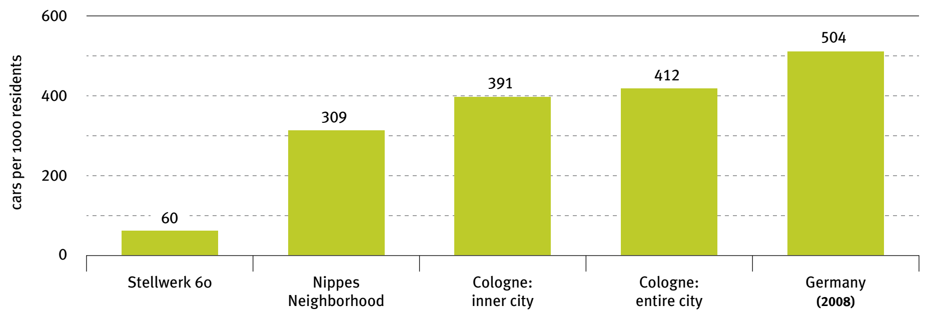
[2] For more information, see the Cambio Carsharing website

Figure 3: Modal split for all trip types



Mantau, 2010;
Stadt Köln, 2008

Figure 4: Car ownership in Stellwerk 60 as compared to surrounding area



EC, 2010;
Mantau, 2010;
Stadt Köln, 2010

Marketing

The development is heavily marketed as being car-free, suggesting that this is regarded as a positive term by the developer and landlords, rather than indicative of being denied something desirable.

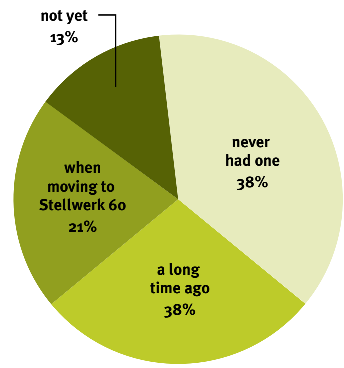
Advertising for the next phase of the development alludes to the peaceful and relaxing nature of a site free of traffic nuisance (Photo 9). Although existing "car-free choosers" are drawn to developments such as Stellwerk 60, given their rarity, the marketing is likely to be of broad appeal to anyone seeking a better quality of life (see also Figure 8).

QUANTITATIVE ANALYSIS

We are grateful for access to survey data collected by University of Cologne student Fabian Mantau. An online survey with a total of 75 questions on actual travel behavior and attitudes towards the development was launched in April 2010, following the distribution of flyers to every household in advance.[3] This was done in cooperation with Autofreie Siedlung Köln, the association that has promoted the concept and district since 1999. 53 people completed all or most of the survey, equivalent to a response rate of 16.5% on a household basis.

[3] http://www.i.am./car-freeinKoeln (accessed 12 August 2010)

Figure 5: Stellwerk 60 residents: when did you give up your car?



Mantau, 2010

Modal Split

Mode share data by distance traveled are presented shown in Figure 3 (data by number of trips are unavailable). More than half the total distance traveled is by transit, with the bicycle accounting for a fifth, the same proportion as the car.

Over half of the respondents cited using a bicycle, with rail-based transit as second-most popular choice. This result reflects the concentration of economic activity in the nearby city center and in other districts easily reached by bicycle, S-Bahn or Stadtbahn. 62% of residents have a commute of between 2 and 10 km, ideal for cycling within a typical 30–45 minute travel time budget. In addition, 2% of homes serve as a place of work.

89% and 77% of respondents cycle and walk (respectively) to shops on a regular basis, suggesting the frequent use of local facilities rather than weekly shopping runs by car. Cycling plays a pivotal role in the everyday mobility — and sustainability — of Stellwerk 60 residents.

Vehicle Ownership

96% of respondents have a driving license, meaning that a car-free lifestyle is a deliberate choice. 71% of Stellwerk 60 households do not own a car, 29% have one car and no households have more than one car. In contrast, only 21% of German households do not have a car (Figure 4).

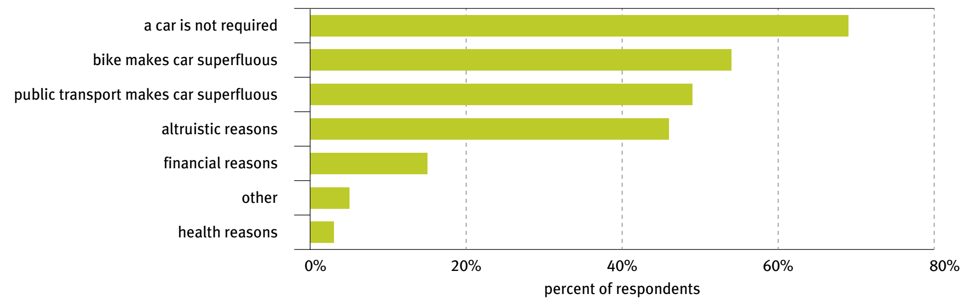
Stellwerk 60 has achieved a seven-fold reduction in car ownership, with only 45 registered vehicles among the current population of 750 residents (Figure 4). In contrast, every household owns at least one bicycle, with 37% also possessing a bicycle trailer.

Respondents were also asked to indicate when they had given up "their" car, and provide the reasons for not owning one (Figures 5 and 6). 66% of those sampled had either never owned one (or made use of a company vehicle) or gave it up "a long time" before moving to Stellwerk 60.

These percentages are of the subset of residents who have either given up a car, or intend to do so: a fifth of respondents disposed of their vehicle around the same time as moving. Figure 5 suggests that two thirds of residents had made a decision to go car-free independently of moving to the development: Stellwerk 60 has attracted people who already live car-free. Respondents were asked to indicate all the factors influencing their decision, from the choice of answers shown in Figure 6.

Almost 70% of respondents believe that they simply do not need a car, with around half attributing this to bicycle use and transit

Figure 6: Reasons for Stellwerk 60 residents giving up their carº



Mantau, 2010

provision. Having an environmental conscience plays a significant role for 46% of residents.

CO_2 emissions

Per capita CO_2 emissions from private car use in Stellwerk 60 are 64% lower than in the wider district, and 75% lower than the average for Cologne (Figure 7). The importance of decarbonizing public transportation can be seen from the doubling of Stellwerk 60 residents' transit emissions, although their overall emissions are significantly lower — halved compared to the city as a whole — thanks to the drastic reduction in car use.

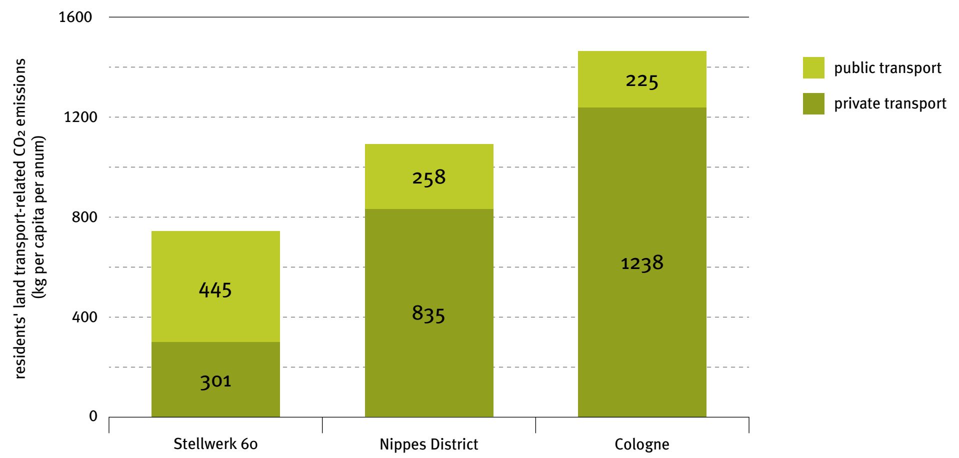
Residents' Views on Stellwerk 60

The survey probed residents' thoughts on why they moved to Stellwerk 60 (Figure 8). A safe and pleasant environment for young families was the most cited reason, followed by a reference to "green living" and being free from the externalities of car use. When comparing the development with "elsewhere," Stellwerk 60 scored highly in two specific areas: (i) 92% think that Stellwerk 60 sound levels are either "better" or "very good," and (ii) 90% regard the carsharing service to be "better" or "very good."

With an almost zero-tolerance approach to motor vehicles within the site, and a choice of 17 carsharing vehicles on offer (as opposed to one in the 3,000 resident Kronsberg development in Hannover), these results are easily explainable. Indeed, 67% of respondents use carsharing vehicles, with a quarter stating that they use the service several times per month.

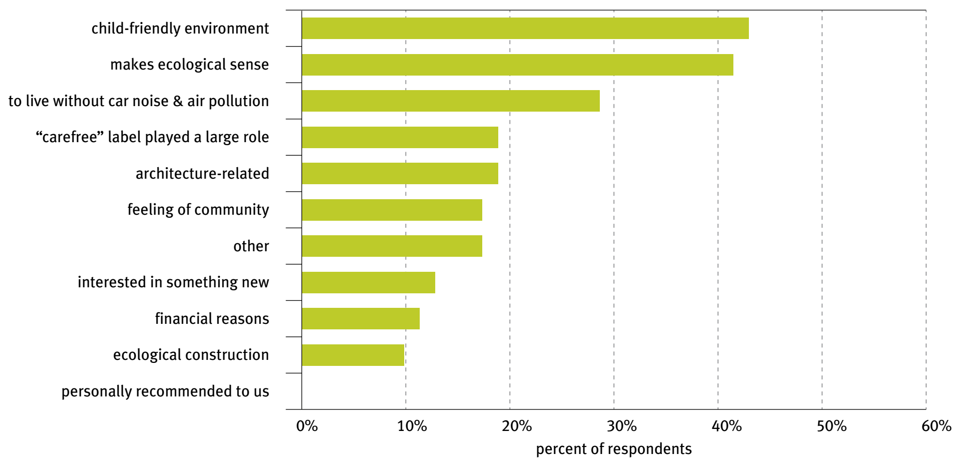
However, a majority of respondents indicated that public transportation, the cycle network and shopping, medical and school facilities are on a par with other districts. On a negative note, 68% feel that a better local recreation area is required, with insufficient green space within the development. This is certainly noticeable in comparison with Vauban, but it is expected that the green space north of the parking garage will eventually be improved.

Figure 7: Transport-related CO_2 emissions



Mantau, 2010; Stadt Köln, 2008

Figure 8: Why did you move to Stellwerk 60?



Mantau, 2010

LESSONS LEARNED

Stellwerk 60 is a clear success in terms of vehicle ownership, which is the primary determinant of car use, and modal split. It's proximity to local facilities, the city center and the availability of a robust public transport and cycling facilities make living car-free simple. The development has its origins in a local group's determination to live free from car noise, pollution and danger, suggesting that it is grassroots demand for radical concepts such as car-free living areas that will see them rolled out more widely. German planning rules made the visually intrusive parking garage necessary, but this does offer a choice for those who want to "have their cake and eat it." The family-friendly nature of housing with a car-free or heavily car-reduced immediate environment is an essential selling point of such developments, whilst avoiding the high cost of underground parking.

An estimated 20 people signed the car-free declaration but own a car, which they park in the garage or in neighboring streets that are not yet part of the Nippes controlled parking zone. This is a source of irritation to other residents. A possible solution is for parking enforcement officers in the Nippes controlled parking zone to work with the residents' association to patrol the car park. The Stellwerk 60 model should provide an incentive for the developer, Kontrola Treuhand, to fund this and other measures required to recover lost revenue.

Is the Stellwerk 60 model transferable? This model requires grassroots support and intention of a community to live car-free. However, many of the best practices including proximity to existing jobs and destinations, provision of high quality transit and cycling facilities, limiting and spatially separating parking, and designing narrow streets to discourage driving could all be applied to other developments, even in less extreme cases.

Specific improvements that could be made at and around this development, and with respect to transit provision, include:

- Making better use of the park to the north of the parking garage, as well as making the land set aside for future car park expansion more attractive;
- Improving the attractiveness of the elevated S-Bahn stations, which suffer from graffiti, poor lighting and a lack of natural surveillance;
- Providing more bicycle parking in the shopping area, and more covered parking at other popular destinations;
- Enhancing capacity on the new bus service to the University, as well as on the Stadtbahn in the morning peak period.

Only the first of these is the direct responsibility of the developer, highlighting the importance of a holistic approach to maintaining high quality infrastructure and services on- and off-site, requiring interventions by a variety of actors.

FUTURE RESEARCH RECOMMENDATIONS

Further detailed research may help establish the potential demand for car-free living, and the circumstances that might precipitate it. This would help to persuade local authorities to consider the concept more pro-actively, and assuage developers' fears that developments of this kind are less profitable. A study examining the re-sale values of privately-owned homes would add value in this regard, although anecdotal evidence suggests data would be difficult to acquire, given low property turnover in Vauban and Stellwerk 60.

The overall effect of Stellwerk 60's parking management is clear, but it might be instructive to conduct travel surveys in the neighboring Lokomotivstraße development: this is of similar size, age and tenure, but with a conventional street layout and one bundled parking space per residential unit, mostly located within a few meters of each home. Such an exercise would provide more evidence for the success of Stellwerk 60 to be attributed to measures peculiar to the development, rather than external factors associated with the Nippes district. ■

SOURCES

ADD-HOME (EU IEE-funded research project): http://www.add-home.eu
Autofrei Wohnen: http://autofrei-wohnen.de/proj-d-nippes.html
Autofreie Siedlung Köln: http://www.autofreie-siedlung-koeln.de
Cambio Carsharing: http://www.cambio-carsharing.de
EC (2010). *Energy and Transport in Figures 2010*. European Commission, Luxembourg.
Flinkster: http://www.flinkster.de
Institut für Verkehrswesen, Universität Karlsruhe (2008). *Panelauswertung 2007. Deutsches Mobilitätspanel (MOP) — Wissenschaftliche Begleitung und erste Auswertungen*.
Mantau, F. (2010). Unpublished Diploma research undertaken at Universität Köln.
Nachbarn 60: http://www.nachbarn60.de
Stadt Köln (2008). Mobilitätsentwicklung: Köln bis 2025.
Stadt Köln (2010a). Die Kölner Stadtteile in Zahlen. 2. Jahrgang 2010.
Stadt Köln (2010b). Statistisches Jahrbuch 2008/2009. Kapitel 4: Verkehr.
Stellwerk 60 (developer website): http://www.stellwerk60.de
Verkehrsverbund Rhein-Sieg: http://www.vrsinfo.de

Image credits
Figure 1: Stellwerk 60
Figure 2: Google Maps
Photos 1–9: Simon Field, ITPD Europe

Thanks to Stellwerk 60 resident Hans-Georg Kleinmann for granting an interview and providing additional information, Fabian Mantau for sharing his research data and Christian Dörkes of Stadt Köln for providing additional statistics.

CASE STUDY

Västra Hamnen

MALMÖ, SWEDEN

Nicole Foletta, ITDP Europe

VÄSTRA HAMNEN SITE FACTS

Developer: Multiple

Architect: Multiple*

Population: 4,326

Projected Population: 10,000

Developed Area: 76.5 ha

Total Area: 175 ha

Current Density: 56.5 persons/ha

Projected Density: 57.1 persons/ha

Current Residential Units: 2,558

Construction Began: 1998

Planned Completion: 2015

Distance from City Center: 2 km

Cars: 440 cars/1,000 residents

Non-motorized Mode Share: 60%

Public Transport Mode Share: 17%

Residents with Carsharing: 3%

* Over 20 architects have been involved; some of the most notable architects include Klas Tham, Ralph Erskine, and Santiago Calatrava.

BACKGROUND

Västra Hamnen is a brownfield redevelopment which provides a mix of uses, high quality cycling and pedestrian infrastructure, good transit access and carsharing, and places an emphasis on mobility management. Non-motorized transportation use is higher and car use is lower in Västra Hamnen than in the city as a whole.

Västra Hamnen (the western harbor) has, in a couple of decades, been transformed from an industrial park into a lively district focused on knowledge and sustainable living. Since the closing of Kockums Machine Halls, the district has become home to new parks, swimming areas, business campuses, schools, and residences. The Västra Hamnen campus of Malmö University opened in 1998 and three years later was the opening of the European Home Fair for Bo01. These two milestones marked the beginning of a new urban district coming to life in Malmö.

The aim for Västra Hamnen is to become an leading example of environmental adaptation of a densely built urban district. It will be a powerful demonstration of Malmö's commitment to increased environmental sustainability. The planning, building and construction of the district was guided by an ecological approach.

The first phase of the Västra Hamnen regeneration project was called Bo01. The vision for Bo01 was to create a new and modern mixed use neighborhood, committed to sustainable principles. The development was featured in the 2001 European Housing Expo. The 350 residential units presented at the Expo were comprised of a mix of tenures and were built following a set of guidelines for architectural quality, choice of materials, energy consumption, sustainable transportation, green issues and technical infrastructure. It has served as a model for subsequent phases of development in Västra Hamnen, which have also been constructed following ecological guidelines and incorporating a sustainability focus.

The most distinctive visual icon of Västra Hamnen is the "Turning Torso" tower (Photo 1), designed by Spanish architect Santiago Calatrava. It consists of nine rotating cubes containing 54 floors, accommodating offices at the bottom, conference facilities at the top, and in between 147 apartments, twisting 90 degrees from top to bottom, with a rooftop observation deck. At 190 meters it is the tallest residential building in the European Union.

Västra Hamnen has received international acclaim, both for its innovative sustainability features and its striking architecture. It demonstrates that modern development can both be environmentally conscious and attractive.

PLANNING PROCESS

Västra Hamnen was primarily used as a port and industrial area, and was home to the Kockums shipyard from the 1990's until the late 1970's when the shipping industry began to decline. In 1979 the Swedish government took over Kockums Machine Halls. By the 1990's the city of Malmö began to recognize the potential of this attractive waterfront area, located close to the city center, and decided to convert this once industrial zone into a new urbanized district with a focus on education and sustainable living. It was decided in connection with Malmö City's Vision Project in 1994/95 to locate a new campus of Malmö University in Västra Hamnen. The university opened in 1998 (*Guide Western Harbor 2009*).

Figure 1: Vasträ Hamnen Neighborhoods

The city also decided to build an eco-village as an international example of sustainable development. The Bo01 project aka the "City of Tomorrow" was showcased at the 2001 European housing expo. The primary investors in Bo01 were the national government, the City of Malmö, and Sydkraft (a regional power company). The City of Malmö received money from the national government through a Local Investment Program, covering environmental measures in Bo01. This money was used for technical systems, soil decontamination, infrastructure, and educational projects. The European Union also gave financial support for energy efficiency measures, the EU required the developers to conduct a scientific evaluation to learn from Malmö's experience and share lessons with future projects both locally and internationally. Ongoing research is still being conducted on topics as diverse as soil decontamination, traffic, mobility management, energy efficiency, green structure, storm water reuse, recycling, and sustainable development (*Malmö Stad Website*).

Expansion of Bo01 continued after the housing expo, including construction of the district's landmark, the HSB Turning Torso tower. The city authorities regarded a tall building in this location as important in terms of giving Malmö a new landmark, and therefore granted the scheme planning permission.

Newer developments in Västra Hamnen include the residential neighborhoods of Dockan and Flagghusen and the University District of Universitetsholmen (Figure 1). These incorporate high density residential units with businesses, schools, service facilities, parks and recreational facilities. So far 76.5 ha of the total 175 ha have been developed, as seen in Table 1. Plans for Västra Hamnen include three additional residential neighborhoods, in addition to blocks dedicated to education and training facilities, a conference center and concert hall, and office buildings. All of these development projects

Table 1: Developed area of Västra Hamnen

	Land area (ha)
Bo01 (mixed use neighborhood)	22
Dockan (mixed use neighborhood)	11
Flagghusen (mixed use neighborhood)	4
Universitetsholmen (university district)	21.5
Green space	18
Total developed area	76.5
Total land area of Västra Hamnen	175

City of Malmö

Figure 2: Map of Vasträ Hamnen

are being undertaken with a focus on sustainability. The district is planned to eventually house 10,000 residents and provide facilities for 20,000 employees and students.

The most recently completed development in Västra Hamnen is the Flagghusen residential area, which consists of 16 buildings and more than 600 apartment units. Planning of included a dialogue between citizens and the developer in order to develop the best solutions for those involved. Important concerns were safety and security, reasonable cost of living, low maintenance costs, parking, energy efficiency, use of non-toxic substances, and local surface water handling. As a result, Flagghusen has set new standards for social, economic and ecological sustainability, demonstrating that Västra Hamnen is continuing to push forward as a modern example of sustainable development (*Guide Western Harbor 2009*).

KEY POLICY AND DESIGN MEASURES

Västra Hamnen was planned to minimize future transport needs and car dependency, in large part by emphasizing cycling. There are 420 kilometers of cycle paths throughout the city of Malmö, which prides itself on being one of the world's leading cycling cities. In Västra Hamnen alone there are 8,185 meters of new cycle paths. Many improvements have also been made in Västra Hamnen in order to make public transport more attractive, including the addition of buses connecting central parts of Malmö with vital areas of Västra Hamnen (Figure 2). These and other policy and design measures, discussed below, aim to reduce car dependency of residents and make Västra Hamnen a quality place to live.

Bicycle and Pedestrian Infrastructure

Västra Hamnen has a focus on promoting cycling and walking (Photos 2 and 3). Cyclists and pedestrians are given priority in the Bo01 neighborhood and the area is nearly car-free. Cycling and pedestrian paths are incorporated throughout the Västra Hamnen district, including more than 8,185 meters of new cycle paths alone (*Malmö Stad Website*).

A long cycling route runs through Malmö from the southern part of the inner city to Universitetsholmen, the university district in Västra Hamnen. A variety of innovative features are being tested along this stretch, aimed at improving bicycle safety and ease of use. These solutions include rails at traffic lights which cyclists can rest against so that they do not need to put their foot down, and mirrors placed at low-visibility intersections so that cyclists can see what is happening around the corner. Different types of lighting will be tested along the route to improve night time visibility. In addition, several mini service stations have been set up where cyclists can pump air into their tires and carry out simple repairs.

The city of Malmö has even given cyclists priority at thirty traffic lights across the city. Radar sensors have been fitted at these crossings to detect approaching cyclists and give them a green light. This allows cyclists to flow more smoothly in traffic and clearly demonstrates the city's commitment to promoting cycling (*Malmö Stad 2009*).

Public Transport

Västra Hamnen is well served by public transport. At least one bus stop is located within 300 meters of every apartment, and buses run at seven minute intervals throughout the day (Photo 4). Many investments have been made to improve the quality of public transport in the area. Buses are given priority at traffic lights. Bus stops have elevated platforms to make boarding faster and easier, and many stops now have weather protection to make waiting more comfortable. In addition, over 100 stops across the city are equipped with electronic timetables so passengers know how long they must wait for the next bus to arrive (Photo 5). Real-time bus arrival information is also available on mobile phones using either mobile internet or a downloadable program.

In addition, from the southern border of Västra Hamnen it is just one kilometer to Malmö Central Station. This station will be connected to the Øresund Bridge through the new City Tunnel, which was scheduled to open in December 2010 and will link train travel north of the city to southern connection points including Copenhagen. The City Tunnel will consist of 17 kilometers of railway and 6 kilometers of tunnel, representing the largest investment in public transport in Malmö's history (*Malmö Stad Website*).

Public transportation in Malmö is run by Skånetrafiken, the regional public transportation authority and operator in Southern Sweden. Skånetrafiken uses a zone-based fare system with integrated tickets between different transport modes and for travel between southern Sweden and Denmark. Public transit tickets may be purchased onboard buses, at automated ticket machines in train stations or at staffed customer service centers. In addition, bus tickets can be purchased and displayed on mobile phones. In 2009 Skånetrafiken introduced a contactless smartcard called "Jojo." Patrons can load transit tickets, monthly travel passes and discount travel cards onto this smartcard. Children pay a discounted price and discounts are also available for family members traveling together. (*Skånetrafiken Website*)

Efforts have also been made to reduce emissions from buses. In 2003, a pilot project was launched in which two city buses operating in the area were fueled by a mixture of 8% hydrogen gas from wind power and 92% vehicle fuel (*Guide Western Harbor 2009*). The project was very successful and now a majority of buses in the city use this fuel mixture. These buses are green in color and promote the efficient fuel mixture through a message on the bus stating "Gas bus for a greener and more beautiful Malmö."

Carsharing

In 2005 the city of Malmö started a program (supported by The CIVITAS Initiative) to introduce carsharing to Malmö. The program is part of the city's aim to develop a transport system where citizens are not dependent on traditional private car ownership for all of their mobility. Membership in a carsharing organization can eliminate the need to own a private car and can reduce the number of car trips taken and vehicle miles traveled. The first Sunfleet Carsharing site was opened in 2005 close to Malmö Central Station. In 2006 the second carsharing site was established in Västra Hamnen. During 2007 two additional carsharing sites were opened in the inner city. By the summer of 2008 all five carsharing sites were opened with a total of 15 cars operating in the city and over 200 members. All of Sunfleet Carsharing's cars are green vehicles, which either run on natural gas, biogas or E85 fuel (85% ethanol and 15% petroleum).

A survey found that local awareness of carsharing grew from 28% in 2003 to almost 47% in 2008. By virtue of the shift from petrol to green fuels, there appeared to be a reduction in emissions from the use of carsharing vehicles in Malmö. The emissions reduction estimates for 2008, based on distance traveled by participating vehicles, are detailed in Table 2 (*The CIVITAS Initiative*).

Today there are two carsharing locations in Västra Hamnen. One location is situated next to Bo01 and has seven vehicles. The other location is in Universitetsholmen and has one vehicle (Figure 1). A survey in 2010 found that 3% of Västra Hamnen residents have a carsharing membership (*ITDP Europe 2010*).

Parking

The planners of Västra Hamnen have recognized the importance of limiting parking in order to reduce car use, however implementation of this strategy has proved challenging. Parking in the Bo01 development was limited to 0.7 parking spaces per household, as compared with the typical Malmö requirement of 1.1 parking spaces per household. However, local residents' demand for parking exceeded that available, indicating that the scheme had ecological expectations more ambitious than current behavior warranted. Eventually, a multi-story parking garage was built in conjunction with the HSB Turning Torso (*Roberts 2008*).

The parking issue was readdressed during the planning process of Västra Hamnen's newest neighborhood, Fullriggaren which requires just 0.75 parking spaces per household. The policy is not a restriction on the number of parking spaces allowed to be built; it is a decrease of the number of parking spaces that are required to be built. It does seem that only 0.75 spaces per household will be built, at least initially. The passage of this policy is at least one step towards limiting the number of parking spaces provided in the district (*Magnus Fahl, pers. comm.*).

Västra Hamnen also uses parking pricing to discourage excess driving. The city of Malmö has three parking pricing zones for public, on-street parking, as outlined in Table 3. Like the city center, the neighborhoods of Bo01 and Flagghusen are classified as red zones and therefore have the highest on-street parking fees in the city. The University District, Universitetsholmen, is classified as a green zone. The neighborhood of Docken, however, does not have a parking zone classification and therefore people may park in this neighborhood for free for up to 24 hours.

Urban Design

Over twenty architectural firms were involved in the design of Västra Hamnen. Some of the most notable architects include Swedish architect Klas Tham, architect/planner Ralph Erskine, and innovative Spanish architect Santiago Calatrava. Klas Tham, in particular, was instrumental in the development and conceptual plan of the district, which includes a variety of notable design features.

Street Layout and Design

The street network of Västra Hamnen consists of a mix of individually designed streets, pedestrian ways, alleyways and open squares (Photo 6). Swedish architect Klas Tham himself describes the street layout as a "grid that has been distorted by the wind" (*Natural Space Website*). The district generally has a grid street network, however within the neighborhoods the streets are narrower and take on a more organic form. Further, the inner area of Bo01 is car-free, consisting of only pedestrian ways and cycle paths. This structure makes it easy for cars to cross Västra Hamnen, but provides a safer environment with reduced car traffic within its various neighborhoods.

Public Space Design

Västra Hamnen has several parks including Ankarparket and Daniaparken. The planners wanted citizens to be able to walk from Västra Hamnen to the city center of Malmö through parks and green spaces. They therefore created Stapelbäddsparken, which beyond providing a green pedestrian way also acts as an activity center including cafes, a climbing wall, a skateboard park, and an ecological playground for children. This mix has made the park a meeting place for all age groups, offering a broad range of activities promoting the health and well-being of visitors.

The conceptual planning architect Klas Tham also had the idea to transform a strip of the waterfront into a promenade. While the idea was controversial at first, today Sundspromenaden is a popular place for citizens and visitors to socialize, sunbathe and enjoy the waterfront views (Photo 7).

Table 2: Emissions reductions from shift to carsharing vehicles in Malmö (2008)

Emissions reductions	Percent reduction
2,530 kg CO_2	42%
1,255 g NOx	60%
15 g PM_{10}	12.5%

Author's elaboration

http://www.civitas-initiative.org

Table 3: Pricing by zone for the City of Malmö

	Price per hour	Charging period
Green Zone	10 SEK (1.1€)	09:00–18:00 Weekdays
White Zone	15 SEK (1.6€)	09:00–18:00 Weekdays
Red Zone	20 SEK (2.2€)	09:00–20:00 Weekdays 09:00–16:00 Saturdays

Author's elaboration

1 Turning Torso Tower

Västra Hamnen is known for high quality urban design and architecture. Its most famous landmark is the Turning Torso Tower designed by Santiago Calatrava.

2

The inner part of the Bo01 neighborhood is completely car-free. The city built 8 km of new cycle paths through the development.

3 Bike parking near waterfront

4

All households in Västra Hamnen are within 300 m of a bus stop.

5

Buses offer real-time arrival information at stations and get priority at traffic signals.

6 Plaza in Västra Hamnen

7 Västra Hamnen waterfront

NO RIDICULOUS CAR JOURNEYS

A large number of "ridiculously short car journeys" (journeys shorter than five kilometers) are made every day in Malmö. The *No Ridiculous Car Journeys* campaign aims to encourage people to think about how they use their cars and to cycle instead of making these short trips by car. One initiative in the campaign was a contest to win a bike by providing the details of a ridiculous car journey made in Malmö. When the campaign was launched in 2007, half of all Malmö residents were aware of it, and as a result, many have since switched their ridiculously short car trips to bike. *No Ridiculous Car Journeys* has gained widespread attention, both internationally and in other Swedish cities. Helsingborg, Kristianstad and Umeå have already used this campaign, and more cities are planning to do so. In Malmö the *No Ridiculous Car Journeys* campaign will be repeated every spring. (*Malmö Stad 2009*)

Table 4: Breakdown of residential unit size in Västra Hamnen

	Area (ha)
Studio (without kitchen)	11%
1 Room	5%
2 Rooms	30%
3 Rooms	36%
4 Rooms	13%
5+ Rooms	5%

City of Malmö

Building Layout and Design

The architectural firms working in Västra Hamnen were given freedom of expression to create new, innovative design structures. One outcome of this is the building layout of Bo01, designed by Klas Tham, which consists of a row of high-rise (5–7 story) flats forming a wall along the sea, creating an effective climate barrier on the southwest side of the district, with a small scale interior including lower rise buildings, pedestrian ways and intimate plazas. This mix gives the area a unique character.

Santiago Calatrava's HSB Turning Torso tower is another example of innovative design, not only its appearance, which has won international acclaim, but also due to its energy efficiency features and mix of uses.

The housing in Västra Hamnen has a mix of tenures including tenant-owned apartments, rental apartments and private housing. This mix guarantees social diversity in the district. The size of residential units also varies, as seen in Table 4.

Beyond housing, Västra Hamnen contains a mix of uses including Malmö University, the Kickum Fritid Sports Complex, the Salt & Brygga restaurant, Orkanen (Malmö's new Teacher Training Department), the Malmö Business Incubator (MINC), and many other businesses, schools, restaurants and other service centers. Overall the district is home to 262 businesses and employs over 9,000 people (*The Western Harbour Facts and Figures 2010*). The development's expansion plans include additional residential uses, as well as a focus on education, training and knowledge centers.

Mobility Management

Malmö has recognized that simply building a sustainable development is not enough; ongoing effort is needed to encourage residents to adopt sustainable lifestyles. Therefore, Västra Hamnen was provided with its own Mobility Management office to carry out travel habit inquiries, develop informational material, and create campaigns to encourage sustainable mobility habits. One such campaign was recently carried out in Flagghusen. The project, entitled "New Address — New Travel Patterns — Flagghusen," was based on a similar project implemented by the Ardeo Centre of Excellence for the City of Malmö in 2006-2007. The Flagghusen project, conducted in November-December 2008, consisted of three steps: 1. A welcome letter was sent by mail to residents, 2. Residents were contacted by phone, and 3. Mobility advisors provided customized mobility advice to residents and mailed information based on the telephone conversation. The phone conversations discussed travel habits, attitudes towards different modes of transport, car ownership, how to take advantage of public transit and cycle paths, advantages and disadvantages of different modes of transport, and information on carsharing. Results from the previous study found that it is most effective to approach residents when they are new to a neighborhood and before they establish travel habits, in order to have a greater influence on their travel choices. The aim of the project was to provide tips and ideas on ways to simplify and improve residents' stay in the neighborhood while taking into account the environment and other residents.

Residents were given various offers, depending on their travel choices, in order to encourage them to use more sustainable modes of transport. For example, those who mainly drive and do not own a bike were offered a free bike for a month. In addition, those owning a car or planning to purchase a car were offered a three month free trial membership to Sunfleet Carsharing. Respondents were also asked what type of mobility information they would be interested to receive. The most popular item was a map of bicycle paths (69%), 47% wanted information on cycling, 34% wanted eco-driving information, and 23% wanted information on carsharing. The idea is that although many residents support the idea of sustainable transport, many need an extra push or incentive to try a more sustainable option for the first time. This first step is often the biggest hurdle to making a change in transport habits (*Ardeo 2008*).

QUANTITATIVE ANALYSIS

Västra Hamnen is located in Malmö, the third largest city in Sweden. The city has recognized transport's role in producing harmful emissions and has taken many steps to reduce this effect. In particular, Malmö participated in the CIVITAS SMILE initiative between 2005 and 2009, during which the city implemented several measures aimed to reduce car dependency, lower hazardous emissions from city traffic and create a modal shift towards public transport, cycling and carsharing.

Table 5: Västra Hamnen compared to surrounding area

	Västra Hamnen	City of Malmö
Population	4,326	290,000
Area (ha)	76.5*	15,600
Population density (persons/ha)	57	19
Residential units	2,558	146,700
Cars per 1,000 residents	440	480
Car parking spaces/residential unit	0.8	NA
Residents with carsharing membership	3%	2%
Mode share		
Car	23%	41%
Public transit	17%	16%
Bicycle	31%	23%
Walking	29%	20%

City of Malmö

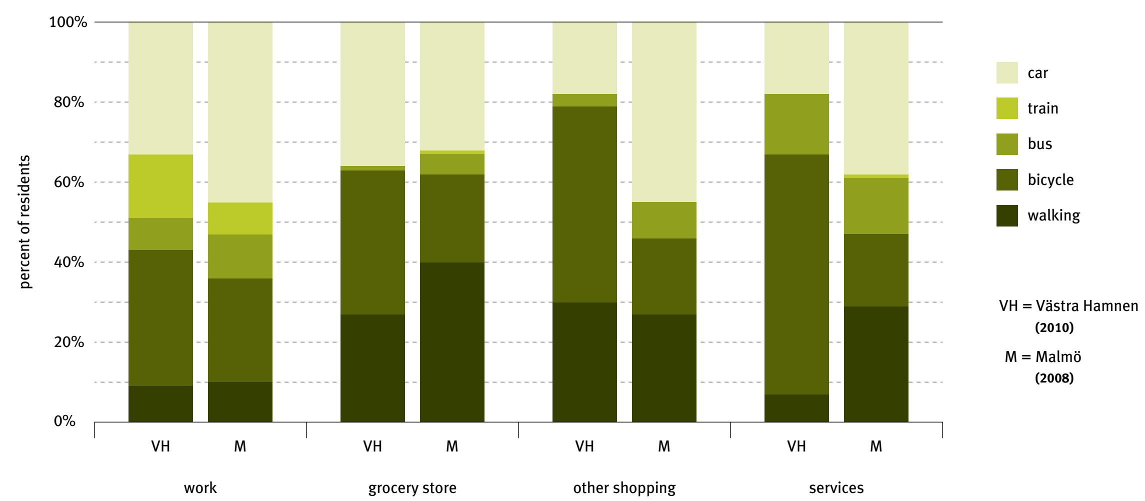
* current developed area

Table 6: Residential unit densities of various neighborhoods in Västra Hamnen

	Land Area (ha)	Population	Number of Dwellings	Dwelling Unit Density (units/ha)
Bo01 (including Turning Torso)	22	2,293	1,394	63
Dockan	11	943	547	50
Flagghusen	4	1090	617	154
Total	37	4,326	2,558	69

City of Malmö

Figure 2: Mode of travel for various trip types



ITDP Europe 2010 and City of Malmo 2008

The following analysis compares statistics from Västra Hamnen to the City of Malmö to show that even within a city as ambitious as Malmö, further reductions in the carbon footprint of residents were possible due to the combination of policy and design measures present in Västra Hamnen.

Density

Västra Hamnen has a more dense settlement structure than the City of Malmö (57 persons/ha in Västra Hamnen versus 19 persons/ha in Malmö), as seen in Table 5. Increased density increases efficiency of resource use. The density of residential units in various

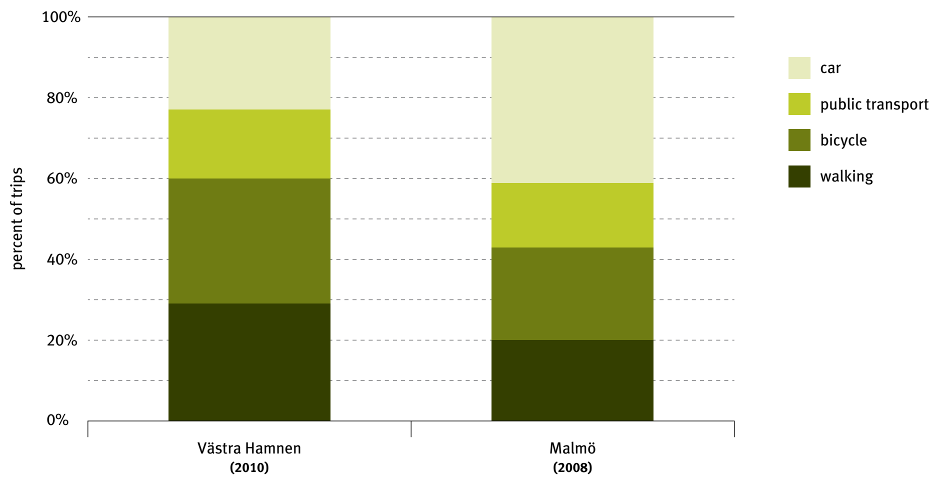


Figure 3: Mode split for all trips

ITDP Europe 2010 and City of Malmo 2008

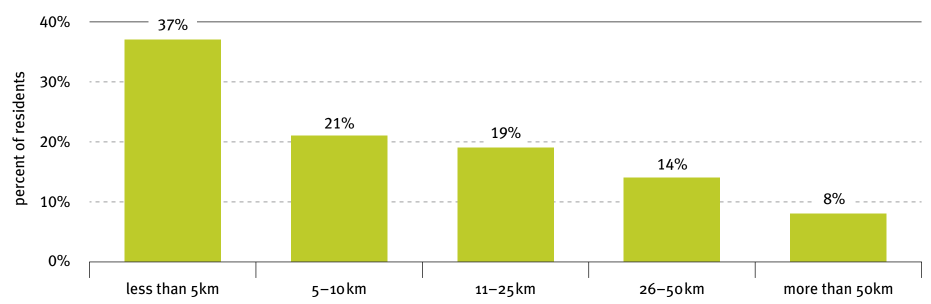


Figure 4: Distance to work for Västra Hamnen residents (2010)

ITDP Europe 2010 and City of Malmo 2008

neighborhoods within Västra Hamnen varies, as seen in Table 6. The residential unit density in Flagghusen is particularly high at 154 units per hectare.

Car Ownership Rate

The car ownership rate is actually quite high in Malmö, and the value for Västra Hamnen is slightly lower. In Västra Hamnen there are 440 cars per 1,000 residents while in the City of Malmö there are 480 cars per 1,000 residents.

Mode Split

Figure 2 compares the mode split of various trip types between Västra Hamnen residents and City of Malmö residents. The Västra Hamnen values come from an internet-based survey of residents conducted by ITDP Europe (in collaboration with the City of Malmö) in 2010; the Malmö values are taken from the city’s 2008 resident travel behavior report. The non-motorized mode share for Västra Hamnen is higher than the City of Malmö for all trip types. In Västra Hamnen, 44% of residents commute to work by non-motorized modes (walking or cycling) versus 36% of Malmö residents. Furthermore, a smaller percent of Västra Hamnen residents commute by car (33% vs. 45%). Västra Hamnen’s non-motorized mode share for grocery store trips is only slightly higher than Malmö’s (63% vs. 62%), and Västra Hamnen’s mode share by car is actually higher (36% vs. 32%). This demonstrates a potential to shift grocery store trips of Västra Hamnen residents to more sustainable transport modes. Västra Hamnen’s non-motorized mode share for other shopping trips is much higher than for the city of Malmö (79% vs. 46%) and its non-motorized mode share for service-related trips is higher as well (67% vs. 47%).

Looking at overall trips taken by residents (Figure 3), Västra Hamnen has a more sustainable mode split than the city of Malmö, as seen in Figure 3. 41% of trips made by Malmö residents are by car and only 23% in Västra Hamnen. Further, more trips are made by bicycle (31%) and on foot (29%) in Västra Hamnen than in Malmö (23% and 20% respectively). The share of public transport trips is similar for both.

Distance Traveled

Looking at distance traveled can reveal the potential for using non-motorized travel modes. People are much more likely to walk

or cycle for a trip that is less than 5 km than for a trip that is 25 km or more. According to the 2010 survey, the average distance to work for a Västra Hamnen resident is 18 km (Figure 4) and the average one-way commute time is 30 minutes. Figure 3 shows a breakdown of travel distance to work for Västra Hamnen residents. More than 35% of residents travel less than 5 km to get to work. These short travel distances make it easier for residents to commute by walking, cycling or public transit. Shorter travel distances also help reduce emissions generated by motorized forms of transportation. In addition, 27% of survey respondents stated that they work from home at least one day per week. Working from home reduces the need to travel and thus has the potential to reduce emissions.

Residents of Västra Hamnen also do not have to travel far to get to a grocery store. A third of residents travel less than 500 m to get to a grocery store and half travel less than 1 km. Based on survey responses, it is estimated that the average distance a resident of Västra Hamnen travels to reach a grocery store is 1.2 km. This is not measuring the distance to the closest grocery store, but rather the store at which the resident chooses to shop, which may or may not be the closest store. These short distances make it easy for residents to travel to the store by foot or bicycle. Furthermore, 4% of survey respondents stated that they have groceries delivered at least once per month. Having groceries delivered also has the potential to reduce emissions.

Luckily, the city of Malmö has recognized this issue and is making more of an effort to advertise the district specifically as an eco-district, with a focus on reduced car use and ownership. In addition, a Mobility Management office has been developed to encourage residents to shift away from car use to more sustainable forms of transport such as walking, biking and public transport.

New sustainable districts in other cities should keep in mind that residents are attracted by a variety of features, not just environmental ones. Therefore it is important to market the focus on sustainable living and reduced car ownership from the beginning and also to provide an on- going effort (such as a mobility management office) to encourage sustainable transport habits. ■

LESSONS LEARNED

Today Västra Hamnen attracts residents based as much because of its attractive location near the water and city center and high quality housing as because of its sustainability features. Therefore, many new residents own cars and want to use them. This has caused increased demand for parking and as discussed, although Bo01 was initially planned as a neighborhood with limited parking, eventually a multi-story parking garage was built to provide more parking. Catering to car users and making the district more car-friendly works in opposition to many of the core goals of the project.

SOURCES

Ardeo (2008). *Ny adress — nya resvanor Inflyttade i Flagghusen Gatukontoret*, Malmö.

CIVITAS Initiative website, http://www.civitas-initiative.org/measure_sheet.phtml?lan=en&id=246 (accessed July 9, 2010).

CIVITAS SMILE Initiative website, http://www.civitas-initiative.org/project_sheet?lan=en&id=1 (accessed July 9, 2010).

Communication with Csaba Gyarmati, Transportation and Highways Department, City of Malmö, August 2010.

Communication with Magnus Fahl, Streets and Parks Department, City of Malmö, May 2010.

Guide Western Harbor (2009). Malmö Stad - Environmental Department, Malmö.

Roberts, Hanna (2008). *Urban Design Best Practice Case Study — Bo01, Malmö, Sweden. Bo01 City of Tomorrow*, Malmö.

Malmö Stad (2003). *Västra Hamnen — The Bo01 Area: A City for People and the Environment*, Malmö.

Malmö Stad (2008). *Malmöbornas resvanor och attityder till trafik och miljö 2008*, Malmö.

Malmö Stad (2009). *Improving Malmö’s Traffic Environment*, Malmö.

Malmö Stad website, http://www.malmo.se/English/Western-Harbour.html (accessed July 9, 2010).

Natural Space website, http://www.naturalspace.com/sweden_broadband/swedentext.htm (accessed July 9, 2010).

Øresundsbro Konsortiet (2009). *Øresundsbron Annual Report*, Copenhagen and Malmö.

The Western Harbour Facts and Figures 2010 (2010). Malmö City Planning Office, Malmö.

Image credits

Figure 1: googlemaps http://maps.google.de/maps/ms?hl=en&ie=UTF8&vps=2&jsv=298d&oe=UTF8&msa=0&msid=116478322990710211544.0004925639cfb8b3008bf

Figure 2: City of Malmö

Opening spread photo: La-Citta-Vita on Flickr

Photos 1, 6: Simon Field, ITDP Europe

Photos 2, 3: Streets and Parks Department, City of Malmö

Photos 4: Nicole Foletta, ITDP Europe

Photo 5: http://www.norden.org/

Photo 6: visitsweden.com, Frederik Tellerup/Malmö Turism

CASE STUDY

Vauban

FREIBURG, GERMANY

Simon Field, ITDP Europe

VAUBAN SITE FACTS

Developers: Multiple, mainly small building cooperatives

Architect: Kohlhoff & Kohlhoff (masterplan)

Construction Began: 1998

Year Completed: 2010

Population: 5,000

Total area: 41 ha

Density: 122 persons / ha

Net Housing Density: 95 / ha

Housing Units: 2,000

Jobs On-site: 600

Distance from City Center: 3 km

Parking Spaces/Residence: <0.5

Cars: 160 per 1,000 residents

NMT Mode Share: 64%

Transit Mode Share: 19%

Households with Carsharing Membership: 39%

BACKGROUND

Vauban is one of the most celebrated "model sustainable districts," comprising 2,000 low-energy homes in an attractive location in the foothills of the Black Forest in Freiburg, south-west Germany. It is a car-reduced brownfield redevelopment with parking-free residential streets: car ownership and use are half that seen in a comparable reference district.

A bottom-up approach to the planning of Vauban was taken from the outset, with groups of potential residents (including those who lobbied for the adopted street design) designing their own homes on allocated plots of land alongside established developers. This has resulted in an architecturally diverse and colorful district with a strong sense of community (Photo 1). With its relatively high density, high standards of thermal insulation[1] and the use of solar energy, renewable woodchip district heating, generous green space provision and communal gardens, Vauban has become a magnet for urban designers and students of architecture.

Vauban, like Stellwerk 60 in Cologne, limits and separates parking from the majority of housing units, but car access to residential streets is permitted for picking up and dropping off (Figure 1).

[1] 65 kWh/m² maximum, with 100 "passive houses" requiring only 15 kWh/m².

PLANNING PROCESS

In 1992 the City of Freiburg held a masterplanning competition for a new mixed-use eco-suburb on 70 ha of previously-developed land on the western edge of the city. This became Rieselfeld, a brownfield redevelopment project with 3–5 story energy-efficient buildings, on-site services and jobs, no through traffic, traffic-calmed streets and a new tram line, which opened in 1997. The same model was to be applied to Vauban, a 41 ha site vacated by the French army in 1992. However, a group of local environmental campaigners formed the association Forum Vauban in an attempt to introduce more radical design measures into the masterplan, explicitly to deter car use and create safe streets where children could play safely. This led to the design of Vauban's characteristic U-shaped streets off a main thoroughfare, with no on-street parking in front of homes in the first and second phases of the development.

A key principle of the Forum Vauban masterplan was that car use should be less convenient than the alternatives. But planners where prevented from completely restricting parking because the Baden Württemberg Land requires every home to have access to a parking space. Forum Vauban, negotiated a compromise resulting in a parking ratio of less than 0.5 per housing unit, with most parking located in parking garages on the edge of the district. Pricing for the spaces was based on land value and the cost of construction. A legal framework to satisfy the City was drawn up, in which residents of

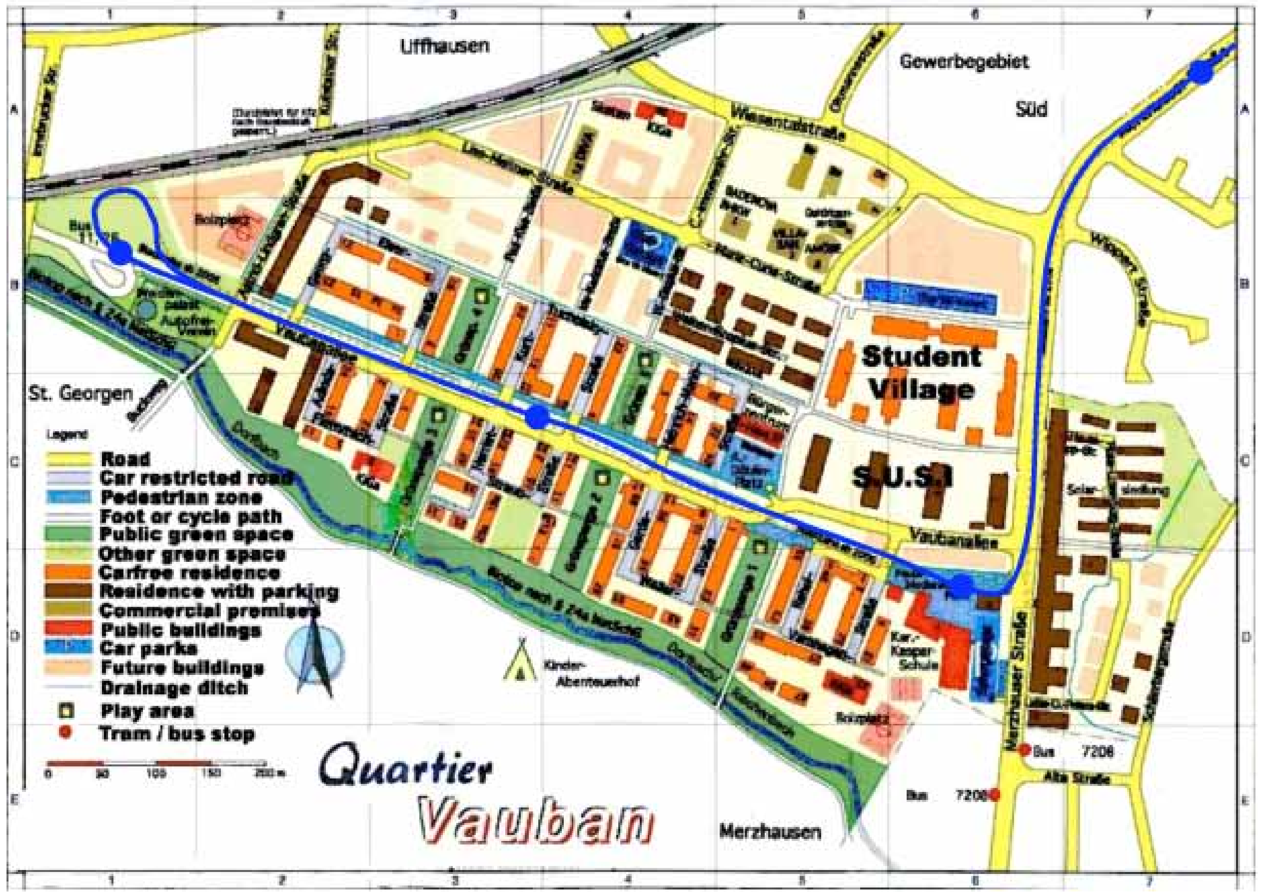


Figure 1: Site plan. Parking-free blocks are in orange and tram route 3 is indicated by a solid blue line. Car-owning residents of the parking-free blocks must park in one of the peripheral garages.

parking-free streets have to purchase a parking space in one of two peripheral parking garages, initially costing 16,000 EUR plus a monthly service charge. If residents wish to avoid paying this fee, they must prove they will not own a car by signing a legal declaration to that effect. However, in order to comply with State laws, the development was still required to set aside land to provide for expansion of parking facilities if future demand requires it. Residents had to help fund this, to the tune of 3,500 EUR. An Association of Carfree Living was created to administer this system. To this day the City of Freiburg does not publicly support the parking-free streets model, serving as a reminder that such radical initiatives are only likely to be considered if grassroots campaigns to demand them are mounted by the electorate.

The architects Kohlhoff & Kohlhoff of Stuttgart blended the ideas of Forum Vauban into the final masterplan shown in Figure 1. A lengthy waiting list of potential residents for the parking-free streets formed rapidly after publication of the final masterplan, but risk-averse developers were unwilling to invest in such an untested concept, despite the cost savings associated with not building expensive underground parking. Forum Vauban was tasked by the City to help coordinate groups of interested architects, residents and financiers into building cooperatives ("Baugruppen" in German), each being sold small plots of land on which to build housing consistent with the densities and minimum energy standards set out in the masterplan and Freiburg's planning regulations. Uptake was enthusiastic, with this model of development accounting for most of the buildings constructed in the first two phases of development, which commenced in 1998 and was completed by 2004.

Although most of the original military buildings were demolished, three were incorporated into the new Vauban: "Haus 37" became a pub and offices, accommodating Forum Vauban and the Association for Car-free Living; a second block formed part of the student village; and a third became part of the S.U.S.I. low-cost, communal living (co-housing) project. Around 10% of all homes are social housing (rented to low-income residents at below market rates), with the remainder almost entirely owner-occupied. One part of the first construction phase was provided with bundled underground parking (grid ref. B5 in Figure 1), and third phase blocks at the western end of the site (marked in brown on the map) also include underground and some on-street parking. Construction was completed in 2010, later than anticipated owing to the global economic downturn. Although Forum Vauban has been dissolved, a thriving residents' association known as Stadtteil Vauban continues to promote the area and organise events such as a summer festival.

FREIBURG TRANSPORTATION POLICY

Freiburg's achievements in sustainable transport since the 1960s include the exclusion of cars from the historic city core; an air quality environmental zone since 2010; reduced city centre car parking with fees of up to 2.20 EUR per hour; extensions of the tram system to Rieselfeld and Vauban; a doubling of local "S-Bahn" train frequencies; re-building of the main rail station to include a new transit interchange and 1,000-space bike storage facility; city-wide 30 km/h or lower speed limits; and "naked junctions" that force drivers to negotiate them at low speed.

Freiburgers have elected a Green Mayor since 2002, suggesting strong local eco-awareness and popular support for "green" transportation policies (Photo 2).

KEY POLICY AND DESIGN MEASURES

Vauban limits car use through parking-free residential streets, spatially and fiscally separated parking and filtered permeability to prevent through traffic. Attractive alternatives include: frequent rail-based transit system and extensive, high quality non-motorized transport infrastructure.

Urban Design

Street design

Vauban is fully accessible to private motorized traffic approaching from the east, but parking is not permitted on the U-shaped streets serving the blocks shown in orange in Figure 1. These roads are around 4 m in width (including drainage channels) and are signed "Stellplatzfrei" play streets, meaning "no parking places" (Photo 2). Vehicles must be driven at walking pace, giving priority to other road users, and may stop only for the purposes of picking up and dropping off. The same rules apply to streets around the residential blocks shown in brown in Figure 1, which are provided with on-site underground parking. In the absence of parked cars, these roads are used as social space, especially by children, many of whom can be seen playing unattended.

A boulevard for pedestrians and cyclists runs along the north side of Vaubanallee, with a further network of non-motorized traffic routes on the northern side of the development. Fixed posts prevent unauthorized access by car users.

Direct access to the neighboring district of St. Georgen from the western end of Vaubanallee is only possible by non-motorized modes, preventing through traffic and thus a major source of noise, air pollution and danger (Photo 3).

Land Use

Residential buildings in Vauban are of four or five stories, with a net density[2] of approximately 95 units per hectare.

Several large green spaces separate the residential blocks, providing recreation areas for the many young families in Vauban and contributing to urban cooling.[3] On the other side of each block are communal (non-fenced) gardens (Photo 4).[4] Additional greenery and walking trails adjoin the stream forming the southern boundary of the site, providing yet another draw for families and minimizing the need to travel out of the district in search of pleasant recreation areas (Photo 5).

A supermarket, neighborhood grocery store, two cafés, pub-restaurant, fast-food take-away, bakery, offices, doctor's surgery,

[2] Inclusive of green and other open space
[3] The opposite of the urban heat island effect caused by heat-radiating hard surfaces
[4] A local law entitles all Freiburgers to rent small (off-site) allotment plots for a low fee

1
Distinctive architecture and car-free streets in Vauban

2

A "play street" where the primary use is walking and playing. Motor vehicles are permitted but must travel at walking speed.

3

Cars are discouraged from many streets, and additional green-way paths make walking and cycling even more direct and convenient.

4
Inner courtyards and communal gardens

5
Public space and bicycle paths

6

Freighburgh's tram system was extended to Vauban in 2006. All households are within 400 m of a tram stop.

7
Tram tracks on Vaubanallee

Trams run on unpaved surfaces to help reduce noise and mitigate stormwater runoff.

8

Tram and bus stop at the western entrance to Vauban, showing access restrictions, "bike and ride" parking and direct interchange between bus and tram.

pharmacy and primary school are all located along the main spine of the development. In addition, an organic supermarket, cosmetics store and discount supermarket are all located on Merzhauser Straße. A public square in front of the pub is used for a weekly farmers’ market and community events.

Parking

The overall residential parking space to unit ratio is less than 0.5, provided with underground and street parking in three parts of the development, and a total of 470 spaces in two peripheral parking garages. Residents of the “parking-free” blocks (orange in Figure 1) must either sign a legal contract with a specially created Car-free Living Association, agreeing not to own a car, or purchase a space in one of the two garages on the edge of the district. These offer a total of 470 spaces, each of which currently costs 18,500 EUR (Solargarage) or 22,500 EUR (Glasgarage) (*Linck, 2010: pers. comm.*), with a further monthly maintenance charge of 70 EUR. Almost all residents of the “parking-free” blocks live closer to a tram stop than one of the car parks, helping to influence modal choice in car-owning households, especially for short trips. This demand management effect is reinforced through inner city car parking fees of up to 2.20 EUR per hour.

Public parking for non-residents is available in the form of 220 metered spaces on Vaubanallee and in the garages. Enforcement of parking and vehicle ownership restrictions is the responsibility of the Car-free Living Association, and thus far has been limited to taking legal action against two residents known to own a car despite claiming otherwise.

Parking infractions are not evenly distributed across Vauban, perhaps reflecting varying levels of community pressure on neighbors to abide by the rules. Unfortunately the problem is particularly noticeable in some blocks, where significant numbers of residents park in front of their homes. The absence of police or local authority enforcement is thought to be a source of frustration for those who moved to Vauban for the benefit of an essentially car-free immediate environment.

Public Transportation

Transit routes to Vauban are summarized in Table 1 below. An extension of Freiburg’s tram system to Vauban opened in 2006, connecting the district with the heart of the city and the rail station in 14 and 18 minutes respectively (Photo 6). No home is more than 400 m from a stop and all trams offer step-free access. Since 2009 the municipal transit operator has purchased “green energy” to power the tram system, and many vehicles use regenerative braking to return energy to the overhead wires for use by other trams. Approximately hourly night buses operate at weekends, and a longer-distance bus route to the rural Hexental area runs at least every hour seven days a week. Land has been set aside for a local rail station (grid A2 in Figure 1), but a lack of capacity means this must wait for the completion of track doubling on the main line to Switzerland.

Trams run on a grassed central reservation along Vaubanallee (Photo 7): this contributes to noise reduction and decreases the amount of impervious surfaces and run-off, it is also aesthetically pleasing. A shelter, timetable, map and real-time electronic departure information are provided at all tram stops throughout Freiburg.

Table 1: Transit routes to and from Vauban

Route	Stops served	Mon–Sat daytime frequency (mins)	Mon–Sat evening frequency (mins)	Sun frequency (mins)
Tram 3 to city center and rail station	Three stops along Vaubanallee	7.5 (10 Sat. p.m.)	15	15
Bus 11 to rail station, conference center, large IKEA store	Innsbrucker Straße (at western end of Vauban)	30 (irregular Sat p.m.)	No service	30

VAG Freiburg

Table 2: Vauban compared to the reference district Rieselfeld

	Vauban	Rieselfeld
Population	5,000	9,000
Area (ha)	41	70
Population density (persons/ha)	122	129
Jobs per resident	0.12	0.09
Cars per 1000 residents	160	299
Car parking spaces/residential unit	< 0.5	1.2
Transit journey time to city center (mins)	14	19
Mode share for all trips		
Car	16%	30%
Public transit	19% *	25%
Bicycle/walking	64%	45%

EC, 2010; Nobis, 2003; Stadt Freiburg Statistics, 2010

* prior to opening of the tram extension to Vauban

Tickets are available from convenience stores, in-vehicle ticket machines (coins and some debit cards only) and from tram drivers.

Freiburg has developed a reputation for innovative, low-cost ticketing since the introduction of transferable monthly passes in 1984, which led to a doubling of transit patronage in the decade that followed (*Fitzroy and Smith, 1998*). Fares include:

- City single ticket, valid for 1 hour: 2.10 EUR;
- 24-hour city ticket: 5.30 EUR (1 adult and up to 4 children), or 9 EUR for up to 5 adults;
- Transferable monthly season ticket for the Breisgau region: 47.00 (or 41.10 EUR per month as part of an annual subscription).

A further benefit for RegioKarte holders is free travel for a second adult on Sundays. These fares are low in absolute terms, and compare very favorably with the monthly Vauban car park service charge of 70 EUR. In addition, residents in the first parking-free block to be constructed were given a free annual RegioKarte and national rail discount pass upon moving in. Transit services and fares are coordinated by the Regio-Verkehrsverbund Freiburg (RVF) agency, which has a comprehensive website with timetables, fares, maps and a sales portal for single-trip and one-day cell phone e-tickets. “Mobility guarantees” are offered by the municipal transit operator and RVF, offering free taxi rides in the event of missed connections and delays.

Pedestrian and Cycling Infrastructure

The district has been designed to make access by non-motorized modes safe and pleasant, with a dedicated network of streets free of motorized traffic (described above). Every home has at least one bike parking space, often in secure cellars accessed by ramps. A community bicycle repair store offering free labor is located within the district.

Both the city center and rail station are reachable in about 12 minutes by bicycle, with good on-road and sidewalk cycle lane provision (Photo 8). A leafy, lightly-trafficked lane through the city vineyard is a popular alternative route during the hours of daylight.

Carsharing

Twelve carsharing vehicles are available across Vauban, five of which are located in the solar parking garage. The not-for-profit Car-Sharing Südbaden Freiburg organization offers a total of 80 cars across the city. Annual membership fees are 350 EUR for an individual, or 600 EUR per household; usage fees vary by length of rental, distance travelled and vehicle class, with no hourly fee for overnight use (when transit service is limited).

A combined transit and carsharing pass known as the RegioMobilCard offers significant discounts on a range of mobility services: for an additional 10 EUR per month on an annual RegioKarte subscription, this pass offers:

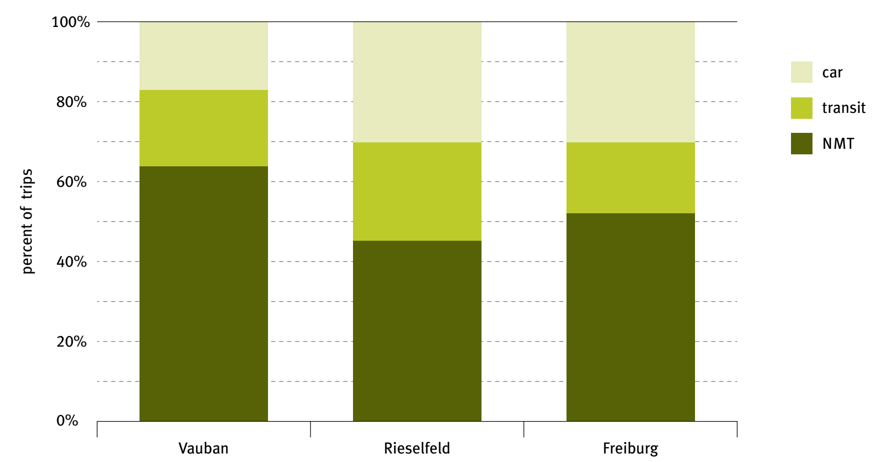
- Carsharing membership for 200 EUR per person, and a 20% reduction on carsharing usage fees;
- A 20% discount on bicycle parking and cycle hire from the “Mobile” bicycle center at the rail station;
- 20% off pre-booked taxis from Taxi Freiburg;

QUANTITATIVE ANALYSIS

This section mainly draws on survey data from May 2002 (*Nobis, 2003*), post completion of the parking-free blocks but prior to the opening of the extension of tram route 3 into Vauban. Nobis compared Vauban with Rieselfeld, a larger but demographically similar development located 3.5 km from the city center.

A comparison of the two sites (Table 2) is particularly interesting given the conception of Vauban as “Rieselfeld II,” i.e. with a range of local services, “play streets” and infrastructure for non-motorized transport users, but retaining free on-street parking or underground spaces bundled into the cost of residential units. In contrast to the Vauban situation, the tram system was extended to Rieselfeld in advance of redevelopment: today both routes operate at the same frequencies.

Figure 2: Mode split for all trips



R+T, 1999; Scheurer, 2001

Modal Split

Car use in Vauban is around 50% of that recorded in the reference district and the city of Freiburg, with NMT accounting for almost two thirds of all trips (Figure 2).

Cycling rates stand out as the key difference in travel behavior among Vauban residents (Figure 3).[5] Across the city as a whole, the bicycle accounted for 34% of commuter trips in 2002, compared with 61% and 91% for Vauban's car-owning and car-free households respectively. A majority of residents in both groups prefer to do daily grocery shopping within Vauban, reflecting the excellent provision of local facilities.

Turning to bulk shopping, one of the most difficult trip types to shift away from the private car, a car is used for only 6% of trips by members of car-free households. In contrast, those with access to a household car make 73% of these trips by car.

Data for the main mode used for leisure trips are shown in Figure 4 (Freiburg data are from 1999). Individuals without access to a household car make an impressive 83% of such trips by non-motorized means, with significantly greater bicycle use compared to car-owning Vauban residents and all households in Freiburg.

Only 2% of leisure trips made by residents from car-free households are by car, clearly demonstrating that car ownership is the primary determinant of car use. The data are not broken down by transit pass ownership, but these and the comprehensive local network are likely to play a significant role in supporting car-free residents' mobility in the region and beyond.

Among car owners, 41% use a bicycle more frequently than before moving to Vauban, but transit use is low, or at least it was prior to the introduction of tram services in 2006. The findings with respect to transit use should be treated with caution, since they applied to a bus service that neither entered the development nor the city center tram and pedestrian zone, leaving passengers with short walks at both ends of the journey. Since then, it is likely that some NMT trips have been switched to the tram among both car-owning and car-free residents, especially in winter.

[5] Nationally, the bicycle accounted for 2.6% of distance travelled for all trip purposes in 2004.

Vehicle Ownership and Carsharing

Considering only the parking-free blocks, approximately 40% of households do not own a car according to the 2002 survey. Figure 5 is based on Stadt Freiburg data from January 2010 unless stated otherwise.

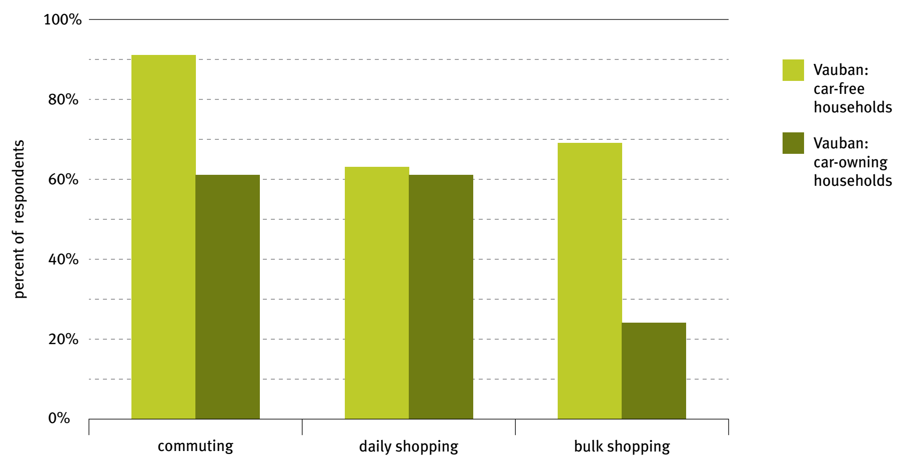
Although Vauban has a greater proportion of low-income residents and students, this is offset by having twice as many households with children, a demographic group expected to be car-reliant, compared with Freiburg. Rieselfeld has succeeded in reducing car ownership to the level of Freiburg's inner districts (300 per 1,000 population), but Vauban has almost halved this.

In 2002, 39% of Vauban households were registered with a carsharing organization, broken down into 59% of individuals in car-free households and 11% of those in car-owning households. At the time, only 0.1% of German drivers were carsharing members. In addition, 70% of respondents without a car use carsharing more often than they did before moving to Vauban.

There is a question of causality: do residents give up their car as a result of Vauban's parking concept, or has the decision to live car-free been made long before moving in? In answer to this, the Nobbys research revealed that 81% of the inhabitants of car-free households previously owned a car: 57% gave up their car just before moving to Vauban. Interestingly, 65% of residents moved to Vauban from elsewhere in Freiburg (*Stadt Freiburg Vauban Website*). These statistics suggest that more than half of those without a car were persuaded to do so by the unique combination of carrots and sticks offered by the district.

In summary, the inhabitants of Vauban are enthusiastic walkers and cyclists, but car-owning residents tend to default to the car for awkward trips, such as those involving heavy loads, and are more likely to jump in the car for longer leisure trips beyond the range of non-motorized modes.

Figure 3: Bicycle use among Vauban residents



Nobis, 2003

Transit Use

56% of car-free households in the parking-free area own at least one RegioKarte transit pass for the region, compared with 47% of car-owning households on parking-free streets and 32% of car-owning households in the conventional area. In addition, 72% of car-free Vauban residents and 49% of car-owning residents own a national rail discount card[6], as opposed to the national figure of 10% (*Nobis, 2003*). These findings (prior to the opening of the tram extension into Vauban) can be interpreted as an indication of the importance of local transit for day to day mobility, and rail as a substitute for the car for medium to longer-distance journeys.

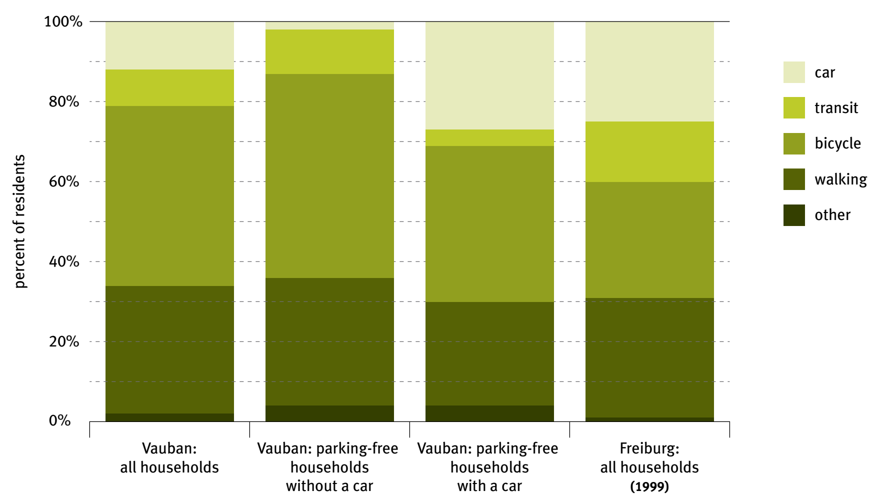
[6] The national BahnCard, which at that time cost 120 EUR per year and gave holders a 50% discount on all second class tickets.

Residents' Views on Vauban

In 2002, 81% of residents from car-free households stated they found organizing their life without their own car "easy" or "very easy." This finding can be attributed to the high quality NMT infrastructure, the convenience of bicycle use compared with walking to one of the parking garages, the provision of local services, proximity to the city center, good regional transit links and the availability of a carsharing service.

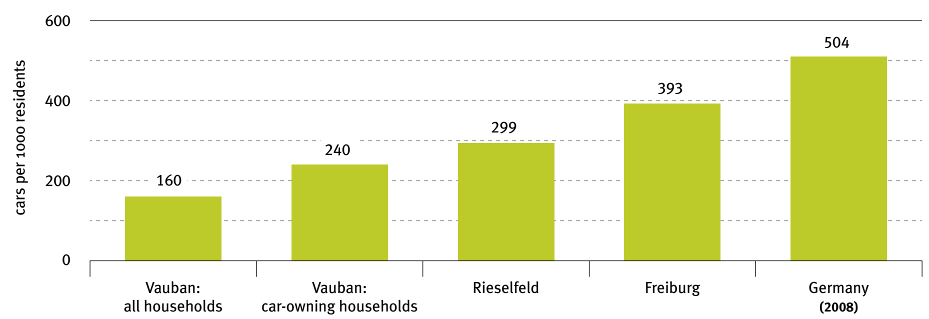
However, 67% of car-owning residents in parking-free streets reported being dissatisfied with being unable to park outside their home. Given that almost 60% of parking-free households have a car, this implies that approximately 40% of these residents considered Vauban's advantages to outweigh this inconvenience, but a significant proportion would like to have "the best of both worlds," helping to explain the parking infractions.

Figure 4: Mode split for leisure trips



Nobis, 2003; R+T, 1999

Figure 5: Vauban Car ownership as compared to surrounding area



EC, 2010; Nobis, 2003; Stadt Freiburg Statistics, 2010

LESSONS LEARNED

Vauban is a success story, with greatly reduced car ownership and bicycle substitution of routine car trips as tangible benefits of the policy and design strategies. Key to this is decoupled parking, meaning both car ownership and habitual use are no longer default scenarios: 40% of parking-free households do not have a car, and 41% of car-owners use a bicycle more than they did before moving. The second vital component is the ease with which people can go about their lives without a car, made possible through the provision of local services and jobs, proximity to the city center, extensive NMT infrastructure and good, low-cost regional transit services. In these circumstances developments such as Vauban can attract people not pre-disposed to an altruistic car-free lifestyle: 57% of residents in car-free households gave up their car when they moved to Vauban. High quality transit should be in place from the outset: a criticism is that the tram extension had not opened by the time most residents had moved in, a factor which could have contributed to greater car ownership and the desire of developers to build later blocks with bundled parking.

Transferability of the economically and spatially decoupled parking model into other new developments is possible, although this is unlikely to be accepted in the absence of carrots of the quality seen in Vauban and the wider Breisgau region. Masterplanning competitions have been successful in Vauban and Stellwerk 60, working to sustainability guidelines developed by local and regional planning authorities. Both developments have demonstrated that legal barriers in the form of minimum parking standards can be overcome: it would help further if these were abolished or could be determined at the local development plan level. The sale of small plots of publicly-owned land to several different associations of developers, architects and potential residents ("Baugruppen") is a model that could be replicated elsewhere, helping to mitigate the unpopularity of and lack of a sense of community in unappealing, anonymous estates of identical homes.

The dissatisfaction among car-owning residents could be ameliorated through personalized travel planning, including advice on how to navigate the transit system, incorporate walking and cycling into daily routines (including for shopping), and how to plan leisure trips without a car. Greater marketing for the RegioMobilCard could be worthwhile, building on the awareness-raising effect of the free annual RegioKarte issued to residents of parking-free households upon moving in.

There is a significant and growing problem of illegal parking in the parking-free streets, which until now has been largely self-policed by residents applying pressure on their neighbors. Formal warnings should be issued to offenders in the first instance, to avoid possible future tensions between residents. Legal action may be required against the small subset of car-owning residents who claim to live car-free and therefore evade parking fees. ■

SOURCES

Broaddus, A. (2010). *A Tale of Two Eco-Suburbs in Freiburg, Germany: Parking Provision and Car Use*. Paper presented at TRB 2010 Annual Meeting.

Car-Sharing Südbaden – Freiburg: https://www.car-sharing-freiburg.org/goto/kosten/ (accessed 12 Aug 2010).

EC (2010). *Energy and Transport in Figures 2010*. European Commission, Luxembourg.

FitzRoy, F. and Smith, I. (1998). Public transport demand in Freiburg: why did patronage double in a decade? *Transport Policy* 5: 163–173.

Freiburg GreenCity: http://www.fwtm.freiburg.de/servlet/PB/menu/1174649_l1/index.html

Linck, H. (2010). E-mail correspondence received from Hannes Link (Verein für autofreies Wohnen e.V.) on 14 September 2010.

Melia, S. (2006). *On the Road to Sustainability: Transport and Car-free Living in Freiburg*. University of the West of England.

Nobis, C. (2003a). *Bewohnerbefragung Vauban: Bericht im Rahmen des Projektes "Umsetzungsbegleitung des Verkehrskonzeptes im Stadtteil Freiburg-Vauban."* Deutsches Zentrum für Luftund Raumfahrt e.V., Berlin.

Nobis, C. (2003b). The Impact of Car-free Housing Districts on Mobility Behaviour — Case Study. In: Beriatos, E., Brebbia, C.A., Coccossis, H. and Kungolos, A. (eds) (2003). *Conference on Sustainable Planning and Development* pp 701–720. WIT, Dorset.

R+T (1999). *Verkehrsentwicklungsplan Freiburg. Teil A: Problemanalyse*. R+T, Freiburg.

Scheurer, J. (2001). *Urban Ecology, Innovations in Housing Policy and the Future of Cities: Towards Sustainability in Neighbourhood Communities*. Murdoch University Institute of Sustainable Transport, Perth.

Stadt Freiburg Statistics: http://freiburg.de/servlet/PB/menu/1143602_l2/index.html (accessed 12 August 2010).

Stadt Freiburg Vauban Website: http://www.freiburg.de/servlet/PB/menu/1167123_l1/index.html (accessed 12 August 2010).

Stadtteil Vauban: http://www.vauban.de

Umweltbundesamt (2009). *Daten zum Verkehr. Ausgabe 2009*. Umweltbundesamt, Dessau-Roßlau.

URBED: http://www.urbed.com/

VAG Freiburg (municipal transit operator): http://www.vag-freiburg.de/

Image credits

Figure 1: Stadtteil Vauban (adapted).

Photos 1, 3–8: Simon Field, ITDP Europe

Photo 2: Payton Chung

BUILDING LOW CAR(BON) COMMUNITIES

Comparative Analysis

Case Study Physical Characteristics

In order to better understand the potential transferability of the strategies presented in these case studies, it is worth noting some of the basic characteristics of each of the sites including size, density and distance from city center. These are shown in Table 1.

Overview of Policy and Design Strategies

These case studies have shown a variety of smart urban growth strategies to discourage private car use and encourage more walking, cycling and transit use, many of which could be deployed in other developments, both old and new. Most of the case study developments employ several strategies in tandem for maximum effect. A comparison of the main measures applied at each of the sites is provided in Table 2. The colorless cells in the table indicate a best practice approach, the light gray cells indicate a satisfactory approach and the dark gray cells indicate a poor approach.

Push Measures

The most widely used push measures make parking more difficult for residents. This can include limiting the parking supply, pricing parking and spatially separating parking from residential units, making access to a car less convenient. Decoupling the cost of parking encourages residents to consider reducing their car ownership, with physical separation leading to the use of alternative modes, particularly for short trips where access time to a remote parking facility would account for a large proportion of the total journey time. Many of the sites applied all three of these strategies. The city of Houten stands out as not applying any: parking spaces are readily available, located near housing and are not priced. It is therefore unsurprising that the car ownership rate for Houten is among the highest of all the sites studied.

Pull Measures

The most widely used pull measures include provision of high quality public transportation, cycling and pedestrian infrastructure, carsharing, and urban design features. Public transportation provision and quality of urban design are summarized in Table 2, but are described more thoroughly in the following sections. Several other innovative measures such as bikesharing systems and car-free declarations, were only applied at a handful of sites.

At a minimum all the developments provide safe, segregated bicycle and pedestrian paths and sufficient bicycle parking facilities. Sihlcity is rated slightly lower than the other sites mainly because the site can be difficult to access by bicycle.

All of the sites provide Carsharing vehicles. Stellwerk 60 has a large program with one Carsharing vehicle for every 63 residents. The availability of vehicles is lower in Houten, GMV and Västra Hamnen. Carsharing services are generally geared towards residential areas, giving citizens access to a car near their home, and therefore it is not especially useful to consider carsharing in Sihlcity.

Public Transportation

Great, cost-effective, easy to access public transportation is an important factor in the success of these development. It might also be one of the most difficult to replicate in other contexts since the decisions that create the quality and access might happen at a scale much larger than the individual development. For example all of the sites considered in this report have transit service with at least 15 minute frequencies and many have some form of public transport operating in the area 24 hours per day. While developers can advocate for these features, these decisions are likely made at a higher level. Therefore the pre-existence of good transit in the region may serve as a criteria for siting new developments, while planners should seek to optimize service to the new development.

Table 1: Summary of site characteristics

Development	Current population	Total area (hectare)	Residential units	Net housing density+ (units/hectare)	On-site jobs per resident	Parking spaces per residential unit	Distance from city center (km)
Greenwich Millennium Village	2,310	29	1,095	55	n/a	0.8	9
GWL Terrein	1,400	6	600	100	0.15	0.22	3
Hammarby Sjöstad	17,000	160	8,000	50	0.31	0.65	3
Houten	43,900	820	18,400	22	0.46	1.1	8*
Sihlcity	—	4	0	—	—	—	2.5
Stellwerk 60	750	6.1	320	95	0	0.3	2.5
Västra Hamnen	4,326	175	2,558	33	2.10	0.8	2
Vauban	5,000	41	2,000	95	0.12	< 0.5	3

+ Number of residential units per hectare of developed land

* Distance from Utrecht city center

Table 2: Overview of sustainable transportation measures used at each site

Development	Parking strategy	Public transport	Ped/cycling infrastructure	Carsharing	Urban design	Other
Greenwich Millennium Village	Limited, priced, spatially separated	High provision	High quality	1 vehicle per 1,155 residents	Good quality	Residents association, sustainable use of resources
GWL Terrein	Limited, spatially separated	Good provision	High quality, cars physically excluded	1 vehicle per 280 residents	High quality	Car-free declaration, umbrella organization, sustainable use of resources
Hammarby Sjöstad	Limited, priced	High provision	High quality	1 vehicle per 460 residents	Good quality	Bikesharing, sustainable use of resources
Houten	None	Good provision	High quality	1 vehicle per 2700 residents,	High quality	Public bikes, employer contributions, educational programs
Sihlcity	Limited, priced	Good provision	Good quality	1 vehicle per 6,300 visitors	Good quality	Storage facilities, bicycle delivery service, smart measures
Stellwerk 60	Limited, priced, spatially separated	Good provision	High quality, cars physically excluded	1 vehicle per 63 residents	Good quality	Car-free declaration, mobility center, marketing, low-energy homes
Västra Hamnen	Limited, priced	High provision	High quality	1 vehicle per 1,040 residents	Good quality	Mobility management, sustainable use of resources
Vauban	Limited, priced, spatially separated	High provision	High quality	1 vehicle per 417 residents	High quality	Car-free declaration, smart measures, residents association, low-energy homes

Table 3: Overview of public transportation provision

Development	Type	Peak hour frequency (minutes)	Weekday operating hours	Max distance to stop	Level boarding	Real time arrival information	Priority	Smart-card
Greenwich Millennium Village	Metro	2–6	05:30–01:00 19.5 hrs/day	1.2 km	Yes	Yes	Completely segregated	Yes
	Bus	5–8	24 hrs/day	200 m	Yes	No	Bus only lane	Yes
GWL Terrein	Tram	10	06:00–00:00 18 hrs/day	300 m	No	No	Segregated tramway	Yes
	Bus	10	24 hrs/day	200 m	Yes	No	Bus only lane	Yes
Hammarby Sjöstad	Tram	7–8	05:30–01:00 19.5 hrs/day	400 m	Yes	Yes	Segregated bus/ tramway	Yes
	Bus	5–7	24 hrs/day	400 m	Yes	Yes	Segregated bus/ tramway	Yes
Houten	Train	15	06:00–00:30 18.5 hrs/day	1.8 km	Yes	Yes	Completely segregated	Yes
	Bus	15	24 hrs/day	1.2 km	Yes	No	Bus only lanes, traffic signal priority	Yes
Sihlcity	Train	10	05:00–23:00 18hrs/day	200 m	No	Partial	Completely segregated	No
	Tram / Metro	3–4	05:00–23:00 18 hrs/day	300 m	Partial	Partial	Partial segregation, traffic signal priority	No
	Bus	6–8	05:00–23:00 18 hrs/day	300 m	Partial	Partial	Limited bus only lanes	No
Stellwerk 60	Train	10	04:30–00:30 20 hrs/day	500 m	Yes	No	Completely segregated	Trial national scheme
	Tram	5	05:00–00:30 19.5 hrs/day	500 m	Partial	No	Completely segregated	No
	Bus	10–20	06:00–22:30 16.5 hrs/day	400 m	Yes	No	None	No
Västra Hamnen	Bus	5–7	05:00–00:30 19.5 hrs/day	300 m	Yes	Yes, at some stations	Bus only lanes, traffic signal priority	Yes
Vauban	Tram	7–8	05:15–00:30 19 hrs/day	400 m	Yes	Yes	Mostly segregated, traffic signal priority	No
	Bus	30	05:30–20:30 15 hrs/day	600 m	Yes	Yes	None	No

Table 4: Overview of smart urban design features

Development	Green space provision	Public space provision	Residential density	Ped/cyclist priority	Mix of uses	Filtered permeability	Traffic calming
Greenwich Millennium Village	High	High	High	Medium: most of the site is car-free	Medium diversity	Medium	Medium: colored pavement, speed limit
GWL Terrein	High	High	High	High: entire site is car-free	Medium diversity	High	High: colored pavement, speed limit, road narrowing
Hammarby Sjöstad	High	High	High	Medium: many pedestrian and cycle paths	High diversity	Low	Medium: speed limit, road narrowing
Houten	High	High	Medium	High: all streets have cyclist priority	High diversity	High	High: colored pavement, road narrowing, speed limit, speed bumps
Sihlcity	Low	High	–	Medium: public spaces are car-free	Medium diversity	Low	Medium: motor vehicles excluded in public spaces
Stellwerk 60	Medium	Medium	High	High: entire site is car-free	Low diversity	High	High: motor vehicles excluded
Västra Hamnen	High	High	Medium	Medium: Bo01 is car-free, other areas are not	High diversity	Medium	Medium: speed limit, road narrowing
Vauban	High	High	High	High: much of site is parking-free	High diversity	High	High: speed limit, road narrowing, tram priority

Table 3 summarizes and compares several public transport features that can affect system accessibility, quality of service and ease of use. The colorless cells in the table indicate a best practice approach, the light gray cells indicate a satisfactory approach and the dark gray cells indicate a poor approach. Services with a high frequency and long operating hours ensure that public transport is available when residents need it, reducing the need to use or own a car.

System Accessibility

Accessibility is characterized by maximum distance to a stop and availability of level boarding. A maximum walking distance of 250 m to bus stops, 500 m to tram stops and up to 1 km to rail services is recommended, but good bicycle infrastructure such as covered cycle parking can increase the catchment areas significantly. The furthest distance residents in these case studies would need to travel to reach a train station is 1.8 km in Houten, and many residents cycle to get there.

Level boarding of transit vehicles ensures that the mobility-impaired, including wheelchair users and passengers with children in strollers, have easier access to public transport.

Quality of Service

Real time arrival information, transit priority and smartcards improve the quality of service of public transport systems. Electronic message boards are provided at transit stops in GMV, Hammarby Sjöstad, Houten, Västra Hamnen and Vauban providing real time arrival information. Although most of these signs in Zurich display scheduled rather than real-time information, reliability and punctuality are both excellent. Many cities now also provide real time arrival information online or through cell phone sms messages.

Transit priority increases transit vehicle speeds, and can be in the form of segregated right-of-way and transit priority at traffic signals. Transit priority at traffic signals means that public transport vehicles get a green light or "proceed aspect" as they approach an intersection.

Finally, smartcards improve quality of service by improving the ease and speed of payment. Details of other innovative ticketing and fare systems, such as time-limited single-trip tickets, carnets and transferable passes, can be found in the individual case studies.

Urban Design

A variety of urban design features were also applied at each of the sites. Some are more geared towards encouraging walking and cycling (incorporating high quality design and public space as well as safety features) while others discourage car use (including the use of filtered permeability to limit through traffic by vehicles). A summary and comparison of these features is shown in Table 3. The colorless cells in the table indicate a best practice approach, the light gray cells indicate a satisfactory approach and the dark gray cells indicate a poor approach.

All the sites provided public space including parks, gardens and green pathways, plazas and children's play areas.

Most of the sites provide a mix of uses so that residents do not have to go far to access grocery stores, pharmacies, health care facilities and even schools. This proximity encourages shorter, non-motorized trips. In addition, all of the sites other than Sihlcity have a relatively high density making walking more attractive and convenient.

All of the sites provide some form of pedestrian or cyclist priority. The low-car environments provide safer conditions for cyclists and pedestrians who do not have to compete with cars for use of the space.

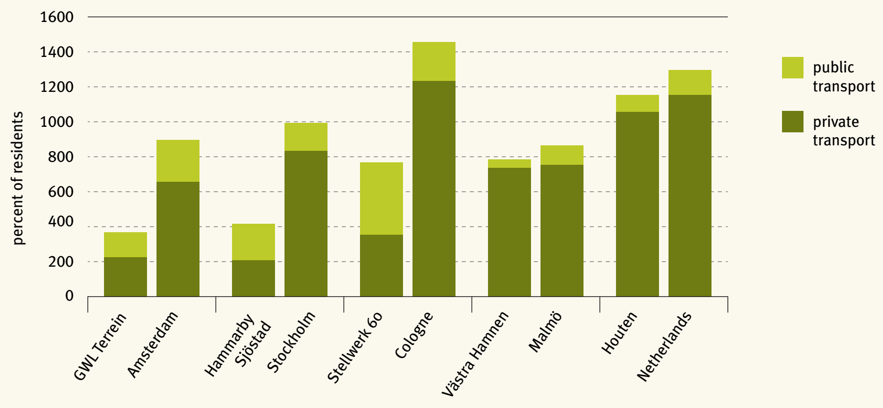
Filtered permeability (also known as a "traffic cell" system) ensures that residents can move from one part of the development to another more easily by cycling and walking than by car. For internal area trips, cars must drive circuitously out to a ring road, around, and

Table 5: Mode share and car ownership rates for study sites and reference areas

Location	Mode share (proportion of all trips) by car	by transit	by bicycle	on foot	Cars per 1,000 residents
Greenwich Millennium Village	18%	49%	4%	29%	350
Greenwich District	44%	29%	1%	26%	350
GWL Terrein	6%	14%	50%	30%	190
Amsterdam West	20%	18%	32%	30%	310
Hammarby Sjöstad	21%	52%	9%	18%	210
Stockholm Reference District	35%	50%	7%	8%	n/a
City of Houten	34%	11%	28%	27%	415
City of Zeist (The Netherlands)	46%	11%	29%	14%	530
Sihlcity: visitor trips	30%	70% (transit, cycling, walking combined)			–
Letzipark: visitor trips	n/a	n/a	n/a	n/a	–
Stellwerk 60	21%*	53%*	31%*	29%*	60
Nippes District	61%*	33%*	3%*	3%*	309+
Västra Hamnen	23%	17%	31%	29%	440
City of Malmö	41%	16%	23%	20%	480
Vauban#	16%	19%	64% (bicycle/walking combined)		160
City of Freiburg#	30%	18%	28%	24%	393

* Mode share based on distance traveled.
+ Data for the smaller Nippes Stadtteil.
\# Mode share data from 1999/2000 (prior to extension of the tram system to Vauban).

Figure 1: Land transport emissions per resident



then back, while trips on foot or by bike can be made by very direct dedicated pathways. This means most trips within the area take less time by bike than by car, thus encouraging bicycle use. Houten is the best example of this among the areas reviewed.

Traffic calming measures attempt to encourage vehicles to drive more slowly, thus providing a safer environment for cyclists and pedestrians. Traffic calming measures include pavement of a different color or material, street furniture, street narrowing, speed limits (with varying levels of enforcement) and speed bumps.

Quantifying Success

As we have shown in each of the case studies individually, these strategies work. Car ownership rates, car usage and transport-related emissions are lower in the case study developments than in comparable areas. It is worth comparing the case studies cities to each other to further understand the implications of the various ways measures were applied and what the outcomes were. Table 5 compares mode share and car ownership rate between each case study site and a reference district, while Figure 1 shows a comparison of transport-related emissions of five of the case study sites.

Car Ownership Rate

The car ownership rate per 1,000 residents varies greatly between the various sites, from 60 cars per 1,000 residents at Stellwerk 60 to a high of 415 cars per 1,000 residents in Houten, which has applied fewer policy and strategies than the other sites studied here. Still, car ownership in Houten is lower than in many other areas that lack designs or policies to reduce car use and encourage other forms of transportation.

Mode Split

Car ownership is important but we should also ask how often are people using these cars. People may continue to own cars for longer trips, but measures can encourage residents to use alternative forms of transportation for short, everyday trips. For all of the sites, the private motorized vehicle mode share was less than 35%, meaning the majority of trips are made by alternative modes. Furthermore, all of the sites have a lower private motorized vehicle mode share than reference sites without integrated policy and design measures.

GWL Terrein has an especially sustainable mode share: 30% of all trips taken by residents are on foot, 50% by bike, 14% by public transport and only 6% by car. Houten and Västra Hamnen also have high non-motorized mode shares. In Houten 27% of trips are made on foot and 28% by bike. In Västra Hamnen 29% of trips are made on foot and 31% by bike. These results demonstrate that even in areas, such as Houten and Västra Hamnen, where car ownership is relatively high, residents may choose to make a majority of trips by non-motorized modes. Likewise, among Vauban's car-owning population, 61% of commuting and daily shopping trips are made by bicycle. These choices are likely influenced by the comprehensive application of policy and design measures in these locations. As the analysis of Houten shows, most trips made within the city appear to be made by bike or walking. However, the high car ownership rate leads to longer trips being made by car.

Land Transport Emissions

While mode share gives a general idea of resident travel behavior, it cannot be used to accurately calculate CO_2 emissions. For five of the sites studied, data on average distance traveled per mode per resident were collected. A simple estimate was made of transport-related emissions per resident per year by multiplying average distance traveled per motorized mode (including both private and public transport) by emissions estimates per passenger-km traveled for each mode. A more rigorous CO_2 evaluation would consider the effect of vehicle speed and trip length on the CO_2 emission rate per PKT, which would reflect the higher CO_2 intensity per PKT for short motor vehicle trips. Figure 1 shows a breakdown of emissions from private transport (e.g. cars) and public transport (e.g. bus, train, tram, metro), and compares emissions between the case study sites and the city or country in which they are located. From this figure we can see that there is a relationship between car ownership rate and emissions from private transport. Private transport emissions are much lower in GWL Terrein, Hammarby Sjöstad and Stellwerk 60 where car ownership rates are low, than in Västra Hamnen and Houten, where car ownership rates are higher. Even though non-motorized mode share in Västra Hamnen and Houten are high, it appears that residents drive for many long trips and these vehicle kilometers traveled increase the carbon footprint of residents. Furthermore, transport-related emissions per resident are much lower for GWL Terrein, Hammarby Sjöstad and Stellwerk 60 than for the cities in which they are located (Amsterdam, Stockholm and Cologne). Transport-related emissions per resident for Västra Hamnen are similar to those for Malmö, and emissions for Houten residents are similar to those for the Netherlands, though a more rigorous CO_2 evaluation method would likely show slightly greater differences. ■

BUILDING LOW CAR(BON) COMMUNITIES

Lessons Learned

This report shows that new developments can be built to facilitate the use of sustainable transportation, reducing the impacts of traffic congestion, greenhouse gases and other pollution, and creating the opportunities for healthier modes of transportation. This chapter recaps the lessons learned and looks at the larger context for the success of these projects, the potential for replication of the strategies used and makes policy recommendations for the future.

LESSONS FOR SMART URBAN GROWTH: POLICY AND DESIGN STRATEGIES

Lesson 1: Intention is key

These developments were all created with a mandate to reduce or minimize driving. The reasons for these mandates may vary (to reduce CO_2 emissions, to limit the traffic impacts of these new developments, etc.). But the fact they exist helps provide political will for all of the urban planning and design decisions that followed. These mandates can be codified using stringent caps on car trip generation and CO_2 emissions or the relaxation of parking minimums if other criteria to reduce car demand are met.

Planners can also use the existence of these mandates to require developers to fund or build transportation infrastructure and services (including mobility management services) as a condition of site approval.

These types of developments are likely to require well-organized grassroots support for the concept from the outset, to demonstrate demand for this way of living and provide additional political will. Masterplanning competitions can also foster further buy-in and innovation in both the built environment and transportation planning.

Lesson 2: Develop neighborhoods designed for walking and cycling.

This includes creating high quality infrastructure for cyclists and pedestrians, and also designing a dense network of streets and paths that make walking and cycling easier.

Walking

Location and density both make walking a more convenient option. But high quality design, including provision of safe and attractive walking routes as well as public spaces in which people want to spend time, is also essential. Vauban features covered arcades for pedestrians along the central avenue, while the Swedish sites studied offer waterfront promenades.

All residential streets are for the exclusive use of pedestrians and cyclists in the car-free sites studied, while GMV, Hammarby Sjöstad, Sihlcity, Västra Hamnen and Vauban exclude cars from parts of the site, offering safe, quiet walking routes.

Bicycling

Cycling similarly requires good infrastructure on-site and in the wider area: on-and off-road cycle lanes, plentiful, secure and covered cycle parking (including at transit stops, workplaces and shops). Low speed limits are essential to encourage on-road bicycle use: a maximum of 30 km/h is common to many of the case studies permitting car access, reduced further to walking pace in Vauban's parking-free residential streets. Traffic calming through street furniture, speed bumps, frequent crosswalks and differently colored surfaces reinforces the message that priority should be given to pedestrians and cyclists.

Filtered permeability is employed in Vauban and Houten, with the latter taking the concept to its logical conclusion by providing a fine-grained network of direct, high quality cycle routes (including dedicated tunnels and roundabouts) that make cycling quicker than the car for many journeys within the city. Cyclists have priority on all streets shared with cars and at junctions where cycle-only streets cross them, and many roads are heavily traffic-calmed with cars permitted "as guests." An on-site bicycle workshop with free servicing is available in Vauban. A bicycle delivery service is offered in Sihlcity, helping to minimize the need to arrive by car to take bulky shopping home.

Bicycles can be taken on board transit services in Cologne and Zurich, and ferries in Stockholm, helping to extend the range of bicycle-transit trips and encouraging bike use in bad weather.

Lesson 3: Make transit accessible, affordable and attractive.

High quality, conveniently accessible public transportation is key to encouraging use of this mode over the car. Ideally these facilities are established in advance of construction of these new developments, and in some cases, such as Sihlcity, developers may be asked to provide funding for or construct new stops as part of the overall development.

Residents in all the sites we studied live no further than 500 m from the nearest transit stop, which are serviced with daytime frequencies of at least fifteen minutes. Operating hours are long and comprehensive information is provided at stops. Integrated transit agencies coordinate timetables and fares in all the case study cities, ensuring connections are optimized and the "one trip, one ticket" principle applies. Orbital transit routes in the larger cities provide a realistic alternative to the car for complex trips other than to/from the city center. Transit priority measures in and around new developments maximize service reliability: trams in Cologne, Freiburg, Stockholm and Vauban run largely on segregated rights of way, while those in Zurich enjoy priority at junctions through traffic signal activation. The Millennium Busway allows buses to avoid congestion as they pass through the GMV area.

And while it is unlikely that any one development can influence the ticketing and payment systems for an entire transit system, the availability of smartcards and discount period passes in the areas studied do help make transit cheaper and more convenient. Recent innovations such as cell phone e-tickets (in Cologne, Freiburg and Stockholm) and print-at-home tickets (Zurich) are improving the transit experience even more.

Providing better options for long distance travel can also help people give up their private cars. Access to rail is an important substitute for longer-distance car journeys in the European context: 83% of Stellwerk 60 respondents undertook a long-distance journey by train within the last three months, and 72% of non car-owning Vauban residents own a national rail discount card. Although beyond the scope of this study, this is a factor to consider when assessing the scale of potential car reduction in new development.

And though these case studies have some of the best transit conditions, there still room for improvement. In some areas unstaffed stations with poorly-lit approach routes and evidence of anti-social behavior such as graffiti make users feel unsafe. It is essential that transit feel safe, even at night, otherwise people will continue to drive or take taxis for these trips. Another issue in some of the sites, is overcrowding on transit at peak times. Planners need to match demand and capacity or else other measures will be undermined.

Carsharing

Carsharing is an intermediate public transport strategy. It is available in or around all the sites studied: it should be considered a prerequisite for strategies to reduce private vehicle ownership, providing residents with a personal motorized transport option for occasional use. The site with the lowest car ownership (Stellwerk 60 with 60 cars per 1000 residents) also has the highest carsharing membership rate (67% of households), and provides one carsharing vehicle per 44 residents. A variety of vehicle types is likely to boost the popularity of carsharing services. Bundling carsharing membership with transit passes (offered in Freiburg and Zurich) offers a complete mobility package for residents without access to a household car. Discounted membership and/or rental rates can encourage take up, as practiced in Västra Hamnen. In the absence of a one-way trip option, the availability of carsharing vehicles in the surrounding residential areas is more important than on-site cars in major trip attractors such as Sihlcity.

Lesson 4: Create compact regions with short commutes and zone new developments for mixed uses.

New developments should be planned as closely as possible to existing job centers and other destinations. Mixed uses (housing, jobs, leisure facilities, shops, grocery stores, etc.) should be incorporated into new developments at site selection and masterplanning stage to minimize travel distances, enabling residents to make routine trips on foot or by bicycle, with convenient public transportation offering a realistic alternative to the car. No amount of policy or design measures will work well if the new development is located far from jobs and services their residents need.

Location

All of the sites studied are located close to a city center with a high concentration of job opportunities. GWL Terrein, Hammarby Sjöstad, Stellwerk 60, Västra Hamnen and Vauban are located within 3 km of city centers. Houten is 8 km from the city center of Utrecht, its "parent city." GMV, the only case study located within a megacity, is 5 km from the Canary Wharf financial district and around 9 km from the "City of London" employment zone (the "Square Mile").

National and regional planning frameworks can be used to prioritize sustainable locations for development, as a pre-requisite for reducing car use through policy and design measures, preferably on previously developed land within existing towns and cities. Peri-urban development at high densities in medium-size cities is the next best solution, provided that distances to centers of economic activity are small. It should be noted that the British "Eco-towns" program (not studied in this report) received much criticism for failing to ensure the shortlisted sites were within easy reach of jobs, owing to their small size and the criterion that they should be physically separated from existing settlements.

Density

Most of the sites studied are of sufficient size and density to sustain at least one supermarket, primary school and other vital services, all of which generate local employment, as well as frequent transit services. Notably the heavily car-reduced developments of GWL Terrein, Stellwerk 60 and Vauban have residential densities of around 100 units per hectare, this being made possible in part by building homes on land that would otherwise be used for parking.

Mixed Land Use

Providing everyday goods and services within walking distance of residences reduces the need to travel by car. Planning regulations and guidance can promote or mandate mixed land use as part of the masterplanning process, as opposed to purely residential "commuter dormitories" which build in a need for daily travel by motorized modes. All of the sites studied either provide a mix of uses on-site or within easy walking distance of the development. Financial incentives can encourage businesses to locate in new developments, generating local job opportunities. For example, the City of Stockholm initially offered subsidies to encourage businesses to move into Hammarby Sjöstad.

Although most of the case study sites fall short of theoretical self-sustainability in terms of jobs per resident, efforts have been made to provide additional on-site jobs in all but the smallest site (Stellwerk 60). In addition, home working has been encouraged through the provision of "live-work" units and shared, serviced office space.

Lesson 5: Increase mobility by regulating parking and road use.

Car ownership and use can be reduced significantly through a reduction in parking supply, combined with the spatial and fiscal separation of the parking that is provided. Low speed limits, traffic calming and filtered permeability further decrease the speed and convenience of car travel. These factors encourage residents to consider whether car ownership is necessary to meet everyday mobility needs, and if so whether it is the most convenient mode for local trips. The provision of carsharing is a prerequisite for any strategy designed to reduce car ownership.

Parking

All but one of the sites studied limit parking, some to less than 0.5 spaces per residential unit. Houten is the exception, and consequently has one of the highest car ownership rates.

Parking is managed in these sites via techniques including limiting parking, pricing parking and separating residential units from car parking through spatial and/or economic decoupling.

Appropriate pricing for on-street and garage parking can also encourage visitors to come via sustainable modes. Generally it is recommended to charge more for on-street parking than for off-street parking to encourage long term parkers to park in garages, providing faster turnover of on-street spaces.

Spatially separating parking spaces from residential units makes car use less convenient in general, and particularly so for short trips that can easily be made by walking or bicycling. This is a key strategy for the car-free developments of GWL Terrein, Stellwerk 60 and Vauban, in which all parking is located on the side of the development, away from residences. As a result, most residents actually live closer to a public transit stop than the peripheral parking garage.

Economically decoupling parking spaces from residential units by requiring residents to purchase parking spaces separately from housing units, makes residents aware of the actual land value of parking spaces, and may discourage them from owning a car. Parking spaces must be purchased or rented in GMV, Stellwerk 60 and Vauban. These fees are unbundled from property/apartment rental prices, with upfront costs of up to 22,500 EUR per car, and an additional monthly service charge of around 70 EUR (more than the cost of a monthly transit pass) in the German case study sites. Legal frameworks for the effective enforcement of parking restrictions are likely to be required if the German "car-free declaration" model, in which an exemption from having to pay for parking is granted only for those without a car, is to be adopted elsewhere.

In most of the other sites studied, residents may park in the surrounding area by purchasing a residential parking permit. The price of residents' parking permits can be set to discourage vehicle ownership, and controlled parking zones or other measures are required to prevent car owners parking in adjacent areas.

Access Restrictions

Restricting car access is another strategy to deter car use. Most of the sites studied have at least part of the development that is car-free. GWL Terrein and Stellwerk 60 are entirely car-free: no cars are permitted on-site. These sites have avoided Vauban's problem of illegal parking in "parking-free" streets by making internal paths narrower and physically barring access to almost all motor vehicles. Deliveries in Stellwerk 60 are made using a variety of free-to-hire human-powered carts and trolleys. Through traffic is prevented in Vauban by providing access to motor vehicles at only one location, whereas pedestrians and cyclists may reach neighboring districts directly via several access points.

Push Measures in the Wider Area

Car use can also be discouraged through pricing and access restrictions in the wider area. Examples covered in the case studies include indirect driving routes in Houten, the exclusion of cars in Freiburg's historic city centre, the central London and Stockholm congestion charges and expensive, limited parking in London and Amsterdam (5 EUR per hour in central Amsterdam). Common to all these policies is a reduction in the convenience of the automobile, whether this is in terms of time, trip costs or the availability of parking.

Lesson 6: Educate and inspire.

Ongoing marketing and travel awareness campaigns complement the provision of NMT and transit infrastructure and services, by promoting sustainable travel behavior in the long-term, especially where car ownership has not been reduced significantly. Sihlcity and the city transit operator joined forces to promote the new tram and bus services through posters in/on vehicles and at stops, as well as on the transit agency and developer websites.

Customized mobility advice is provided in Malmö, reinforced through incentives such as free bicycle use and discounted carsharing membership, and residents of the first parking-free block to be built in Vauban were given free annual transit passes and rail discount cards upon moving in. Such "smart measures" are particularly effective if initiated when residents move into a new district, as this is the period in which people are receptive to change. It is much harder to change travel behavior once residents have developed a routine of habitual car use.

Lesson 7: These developments work best in places where the larger policy and transportation context can support them.

Transportation policies at the city, regional and national levels play a key role in shaping daily travel behavior and residential location in the longer-term. Congestion charges, priced and limited parking at destinations, high fuel prices, access restrictions, filtered permeability and high quality transit all influence modal choice, reinforcing site-specific measures. All of the case study cities are served by national railroad systems, providing an alternative to the car for longer-distance journeys, thereby complementing measures to discourage car ownership and use in the local area. This is discussed more below.

MECHANISMS FOR THE DELIVERY OF POLICY AND DESIGN MEASURES

Role of the Planning System in Integrating and Financing

Planning regulations facilitate or impede sustainable transportation measures, such as NMT infrastructure, transit improvements and reductions in car parking standards, as our case studies have shown.

Two of the sites stand out for the use of formal mechanisms for the integration of more sustainable transportation policies into new developments: Planning Obligations (Section 106 Agreements) in England and accessibility planning criteria in Swiss City and Canton development plans. The former were introduced in the Town and County Planning Act of 1990, facilitating negotiations between local planning authorities and developers to offset the negative impacts of new development, such as the loss of green space and traffic generation. This system is used to obtain financial or in-kind contributions "directly related to the scale and nature of development" from developers. It is typically used to deliver access roads and other infrastructure such as parks, bicycle parking, community centers and even schools, as well as revenue support for new transit services and funding for smart measures such as personalized travel planning. Full planning permission is granted only upon the completion of these Section 106 negotiations.

The Zurich approach combines regional spatial planning criteria to select the most appropriate sites for development, together with car parking reduction factors based on the type of development, proximity to the city center and transit accessibility. Further conditions can be imposed on developers, namely requirements to enhance local transit and NMT infrastructure, provide funding for new transit services and charge for car parking. Additional incentives for developers to promote alternatives are provided by the Zurich access contingent model, capping the maximum number of car trips permitted: this has resulted in high parking costs at Sihlcity (based on the predicted elasticity of demand), and the prioritization of printed and website information for access by non-car means.

In contrast, minimum parking standards at the federal and regional levels thwarted attempts to eliminate parking from Vauban and Stellwerk 60, requiring the development of legal agreements to reassure planning authorities that parking would not be displaced to neighboring districts. This in turn has necessitated the creation of legal bodies to administer and, in theory, enforce the "car-free declarations" that forbid personal car ownership.

The Netherlands' Vine Program for sustainable new growth lays out some principles that align with sustainable transportation policies, such as promotion of mixed use development, accessibility of urban facilities by NMT or public transit, housing densities and conservation of green space. However, the program provides no regulations for pricing or limiting parking. As a result, Vine Locations such as Houten do not make an attempt to restrict parking.

Participatory Planning

Residents and potential residents can also play a large part in shaping car-free or car-reduced developments. GWL Terrein, Stellwerk 60 and Vauban all had citizen involvement from initial masterplan consultation through to the creation of lobby groups to influence the masterplanning process, and even voluntary car-free declarations, as was the case in GWL Terrein. This grassroots pressure is important to supporting (or sometimes pushing) planning authorities to reduce and decouple of parking. For example, the City of Freiburg does not officially support the principle of "parking-free" streets, preferring instead the Rieselfeld "carrots only" approach. However, experiences from GWL Terrein, Stellwerk 60 and Vauban demonstrate that sustained public support can influence the implementation of radical measures, such as car-free developments with reduced and decoupled parking.

Legal and Institutional Barriers

Minimum parking standards are the major legal barrier to the construction of further car-free developments, being directly responsible for the need to introduce complex legal agreements in the German case studies.

The lessons here are that car-reduced and car-free developments are more likely to be rolled out if:

1. legislation for the implementation of controlled/residents' parking zones is in place or introduced;
2. national and regional minimum parking standards are abolished, significantly reduced or made more flexible, taking into account local circumstances;
3. local authorities and developers perceive that demand for them exists, i.e. that they are vote-winners and as profitable as conventional development.

As mentioned above, local people are responsible for demonstrating the demand for car-free living.

RECOMMENDATIONS FOR FUTURE RESEARCH

Further detailed research to determine mode share and distance traveled, as well as longitudinal studies to quantify and understand the reasons for changes in mobility behavior in the long-run, are required to add to the evidence base presented here, strengthening the case for the application of the types of design and policy interventions documented in this report. Accurate assessments of potential CO_2 emissions savings will further justify the use of neighborhood and area-wide measures as an effective climate change mitigation avoid–shift strategy.

The efficacy of many of the measures described in this study are well understood. However, the acceptability of various forms of car-free development is an area of weakness, as this model is considered radical, may not enjoy political and institutional support, and a lack of case studies means a dearth of data to make the case for implementation elsewhere. It would also be instructive to compare turnover and property prices in car-free and neighboring conventional development, to assuage developers' and planners' fears over the unpopularity of car-free living.

Background levels of overall mobility and motorization, as well as NMT infrastructure and transit quality in the wider area, vary considerably in other regions. However, many of the most effective policies and lessons learned are transferable beyond the borders of western Europe: these include the selection of sustainable locations for development and the pricing of parking. Efforts in the years ahead should primarily be focused on the dissemination of these findings to politicians, planners and developers across the world.

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