# The role of settlement structures within the concept of sustainability – the Arnum West case study

Key words: urban planning, sustainability, parking space management, preference of slow modes

## Introduction

Around big urban agglomerations settlements evolve, which usually have been optimised for use of the personal car. They present such a low population density that there is not enough potential for public transport, grocery stores nearby and workplaces in trade and service. These settlements are in most cases "dormitory towns" from where people commute to work to big agglomerations in their private cars. The resulting problems especially in the municipal sector bring most townships to the verge of existence. On one hand expensive infrastructure – roads, supply and waste lines – have to be built for many scattered settlements, absent businesses cause missing tax revenues which on the other hand are necessary to build and maintain that infrastructure. The big urban agglomerations nearby choke on the never ending increase of motorised individual traffic, because the surrounding dormitory settlements have not enough potential for public transport. Furthermore it appears, that an increase in road infrastructure does not lead to the hoped relief of the existing roads, but advances the increase of dormitory settlements with all the well known problems.

Arnum is located in the southern periphery of Hannover, Germany. In the course of a proposed extension of the city railway from Hannover to Arnum, an architectural contest was undertaken for Arnum West.

The city enlargement area Arnum West is – strictly speaking – another dormitory settlement around Hannover. Even though it was attempted – with an architectural contest – to find new ideas for such a settlement, it cannot be denied that the contractor still banks on renowned solutions:

- The development for the private car must not be challenged.
- The extension of the light railway system from Hannover does not take place until the expansion of the road networks (by-pass road B3) is finished.
- A Park & Ride facility – which has contra-productive effects – is considered essential to solve the traffic problems.
- Not enough population densities to enable nearby groceries and public transport.

In this paper a follow up and a complement to our contribution to that competition will be presented.

First we take a look at different concepts on the development of settlements to get a setting for our work. Then the Arnum West case study is explained with theoretical background as well as the implementation. In the last part, three different scenarios are compared to find the settlement structure which is most sustainable.

## Theoretical concepts on urban development[1]

On the process of urban development a multitude of theoretical concepts exist. Therefore only a brief overview on selected concepts is given.

Klaassen, Bourdrez et al. (1981) and van den Berg (1989) distinguish four stages in the development of urban agglomerations where in stage one the urban region becomes more important through absolute gains of the core city in the process of urbanization. In the subsequent counter-process of suburbanization the hinterland obtains a greater share of development, resulting firstly in a relative, then in an absolute loss for the core city. The process culminates in a de-urbanization in which the city region as a whole loses importance in favour of areas outside the region. Finally, the core city regains population and economic activity through re-urbanization. Without giving detailed empirical evidence, they state that in the 1970s and 1980s most European cities were in phases of 'urbanization' and 'suburbanization' and the process is most advanced with big cities of regions which have experienced early industrialization.

Axhausen (2000) characterises the transport perspective of urban geography which prevailed in the 20th century. Urban visions in the first half of the 20th century isolated traffic as a separate function which lies – in terms of planning and decision making – in hand of transport planning and traffic engineering professions.

[1] Excerpt from the dissemination paper of the EU Project PeriUrban, 2006.

Consequently, they developed their own 'network logic' which has overpowered traditional urban logic. The main concerns of network logic, efficiency of operations, speed and safety, result in functionally differentiated transport networks which minimize the interaction between flows of traffic. The availability of funding and guidelines (such as the early US AASHO guidelines which later all other Western countries adapted) gave dominance to the profession of transport engineers. Based on the scientific American sprawl literature, he summarizes the factors determining the suburbanization with less place-dependent social networks and living arrangements:

- the oppressiveness of the place-based networks
- increased participation in higher education
- greater fluidity of many labour markets
- the car
- subsidised housing ownership

With the focus on the influence of transport, Newman (2001) combines these concepts by presenting three mobility-related development stages of cities.

Since almost 5 million years walking[2] and nearly two million years of human evolution running was fundamental for survival[3]. The need to walk became less evident as people gathered in larger settlements due to the introduction of agriculture. However, walking remained the dominant mode and traditional cities never exceeded a size of 5 to 8 kilometres in diameter. This distance corresponds roughly to a *one-hour* walking trip. It should be noted that the 'one-hour' trip time is a crucial assumption in this approach.

The industrialisation required work for thousands of additional people, more than the traditional city could possibly hold; the density and form of cities was not appropriate anymore. Infrastructure, such as water and wastes pipes and channel or railways for transporting people and goods, enabled the city development along these corridors. The result was a new urban pattern, the 'Transit City'. The new Transit City could now spread 20 to 30 km along its corridors while maintaining the *one hour* time horizon for mobility. The original pedestrian-oriented environments were now complemented functionally at the railway network nodes, creating a duplication of the walkable city.

The post 1940's economy in the industrialised world gave rise to the automobile as a mass form of movement. The car's popularity in "creating new freedom over space and time" stimulated a new momentum for urban change. In spite of the promised freedom over space and time, the automobile is also constrained by the 'one-hour' wide city which means an extension of 40 to 50 km in every direction. This resulted in the suburban developments, filling gradually the area between the transit corridors.

Newman adds an additional stage as the automobile city reaches its limits. He argues that the latent human need to walk and to maintain local social networks will finally result in a renaissance of 'walkable' urban structures.

Bronger (2004) describes urban development as the emergence of (i) administratively dependent settlements in the outskirts ('Vorort' in German), (ii) administratively independent suburbs ('Vorstadt' in German), the formation of twin cities, i.e. conurbation, and the development of self-contained cities outside the urban agglomeration.

In a social science-oriented definition, Bronger (2004) defines 'suburbanization' as a process which involves a conceptual, a spatial and a temporal dimension. The conceptual aspect describes suburbanization as part of the overall urban development process, including the participation of non-urban population within urban agglomerations in growing material, social and cultural wealth. Theoretically, suburbanization covers all aspect of life. Temporally and spatially there is a distinction between internal and external suburbanization expressing the spatial scope of the process. For the driving forces of suburbanisation, Bronger distinguishes - on a most basic level - incentives for migration into 'push' and 'pull' factors, i.e. negative and positive aspirations about living or business conditions in a certain area. He noted, however, that this distinction is not entirely selective, as both kinds of factors potentially presuppose each other. Some argue therefore that

[2] see http://www.agiweb.org/geotimes/sept05/feature_humanclimateevolution.html, viewed at April 12th, 2006

[3] see http://news.nationalgeographic.com/news/2004/11/1117_041117_running_humans.html, viewed at April 12th, 2006

the discussion on which regime is prevailing, makes only sense if detailed empirical survey are available (Bronger 2004).

Brake et al. (2001) conclude on recent suburbanization trends in Germany that suburbanization extends into more remote areas in the form of 'urban sprawl' which corresponds to external suburbanization as defined by Bronger (2004). Therefore it seems justified to qualitatively consider 'suburbanization' and 'urban sprawl' as synonyms, with differences concerning only the exact spatial definition.

The attempt to find an operational definition of suburbanization and urban sprawl which lends itself to empirical analysis reveals the ambiguous character of the qualitative concepts described above: suburbanization can be considered both, as a state and a process. It is just as well reasonable to state that there was urban sprawl, say, in Paris in 2001 as to conclude that urban sprawl occurred in the period 1991–2001 in Paris (Prud'homme and Nicot 2004).

Relating to the state interpretation, two common basic concepts can be observed: (i) The morphological interpretation is based on spatial proximity to the urban core. The major problem associated with this definition is to define a consistent spatial delimitation concept. (ii) The functional definition is most often based on commuting or shopping patterns and is frequently used for the definition of (functional) urban areas, e.g. by statistical offices (Prud'homme and Nicot 2004).

The process definition, i.e. what happens over time with a given urban area, can be interpreted as flattening of density gradients. As a practical indicator, Prud'homme and Nicot propose the 'median distance' which is the radius of a circle with one half of the population living inside and the other half living outside the circle. Changes of this 'median radius' are a sign of urban sprawl.

Hesse (2001) argues that decreasing spatial frictions result in more transport-intensive settlement structures. Simultaneously these structures lead to individual behavioural patterns which involve high levels of travel as a consequence of a personal 'trade off' between transport and spare time.

In a combined cross-sectional and longitudinal study about the effects of suburbanization which caught considerable attention in academics, Newman and Kenworthy (1989) study the interaction between urban form, transport and energy use in 32 cities from North America, Europe, Asia and Australia for the years 1960, 1970 and 1980. The results juxtapose Asian cities with high densities and low fuel consumption and American agglomerations with low densities and high fuel consumption, whereas European and Australian cities constitute intermediate cases. They argue that there seems to be an overall urban density of 30 to 40 people per hectare where a less auto-based kind of urban transport occurs thus reducing the transport energy consumption for cars significantly.

The most fundamental planning recommendation is to integrate transport and land-use policies, also in terms of institutional organisation (Knoflacher 1996; Wegener and Fürst 1999; Duany, Plater-Zyberk et al. 2000; Newman 2001). The aim of such integration is to implement an optimum spatial distribution of activities and a well balanced transport system linking these activities in an efficient and sustainable way. To achieve sustainability, such a combined land-use/transport system should reduce the need for motorised travel by implementing policies aiming at higher-density, mixed-use land uses. The desired result is that people find a greater number and variety of activities in small-scale urban structures. Such structures are expected to bring about a high number of personal encounters thus facilitating the maintenance and establishment of local social networks.

To show a way how these theories can be implemented, the Arnum west case study was developed.

## Arnum West case study

### *Objectives*

- independence of external energy usage for the accomplishment of daily requirements and needs
- efficient use of resources for the daily mobility, especially of public space and of non renewable energy
- a reduction of the daily covered distance through an intelligent use of space, and with it the reduction of traffic performance in all modes

## *Introduction to Arnum West*

Arnum is located in the southern periphery of Hannover, Germany.

It is surrounded by recreation areas which are partly protected and conserved.

Arnum to this date is a “dormitory town”. All the relevant workplaces are in Hannover, the commuting is done by private car.

At present Arnum consists of an accumulation of single occupancy houses, row houses and low storey buildings without a mentionable centre.

In the course of a proposed extension of the city railway from Hannover to Arnum, an architectural contest was undertaken for a building site of 35ha west of Arnum – Arnum West.

## *Basic principles and planning guidelines*

### Precedence for pedestrians and cyclists

Foot traffic is the oldest and most natural form of locomotion for humans.

The human being is a subjective being, meaning his perception is not objective but subjective. Something is perceived not as is, but the way it is received in a logarithmic scale.

Pedestrians are very sensible to outside influences. Therefore these have to be taken especially into consideration. Outside influences are for example distance, variety, “beauty”, possibilities for orientation, recreational spaces, the purpose of a trip et al.

The length of a trip may not exceed 150 – 170m. Therefore public transport stops should not be more than 300 – 350m apart to address as many residents as possible (see “Public transport“ for more detail).

To make the trips as attractive as possible – the human eye demands variety – smaller and bigger plazas are located in an interval of 150 – 170m throughout the whole settlement structure. Also important for an attractive foot lane network is a mesh network of 20 – 60m. This means that every 20 – 60m there has to exist a crossing possibility to the next street (see “Settlement structure“ for more detail).

Straight streets and lanes get quickly tiresome for the human eye. With a rolling arrangement of the roads, “there is behind every corner something new to discover”.

The drainage is placed in the middle of the road, which reduces the construction effort and has no separating effect (see “Settlement structure“ for more detail).

Distinctive buildings/plazas/situations ease the orientation within the settlement.

All the above is also true for cyclists.

There are a lot of reasons to encourage cycling. To mention only two: cycling is the most efficient way of locomotion and the landscape in Arnum is made for cycling – wide and open.

The most important thing to boost the share of cyclists is – beside cycle-friendly roads and infrastructure – the possibility to park the bicycle weatherproof and secure. To meet these needs, appropriate bicycle stands are placed in front of every publicly available building and public transport stop.

To make cycling possible all the year round, also all the roads have to be cleared of snow in the winter.

### Public transport

A sustainable settlement has a high percentage of short trips (of pedestrians and cyclists). The inevitable trips to the next bigger centre have to be made by public transport.

Therefore the public transport has to be pushed and the infrastructure for the motorized individual traffic must not be extended, better yet, it has to be reduced.

Arnum is, due to its proximity to Hannover, a “dormitory town”. This causes a lot of commuter traffic. On that account it is most important to extent the light railway system from Hannover (the ÜSTRA) down to Arnum. This is the fundamental condition, a foundation so to speak, for Arnum West.

The ÜSTRA will have three stops in Arnum West (the thick blue line in Figure 1).

After completion of the extension the existing bus lines will be adapted to feeder lines (all the other lines in Figure 1) unless they access other areas and have other destinations in Hemmingen and Hannover.

The existing settlement will be made accessible with city or interurban buses which are connected to the ÜSTRA.

**Figure 1: Public transport in Arnum**

## Motorised individual traffic

Motorised individual traffic – as is – forms a city-incompatible mode. The increase of travel speed destroys small scale structures within walking distance. Through the reinforced use of the car, settlement structures are created, which are only accessible with the car. That makes the residents even more dependent on external energy.

To antagonise such development and create a settlement worth living, which is inoffensive from an ecological view as well, Arnum West will abandon the own car in the close-up range of residences.

The expansion of Arnum is planned after the criteria of equidistance to enable free choice of means of transport: the parking garages are at the same distance or further away as the next public transport stops.

Two central parking garages for residents are provided at the two ÜSTRA stations at the edge of the settlement area. At the third stop in the middle of the settlement only extensive bicycle parking facilities are provided (see Figure 3).

Basically motorised individual traffic is not prohibited. But the fact that no public parking place is provided in the whole settlement area – only at the one-family houses parking is possible on private property – makes car driving not attractive.

This was meant as concession to the specification of the architectural contest. To make a settlement sustainable no parking at all has to be allowed.

Only the following motorised traffic is meant to take place:

- Emergencies (ambulance, police, fire department, …)
- Municipal maintenance and disposal
- Delivery vehicles, as well as
- Transport for sick and disabled people

## Road and lane network

The main modes of transport in Arnum West are pedestrians and cyclists. Both are defined as range- and energy efficient. Because the automobile is not the main means of transport, the road and lane network is organized accordingly (see Figure 2 for more detail).

Over a wide-meshed road network every building is accessible by car or truck. But only the access is provided, not the passage. A very close meshed complementary lane network allows pedestrians and cyclists to cut across the settlement in every direction on the shortest route. Short trips to public transport stops and to central facilities on the plaza are made possible. The settlement is extremely permeable which accommodates the pedestrians.

Trees provide a comfortable climate and appealing streetscape. Benches, ponds, facilities for playing and, not last but least, offset lanes for low speed driving make the roads suitable to linger and communicate. Children can play safely on these streets.

Due to this attractive design there never arises the urgent need to spend every free minute in the green countryside for recreation. This provides not only an ideal settlement option for young families with children but also for retired couples and singles.

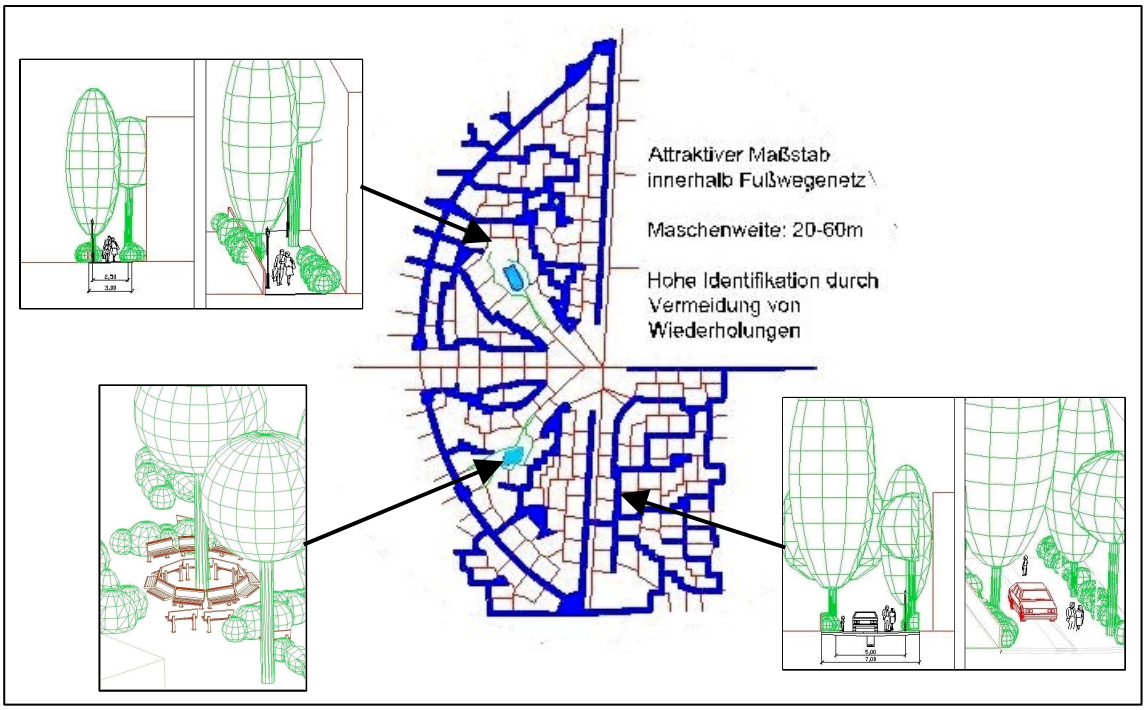


**Figure 2: Roda and lane network**

## Settlement structure

The main development of Arnum West takes place over the public transport stop on the Plaza. That way the crucial "purse" frequency for the located businesses and shops is ensured.

The height and density of the buildings decreases from each of the three ÜSTRA stops (Figure 3). This way the most part of the residents live in close proximity to the public transport stops. The buildings around the Plaza have the most height of the settlement to reinforce the central character and to secure the potential for trade and commerce. This is reinforced as mentioned above by the central ÜSTRA stop.

One recreational area lies to the West, lakes and leisure facilities to the east and south.

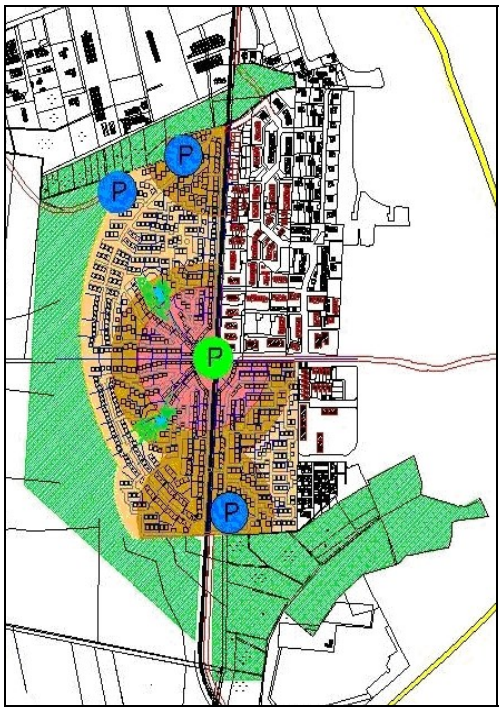


**Figure 3: Population density**

## The central Plaza

One characteristic of a “grown” settlement is for the most part a central plaza or main square with its distinct functions. On or around that plaza trade and commerce, gastronomy and culture are located. Around that the residents live.

With the extension west Arnum gets an identity giving centre. The central plaza is placed at the intersection of the ÜSTRA extension, which comes down from Hannover, with the East – West – axis coming from the existing Arnum going across the settlement to the near recreational area.

The central plaza provides not only space for the above mentioned distinct functions, but also enough room for weekly “farmer markets”, seasonal festivals and other cultural events.

Different views of the central Plaza are shown in Figure 4.

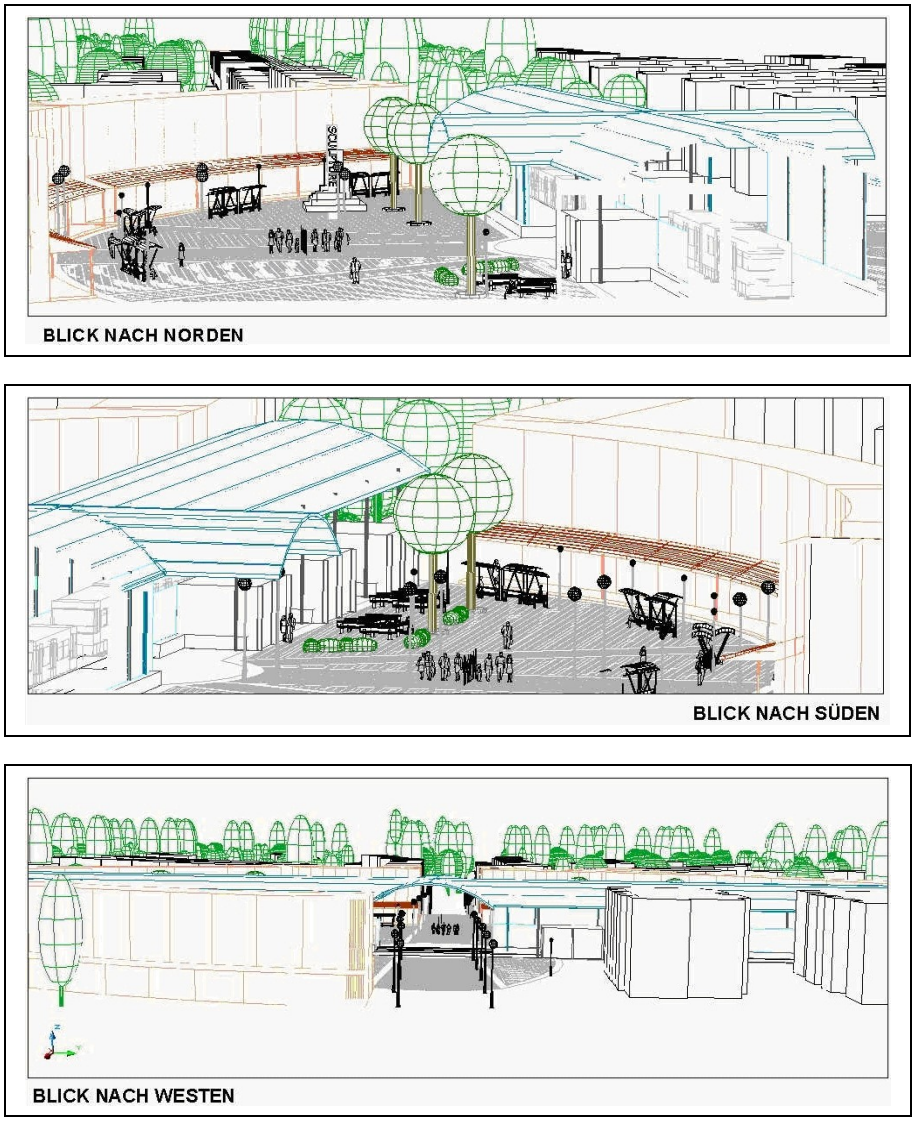


**Figure 4: Central plaza**

## The impact of settlement structure

To be able to calculate and compare the impacts of different settlement structures on the environment three scenarios were used:

- business as usual (BAU),
- business as usual with the impact of Arnum West (Arnum West) and
- a fictitious sustainable settlement as a whole – like Arnum West (Like West).

### *Indicators*

To find out if a settlement structure is sustainable or not indicators to compare different settlement structures were employed. According to "dictionary.com" an indicator is a variable used to forecast the value or change in the value of another variable.

From a plenitude of adequate indicators for this task such as

average daily covered distance, city structure, commuter flows, consumption of open space, density of public transport stops, energy consumption, level of motorisation, population density, share of modes, shopping trips, supply of workplaces, travel time, travel speed

the following were chosen, because they are independent from each other:

- consumption of open space
- energy consumption
- population and workplace density

### *Consumption of open space*

The total consumption of open space consists of the space claimed by the different modes of transport – walking, cycling, public transport and motorised individual traffic – and the space needed by each of the modes for parking (Table 1).

| | ***BAU*** | ***Arnum West*** | ***Like West*** | |
|---|---|---|---|---|
| ***Population*** | 7000 | 9490 | 9490 | |
| ***Total area*** | 210,4 | 263,9 | 263,9 | ha |
| ***Space for traffic*** | 45,1 | 49,1 | 34,2 | ha |
| ***Space for traffic / inhabitants*** | 64,4 | 51,8 | 34,2 | m²/inh |
| ***Space for traffic / Total area*** | 21,40% | 18,60% | 13,00% | |

**Table 1: Comparison of consumption of open space**

### *Densities*

Indicators to calculate the difference in settlement structures fairly easily are population and workplace density. Table 2 shows that the population density of "Arnum West", compared to "BAU", is 8% higher; the same applies to "Like West". At present workplaces are very rare in Arnum, our planning provides a workplace for every second citizen directly in the settlement, these are as many workplaces as required for all inhabitants of Arnum.

| | *BAU* | *Arnum West* | *Like West* | |
|---|---|---|---|---|
| ***Population*** | 7000 | 9490 | 9490 | |
| ***Workplaces*** | 0 | 1000 | 4745 | |
| ***Total area*** | 210,4 | 263,9 | 263,9 | ha |
| ***Population density*** | 33,3 | 36,0 | 36,0 | inh/ha |
| ***Workplace density*** | 0,0 | 3,8 | 18 | wp/ha |

**Table 2: Population and workplace density**

## *Energy consumption*

One of the most decisive indicators for appraising a settlement structure is energy consumption, especially the consumption of fossil fuels – and the output of carbon dioxide that goes with it. The energy consumption for locomotion of people and vehicles, for production and maintenance of the infrastructure, for production of vehicles and for heating the apartments was taken into account.

### Energy consumption of traffic

For the evaluation of mode share and daily covered distance the experience of Schnabel and Lohse (1997) was used.

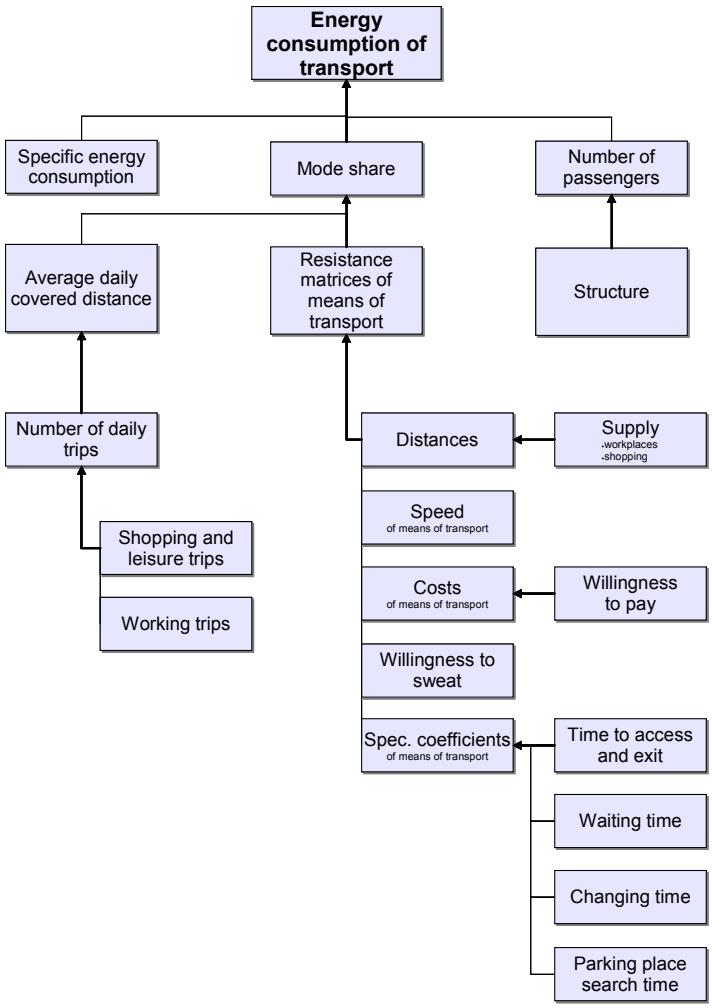


**Figure 5: Organization chart of energy consumption of transport**

For illustration of the calculation process see Figure 5. The number of average daily covered distances is independent of the structure; the main magnitude of influence for the mode share is the resistance to cover a distance. Trip-time was calculated as resistance between the origin-destination-relation.

### Mode Share

| % | BAU | Arnum West | Like West |
|---|---|---|---|
| ***Pedestrians*** | 8,2 | 9,7 | 14,2 |
| ***Cyclists*** | 6,2 | 7,4 | 10,8 |
| ***Public Transport*** | 16,6 | 21,0 | 36,3 |
| ***Motorised Individual Traffic*** | 69,1 | 61,9 | 38,8 |

**Table 3: Mode Share (in %)**

### Energy consumption of transport and living

For the evaluation of energy consumption of the passenger traffic volume the specific energy consumption of the particular mode and the covered distance was used beside the above calculated mode share. The energy demand for the manufacturing of the means of transport is composed of yearly covered kilometres per person, the residents, the total energy use for production and the durability. The energy needed for the production and maintenance of the infrastructure is calculated from the total public thoroughfare, the energy used for construction (Macoun 1999) and the average durability (Macoun 1999) (Table 4). Because in the development area only low energy houses are allowed the energy consumption is noticeably reduced[4].

| | BAU | Arnum West | Like West | |
|---|---|---|---|---|
| ***Traffic alone*** | 16842 | 11668 | 7099 | MJ/Pers . a |
| ***Means of transportation*** | 1249 | 1027 | 1027 | MJ/Pers . a |
| ***Heating the apartments*** | 31284 | 23635 | 2133 | MJ/Pers . a |
| ***Traffic infrastructure*** | 5913 | 2758 | 2758 | MJ/Pers . a |
| ***Total*** | 55288 | 39088 | 13017 | MJ/Pers . a |

**Table 4: Calculated energy consumption for traffic alone, for the production of the means of transport, for heating the apartments and for production and maintenance of the infrastructure**

As can be seen the scenario “Like West” wins in all categories, meaning it is most sustainable. That also shows, the way a settlement is organized and structured is crucial for its later use.

## Conclusion

Renowned solutions for city enlargement areas like Arnum West are still state of the art: expansion of road networks lead to settlements being optimised for use of the personal car which brings low densities about with all the well known problems.

In this paper a different way was pointed out.

The turning point is the renunciation of the current dogma to optimise settlement structures for car use. As a consequence the principle is to optimise the transport and settlement structure for pedestrians and cyclists.

If a settlement of the size of Arnum West has to be constructed on the green field, it has to be planned and build in such a way that the appending township benefits. But Arnum can only benefit if the development towards a “sleeping town” is brought to an end – if local workplaces develop, if the faceless sea of one and more family houses get features of architecture and urban planning, if the infrastructure is build for non-motorists and if different parts of the settlement get distinguishing marks.

[4] See www.gesis.org/.../w004.pdf, Fa. Gesis; www.heinzmann-gmbh.com/Deutsch/Energie.htm, Fa. Heinzmann, viewed at October 3rd, 2003

Exactly that is realised in Arnum West.

With the central plaza both the new as well as the existing settlement get a centre. Around the plaza – for pedestrians and cyclist optimal accessible – businesses can prosper. The compaction of the settlement around this centre combined with the existing settlement will have enough potential for those businesses.

The light railway system amidst the settlement ensures the connection to Hemmingen (municipal office, administration) and to Hannover (the next urban agglomeration, workplaces) in a sustainable way for the environment and the settlement structure. The renunciation of road infrastructure expansion maintains the potential for public transport.

The concept of a settlement aimed for pedestrian lanes with a constant succession of little plazas leading to the important facilities in an attractive and widely car-free environment is the foundation for a new – but still approved over thousands of years – settlement structure.

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