Urban Development for Carbon Neutral Mobility

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1. Introduction

Urban development of the last decades was guided by the thinking, that the ability to bridge long distances in transport of persons and goods is an indication of high development standards of a culture, increasing mobility. Hereby, a general definition of 'mobility' is to be found in the Glossary of the European Environment Agency[1]: *"The ability of groups or individuals to relocate or change jobs or to physically move from one place to another".*

However, in recent decades, mobility has become a value in itself. Travel distances have increased along with travel speeds and people generally now have to cover greater distances than they used to in order to fulfil the same needs as before: getting to school and to work, doing the shopping, visiting friends and family, etc. Most of this mobility is depending on cheap fossil fuel, so we call this kind of mobility the "carbon mobility". Now the basis of this development, cheap fossil energy, is questioned by two interrelated factors: the limitation of fossil resources becoming more evident (Schindler/Zittel, 2007) and climate change.

The possibilities of society (policy, economy, citizens) to react on this challenge can be aggregated in two main scenarios:

1. continuing business as usual (producing sprawl) with a little more emphasis on efficiency of technologies (e.g. the motors of cars) as well as on using alternative fuels (addition of "bio"-fuels) without questioning key systems for mobility
2. adapting urban development to reduce distances, ensuring accessibility by transport modes independent of fossil resources and at the same time creating a liveable environment - may be forced by circumstances or achieved by precautionary and voluntary attempts

As an assumption of this paper the possibility to sustain long-distance transport of persons and goods in post-carbon times according to scenario 1 will be considered very unlikely for several reasons:

First, many calculations of renewable energy supplies point out that carbon neutral societies can only work on a much lower level of energy consumption due to the following arguments:

- there are limitations in the potential availability of renewable energy sources
- the energy density of renewables is low compared to fossil energy, thus much land (and also much material in the case of photovoltaic, e.g.) is required to capture renewable energy

[1] http://glossary.eea.eu.int/EEAGlossary/M/mobility [accessed January 2005].

- supply of wind and solar energy fluctuates in a considerable range due to meteorological conditions, thus large backup and storage capacities are required
- the establishment of a renewable energy infrastructure is a huge investment, both in monetary and energy terms. It is questionable to what extent this investment is possible in a world with scarcer fossil energy supply

Second, many technical developments to increase the efficiency of transport means like cars still work on combustion processes that cause nitrogen oxides, further ozone and harm the ozone layer as well as support climate change.

Third, many bio-fuels [2] cause a lot of negative environmental effects (devastation of rain forests) as well as problems in food supply due to increasing prices.

Therefore, the aim of our paper is to discuss the usefulness, feasibility and sustainability of short distances according to scenario 2. To tackle these developments a shift in the definition of mobility is necessary. In this context, mobility is determined by the ability to reach a great number of destinations within the shortest possible time while covering the shortest possible distance. Short travel times are thus not a function of high travel speeds but mostly of short distances. Therefore, mobility should be defined as the number of destinations that can be reached within a certain time. The question, how far the distance is, depends on the transport reason: it varies from persons to goods and from the frequency of the destination. For instance, the workplace or daily supply shopping has to be reached five or six days a week, whereas, specialised healthcare or specialised shopping might have to be reached only several times per year.

Buildings are the products with the far largest material-input and the longest lifetime. Their location influences transport demand, their construction heating demand, both met at present to a large extent by fossil fuels. To ensure mobility in the post-carbon era requires, due to the long lifetime of the built structure, a strategy for both the urban pattern of new development and an appropriate transformation of the huge amount of existing structures.

We will examine options for post-carbon mobility as well as logistics and identify appropriate urban patterns taking into account the influence of settlement structures and population density on distances. Therefore, the aim of the paper is to look beyond transport issues, considering key factors of mobility requirements like the spatial distribution of functions and corresponding settlement structures on the examples of four approaches: Ecocity, Post Carbon Cities (including Transition Towns), Carfree Areas, Transit Oriented Development.

Therefore, the paper is structured as follows: In section 2 these four approaches are introduced. In Section 3 several groups of measures for interlinking urban development and carbon neutral mobility are derived from the concepts addressing aspects of transport of persons and transport of goods. Section 4 discusses benefits from the approaches and the measures. In section 5 we draw some conclusions.

[2] In the German language the term bio-fuels is misleading because it might be easily associated with organic production which is not true. Therefore, the term agrofuels (German: Agrotreibstoffe) would be more precise.

2. Urban development approaches for carbon neutral mobility

The presented approaches are dealing with different levels: Carfree Areas, and Transit Oriented Development are focusing on the transport sector, Post Carbon Cities on the whole energy sector (including transport and land use planning issues) while Ecocity aims at integrating the most important sectors of urban development. All these approaches describe primarily an intended situation (state), others like Transition Network focus on the process towards this situation.

2.1 Ecocity

This is an integrated approach towards an ecological urban environment.

The term „Ecocity" is used differently, for both *concepts* for transforming existing cities towards ecological objectives and *realised* ecological urban patterns – there is no standardised definition.

For the EU-project ECOCITY (Urban Development towards Appropriate Structures for Sustainable Transport) the following characteristics of an Ecocity were formulated: The idea of an ECOCITY is that it should be in balance with nature. This can be achieved through space-saving and energy-efficient settlement patterns, combined with transport patterns, material flows, water cycles and habitat structures that correspond to the overall objectives for sustainability.

An ECOCITY is composed of compact, pedestrian-oriented, mixed-use quarters or neighbourhoods, which are integrated into a polycentric urban system in public-transport-oriented locations and consist of solar-oriented buildings with high insulation standard. It is powered as far as possible from renewable energy sources and water is used efficiently (including a rainwater management). In combination with attractively designed public spaces, integrating green areas and objects of cultural heritage to create varied surroundings, an ECOCITY should be an attractive place to live and work. Such sustainable and liveable structures contribute to the health, safety and well-being of the inhabitants and their identification with the ECOCITY. (Gaffron/Huismans/Skala, 2005)

The main goal of the project was to develop settlement patterns for sustainable cities (ECOCITIES), emphasising the implications for an environmentally compatible transport system and implying higher quality of life and reduced consumption of resources.

To intensify the implementation of agreed principles and to demonstrate the feasibility and desirability of future urban living compatible with sustainability requirements, model settlements for specific sites in the European municipalities Bad Ischl (Austria), Barcelona (Spain), Györ (Hungary), Tampere (Finland), Trnava (Slovakia), Tübingen (Germany) and Umbertide (Italy) were designed.

One of the Ecocity-pioneers was Ecocity Builders, a non-profit organization dedicated to reshaping cities, towns and villages for long term health of human and natural systems. The goal is to build thriving neighbourhood centres based on human needs and "access by proximity", convenient to walking, bicycling and transit, while reversing automobile driven sprawl development.

An approach of Ecocity Builders to implement this goal is the Ecocity Zoning Map
- indicating potential areas for higher density and diversity as well as for removal of car-dependent development
- illustrating the transformation of a city towards centres linked by public transport and bicycles, with natural watercourses restored and auto dependence virtually eliminated (Register, 2002)

2.2 Post Carbon Cities

The main focus of "Post Carbon Cities"-initiatives lies on preparing for uncertainties caused by diminishing supply of fossil fuels (this phenomen has become popular under the notion of "peak oil") and climate change.
This focus of attention is one of the main differences compared to other initiatives focussing primarily on ecology and sustainability. The proposed measures and outcomes of decision processes might not differ that much – measures preparing for the time after the oil peak usually also have positive ecological impacts.
The key problem posed by both peak oil and global warming is ultimately one of uncertainty (Lerch, 2007): these phenomena are creating changes in economies and ecosystems at the global, regional and local levels that cannot be easily predicted. For local governments – responsible for managing local public services, planning for future land use and transportation, and protecting the community's economic and social health — this uncertainty creates a wide variety of risks and vulnerabilities. Measures need to be undertaken to strengthen local resilience with regard to these risks and vulnerabilities.
The main strategy to strengthen local resilience is *re-localization* which aims to increase community energy and food security, strengthen local economies, and improve environmental conditions, social equity and participation. "Post Carbon Cities"-initiatives are currently situated in North America (USA and Canada), countries with enormous oil dependency and thus high vulnerability in this respect.

According to (Lerch, 2007) and (Moerman, 2006) the following principles (to be integrated into local government's decision-making and planning processes to comprehensively address energy and climate uncertainty over the long term) can be identified. These principles are divided in two main categories: Thematic principles (*What* to do?), Process-oriented principles (*How* to implement the necessary measures?).

a) Thematic principles (*What* to do?)

1. Deal with transportation and land use:

- Fundamentally rethink your municipality's land use and transportation practices, from building and zoning codes to longrange planning.
- Make land use and transportation infrastructure decisions with 100-year timeframes.
- Protect farmland at all costs. (Local food production will become a crucial issue in the post oil peak era. Farmland is too precious for growing biodiesel.)
- Promote closer structures (the need for transportation should be avoided as far as possible)
- Every new development should pass the $500-a-barrel test. (-> can the development "survive" when oil costs $500 a barrel?)
- Perform triage and palliative care on areas that cannot or will not adapt. (-> many suburban areas will have to be abandoned)
- Promote electrical public transportation systems (if energy is available at all it will more and more in the form of electricity)

2. Tackle private energy consumption:

- Use the tools you already have to encourage serious energy conservation and efficiency in the private sector. (adaptation to peaking fossil energy sources will be mainly achieved by conservation, to a smaller degree by a shift to new energy sources and technologies)

3. *Relocalize the business sector*

- Engage the business community aggressively, challenging your local business leaders to reinvent the local economy for the post-carbon world. (The peaking and decline of fossil fuels means the occurrence of many structural discontinuities – e.g. the trend towards economic globalisation will reverse.)

b) Process-oriented principles (*How* to implement the necessary measures?)

1. Attack the problems piece-by-piece and from many angles:

- Meet your energy and climate uncertainty response goals with multiple, proven solutions, pursuing many different kinds of solutions at different scales.
- Enlist the entire community, setting clear community goals and spurring action from all sides to meet them.

2. Plan for fundamental changes… and make fundamental changes happen:

- Educate and involve your fellow elected officials, staff and community stakeholders about energy and climate uncertainty, challenge them to come up with serious solutions.
- Prepare both a long-range plan and an emergency plan. (->Be prepared for both gradual depletion and sudden shortages)

3. Build a sense of community:

- In short, do anything you can to get people talking with each other, forming relationships, and investing themselves in the larger community.

Transition Network

This network started in England with a similar approach, also tackling Peak Oil and Climate Change together. The mission, talking about Transition Cities, Transition Towns, Transition Villages, Transition Islands etc., is to inspire, encourage, network, support and train communities to establish a Transition Initiative in their locale. [3] People are involved in this process in sub groups for all aspects of life that are required by a community to sustain itself and thrive (e.g. food, waste, energy, education, youth, economics, transport, water, local government) to find the answers to the question: how are we going to significantly rebuild resilience (in response to peak oil) and drastically reduce carbon emissions (in response to climate change) ? The necessary actions identified in the sub groups are combined to form an Energy Descent Action Plan

Two crucial points of the idea are:
that we used immense amounts of creativity, ingenuity and adaptability on the way up the energy upslope, and that there's no reason for us not to do the same on the downslope
if we collectively plan and act early enough there's every likelihood that we can create a way of living that's significantly more connected, more vibrant and more in touch with our environment than the oil-addicted treadmill that we find ourselves on today.

Meanwhile more than 40 Transition Initiatives have been established in UK and some also outside in Ireland, Australia and New Zealand. [4]

[3] The term transition is also used in a contradictory correlation, for countries following the American example of development with focus on – economic – growth.
[4] Transition Network, http://transitiontowns.org/TransitionNetwork/TransitionNetwork, accessed 2008

2.3. Carfree Areas

This is a sectoral approach, tackling with the need for and presence of individual motorized transport in an area one of the key problems of a carbon neutral society, but as usual for transport issues strongly linked to urban planning.

The "Institut für Landes- und Stadtentwicklungsforschung des Landes Nordrhein-Westfalen" included definition and main objective of carfree housing in a short formulation:
Carfree Housing means a special offer for households not owning cars, with the intention to create benefits for them. (Dittrich/Klewe, 1996)

Essential characteristics of a carfree area are:

- that an appropriate design of urban pattern for pedestrians, cyclists and public transport ensures good accessibility of all important destinations (e.g. infrastructure facilities for mixed use) without the need for and presence of private cars
- that driving private cars within the area is not permitted and inhabitants should not own conventional cars for private use
- that the number of parking spaces is greatly reduced (less than 0,2 per dwelling e.g. for a car-sharing-service, which is often provided) and they are located at the edge of the area.

Elements of carfree urban patterns are:

- multi-storey residential (multiple dwelling) and commercial buildings
- pedestrian paths and areas, weather protection (arcades) to make walking comfortable
- public transport tracks, preferably rail; station/stop in the centre of the carfree area
- areas and parking facilities for bicycles and necessary motorised transport (e.g. for emergency, delivery of goods and services, waste disposal …)

Another term – "Carfree Environments" – is used by the World Carfree Network [5] and defined as *places that do not accommodate (permit the entry of) automobiles*. *An "environment" can be an entire village, town or city; a portion of a village, town or city; or a place such as a resort.* A possible step towards a carfree environment is an area with peripheral parking, keeping public space within the area carfree.

Only an area of sufficient size allows the advantages of carfree living (space for people, safety, lack of noise pollution, etc.) to be experienced. Most projects implemented until now are (too) small: blocks of houses or single multi-storied buildings.

Carfree Areas should be a step of the transition towards carfree cities to avoid future dependence on fossil fuels.

2.4. Transit Oriented Development

This sectoral approach, linking a transport mode and urban planning, is promoted in the USA by New Urbanism (http://www.cnu.org/) and the Center for Transit-Oriented Development (http://www.reconnectingamerica.org/html/TOD/).

[5] World Carfree Network (WCN) brings together organisations dedicated to promoting alternatives to car dependence and automobile-based planning at the international level and working to reduce the human impact on the natural environment while improving the quality of life for all; http://www.worldcarfree.net/

Transit Oriented Development, according to the TDM Encyclopedia (http://www.vtpi.org/tdm/tdm45.htm) of the Victoria Transport Policy Institute (Canada), *refers to residential and commercial centers designed to maximize access by public transport and non-motorised transportation, and with other features to encourage public transport ridership.*

It is essential to make the development of the transportation and the settlement system compatible by co-ordinating the extension of local transportation systems and the extension of a settlement.

The best conditions for an attractive and economically sustainable local public transportation system arise by choosing appropriate locations for future urban development. This implies that new buildings should be concentrated around public transport stops in the form of compact, mixed use, to a great extent autonomous urban quarters, located along planned development axes (see also point 3).

The public transport system should preferably be based on tram lines (light rail) using modern, reduced noise low-floor trams, thus an attractive mean of local transport, as opposed to a regular train which tends to separate the two sides and be noisier.

Rail oriented urban development can come in different forms:

- Extension (and filling in) of existing quarters around public transport stops already in use
- Development of new quarters around new stops of already existing lines
- Development (and filling in) of new quarters along settlement axes and construction of new lines

Such quarters may be referred to as “Tram-Cities”.

2.5. Summary

What all of these approaches have in common are high-quality walking environments (Pedestrian-City) with short distances. They are interrelated, Pedestrian-City and Tram-City (transit oriented development) being the basis for a Carfree-City with a minimal on-site automobile presence, resulting in minimised energy demand for transport.

The second large proportion of energy demand in a city, caused by buildings (especially for heating) is minimised by low-energy construction and solar architecture in a Solar-City.

Sustainable transport (Carfree-City) and sustainable buildings (Solar-City) are the key elements of an Ecocity (where also other resources, especially water, are used carefully) and make it also carbon neutral. Moreover the environment of an Ecocity improves the social conditions, promoting contacts.

Post Carbon Cities emphasise the concept of “re-localisation” in a broad sense, implying also to tackle the issues of re-localising food, energy supply and the economy as contribution to a Carbon Neutral Society.

Important for the acceptance of these approaches is, that their realisation does not detract from the well-being of the inhabitants, quite the reverse it increases their quality of life in a Liveable City (see benefits point 4).

In this paper the emphasis is on transportation and urban planning concepts.

The ideas and discussion of the last decades how to organise “attractive” and “sustainable“ settlements and which elements are important in the evolving concepts can be summarised in the following graph (Figure 2)

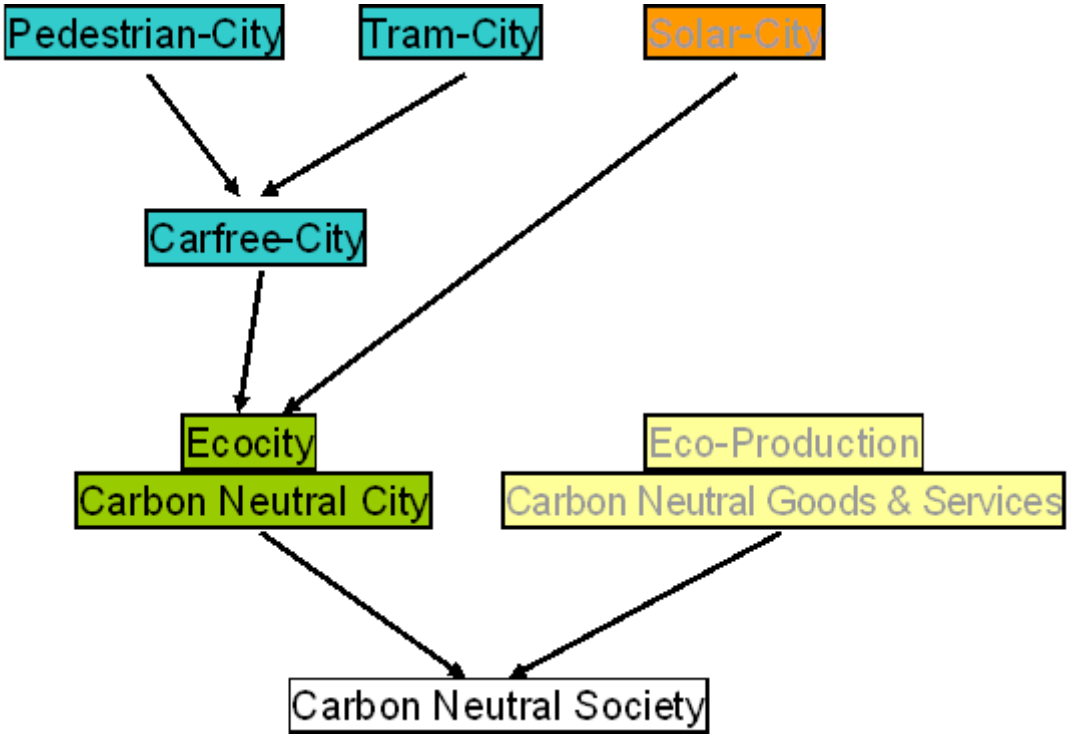


Figure 1: Elements of a Sustainable and Carbon Neutral City and Society

In the following brief overview some of the ideas considered and (at least partially) implemented in the approaches are summarised.

3. Urban development measures for carbon neutral mobility

3.1 Design of urban patterns

The location of new urban development is of great importance for the efficiency of a transport system. As stated above the urban pattern needs to be appropriate for pedestrians and public transport to make mobility carbon neutral.
The various distances to be covered via the modes walking, cycling and public transport result in areas of different size being influenced – while walking and cycling should determine the structure of small settlements (quarters of a city, villages, small towns), public transport is important for the location of these small settlements within a larger city or a region.

The question as to what makes a settlement **attractive for pedestrians** can be answered in a nut-shell:

A compact city of short distances, achieved by:

- An appropriate/qualified urban density given by attractive multi-storied buildings

- Mixed land use, characterised by a well balanced ratio of residential and business use. Location of necessary facilities, particularly for everyday needs, in a central area to create short distances from all parts of the quarter allowing combined trips (more detailed see point 3.3)

- Limitation of the total area for a quarter, roughly defined by a 300 m radius around the centre.

Attractive public space characterised by:

- A net of streets and squares with buildings showing varied facades as well as open space elements and architecture in a high aesthetic quality

- Limitation of automobile traffic to only absolutely indispensable trips within the quarter

- Pathways for prams, wheel-chairs and shopping trolleys free of obstacles

- Seamless weather protection for pedestrians (arcades, etc.), particularly in the central area.

Most important for making an urban pattern **appropriate for public transport** is the selection of suitable sites for new construction respectively for a new settlement to achieve:

- a linear polycentric development (with attractive destinations at both ends)

- a decentralised concentration in walking distance around stops (stations)

Such patterns are essential for the efficiency of public transport.

Additional important requirements are

- a balanced ratio of dwellings and working places in such neighbourhoods around stops to achieve a more even distribution of passengers in both directions

- concentrating parking lots at the edge of such neighbourhoods resulting mostly in longer distances from dwellings than the public transport stop

Main supra-regional roads with heavy car traffic are not suitable for the location of sites for future development because of the great negative impacts (noise, separation) and thus they are not suitable for a public transport route, where future development should be concentrated.

3.2 Decentralised Concentration as principle for location of new development

The above described measures for the location of new urban development are corresponding to the principle of decentralised concentration, which is a guiding principle of the Austrian spatial development concept (Österreichisches Raumentwicklungskonzept 2001):
It results in the objective for the agglomeration development to warrant a clear structure of new settlement areas in the urban ring instead of creating non-structured sprawl - important urban functions should be concentrated in well defined locations and the transportation infrastructure should be planned accordingly.
This is specified for the development of the settlement system driven by migration, which should not lead to growth of the core city but rather to a distribution to several decentralised settlements, well equipped with services and well connected by public transport. In rural areas this development should take place mainly in those central places of the communities which have good public transport connections to the superior centres. The regional aspects should be taken care of by co-operation between communities affected. Such development is seen as contribution to sustainability in local transportation of people.

Decentralised concentration means to find a balance of centralisation and decentralisation – to minimise the length of trips as many of the necessary facilities for different purposes (working, shopping, leisure time) as feasible should be decentralised and concentrated in quarters or neighbourhoods of sufficient size.

Following the principle of decentralised concentration also means to avoid the further implementation of elements of sprawl as large shopping-centres or detached single family houses

3.3 Location of facilities within settlements

The spatial distribution of all different facilities in the settlement area is determined by the best opportunities for supply with goods and for the accessibility by the users adjusted with the frequency of use (Lung, Mayerhofer, Skala, 1998).
Facilities with demand for transport of greater quantities of goods respectively heavy products (ecologically-compatible production enterprises) should be situated at the boundary of a settlement unit with access to a railway.
Facilities with demand for transport of goods as well as for good accessibility by the users (shops) should be situated in central sites along an axis, but also near to a main road, allowing short distances for goods distribution.
For the location of all other facilities passenger traffic is the determining factor - facilities, which only exist once in a settlement unit form the centre to guarantee best accessibility for all inhabitants.

3.4 Places of work in mixed use

The example of two small municipalities in Upper Austria shows the success of improving the settlement structure, especially the mix of uses by creating new places of work in a predominantly residential settlement. Their starting points were different:

In Hagenberg (in the agglomeration around Linz) the initiative is concentrated on one large project, creating a technology centre for software solutions, which started as a way of finding a useful purpose for a partly dilapidated castle.
Steinbach an der Steyr elaborated a sustainable development concept including many smaller projects (basing on the local strengths) after it was struggling with declining economy and population.

In both cases the increased number of places of work resulted in a significant increase of internal work trips, but only in Steinbach the commuter trips were reduced, while the number of commuters to Hagenberg increased (probably due to the specific expertise needed for the jobs).

Table 1: Places of work and commuting

	Hagenberg			Steinbach		
	1991 (1992)	2001	%	1991 (1992)	2001	%
Inhabitants	1917	2353	23	1812	1867	3
Employed	150	478	219	134	251	87
Places of work	37	81	119	36	56	56
Internal trips	86	244	184	74	185	150
Commuters out	709	845	19	588	462	-21
Commuters in	119	201	69	20	4	-80
Trips total	914	1290		714	756	
Trips/inhabitant	0,48	0,55		0,39	0,40	

Sources: Statistik Austria, Arbeitsstättenzählung 15. Mai 2001
Hagenberg - http://www.statistik.at/blickgem/az5/g40604.pdf,
Steinbach - http://www.statistik.at/blickgem/az5/g40920.pdf
Amt der Oö. Landesregierung, OÖ. VERKEHRSERHEBUNG 2001 -
http://www.ooe.gv.at/cps/rde/xchg/SID-3DCFCFC3-1E2AD5A1/ooe/hs.xsl/29857_DEU_HTML.htm

3.5 Re-localisation and regionalisation of the economy

Following the theories that the peaking of fossil fuels leads to structural breaks and discontinuities that reinforce local or regional production of consumer goods in contrast to the current globalised production mainly in low-social standard countries a re-localisation or regionalisation of economies is very likely necessary. This means the use and reliance on local or regional resources as well as short transport distances of resources, pre-manufactured goods and consumer goods. Furthermore, this likely means locally and regionally available jobs in sectors that were already transferred like the textile sector. As a precondition the establishment of local and regional consumer-dealer-producer relationships and networks has to be enforced.

4. Benefits of carbon neutral urban development

For the general public all approaches to a carbon neutral urban development (point 2) offer reduced air and noise pollution and a lower risk of injuries by traffic accidents. There is more space for people in an attractive, quiet, safe and wholesome environment (car-free streets and squares, a great variety of green areas), promoting a slower-paced, more relaxed, wholesome and thus more sustainable lifestyle. This allows more personal interaction with neighbours, resulting in the presence of more people in public areas, thus creating a greater sense of community and possibly lower crime rates.

Living in close proximity to various facilities in mixed-use neighbourhoods means shorter routes to public transport stops, to jobs, to school, for shopping, recreation, etc., thus saving time and energy. Varied green areas (an important factor for residents' satisfaction), integrated into compact settlements as well as the surroundings are easily accessible and solar architecture provides convenient temperatures and daylight for high indoor comfort. A balanced social mix and social services and facilities for all groups of residents foster their well-being.

These benefits can be experienced by all people, but they are of additional importance for some individual groups: carbon neutral urban patterns privilege **non-drivers** (who are disadvantaged by car-dependent transport and land use patterns), increasing their mobility and accessibility options. An internal pathway system free of private cars and barriers but with sufficient social control combined with short distances, creates an attractive and safe environment for **children** (to play safely outdoors and walk on their own) as well as for the mobility of **senior citizens** and the **handicapped**. [6]

[6] Sources:
CarFree City USA, Benefits, Berkeley, CA http://www.carfreecity.us/benefits.html
NewUrbanism.org, Benefits of new urbanism, Alexandria, VA, http://www.newurbanism.org/pages/416429/index.htm
Todd Litman 2005, Rail Transit In America, A Comprehensive Evaluation of Benefits, Victoria Transport Policy Institute, Victoria, BC, CANADA, http://www.vtpi.org/railben.pdf

5. Examples for different approaches

Among many good practice examples representing smaller or greater most sectoral steps towards a Carbon Neutral Society some were selected, being more considerable steps forward.

5.1 Ecocity Bad Ischl, Austria (concept)

Municipality Bad Ischl: about 14 000 inhabitants

Ecocity neighbourhood: planned for about 2000 inhabitants

The concept was developed within the EU-project ECOCITY.

The objective to design appropriate urban patterns for sustainable (carbon neutral) mobility was met for public transport by selecting the site for the ECOCITY model settlement to reinforce the development axis between the centre of Bad Ischl and the neighbouring municipalities Strobl and St. Wolfgang. As an alternative to urban sprawl a new compact sub-centre for the municipality was designed within a radius of 300 m around the stop of a planned public transport line in the centre.

The following solutions contribute to make the urban pattern appropriate for pedestrians:

- giving priority to attractive multi-storeyed residential and commercial buildings with appropriate height (maximum 4, minimum 2 storeys) to achieve an appropriate urban density and with
- location of facilities, necessary for a balanced mixed use in a central area to create short distances from all parts of the sub-centre and to allow easy trip chaining
- design of a liveable public space, providing a barrier-free network of pathways and squares by keeping car traffic in garages on the edge of the settlement
- conserving sensitive parts of the greenfield site (e.g. a small creek and its typical vegetation, green corridors, small forests) and integrating them into the settlement pattern
- concentrating small public services in “service points” within public space to make these services easily and quickly accessible.

Garages are located as noise protection along the main road passing by the edge of the site and keep private cars outside the area.

Locating facilities, which are connected with transport of goods (supermarket, business yard, logistics centre), near the access to the main road keeps vehicles for goods transport outside the area.

High insulation standards of the multi-storeyed buildings, most of them oriented to the South to promote the use of solar energy minimise heating demand.

The map of the neighbourhood shows an example for the location of the necessary facilities for different purposes feasible for its size (places of work, shops, etc.)

Facilities

1	Hotel
2	Gastronomy
3	Shopping Mall
4	Shops, Services
5	Kindergarten
6	Cultural Center
7	School
8	Business Yard
9	Logistic - Center
10	Cogeneration Plant

0 100 200

M= 1 : 7500

Location of mixed use facilities
(1 – 10)

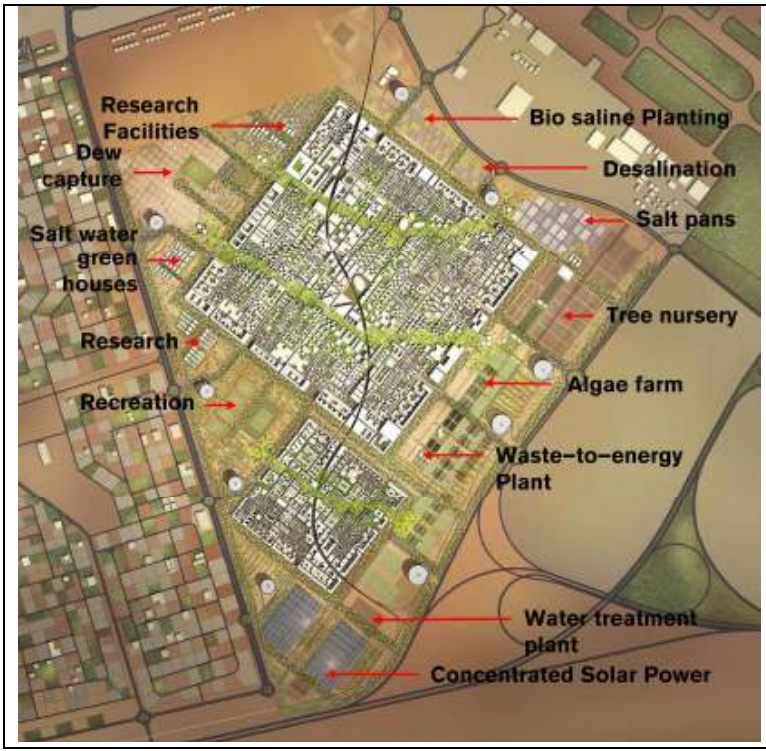
Figure 2:
Mixed use facilities, Ecocity Bad Ischl

5.2 Zero carbon city in Abu Dhabi, United Arab Emirates (concept in implementation)

The development of the Masdar zero carbon, zero waste city as part of the fast growing city Abu Dhabi is part of the Masdar Initiative, set up by the Government of Abu Dhabi to promote the development of innovative and sustainable energy technologies. Fundamental principles of the masterplan are: controlled growth instead of sprawl, low rise high density development and sustainable methods of transportation.

Rooted in a carbon neutral ambition, the Masdar area itself is car free (cars are parked at the perimeter). With a maximum distance of 150 m to the nearest transport link and amenities, the compact network of streets encourages walking and is complemented by an electric, driverless personalised rapid transport system within the area as well as a light rail link to the city centre. The shaded walkways and narrow streets will create a pedestrian-friendly environment in the context of Abu Dhabi's extreme climate. It also articulates the tightly planned, compact nature of traditional walled cities (Foster + Partners, 2007).

The surrounding land will contain wind and photovoltaic farms, concentrated solar power installation, solar powered desalination, a waste to energy plant, waste recycling, research fields and plantations, so that the city will be entirely self-sustaining.



Municipality Abu Dhabi: more than 500.000 inhabitants

Masdar development:

Population on site	30.665
Commuting workers	36.166
Site area:	550 hectare
Floor space:	6.0 Million m²

Density per Floor space:
2.1 m² Floor area / m² Ground area

Figure 3
Masterplan, landscape strategy
Source: Foster + Partners, London
www.fosterandpartners.com

5.3 Ecological Model Quarter Vauban in Freiburg, Southern Germany (implemented project, start 1998 – nearly completed 2007)

Vauban is an acknowledged example for large projects with an integrated approach, including ecological solutions for most relevant sectors (mixed use structure, transport, energy, social aspects etc.) and especially for the participation process, which involved future inhabitants in the "Forum Vauban". [7]

[7] for more information see: http://www.vauban.de/info/abstract.html

This urban quarter proved to be very successful in avoiding car trips. Many families live carfree and a car-sharing service is available. Cars were used for only about 10 % of the trips, while the share of bicycles was more than 50 %.

Municipality: about 200.000 inhabitants

Vauban: about 5000 inhabitants in an area of about 42 ha

Figure 4

Aerial view of Vauban 2006
Source: City of Freiburg, http://www.freiburg.de/servlet/PB/show/1169077/Vauban%20Luftbild%202006.jpg

5.4 Carfree areas

The largest existing example of a carfree area is “GWL-terrein” in Amsterdam, Netherlands (completed 1998).

“GWL-terrein”, District of Westerpark

600 dwellings (rental, ownership) and several businesses in an area of about 6 ha

http://wwwistp.murdoch.edu.au/publications/projects/carfree/carfree.html#gwl%20terrein

http://www.gwl-terrein.nl/ (only Dutch)

Figure 5 Car-free Settlement GWL-terrein
Source:
http://www.gwl-terrein.nl/gWLTerrein/plattegrond/index.html

5.5 Transit oriented development in Linz, Austria (implemented)

The city extension necessary, accomplished on the Southern fringe of the city’s area in the form of a model project for the use of solar energy (“solarCity”), brought about also an extension of the tram network. Passing through Ebelsberg, an area dedicated for new construction, a new tram line was built to the solarCity. It merges with an existing line and runs in paralell to the terminus in the North of Linz. Ebelsberg and the solarCity are connected this way with the main train station, the city centre, the university as well as other sections of town. Running three tram lines in parallel in the core of the city makes short intervals of less than 5 minutes (between 8 a.m and 6 p.m.) possible.

Linz: about 200.000 inhabitants

solarCity Linz-Pichling

1300 dwellings on an area of about 60 hectare

(for details see: http://www.linz.at/english/solarcity/frameset.html

Figure 6

Aerial view
Source: Magistrat der Landeshauptstadt Linz

Another example for Transit oriented development was realised in the area around the main train station, which was turned into a hub for local transportation, a place where all the tram lines and most of the bus lines are connected with the regional as well as long distance train system. This location of maximum accessibility using means of public transportation was chosen for building the new seat of the provincial government, given its overall importance in the super-regional system. Most of the sections of the government now have their offices in this node.

6. Conclusions

It is likely that constraints of energy resources will limit the transport capacity for persons and goods. To adapt to the framework of a post-carbon society, a rethinking of settlement policies and spatial planning paradigms on all planning levels (international, national, regional and local) is a necessary precondition and shall include:

- fostering of decentralisation, mixed use, short distance supply, local and regional material and energy supply structures and economic cycles
- prevention of sprawl and long distance supply structures.

These goals would help to reduce the transport necessity of persons and goods so that the remaining transport demands could be satisfied in a more environment friendly and carbon neutral way. Furthermore, these strategies might also contribute to a higher quality of life.

Furthermore, re-localisation in all fields of supply with basic goods (especially food and energy) will be necessary to get towards a Carbon Neutral Society.

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