4. CLIMATE FRIENDLY URBAN STRUCTURE AND LAND USE

As covered in an earlier chapter, climate change is concentrated in the cities, not only in terms of its causes, but also in respect of its impacts and the problems which arise from it. The built-up parts of urbanised areas warm up more (due to their higher albedo value), particularly as the emission of greenhouse gases is higher due to the heavy traffic, to which the direct effect of the infrastructure, heating, transport and production – so-called thermal pollution - also contribute. The enclosed character of the settlements restricts air movement and the possibility of ventilation is also limited, further compounding the problem. Besides the temperature change, several other ecological conditions are also modified in built-up areas, for example the reduction of the air's moisture content and disruption of the water cycle. The more built-up a settlement is, the more this affects the micro-climate. This means that due to the higher number of residents in a city, the unfavourable impacts and dangers affect many more people's quality of life, and hence require increased attention. Over and above their contribution to global climate change, it is also important that at local level we understand and manage the factors resulting in the change of the micro- and mesoclimate; besides adaptation, reducing the modification of the local climate is also a relevant task for cities.

The spatial structure of cities - the location of the different functions, the spatial structure of the connections, the physical, spatial morphology and land-use patterns - is of significance in reducing the concentrated emissions that result in climate change, as well as adaptation to climate change. Naturally, the geographically determined and historically developed structure of the cities may not be restructured in the short-term; however, alongside concerns such as sustainability, efficiency and quality of life, climate protection may also play a significant role in local strategic policy on urban spatial structure, prioritising land-use development with clearly stated, wider goals.

4.1. STRUCTURE AND CLIMATE

A city’s spatial structure determines several aspects of the urban climate. From a climatic point of view a key factor of the urban energy balance is the perceptible and latent heat effected by the city’s layout, which depends on the situating of vegetation, on the proportion of paved surfaces, on the characteristics of the urban morphology and of the physical layout of the city, as well as on its horizontal and vertical division, the development of shading and on the natural ventilation capability of the streets. With the localisation of urban functions and the proper design of spatial networks, accessibility between two places can be improved and the city’s traffic needs can be significantly reduced; the latter is responsible for most harmful GHG emissions. The spatial development of residential areas, from both a quantitative and a qualitative perspective, and the shaping of residents’ and organisations’ typical traffic routes, are important issues of designing settlement’s structure. Temperature increase of the surface can be influenced by the careful choice of land-use and its spatial organisation, while the spatial structure and density of buildings determine the settlement’s ventilation potential.

General climate-modifying land-use arrangement principles are the following (based on Nagy I. 2008):

- temperature reduction by limiting paved surfaces (increase of water surfaces and surfaces covered by vegetation);
- limitation of irradiation by shading critical areas;
- increase of near-surface airflow in order to ventilate polluted air;
- establishment of air filter zones in order to reduce heavy pollution;
- attaining favourable micro- and mesoclimate, and thermoregulatory effects;
- colour of façade, its covering with green vegetation.

Through avoiding certain types of production or influencing their territorial separation, the concentration of pollution may be significantly reduced.

It follows that urban land use oriented structure (spatial) planning has a determining responsibility in the field of managing climate change at local level. Land-use zoning policies have a wide-ranging, long-term effect on sectoral policies to address climate change. Spatial planning affects the placement of the built environment and therefore the distances required for urban travel, the energy required to heat and cool buildings, and the vulnerability of the built environment. Urban master plans and land-use zoning policies determine the set of land-uses that are allowed in a particular zone – at the most basic level these include residential, commercial, industrial open space and mixed uses – and the degree to which land-uses are separated from one another. These decisions shape the built environment and determine long-term travel patterns, building placement, access to amenities and exposure to natural hazards. Land-use zoning policies impact transportation and GHG mitigation policies by determining the degree of segregation among land-uses and therefore energy required to travel between home, work, shopping and other activities. (OECD, 2010) The importance of urban structure planning, land-use planning is also increased by the fact that the other possible areas of intervention to be introduced in other chapters of this handbook – e.g. transport, infrastructure, architecture, etc. – are also influenced by the city structure, the spatial plans and land-use regulations determine their constraints and possibilities in certain locations.

It is important to emphasise that the urban structure planning should be based on the on the integrated strategic planning, which was already introduced in the third chapter. A good strategy based settlement-level masterplan defines territorial structure, which serves strategic objectives and, besides the direct ecological aspects, also takes into consideration the social needs and economic realities which differ from area to area.

Appropriate planning is not worth anything if its content cannot be realised and enforced. As well as regulation related to settlement-structuring, a wider and multi-level set of tools is needed for realising planning goals, to help influence the economic players and the residents – in partnership – in order to create the desired spatial structure. Some considerations on the tools of implementing the spatial plans are introduced in chapter 4.8.

We have to make clear that the creation of a sustainable urban structure which is also ideal from a climatic perspective is not one shot process, but a **constant effort to shape and controll the urban system**. Generally, these structures cannot be constructed but rather the existing settlement structure can be adapted and formed one step at a time, in order to get closer to the desired status. The level of success of the interventions depends on the degree of organisation, the local authorities' financial power, and the success of the partnerships created for the programme's realisation. Climatic considerations can be maximally enforced when constructing a new district and they may also be relatively widely applied during comprehensive urban rehabilitation. Normally there is opportunity only for smaller interventions, for example, through one or other development investment or while revising certain planning tools. However, in order for these small steps to lead to an even better structure, it is important that solid objectives and principles be identified that can be enforced during the actual decision making processes, and that these be instrumental in every decision. However, it is also essential that urban development be accompanied by a continuous monitoring process that takes into consideration climatic aspects and is integrated into decision-making processes. Beyond the regular urban environmental data collection, the transparency of these information and communication are essential aspects of climate friendly planning.

The climate-friendly urban structure has no unified European 'recipe'. The difference in climatic zones, geographic circumstances, the historical structure heritage of settlements, and even the different lifestyles of the various regions requires specific solutions. Within the scope of this chapter a few, in most cases legitimate, urban structure-forming considerations are introduced which may be successfully implemented in urban planning and development, and while developing solutions adapted to particular urban circumstances.

What is a good structure like?

If we want to find an answer to the question of what kind of factors determine whether an urban structure is climate-friendly or not, then we have to take into consideration the city's **developmental period**. Generally, literature defines four phases in long term urban development. The first phase is an explosion in the city's growth (quick *urbanisation phase*). It is followed by period, when the suburbs are growing, often the too-quickly expanding city 'swallowing up' the surrounding settlements, and in many cases it leads to the so-called *urban sprawl (suburbanisation phase).* The next phase in the development of the settlement structure is the so-called *dezurbanisation*, when urban-type development and services reach the distant, rural areas as well. Finally the *re-urbanisation* phase comes, when the population of the metropolitan core area starts to grow again. In reality these phases are not periods following each other, happening due to necessity, but dynamics working parallel to each other which form the urban structure with varying intensity. These processes may be restricted or stimulated with different measures but first and foremost have to be channelled in such a way that the effects shall be favourable in respect of the city's sustainability, or at least mitigate its negative consequences. When identifying local climate policy's objectives and measures we have to consider whether, at a given time, in a given city, the dominant dynamic is one of suburbanisation and sprawl, re-urbanisation or other.

From a climatic perspective, the suburbanisation phase - the expansion of urban construction - is theoretically the most damaging; however it is important to see that in certain cases and with proper preparation, from certain climatic perspectives it may assist the diffusion of critical urban concentration. Re-urbanisation - renewing the inner urban areas - is primarily positive from a sustainability perspective, although with improper implementation, urban rehabilitation may have disadvantageous climatic consequences, e.g. construction in wind corridors, increasing amount of traffic congestion, etc. However, this climatically desirable later period is not inevitable, and is only realised in small areas. If spontaneous, re-urbanisation will only be partially successful, therefore organised support and coordination is generally necessary. In theory, the process of dezurbanisation assists polycentric development and strengthens rural resilience. However, there is a danger that due, for example, to low real estate prices, this can result in the turning relatively large areas into urbanised areas with e.g. high density of mineralised surfaces.

Geographic location fundamentally determines what structural factors are favourable or unfavourable. As was introduced in Chapter 1 of this handbook, cities are faced with entirely different challenges in the different climatic zones. For example, in the mid and southern parts of the continent, urban heat islands have to be counteracted and climatically favourable residential areas have to be created, whereas in flood risk zones the instruments of flood defence and supplementary reservoir areas have to be provided for in the spatial structure. While in wetter Northern Europe rainwater has to be drained, and – in the name of sustainability – retained and collected, even possibly reused, the coastal and low lying cities have to take into consideration the rise in sea level when creating long term settlement structure. Besides these main types, every settlement has to be evaluated on its own, depending on the given place and within the given circumstances, to identify what qualifies as sustainable.

It is nevertheless possible to state **general aspects** for creating a climatically and sustainably ideal urban structure, which is acceptable to Europe, too. Generally the urban structure is climate-friendly if it can contribute to decrease in emissions and in a spatially selective way reduce unfavourable impacts and aid adaptation. 'The sustainable urban spatial use is characterised by diversity both vertically and horizontally. The sustainable settlement structure constitutes a pattern of urban functions and public transport that result in a low resource use (ecological footprint).' (Dr. Klára Hajnal).

Key issues:

– The proportion of different **land-uses** and their spatial pattern is also of determining significance. From a climatic point of view, the green areas, water surfaces and other non-developed open spaces generally represent a favourable land use, while the constructed, covered surfaces are primarily unfavourable.
– Developments resulting in the excessive use of land need to be avoided, and it is suggested that greater emphasis be put on the creation of **green area** networks, which separate different land-uses in the city, while maintaining their connectivity. This has significant positive effects on the urban climate, for example, the cooling effect of the green areas through evaporation, or by ensuring ventilation which improves urban air quality. We have to choose material with a lighter colour for their favourable albedo and higher reflective ability, and at the same time properly insulate.
– During urban planning the measureable, so called rate of **biological activity** needs to be increased or at least maintained. This is laid down in law in certain countries (e.g. in Hungary).
– Ensuring **spatial order** and increase the **level of planning** is essential from the point of burden on environment, of efficient and saving land-use, and even of the citizens' quality of life. It is necessary to separate the areas serving different functions; however these should not be too far from each other as, for example, the larger the distance between the home and the workplace, the more significant the impact through increased transport needs.
– Special attention needs to be paid to the location specific **sources of risk** or danger emerging along with climate change when shaping the urban structure and during construction work. We have to avoid construction and other intensive uses of areas at risk from extreme weather due to climate change – e.g. subsidence, landslides, vulnerable to flooding. It is a general rule that the deeper lying areas, inland areas prone to flooding and areas with subsidence may not be constructed on. However, these risk areas may become a valuable part of the green area system through e.g. forestation.
– Flooding is the most important effect of climate change in seaside cities and cities lying close to the rivers of Europe. Unique **water management** tasks need **integrated into urban planning** when reorganising the settlement structure, thus providing dams, support reservoirs, filling up the areas available or made available as part of the revitalisation programme, etc.
– Determining the ideal **urban density** of the population, technical infrastructure, workplaces and institutions is of key importance. From a climatic perspective, in general dual, partly controversial targets have to be followed. On the one hand the extensive spread of the quantitative urbanisation, the expansion of construction and spatial reorganisation has to be stopped; on the other hand, the damaging effects resulting from density, for example, heat islands and smog, have to be avoided. It is generally true that, if possible, 'space consuming', sprawling, very low density urbanisation has to be avoided, as well as the over-concentration that encourages unfavourable climatic effects. In order to understand this topic more deeply, in the following we will go through the different aspects of compactness, dividing and polycentricity.

General aspects of the creation of the climate-friendly city structure:

– reduction of travel needs, optimisation of travel connections,
– avoiding production activities causing air pollution, as well as their spatial optimisation,
– taking into consideration the environmental geographic conditions of the area,
– reducing the proportion of those types of land use resulting in higher warming,
– efficient and saving land-use,
– compact structure,
– dividing the urban territory,
– enforcing polycentric urban structure,
– ensuring cross-ventilation,

- reducing, stopping or optimising the encroachment of urban functions and construction (urbanisation of the neighbouring rural settlements, near-wild and agricultural areas),
- the energy and material cycle of the city (urban metabolism) increasingly located in the local - regional space,
- high biological activity rate and green network,
- dealing with extreme weather situations in the city structure (flood canalisation, support reservoirs, dams, etc.),
- favouring public transport and spatial optimisation of its networks.

4.2. COMPACT AND SEPARATED

Today, from a sustainability and efficiency perspective, the compact city model may be considered the most supported urban development paradigm. **Based on the model of the compact city structure** the aim is to optimally locate activities and development to avoid urban sprawl, to contain the development processes and urban expansion within a clearly defined area and clearly marked boundaries.

Between boundaries

City life is characterised by constantly changing functions. The population, economy, the needs of its inhabitants or the needs of the institutions change continuously. Thanks to this certain functions are overshadowed and devalued, while new needs search for mostly new – and not least, cheaper – locations to develop. A typical example of this is the construction of plazas which in many countries – including a near explosion in growth in the majority of the new market economies in Eastern-European countries – are located in the suburbs, often as green-field investments, because in the inner urban areas these would be more expensive and less accessible by private car, or because there is no real estate of a suitable size. A similar example is the restructuring of residential space, when the living quarters of the earlier, inner city areas are no longer sufficient due to an increase in the standard of living, changing demographics, or due to physical features such as the size of the flat, the degree of comfort, available sunshine, and internal height. As a consequence, due to the lack of properly planned interventions, the former residential areas become abandoned and later undervalued. Inner-city poverty will become concentrated here, while on the outskirts of the city or in the neighbouring settlements a new housing supply appears to meet modern needs.

What are the main arguments for the compact city?

On the one hand, in the case of higher urban density, public transport and public utility systems are generally more efficient and their energy demand is lower. A city remaining within its own boundaries does not erode the contiguous, biologically active areas. The variety of services and workplaces make the city a better place to live and reduces transport needs. However, this latter argument is not always true as many services used by residents are further away, or they find a better workplace in a different location, and therefore there is a huge movement of commuters between certain parts of the city (agglomeration) at least twice a day. Those opposing the compact city refer to alienation, the crime problem and the high concentration of factors damaging both the environment and quality of life, issues that are also problematic from a climate change point of view. (K. Szántó – J. Sarlós)
The higher energy consumption of urban transport clearly indicates the in negative environmental consequences of low urban density. (See next figure)

Policy objectives promoting compact urban development aim to control spontaneous urban growth and facilitate a change of functions in inner areas. This process calls for strong coordinating role of the public sphere with high level of planning and strong toolkit of interventions such as regulation and market intervention. For all these we need proper support from society hence it is vitally important that the citizens are also aware of the significance of these questions and their damaging effects. Local society will be more supportive if unequivocal and clear advantages are connected to any imposed restrictions. An example of this may be connecting public parks and open-air recreation spaces to compact, built-up areas, making sure that the urban area exempted from construction is accessible to everybody and is valued as a pleasant, near-natural area with a well-kept landscape. Likewise, within the confines of the compact city it is important to make the most of the residential areas' environmental possibilities, such as, for example, improving air and light quality. So, in the compact city model, development takes place separated from non-urban areas by more or less distinct borders but is necessarily accompanied by an increase in construction in city spaces and a growth in the density of functions.

Nowadays, quantitative urban development continues to go hand in hand with an increased demand for space, which typically still prevails even when the population is not increasing. If horizontal expansion is successfully restricted by strict zoning policies focusing on compact development, the cities' vertical expansion becomes necessary, such as an increase in the height of buildings and an increase in subsurface building. Besides forming the cityscape, **vertical expansion** also determines other factors influencing the climate of the city. Narrow streets bordered by high buildings may provide less optimal climatic conditions for the residents due to reduced ventilation and the constant shading effect, than wide streets bordered by apartments of differing heights. Research into psychology and buildings throws light on the damaging effect taller buildings have on humans. However, there is no doubt that should tall buildings be substituted for several smaller buildings, theoretically the possibility arises to exchange part of the built-up area for construction-free areas; thus from a global warming perspective it is possible to achieve a more favourable land-use that is in all respects preferable.

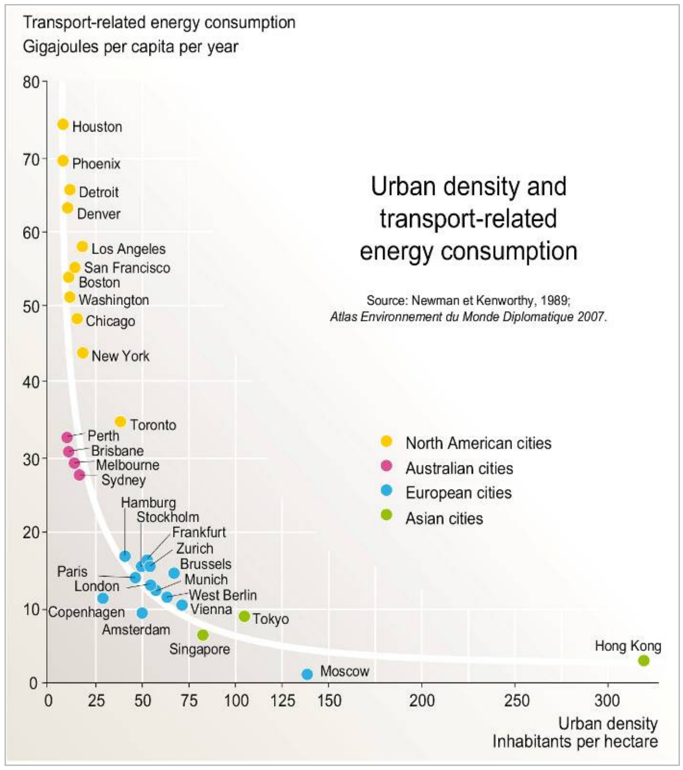


Figure 5: Urban density and transport-related energy consumption

Source and further information: Urban density and transport-related energy consumption. (2009). In UNEP/GRID-Arendal Maps and Graphics Library. Retrieved 11:06, March 31, 2011 from http://maps.grida.no/go/graphic/urban-density-and-transport-related-energy-consumption1.

Too high human-, development- and real estate density is increasingly problematic from a climatic perspective; hence striving for a compact city is not a solution in itself.

Compact city characteristics:

- high residential and employment densities,
- mixed land-use,
- fine grain of land-uses (proximity of varied uses and relatively small size of land parcels),
- increased social and economic interactions,
- contiguous development (some parcels or structures may be vacant or abandoned, or surface parking),
- contained urban development, demarcated by legible limits,
- efficient urban infrastructure, especially sewerage and water mains,
- multi-modal transportation,
- high degree of accessibility: local/regional,
- high level of street connectivity (internal/external), including sidewalks and bicycle lanes,
- high degree of impervious surface coverage,

- low proportion of open-space,
- unified regulation of land development planning, or closely co-ordinated supervision,
- sufficient government fiscal capacity to finance urban facilities and infrastructure.

Source: Neuman, M. (2005), 'The Compact City Fallacy', Journal of Planning Education and Research, Vol. 25, No. 1, Sage, London, pp. 11-26.

Dividing the city

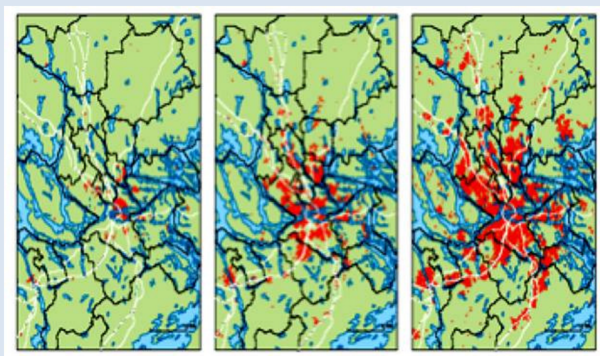
From the point of view of the city's climate, the **division or separation of the urban, highly urbanised and built-up areas** is extremely important. We need wind corridors that improve the city's climate, providing ventilation that, besides tackling warming, also plays a key role in dealing with air pollution and dampness. It is also important for the cities' ecological network to separate according to green areas.

Stockholm, 'the city building inwards'

The challenge of urban sprawl in the Swedish capital, Stockholm, was tackled by a method based on complex incentives. The following pictures show clearly the long-term process of urban sprawl which led to the principle of the 'city building towards the inside' being targeted in its development plan, 1999. (H. Bekele, 2005)

Hammarby Sjöstad, an early industrial quarter, was turned into an area with residential and commercial use as part of a brownfield investment. The development project demonstrates many excellent examples of environmentally-friendly solutions: recycling facilities were built, public transport was developed, and recreation areas were created. In the suburban zone the polycentric structure played a central role.

A polycentric settlement network cannot be achieved unless there is a possibility for the smaller settlements to raise the number of their residents, too. By connecting these settlements to the city centre (with high speed trains), those people migrating out of the city had more possibility to choose their homes, hence population density can even out. The increased efficiency of public transport can lead to a reduction in the need for individual transport, thus environmental pollution and time spent on transport is reduced.



1910 1944 1999

Contact:
Web: www.stockholm.se

From division point of view open lawn areas are also useful, as, should the daily temperature be high, they are able to cool down at night. Similarly, water surfaces are also important in that they have an especially favourable climatic effect. At the same time, **green and other non-built-up areas** of the city may fulfil the people's need for green areas and open spaces (parks, open air sports facilities, etc.) close to their homes. It improves the inner city residents' quality of life and raise the value of urban residential areas, an important factor in slowing down suburbanisation reinforcing reurbanisation, too.

Wind channels, aided by the constructed urban environment, have to be included in longer term planning, taking into consideration the prevailing wind direction (which may vary according to seasons), the geomorphology of the surrounding land (mountains, valleys), as well as the water surfaces and local land-use, after which they should be consistently taken into consideration during urban development and structuring decisions. When determining the divisions in the mass of the city, e.g. avenues, grassy parks, and also parking lots can be considered as open areas for the prevailing wind directions. Construction has to be restricted along these axes; moreover, any existing and unfavourable construction should be removed as part of urban rehabilitation. The system of ventilation can be organized for the naturally open spaces, e.g. the larger rivers. The possibility of ventilation is particularly important in those areas of the city where is risk of high concentration of emission, e.g. streets with high car traffic must be wide enough and the distribution of buildings along the street must ensure the ventilation.

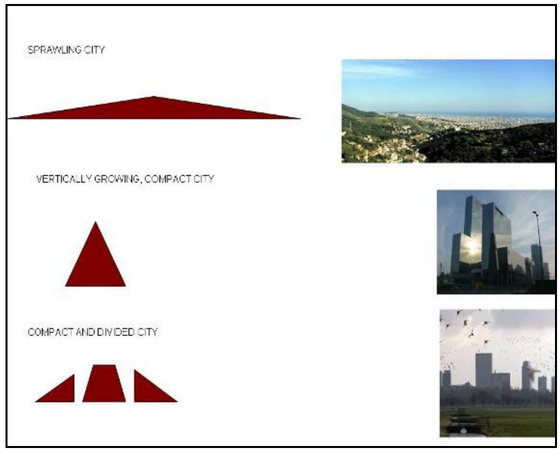


Figure 6: Examples for the structure of the city (Source: G. Salamin)

4.3. POLYCENTRIC PATTERN

Polycentric development and the polycentric city network has become an important element of European thought and is stated as a common objective in the European Spatial Development Perspectives (ESDP) and the European document entitled the Territorial Agenda of the European Union (2007).

The model of polycentrism – as opposed to territorially concentrated development - means the territorial spread of resources and growth dynamics, although within a particular given area it calls for a certain type of concentration and strengthening of centres that results in a more balanced spatial structure. This also deserves attention from an enviro-climatic perspective as it helps to find the balance between economic activities and urbanisation's environmental impact, without either of these becoming excessive and increasing climatic modification. Within a region this aids effective and prudent land-use and does not lead to urban sprawl or extremely heavy transportation needs. The advantage of many smaller sized centres as opposed to a few big centres is that there is a larger space available for renewable resources (geothermal, solar energy, rainwater collection, etc.) within the own region of the city.

At national **and regional level** polycentricity concentrates on the spatial distribution of the centres and emphasis is put on strengthening the weaker centres. This may be considered as beneficial from a climatic point of view as:

- energy consumption and the climatic load is lower due to smaller commuting distances;
- no 'hotspots' are created, and the 'urban load' is more evenly distributed;
- contiguous, built-up, 'grey' zones are smaller within the green space, hence it is easier to deal with pollution hotspots.

Sub-centres in the city region

When considering the climatic consequences of polycentricity at the level of the city region, we find many similarities to the national level. The city centre is becoming more and more congested; it imposes such a heavy burden on its environment, including the climate, that its negative impacts have become largely uncontrollable. However, if this can be divided by green areas within an urban region, and can be separated into multiple centres contamination stays at a manageable level. If workplaces can be created in the city region's smaller settlements and services can also be provided in the localities, this reduces the need to commute and the corresponding energy use.

The polycentric city

The circumstances which negatively affect the urban climate are increasingly prevalent in cities with a single centre. This can be attributed to several factors: for as long as the density is higher in the centre, the pollution caused by commuter traffic is concentrated; the green spaces and non-built-up areas which support ventilation are widespread and lie far from the settlement's core, hence are not able to compensate for the damage caused by air contamination, noise, etc. Should a settlement have multiple centres (and these are functionally balanced), then it is possible to spread these loads among them, thus the unfavourable effects – also from climatic aspect – can be more easily balanced.

In a well-functioning polycentric city the need for travel is reduced, as the sub-centres are able to ensure a higher level of services and number of workplaces. Cities with multiple centres, where those functions serving basic needs (e.g. food shops, etc.) are within walking or cycling distance, have a more evenly distributed and lower environmental impact and provide residents with better living conditions than a one-centred city. The advantage of the polycentric urban structure is that by dividing the urban burdens it is easier to counterbalance different types of pollution, so the extremities of the urban climate may also be treated more effectively. For example, as mentioned, the reduced demand for transport obviously leads to lower traffic-related emissions. Cities like this may also be better from a quality of life perspective, as the environmental and social conflicts rooted in urban density, as well as the extremely high costs these incur, are less prevalent. At the same time, many of the 'liveability' advantages of middle and smaller cities can be found here.

It is possible to support the establishment a polycentric city by using different tools at the same time. **Transport** systems have to be created in a way that improves the accessibility of the sub-centres; special attention needs paid to strengthening public transport, including rail-based solutions. At the same time, the pedestrian and cycle routes to the centre have to be created for the surrounding areas, whether these already exist or are just planned. It is also necessary to create transversal connections between the urban sub-centres, so they can communicate while avoiding the traditional centres.

It is necessary to set up central functions by, on the one hand, establishing or expanding already existing **state-municipal institutions** and, on the other hand, by **encouraging investors**. In the latter case it is important to introduce incentives such as creating an adequate supply of real estate, offering tax reductions on certain places for key functions, or highlighting the future role of the area through communication. Community spaces, public spaces, parks, or urban design elements and the location of more definite architectural 'signposts', all can play an important role in the creation of sub-centres. Naturally, all these shall be included in the land-use plan and the urban building regulations. In respect of demand for land to establish city centres, it is important to support brownfield investments and the functional change of already built-up areas, avoiding the conversion of those areas not yet built-up.

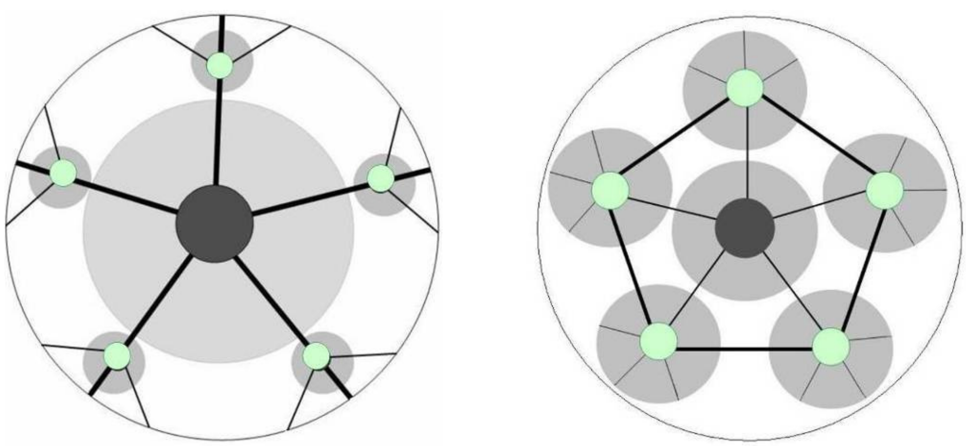


Figure 7: The theoretical sample of the traffic structure of a city having one centre and a polycentric city (Source: G. Salamin)

4.4. URBAN RURAL CO-OPERATION, HANDLING THE TERRITORIAL SPRAWL OF THE CITIES

As was introduced earlier, the tasks of the urban areas in connection with climate change may not end at the city border, since the bigger cities form a closely connected system with their wider region, thanks to their ever more intensive socio-economic and environmental relations.

The division of labour between those cities with a central role and the agglomeration and all the hinterland, which provides agricultural land and production, has been in existence since the beginning. Urban-rural relationship has changed with the different stages of urbanisation, which has resulted in challenges (e.g. urban sprawl) as well as opportunities. The recognition of the factors of sustainable development - the strengthening of urban and rural connections and their partial reinterpretation - offers strong potential for the creation of sustainable urban regions. The ecological functions of the closer and more distant areas and green spaces – important also from a climatic perspective - shall have more value for the cities. Chapter 4.6. presents in detail the role of the green areas around the cities and the possibilities of their development.

4.4.1. Food from the neighbourhood! Strengthening the trade co-operation within the region

Revitalising the role of the area surrounding cities as a supplier of traditional food and raw materials could potentially strengthen sustainability and at the same time strengthen the internal cohesion of urban regions. Should the distance a product travels from producer to consumer be shortened, then the carbon-dioxide emission of the concerned product may be significantly decreased. Furthermore, this relationship also benefits the local economy, helps ensure food safety, as well as the feeling of responsibility which citizens have for area’s values. Urban regions are those territorial units which are sufficiently complex to be self-sufficient in certain respects, have the ability to organise a market, and a critical mass in terms of purchasing power.

The urban sale of the neighbouring area’s agricultural products may be supported by several **means**:

- preference given to traditional markets in cities through both regulation and taxation;
- modifying the main touristic and community squares in the city to allow them to hold occasional markets;
- supporting intensive agricultural production in the peri-urban areas;
- preference given with administrative advantages or tax reductions to the region’s producers;
- local supporting opportunities for direct sales for farmers of the region;
- local and regional food branding, establishment of trademarks;
- awareness-raising among urban residents and popularisation of local products;
- encouraging co-operation between regional sellers and producers, supporting networks, and the creation of a quality assurance scheme.

Naturally, other further forms of co-operation between the city inhabitants and the neighbouring farmers may be developed, ranging from countryside tourism to co-operation in the fields of education and culture. However, it also has to be said that self-sufficiency (which, as mentioned earlier, is significant from an enviro-climatic perspective) in renewable energy systems (ground heat, solar energy, wind energy) and water supply can also be strengthened, should the city meet its needs in unity with its surroundings, and within the frame of the urban region.

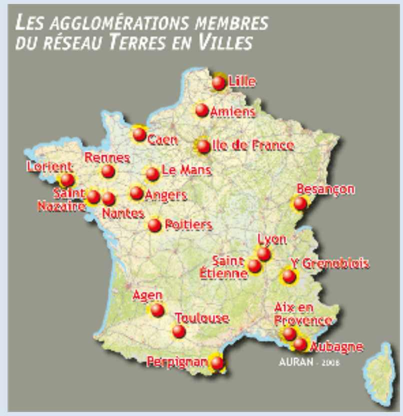
TERRES EN VILLES, a network in France supporting cultivation around the city

The Terres en Villes is a network made up of local organisations whose main target is to protect, strengthen and position cultivation close to the city. This initiative includes surrounding forests and the whole unused area around the city. Special attention is paid to the sustainability of the built-up areas and the urban regions.

At the moment 20 urban agglomerations are members of Terres en Villes. All cities are represented by intercity agglomeration councils, local agricultural chambers or similar bodies, in close co-operation with the urban development agencies and the French Agricultural Chamber.

The aims of the network of the Terres en Villes are
- to create political proposals in the field of agriculture and forestry in the city surroundings;
- to share experience;
- to exchange know-how amongst the members.

The network and its members work on four main areas
- to draft, cooperatively, the agricultural policies of urban regions, by mapping the present situation, the best practices and the creation of the Terres en Villes Charter;
- to protect the agricultural, forested and natural surrounding areas, and to make rational and reasonable use of the possibilities they offer: to further develop farming technology and the SCOT method (a scheme for agricultural, environmental, urban and county planning) through co-operation between the concerned bodies;
- to collect examples of good practice and regulations on the sale of local products in the city, and the creation of regional product brands and trademarks;
- to form European policies with respect to urban regional farming and the possibilities of uncultivated areas.



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4.4.2. The city spreads: the urban sprawl phenomenon and its consequences

Since cities began, they have, without exception, been subject to development, expansion and growth, which have gone hand in hand with continuous structural change. Due to the increased significance of industry and as a result of the relegation of certain urban functions further and further away from the centre, the expansion of the city can be seen to have been a centuries-long tendency. In the past half century the relocation of residents to the suburbs has been a determining factor, and this was accompanied by the movement of several other functions – e.g. retail concentrated into the shopping malls, or industrial activity.

During the already-mentioned suburbanisation phase of the urban development path, which follows the explosion in urban growth, the residents and certain economic activities (e.g. commercial functions) move out towards the edge of the city, even to the neighbouring smaller settlements. This sprawl outwards is usually spontaneous, happens through unco-ordinated urban sprawl, and as a consequence is accompanied by a loss of functions in the centre, excessive land-use and devaluation of the inner urban areas, which in turn bring multiple social, financial, economic and environmental tensions. In the countries in the Eastern half of the European Union this process emerged later, but in the last twenty years is characterised by an accelerated 'boom'; the earlier, central planning and the dominance of state property was followed by a new situation, characterised by the market economy, the liberalisation of the real estate market, the increase in private income for certain social groups, motorisation and the settlements' pursuit of their individual, short-term interests.

The local governments of **settlements situated on the outskirts** of cities in a suburbanisation phase, **often significantly extend those territories designated for urban development in the pursuit of short term advantages**; this lacks proper foresight and is contrary to the principles of long-term development and sustainability. This means there is a radical change in the use and structure of the land around the city, where the urban elements tend to become dominant. The urban effects turn the internal structure of the urban region upside down (city and its wider surroundings), even eliminating greenbelts or non-built-up areas, and results in the growth of a significant demand for travel by increasing the intensity of commuting. However, trends going against suburbanisation have also emerged. Urban sprawl has led to an increase in both the amount of time and money needed for travel, and their corresponding costs; these are disadvantages which the better quality of life promised by the suburbs is less able to compensate for. However, this spontaneous reurbanisation does not necessarily result in the restructuring of the urban suburban areas that would lead to the revitalisation of the eco-climatic and agricultural functions.

From the climate change perspective, the most important consequence of urban sprawl is the extremely high energy consumption (commuting, energy supply), the growth in built-up areas, which together extend the extent of unfavourable urban effects. This erodes the green areas around the city which are vitally important from a climatic point of view, while the creation and use of transport, the public utility network, and public services waste land and energy.

However, it has to be mentioned that those rare suburbs which have proper restrictions on the intensity of construction, have adequate central functions can have their own climatic advantages. The larger land areas which belong to the properties make it possible, for example, to utilise local, closed-system, ecological, infrastructure solutions, such as the use of rainwater, solar and geo-thermal energy, wastewater treatment, etc. A garden suburb created according to sustainability principles and less built-up, can have higher biodiversity than cropland, for example.

Key factors in our final judgement may include; restrictions on construction and environmental transformation; reduction of increased commuting needs (with working from home, local centres), the use of locally-contained eco-technologies such as solar energy, instead of large scale infrastructure, etc. As a result of global crisis, society has shown a greater need for the ecological services provided by the countryside (carbon sink, biological diversity, protection of drinking water resources, nature-friendly recreation, etc.) that has resulted in the spread of (land-use) restrictions that serve protection (unfortunately, in many cases, too late).

The consequences of urban sprawl from the point of view of sustainability and climate change:

- increased amount of private traffic,
- increased energy consumption,
- increasing size of areas which are unfavourable from a climatic perspective,
- increased infrastructural needs, increased costs of the infrastructure and services,
- decrease in green and non built-up areas around the cities,
- excessive land-use,
- social isolation, the organisation of public health supply for the elderly becomes much more difficult,
- it is even more difficult for everyone to find ideal transport solutions and make these attractive while ensuring quality,
- increase in time spent on travel, mainly for commuters,
- economic downturn in the traditional city centre,
- negative effects resulting in the decrease in the quality of the countryside and the natural environment,
- exploitation of ecological and cultural values,
- loss of good quality agricultural areas, soil erosion,
- destruction of habitats, fragmentation of the ecological systems and reduction of biodiversity,
- endangering the cultural landscapes and their fragmentation.

4.4.3. What is needed? A common system of values, responsibility and strong policies.

A basic principle of the handling suburbanisation and sprawl is that the whole affected urban region should be adequately co-ordinated and some kind of governance should be implemented, based on planning for the whole region and with the co-operation of the urban and rural participants. In order to achieve this there is a need to define common interests, the objectives of the participants, and the strategic definition of common goals; these need to be decided for the whole city region, according to multi-level governance as described in Chapter 2. It is important to have national level policies which encourage the treatment of urban-rural problems through sectoral policies, by legislation and by the motivation of the local-regional actors.

An urban sprawl policy oriented towards the sustainability of the urban region may be built on the following principles:

- commitment to common responsibility at the urban region level;
- long-term, conscientious, future-oriented thinking;
- partnership at urban regional level, common planning;
- acknowledging the need for a green, liveable, healthy, residential environment.

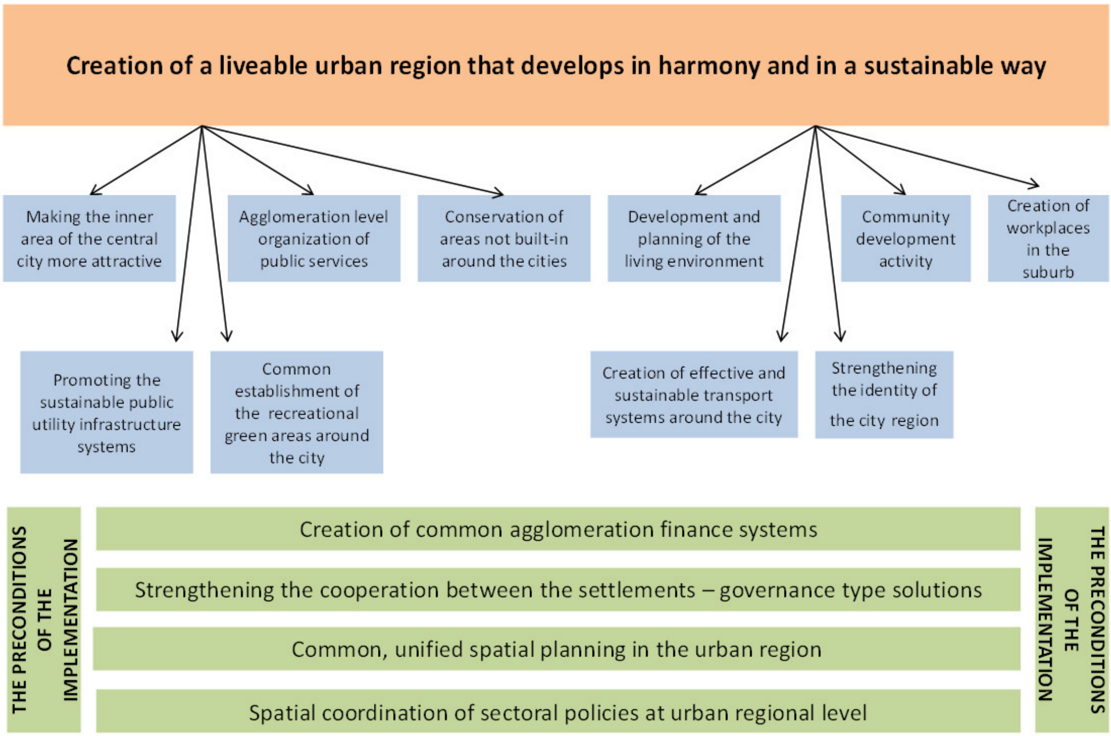


Figure 8: Possible strategies for managing urban sprawl, growth of the agglomeration (VÁTI, 2009)

4.4.4. Spatial planning at city region level: sustainability and climate related considerations with special reference to urban rural co-operation

One of the most important areas of co-operation between the settlements is systematic planning ensuring community coordination. Spatial or urban planning is usually the competence of local authorities or, in some cases, regional institutions. Although in certain cases legitimate governmental and planning institutions were created at the urban agglomeration level (e.g. Budapest agglomeration, Dutch city regions, metropolitan region in Germany from the middle of the nineties, etc.), the concerned administrative bodies and local governments can successfully plan and co-ordinate urban regions, basically by sharing their own planning competences and through voluntary co-operation. The themes that should be **commonly planned** can easily be different in the case of urban regions with different conditions, size or geographic characteristics. However we think that it is usful to **determine certain general considerations** for joint planning in city regions with special reference to urban rural co-operation and aspects of sustainable development and climate change. (See the boxes below)

General sustainability and climatic aspects for joint-planning of urban regions:

- creation of sustainable, not excessive land-use,
- avoiding intergrowth of built up surfaces between the settlements
- ensuring the continuity of the ecological network,
- reduction of transport needs through spatial organisation,
- principle of polycentricism - polycentric urban region and cooperating group of settlements,

– delineation of areas primarily suitable for forestation, determination of the areas not proper for intensive agriculture,
– rehabilitation of inner cities, increasing their attractiveness.

Possible thematic areas and aspects in respect of joint-planning for urban regions and agglomerations

Regional green space and recreational facilities

Aspects:

– The green belt; the green system around the city has to form a useful zone in the space surrounding the city. The task of planning is to indicate the main zones and sectors. All activities that reduce green areas or erode the landscape, natural and aesthetic value need to be avoided; furthermore, the necessary recreational infrastructure has to be developed. Securing the ecological network is important as is the increase of forested areas.
– In forest and lawn management surrounding the city, ecological, protective, climatic and recreational factors need to be given preference over economically productive considerations. (See more information on peri urban green areas in subchapter 4.6.4)

Economic zones and developments with regional significance

Aspects:

– Locating an optimal (space-saving, sustainable, easily-accessible) solution for the whole region – and hopefully for the investor - which provides larger added value at regional level in respect of economic activities, instead of promoting strong competition between neighbouring settlements.
– The investments (and their sites) shall be located so as to be easily accessible; they will have the least possible environmental (or landscape aesthetic) impact.
– Sharing the income from industry tax for joint-planning.
– Shared, effective organisation of the common employment market.
– Co-operation and synergies instead of competition: common representation when competing for sites – even as far as sharing local tax incomes.
– Reorienting transport networks and infrastructures so that the main places of employment shall be accessible from the residential areas, primarily by public transport.
– Protection of valuable natural and agricultural areas.
– Restriction of retail zones around the city (shopping centres), renewal and strengthening of the commercial function of the city centres.
– Increasing opportunities to work from home.

The co-ordinated, moderate enlargement of residential areas

Aspects:

– Adapting the transport networks, and public utility infrastructures to the residential areas.
– Enlargement along rail-based public transport axes; joint-development.
– Protection of sites of natural value and valuable agricultural areas.
– In order to protect the quality of the residential environment, securing green and open spaces that subdivide residential space; selection of sites promoting compact city development.
– Favouring the rehabilitation of the existing residential areas, reuse of abandoned and brownfield sites.

Strengthening the regional energy system and water management

Aspects:

– Increasing the proportion of local, renewable energy sources within the urban region, keeping closed cycle energy systems within the region.
– Local-regional public utility systems and waste water management.
– Strengthening different aspects of sustainability, for example use of renewable energy sources, supporting water conservation.

- Giving preference to decentralised energy management models, making use of the development and employment possibilities offered by local renewable energy sources which can contribute to the strengthening of the region's economic vitality and to the development of local society's awareness and self-sufficiency.

Protection of agricultural areas

Aspects:

- Protection of quality soils.
- Maintenance and reservation of strategic agricultural lands (in order to secure local food supply).
- Helping the creation of local commercial relations between the city and the surrounding agricultural areas.

Joint organisation and establishment of public services

Aspects:

- The spatial establishment of certain public services, optimalisation of their accessibility (with public and sustainable alternative transport) in close coordination with transportation.
- Urban regional institutional co-operation for the division of tasks and for financing.

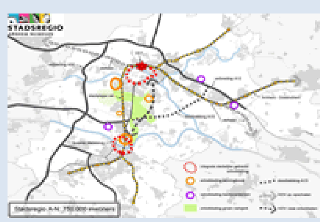
Planning of agglomeration transport systems

Aspects:

- Preference given to public transport networks. Priority of the rail based transport (tramway, suburban train).
- Bicycle and other alternative transport networks (including those internal network elements that connect larger units, including parts of the urban transport axes).
- Intermodality, development of the P+R, and B+R systems.
- Support for the establishment of the polycentric structure, strengthening transversal connections.
- The lines of the network have to connect the main functional areas (workplaces, living areas, recreational areas); however, areas where construction is not planned need to be respected for their ecological, agricultural or recreational functions.

Urban regions: A new level of governance in The Netherlands

In The Netherlands there was a central decision after the 2nd World War that they will not continue strengthening the big city centres but start a 'spread-type' of development across the whole country; this means that growth was directed towards the smaller cities. Thus they intend to create a more civilised version of the urbanisation of the last 50 years or more. There is a community consensus on this topic; for the past 50 years the compact city and compact development has been a national target in The Netherlands (this is understood as less than 35 person/hectare population density; moreover, developments should be oriented towards the existing railways and, furthermore, polycentricism as a stated objective means that further growth and development is oriented towards the smaller centres).



In order to strengthen a more balanced development the urban regional level was introduced as an experience next to the existing three administrative levels (the real administrative levels are the national, county and local levels), and seven urban regions were created. Although the role of the regional government (urban region) is limited, it has emerged as a successful partnership. The city region of Arnheim-Nijmegen, with 720.000 residents, is a good example of this.

The urban region contains 20 municipalities, and was created to enable co-operation in the following areas: economy, territorial planning, infrastructure, public transport and climate policy. A good example of consensus-based decision making is how the growth limits of the cities were indicated, taking both local and regional interests into consideration. Every municipality determined the boundaries of its own growth and the limit of the built-up area (new constructions may be determined within this without restrictions), and beyond these limits no development is allowed.

New constructions could be built on the condition that 50% is ’affordable’ construction, earmarked to be a rented house or self-owned, valued below 70.000 EUR. The urban region is successful due to enforcing simple and affordable (smart) growth.

4.5. ESTABLISHMENT OF CLIMATE-FRIENDLY URBAN PUBLIC SPACES

Urban public spaces include many kinds of areas, for example, street network, playgrounds, public squares, public parks, ‘wild’ areas, water surfaces.

Public spaces play an important role city life:
– Public spaces are the sites of community life.
– Public spaces render character to the city.
– Public spaces strengthen the city from an economic aspect.
– Public spaces protect the environment.
– Public spaces ensure sites for culture.

Figure 9: Shading of public spaces in Brussels (Photo: G. Salamin)

Considering climate in planning already existing and newly established public spaces
Redesigning and establishing public spaces has, on the one hand, a mitigation effect, if they include a sufficient area of green space, and energy conservation is also considered. Should city-dwellers really use the well-designed public spaces and there is an increasing focus on an environmentally-friendly lifestyle, the use of environmentally-friendly transport methods (e.g. cycling, walking) can be expected grow, which also reduces emissions.
However the different aspects of adaptation must also be taken into consideration (e.g. drainage of sudden heavy precipitation, adaptation to heat waves). When starting to plan new public spaces or transforming existing ones.

Key aspects:

– City-dwellers are expected to spend more time outdoors due to warmer summers and increasing temperatures. All there require the **shading** of public spaces. Trees and plants have an special role in ensuring shade in squares and streets and numerous architectural solutions can also be applied (e.g. installation of arcades). Naturally, architectural solutions also have to take enhancing the positive effects of winter sunshine into consideration). We can ensure appropriate **seating and resting places** for people in public spaces by installing more street-furniture.
– Climate change raises the importance of **water**. In public spaces and playgrounds the number of wells and lavatories has to be increased as well as fountains and larger water surfaces which cool and improve the microclimate. Water conservation solutions must be chosen for irrigation of trees and plants in public spaces, and every effort has to be made for collecting and utilising rainwater. Enhancing the **permeability** of covered surfaces (e.g. use of surfacing with small elements applying permeable jointing instead of asphalt, use of crushed stone) facilitates the drainage of precipitation. The importance of plants cannot be emphasised enough, as areas covered by plants greatly facilitate water drainage; furthermore they significantly improve the microclimate by evapo-transpiration and evaporation.
– Adequate **shelter** must be provided against storms, sudden rainfalls and wind blasts for people being outdoors: these functions are provided by trees as well as built elements such as roofs.
– Also, **material use** has to be adjusted to the changed weather conditions. Besides the total lifecycle of the used materials, the material and energy demand of their manufacturing and

disposal has to be taken into consideration. Materials used on surfaces must be selected to ensure minimal heat absorption capacity for the sake of reducing the urban heat island effect. In this respect white and light surfaces – except for walking surfaces – are more desirable, than grey and dark ones. When operating various facilities care must be taken to utilise energy conservation systems and renewable energy resources.

- The natural ventilation of cities and the drainage of precipitation are supported by ensuring an appropriate **public space network**. Suitable planning of streets and public spaces, as well as footpaths and bikeways, encourage the spread of more sustainable means of transport.
- Enabling **accessibility** to public spaces and green spaces further strengthens the possibility of achieving the desired social and environmental goals; it is important that these really are accessible for urban-dwellers – even within walking distance. A good example of this is holding local markets in urban squares.
- Special attention must be paid to safeguarding the historical heritage of public spaces, as well. In historic gardens (which in many cases have become public parks over the course of history) and in historic public spaces, previously dismantled fountains should be replaced, not only because of their aesthetic value, but because of their clear microclimatic effects; other water surfaces, which are an element of garden composition, and drinking wells should also be restored. Moreover, the negative effects of climate change have to be mitigated by landscape architectural tools. When restoring garden compositions, the original types of plants should be planted anew; however, the effects of climate change and especially those of the urban microclimate must not be left out and consideration has to be paid to this when selecting plant varieties.

4.6. INCREASE AND DEVELOPMENT OF GREEN SPACES

According to certain forecasts, growing urbanisation is going to result in an increase in urban infrastructure and the spread of residential areas in the coming decades, as a consequence of which green spaces will be reduced and their fragmentation will increase. At the same time, the improvement in the quality and quantity of urban green spaces has growing significance in Europe; as climate change affects cities, green space improves the liveability of the cities and decreases suburbanisation tendencies. Instead of the principle 'Move to the green' the principle 'Let's bring green to the city' has to be implemented.

When an urban authority elaborates its own green space policy, the external benefits of green spaces which are difficult to quantify in terms of money, also need to be considered. Those benefits are well demonstrated by the fact that in many cities – despite their higher prices – real estate designed with a high proportion of green space is the most sought after.

4.6.1. Significance of urban green space from an urban climate perspective

Urban green spaces are important from many perspectives - urban-ecological, social, recreational, urban structural, aesthetic and economic. Favourable effects on the local climate are also manifold:

- Cooling effect due to evapotranspiration, evaporation and shading, reduction of urban heat island effect.
- Modification of solar radiation conditions and heat budget through reflection and absorption of sunshine.
- Improvement in air quality due to oxygen emission and increase of moisture content ('natural air-conditioning'), binding and filtering of airborne particles and pollutants.
- Sequestration of carbon dioxide.
- Ventilation effect, windbreak.
- Urban green spaces help store rainwater.

These positive effects can only achieve their expected impact if the green spaces are healthy and of a suitable size. Not only the proportion of green space is significant, but also their size, form, number, distribution and connection within the territory of the city. In ideal cases green spaces create a harmonic network, a green pattern. The state of the plants' health, as well as the quality of the planted areas and how well maintained they are, fundamentally influence the realisation of the above favourable effects (URGE Project). In respect of climate change, green space elements play an essential dividing, separating and connecting role in urban structure.

Effects of climate change on urban green spaces

The changed climate has a great impact on green spaces and natural systems. In the case of urban green spaces, the following main effects can be observed:

- Warmer and drier summers increase the irrigation demand. Plants with shallow roots (e.g. lawn) are more vulnerable. In periods of drought or water shortage there are less possibilities for irrigation, thus retention of precipitation is of primary importance.
- Pests and pathogens characteristic of warmer climates are spreading further afield. As they are relatively unknown and non-endemic, greater damage is expected.
- In hot summers residents will presumably use urban green spaces more intensively; while this increases their importance, it simultaneously increases pressure on the space.
- As a consequence of the above, maintenance expenses for green spaces will increase; this can be counterbalanced by correct planning solutions, water conservation management, and choice of suitable plant varieties. Spaces should be established which are able to bear the pressure from increased use, thus sparing the most sensitive green spaces.

Questions concerning mitigation and adaptation of green spaces

Urban green spaces are primarily essential from an adaptation perspective; however, they play a role in mitigation, too. Any urban green space – regardless of form, size and type – supports the **adaptation** of cities to the effects of climate change. **Open spaces** within cities serve adaptation more efficiently than the greenbelt around the city. These areas ensure shade, facilitate the filtration of precipitation and improve the microclimate. A proportional increase in urban density ensures the provision of these areas and prevents a decrease in green spaces. Additionally, green spaces contribute to the settlements' flood protection. Adaptation measures have to pay special attention to avoiding an increase in greenhouse gas emissions (e.g. maintaining lawn requires energy input).

An increase in green spaces contributes to **mitigation**, as well; plants clean the air and absorb CO_2 from the atmosphere; their cooling effect reduces the demand for energy-intensive, active cooling such as air-conditioning appliances. Green spaces shape the inhabitants' attitudes, too; an increase in walking or cycling reduces the use of cars. The gradual spread of community gardens also decreases the demand for energy for transportation.

Paying attention to disadvantaged groups

Residents living in cities or districts which are socio-economically disadvantaged are generally more vulnerable to the effects of climate change. Usually less trees and green spaces can be found in these districts and as they are difficult to reach, their environmental impact – for example through transport – is higher. As a consequence of these factors air quality is generally poorer and fewer tools are available for adaptation to climate change. Therefore local governments must pay increased attention to the establishment of green spaces in these districts.

4.6.2. Various possibilities for urban greening

It is the responsibility of city authorities to encourage and increase the establishment of green spaces in the already existing urban fabric, as well as in newly built-up areas.

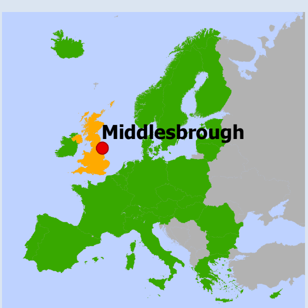
Regulation to encourage the establishment of green spaces

Adequate national, regional and local regulation and planning policies are of fundamental importance for the efficient planning, management and development of green spaces. Similarly, the implementation of these policies requires adequate legislative and regulatory tools. Examples include time-tested solutions such as the use of fines, imposed for misuse of public and green spaces, or the stipulation of a minimum ratio of green space, both common tools in planning regulations. Green space planning has to be harmonised with other planning processes (e.g. traffic, public utilities planning). In the course of elaborating green space policies and green space plans, priority must be given to involving stakeholders (e.g. residents, investors, entrepreneurs, non-profit organisations).

Proposals for greening the urban fabric

The following examples refer to the greening of existing urban areas and areas to be newly constructed; these refer to both public and privately-owned areas. Green spaces, amongst other things, play an important social role. They are the hub of community life, and by involving the local community, the residents can also play a role in the maintenance of the space. Green spaces fulfil multiple functions simultaneously; the same area can be useful in urban flood protection, while also being a remarkable community space.

- **Planting of avenues of trees and rows of plants** on public space along the roadsides, which are able to withstand the air pollution from traffic as well as absorb the pollution. Transport, utility and public space plans must ensure enough space for the roots of the vegetation. For example, building underground garages prevents trees being planted at a later date. During planning, the maintenance costs of green spaces also have to be considered.
- Protected urban areas with a high ecological potential are also valuable due to their CO_2 sink capacity; these must be given a greater level of protection. The level of protection given to valued areas must be reviewed, and the necessary protection given to valued natural areas and urban woodlands.
- **Planting up traffic spaces** while reducing paved surfaces (it needs mentioned that maintenance of the intensively grassed surfaces between tramlines demands a high energy input).
- **Local government leads by example**: expansion and renovation of green spaces in the gardens and courtyards of public institutions, schools, hospitals and in public cemeteries.
- Establishing **roof-gardens** is a welcome initiative; however, this should not result in the reduction of green spaces or an increase in construction density. Extensive roof-gardens are favoured over intensive **green-roofs**. Adequate planning and expertise is essential for establishing roof-gardens.
- Besides improving air quality, green façades provide, on the one hand, some protection against façade damage caused by heavy rainfall or hail and, on the other hand, they have a positive effect from a building energetics' perspective. Furthermore, they favourably influence the microclimate of streets which have little green space, especially in the summer months. More opportunities exist for greening **façades**. In this publication we recommend those methods which incur lower installation and maintenance costs, e.g. planting climbing plants.
- All over the world **urban farming and gardening** are gaining popularity. **Community gardens** are advantageous not only from an environmental point of view but they also play a role in strengthening community resilience. An outstanding initiative is the greening of apartment blocks by the creation of **courtyard gardens**.



Middlesbrough, urban farming

Middlesbrough is located on the South bank of the River Tees in the North-Yorkshire county in North-West England. The Middlesbrough Urban Gardening Project's aim is food production and urban farming in urban public spaces. The programme started in 2007 as part of the 'Designs of the time 2007' project, supported by Middlesbrough Council, non-governmental organisations and other partners. The partnership began in 2007 with funding of 8.8 million GBP. In 2007 it won 4.1 million GBP in funding from the Healthy Community Challenge Fund.

The project implemented the following activities at 264 sites: use and development of distribution sites, professional horticultural training for the community, urban catering, setting up industrial co-operatives dealing with local food, and setting up a food policy council. The programmes offered residents the opportunity to work together, grow plants, become acquainted with local food producers and gardeners. In the first year more than 2,500 people tried the urban produce and 8,000 participated in the programmes. More than 80 groups, schools and other organisations showed interest in the programme and participated in the campaign 'from the soil to plate'. With the permission of the local council, the Urban Farming Teams could plant extraordinary plants and seeds in a dedicated area in the city's main park. The project aims to make people aware of the significance of 'food miles' (the journey food takes from the production site to the consumer) and local products, furthermore to enable experimentation in efficient, multi-functional green spaces. The long term goal is for Middlesbrough to become self-sustaining, and the city, as well as other post-industrial settlements of Great-Britain, to participate in the creation of a sustainable future.

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Budapest, GANG-group

The Hungarian capital plays a central role in the country. In this metropolis, with its population of around 2,000,000, various environmental problems are accumulating; over-crowding, air pollution, lack of green space. In the 1950s-60s, apartment houses in the inner city had their courtyards paved, often to be used for car parking. Lack of green space is often a problem in these areas, and this has led to many positive initiatives for improving residents' quality of life.

GANG was founded by a group of friends in autumn, 2006. Dealing with creating and creatively transforming gardens, the group began its activity in the inner city of Budapest, where they successfully renovated three gardens and courtyards together with the houses' inhabitants. After these successful initiatives, more apartment houses in the inner city turned their courtyards into green courtyards.

Taking the inhabitants' ideas into consideration, the group elaborated garden-layout plans, consulting the stakeholders and organising residents' meetings. The gardens were created through the residents own efforts, digging and planting during weekends. Funding was obtained for plants and soil, and the projects were supported by other non-profit organisations.

GANG's aim is to create a city where community-life thrives and it is possible to lead a close-to-nature lifestyle. To achieve this they would turn more and more Budapest courtyards into gardens, creating a common open-air living room, and helping the houses' residents take an active part in forming their own living space.

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(Photo: Z. Molnár)

- As a result of climate change, **maintenance and watering costs** increase, drawing attention to the importance of water conservation. It is desirable to retain and use precipitation, and in the longer term, to utilise grey-water in irrigation. Reducing sealed surfaces and increasing the permeability of surfaces allows makes water available for vegetation.
- Local government can help residents' and local businesses' efforts to green the cities by providing **guides and financial support**.
- **Composting** the green waste that is produced by the green spaces considerably reduces the overall quantity of waste; this opportunity is not only possible in areas with detached houses and gardens.
- Local authorities must **communicate** with the population about their actions on climate change. The population must be involved in the planning and management of green spaces. At the beginning this may seem a nuisance to the local authorities but the costs incurred shall be recouped by the increased acceptance of the plans and reduced maintenance costs.

The following factors should be considered when establishing new green spaces

- Considering bio-diversity in plant variety, is important in cities, too. Multi-level, larger green spaces are more resistant, the natural processes perform better here. This is an advantage from the point of view of garden maintenance and also has economic benefits. Urban flora is characterised by the high proportion of non-native plants. As a general recommendation it can be said that from an environmental sustainability perspective, it is preferable to plant vegetation able to adapt to a changing environment, keeping in mind the potential impacts of climate change.
- From a climatic perspective larger foliage is favourable; different types of tree have a different pollutant-binding capacity.
- Maintenance costs of green spaces: maintenance of intensive lawn-surfaces (e.g. owing to fertilisation) has relatively high GHG-emissions, balances out the positive effects. Plants growing in containers and flowerbeds need lots of attention; their maintenance is expensive.
- While selecting varieties, predictable weather conditions and their climatic effect must be taken into consideration. Drought-hardy plants are less favourable from the aspect of adaptation, although they need less watering. For the sake of watering it is important to retain precipitation locally.
- The cooling effect of green spaces varies according to the structure of vegetation: the cooling effect of large, contiguous areas is stronger than smaller areas. Thicker green surfaces have a greater cooling effect.
- In order to decrease the intensity of the heat island phenomenon, it is important to pay attention to preserving or increasing the proportion of green cover when creating or adapting green spaces.

4.6.3. Establishment of adequate management for green spaces

Development and maintenance of urban green spaces requires adequate city management, and maintenance costs have to be taken into consideration during the planning period. Decision-makers often regard urban green spaces as an expensive urban area not bringing financial benefit. They do not consider the significance of the intrinsic value of green spaces, they do not calculate with the services of the offered ecosystem (e.g. climate regulation, maintenance of biodiversity, cultural, recreational and aesthetic services) and with its other social effects. It is generally accepted that multi-functionality contributes to the maintenance of a great number of urban areas. In the case of green spaces this could mean, for example, the organisation of events, concerts, and markets depending on the capacity of the area. Revenues received in such a way must be spent on the maintenance of green spaces.

4.6.4. Green areas surrounding the city

Due to the built-up nature of larger cities, residents are only able to satisfy the greater part of their need for green space in areas out of the city, which often don't actually belong to the city's administrative area. Among the natural areas around the cities, forests play a primary role. Peri-urban forests have an important mesoclimatic function – e.g. moderation of heat fluctuation, filtering of pollutants – while they also play a decisive role in satisfying the inhabitant's environmental and recreation needs; these are constantly increasing due to climate change and the growth in healthy, environmentally-sensitive lifestyles. This lifestyle requires opportunities for open-air and green space recreation, like walking, day-trips, cycling, other outdoor sports activities. At the same time, it is important for inhabitants to be able to satisfy these types of needs in an environment near to the city, i.e. without greater need for travelling.

That is why the comprehensive planning and management of peri-urban green spaces is of primary importance; both the urban-climatic (mitigation) needs of forest areas and the ecological-recreational needs of society (adaptation) need considered. In addition to the local authorities' role in coordinating and creating incentives, local farmers, entrepreneurs, and forestry authorities also have a significant role to play, and co-operation with them is a basic criterion for success.

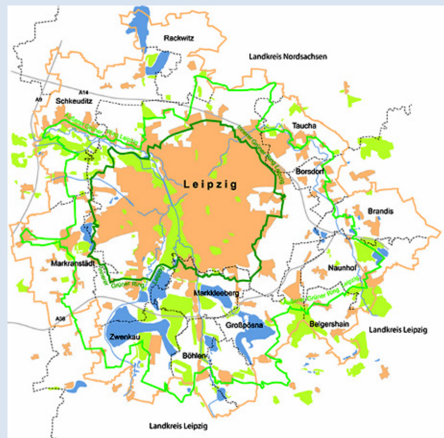
When developing or establishing peri-urban green spaces, forests and other non-built-up areas, the following factors need considered:

- **Common city region level strategy** for peri-urban green spaces; it is recommended to develop a determined strategy in respect of ecological networks and connecting recreational sites.
- Consideration of comprehensive **climate protection** factors in the course of planning peri-urban green spaces, and in co-operation between the city, neighbouring settlements and relevant authorities.
- In the 10 to 50 km zone around the city, **recreational-ecological functions** are to be given preference to production (lumbering) in forest management. This has to be guaranteed in the land-use plans.
- The **aesthetic quality of the landscapes** should be protected and develop in a systematic way.
- Plans regulating land-use must also be elaborated jointly, or at least in close coordination.
- Establishment of **open space recreational sites**: establishment of forest-fields with a recreational and training-demonstrational function (e.g. forest parks), creation of other open areas, nature-like sports areas, sites.
- **Polycentric** networks should be strengthened also for peri-urban green spaces. Besides helping the ecological networks, developing and strengthening green networks - perhaps even greenbelt - also helps ensure that recreational use has a more even spatial distribution, in closer proximity to residential areas.
- Peri-urban recreational sites have to be **accessible in a sustainable way**, possibly by rail-based community transportation or by cycle.
- Control of construction based on the joint city region strategy.
- Community access must be ensured in peri-urban green spaces – with consideration to the carrying capacity of the environment.

Leipzig, Green Ring

With its population of half a million and its territory of 297.6 square kilometres Leipzig is the largest city in the Saxon Federal State. It is located in the Eastern part of Germany, at the junction of the Rivers Pleisse, White Elster and Parthe. The city, founded in the middle-ages, has been a trade and cultural centre for centuries. Since the mid 1990s, in the framework of developing green spaces, a deep and diversified co-operation has developed in Leipzig. The Green Ring (Grüner Ring) Project, realised between 1996 and 2008, was implemented as a result of the co-operation between the settlements around the city, two counties and environmental organisations.

The Green Ring Project was implemented through 26 key projects in the framework of landscape maintenance, water development and tourism. Developments were carried out on the following areas, according to an environmentally-friendly technologies' road plan: renewable energy resources, noise pollution, environmental-awareness education, biotechnology, environmentally-aware construction industry. Within the framework of the project deserted, open-cast brown coal mines in the surroundings of Lepizig were recultivated and brought into the green spaces development programme; furthermore, the woodland within the area of the Greenbelt was increased. Within the framework of the project two regional bicycle routes were also built, the 65 km long inner green ring, leading along the boundary of Leipzig as well as the 160 km long external green ring, connecting the settlements around the city. Among other things, the development has led to an increase in the value of the environmental landscape and quality of life in the region of Leipzig.



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4.7. REHABILITATION OF BUILT-UP AREAS

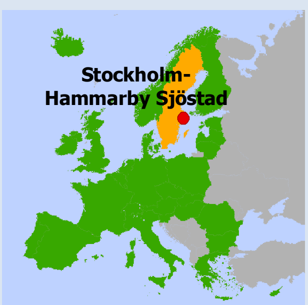
From a sustainable urban development and climate protection perspective it is of primary importance to strengthen the regeneration of areas with devaluing functions; to undertake new developments in already built-up areas, and not in those which are not built-up or have less intensity. In a great number of cities such already built-up, old districts can be found; the rehabilitation of these cannot be avoided due to the high proportion of obsolete, old buildings and the run-down condition of public areas. Out-of-use brownfield areas and extended rust belts cause further problems in the urban fabric; brownfield areas are unused or underused former industrial or military sites (such as barracks), which are in poor state, burdened with environmental pollution and cause a settlement structure problem. The well-thought out renovation of these areas is essential, taking into consideration environmental, social and economic aspects, which is useful from a climate protection perspective, too.

- Re-use and rehabilitation of these areas is always favourable as they do not require any further occupation of land. Their renewal reduces the development of peri-urban areas and urban sprawl, which generates much greater energy consumption and transport needs.
- These old districts are generally characterised by high density and diversity, therefore the mobility needs are lower here and residents use public transport and environmentally-friendly kinds of transport more frequently. All these are in harmony with the concepts described in the section on climate-friendly urban structure.

- The energetic characteristics of older buildings are generally inferior; therefore their renovation results in remarkable savings.
- The integrated regeneration of already developed areas contributes to the rejuvenation of traditional pedestrian precincts and to the prosperity of local commercial life; this is also better for the environment than shopping by car in the peri-urban big shopping centres and leisure-centres.
- Brownfield areas are generally polluted. The often costly remediation of these sites is absolutely necessary; from a climate protection perspective investments that prevent the pollution of groundwater also serve to protect increasingly scarce drinking water resources.

The **climate-friendly regeneration** of built-up areas implies the following activities:

- Establishment of attractive, secure, liveable and green districts, which are able to compete with new, peri-urban and greenfield buildings.
- Elaboration of programmes for the renovation of transition zones, regeneration of run-down districts, remediation of abandoned brownfield (industrial, transport) areas.
- Shaping local government housing management policy in respect of old districts, with the aim of letting unused private and municipal apartments, setting up and running a social housing system for deprived individuals.
- Municipal incentives and support for the implementation of energetic aspects in the course of regeneration.
- Municipal support for the local economy, as well as professional and financial assistance to local entrepreneurs and incentives for co-operation. As a result of this – for example – the transport kilometres and the GHG emissions will decrease.
- Realisation of the above activities requires moving substantial financial resources; they can usually be implemented over the space of many years, within a programme framework. Local government has a directing and leadership role; their task is to co-ordinate the various participants.



Hammarby Sjöstad – a unique environmental project in Stockholm

The basin of Lake Hammarby is in the Southern part of Stockholm, the capital of Sweden. Until 1990 it had been an industrial area with highly polluted soil. In 1990 the city's leadership drew the plan of a new subcentre around the lake. The strategy was to build an environmentally and architecturally modern, and eco- friendly city. The plan is that by 2015 11,000 residents and other buildings have to be constructed. 80% of the programme has already been realised, but once it gets finished over 11,000 people will have homes in Hammarby.

Hammarby has architectural solutions of the 21st century. Modern flats and service buildings cater all needs of the inhabitants. The district has many green surfaces, and parks where people can do sports or enjoy simply their spare time. Not just the parks, but the overall space is bigger as well in Hammarby than in other parts of Stockholm, here the space between houses and the street has to be at least 15 m^2. Local transport consists of several tram routes, and cycle paths. It is important that travelling happens in a climate-friendly way. Hammarby Sjöstad has integrated environmental solution along structural novelty. The district has its on system that consists of renewable and sustainable energy, recycling waste and water usage.

Goals related to the adaptation to the climate change:

- the entire heating supply shall be based on waste energy or renewable energy sources;
- district heating connection with exhaust air systems;
- solar cells and panels to ensure extra electricity and water

heating. 1 m^2 cell will produce 100 kWh/year energy;
- consumption of biogas; usage of Hammarby's waste water as fuel in vehicles.

Hammarby Sjöstad can be an excellent example for cities, which want to create a modern and eco-friendly district of their city also a solution to improve eco-cities in many ways.

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London 2012 project – brownfield investment

London was elected to be the host of the Summer Olympic Games of 2012 on 6 July, 2005 at the 117th session of the International Olympic Committee in Singapore. The central site of the Olympic Games in London will be an area of 2.5 km^2 in the valley of the River Lee, which functioned earlier as industrial enclosure area and landfill.

The site for the grandiose event will be ensured by the rehabilitation of the lower valley of the River Lee. The whole region may profit - even after the Olympic Games - from the revitalisation project, which requires substantial resources. In the National Brownfield Strategy prepared by English Partnership, the underused brownfield areas were divided into four categories, out of which the area serving as the site of the Olympic Park belongs to the sites of category 3 and category 4. In these areas rehabilitation and rejuvenisation are possible only with intensive state intervention. This is due to the high costs of environmental remediation, the necessary development of the utilities and transport network, and unsettled land ownership issues.

The London bid promised new facilities, the renovation of the already constructed buildings and temporary investments, including, among others, the Olympic Stadium with a capacity of 80,000, the Wembley Stadium, and the Olympic Village with a capacity of 17,320 beds. According to the plans, the Olympic Village will be transformed into one of the largest European city parks, and the buildings will be turned into residential homes in the future. In addition, the bid committee promised to develop the public transport, which means, above all, the extension of the West-London line of the subway network and the development of the Docklands Light railway.

The budget of the Games will presumably be around 9.345 billion GBP, including the development of the Eastern part of the British capital. Building the sites and the development of the infrastructure and the area of the Olympic Park will be financed from public money.

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4.8. KEY INSTRUMENTS FOR SHAPING URBAN STRUCTURE

In shaping climate-friendly urban structure, it is of key importance that the goals formulated in the plans and the identified area structures can actually be implemented. The settlement land-use plan is a significant tool (settlement-level physical planning), however, in shaping urban structure the key issue is how stakeholders can be successfully influenced, as a considerable part of the area is generally privately owned by companies and citizens. Today, it has become clear from our experience in Europe

that under market economy conditions preparing land-use plans and related regulations is not enough to allow a merit-based development of the settlement's structure.
It is vitally important to successfully influence the market actors and also to convince the citizens. Involving the stakeholders and using a participatory planning approach is of fundamental significance. In addition to the involvement of the population and market actors, **establishing ongoing partnerships** with the local-regional public institutions can also be useful, primarily with high schools, universities and research institutes; this points to the need for more varied, creative tools which embrace not only physical planning issues.

Main tools used in shaping urban structure and land-use:

- **Regulatory-type solutions:** it is worth emphasising the following tools for use in territorial and physical planning; the application of *absolute restrictions (*zoning limitation, building licenses, development moratoria); '*transferable development rights*'; other, *not absolute restrictions*, for example, *shift of development costs* to the developers.
- **Land-property related opportunities**: purchase of lands owned by the state or by the local government has a great effect on urban spatial structure and influences the way in which urban areas grow. A further interesting solution is the possibility of founding new cities, a question that regularly comes up in many countries.
- **Incentive-based solutions:** non-desirable investments are decreased by financial or non-financial interventions. These include *development, capital and real estate taxes*, but also the adequate establishment of *various incentives of brownfield developments* or *housing support systems* or even *state support of local development zones*. Non-financial interventions worth highlighting include *increasing the attraction of downtown areas* or *regionalisation of urban services*.
- **Solutions concerning governance:** *many tools can be included in this category* from *the informal* (voluntary, bottom up) *co-operation of local governments or other market and social actors* through promotion of *co-operation activities across administrative boundaries, to the reorganisation of public administration*. Furthermore, it is worth mentioning the application of various tools of *demand-oriented management* (urban marketing) and the implementation of '*good governance*' on a territorial basis.
- **Possibilities for awareness-raising***:* such 'soft' interventions include shaping public opinion through awareness-raising, by providing information on the effects and consequences of urban sprawl. *Information and educational campaigns* also belong to this category; however it is also worth emphasising the *necessity of building a local-regional identity*.

4.8.1. Plans

The aims and concepts shaping a city's structure are reflected most clearly in land-use plans and local building regulations; these best serve their function if they are simultaneously able to successfully realise the comprehensive climate protection strategy and goals introduced in Chapter 2.

In Europe the regulation of planning is purely national competence, and hence the planning systems are very diverse. Nevertheless, in terms of goals and duration, certain types of planning are implemented in almost the same form in most countries. An urban development vision, a strategic concept document, a more general structural zoning plan and a detailed land-use regulating plan generally exist in most states, and are in many cases supplemented by programme plans supporting the implementation of the actual urban development goals. In some countries (England, Switzerland and Sweden) combined, comprehensive plans serving these objectives are elaborated in an integrated manner. On the basis of the integrated urban strategy the closer and clearer relationship between the development plans and the land-use plans increases the efficiency of their implementation. In several European countries, besides the traditional, zoning regulation and prescriptive planning practice, there is a shifting tendency from detailed **regulation** towards **directives** and **investment orientation** (generating demand). At the same time, the ability to consistently and concretely enforce the regulations is also of prime importance

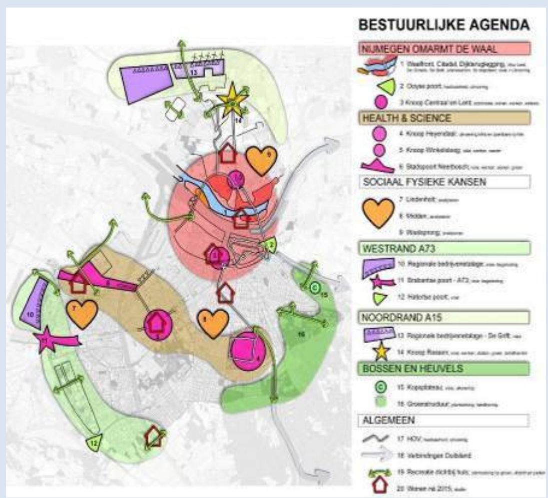
Transparency and clarity are of primary importance in planning; however, in many countries planning regulations are too complicated for the public, and there is a risk that they bind the hands of local authorities in such a way that they restrict the enforcement of strategic goals. Instead of so many regulations, it is advised to move towards **clearly formulated directives** in order to efficiently support settlement-level planning.

Urban structural vision: Do not get lost in the details!

When planning strategically, spatial use should also be enforced in the land-use plan determining the placement of functions. Therefore it is useful to elaborate a **conceptual spatial structure vision** - as part of the integrated strategy - prior to the detailed land-use plan, which indicates the large structures within the settlement, as well as envisioning the desirable character of the main zones and sectors without, however, going as far as to set actual parameters. Through this, the actual form of the spatial structure concept and the settlement's long term plans and goals become clear to the population and business actors.

The strategic nature of these plans means that, besides establishing the functions and land-use, the **financing and schedule** of implementation should also be elaborated, project leaders should be nominated for each target, and hence a kind of **programme** is created for shaping the spatial structure assigned in the plan.

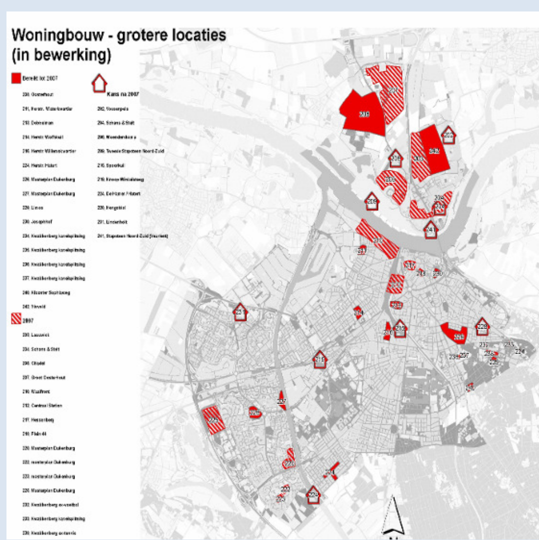
Nijmegen, strategic functional urban structure vision in a plan



Nijmegen is a city with a population of 160,000 in the South-East of Holland, near to the German border.

The spatial structure vision of the city (Kansenboek – 'Book of Possibilities', 2007) broadly determines the sites of the desirable functions within the city. The simple, clear form makes it possible for the public to have access to understandable information concerning ideas about the future of their city.

The second figure shows one of the thematic plans from the 'Book of Possibilities' regarding the so-called 'strong districts'.



Source: City of Nijmegen Local Government Office

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4.8.2. Local society's responsibility – Involving the people

Examples of successful European practice prove that if local residents regard the shaping of the town image, environment and the spatial structure of their own settlement as a public affair, this strengthens the efficiency of urban planning and consequently its efforts for climate protection. If this 'issue' becomes a public topic among the residents, it becomes an important issue for the elected politicians, too. Activities undertaken together at local level - bottom up initiatives - contribute to the long term success and liveability of the settlement. Considering one's own living environment as valuable, the feeling of togetherness, are values upon which top down initiatives may build. For these purposes local residents have to be made aware that they are also concerned and can shape local processes.

Successful community planning needs not only space and time but appropriate expertise and development techniques have to be drawn upon. The population can be activated by consistent use of flexibly chosen techniques and methods, such as community events, sports day, children's day, drawing competition.

Implementation of the following considerations helps **urban planning to become a public affai**r:

- The population must be made interested in participating in shaping its own place of residence with tuition, educational, community-building tools.
- The aim of community-building and development is for citizens to recognise their common interests and act as a local community, together; furthermore, it helps strengthen civil society.
- Through awareness-raising activities, citizens can become 'public or civil' individuals and think in terms of long-term interests.
- Full publicity, transparency of plans, planning and information have to be ensured.
- Investors have to recognise that they have to make planned investments which are accepted not only by the local politicians, but must also be attractive for the whole of the local community and correspond to their values.

Strengthening the control of civic society is definitely important; where settlement planning and climate protection is an properly handled public issue, the democratic role of the local society may be of key importance.

4.8.3. Transparent partnership with economic actors

In the course of urban development, and in shaping urban space, the will of private capital cannot be disregarded. Recently it has gained even more importance due to the significant cuts in the public budgets in most European countries. The involvement of private investors in urban development is important, but it must be involved in a way that the interest of the public is not violated. The local government should establish stable, predictable, and well-organised offers of areas, sites of development to interest investors, retaining some flexibility for possible negotiations. This offer of 'spaces' has to reflect the urban structure concurrent with public interest.

A widely-known and applied method of co-operation with private capital is the **PPP** (*Public Private Partnership*), the co-operation between the public and private sphere. In order to reach urban development objectives, so called institutionalised PPPs are created, such as **urban development companies**, in which public and private capital, public and private interests are represented equally.
In European countries **market-based tools** are increasingly used in settlement planning and development, and during the implementation of plans. The public sphere (the local government) is more and more a supervisor and coordinator of the processes, delegating implementation to well-operating market processes and automatism.

Numerous financial tools may be available for the local governments to orient investors and enforce public interests.

Development deals
'Deals' between private investors and the local government can be formalised in contracts. In this way local governments attempt to implement previously incalculable public developments by placing an unequal burden on developers. In big cities the introduction of a **normative infrastructural contribution** is useful, differentiated according to the character and location of the development, by which the investment's public dues can be calculated; this can provide a suitable basis for financing more expensive public investments.

Introduction of a market for development rights and development bonus system
The use of **development rights**, as known in the United States, is less widely used in Europe. A further example for co-operation between the public and private sphere is when the local government transfers its development rights to a project-company and in exchange for this the local government can determine terms and conditions. When the area is later sold, the community also participates in the profits.

Betterment tax - development and/or normative infrastructural contribution
Taxing the surplus value generated by community investments and public developments can facilitate financing, which can be realised with the introduction of the **normative infrastructural contribution** and the **increment value tax**. The increment value tax or duty **taxes the real estate/land value increase incurred as a consequence of the developments by members of the community,** by compelling the concerned owners to contribute to the costs of community development. An extended system of local taxes can influence people's space use - beyond construction and function installation (e.g. taxation of construction) – for example, by taxation of urban car use (e.g. parking and access) and by support of public transport.

Other area based selective taxes
With spatially selective taxation of buildings and land-use, the shape of the spatial structure of cities can be efficiently influenced, for example, for controlling urban sprawl or ensuring appropriate biological activity.

4.8.4. Communication and assistance relating to plans

Inhabitants intending to build, or even investors, consider land-use plans as a kind of restriction, and as a barrier to the implementation of their ideas. At the same time planning and regulation could render assistance, thus it can have a kind of **public service function**, as well.
Support given for adequate site selection and orientation of developments helps not only the builder or the developer, but by orienting the participants it supports the implementation of the plans. Assistance may include personal counselling (where to settle down, what can be developed), preparation of publications, information forums as well as the preparation of comprehensive and easily available information, or a direct information service supported by help with terminology. **Information services** may include not only planning documentation, but also data (real estate prices, environmental data, air, noise pollution, accessibility, etc.), various thematic maps and, of course, land registry records. Formulation and publication of local plans – both physical land-use plans and development plans – in a non-technical manner can result in an improvement in relations with the residents, as well as with the developers and potential investors. Becoming acquainted with and attracting developers must be supported by such publications, communication materials or even internet surfaces and interactive plans that are **available**, and understandable **for a wide-range of the public,** drawing their interest to the settlement plans.

BRIEF RECOMMENDATIONS

- Travelling and transport needs within and outside the city must be reduced, especially commuting; these needs have increasingly to be satisfied through networks of environmentally-friendly means of transportation (public transport, cycling, etc.).
- Establishment of a compact urban structure, in which interactions are intense, infrastructure utilisation, is efficient, transport distances are moderate and urbanised land-use is restricted.
- Urban structure must be divided by non-built-up areas, green zones, zones ensuring ventilation with regard to the climatic characteristics of the city and its surrounding, and the prevailing wind directions.
- Polycentric structure must be strengthened on regional and urban region level, as well as in the inner structure of the cities, by development of sub-centres (or equal centres) and shaping their relations.
- Urban public spaces should be extended and made climate-friendly.
- Urban green spaces must be extended and their quality improved, keeping in mind connectivity.
- Co-operation of the city and its surroundings, based on division of labour, must be strengthened in a way that avoids the rapid transformation of rural areas.
- It is necessary to create incentives so that an increasing proportion of urban food needs can be met by agricultural producers in the nearer and wider region, shortening the regional distribution chain.
- The intergrowth of the built up areas of settlements around big cities assigned for construction should be prevented.
- Urban sprawl must be moderated and controlled to prevent increased energy consumption, loss of spaces with ecological functions, or the many potentially harmful effects of commuting.
- In urban regions, it is necessary to have effective partnership between the concerned settlement, regional and national authorities, taking into consideration common sustainability values. Multi-level governance is also needed.
- Urban land-use policies have to consistently enforce strategic urban structural goals; a broad and transparent equal partnership shall be implemented between stakeholders, business actors and the local society alike.
- When implementing urban structure related plans transparent and efficient partnership with economic players and involvement of the local society is essential.
- The multiple functions of urban regions, their spatial structure shall be planned comprehensively and in partnership.

5. CLIMATE FRIENDLY URBAN TRANSPORT

One-fifth (19.6%) of carbon dioxide (CO_2) emitted in the territory of the European Union and 3.5% of global CO_2 emissions originate from transport. Additionally, unlike from other sectors, greenhouse gas emissions from transport have been continuously growing over the past decades; between 1990 and 2007 this increase was 28% in the countries (EU27 + EFTA4 + Turkey) participating in the work of the European Environmental Agency.

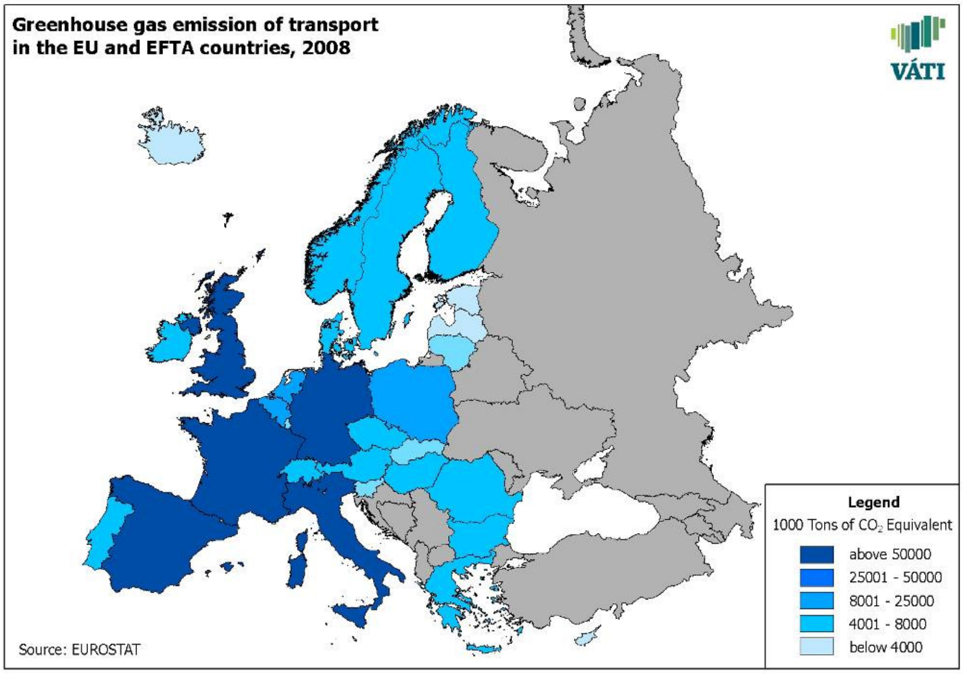


Figure 10: Greenhouse gas emission from transport in the EU and EFTA countries, 2008

Attempts to decrease greenhouse gas emissions from transport have been successful only in four countries (Bulgaria, Estonia, Lithuania and Germany) during this period. (EEA, 2010a) Within transport, road traffic is responsible for the highest share of greenhouse gas emission, nearly half of which (41%) is generated in the cities (UITP, 2006). Data indicate that the adjustment of the transport systems of European cities by taking climate protection aspects into account may significantly contribute to the success of efforts made to halt global warming. The implementation of the actions suggested in the following also improves the life quality of urban inhabitants because a truly climate-friendly urban transport system, through mitigating the demand for motorized means, leads also to a reduction in pollutant emissions and, consequently, to cleaner air, less noise and improved urban health.

Recognising the social, economic and environmental significance of urban transport, the European Union issued a green paper entitled ’Towards a new culture for urban mobility’. In this document, the major problems of urban transport are identified some relevant possible solutions are presented, and the question is posed concerning the potential role of the European Union regarding the topics raised. As an outcome of the consultation following the publication of this green paper, the Commission adopted its 'Action plan on urban mobility' in 2009 denominating concrete actions, as recommendations, for the cities in order to help developing sustainable transport.

Due to their comprehensive nature, planning, implementation and maintenance of climate-friendly transport systems assume the joint application of several (planning, regulatory, economic, technological and communication) instruments. Consequently, sustainable transport can be planned only in an integrative way and its implementation has to be in harmony with the development plans related to the entire city. However, it is practical, especially in the case of large cities, to prepare an urban mobility plan, the results of which can be utilised well in the integrated urban planning process.

The mitigation and adaptation possibilities affecting transport are varied in their costs. The modernisation of public transport may require enormous sums in a big city, while the carefully thought-out reorganisation of traffic or the promotion of pedestrian traffic may need some attention only. However, when estimating the costs it is always important to count in indirect expenses, savings by individuals due to the reduced traffic (fuel, maintenance of vehicles), the increase or decrease in the value of the affected properties, the change in additional expenses caused by noise, and most of all, the global impact of environmental emissions. In each case, these have to be established separately; therefore, in respect of the individual proposals, maximum the investment costs can be estimated in a generalised way; the final result is always decided locally. It may happen that because of the more substantial decrease in emissions, the replacement of the bus or tram fleet of a big city proves more beneficial than the reorganisation of traffic control implemented in a smaller city; just oppositely than based on the expenses. Nevertheless, developments requiring smaller investments must be given increased priority as they can be carried out faster and in greater numbers setting a good example.

The future cannot be disregarded when planning urban transport. Besides preventing and mitigating climate change, for the sake of precaution, preparations have to be made for expected changes, which must include the consequences of climate change as well due to their impact on transport systems. The timely implementation of measures serving the adaptation to changed climatic conditions decreases the prospect of emerging transport chaos in the future.

5.1. MITIGATION POSSIBILITIES IN URBAN TRANSPORT

Greenhouse gas emissions can considerably be decreased by way of the climate-friendly transformation of urban transport, which contributes to the mitigation of climate change. This can be achieved by setting and simultaneously fulfilling three objectives. Firstly, occurring **travel demands** have to be reduced. Secondly, more **efficient and sustainable ways of meeting** these demands have to be found e.g. by giving preference to electric and other environmentally sound modes. Thirdly, the **energy efficiency of transportation** means has to be improved, thus diminishing the quantity of greenhouse gases emitted by vehicles running on fossil fuels. No significant breakthrough in decreasing the emission of greenhouse gases can be expected from performing just one of these objectives. To some extent, these efforts represent theoretical steps building on user awareness as well as strengthening it, and keeping the sustainability of mobility in mind; while they are also practical tasks in the significant restructuring of mobility.

5.1.1. Reducing demands in urban transport

The most efficient way of reducing demands in urban transport is developing a settlement structure where the mitigation of transport demands is seen as a priority in forming the utilisation of space by the different urban functions. Due to its significance, the handbook discusses climate-friendly settlement structure in a separate Chapter 4.

5.1.2. Spreading of more sustainable modes of transport

Even if a settlement structure is achieved that entails the least possible demand for motorised transport, the persistence of considerable urban traffic has to be reckoned with in European cities. The following section includes proposals for organising this remaining traffic in a climate-friendly manner, i.e. in a way that results in low greenhouse gas emission.

Development of the public transport network

The basis of a sustainable and climate-friendly urban transport system is a public transport network of excellent quality, easy to access, ensuring a quick reach of destinations and offering an attractive alternative to people who otherwise would travel individually in passenger cars. As a consequence of the size of cities, their inhabitants certainly need motorised means of transport. The partial substitutions of motorised individual transport can only be achieved by making public means attractive and developing it in a way that it can satisfy a wide scale of demands. However, it has to be emphasised that making public transport attractive is only one of the segments of establishing sustainable transport. Following appropriate preparatory work, mild, coercive and restrictive measures encouraging the use of public transport are, indeed, necessary, such as for example, banning traffic from certain areas, introducing some way of charging for usage, or limiting and transforming parking possibilities, and in general, by pricing and usage limitation which take into account the caused externalities.

In the European Union the average utilisation rates of both the individual and the public transport is 25%. However, while maximum 8 people can travel in a single passenger car at a time, the means of public transport can carry lot more passengers, so their per capita greenhouse gas emission is much lower, and in certain subsectors of the public transport we can speak of zero emission. During the rush hours, the difference in energy efficiency of individual and public transport may even grow to more than tenfold. (UITP, 2006)

Considering all the aforesaid, it is particularly disquieting that within urban transport, the share of public transport is continuously declining almost in all the cities of Europe. Currently, taking the number of trips by person as a basis, the proportion of public transport is near 30% in the cities of the European Union. However, there are significant differences across the continent: the highest values (over 50%) can be observed in the cities of Eastern and Central Europe but the proportion has been decreasing here, too. In certain European cities, some increase in the share of trips carried out via public transport has been achieved at the same time. (UITP, 2003)

The probability of using public transport depends on a number of factors. The usage of public transport in the urban and agglomeration space is ensured if the following conditions exist:
- a favourable network cover;
- an integrated tariff system, tariff community – interoperability between the individual modes and service providers;
- favourable pricing;
- efficient alternatives to reach destinations (speed, time, preference);
- high travel comfort;
- reliability, regularity according to schedule, safety;
- appropriate frequency and continuous access 24/24h; and
- availability and functional diversity of possibilities for changing modes.

Besides, the usage of public transport is influenced by a number of subjective factors:
- strength or weakness of the passenger car as a status symbol;
- individual assessment of public opinion on public transport;
- generalisation from own experience;
- the existence and efficiency of campaigns reaching the individuals; and
- the degree of environmental awareness.

It is a primary condition for a well-operating public transport network that its individual means can be **combined well with each other**. In the course of planning transportation links, one should pay attention not only to the demands of public transport in a narrow sense: in order to achieve the optimal effect, one has to open also in the direction of certain 'alternative' and environment-friendly (e.g. cycling) and motorised individual forms of transport. This way it has to be made possible that even those who set off for the city by car cover the shortest possible distance by this means. Therefore, in the vicinity of the stops and stations of fixed track transport in the agglomeration settlements and outer city quarters, large car parks (P+R) and bicycle storage facilities (B+R) have to be constructed, and the transport of bicycles has to be allowed on some of the public means of transport, especially those covering longer distances. It is important to improve the accessibility of universities via public transportation and bicycle routes because of their significant, yet mostly only passenger traffic. It is imperative, however, that public and environment friendly transport services offer an alternative for passengers for the entire travel chain as much as possible.

The various transportation modes serve the interests of the city dwellers the best if they are not competing with but complementing each other.

The competitiveness of public transport is greatly dependant on its **affordability**. According to a survey carried out in Germany, in an average German city (Freiburg) the share of passenger cars in the local transport is 42%, and the shares of public transport, pedestrians and cyclers are near 20% each. However, out of the expenditures of the city allotted for transport, nearly 60% is used for supporting individual car transport. This distribution does not help public transport gain more ground. If we really want to change the status quo, public transport has to be given priority in finances. The support scheme of the subsidies provided by the EU is already sufficiently broad for the implementation and development of efficient urban and suburban fixed track transport systems from community resources. However, it is the cities' and regions' responsibility and duty to prioritise among developments, as well as to recognise the most urgent problems and define their treatment.

From the perspectives of both affordability and the integrative approach, the attractiveness of public transport can be increased by a **uniform season ticket** and ticket system covering the entire city and even the agglomeration settlements, i.e. by a tariff community, which is based on the logic of transport associations and means one of its branches. Furthermore, by defining different tariff zones for P+R systems with generally low prices and free-of-charge use in the outer areas and in the agglomeration, mode-switching can be encouraged. In case of smaller cities, making the entire public transport network free is also possible, taking, however, into account that the European experiences are very diverse in this respect and, socially, broadening the spectrum of users not only solves but also creates problems.

Although the construction and operation of public transport systems are financially costly, taking also its social and environmental benefits into account, in economic terms, efficient investments can become remunerative. Contrarily to the 'hard', isolated infrastructure constructions (e.g. non-interoperable metro/underground), efforts have to be made to establish **interoperable fixed track systems** (utilisation of Light Rail Transit - LRT, tram and railway lines in urban transport). These solutions can ensure the integrability of the existing and new network elements and the minimisation of the number of transfers, which shorten travel times and increase the attractiveness of public transportation as a worthy competitor of individual transport.

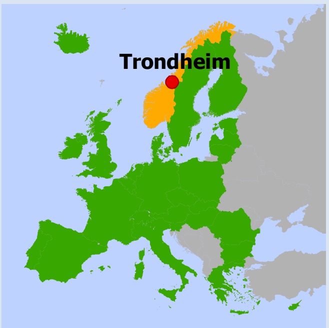
Trams are one of the most flexible means of transport, and are currently having their renaissance in Europe. They can be operated even in pedestrian streets or limited traffic areas where they run nearly at the speed of a pedestrian (and they contribute to the good atmosphere of public spaces), while in the outer areas, they can play the role and reach the speeds of underground and local railways. In addition, the distances between stops can optionally be varied in each section, so they can be better aligned with local transport demands. The competitiveness of trams is improved by the establishment of a system which enables the tram to switch the traffic light automatically in junctions after checking in so that it is given way and can, consequently, run continuously. All these advantages can be reached approximately for one-twentieth of the construction costs of a metro system (Michael Cramer, 2006).

An ideal means of transport in the internal city quarters is the **trolleybus** widely used in Eastern and Central Europe. Similarly to trams, it does not cause direct emission of pollutants; at the same time, the construction of the necessary overhead contact line network and its potential relocation is cheaper and can be implemented more simply than laying tram rails. However, its disadvantage is that it 'contributes' to the potentially forming urban obstacles and traffic jams just as buses do because contrarily to trams, a trolleybus does not run along a protected, closed track. On the other hand, similarly to trams (but differently from buses), in case of an obstruction to traffic or an accident, trolleybuses cannot 'escape' to any bypass road either, due to their fixed system of overhead contact lines, which also, has quite a significant effect of deteriorating the cityscape.

However, it is important to mention that the formerly existing sharp borderlines between the individual transport subsectors are slowly disappearing. In case of the modern vehicles, the difference between buses and trolleybuses has significant decreased; the automotive trolleybuses (battery, supercondenser, diesel engine, etc.), and the nearly zero-emission buses or those supplied with EUR5 engines are already almost compatible with each other. In several cities there are vehicles (e.g. Translohr) that constitute a transition between trolleybuses and trams.

Bus Rapid Transit (BRT) introduced in a number of cities in Asia and South America, e.g. in Bogota, is also an interesting possibility but it is not the model for European cities. This system is similar to the tram lines to the extent that the traffic is performed along a track separated from the other segments of transport, i.e. it operates in a bus lane system interweaving the city. In this case, the cost of laying the tram rails can be spared. Its installation can be recommended primarily in places where neither a tram or metro/underground system nor any adequate financial resources are available yet, but in the cities of the Third World growing by leaps and bounds a short-term and efficient solution is needed.

In summary, the milestones of an efficient public transport are as follows:
- good combination possibilities taking the regional and urban development features and intentions into account;
- uniform ticket and season ticket system and tariff community as part of the transport association model;
- competitive ticket prices;
- easy availability;
- some kind of a public means of transport has to be available within 500 metres;
- predictable and regular frequency of services, reliable schedules;
- appropriate comfort level, including cleanliness on the vehicles and at the stations and optimal utilisation (not very crowded services);
- establishment of bus lanes;
- automatically giving way to the vehicles of public transport but always to fixed track vehicles at junctions (by the help of using Intelligent Transport Systems);
- growing usage of fixed track systems within the cities; ensuring interoperability.



Trondheim: promoting public and individual non-motorised transport

Trondheim is the third largest city of Norway with approx. 160,000 inhabitants.

Since the 1990s the city of Trondheim has been making efforts to take actions for limiting the emission of greenhouse gases, but the number of cars has continuously grown. Therefore, in the interest of achieving the objective set, it has elaborated a Green Transport Package whose main goal is that by 2018 the city reduces its CO_2 emission by 20% by making both public and non-motorised transport gain ground.

In order to achieve this objective, in 2008 separate bus lanes were constructed throughout the city to increase the efficiency and speed of urban public transport, in which lanes the buses can run at high speed and without any obstacle. At the same time, the allowed speed of cars has been limited. Also, the action of the city management, namely concentrating the workplaces in areas easily approachable by public transport, has contributed to increasing the utilisation of public transport. They relocated 1,000 existing workplaces to a designated area and, simultaneously, they specified that min. 60% of the new workplaces had to be established in this area.

After the relocations, Trondheim launched a campaign supporting bicycle and pedestrian traffic. The aim of the campaign is to make employees living in the city cycle and walk more and more. The number of so covered kilometres are measured and, based on their performances, the employees can be awarded. As a part of the project, it has been organised that the employees still using a car take more of their colleagues to their workplace by sharing their cars, thus reducing further the emission of greenhouse gases. Additionally, the management of the city uses more and more electric cars; today Trondheim, owning 23 such cars, has the largest electric car fleet in Norway.

As a result of these actions, the number of trips in passenger cars has decreased by 150,000 annually, the proportion of employees going to work by car has diminished from 50% to 16% and car usage measured at rush hours has dropped by 20%.

It is thought-provoking that, according to the survey made on the popularity of the project, the action was not popular in the beginning (55% of the respondents had a negative and only 45% of them had a positive opinion about the innovation) the ratio was reversed in a year (63% had a positive and only 37 % had a negative opinion).

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The Swiss Association of Public Transport

In order to increase efficiency and the number of passengers of the railways in Switzerland, a complex multistep public transport structure was introduced in 1982 based on an integrated, symmetrical regular-interval timetable (*Integrierter Taktfahrplan* – ITF). The system is based not only on periodic train departures but harmonizes the whole of the public transport network. The competitiveness of the community transport could be significantly increased by reducing and harmonizing the transfer times between trains and by establishing two-directional symmetry of traffic in the timetables As the maintenance costs of the railway network are considerably higher compared to the operational costs of the lines, increasing the supply of service proved to be reasonable. Thus, with the introduction of ITF, a mere 4% increase in costs resulted in a 21% growth in the services offered. In the 1980s, several private railway companies as well as urban transport and bus enterprises operating in Switzerland joined this system, which has been continuously developed to satisfy the needs of the passengers as much as possible. In 2004 already 55% more passengers travelled by train than prior to the launch of ITF, clearly justifying its introduction.

An inevitable part of this system was the harmonization of urban and long-distance transportation. Not only are the timetables adjusted to each other: the main transport service providers were also integrated into a transport federation, a tariff community. The distribution of revenues is a key issue here. The revenue from tickets purchased within the uniform tariff community goes into a single account, which is then allocated among the service providers according to the distribution of demand. The distribution is based on the passenger-kilometres and the number of trips, taking into consideration, of course, the characteristics of the different modes of transport. Such distribution of revenue, i.e. in proportion with actual demand, incites the service providers to improve service quality and to increase demand. The mutual interest of the different service providers and the transparent financial arrangements ensure the successful operation of the system, which is proven by the results achieved so far and the large number of participants in the transport association.

The revenue distribution system was presented as a good example within the framework of the SPUTNIC project. SPUTNIC (Strategies for Public Transport in Cities) was supported within the 6th Frame Programme of the EU. Its aim was to make public transport more attractive and efficient by preparing the interested parties for expected challenges, giving them an up-to-date overview of relevant professional knowledge and research, as well as providing them with concrete guidelines and practical tools.

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Traffic calming – traffic evaporation

In line with earlier traffic planning theories, the extension of the road network was most often seen as the proper means to improve the traffic situation along congested road sections with regular traffic jams. However, sustainable, climate-friendly cities do not consider this to be a solution to the problem: instead, they strive to reduce traffic in the problematic areas – or optimally, in the whole city – by focussing on the rearrangement and reduction of mobility needs. This means that these cities do not fulfil the space demand of passenger cars but intend to reduce it. This can be achieved by **consciously regulating the terms of passenger car traffic** – by employing supportive and restrictive instruments. According to observations, the gradually declining traffic circumstances may discourage city dwellers from using passenger cars and can result in an increased use of bicycles and public transport. Nevertheless, this can be a successful method only if implemented successfully within an integrated approach. Real and lasting success can be achieved only by improving alternative transport modes (public transport, the conditions of bicycle and pedestrian traffic) simultaneously with and complementing restrictions on car traffic. This means that first alternative means have to be made available providing adequate proper options for mode shifts to those who want to use public transport services.

Meanwhile, provided certain conditions are met, some part of passenger car traffic may even ‘disappear’. According to a case study (Goodvin et. al 1998) evaluating more than 100 cities, in almost 100% of the cases, 14% of the original traffic can wear off. This means that greenhouse gas emission by cities is reduced by the exhaust gases produced by this amount of cars. Immediately after the introduction of traffic restrictions temporary traffic chaos may emerge for a couple of weeks, however, this situation only lasts until the drivers learn which ways are better to go amidst the new traffic conditions. Within a year after the restrictions were imposed, the new habits are formed, people using cars may (partly) start switching to other transportation means, and may reassess the practicality of driving into the traffic-calmed areas. The long-term effect of traffic calming strongly depends on the complementary measures. In some of the studied cases, although lower intensities of traffic become more and more adopted, it may happen that cars slowly reappear on the roads. The precondition for an actual decrease in traffic is that road closures and the inhibition of passenger car traffic is realised in practice. In case there are significant unused capacities in a different period of time in the given part of the town or free capacities offered by alternative routes, the traffic is only transferred to these time periods or routes, and will not be reduced altogether.

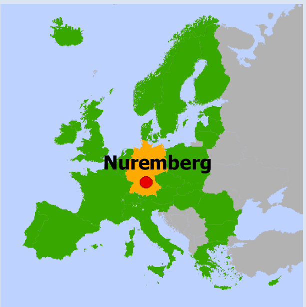
One of the simplest methods from among the wide range of traffic calming instruments is the partial or total **closure of certain roads, squares** – in area or time – from traffic. Pedestrian areas or areas of mixed use may function as local public spaces, and can assist the increase of the city's tourism potential, which in turn, invigorates trade in the concerned areas of cities, substantially contributing to the revitalization of these - mainly downtown - areas and help stop their decline. However, logistics in these city parts needs to be adequately handled, the storage of the local residents' vehicles has to be solved by means of parking houses, garages, and client parking has to be effectively regulated in surface parking lots. A more extreme, but effectual way of regulating parking is the reduction of the number of parking lots, which allows alternative uses of these areas (bicycle tracks, sidewalks, green area, etc.).

The introduction of **entrance fees** may also lead to a decrease in traffic in certain – mainly downtown – areas (generally called as '**congestion charge**'). This instrument is applied in several cities of the world with different emphases: while e.g. in Oslo the aim was to generate income, in London and in Stockholm this measure was introduced to reduce congestion, and in Milan the emphasis was on the cutting exhaust emissions. The smaller towns of Durham (England), Znojmo (Czech Republic), Riga (Latvia) and Valletta (Malta) also use congestion pricing to reduce traffic jams, particularly during the peak tourism season. Based on the experiences from functioning charging systems, following their introduction, people partly adapted by choosing other times for travel, and partly by modifying their routes, while others switched over to public transport or bicycle; also, certain part of earlier traffic disappeared, by which total traffic was reduced. At the same time, the received income can be utilised for the enhancement of the more sustainable means of transport. However, this measure for reducing congestion in dense city areas is a controversial one. The most important limiting factor of implementing it is that without sufficient parking space and an effective public transport system, the expected benefits cannot be reached. Also, the creation of parking lots can concentrate car traffic and increase pollution in their neighbourhoods. Besides, even in a perfect system, the situation arises that those who live outside the urban area have to pay this tax, while the external benefit is granted to those who live within the given area.

Setting **parking charges** is also a practical way to achieve decrease in traffic. According to observations, the introduction of parking fees reduces the volume of passenger car traffic by an average of 10%. However, parking fees and regulations cannot be efficient unless they are determined within a comprehensive, integrated urban development plan designed for the whole city, in accordance with a parking management plan. Information systems reporting on the currently available free parking capacities must form an integral part of the parking system of cities. With their help, parking space seeking traffic emerging in the area of downtowns (which can be as much as 20% of the total traffic) can be significantly reduced. Parking in agglomeration or suburban areas facilitating transport mode change, downtown residential parking and client parking have to be clearly distinguished within the parking system and the time-frames and logic of defining their fees have to be differentiated accordingly.

A further possibility is to consciously locate traffic calming installations that **reduce the speed of traffic**, and which urge drivers to rather avoid the particular road. Locating the sidewalks, bicycle roads and parking lanes on the same level may also result in the same effect. However, when planning these traffic calming measures, the proper evaluation of traffic needs and the capacity of the surrounding road network is extremely important. If there is no other alternative route in the neighbourhood, and it is not possible to reduce traffic needs, it may happen that the traffic along a road 'packed with obstacles' will not be reduced but progress will become slower, traffic jams will occur more often, and as a consequence, local air pollution levels may significantly rise.

Traffic calming may not only cover several roads, squares but also be extended to entire residential areas. By way of careful planning, involving local actors, some spaces within the city may be created where inhabitants do not own cars, and where only vehicles of emergency services are allowed to drive into.



Nuremberg, traffic calming

Nuremberg is situated in the south-western part of Germany, in Bayern, having approximately 500,000 inhabitants.

Solving the problems coming from increasing traffic was becoming more and more urgent during the 1970s due to growing air pollution, noise, the slower and slower traffic, and progressively growing congestion. The leadership of the city intended to reduce the traffic load; therefore, for the first time they started to clear out traffic from the city centre. This was implemented in several steps, till finally, by 1989, certain parts of the downtown had been transformed into pedestrian zones. However, public transport services were continued here as well.

Besides blocking motorized traffic from certain areas, buildings were renovated, street equipment was developed, and pieces of art were installed so that the atmosphere of the city became more attractive for both the inhabitants and the tourists.

The interventions related to the roads have had a significant effect: downtown traffic was actually reduced by 21,176 vehicles (double what had been planned), and by 1993 traffic was reduced by 36,044. This decrease was not transferred to the external rings, where measurements also showed a decline in traffic (between 1989 and 2000, by 10,000 vehicles). So closures have not resulted in bigger traffic jams but on the contrary, in reduced congestion, which have led to an improvement in air quality.

Traffic reduction on Rathausplatz represents the success of the measures: between 1988 and 1993 traffic was cut back to zero from 24,584 cars daily. Despite this, traffic on the surrounding roads did not increase but also dropped from 67,284 to 55,824 cars during the examined period of 5 years.

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Bicycle road network and connected developments

Riding a bicycle is an integrated part of urban transport, which is dealt with due consideration by the managements of climate-friendly cities. Increasing the proportion of the bicycle usage can result in a reduced use of passenger cars, and as a consequence, in lower levels of greenhouse gas emissions. Riding a bicycle has several positive effects: due to its positive impact on urban air quality and the growing preference of physical exercise, it is advantageous to the inhabitants' health; it can help reduce the number of traffic accidents in the city; and because bicycles are more economical with space than cars, certain infrastructures (mainly parking places) become redundant and their surface may partially be converted to green areas. Altogether, cycling is also cheaper than traditional individual motorized transportation.

The chances are higher for the large-scale adoption of the bicycle as a means of transport in those cities especially which lie on flat land; although, based on experience, the climate has less significance, contrary to preliminary estimations. Interestingly, riding a bicycle has the highest popularity in those cities where the weather is typically cold, wet and windy. Several **preconditions are needed for making cycling popular**; these have to be indicated in the integrated urban development plan.

– Riding a bicycle may be effective and widely accepted where the riders and the other participants of traffic mutually acknowledge and respect each other, no matter what kind of infrastructure is available.
– It is necessary to have a continuous bicycle network. This means not exclusively or primarily the existence of separate bicycle roads; there is a large variety of other solutions ranging from traffic-

calmed roads, through widened outer lanes, bicycle tracks, and open bicycle lanes to separate bicycle roads. When scheduling their construction, it is advisable to make sure that connections are already available to the newly constructed sections or that there are safe connecting roads between each section. The bicycle network has to be linked to the public transport network. Proper bicycle storage facilities have to be created at the stations; furthermore, the transportation of bicycles has to be made possible on the means of long-distance public transport (mainly suburban trains).

– Networks that may be used by bicycles have to be adjusted according to the main transport directions. Therefore, the construction of bicycle networks demands serious planning preparations, taking into consideration already existing innovations, as well as the application of transport-technological solutions that are favourable for the cyclists.
– Bicycle tracks and roads must be maintained.
– The identification and construction of roads where cyclists may ride has to be accompanied by efforts to popularize the bicycle as a means of transport, as well as with the provision of up-to-date information about the bicycle network.
– Bike racks must be set up in all parts of the city.
– Following a variety of popular practices in Europe, bicycle rental systems have to be set up to cover ever increasing areas.
– Both physically as well as in terms of air quality, safe conditions for cycling have to be ensured as a priority during both planning and operation of the infrastructure.

In Western Europe it is a common practice to establish **bicycle rental systems** with parking places and free-of-choice pick-up and drop-off possibilities. Their construction is very important, as they increase the proportion of cyclists in the city. However, it is only viable if there are already existing well-developed, cyclist-friendly networks, or at least, those are constructed simultaneously. Besides cash and credit card payment options, it is advisable to introduce other payment methods (through the mobile phone or the city card for tourists) when renting a bike. It must also be mentioned that – mostly in cities with greater populations – cycling serves more as an alternative to pedestrian traffic and public transport than having any significant effect on the volume of motorised traffic. However, for people coming from the external areas of towns – mainly the younger generation – and for tourists, using the bicycle may be an attractive possibility in case bicycle renting stations connect well to the public transportation routes. Serious political commitment is necessary for the construction and operation of a bicycle renting network. Its costs are covered by the sale of promotional surfaces, or in other places, by the revenues from parking fees.

Lyon, bicycle sharing network

Lyon lies in France, 460 km from Paris in the South-Eastern part of France, with a population near 470,000 inhabitants.

In order to reduce passenger car traffic in the city, and keeping an eye on the health of residents, the city management of Lyon cooperating with the JCDecaux marketing company launched the Vélo'v project in May 2005, and at several locations in the city, bicycles could be rented. Renting a bicycle takes place as follows: there are cards in the renting stations, and bicycles may be rented for a 24-hour period. The first 30 minutes are free, from 30 to 90 minutes, the use costs 1 euro, and over 90 minutes, each additional hour costs another 2 EUR. In case of a long-term rent, one has to register in the system and pay a registration fee.

After use, bicycles do not have to be returned to the same spot where they were rented, they can be left at any Vélo'v station. Currently there are 340 bicycle renting stations in Lyon, but according to plans, in the future there will be stations located in every 300 metres. In year 2006, these bicycles were rented a total of 22,000 times, which actually meant a 44% increase compared to 2005. Calculating from the number and location of rents, the total length of the routes covered on bikes was altogether 6,400,000 km.

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Supporting pedestrian traffic

When planning urban transport, pedestrian needs have to be also taken into account. Like cycling, walking is also an environment-, climate- and health-friendly mode of transport. Significant increase in its proportion can be expected mainly in areas blocked from passenger car traffic as well as in traffic-calmed areas. However, besides these compelling factors, people have to be inspired to walk short distances. For this, however, proper circumstances have to be established. Broad, shadowy **sidewalks** surrounded by green areas and suitably equipped with benches can be attractive for short walks. The **minimization of the number of stairs** to be climbed is a basic expectation on behalf of the handicapped, the elderly and residents with small children, as well as the construction of ramps and a complex barrier-free system. It is important that the otherwise wide-spread **pedestrian streets** are connected to each other and give access also to the green areas of the city (especially taking into consideration families with small children).

The attractiveness of pedestrian transport can be further increased by installing **traffic lights** at intersections in a pedestrian-friendly way. This means that on the roads having heavy pedestrian traffic across them, traffic lights have to be programmed so that they turn green for pedestrian traffic at least once every minute even if this is less beneficial to other, motorized traffic. Connected to this, in the inner city areas, pedestrian crossings can be also elevated, which renders pedestrian crossing more convenient and forces cars to slow down. It has to be evaluated in each case what has a bigger priority at the given intersection: facilitating an undisturbed flow of vehicle traffic, or the preference of walk. Where the emphasis is put on is a political decision; conflicts arising from the changes and rearrangement of priorities can be resolved in the long run.

However, a single important circumstance fundamentally influences the increase of pedestrian traffic. An **integrated urban texture** must be created where distances are small because the workplaces, sites of shopping, entertainment as well as residential areas lie close to each other. Additionally, the popularization of pedestrian transport is necessary. A good example for this is the 'institutionalized' popularisation of walking among children through the 'pedibus'.

Eisenstadt, PEDIBUS

Eisenstadt is the capital of the easternmost province of Austria, Burgenland, with a population of 14,000 inhabitants.

The idea of the PEDIBUS project was conceived in the minds of the local school leaders when, as a result of a thorough school renovation and reorganization project, the traffic around the school significantly increased, with frequent traffic jams around the rush hours, which led to a significant increase in polluting emissions, and significant risks to the children. When launching the project, the organisers' main target was a 60% reduction of traffic around the school.

The PEDIBUS means that children from the school walk on a selected road under the supervision of an adult, on foot to and from school every morning and afternoon. One may join the 'school march' in the indicated stops, where the adult supervisors replace one another as well. The project was launched in the school year 2007/2008, along 3 routes. At the end of the school year, the project was considered successful, therefore, the participants decided to continue it. The targeted 60% decrease of traffic was achieved as well. The other outcome of the project was the positive effect on the community and the social attitude.

The advantage of the PEDIBUS is that by using a minimum budget, it can be realized with the assistance of the parents. The only possible cost may be the fee of the escorts, however, in Eisenstadt this was performed as volunteer work by the participants.

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Propagation of alternative public transport solutions (car-sharing, full-car system, organized hitch-hike)

The largest disadvantage of public transport is that it is not adjusted to the destination of the individual traveller, which means that one needs to walk much during the travels and the transfers and waiting take a considerable amount of extra time. A well-organized public transport network may however, significantly reduce these drawbacks, though it may not solve these problems absolutely. There are some public transport modes that are suitable to be adapted to the needs of individual travellers. Although their disadvantage is that they can carry only a fewer number of people, and therefore they are less effective than traditional public transport modes, compared to individual transportation, they are more efficient. Such modes introduced below may be appropriate ways to reduce passenger car traffic in a city, and thus, the emission of greenhouse gases. Nevertheless, it is true that this can be achieved only provided that certain conditions are met.

'**Car-sharing**' is a special form of borrowing a car. It provides a car for a short term (e.g. a few hours) for the participants; but depending on the type the vehicle, the car may be rented for days. The primary target of the system is to contribute to reducing the number and the use of the cars privately owned. The cars may be hired from and dropped off at any pre-indicated station if the system is a well-operating one. Nowadays, this kind of short-term car-rental service is taken on mainly by private enterprises, but several transportation companies keep significant fleets, like for instance, the German Railway Company (DB) in Germany, or the STIB, the local transportation company in Brussels. However, in order to reinforce the climate protection aspects, local governments can also operate such car parks since following the initial investments, the running expenses are relatively affordable. A cut in greenhouse gas emissions may be achieved most effectively if the car rental stations are located close to where long-distance train lines reach the city, and to the stations of suburban railways, tramways, and to bus terminals. This way the distance of travel covered by those arriving from the suburbs and the agglomeration settlements may be reduced. This can decrease traffic on the incoming roads in the outskirts of cities; however, significant reduction in traffic cannot be expected in the city centres. The latter can be achieved only if the cars for rent are powered by environment-friendly technologies (electric, hybrid). At the same time, a significant benefit from this system is the decrease in the number of cars parking in the downtown area, which in turn results in the increase of spaces available for other purposes.

Besides municipalities, employers may also establish similar systems, where company-owned cars collect the employees each morning and transport them home in the afternoon (carpooling). Of course this means certain inflexibility for the inhabitants, however with a proper incentive scheme both the enterprises and the employees can be persuaded to operate and use such systems. The cars serving such goals can be specially marked – depending on their loads – and be allowed to use bus lanes; and both the employers and the employees can be motivated financially with allowances or tax reductions. In order to operate this system, it is necessary also to provide cars for trips during the day in a rental system.

A complementary form of public transport may be – especially in sparsely populated agglomeration and suburban settlements – the creation of favourable conditions for **hitch-hiking**. The essence of this transport mode is that stops shall be designed and marked where passengers may be picked up. It is advisable to locate these stations next to the main roads and close to public transport stations. We cannot expect much from the resurrection of hitch-hiking since it requires a huge amount of trust on behalf of both parties. However, the creation and maintenance of the stops cost very little, it is reasonable to offer them to those few people who would like to use them. Besides, they may have an exceptional marketing potential!

Climate-friendly freight transport in the city

The methods introduced so far and aiming to reduce the traffic load on cities are, without exception, targeting the reduction of passenger transport. However, freight transport vehicles participate heavily in urban traffic, contributing much to the production of local air pollution. A wide-spread measure to regulate urban freight transport is the prohibition of large trucks from entering certain – mainly downtown – areas of cities. This decreases air pollution of those particular districts; however, this regulation does not have a decisive reducing effect on the volume of greenhouse gas emissions in the whole city and region.

However, city management can create the foundations of climate-friendly freight transportation that results in reduced emissions of greenhouse gases. The key to this may be the creation and operation of **consolidation centres**. These latter are such logistic bases which are located nearby the areas to provide for – mostly a certain part of the city, or an entire town, a shopping mall, a major construction site –, which areas are supplied from these bases mostly by means of smaller vehicles (M. Huschebek, J. Allen, 2005). Opinions vary on the advantages and disadvantages of urban logistic centres, however, there is agreement as to the fact that they are efficient from the point of view of environmental and climate protection. An assessment of the results from 17 sample projects indicates that after launching the system, the total distance covered by the trucks decreased on average by 35-40% in the related part of the city, the capacity utilisation levels of the vehicles increased by 15-100%, and as a consequence, NO_x and greenhouse gas emissions by trucks decreased by 25-60% (M. Bourne, M. Sweet, A. Woodburn, J. Allen, 2005).

Nevertheless, in order to for these transit stations in cities to be really effective, several conditions have to be ensured; otherwise these centres can easily cease to operate completely, as it has happened in some cities in Germany over the last decade. Therefore, the creation of urban consolidation centres requires well-grounded and comprehensive demand survey and planning. The establishment and operation of consolidation centres can generally fulfil expectations if they are operated in a clearly delineated city area with some special features (e.g. downtown area, car-free zone), where there are a lot of shops that do not belong to any commercial chain (and as a consequence, neither to any supply chain), and where traffic on the roads is high. The establishment of city consolidation centres in large construction and commercial areas, although it is less noticeable to residents, serves the reduction of greenhouse gas emissions in the city.

5.1.3. The reduction of specific emission of greenhouse gases by transport means

With the help of the methods introduced above, transport needs may be reduced only to a certain level. In order to decrease further the emission of greenhouse gases deriving from urban traffic, the reduction in the specific emission levels of vehicles is a precondition. With a Decree in 2009, the European Commission set the maximum greenhouse gas emission level to be applied to new passenger cars. According to the Decree, by 2020, compared to the values in 1990, emission levels have to be reduced by 30%, i.e. to an average of 95 g/km. However, city management should not be content with the reduction in greenhouse gas emissions coming from this measure, but has to support the targets of climate protection with the following instruments.

Increasing the proportion of low-emission vehicles in public transport

There are significant differences between the CO_2 emissions of vehicles. The following chart contains average figures for various types of passenger transport vehicles:[1]

Passenger transport vehicle	Grams CO_2 per seat km	Number of seats
Medium-category car	78	5
Urban diesel train	60	146
Metro/underground	46	555
Tramway	39	300
Light rail	38	265
Diesel bus	33	49

Table 1: The CO_2 emission of vehicles (Source: David A. et al., Oxford, 2003)

With respect to the data above, and with a consideration of climate protection, the proportion of suburban train, tramway, light rail and buses has to be increased within urban public transport. When purchasing vehicles, one has to take into consideration the costs arising during the entire life cycle of the given vehicle, due to which those energy-saving vehicles which first appear to be costly can turn out to be in fact, less expensive. In the following, from among these possibilities, we would like to introduce some solutions by which the emissions by light rail and buses can be decreased. Nonetheless, it has to be emphasized that each city and region will have to find the best solution being aware of their already existing systems and their inter-operability potentials.

Light rail may be considered as a climate-friendly and energy- efficient solution in urban transport, especially in suburban areas. In order to increase the energy efficiency of these, a survey was performed to find out which aspects influence their energy efficiency to the greatest extent. Based on the findings of the MALTESE project targeting the above aim, these features are the following: the number of intersections; the number of stations created within underground sections; the construction of the lighting and ventilation systems of the underground sections; train succession density; the distance of the garages from the metro line; the frequency of acceleration and braking; and the load of the rolling stock. Some of these aspects can be optimised by simple and feasible actions, but some require expensive technical solutions. In case of the latter, the responsibility of an environment-friendly local government is limited to the consideration of energy efficiency aspects when choosing the vehicles. However, implementing measures to raise energy efficiency by means of the organization of traffic is a task of city planning and operation. Below is a short summary of solutions serving the energy-efficiency of light rail, grouped according to the most critical aspects of energy consumption:

- The number of intersections:
    - Application of a traffic light system which gives priority to trains (ITS – Intelligent Transport System),
    - Constructing stations close to the intersections.
- The length of the underground sections, and the number of stations:
    - Replacing underground sections where possible by protected surface lanes,
    - Shared use of the underground tunnel by several light rail lines.
- Lighting of the underground stations:
    - Covering the wall of the stations in bright, reflective substances,
    - Possible minimization of lighting, use of energy-saving lamps and bulbs.
- Train density: the effectiveness and the enhanced role of light rail within the public transport system depend on the frequency in train succession. Its optimal level contributes to efficient utilisation. Rapid succession is required especially in the rush hours.

[1] The data were provided by the public transport companies of the United Kingdom to the authors of this book. The authors compared these with the data referring to the European cities, and they found significant differences, therefore the below data are general for the whole of the EU.

- Location of garage:
  - The garage has to be the closest possible to the lines.
  - Daytime the trains may stay out of the garage; they may as well park on a sidetrack.
  - The vehicles should be used for passenger transport also between the garage and the lines.
- Acceleration / braking: there are several technical solutions for the reduction of the energy use and loss occurring during acceleration and braking. When choosing the vehicles, it is advisable to pay attention also to this.
- Load of the rolling stock.
- The size of carriages has to match the size of traffic.
- In case of low traffic, shorter trains have to be used.

Dublin, light rail

Dublin, the capital of Ireland, has 1 million inhabitants including its agglomeration.

In order to reduce air pollution, two light railways were built in Dublin co-financed by the Regional Development Fund of the European Union with a sum of by 82.5 million EUR. The constructions were started in 1999, and the two lines were finished in 2004. The idea was successful: in the year 2008, 27 million passengers used this means of transport; furthermore, the project needed support for operation costs only in the first few months, afterwards it started to produce profit. Motivated by this success, Dublin is planning to establish further lines.

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Concerning solutions for **buses**, in the area of reducing CO_2 emission, a breakthrough can be expected from the spread of hybrid buses in the short run and in the long run, provided that renewable energy is used, the spread of fuel-cell buses. Both bus types can be acquired yet at a relatively high price, however, their operation does not cost more than that of traditional buses. The use of hybrid buses may result in a reduction of fuel consumption by 30%, which can significantly reduce greenhouse gas emissions (www.volvobuses.com). Before introducing hybrid buses into regular-service operation, it is advisable to try these buses during a test period on potential lines to investigate on which line hybrid buses can operate the most economically.

Ljubljana, hybrid taxis

Ljubljana, the capital of Slovenia, has approximately 280,000 inhabitants.

When expanding its fleet, Rumeni Taxi of Ljubljana aimed at giving preference to the most environmentally friendly option in their choice of technology. Therefore, the company purchased three environmentally friendly vehicles in 2004 and in 2005; Toyota Prius cars were chosen. The taxis were equipped with a P-Box as well to increase the efficiency of engine power by optimising fuel injection system.

Besides an internal combustion engine, a hybrid car runs also on another, less polluting type of energy source. As a consequence, they do not mean as high an environmental load as traditional vehicles. Also, they are more silent and thus they help decrease noise pollution.

These measures met with great public approval. Certain environmental parameters and the extent of costs reduction are monitored also by the company. According to the first results, fuel consumption was decreased by an average of 1 litre/100 km with the use of the P-Box, which favourably influenced operational costs.

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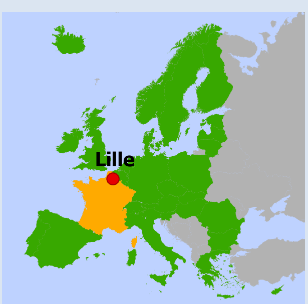
From a climate protection point of view, fuel-cell buses represent the most perfect solution since they do not emit greenhouse gases at all. However, the production of hydrogen is a rather energy-demanding procedure, and consequently, considering their entire life-cycle, the level of greenhouse gas emissions by hydrogen-driven buses is high except for the case when hydrogen is produced with the use of renewable energy (e.g. wind or hydropower). Purchasing fuel-cell buses and putting them into operation can only be carried out in part of integrated urban planning since their operation requires the existence of the hydrogen-filling stations. Until the construction of these hydrogen fuelling stations, the use hybrid buses can provide a proper alternative.

The Fuel cell
In the fuel cell, the reaction between oxygen and hydrogen gained from the air produces water and electric energy. To prevent the formation of dangerous detonating gas, the hydrogen and the oxygen gases are channelled into the narrow routes of the cell plates laid upon one another, and these two gases are separated from each other with a platinum-covered proton exchange membrane. Hydrogen molecules split into positive hydrogen ions (protons) and electrons on the anode plate of the fuel cell, and the protons migrate through the membrane to the oxygen atoms on the cathode plate. Meanwhile, the electrons remaining on the anode plate cannot cross the membrane but they must travel along an external circuit to the cathode, creating an electric current. The electricity so produced is converted into a 250-380 Volt current, and feeds the electric engine driving the vehicle. The fuel cells, like common batteries, produce electricity with chemical reactions; the difference is, however, that while batteries have to be disposed of after they are 'empty', a fuel cell keeps on working as long as it is filled with fuel.

There is another promising solution: the introduction of **biogas-fuelled buses**. Biogas may be produced at waste disposal sites and sewage works.
buses can operate the most economically.



Lille, Buses driven by biogas

Lille lies in the North of France. It is the fourth largest agglomeration centre in the country having approximately 1,150,000 inhabitants. In the agglomeration of Lille, in the so-called Big Lille, approximately 4 million passengers are registered daily, and 90% of this traffic takes place in the city. Since, according to estimations, both the population of the city and the number of travels will increase continuously in the coming years, it has become reasonable to rethink traffic development of the relevant urban regions, as well as to investigate the applicability of the different means to meet the rising travel demand in a sustainable way.

The 'Air and Rational Energy Consumption Act' accepted in France in 1996 obliged the cities with over 100,000 inhabitants to outline an 'Urban Traffic Plan'. The City Council of Lille drafted its Urban Traffic Plan in 1997, in which they aimed at supporting the use of energy resources resulting in lower pollution. The pilot project with biogas-fuelled buses was a part of this plan, too.

The goal was to run the urban and suburban buses on the biogas produced at the sewage treatment plant Marquette. Until 1990 15,000 m^3 biogas produced on this site was used to generate heat and energy for the treatment plant itself, while the remaining amount of 3,000 m^3 was burnt. From this, 1,200 m^3 was planned to be utilised as fuel. In 1995 a biogas cleaning system was installed on the site with a cleaning capacity of 100 m^3 biogas per hour and producing 50-55 m^3 bio-fuel per hour. This was enough to supply eight buses with bio-fuel by 1999.

In 2006, as a continuation of the project, a biogas power plant utilising organic waste was constructed in Sequedin (in the agglomeration area of Lille), with a bus depot next to it for 150 buses. This plant processes domestic and garden biowaste collected in special containers provided to every urban household. This biowaste (100,000 tons annually) is gathered weekly by refuse collecting vehicles that also run on biogas. Biogas is produced from biodegradable materials by fermentation technology, and then it is converted into biomethane fuel and transported to the nearby bus terminal. The buses tank once a day. They are more silent and emit less polluting material than traditional buses.

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Climate-friendly driving style ('ecological driving')

In the past decades, the engineering characteristics and constructions of vehicles have significantly changed, and most of the drivers have failed to accommodate to these altered conditions. 'Eco-driving' is a driving style which results in lower fuel-consumption during the same travel period.

The five principles of climate-friendly driving are:
– Shift into higher gears as soon as possible!
– Keep a continuous speed!
– Act according to the traffic!
– Brake carefully!
– Check the tyre pressure!

Climate-friendly driving can result in significant fuel-saving, and according to the European Climate Change Program, 50 million tons of CO_2 emission may be saved yearly in Europe through its widespread application. In 2000, following a climate-friendly driving style course organised at Austrian bus company NIGGBUS, fuel consumption was reduced by 5%, and this value was increased to 7% by 2001 (www.ecodrive.org). Other advantages of climate-friendly driving are that it can help substantially reduce repair costs and the number of accidents as well.

One may learn to adopt the climate-friendly driving style in several ways, e.g. with the assistance of a simulator downloaded from the Internet. However, it is more effective to participate in a 1-2 day course organized for this purpose.

Cities can contribute most to the mitigation of climate change if the largest possible part of drivers learn and adapt ecological driving. Since it is a cheap and effective method, 'poorer' cities may also afford to organize courses themselves and can popularize this method. The management of the city can decide whether to make participation in the eco-driving courses obligatory for those who drive the vehicles owned by the city; furthermore, they may choose to award premiums to drivers who manage to reduce their fuel consumption.

Helsinki, route planner and CO_2 emission calculator

Helsinki, the capital of Finland, has approximately 570,000 inhabitants. Including its agglomeration, annual CO_2 emission is approximately 1,300 kg / person.

The Helsinki Region Traffic Authority (HSL), within the framework of the JULIA 2030 project, published a route-planning interface on its website which shows the CO_2 emission by certain means of transports. As a basis, the calculator takes the direct emissions by buses and cars, as well as the CO_2 released from producing the electricity used to operate other vehicles in transport. The emission of walking and riding a bicycle is zero; so for instance, the food consumed by people is not taken into consideration. The emission of other greenhouse gases is converted into their CO_2 emission equivalents.

It is a rather interesting feature of this tool that the energy consumed during travel by different means of transport or by walking is not only expressed in SI units (kJ) but also in chocolate-slice equivalent.

Carbon dioxide emissions and calculation methods

Keskuskatu 2, Helsinki - Kuusitie 5, Helsinki

Mode of travel	Distance	Emissions	Annual emissions per commuter trip *	Annual emission reduction **	Energy consumption of walking and cycling ***
Route suggestion 1	4,8 km	0,4 kg	77 kg	117 kg	167 kJ / 40 kcal = 1 pieces of chocolate
Route suggestion 2	4,7 km	0,3 kg	75 kg	119 kg	167 kJ / 40 kcal = 1 pieces of chocolate
Route suggestion 3	5,4 km	0,4 kg	90 kg	103 kg	147 kJ / 35 kcal = <1 pieces of chocolate
Cycling	5 km	0 kg	0 kg	194 kg	523 kJ / 125 kcal = 2.5 pieces of chocolate
Walking	5 km	0 kg	0 kg	194 kg	1047 kJ / 250 kcal = 5 pieces of chocolate
Car	5 km	0,9 kg	194 kg	0 kg	0 kJ / 0 kcal = 0 pieces of chocolate

* Emissions have been calculated for a round trip, 220 working days a year.
** Emission reduction has been calculated by comparing the emissions of suggested routes to emissions from an average car.
*** Walking included in travel by public transport has been taken into account in the personal energy consumption.

The development of the calculator was supported from the fund of the LIFE+ program of the European Union (LIFE07 ENC/FIN/000145). The budget of the JULIA 2030 project was 2,146,230 euro, out of which a sum of 1,073,115 EUR (50%) was co-financing by the EU.

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Traffic regulation

Besides the efforts aiming to spread the theory and practice of the climate-friendly driving, cities have several instruments to enforce its practical adaptation by the participants of transport. Speed limitations are among these solutions, as well as traffic regulation measures aiming to eliminate frequent stops and restarts, i.e. supporting the continuous flow of traffic. From the climate-protection perspective, the **reduction of speed** is recommendable mainly along the roads connecting settlements where a difference in speed can be reached which results in a noticeable reduction in emissions. According to surveys, the difference between the driving speeds of 120 km/h and 80 km/h reduces fuel consumption and consequently, the emission of greenhouse gases, by 30% on average. Reductions in emissions could be best served by revising the allowed highest speed on exit roads.

In urban traffic it is (much) more important to develop regulation that prevents (traffic) jams and frequent stops in the flow of traffic. These efforts have already meant a significant guiding principle in traffic regulation; in this chapter we only emphasize them further because a more continuous flow of traffic lowers the levels of greenhouse gas emission by a city. The creation and application of **Intelligent Transport Systems (ITS)** makes it generally easier to realize these aims. The basis of these systems is that the information related to transport and traffic is provided to the users in real time. With a wide-spread use of ITS – according to prevalent professional opinion – greenhouse gas emission deriving from traffic may be significantly cut, but no research is at disposal regarding the precise extent of this reduction (SE Consult, 2009). Optimal travel routes may be planned with the assistance of ITS based on the use of road sections without accidents, errors, traffic jams. The use of ITS makes it possible for traffic lights at intersections to change always according to the given traffic situation, reducing emission of the greenhouse gases (and other air pollutants) by way of decreasing the occurrence of unnecessary waiting and restarting.

5.2. ADAPTATION POSSIBILITIES IN URBAN TRANSPORT

According to widely accepted scientific theories, the transport sector can be itself exposed to significant damage caused by climate change besides substantially contributing to it. In order to prevent this damage, all actors of transport have to adapt to the changing climate. If the necessary measures in adaptation are implemented on time, the extremities will not affect transport companies unexpectedly and there will be less obstruction to urban traffic. Since the effects of climate change are very different across Europe, the necessary adaptation measures have to be also regionally specific.

Since they belong to different authorities, the problems of public transport and those relevant to the road network are discussed below in two separate sections.

5.2.1. Preparing the public transport network for climate change

Due to climate change, more frequently emerging extreme weather events may significantly depreciate the conditions of public transport, through which they may seriously affect the life in cities. In order to prevent this, local transport companies (their contractors and owners) have to be prepared for extreme weather situations. First those specific effects of climate change have to be identified that can be expected to occur more often in the particular city. The compilation of a matrix may be a good method where different modes of public transport are listed in the rows and various locally relevant climate change effects are indicated in the columns. The expected potential impacts of weather events on particular sub-sectors of public transport can be then listed in the cells of the matrix. From among the various weather effects, especially summer heat waves and floods have be taken into consideration because of their significant influence on transport.

Summer heat waves

Until recently, summer heat-waves have been typical primarily in Southern Europe; however, as a consequence of climate change, they will occur increasingly often also in Central and Western Europe. Furthermore, people living in these regions are not accustomed to extremely warm periods, and as a consequence, the ever frequent heat waves are expected to pose a serious threat to health in these parts of the continent. Heat waves represent a particularly significant burden to the participants of public transport. According to surveys, the temperature within the vehicles of surface transport can be as much as 4°C higher in the rush-hours than outside. In case of an extremely high outside temperature, the 4°C difference can raise the temperature to a life-threatening level inside the vehicles.

In the event of a heat wave, in order to protect passengers, the following measures have to be taken:

– Considering public health aspects, **air conditioning** systems have to be installed in public transport vehicles where it is needed and feasible. However, in climate-friendly cities, air conditioners may only be used if certain conditions are fulfilled since their use will significantly raise the fuel consumption of the vehicles, and consequently, their greenhouse gas emission levels. It is a basic rule that an air conditioner may only be used when it is really needed, and in the cooler hours of the day, cooling has to be done by ventilation (airing). Nevertheless, the additional emission caused by air conditioning equipments can be still a reasonable compromise since lacking them can be indirectly more harmful: passengers, looking for more comfort, may shift to using their own cars, which results in more serious air pollution.

- When a heat wave comes, **drinking water has to be provided** at the stations.
- The heat wave can alter the regular daily rhythm of traffic, so when assembling trains, it is advisable to flexibly react to the changed needs, and to facilitate an optimal utilisation of vehicles in order to reduce greenhouse gas emissions.
- For the vehicles participating in – especially, urban – public transport, it is important to have **large, opening windows** besides air conditioning, which enhance the ventilation and the cooling of the vehicles for temporary periods.

Although, underground transport vehicles are partly protected against outside temperatures, it may cause a problem that the large amount of heat produced in the tunnel is replaced at a slower rate than necessary due to the equalization of the underground and surface temperatures. In order to eliminate this problem, ventilation has to be increased in the summertime. For the purpose of cooling (and in winter, for heating) underground stations, the construction of geothermal heat pump systems have mostly excellent conditions.

Furthermore, heat waves do not only influence the state of the running vehicles but also that of the **infrastructure**. Railway or tramway tracks can be deformed by heat, which can necessitate speed limitation or temporary track closures. As a consequence, delays may occur, which also weaken the competitiveness of public transportation modes. Proper shading techniques can help reduce the extent and the occurrence of deformation caused by heat in the elements of the infrastructure; this practically means planting trees close to the tracks, planting grass between the tracks and using a material to build railway and tramway rails that are more resistant to changes in temperature (i.e. an alloy that has a lower thermal expansion coefficient). This measure – if it involves a bigger area – can have a favourable influence on the microclimate of the city. A further possibility is to cool the rails with sprinkler cars, although in dry weather, this can be feasible only in the busiest rush-hours.

Stations are important elements of public transport. When constructing them, changed climatic conditions have to be also taken into consideration. Flow-through ventilation, the structural design of the buildings and the formation of parks have to be carried out as described in Chapters 4 and 7 of this handbook referring to green areas and architecture.

Floods, storms

Floods mean an evident risk in case of towns located close to rivers. Underground tunnels in the lower lying areas and floodplains can be flooded; and the access to stations and platforms of surface transportation modes can become also obstructed. In settlements threatened by flood, it has to be investigated which are those sections of roads and tracks that are prone to flooding, and – if possible – it is advisable to raise the level of these. It is recommended to prepare an **emergency plan** in case certain sections of public transport have to be closed because of a flood. Alternative routes of public transport lines as well as substitute vehicles can be planned in advance. When designing this alternative public transport network and schedule, the changes in transport needs due to flooded sections have to be taken into consideration, too. These all may seem a small issue, but in case of emergency, these measures can help the situation so that the life of the city does not turn upside down even amidst extreme circumstances. Those parts of the infrastructure where there is a danger of wash-out, continuous attention has to be paid to, and the dams have to be strengthened. In the stations, the diversion of the redundant water has to be taken care of; Chapter 8 on water management provides some guidance concerning climate-friendly ways of doing that.

5.2.2. Development of the road and sidewalk networks

A significant part of urban traffic takes place by individual means, in cars using the road network of the city. Bus traffic, as a definitive component of public transport, also uses these roads. When a part of the urban road network suddenly becomes inoperative, this brings an extraordinary mess and upsets the life of the whole city, which situation can be further aggravated by the destruction of the sidewalks. Extreme weather can strongly influences these systems.

Summer heat-waves

During summer heat-waves, high temperatures can start melting the asphalt cover. This, on the one hand, disadvantageously influences traffic, and in extreme cases, may require the closure of certain road sections as well as the restriction of public transport using those; on the other hand, the scorching asphalt surfaces may further heat the already hot air of the cities.

The load bearing capability and wear resistance of asphalt depend on temperature. In high temperature range, above 30°C plastic deformation is more probable, this means that asphalt melts. The temperature of the asphalt surface much exceeds that of the air. Depending on the extent of radiation, on an average summer day, when the maximum temperature is 25°C, the temperature of asphalt may rise to 40°C. Temperatures above 50°C are not infrequent in the event of heat-waves. At such high temperatures, the rigidity of asphalt is over 20 times lower than it is at 10°C, and is still three times lower than at 30°C. However, the degree of deformation in the asphalt surface depends significantly on the composition of the asphalt mixture. Although it is true that the actual differentiation in rigidity between different compositions decreases along with temperature increase, there still remains a two-fold difference between the most and least rigid asphalt mixtures (L. Pethő, 2008). Of course, during winter time these differences would be favourable in just the opposite way. Naturally, choosing the size and the asphalt surface of the roads does not belong under the competence of city management but is the task of the professionals. However, the city can include these aspects as requirements in their calls for tenders in road planning and renovation; and what is more important, it is recommended for the city to cover the additional costs resulting from the use of better-quality asphalt.

In addition, it is advisable to make the surface of the road sections more resistant against heat where there is a higher point loading, e.g. in bus stops or at junctions. Shading the roads prevents the asphalt surface from heating up. As in many other cases, planting trees along the roads can offer a solution here, too.

Most of the sidewalks are typically made of asphalt as well. In places prone to experience heat-waves, the consideration of alternative pavement of sidewalks is recommended. According to surveys, walkways made of concrete get warm much slower in the summer than asphalt. In the hottest summer midday hours, when the temperature of asphalt may rise to 50°C, concrete heats up only to 25°C. A further advantage of concrete is its lower thermal sensitivity, meaning that it resists heat without any damage (www.terko.com). For sidewalks, too, shading, possibly by planting trees has a great significance.

Floods, storms

As a consequence of floods and sudden storms, part of the road and sidewalk network may be covered by water for a longer period, which may result in the closure of certain road sections in an extreme situation. Unlike in the case of floods, where it may be predicted which sections will be more affected, road sections potentially endangered by storms are more difficult to identify. In cities where storms can be expected to become more frequent, furthermore, where there is a higher likelihood of rainfall onto a cold surface in winter it is absolutely necessary to apply water permeable surfaces. Thus a puddle-free surface may be created with several climate-friendly characteristics. On the one hand, the chance of dangerous frost is reduced in the winter, on the other hand, this permeable surface does not close the groundwater system and the flora and fauna of the soil hermetically from surface precipitation.

From among the different building materials of sidewalks, bricks, loosely laid stones, concrete pavement blocks with enlarged joints, and granular road cover without binding material have favourable water-permeability characteristics. Considering the purpose of sidewalks, it is not a disadvantage that the load bearing capacity of these surfaces falls behind the commonly used asphalt.

BRIEF RECOMMENDATIONS

– Construction of climate-friendly, sustainable urban transport by means of reducing motorized transport needs.
– Preparation of an urban mobility plan.
– Reduction of emerging travel needs, and serving them more effectively and sustainably.
– Enhancement of the energy efficiency of the means of transport (e.g. raising the proportion of low-emission vehicles), promoting environment-friendly modes.
– Stimulating the use of alternative, environment-friendly (e.g. bicycle) means of transport instead of motorized individual transport modes.
– Development of the public transport system (of perfect quality, easily accessible, providing quick transport, and has regular frequency), making it attractive and creating a wide spectrum of needs, and widening its use in the city.
– Establishing large P+R parking lots and bicycle storage places (B+R), close to the stations and terminals of the railway lines in the agglomeration and suburban areas at low and zone-specific prices.
– Instead of constructing hard, isolated infrastructure (e.g. non-interoperable metro /underground), focussing on inter-operable rail transport (light rail, tramway, use of railway in urban transport).
– Introduction of traffic reducing measures.
– Forming traffic regulation which results in lower emission levels.
– Establishment and use of Intelligent Transport Systems.
– Creating and operating urban consolidation centres in order to make urban freight transport more climate-friendly.
– Preparation of the public transport network for extreme weather events (heat waves, floods, and storms).

6. LOW CARBON ENERGY MANAGEMENT OF THE SETTLEMENT

Reducing greenhouse gas emissions, improving energy efficiency and increasing the role of renewable energy play a significant role in the energy policy of the European Union. The target is to decrease total energy consumption by 20% by 2020, and to further increase the proportion of the renewable energy in the final energy consumption of the EU to 20%. In order to reach these targets and reduce greenhouse gas emission to different extents in different member states, increasing the use of renewable energy and improving energy efficiency are also crucial tasks in settlement level energy management.

Being part of the national network settlement energy management is constituted by those individual and other energy systems and subsystems whose regulation and physical variation can be influenced at the settlement level. Accordingly this chapter introduces possibilities, ideas and concrete examples for the amelioration, conversion and regulation of settlement level energy production and supply systems. Energy effiency refurbishment of public buildings, the improvement of energy efficiency of district heating, public lighting and other public utility systems belong to this topic as well. Individual applications (e.g. energy efficiency development of the residential buildings) and suggestions for the use of certain renewable energy sources in transportation are introduced in Chapter 7 on architecture solutions and Chapter 5 on urban transport.

Settlement level energy management is mainly connected to the mitigation of climate change, since improving energy efficiency and increasing the share of renewable energy sources in the local energy mix result in the decrease of greenhouse gas emissions. Options regarding adaptation are much more narrow in settlement level energy management. One example is the conversion of energy provision systems in order to reduce vulnerability against extreme weather events that are expected to occur more often in connection to climate change.

In the case of energy modernizations and energy system improvements the aggregate effect of numerous aspects determines the real economic profitability of individual investments. The role of expenditures is lower here than in the case of traffic related improvements, since decrease in the safety of energy supply in itself can cause material damage, which exceeds manifold the cost of the initial investment. On the other hand better utilization of local energy resources reduces not only the one-sided dependence (both from financial and supply safety aspect) but can create new jobs and contributes to economic development as well. Apart from naturally considering other indirect economic effects, for example the decrease of costs incurred due to environmental loads and economic development due to savings, etc., determining the relation between investment costs and real profit is perhaps the most complicated in the energy sector. At the statement of profitability of the individual projects, related investments also play a significant role, therefore in most cases no general judgement can be made about a solution.

The implementation of mitigation measures in the mid- and long-term contributes to reducing the dependence of the EU on external energy sources, it may contribute to reducing the energy costs of local municipalities. Furthermore, mitigation measures may assist the strengthening of local cohesion, increase employment and the competitiveness of the region. Therefore the implementation of mitigation measures and co-benefits deriving from them largely overstep climate protection considerations.

6.1. MITIGATION OPTIONS IN SETTLEMENT LEVEL ENERGY MANAGEMENT

Climate conscious conversion of energy management of settlements – through the reduction of the emission of greenhouse gases – could significantly contribute to the mitigation of climate change. Mitigation possibilities may be put into two groups that are strongly connected to each other, at the same time can be clearly distinguished. One can be achieved through the increase of energy efficiency and savings by updating existing energy systems, as well as rational energy management and the decrease of energy end-use. The other main group of the mitigation options concerns the wider application of renewable energy resources that makes it possible the reduce the use of fossil fuels and thus leads to the reduction of greenhouse gas emissions. In order to reach these targets it is the task of the settlement management to develop an energy conscious settlement management system. This should be in accordance with the integrated urban development plan of the city and contain plans, financial and regulatory measures relevant to all energy related activities belonging in the competency of the settlement.

6.1.1. Energy-conscious settlement-management

Energy consciuos settlement management may be separated into two major action direction. The first and probably the most important is the shaping of an appropriate approach, which incorporates both decision-making as well as operation. The other target – deriving from the aspect changes – is the enforcement of technologies of high energy efficiency and energy-efficiency as horizontal principle both in the own activity of the local government and in case of other local economic actors including public institutions and households of the settlement. The third target is the promotion and incentivisation of the use of renewable resources to the possible greatest extent. Taking maximum considration of the aspects of these three targets the settlement management system can help to improve energy-efficiency significantly, which will lead to the reduction of energy consumption and reduction in the emission of greenhouse gases. All these aspects must be integrated into the public procurement process and supporting systems. Furthermore, they have to be taken into consideration when choosing technologies and materials applied in investments and during the operation of various machines and equipment. These action directions in settlements are equally valid for households, private and community services as well as for production activities.

Means of the energy-conscious settlement-management (Municipal Energy Efficiency Program of the City of Vienna, 2006-2015):

Development of an energy strategy

- In order to determine the objectives of the energy strategy a detailed situation analysis is to be carried out, by which the characteristics of the energy consumption of the settlement as well as the carbon dioxide and GHG balance shall be reveale. Furthermore the energy-saving and renewable energy potential of the settlement shall be defined.
- Determination of future vision and objectives of the settlement energy system; development of the energy supply and energy utilization options and choosing the most favourable for the settlement.
- Objectives conceived in the energy strategy have to be integrated with sector specific and horizontal (e.g. local transport, urban development, environmental, sustainability) strategies.
- As a part of the energy strategy, proposals shall be developed for the enforcement of aspects defined therein and for mainstreaming with other development documents. The integrated development plan of the settlement must be included in the latter by all means.

Energy conscious land use planning and local building regulation

- According to the principles and objectives set forth in the energy strategy for the enforcement of the energy efficiency and energy saving aspects (e.g. planting of tree rows for wind cover, orientation of street networks, modification of building regulations) revision of the land use plan and redesigning of the local building regulation is proposed.
- During obtaining the license of the building authorities the erection of buildings of low energy-use and the active (e.g. additional heating by solar collector) and the passive (e.g. orientation of buildings) utilization of renewable energy resources shall be preferred.
- In case of constructions or renovations the utilization of renewable energy resources should be made compulsory or incited in order to ensure the possible widest application – in consideration of the features of the settlement.

Redesigning of the local regulatory environment along the lines of energy conscious operation

- The cut-back and elimination of legal and administrative restrictions eventually hindering energy-efficiency and renewable energy investments is of primary importance, as well as the establishment of a climate-friendly statutory environment.
- Application of environmental and energy certification standards of suitable quality during operation of community organizations and buildings.

Continuous tracking of energy supply and use

- Continuous metering, tracking of the energy consumption and other relevant characteristics (technical characteristics, number of building users, function of the building, temperature data, volume and source of used energy, etc.) of municipal institutions.
- Establishment of an interactive, publicly accessible energy monitoring system for the entire settlement, based on geographical information system, equally comprising the data of the individual institutions, households and economic actors, in which the energy production and consumption practices, data characteristic for the entire settlement may be tracked.

Establishment of a financial incentive system supporting the application of sustainable energy solutions

- Redesigning of the local tax and fee system, elaboration of benefits for sustainable energy solutions (including energy efficiency and renewable energy).
- Elaboration of a support options for the increased application of renewable energy resoruces and for the promotion of energy efficiency investments.
- Establishment of a ‘green public procurement system’.
- Establishment of a ‘climate fund’ for the settlement.
- Loan guarantee.

Awareness raising and information provision

- By organizing information campaigns and launching model projects successful energy efficiency and energy saving projects can be presented. Furhtermore, informing inhabitants and influencing consumption habits are also of great importance.
- The local government of the settlement can provide technical, legal, financial and tender advice to potential investors with regard to utilization of renewable energy sources and energy management. This contributes to information provision about sustainabel energy related objectives of the settlement, local resources and support possibilities.

Barcelona, Solar Thermal decree

Barcelona is the second largest city in Spain, with population combined with the agglomeration exceeding 3 million.

Barcelona was the first city in Europe that by a decree obliged house builders and owners engaging in building renewals by a decree to use solar energy. The draft of the so called 'Solar Thermal' decree was elaborated in 1998 and was accepted by the town council in 1999. The legal provision came into force in 2000 after a one-year moratorium.

The decree required first in case of buildings of an annual energy consumption exceeding 292 MJ, commercial buildings and buildings consisting of more than 16 apartments that in case of reburbishment or new building at least 60% of hot water demand should be produced by solar energy. Additionally the decree made obligatory that the complete heating demand of swimming pools must be covered from solar energy. Collaterally with the decree a support program was introduced for the owners and operators of smaller buildings to incite the increase of solar energy utilization. In 2006 the decree was modified, accordingly the annual limit of 292 MJ was revoked and the decree was extended to all new buildings or buildings to be refurbished, independently of the size or character of the building.

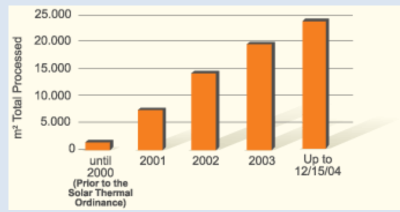

Figure 11: Change of the area heated by solar energy in Barcelona due to the "Solar Thermal' decree

As a result of the project annual carbon dioxide emission decreased by approximately 5,640 tons. Besides the sustainable energy modernization of privately owned real-estates the decree obliged also buildings of community ownership to utilize solar energy. By implementing these changes the city saved 220,000 EUR in operation costs due to efficiency improvments. Through the entry into force of the decree annual output of solar collectors reached 32,076 MWh. The energy agency of Barcelona city supports the implementation of the decree through education and information programs, counselling, and by engaging in continuous monitoring and controlling activity.

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6.1.2. Energy-efficiency and energy-saving measures, investments

Energy efficiency modernization of public buildings

Energy efficiency modernization of buildings is one of the best options for reducing energy use. The first step is to assess the energy consumption of municipal and community buildings. The second step is their modernization, taking into consideration the requriements of energy effciency. Chapter 7 of the handbook provides the details on refurbishment options. These are organized in a separate chapter as the modernisation of buildings appear mostly as individual interventions and no considerable differences can be identified between the energy efficiecy modernization of public and privately owned buildings. Energy efficiency modernization of buildings is characterized by long pay-back periods, meaning that resulting financial returns often occur only after a decade. At the same time their positive environmental effects manifest immediately after the completion of the investment. To support such investments it is necessary to develop central financing schemes and to establish loan-guarantee systems.

Improvement of the energy efficiency of public lighting

Modernization of public lighting is an important step in increasing energy efficiency at the settlement level. As part of Directive No. 2005/32/EC, accepted by the European Committee, Decree No. 245/2009/EC on environmentally friendly planning requirements of different lighting sources, forecasts energy-savings of approx. 38 TWh until 2020 for products under effect of the Decree. Within this framework inefficient lightbulbs and lighting fittings will be gradually withdrawn from distribution. Consequently, modernization of public lighting systems will become inevitable.

In order to improve energy-efficiency traditional light bulbs and lighting fittings used in public lighting systems shall be replaced by sources characterized by low energy consumption (e.g. sodium lamps, heavy-pressure sodium lamps, LED lamps). Furthermore, lighting fittings designed according to energy efficiency consideration shall be developed to enable sufficient focusing of the light source to minimize light loss.

Auroralia-prize

The prize was established by LUCI (Lighting Urban Community International). The organization was founded in 2002; its members are 63 cities from 4 continents, as well as emerging communities in urban public lighting, universities, public lighting experts and representatives of the lighting industry. The prizes are awarded in Lyon, France to cities that apply innovative solutions besides the incorporation of sustainability aspects. Application are judged by an international professional jury, with members coming from different parts of the world.

Applications are examined on basis of energy consumption, carbon dioxide emissions, total cost of the project, resources necessary for the production of the lighting system, transport, possibility of recycling, originality and beauty of the conception, its impact on the dwellers' life quality, social and cultural effects, health protection, improvement of the night view of the city and incentive effect of the project on other cities.

In 2009 the municipalities of Berlin, Lyon and Westminster won the high level award. In 2010 the first place was awarded to Budapest, the second place to Geneva and the third place to Tilburg in Holland. The first received 6,000 EUR, the second 3,000 EUR and the third 1,500 EUR.

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In recent years LED-technology has significantly developed. The positive features of this technology are low consumption and prominently high service life, reaching even 100,000 hours. Those features enable the economic use of light sources connected to the electricity network or utilizing solar energy in public lighting systems. Installation of solar public lighting lamps is rather expensive, however their operating costs are very low. Therefore their installation is reasonable in areas where no electricity network is available.

Brasov, modernization of public lighting

The city of Brasov is located in the middle area of Romania in the Eastern edge of the Transdanubian basin, at the piedmont of the South Carpathian Mountains, with a population of almost 350,000.

In order to reduce settlement level energy consumption the local government of Brasov initiated the modernization of the public lighting system in 2002. Public street lighting as well as the decorative lighting of certain buildings was partially renewed. As a result of the investment the city saves yearly approximately 2,004 MWh of electricity, which is about a fourth of the earlier energy consumption. This means an annual saving of approx. 163,000 EUR, together with the annual saving of 70,000 EUR due to the reduction of maintenance costs. Total costs of the modernization amounted to 500,000 EUR, financed completely by the local government. In consideration of the significant savings, the investment amount will return very soon, thus the investment generates remarkable economic advantages besides the environmental advantages.

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Modernization and establishment of district heating and cooling systems

Heat supply of buildings is accompanied by significant greenhouse gas and air pollutant emissions. Therefore improvement of the energy efficiency of heat supply is of primary importance for the mitigation of climate change. One possible solution is the establishment or modernisation of the district heating infrastructure, as it is characterized by essentially lower emission levels – in ideal cases – compared to individual heating., Furthermore the required energy can be produced more efficiently as part of combined heat and power (CHP) generating plants.

The advantages of district heating include:

– removing the heat source together with the associated heat and air pollution from the densly built interior zone area;
– ability to utilize large or exptensively large quantities of renewable energy and waste-to-energy sources that is impossible to do for individual consumers;
– more efficient energy utilization compared to individual and small consumers;
– in optimal case ability to supply not only heating but also air conditioning energy demand by renewable and waste-to-energy resources.

However, district heating systems can be rather obsolete – especially in the former socialist countries. Substantial losses may thus incur in insufficiently insulated apartments, as well as in out-of-date power plants and dilapidated infrastructure. These factors considerably deteriorate the environmental performance and competitiveness of such systems. Complex modernization including all elements of district heating systems is necessary to solve this problem. Proposals in this section focus on increasing energy efficiency of power plants and supply networks only. Energy efficiency refurbishment of apartments supplied by district heating does not significantly differ from that of apartments supplied by individual heating; therefore proposals for their modernization are discussed in Chapter 7 of the Handbook.

Diversification of energy sources must be a key consideration during modernization. For this purpose the possibility of utilization of renewable energy sources has to be explored (see Chapter 6.1.3 'Utilization of renewable energy sources at settlement-level'), as well. Out of the latter utilization of solid biomass and biogas ensures the best possibility to establish a district heating system. However, in areas characterized by suitable geological conditions geothermal energy can also be used. By application of renewable energy sources autonomous central heating plants can be established at the settlement level. These plants are independent of external energy sources and improve the competitiveness of the local economy by producing energy resources on site. They can contribute to the reduction of operation costs of public institutions. Furthermore they can increase own revenues of the local authority, if the district heating plant is in the ownership of the municipality.

During modernization of the district heating infrastructure the distribution system of the produced heat energy has to be optimized. Attention must also be devoted to the insulation of transmission infrasturcutre to the highest possible efficiency level, and to ensuring energy efficiency of the distribution centres.

Bansko, biomass central heating plant

The Bulgarian city of Bansko (with a population is approx. 10,000) is located approx. 150 km to the South of Sofia, the country capital.

The city of Bansko initiated the establishment of a district heating system based on solid biomass (especially silvicultural waste) in 2005. The aim of the investment was the setting up of an environmentally friendly heating system based on local energy resources with low cost demand.

The first block of 5 MW was handed over in 2005. In 2007 as the second phase of the investment another block with a capacity of 5 MW heat output was built. The woodchip-based central heating plant with a total output capacity of 10 MW supplies heat to 25 private buildings (hotels, dwellings and a church) and 20 municipal buildings, including schools, the kindergarten as well as the city hospital and museum.

The investment ensured remarkable advantages for the settlement, including economic and pollution reduction related benefits. Since commissioning of the central heating plant energy costs were reduced by approx. 50% and emission of pollutants decreased by 50%. It successfully saved annually more than 4,500 tons of carbon dioxide, 1,300 tons of methane, 1,700 tons of nitrogen oxide and more than 1,600 tons of sulphur dioxide. This can be regarded as a highly substantial result.

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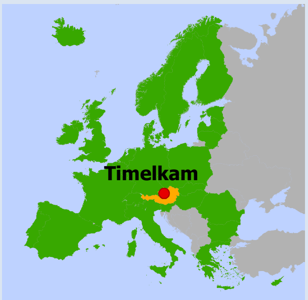
Combined generation of heat and power (CHP)

Energy efficiency and competitiveness of district heating is greatly increased by the use of up-to-date cogeneration power plants. The essence of the technology is that power plants produce both electricity and heat simultaneously. Consequently two-thirds of the heat generated by traditional electricity production as waste heat may be still utilized. As a result efficiency of such equipment is extremely high, reaching 80 to 85% (35 to 40% electric, 45 to 50% thermal efficiency). Any energy resource used in heat production is suitable for establishment of the cogeneration system; accordingly it can be operated also by renewable energy resources.

The produced heat energy is gained in the form of steam or hot water. The transmission of heat to more remote locations is a more difficult compared to that of electricity. This is the reason why cogeneration power plants are primarily suitable for meeting local heating needs (heating and cooling of buildings, technological heating, water heating, district heating supply, etc.). For economical operation of these plants the existence of facilities in their proximity characterized by appropriate heat demand is crucial.

The high efficiency of the cogeneration systems can only be achieved if the produced heat energy is utilized. This can only be easily ensured during the heating season, however this condition is not unconditionally fulfilled during summer time. So-called trigeneration systems providesolution to this problem. They are suitable to satisfy the cooling demand of buildings and to reduce air humidity content by utilizing the produced heat via absorption technology. District heating systems can also be established using this technology, at the same timeas a result of efficiency reasonsit is better suited fornew buildings originally palnned to be connected to district heating, In other cases the cost of redisigning heating and cooling systems of buildings in order to be connected to the network can be exessivly high.

Modernization of power plants mostly exceeds the financial possibilities of settlements and settlement associations. At the same timedistrict heating is a key operative element of urban life. Therefore the local government is a primary stakeholder in developments concerning the district heating system, even if the investment is implemented by the state or a private company. Consequently the local government (among other stakeholders) can play a significant initiator role in suchinvestments. It may propose the modernization of the power plant to the owner (which may be the state), and it can participate in such tenders as a partner according to available means.



Timelkam, cogeneration power plan

Timelkam is a small city located in Upper-Austria, North of Attersee, with a population under 6,000.

The city of Timelkam in Upper-Austria can be regarded as a significant energy centre, as sevarl power plants are operating in the city. These power plants play an important role in the electric power supply of the entire province. Furthermore they supply district heating services for the city of Timelkam. In recent years significant investments were implemented for increasing energy efficiency, as well as for reducing pollution and greenhouse gas emissions. Within this framework the old, coal-fired power plant operating since 47 years was replaced by a state-of-the-art combined cycle, natural gas fired cogeneration power plant. Even though the new plant not based on renewable energy, it has a a remarkable advantage from the aspect of climate protection: it was implemented by the reconstruction of a rather obsolete coal-fired power plant, thus providing an example for the possibilities inherent in the modernization of less efficient, obsolete technology.

The electric performance of the new facility, established as a result of the project, is 405 MW producing capacity for electric power of 2,400 GWh yearly. Thiscan cover the needs of 700,000 households. At local level it is an essentially better result that the power plant supplies the heat energy for the urban district heating system. Heat performance of the power plant is about 100 MW, while the yearly produced heat quantity reaches 140 GWh.

From an environmental aspect a major advantage of the replacement of the former coal-fired power plant is that it significantly increased the efficacy of the power plant (59%) and the CO_2 emission per 1 kWh electric power decreased by two thirds. In addition the sulphur and nitrogen oxide as well as the particular matter (PM 10) emissions of gas-fired power plants are substantially lower.

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6.1.3. Utilization of renewable energy resources at settlement level

Under renewable energy resources we understand those wherethe available quantity continuously renews or reproduces. Energy resources may differ according to whether they are unconditionally and conditionally renewable. The first category includes energy resources available in unlimited quantity, such as geothermal, solar, wind, tidal and hydropower. Conditionally renewable energy resources – the reproduction of which requires human intervention – comprise biomass, waste and hydrogen.

In the last decade utilization of renewable energy resources has gradually increased in the European Union. By the Eurostat the total renewable energy production in 2008 exceeded the quantity of 148 million toe (ton of oil equivalent). This represents a more than 50% increase compared to the value in 1998 and exceeds 17.5% of the total energy production of the EU27. Among renewable energy resources the highest proportion was achieved by biomass and waste based energy production (69%), followed by hydropower (19%) and wind energy (7%). Utilization of geothermal and solar energy was relatively lower, reaching 4% and 1% respectively.

Priorities and action areas of the European Energy Policy accepted in 2007 aim at the implementation of three central founding principles: achieving sustainable development, increasing competitiveness and safety of supply. The achievement of these goals is greatly facilitated by the increase of utilization of renewable energy resources, inducement of the local economy, decrease of pollutant emission and reduction of energy imports. The so called 20-20-20 rule is a part of the Energy Strategy. According to itthe EU aims to reduce its greenhouse gas emissions by 20%, increase the proportion of renewable energy resources within final energy consumtion to 20%, and to improve energy efficiency by 20% until 2020. The Directive on Renewable Energy Resources accepted in 2009 serves as an instrument to fulfill these objectives.

The action directions set out in the Directive on Renewable Energy Resources requires decisively national level actions and measures to be determined in the national action plan. At the same time considerable results can be achieved at settlement level by local measures. These include the simplification of licensing procedures, promotion of knowledge transfer as well as active participation in investment or promotion of inducement.

It is abasic principle that individual renewable energy resources have to be utilized not individually, but in a complex way, by establishing a so called ‘energy mix’. Thus a stable energy system can be developed, which is less exposed to weather conditions and to constraints specific to the given energy resource. In smaller size – in case of small and middle-size cities – the development of an autonomous energy system can be targeted. This would ease external energy dependence of the settlement and ensure possibility to support the local economy and to develop competitiveness; Furthermore it would contribute to achieving social objectives. Renewable energy resources are particularly suitable to be included in such complex, diversified energy systems.

Güssing, establishment of an autonomous energy system

Güssing is located in the south-eastern part of Austria, in the district Güssing, near to the Hungarian border. Its population is about 4000.

Objectives of the project included development of the local economy, decreasing dependence on fossil fuelss, increasing competitiveness and employment creation. In 1988 the region of Güssing was one of the poorest micro-regions of Austria. Reason for this included the unfavourable location of the region, lack of larger industrial factories and the low number of jobs. In compliance with the decision passed in 1989 the settlement targeted entire independence from fossil fuels. Consequently, in coming years energy consumption of buildings in the settlement was optimized, enabling the city to achieve an energy saving of 50%.

Furthermore several heat and electric power plants relying on sustainable energy sources were established. Within the framework of the project the following facilities were built in the micro-region:

- wood fueled district heating plant in Güssing. the generated heat warms water in the central heating boiler, which is transported to consumers through well insulated transmission lines;
- cogeneration biomass power plant in Güssing that produces electricity and heat by innovative wood gasification technology;
- photovoltaic solar installment in Güssing;
- biogas installment in Strem producing thermal and electric energy from vegetable matters (corn, clover, grass);
- more than 20 biomass district heating plants in the district of Güssing.

The result of the project is an autonomous local energy system. The current degree of self sufficiency in the town of Güssing regarding heat and electricity is 100% (private households & public buildings). The Eureopean Center for Renewable Energy is an international accepted organisation which develops sustainable regional concepts. Güssing became an important research center with the focus on wood gasification technology. Several elements of the project were partially financed by the European Union.

As an effect of the complex local energy-management project the number of jobs and enterprises increased in the micro-region. Only in Güssing 50 new companies and 1,000 new jobs were created since the beginning of the project. This can mainly be attributed to the stable, calculable energy supply, which is cheaper compared to world market prices. The great number of created jobs improved manpower retention ability of the region. In connection this the formerly rather high commuter rate (70%) decreased.

The energy facilities decisively use local agricultural and silvicultural base materials. The fact that they rely on base materials produced locally led to the creation of new jobs. Furthermore old jobs became more stable. In addition to this conference and eco-tourism activities increased in the cityas a lot of people are interested in the good example. Sustainability is a key principleboth in the case of agricultural andsilvicultural activity. Plants are not cultivated in monocultures, accordingly the soil is able to regenerate. Attention is paid also to the appropriate renewal of the forest stand.

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Integration of renewable energy resources into the local energy management system and the establishment of the autonomous local energy system requires appropriate preparation. In order to identify all possible renewable energy resources a detailed survey of potentials is needed exploring the extent of the expected energy production for each kind of energy resource. Such a survey is necessary in order to define the conditions satisfying the emerging needs. The complex, diversifiedlocal energy management system has to be established by using the results of this survey, taking into account the aspects of climate protection, sustainability, energy efficiency and supply safety. This practice facilitates the improvement of economic competitiveness of the settlement, contributes to decreasing energy poverty, and improving climate protection.

Solar energy

Areas in Europe which are most suitable for utilization of solar energy are located in the basin of the Mediterranean Sea, as well as on the Iberian and in Balkan penninsula. Naturally this does not imply that the middle and Northern territories (except from the most Northern areas: the Norwegian and Scottish coasts) would not be suitable for the utilization of solar energy. The quantity of solar energy per square meter exceeds 1,000 kWh on average in Europe. The application of solar power systems is possible in most parts of the territory of the European Union. This is especially true in the case of more efficient solar collector systems. At the same time withphotovoltaic systems of 1 kW peak performance more than 750 kWhs of electricity can be produced in most parts of the EU.

The extent of solar energy utilization is continuously increasing in the European Union. Despite of this fact, according to Eurostat data, the share of solar power within total renewable energy production hardly exceeded 1% in 2008. The sspread of solar power is hindered by high initial investmentcosts and rather low efficiency, characteristic for photovoltaic systems. For compensation of these factors various support systems are applied in the EU-member states on the basis of Directive No. 2001/77/EC. Direct price support schemes(in case of electricity production) and investment support mechanisms are the most frequent forms of incentives.

Utilization of solar energy may occurin passive or active manner. The essence of **passive solar energy utilization** is that available solar energy can be utilized to the possible greatest extent without separate supplementary equipment, machines and tools, merely through the application of appropriate architectural orientation, as well as shading, efficient building insulation and suitable structural building materials. This way energy use can be reduced and energy efficiency may be increased. Passive solar energy utilization mainly facilitates the improvement of energy efficiency of the buildings. At the same time for example throughsuitable orientation efficiency of active systems can be increased as well.

Active solar energy utilization is constituted by those application modes that indirectly (e.g. solar collectors, solar power plants) or directly (e.g. solar cells) utilize the energy of sunshine. The most widespread application is heat generation by solar collectors, which is able to ensure the heating and hot water needs of residentialand public buildings. Furthermore electricity generation by solar cells is mainly suitable for smaller appliences. Both solutions are perfectfor smaller, decentralized and local energy production, and therefore constitute a key element of settlement level energy systems.

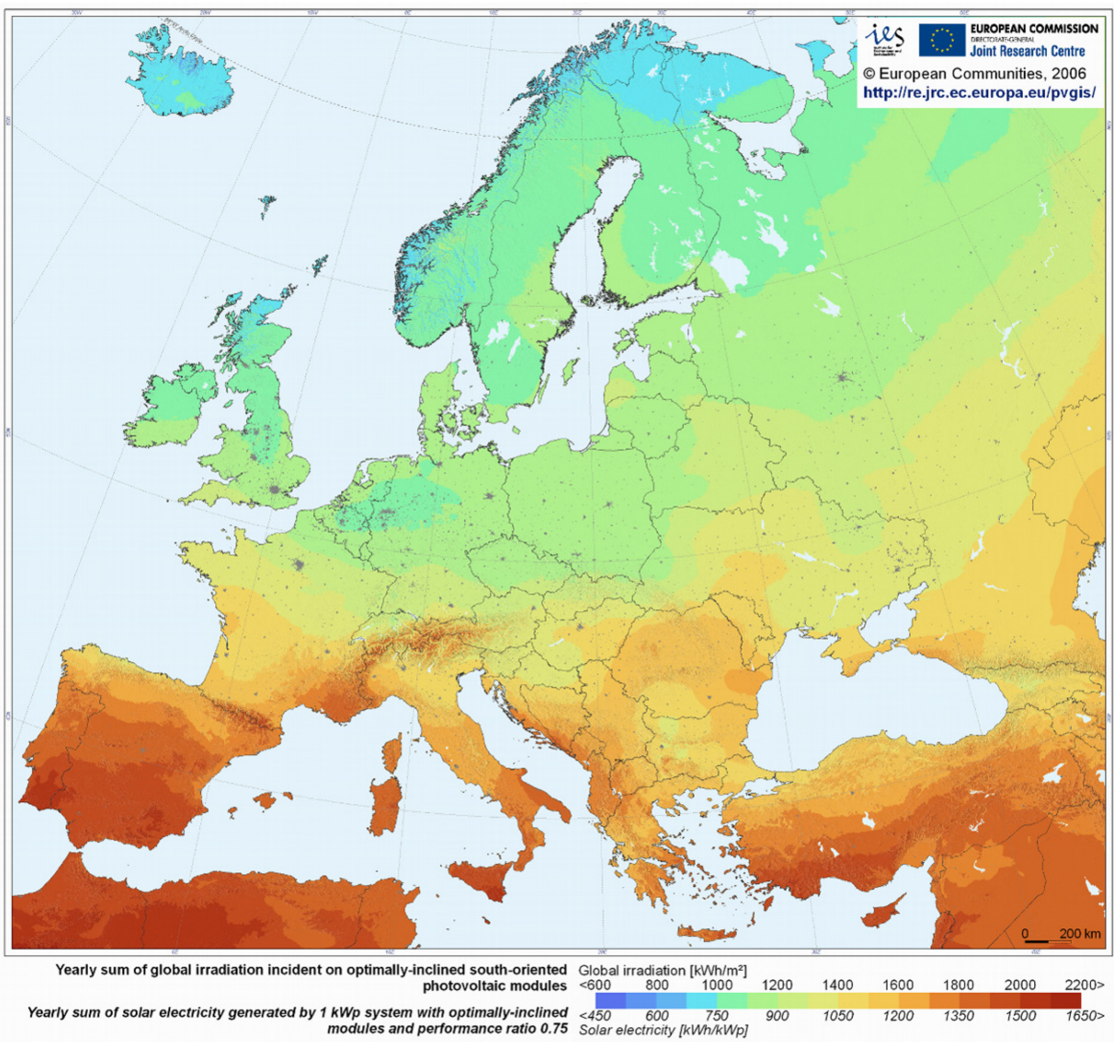


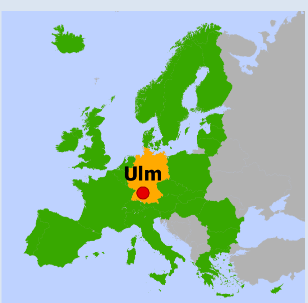
Figure 12: Extent of global irradiation and photovoltaic solar energy potential in Europe (source: sunbird.jrc.it/pvgis/)

The essential feature of **heat production by solar collectors** is sunshine warming the liquid circulating in the collectors. This in turn transfers the heat to heating and hot water systems of the building. This solution is primarily suitable to increase building energy efficiency. Solar collectors can be installed in clusters as part of energetic modernization of buildings. The installation of solar collectors – compared to heating based on traditional energy sources – is relatively expensive. However their operation carries many benefits and the expected service life of such systems is high, thus facilitating the return of the investment. Solar collectors can play an important role in the energy system of the settlement by improving energy efficiency of rbuildings in the community and of buildings owned by the local government. Installation of solar collectors on public buildings as a tool of energy-conscious settlement management can be a good example to the population and other investors. and can promote widening the application of this solution.

During **photovoltaic energy production** the semi-conducting material of solar cells transforms the energy of sunshine and light directly into electricity. The efficacy of solar cells is still rather low and their installation is very expensive At the same time due to electric power feed-in obligation systems established in several countries of the European Union, costs can be recovered easier in the long run. Solar cell power plants are suitable for insular or network based production, therefore they can be a useful part of the energy system of the settlement. In insular use it can cover the electric energy need of individual buildings, while in case of production for the network it may be part of the national or the local electric power grid. Production of solar cells is more calculable compared to wind power plants, as the quantity of sunshine is less fluctuating compared to wind velocity; consequently integration of solar cell power plants to the electricity gridis easier.

Utilization of solar cells in an urban setting is very advantageous, since there are plenty of free roof surfaces that are perfectly suitable for installation of solar cells. The individual utilization of solar cells may also have many advantages, as they can provide individual machines, and equipment characterized by low consumption (e.g. public lighting lamps or other devices of the traffic infrastructure) with electrictricity.

Thermal solar power plants transform solar energy to heat and by its further transformation generally produce electricity. Power plants transforming solar energy to heat characteristically concentrate solar energy (e.g. with parabolic mirrors or sun following mirror systems) and operate at extremely high temperatures. This solution is less suitable for local, decentralized electric power generation, since its establishment has rather high expenses, it is characterized by large space demand and such systems are technically complicated. Furthermore the scale of energy production does not adjust to these smaller systems either. However it must be mentioned that a thermal solar power plant is able to cover the entire electricity demand of a small town.



Ulm, utilization of solar energy

Ulm is located in the Southern part of Germany in the province Baden Württemberg. The population of the city exceeds 120,000.

The Sun constitutes an inexhaustible and pure form of energy. Therefore in the city of Ulm solar energy is utilized in addition to other renewable energy resources (including hydro power and biomass). Ulm and Neu-Ulm co-founded the Solarstiftung Ulm/Neo-Ulm foundation in 1995 with he goal of improving the framework conditions of renewable energy resource utilization in the region. The organization provides counselling and information services, as well as co-ordination among concerned parties. Furthermore it initiatiates projects.

The spread of solar energy utilizing systems and the increase in environmental awareness is greatly supported by the resolution of the City Council. According to the resolution on the roof of every public building which is suitable for utilization of solar energy solar cells or solar collectors have to be installed. Otherwise the surface itself has to be placed at the disposal of the inhabitants for installation of solar energy utilizing equipment. Widespread and large-scale application of renewable energy resources (including solar energy) is also supported by the resolution of the Supervisory Board of the municipal utilities (SWU Stadtwerke Ulm /Neu-Ulm GmbH). According to the resoltuion by 2020 100% of the electricity demand of all industrial works and households must be covered from renewable energy sources. In order to support the implementation of these objectives, in addition to the regulatory and investment support instruments, awareness rasing campaigns and information programs are also organized with theinvolvement of Solarstiftung Ulm/Neo-Ulm.

Due to the co-operation between the foundation, the City Council and the municipal utilities the total surface of solar collectors in Ulm reached 150,000 square meters by 2010, Thus the solar collector surface perinhabitant is 0.13 square meter, which is an outstanding value. Besides solar collectors the application of photovoltaic systems is also very widespread. Installed capacity of solar collectors reaches almost 13,000 kWs. Solar cell systems have been established so far on around 30 public buildings, starting withschool buildings and sport facilities.

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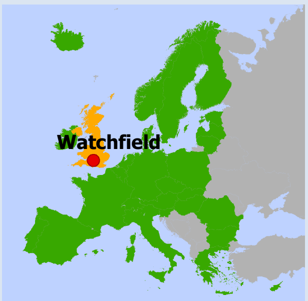
Wind energy

The coastal territories of Europe are the most suitable for the utilization of wind energy, however due to relief and meteorological characteristics also of inner territories of the continent can ensure good conditions for wind energy production. By the Eurostat the total wind energy production of the European Union increased tenfold since 1998, thus it exceeded 10,000 toe in 2008. The largest producers are Germany and Spain, being responsiblefor more than 60% of the total wind energy production of the EU. Since 2004 growth rate of wind energy output of the newly acceded 10 countries is far higher compared to the old member states. Wind energy production increased to the greatest extent in the Czech Republic, in Hungary and in Lithuania, by about twenty fold, partly due to the energy policy and support system of the European Union and the establishment of feed-in obligation systems.

One of the most significant problems faced by wind energy utilization is that wind velocity can be rather variable in time. Relatively constant wind velocity can only be expected only at coastal areas. A further problem is the frequent alteration of wind direction. Despite of the fact that wind power plants are adjusting to the prevailing wind direction, in areas characterized by highly variable wind conditions, the establishment of wind power plants with traditional horizontal shaft is less advisable (even if the wind velocity is appropriate). The height of wind power plants is generally between 75 and 100 meters. Therefore surface wind conditions are not decisive. As part of the comprehensive situation analysis and impact study to be conducted prior to the establishment of the wind power plant not only wind conditions but also the features of the electricity grid must be thoroughly examined. The resason for this is that these networks can hardly or not nearly balance the significant performance fluctuations without appropriate counterbalances (e.g. pumpe-reservoir based hydro power plant, or gas-fueled power plant, eventually hydrogen-based systems).

A new type of wind power plant- which could be very well utilized in settlement level energy systems- is the enhanced, low height wind power plant with vertical axle, reaching no more than 3 meter. The main advantage of this device is the ability to utilize wind of any direction. Furthermore, since enhancers can achieve a 9 to 25-fold wind energy increase, the rate of utilization may reach 60 to 80%. It is sutiable to utilize at the settlement level as it can be installed at optional sites, it offers suitable solution also for private persons, communities, apartment buildings (prefabricated buildings, residential complexes) to ensure safe electricity supply.

One possible utilization method is to use motional wind energy by directly applying **wind wheels** to operate machines (e.g. pumps). Energy produced by wind wheels applied as an individual solution can play a supplementary role in settlement energetics. Advantages of this solution include the replacement of electricity use in case of public institutions or dwellings. **Wind power plants** offer a more widespread solution that can be better applied in energy supplysystems of settlements. So called wind parks comprise several wind power plants transforming motional wind energy to electricity. Characteristic performance of wind power plants is nowadays between 1-2 MW but power plants with 3 MW or higher performance already exist as well. Wind power plants are particularly suitable to supply the independent settlement energy system. At the same time they can produce also for the regional or national network. Under appropriate circumstances this can solve the problem of fluctuating production as well. Should the settlement endeavour to establish an independent energy system, it can apply wind power plants in an integratedmanner, together with other – preferably renewable – energy resources that ensure the balance of the system and the safety of supply.



Watchfield, Westmill Wind Farm project

Watchfield is located in the county of Oxfordshire in South-East England with more than 2,000 inhabitants.

The Westmill Co-operative, with a present membership of 2,347, was founded in 2004 with the objective to ensure the supply of the local community with green energy. For implementation of this goal the co-operative decided to establish a wind farm comprising 5 turbines half mile far from Watchfield in South-England. The works started in 2007; in 2008 the wind power plant farm was ready for use. The installation costs of the turbines with a 25-year service life, amounting to 7.5 million pounds were financed from bank credit, collections and contributions of the members; the wind farm is in 100% ownership of the members.

The generators are 49 meter high; the length of their blades is 31 meter. The blades start to rotate at a wind of 3 m/s velocity; however at a too high velocity over 25 m/s they stop to avoid any damage. The performance of the individual turbines is 1.3 MW, thus the established performance of the farm is total 6.5 MW. The wind power plant farm ensures the electric power supply of 2,500 average apartments and saves yearly 5,000 tons CO_2.

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Geothermal energy

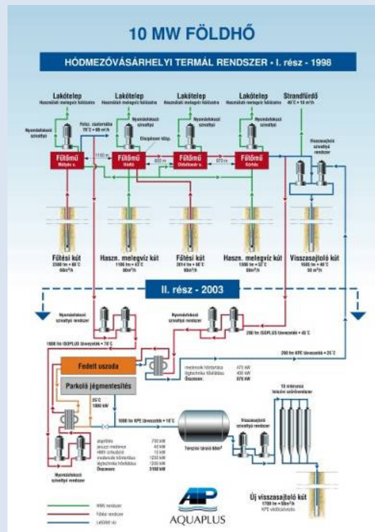
The proportion of geothermal energy production in total renewable energy production of the European Union is altogether 3.5%. This means that it constitutes the second smallest proportion after solar energy utilization. Reasons for this include unsuitable geological conditions, high cost of installationand complicated technology. Within the European Union utilization of geothermal energy is the most important in Italy. At the same time Hungary, although the utilization is less widespread here, is characterized by excellent potential due to favourable geological conditions and the high geothermal gradient.

Geothermal energy may be utilized in two main ways. When utilizing geothermal energy through **heat pumps** heat is extracted from an environment characterized by lower temperature and transported to a site of higher temperature. Thissolution, used exclusively for heat production, is able to porivde heating and hot water demand of individual buildings. At the same time geothermal energy is also suitable for larger scale application provided that e geological conditions enable the exploitation of thermal water suitable for energy utilization. This takes place through the establishment of **geothermal power plants**, which may provide the heat supply of a district or the cogenerated heat and electrictricityproduction of a settlement. Further advantages of the establishment of geothermal systems include supplemental touristic (e.g. thermal bath) and agricultural (e.g. greenhouse based crop production) applications through the utilization of residual heat. In this case a complexsystem can be developedinfluencing the economy of the entire settlement, through reducing energy costs, increasing revenues from tourism, and improving competitiveness of local agriculture.

Hódmezővásárhely, geothermic district heating system

Hódmezővásárhely is located in the South-Great Plain region of Hungary,, with apopulation exceeding 47,000.

The South-Great Plain region of Hungary is characterized by extremely highpotential for the use of geothermal energy. In order to exploit this potential, a geothermal public utility system was built in Hódmezővásárhely, which is intended to replace fossil fuels, reduce GHG emissions, anddistrict heating costs. The main feature of the geothermal public utility system is that in order to ensure heat energy and hot water supply the insulatedunderground transmission network connects the four independent district heating systems operating in residential areas, public institutions, as well as the bath and indoor swimming pool of Hódmezővásárhely.



The hot water supply system is based on two wells with a total depth of 1,300 m. High quality thermal water extracted from these wells - after degasification - will be delivered to 2,800 district heated houses, 10 public institutions (including the municipal hospital) and the sport swimming pool using pressure boosting pumps and almost 4,200 m of insulated transmission lines. This system produces annually approximately 170,000 m^3 hot water (resulting in a reduction of 23 TJ/year in natural gas consumption), which is only a fragment of the wells' capacity. The water used in the hot water supply system cannot be extruded back under the surface, so it is collected in the city sewage collection pool.

The geothermal heating system uses three producing wells with a total depth of less than 2,000 m and two thermal wells for reverse extrusion. Obtained thermal water with a temperature of 80 to 88^{o}C is pumped into heat substations connected to a 6,500 m insulated transmissionline network. This ensures the replacement of the entire circulatory heat loss of the hot water supply system and plays a determinant role in the satisfaction of heating energy supply requirements.

The end points of the thermal circuits are located on the territory of the city bath, where the repeatedly heated medium of an incoming circuit with a temperature of 40 to 45oC ensures the maintenance of a temperature of 27^{o}C in the open, 50 m pool, through a plate heat exchanger. The thermal water with a temperature of 27 to 30^{o}C, is then placed in a return extrusion well installed on site with a total depth of 1,700 m. The second incoming circuit satisfies the heat demand of the indoor swimming pool (3.2 MW) and ensures the defrosting of sidewalks around the pool. Then it is recharged back into the second well also with a total depth of 1,700 m. The entire heating system contributes to the city's annual heat demand with a heat amount of 110 to 120 TJ.

The project is considered beneficial both from an environmental as well as from aneconomic aspect, as it contributes to saving an amount of 4 to 4.5 million m^3 of natural gas. This development resulted in a significant reduction in the production costs of heat energy. The restricted self cost of hot water production and heating energy production (including reverse extrusion) is about 15 to 20% and 30 to 35%, respectively, compared tothe cost for production based on the use of natural gas. In addition to the above, a significant improvement in local energy security was also noted, since this system uses an import-independent and permanently available local energy source. Thereafter the city set the objective of meeting the entire energy demand of the district heating system using geothermal energy and further extending the system.

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Complicated construction requiring accurate preparation, high building costs and the regulatory restrictions all poseproblems to the establishment of geothermal energy systems. It is a strongly restricting factor that the extracted thermal water has to be extruded back to the geological layers. Furthermore it must be ensured that the extruded thermal water is not polluted. Naturally this does not apply to the utilization of water for bathing purposes because in this case the exclusion of pollution cannot be ensured. However, difficulty can occur due to the high salt content of thermal waters and their higher temperature compared to surface-waters, whcih can damage plant and animal life; therefore special attention must be givern to environmental considerations.

Hydropower

In the past years no considerable expension can be observed in hydropower production of the EU, which represents almost 20% of the entire renewable energy production. However the use of low capacity hydropower is gradually gaining ground. As opppsed to large-scale hydro, their application may serve as a solution in atsettlement level energy management. Generallyat the settlement level neither appropriate conditions, nor the necessary resources are available for the establishment of a large-scale hydropwoerplants,.

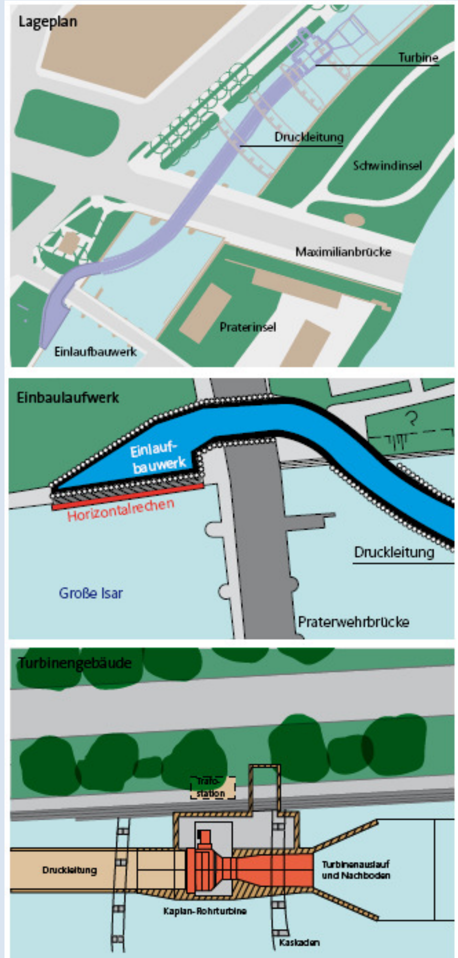
Small- (100 KW to 25 MW) and **micro-scale hydropower plants** (under 100 kW) can serve both water management and energy supply purposes. Their environmental impact is generally not significant. Due to the small performance level their importance is not considerable in the national or regional electrictricity production. At the same time they can be a very useful element of local energy supply. Further advantage include that their establishment does not require the buildingof large reservoirs; and often the renewal and redesigning of channels supporting older mills enables their installation.

If the settlement disposes of suitable potential, the utilization of hydropower can be deemed as a good alternative in the localenergy management system, since the production of energy produced in this way is relatively constant. With the help fo small scale hydro, production originating from other renewable energy resources- those strongly depending on fluctuating weather conditions - can be well balanced. Thus its use contributes to ensuring security of energysupply. Hydropower plants can also be applied as an environmentally friendly solution for energy storage by the establishment of **pumped-reservoir power plants**. For the implementation of the aims of sustainability and climate protection the reservoir should be filled withenergy generated from another renewable source.

Munich, low capacity hydropower

Munich, the capital of Bavaria is located in the Southern part of Germany. Its population exceeds 1,300,000.

Utilizing the favourable hydropower potential the first such plant was established in Munich at the end of the 19^{th} century. Currently six such facilities can be found on the Isar river crossing the city and 6 further water power plants are located in the surrounding of the city. These belong to the public utilities of Munich, their total built-in capacity reaching 119.3 MW. The latest hydropower plant is the 'Praterkraftwerk'. Its construction started in the spring of 2009 and it was handed over in summer of 2010.



The power plant was implemented as the investment of Praterkraftwerk GmbH co-founded by the municipal utilities and a company in private ownership. As part of the investment an existing dam was supplemented with a turbine. This, together with the relevant engineering structures is installed entirely underground. Thus the power plant, whcih is built in a highly frequented area of the city does not ruin the cityscape.

The new power plant with a peak performance of 2.5 MW produces 10 million kWh electrictricity annually, which is sufficient to supply 3,500 to 4,000 households and saves around 4,500 tons of CO_2 yearly. As a result of the investment total built-in capacity of hydropower plants operating in the city increased to 10.9 MW enabling an annual production of 55.1 million kWh electrictricity and the provision of more than 20,000 households.

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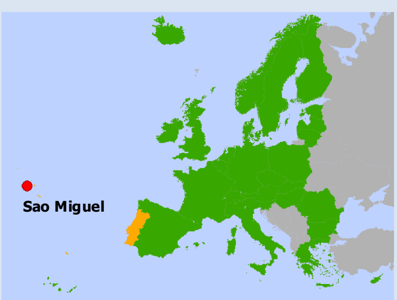
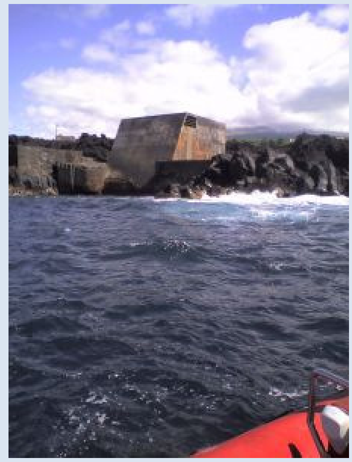


Azores, Pico wave energy centre

São Miguel Island is the largest and most populous island in the Portuguese Azores archipelago. The island is 759 km^2 and has around 140,000 inhabitants, 45,000 of these people are located in the largest city in the archipelago Ponta Delgada.

It is a big challenge to ensure energy supply on the islands. The Portuguese government and other authorities set up a project to use a new kind of resource, the waves of the ocean. The climate-friendly power plant was planed on the island of São Miguel, next to the highest mountain in Portugal, the Pico. The construction was concluded in 1999, involving several Portuguese companies under scientific coordination of Instituto Superior Técnico. The operation of the plant is very simple: the incident waves cause vertical oscillation of the water column inside the chamber, which in turn causes alternate air flow to and from the atmosphere, driving the turbine and the generator attached to it.

In 2003 the staff of Pico Wave Energy Centre (named after Pico mountain) was ready to set the power plant in action. Since September – November 2005 and June - October 2006 regular performance tests have been undertaken, revealing the persistence of technical limitations of the structure. The Wave Energy Centre needs some technical adjustments. If these corrections are completed Pico can produce electric energy up to 7000 kWh. This amount of energy is enough for the cities of São Miguel or even other islands. This project can show us how to use our resources in alternative ways that we have not thought about before.



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Solid biomass utilization

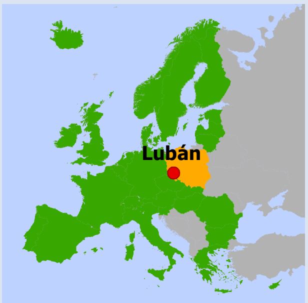
Nowadays solid biomass is the most widely utilized renewable energy resource. It constitutes more than 63% of total renewable energy production of the EU. Its available potential is closely related to the agricultural potential of the region, keeping in mind that the raw material must be produced in a sustainable manner. Solid biomass is available as a by-product or waste of agriculture, silviculture and the timber-industry, and from plantations cultivated specifically with the purpose of generating energy. At the same time, solid urban waste – similarly utilizable as other types of solid biomass - may be included in this group as well.

In case of utilization of silvicultural and agricultural raw materials it must be a fundamental aspect that utilization for generating energy may not damage and jeopardize either the natural environment, nor security of food production and supply. Consequently, farming of energy crops (energy grass, energy forest) is recommended only in areas where the soil is of inferior quality and does not enable the production of food plants in suitable quality, furthermore it is not connected to a natural reserve area. From the aspect of energy utilization by-products and wastes of agricultural production are the most ideal biomass sources.

Decentralized energy production based on solid biomass has many benefits. It can ensure appropriate, secure and efficient energy supply of a settlement or region. Furthermore, the connected agricultural and silvicultural activities can significantly improve competitiveness of the local economy – especially in rural and agricultural regions – and facilitates employment creation, thus promoting the catching up of under-developed regions.

Solid biomass can be utilized in direct way for **heat energy production** through burning and also indirectly through chemical transformation. In this case vehicle fuels can be produced through fermentation to alcohol (**bio ethanol**) or through esterification of vegetable oils (**biodiesel**), Furthermore, **biogas** can also be gained through anaerob fermentation. Utilization of solid biomass in settlement energy management systems is recommended mostly in heat energy production or in the cogeneration of heat and electricity. Solid biomass can be used for this purpose directly – without pre-treatment or in pellet form –, or after fermentation in the form of biogas, as well.

Solid biomass is primarily appropriate for individual heating of buildings. At the same time based on this principle independent central heating plants can also be established, as part of modern systems cogenerating heat and electicity simultaneously. By establishment of a district heating system an independent local energy management system can be realized that may be able to sufficiently supply the total heating demand of smaller settlements. However, numerous examples demonstrate that it is worthwhile to establish such a system even exclusively for the heat supply of public buildings.



Lubań, biomass central heating plant

Lubań is a small town with a population of 22,0000, located in the Southern part of Poland.

Lubań started to modernize its district heating system in 1997 with the objective to reduce energy use of the city and air pollution caused by coal-fired boilers by introducing a new, environmentally friendly, straw-fired heat production system. The investment took five years, with the first phase taking place between 1997 and 1999, and the second phase between 2000 and 2001.

In the first phase 7 coal-fired boilers were eliminated and 7 new heat exchanger centres and network connections were built. Furthermore, the earlier existing 28 heat exchangers were modernized. One straw-fired boiler of 1 MW heat performance was built together with the relevant infrastructure (e.g. straw storage facility). In the second phase of the investment the system was extended by further boilers, during which two new boilers of 3.5 MW each were commissioned. In addition the serving infrastructure of the central heating plant and the machine park for straw preparation were developed. The installed capacity of the three straw-fired boilers is altogether 8 MW, their efficacy is 84%.

The total cost of the investment amounted to 1,608,275 EUR, out of which 43% was financed by EkoFundusz foundation as a donation. Further 20% was ensured by the Environmental and Water Fund (WFOŚiGW) in the form of a loan.

As a result of the project, price of the heat supply became controllable and stable. Annual average revenue from supplying heat is 7 million PLN. It can be regarded as a remarkable result that by the completion of the investment coal use was reduced to half, thus considerably reducing pollutant and greenhouse gas emissions. Heat energy produced by the district heating plant ensures heating for 60% of the population.

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Biogas

The extent of biogas utilization is no more than 5% of total renewable energy production in the European Union, thus preceding solar and geothermal energy production. The scale of its importance is equal to that of wind energy. Biogas is produced by fermentation, putrefaction of biological wastes. Raw material can be almost any organic biologically dissociable substance. By-products and wastes of agricultural and food industries as well as wastewater sludge mostly serve as raw material for biogas production. In settlement energy management systems primarily the by-products and waste of various utilities (wastewater treatment plant, waste treatment plant, holticulture) can serve as basis for biogas production. In leading agricultural regions agricultural waste and by-products originating from such activities in the surrounding of the city may be also utilized for biogas production.

Biogas generated through fermentation can also be used directly for heating of individual buildings, district heating or as fuel for cogeneration power plants. By further treatment of biogas biomethane can also be produced. This can be utilized as vehicle fuel or directly fed into the gas supply network.

In settlement energy management systems the utilization of biogas – like solid biomass - is the most advantageous in **heat and electricity cogenerating power plants**. This solution can constitute a key element of an autonomous settlement energy management system. Besides electricity production it ensures the satisfaction of heat and hot water demand of the settlement in a calculable manner. **In smaller size** it can be applied for increase the energy-efficiency of the settlement's utilities as well as for independent energy supply. In this way operating costs of the service providers and parallel to this public utility costs of the population can be reduced.

Athens, utilization of biogas discharge from waste water sludge

Athens is the capital of Greece, its population with the agglomeration exceeding 3,500,000.

Europe's largest waste water treatment plant is located 1,500 meters from the coast of the Greek capital, Athens, on the island of Psyttaleia. The plant starteded to operate in 1994 and currently treats 750,000 m^3 waste water daily. Although the facility hindered the entering of waste water to the sea it did not offer an appropriate alternative for waste water sludge treatment. To solve this situation, the sludge treatment plant started its operation on 1 June 2007, ensuring disposal and utilization of waste water sludge.

In the waste water treatment plant a biogas-fired cogeneration power plant was built with the support of the European Union, using biogas discharging from waste water sludge to produce electricity and heat. At annual level the power plant produces 64 GWh electricity, covering the energy demand of the waste water plant on the one hand, on the other the surplus energy being fed into the electricity network. During the process heat is generated in addition to electricity, which is used for waste water sludge treatment and heating of fermentation containers.

Efficacy and usefulness of the facility is confirmed by several data sources. Since commissioning of the power plant methane emission decreased from daily 20,000 Nm^3 to 0.2 Nm^3, hydrocarbon emission reduced from 120 Nm^3 to 0.2 Nm^3. Furthermore, carbon monoxide and nitrogen oxide emission could be maintained under 650 mg/m^3 and 500 mg/m^3 respectively. The biogas power plant was implemented by co-financing by the European Union, its total budget amounting to 11,113,720 EUR. Own funds were ensured by the Water and Waste Water Treatment Company of Athens.

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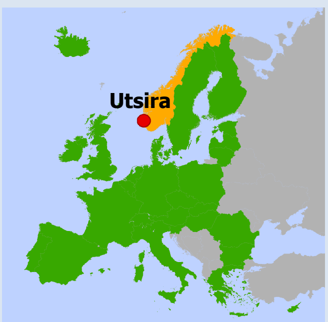
Hydrogen based energy production

The Earth is characterized by the availability of large quantities of hydrogen. However hydrogen is not available independently, in pure form, only in its compounds (e.g. water, methane). Out of these compounds it can only be produced through using energy. Hydrogen can be generated through various processes (e.g. electrolysis, natural gas reforming, coal gasification). The most widespread method of is natural gas reforming, during which hydrogen is gained from methane. At the same time in this case CO_2 is generated in large quantities as a by-product. As this can hardly be harmonized with climate change mitigation objectives, the present publication does not discuss furhter the natural gas reforming technology. Production of hydrogen from hydrocarbons has a further disadvantage: by burning or applying in fuel cells hydrogen, produced through this method large quantities of ‘new’ – in the atmosphere not earlier present – water vapour is generated. Water vapour is also a greenhouse gas and effects of the increase of its concentration are not yet precisely known.

Another widespread method of hydrogen production is electrolysis. As part of this process, thorugh the use of electricity water molecules are decomposed into hydrogen and oxygen. Electrolysis fits with the considerations of climate protection only if electricity used derives from renewable energy sources. Hydrogen produced through this method is highly suitable for the storage of surplus electricity produced during so-called valley-period. Vallex-period indicates periods, during which energy consumption is the lowest during the day. During this period mamagement of electricity produced by less flexible power plants causes problems for the electricity grid system. During peak periods the stored electricity can be regained quickly and flexibly through burning or by applying fuel cell technology.

Several options exist for the application of hydrogen based technoligies. It can be used for example as vehicle fuel (see Chapter 5, ‘Climate friendly urban transport’). Furthermore, in energy management of settlements hydrogen technology can be used for balancing fluctuations in electricity production. This can be necessary in the case of renewable energy sources subject to weather conditions or other factors and in the case of nuclear power plants during so-called valley-periods. In co-generation power plants (e.g. wind-hydrogen or solar-hydrogen) hydrogen increases efficiency, reliability and planning possibilities of renewable energy production. Thus it contributes to feeding energy originating from renewable energy resources into the national or regional electricity grid, and creates the possibility of establishing autonomous local electricity supply.



Utsira, establishment of a combined wind-hydrogen system

The settlement of Utsira with a population of 212 people is located on the island having the same name, 18 kilometres from the Southern coast of Norway.

Norsk Hydro, a Norwegian energy company and Enercon, a German wind turbine manufacturer built together a wind-hydrogen system on the island between 2003 and 2004 with experimental purposes. The plant has been operating since winter 2004/2005. The system provides electricity for 10 households of the settlement, i.e. it is a very small size. At the same time it can also operate at higher capacity and can be a solution for balancing the intensively fluctuating energy production in case of the individual renewable energy resources (solar and wind). It is also suitable for energy storage.

The advantage of the wind-hydrogen system compared to classic wind power plants is that during stronger winds the produced surplus energy will not be lost but it will be used for hydrogen production. The system consists of the following parts: wind turbine, accumulator, energy storage wheel, hydrogen container, electrolysing appliance, network connection station, as well as an energy balancing device and the fuel cell.

It is the main feature of the system that in case of stronger winds the wind turbines produce more electricity than required by the settlement. Subsequently the system uses the outstanding electricity surplus for the electrolysation of water, i.e. for production of hydrogen or – if there is no more demand on hydrogen production – it feeds the surplus into the national electricity grid. The produced hydrogen is stored in gas containers under high pressure. If the velocity of the wind is not sufficient – low or too high – and therefore the wind turbines do not produce electricity in a sufficient quantity, energy will be produced from the stored hydrogen with the help of the fuel cell.

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Renewable Energy Sources (RES) Champions League

The RES Champions League composed by national RES leagues and local authorities set the target to motivate people and encourage them to exchange views and information with each other beyond the national borders.

The project started in September 2008 willing to popularise the solar energy application. Since that time the Champions League has been organised every year in 7 countries of the European Union. The aim of the project is to find the most active European settlements in solar energy application. Every city, town and village with a population of from a few inhabitants to a few million inhabitants can join the competition. Every year, the winner settlement is the one which has the biggest solar power system (solar collector and solar cell) per inhabitant.

The winner of the competition was selected based on three data:
- 1st: total area of the solar collectors in the settlement, m^2
- 2nd: total capacity of the solar cells in the settlement, kWh
- 3rd: total scores of the previous two data per inhabitant

The ranking is based on a simple ratio: installed power (or area) per inhabitant.

Three technologies of energy production from two renewable sources (solar, biomass) are eligible to the competition:
- solar category:
  - solar photovoltaic;
  - solar thermal.
- wood category:
  - collective heating systems and boilers (heat).

A European Championship Celebration is organised every year, more or less at the same time than the football Champions League final. The European champions of the 2010 season are, per size:

Division	European champions
General ranking: *all sizes*	1st: Prato-allo-Stelvio (Italy) 2nd: Schalkham (Germany) 3rd: Hostětín (Czech Republic)
Small cities: *from 5,000 to 20,000 inh.*	1st: Nowa Dęba (Poland) 2nd: Bansko (Bulgaria) 3rd: Montdidier (France)
Medium cities: *from 20,000 to 100,000 inh.*	1st: Neckarsulm (Germany) 2nd: Orosháza (Hungary) 3rd: Litoměřice (Czech Republic)
Large cities: *more than 100,000 inh.*	1st: Ulm (Germany) 2nd: Grenoble (France) 3rd ex-aequo: Częstochowa (Poland) 3rd ex-aequo: Plzeň (Czech Republic)

The partners of the RES Champions League network are involved in upgrading the competition by generating new ideas and by shaping the rules that apply for it.

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A more common exploitation of renewable energy resources such as wind or photovoltaic energy, or the wide-spread use of home-charged hybrid cars cannot be achieved based on the ordinary electric power grid system. In order to handle the rapidly changing consumption or energy production by individual users, an intelligent system is needed which can provide real-time data. A **smart grid** relies on two-way digital communication between the consumers and suppliers of electricity. This makes it possible to synchronise production and consumption in a more precise way. The European Technology Platform SmartGrids defines smart grids as electricity networks that can intelligently integrate the behaviour and actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. It is not a new grid system, but the evolution of the existing one. The smart grid includes an intelligent monitoring system that keeps detailed track of all electricity flowing through it. It has the potential to integrate renewable energy more effectively than the traditional system. When power is the least expensive, the user can allow the smart grid to turn on selected home appliances, while at peak times, it can turn off selected appliances to reduce demand. This could save energy, reduce costs and increase reliability and transparency.

The smart grid is ideal for national grid systems, but it can be implemented at the local scale, for example in a city, too. The world's largest smart meter deployment was undertaken in Italy with a coverage of over 27 million customers; but in the UK, the Department of Energy and Climate Change announced its intention to have smart meters in all homes by 2020. The European Union, to make low-carbon technologies affordable and competitive, launches the European Strategic Energy Technology Plan (SET-Plan). This plan includes the Smart Cities Initiative, which supports the implementation of smart grids, too.

6.2. ADAPTATION POSSIBILITIES IN THE ENERGY MANAGEMENT OF SETTLEMENTS

Adaptability of a region or a settlement refers to the stenghtening of its resilience and reduction of its vulnerability to the impacts of climate change. The effects of climate change may considerably vary in different regions; consequently it depends on local characteristics, what type and extent of change a given settlement must be prepared for. During the development of the settlement energy strategy, as part of the founding examinations, expected impacts of climate change affecting the settlement shall be assessed. Adaptation measures of the settlement energy management system should be designed accordingly.

The relevance of settlement energy managment systems is higher in case of mitigation measures. The scope of adaptation options is far narrower since energy systems are more suitable to reduce greenhouse gas emissions and strengthen mitigation efforts. However, this can be done in line with the adaptation needs of a settlement. The establishment of autonomous settlement energy management systems can contribute to improving the resilience of a region or settlement by strengthening the competitiveness of the local economy and by reducing dependence on external factors.

As an effect of climate change various extreme weather conditions will become more frequent, intense and longer. This can cause serious problems in energy supply systems, especially in electricity lines. It must be examined which extreme weather condition are most likely to occur in the specific region. Energy supply systems must be developed and modernized accordingly.

Energy consumption – mostly during heat waves – will significantly increase, proportionately with warming. For this reason in order to reduce the increase of energy consumption and to facilitate adaptation to changed weather and climate conditions, review of settlement-level physical plans and local building regulations is recommended. As part of this, attention must be paid to the incentivisation of passive energy utilization and energy saving. Suitable orientation and optimization of the street network and buildings, application of green roofs and planting tree rows for wind protection can greatly enhance adaptation. These measures can decrease the energy demand of individual buildings, decrease total energy consumption of the settlement and release the load of the settlement energy system.

During extended hot periods during the summer energy consumption remarkably increases due to the increased spread of air conditioning. During summer (which is expected to get warmer because of the effects of climate change) and during the course of increasingly warmer and longer heat waves the load of energy systems can be extremely high. Therefore in order to avoid more serious breakdowns and to safeguard the security of energy supply, it is recommended to prepare energy production systems in order to be able to appropriately satisfy energy consumption peaks during the summer.

Because of extreme wind force, storms and thunder occuring mainly in summer periods, replacement of electric air cables by ground cables could be a solution, especially in urban wind channels. The break of air cables during winter periods due to frost damage could be also avoided through the application of ground cables.

BRIEF RECOMMENDATIONS

- Increasing the share of renewable energy sources (solar, wind, hydro, geothermal, biogas, solid biomass utilization, hydrogen-based energy production).
- The climate aware transformation of urban energy management by reducing the emission of greenhouse gases.
- Increasing the energy efficiency and saving energy (public lighting, modernizing the energy systems of local institutions).
- Improve the efficiency of he municipal power supply systems. Conversion and regulation in order to reduce the vulnerability the more frequent extreme weather situations.
- Creation of energy aware settlement-management system.
- Creation of energy strategy.
- Development of energy aware urban structure planning, land-use planning and local building regulations.
- Transformation of local regulation policy in order to increase the energy aware operations.
- Energy development.
- Developing a system of financial incentives (local tax and system, ‘Green public procurement system’, local climate fund creation).
- Creating autonomous municipal energy systems for small and medium-sized cities.
- Support the passive use of energy and energy-saving.
- District heating based on renewable energy and waste to achieve.