SUSTAINABLE URBAN DISTRICTS: EUROPEAN ENVIRONMENTAL SHOWCASE MODELS

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SUMMARY

Starting from the 90s, the design of new districts having strong environmental and energy sustainable profiles has gained attention among public administrations and project teams. These co-operations have brought new lines of research oriented towards the definition of different energy strategies at the urban and local scales. This paper analyzes the importance of local polices to create sustainable districts: main European case-studies; The research has been conducted on main European ecological showcase models; Compact city, solar and wind design, mobility and car free development, environment, biodiversity, green and water infrastructures, role of the inhabitants (public participation processes) are the focus areas in which the districts can be allocated. Common aspect of the different projects is the compact city concept, which joins the nowadays debate around dense urban areas. Several conclusions can be drawn related with the sustainable design of new settlements. In general the high density and compact city concepts are applied in the entire analyzed projects, which recognize the positive effects related with the installation of DER systems, public transport, and public services in accordance with principles of effectiveness and efficiency. The compact city is linked with the increase of functional mix and that has positive effects on reducing energy demand peaks.

Key words: European Eco Cities, Sustainability, New Districts, Compact Cities, Environment, Energy Efficiency, Resilience

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INTRODUCTION

Starting from the 90s, the design of new districts having strong environmental and energy sustainable profiles has gained attention among public administrations and project teams. These co-operations have brought new lines of research oriented towards the definition of different energy strategies at the urban and local scales.

Over the past twenty years, a growing attention to the sustainability of cities and neighborhoods has emerged, gaining space in the political and design debate. Cities are identified as best starting point for apply the targets of sustainable development and sustainable energy set by international agreements and national policies (Commission of European Communities, 2007; IPCC, 2007). In particular, the role of the design of new and existing areas has shown the potentiality for adapt the urban grid to the climatic and environmental characteristics of a place (Breheny, 1992; Jenks et al., 2000), contributing in changing energy and environmental performance of a settlement, thanks also to the feasibility for installing energy saving and production technologies (Bell et al., 2003; Steemers et al., 2000).

Despite the studies undertaken in the field of urban sustainability, it is still possible to identify an imbalance of knowledge between city and building, with the latest prevailing in the technical and design point of view. Since the city is not formed by the mere sum of single buildings, and their energetic performances – although high – do not necessarily bring to high performances at the urban scale. Studies related with the energetic role of urban morphology thus need to focus and strength to a different level (Droege, 2006). At the same time, also the energy certifications and rules developed for the housing sector, as well as the simulation models, do not find similar equivalents at the urban level, where governmental directives define quite unspecific strategies of demand control and energy reduction.

The city and its districts, moreover, are required to be used in different moments by different users, and this organization cannot be controlled only at the architectural level (Jenks et al., 2000). Different forms of mobility, use of open spaces and services are significant points whose management seems to be very difficult, if not impossible, without a coordinating actions and plans.
Identify design parameters – based on morphological and typological variables – that can affect energy performance, as well as technologies applicable at the neighborhood scale (such as cogeneration and district

heating or cooling, reuse of waste products, water cycle, etc.) become thus a central point of the research (Bell et al. 2003; Steemers et al., 2000).

Understanding the connections between urban form and energy – the energetic urban metabolism – is becoming increasingly important. In particular, the micro-scale of the neighborhood holds potential for improving the energy performance by acting on the morphology of the built environment (Breheny, 1992), control the energy peaks by calibrating the mix of uses (Burchell et al. 1982; Banister, 1997), mitigate the microclimate by greenery and water (Voogt, 2002), exploit local energy resources and identify the most appropriate solutions (Beatley, 1999).

Since the need of a shift in the design of urban areas towards sustainable concepts – using the keywords social, ecological, and energetic – has risen, many cities around the world have engaged projects for renewing their built environments and improving their management procedures. Define urban density, morphology of the built environment, natural and technical solutions can significantly contribute to energy savings, both in terms of energy consumed and supply of goods and services. The positive factors related with neighborhood design, and the application and test of policies identified at higher levels, have led different municipalities to promote new eco-sustainable projects (Eco-Valle, 2006).

Among the different experiences of sustainable districts, some projects have gained general awards thanks to the improvement and innovation in the introduced planning, design and management procedures. Though sharing some common ideas – such as the importance of embodied technologies in buildings and a general concept of reducing CO_2 emissions and ecological footprint – each of the districts here selected is characterized by specific focus points, which can help to understand limits and capabilities of different approaches and solutions for achieve sustainability in city.

Focusing on sustainable districts characterized by high interrelation of human and natural factors and mix of functions – fundamental elements that can lead to a change in the energy and environmental performance of a city – it is possible to point out three main categories of site choice: conversion of brownfields, renewing of existing urban areas, development on green fields (SOURCE, 2008). Moreover, it is possible to indentify projects specifically focused on energy performance of buildings, thus missing out the concepts of integration with the city and its nets, and therefore losing the full potentialities for enhancing the quality of life in cities.

In particular, at the European level, it is possible to point out for the contribution given in the sustainable planning the districts of:

- BedZed and Greenwich Millennium Village (London, United Kingdom). The first one, although not characterized by a significant dimension of the development plot, and thus reducing the impacts at the city level, is one of the first projects which has approached the eco-design in a holistic way.
- Hammarby Sjöstad (Stockholm, Sweden), and Bo01 (Malmö, Sweden). The Swedish approach is characterized by a strong relation between energetic regulations (at national and local level) and project outputs. The case of Stockholm has demonstrated the importance of a management model (The Hammarby Model), while Malmö is characterized by a learning-by-doing process and an innovative use of urban morphology for wind regulation.
- Viikki (Helsinki, Finland). The preservation of natural areas and their integration into the urban grid have characterized the design process.
- GWL-Terrain and Ijburg (Amsterdam, Netherlands), Leidsche Rijn (Utrecht, Netherlands). Focussed on compact city in order to reduce the consumption of natural land, the projects are strongly influenced – especially GWL – from the public and bicycle transports that characterize the Netherlands.
- Vauban (Freiburg, Germany). Widely recognized as one of the first and most important sustainable projects of Europe, the planning procedures have underlined the role of the inhabitants, both in the designing and management phases, has a key point for reducing energetic and environmental impact of urban areas. Moreover, the project enhances the role of cross connections between research, industry and application/development, with a focus on solar energy, in which the city is one of the leaders of the European market.
- solarCity (Linz, Austria). The optimization of solar energy is the key point of the design. The masterplan had a fundamental leading role for the decisions undertaken and the targets achievement.
- eco-district CasaNova (Bolzano, Italy). Characterized by the design of an urban morphology able to enhance solar gains. Moreover, the project focuses on the connection with green and infrastructure nets between city and development area.

Compact city, solar and wind design, mobility and car free development, environment, biodiversity, green and water infrastructures, role of the inhabitants (public participation processes) are the focus areas in which the districts can be allocated.

Common aspect of the different projects is the compact city concept, which joins the nowadays debate around dense urban areas. The idea of designing a denser city aims to reduce land usage, economic costs connected with urban infrastructures implementation and air pollution related with car-based transport. The majority of the sustainable projects are, indeed, characterized by medium/high urban density, in a range from 60 to 100 dwelling per hectare. Moreover, they are mostly located in brown fields, accomplishing both the function of urban renewal and natural land conservation.

Among the other countries, Sweden and Netherlands have promoted in the last decades polices oriented towards an increasing compactness of the urban areas and a strong connection with the public transport system.

In the beginning of the 50s the City of Stockholm based large part of its development on new suburban self-contained centers, connected with the public transport. The new districts were characterized by high density of the built environment in the areas close to the station (usually 500 meters), while the dwellings for the middle-upper classes – having less density – were located in a ray of 900 meters. Despite the innovative concept of this policy, there have not been reductions in commuting trips to the capital, although the high rate of public transport usage has contributed to reduce gas emissions.

Similar strategy was undertaken, from the middle of the 60s to all the 80s, by the Dutch government, supporting actions for sprawl containment, while endorsing compact developments in – or close to – existing areas and transports nodes. Thanks to this policy, known also as concentrated deconcentration or clustered deconcentration (Beatley, 1999), 15 new urban centers, generally located in the Randstad area, were created. National funds partially subsidized the projects.

Solar gain is a well known and extensively used concept for districts and buildings design thanks to the significant energy reduction achievable, both active (i.e. solar and photovoltaic panels) and passive (i.e. reduced need of artificial light and heating). Nevertheless, some projects have adopted the solar concept as key point of their development strategy, testing a new way of designing and thinking urban areas. In particular, solarCity (Austria), Vauban (Germany) and BedZed (United Kingdom) have deepened this aspect, and are nowadays considered as best practices.

Solarcity, 32 hectares and 3 thousands inhabitants, is particularly interesting in connection with the holistic approach adopted, the innovation of the design process, and the technologies installed, which allows an easier reproducibility in other contexts.

Vauban, although similar for dimension (38 hectares and five thousands inhabitants), is characterized also for the connection with the urban polices and the strong role in the decision process of the dwellers-to-be. BedZed, although the choice of the morphology comes from detailed analyses of solar maps, is a small scale project (1.7 hectares and 250 inhabitants), reducing broader scale outcomes.

THE INFLUENCE OF URBAN DEISGN ON ENGERGY AND ENVIRONMENTAL SETTLEMENTS: PARAMETERS AND INDICATORS FOR EVALUATING THE ENERGETIC SUSTAINABLE LEVEL OF NEW SETTLEMENTS

As shown by best practices and sustainable projects, it is clear that the energy and environmental sustainability of new districts can be reached in several ways, implementing different aspects that contribute to improve the performances of the settlements. Thus it is important to define a common way to compare the development processes, understanding under which aspect they can be considered sustainable (energetic, environmental, social, and so on) and indentifying the role played by urban design in improving the energy performance of new settlements.

Basing both on research achievements (theories and studies related with energy and urban morphology) and field applications (sustainable districts), it is possible to identify five thematic groups that help to underline the relations between design choices and sustainable outputs. The thematic groups are related with compact city and mix of functions; solar gain and wind design; mobility; green and water design; technologies.

The first group *Compact city and mix of functions* includes aspects related with high residential density, reuse of urban areas, land use and functional mix, presence of public services. The second group *Solar gain and wind design* includes aspects of passive solar design, solar collection for energy production, thermal properties of building and natural materials, control and modification of the microclimate, dispersion of pollutants, and power generation. The third group *Mobility* includes aspects related to accessibility improvements (internal and external connections), wakability, the street and urban grid design, behavior of the inhabitants (modal choice). The fourth group *Green and water design* includes aspects of climate mitigation and heat island effect control, green infrastructures, water management, and energy generation (biomass and waste). The fifth group *Technologies* includes aspects of DER – distributed energy resources, in particular regarding CHP plant, district heating and cooling, incinerators plant and waste recycle, solar and photovoltaic panels, and characteristics of building materials.

After identifying the thematic groups, assessment tables have been developed for evaluate with common methodology the case studies, overcoming particularities. The tables identify for each area optimal design elements, as coming from research and best practices. Each of them constitutes an indicator of performance and evaluation, to which correspond different points, according with the performances achieved by the project.

Three score levels have been defined:

- Low, the project achieves partially the requirements.
- Medium, the project requires further development and integration.
- High, the project incorporates the key elements identified by the indicator, and attains high energy performances.

Some indicators are based on the presence / absence criteria (yes / no), as it is not possible to have an intermediate level (e.g. in case of district cooling, either it is realized or not).

The maximum achievable points for each indicator are related with the influence that it plays in influencing the level of energy sustainability of a settlement. When an indicator has strong impact on other elements of the project and to the global energy performance, greater weight (points) was given.

The points are then assigned to the project in relation to the level reached for each parameter. The maximum obtainable score for each thematic group is 10, with a global score of 50 points in the five areas. The proposed method refers to the one developed by LEED ND, but it focuses specifically on the interaction between urban design and energy, and thus simplifying and merging some areas of analysis.

COMPACT CITY AND MIX OF FUNCTIONS

High residential density Increasing the compactness of transformations	Low units /hectare $\leq$ 50	0

and units per hectare. The main characteristics of the urban grid are based on the traditional city model, integrated with the nowadays socio-economic conditions and the need to achieve better energy performances.	Medium units /hectare between 51 and 70	1
	High units /hectare ≥ 71	2
Reuse of urban areas Reuse of brownfield sites (industrial, harbor, rail, etc..), decrease of land consumption.	No	0
	Yes	2
Mix of land uses and social classes Creation of functional (residential, commercial, offices) and social mix thanks to different accommodation types (ownership, rent) and price range (social housing, private market).	Low Only residential	1
	Medium Residential and at least one other function. Social housing among the other form of rental/ownership.	2
	High Mix of functions and users, with the aim of create a new area of the city (liveable city concept)	3
Presence of public services Public services and meeting places having both local and urban scale, connceted to the transport system and pedestrian network (distance 500 m).	Low Only local services	1
	Medium Local public services connected with public transport net	2
	High Local and urban public services connected with public transport net	3
Score		10

SOLAR GAIN AND WIND DESIGN

Solar gain	Passive Solar Design Road network and urban design defined to optimize solar gain. Attention to the liveability of urban spaces: avoid summer overheating and provide sunlight during winter time.	Low Only limits imposed by law	1
		Medium Passive solar design	2
		High Passive solar design (indoor) and urban comfort	3
	Solar energy Use of solar and / or photovoltaic panels for energy production, and increased	No	0
		Yes	1

	exploitation of renewable sources.		
	Thermal characteristics of building and natural materials Attention to the characteristics of urban materials (green, water and artificial elements) in relation to albedo (reflection coefficient) and thermal transmittance.	Low No specific attention to the used urban materials	0
		Medium Green areas and basins	1
		High Thorough choice of the materials. Design based on studies and simulations.	2
Wind design	Microclimate and dispersion of pollutants Design of the road section, orientation of the urban grid, and use of natural materials to protect settlements from winds, reduce winter heat losses, and improve outdoor/indoor comfort in summer.	Low No specific attention to the design of the urban grid	0
		Medium Wind used to disperse pollutants and / or for summer climate mitigation	1
		High Preliminary studies and simulations to define the correct grid orientation (wind protection and exploitation of air flows)	2
	Power generation Use of micro wind turbines stations, wind turbines plant, passive ventilation of buildings as part of the urban renewable energy mix.	No	0
		Yes	2
Score			10

MOBILITY

Increased accessibility of the connections (within the development and to the city) Construction of new public transport connections, evenly distributed within the neighbourhood and within walking distance (maximum distance 500 meters). Distances to train and subway stations can be higher (800 meters), but must be served by public transport or bicycle-pedestrian paths. Reduction of physical barriers and construction of new infrastructures (bridges, roads), if necessary.	Low Private mobility prevails on public transports	1
	Medium Public transports net	2
	High Variety of public transports means (subway, bus, tram, etc.). Reduction of the barriers	3

	in the district and to the neighbour areas.	
Increase cycling and walking (short distance) Construction of pedestrian and bicycle paths to major urban functions and public services. Creation of public transport interchange points.	Low Low rate of pedestrian and bicycle paths	1
	Medium Pedestrian and bicycle net used also as connection between public services	2
	High Pedestrian and bicycle net connected with public services and transports.	3
Design of the road section and urban grid Design of the road section to separate the different traffic flows, protected trails for walking / cycling. Green areas along the roads used also as ecological corridor. Development of car-free settlements.	Low No specific attention to the design of the road section	0
	Medium Design of different lanes for different transport means.	1
	High Car-free developments, street's net used as green corridors, separation, and separation of different traffic flows.	2
Behaviour of the inhabitants (choice of transport means) Promotion collective transport modes (car sharing, mobility manager), reduction of car ownership, increase soft mobility for short trips (800 m / 5 km). Reduction of parking plots: minimum threshold for significant reductions is 0.7 lots / units, further results are obtained with a ratio lots / units of 0.2.	Low Inhabitants are not involved	0
	Medium Car sharing and/or reduction of car lots/units (≥ 0.7)	1
	High Polices to reduce the car ownership rate between the inhabitants, car sharing, reduction of car lots/units (≥ 0.7), car-free development	2
Score		10

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GREEN AND WATER DESIGN

Climate control and heat island effect reduction Heat island effect reduced through green areas and water elements, winds can be conveyed within the settlements for cooling purposes.	Low Design of green areas and/or basins with low impact on the micro-climate	1
	Medium Design of green areas and/or basins with impact on the district's micro-climate.	2
	High Interconnection of green and water systems, able to reduce the district's temperature and cooling energy demand.	3
Green Infrastructures Protection of existing natural areas, inclusion of new green areas, lakes and canals in the development site to create ecological corridors. Streets are used to create ecological networks between cities and outdoor areas.	Low Green areas and basins not connected to each other.	0
	Medium District ecological net	1
	High Ecological net between city and outdoor areas.	2
Water management Implementation of a water "closed" circle, district sewage treatment plant, runoff reduction (green roofs, increase of permeable areas), and rainwater reuse. Water consumption reduced by new sanitary systems, wastewater quality increased thanks to public information campaigns.	Low Only one system (sewage treatment, *runoff* reduction, water consumption reduction)	1
	Medium Design of at least two systems	2
	High Comprehensive management of the district water cycle	3
Energy from waste and sewage Reuse of heat coming from waste/sewage treatment processes, biogas production, dried sludge use as fertilizer. Use of the neighborhood biomass (green waste) for electricity production. Increasing of the local energy mix from renewable sources.	Low No use of biogas/biomass	0
	Medium Use of at least one outcomes of the sewage treatment (biogas, biomass, heat from sewage treatment, etc.)	1

	for energy production.	
	High Comprehensive use of the energy from sewage and waste treatment.	2
Score		10

TECHNOLOGIES

District heating and CHP plant District heating and / or CHP plant for the whole neighborhood, powered (totally or mainly) with local energy resources (not less than 20%).	Low District heating doesn't cover the all development site	0
	Medium District heating, CHP plant fuelled with local renewable sources (≤30%)	1
	High District heating, CHP plant mainly fuelled with local renewable sources (>30%)	2
District cooling District cooling – propelled with local energy resources (i.e. water purification) – primarily used for public services, offices and shopping malls.	No	0
	Yes	1
Termovalorizzatori e riciclo dei rifiuti Realizzazione di centrali di termovalorizzazione, alimentate con energie rinnovabili prodotte localmente (completamente o parzialmente, con quote non inferiori al 30%). Riciclo dei rifiuti prodotti e riduzione dei materiali inviati in discarica (≥ 70%) Definizione di politiche di accompagnamento ed informazione alla popolazione per il corretto riciclo dei materiali. Incinerators and waste recycle Incineration plants powered by local renewable sources produced locally (totally or mainly, with shares not less than 30%). Waste recycle and reduction of waste for infill (≥ 70%). Definition of policies and public information campaigns for improve recycle.	Low CHP plant fuelled with local renewable sources (≥30%) or reduction of waste for infill (≥50%)	1
	Medium CHP plant mainly fuelled with local renewable sources (≥30%) and/or reduction of waste for infill (≥50%)	2
	High CHP plant mainly fuelled with local renewable sources (≥50%) and reduction of waste for infill (≥80%)	3

Solar and photovoltaic panels Use of solar and / or photovoltaic panels. Increase exploitation of local energy mix from renewable sources.	Low No use of solar energy	0
	Medium Use of solar and photovoltaic panels (no smart grid)	1
	High Solar and photovoltaic panels integrated in a smart grid.	2
Characteristics of building materials Use of high-performance materials, Life Cycle Analysis.	Low	0
	Medium Building consumption according to the standards set by law	1
	High Building consumption lower (at least 20%) than the standards set by law.	2
Score		10

To enlighten the different characteristics of the analyzed case studies, their level of sustainability and strength areas, comparative tables and spider charts have been developed. Aim of the tables and charts is therefore to presents in an easy-to-read language the evaluation processes, improving the results communication. The scores achieved for each area are displayed as colored dots - red, yellow, green - depending on project outcomes and/or presence within the design process of different elements. The assignment of the green color represents not only the attention to a specific aspect of design, but also to the correspondence between project objectives and achievements. The yellow color represents intermediate situations, arising both from the lack of certain aspects in the design phase and/or weak results. The red color represents the complete lack of specific issues related with energy sustainability and/or the failure of the set goals.

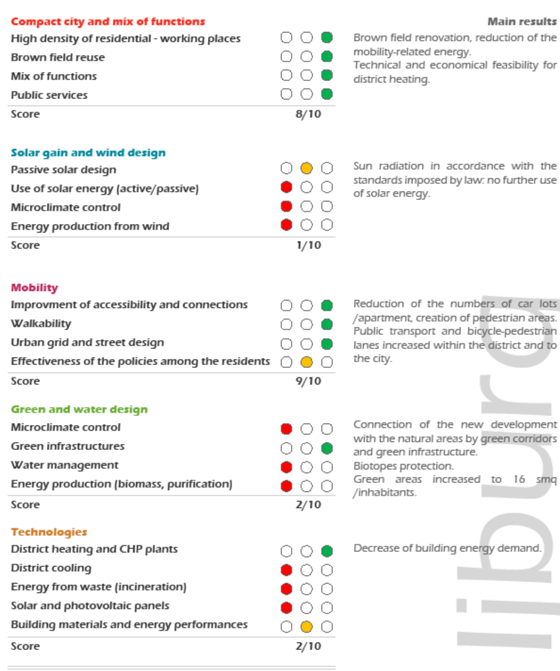
For each thematic area a synthesis of the achieved results is reported. Spider charts complete the evaluation, allowing a fast comparison of the different case studies and showing strength and weakness areas of the projects. The charts show in each axe, which represents one of the thematic groups, the score reached by the project.

Photo: Ijburg – Amsterdam and Leidsche Rijn, atelier GROENBLAUW, Madeleine d'Ersu, 2009, Reproduced by Permission

The importance of local polices to create sustainable districts: main European case-studies.
COMPACT CITY CONCEPT

Ijburg – Amsterdam and Leidsche Rijn – Utrecht, Netherlands

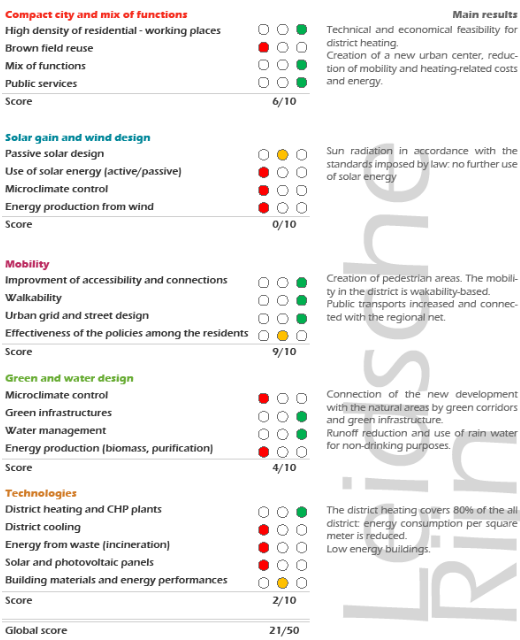
Policies and actions for promoting urban compactness have been carried on from the City of Amsterdam since 1978, as tool to contrast the sprawl phenomena. The development and reuse of lands close – or into – the border of the city has thus been the main results of these policies.
The district of Ijburg, an on-going project of 430 hectares spread over six artificial islands, partially newly realized and partially former industrial docs, is located in the heart of the city and close to the



		Main results
Compact city and mix of functions		
High density of residential - working places		Brown field renovation, reduction of the mobility-related energy. Technical and economical feasibility for district heating.
Brown field reuse		
Mix of functions		
Public services		
Score	8/10	
Solar gain and wind design		
Passive solar design		Sun radiation in accordance with the standards imposed by law: no further use of solar energy.
Use of solar energy (active/passive)		
Microclimate control		
Energy production from wind		
Score	1/10	
Mobility		
Improvment of accessibility and connections		Reduction of the numbers of car lots /apartment, creation of pedestrian areas. Public transport and bicycle-pedestrian lanes increased within the district and to the city.
Walkability		
Urban grid and street design		
Effectiveness of the policies among the residents		
Score	9/10	
Green and water design		
Microclimate control		Connection of the new development with the natural areas by green corridors and green infrastructure. Biotopes protection. Green areas increased to 16 smq /inhabitants.
Green infrastructures		
Water management		
Energy production (biomass, purification)		
Score	2/10	
Technologies		
District heating and CHP plants		Decrease of building energy demand.
District cooling		
Energy from waste (incineration)		
Solar and photovoltaic panels		
Building materials and energy performances		
Score	2/10	
Global score	22/50	

central station. The green areas will occupy a surface of 53 hectares, while 40 hectares will be dedicated to commercial and office functions, aiming to create a new autonomous centre, although strongly connected with the city.

Launched by the City Council in 1997 to respond to the increasing need of new dwellings, in 2025 – forecasted date of the conclusion – the district will have eighteen thousands apartments and forty-five thousands inhabitants. To improve the social mix, 30% of the dwellings will be rented out at low fares, supporting young and new families, while the others will follow market prices.

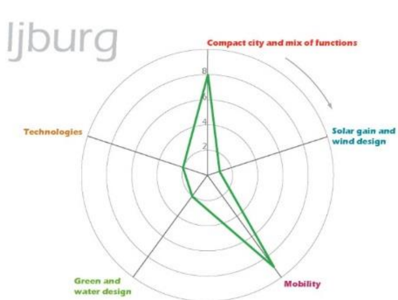


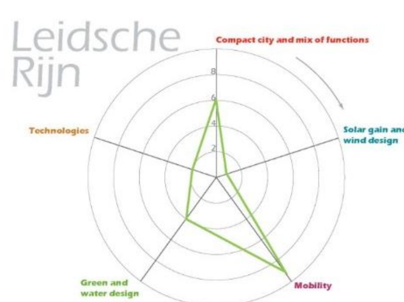
		Main results
Compact city and mix of functions		
High density of residential - working places		Technical and economical feasibility for district heating. Creation of a new urban center, reduction of mobility and heating-related costs and energy.
Brown field reuse		
Mix of functions		
Public services		
Score	6/10	
Solar gain and wind design		
Passive solar design		Sun radiation in accordance with the standards imposed by law: no further use of solar energy
Use of solar energy (active/passive)		
Microclimate control		
Energy production from wind		
Score	0/10	
Mobility		
Improvment of accessibility and connections		Creation of pedestrian areas. The mobility in the district is wakability-based. Public transports increased and connected with the regional net.
Walkability		
Urban grid and street design		
Effectiveness of the policies among the residents		
Score	9/10	
Green and water design		
Microclimate control		Connection of the new development with the natural areas by green corridors and green infrastructure. Runoff reduction and use of rain water for non-drinking purposes.
Green infrastructures		
Water management		
Energy production (biomass, purification)		
Score	4/10	
Technologies		
District heating and CHP plants		The district heating covers 80% of the all district: energy consumption per square meter is reduced. Low energy buildings.
District cooling		
Energy from waste (incineration)		
Solar and photovoltaic panels		
Building materials and energy performances		
Score	2/10	
Global score	21/50	

The design concept is primary based on compactness of the built environment (60 to 100 units/hectare, plot usage 42-50%) and conservation/creation of green areas and green infrastructures. Public transport, services, and schools are equally distributed in the area, while commercial and offices are located at the transport nodes, maximizing the accessibility.

Due to the dimension of the district, the construction of new infrastructure lanes and bridges, both pedestrian and driveway, assumes a key role for create connections within the borough and to the city.

The mobility needs of the district are also supported by an extension of the





public transport net. Following a policy of car trips reduction, adopted at the city level, the public functions are connected through bicycle lanes and pathways, while car speed is reduced to 30 km/h, and the ratio parking place/unit is decrease to 1.08-1.25 (half of the average value of the city).

The building energetic standards are based on the Environmental Protection Act, and tested using the indicators of EPC evaluation. All the buildings are going to be connected to the district heating.

Concepts of urban densification, localization of main functions nearby transport nodes, predominance of bicycles and pedestrian connections, and conservation of green areas are leading principles also for the new development area of Leidsche Rijn, located in Utrecht. The development site, which will contain 75% of the expansions of the entire region, is strongly connected with the Randstad Green Heart, enhancing the biodiversity of the project.

The energy reduction is achieved through district heating and low energy buildings, reuse of rainwater for non-drinking purposes, reduction of car trips by new train stations, busses and commuting parking areas.

SOLAR DESIGN AT DISTRICT SCALE
Linz-Pichling, Austria

Photo: Linz Solar City, Esther Vidal Bartoll, 2011. Reproduced by Permission

The project of solarCity, started in 1992 with the definition of the masterplan and concluded in 2005, has among its aims the creation of a research pole for energy solutions in the building sector. Funds coming from the European Union, which contributed to the realization of the district, influenced the choice of strong integration between development and energy.

A general agreement to the main focuses of the project – economic growth, social progress and ecological balance – and the set up of a management team are the main factors that contributed to the success of the initiative. Added value of the development is related with the public ownership of the land, which avoided conflicts between public choices and developers needs. Important international architects – such as Norman Foster, Richard Rogers, Thomas Herzog e Norbert Kaiser, who constituted the READ group - Renewable Energies in Architecture and Design – were part of the design group, increasing the international interested on the area.

Solar energy has been a guide parameter both for urban and building design, that followed the guidelines of the *European Charter for Solar Energy in Architecture and Urban Planning* (1996). Quality agreements were stipulated between municipality and construction companies, setting the reference values for energy production and maximum energy demand for each building. As results, all the constructions have a low energy design and high resistance against overheating during summer time, while solar panels provide energy supply. The urban grid has been defined in order to take full advantage of the solar energy, providing equal amount of solar light to all the apartments and avoiding shadowing. Geomorphology of the site and natural characteristics were taken into account during the planning process, and integrated in the urban grid. Strong correlations between buildings orientation, height, glazing surfaces in the south façades, and choice of the materials contributed to enhance the energy sustainability of the project.

Criteria				Main results
Compact city and mix of functions				
High density of residential - working places	○	○	●	Technical and economical feasibility for district heating. Creation of a new urban center, reduction of the mobility-related energy.
Brown field reuse	●	○	○	
Mix of functions	○	○	●	
Public services	○	○	●	
Score	5/10			
Solar gain and wind design				
Passive solar design	○	○	●	Building's energy consumption reduced to 36 Kwh/smq. 50% of the sanitary hot water produced with solar panels, as well as 1/3 of the whole energy demand of the district. Heat island effect maximized through urban design: reduction of heat energy consumption during winter.
Use of solar energy (active/passive)	○	○	●	
Microclimate control	○	○	●	
Energy production from wind	●	○	○	
Score	6/10			
Mobility				
Improvment of accessibility and connections	○	○	●	Increase of public transports and bicycle-pedestrian lanes. Connection of the public services with bicycle-pedestrian lanes.
Walkability	○	○	●	
Urban grid and street design	○	○	●	
Effectiveness of the policies among the residents	○	●	○	
Score	7/10			
Green and water design				
Microclimate control	○	○	●	Connection of the new development with the natural areas by green corridors and green infrastructure, biotopes protection areas increased. Runoff reduction and use of rain water for non-drinking purposes. Sewage water used as agricultural fertilizer.
Green infrastructures	○	○	●	
Water management	○	○	●	
Energy production (biomass, purification)	●	○	○	
Score	7/10			
Technologies				
District heating and CHP plants	○	○	●	CHP power plant propelled with biomass (17%): supplies 50% of the energy needed from the district. Building energy consumption reduced to 36 kWh/sqm.
District cooling	●	○	○	
Energy from waste (incineration)	●	○	○	
Solar and photovoltaic panels	○	○	●	
Building materials and energy performances	○	○	●	
Score	6/10			
Global score	31/50			

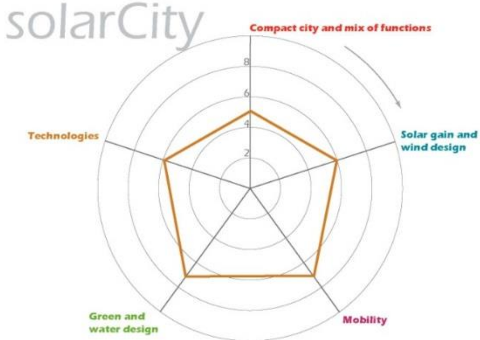
In this project, the densification has been used as mean for increase the heat island effect, since thermal losses play an important role in the yearly energy balance compared with cooling needs, due to the local climatic conditions.

As for the other case studies, social integration, sustainable mobility, and functional mix were integrated in the planning process.

Green areas and infrastructures were designed to reduce the anthropic pressure on nature and conserve the biodiversity. Moreover, they have a water filtering function, being connected with the local purification plant. At the same time, a closed cycle water system was developed, creating separated pipelines for sewage and rain water, and reusing the organic material in the agricultural sector. Green areas play thus an important role for groundwater regeneration and filtering.

The area is connected with the district heating net of the city, the integration between new development and existing net was undertaken since the beginning of the planning process, reducing cost and technical problems. At the same time, energy losses along the pipes were reduced by 8% (measured from the plant to the flat), thanks to better isolation materials. In 2004 a new biomass power plant[3] was installed, supplying 17% of the annual heat demand. Thanks to the CHP plant (combined heat and power plant) economic benefits (i.e. cost reduction and environmental quality improvements) were achieved. Additionally, 50% of the warm water demanded is produced by 3.500 m^2 of solar and photovoltaic panels.

[3] 1/3 biomass and 2/3 oil and gas.



Linz, innovative in its concept of solar design at district level, is part of the Austrian social housing process of low energy buildings construction. The nowadays average energy demand is 36 kWh/m^2, lower than 44 kWh/m^2 initially set from the project.

These results show the importance of a clear design strategy, both at urban and building scale, for reducing the energy demand.

The global development costs amount to 190 million of euro: 125 for residential buildings and public services, 65 for infrastructures. The European Union General Directorate XII for Research and Development funded the project with 600 thousands euro. Furthermore, the City of Linz subsided solar system in public buildings with 720 €/ m^2, plus 150 €/ m^2 for solar panel.

Vauban-Freiburg, Germany

Photo: Der Freiburger Stadtteil Vauban: Foto: Ingo Schneider, 2009. Reproduced by Permission.

During the 70s the City of Freiburg started the first actions for promoting sustainability in the urban planning system, aiming to reduce car trips while increasing public transports. The concept of “energetic planning” appeared in the middle of the 80s when, after strong public oppositions against new nuclear power plants, the city launched an holistic energy policy, based on cross cooperation between environmental organizations, economic sector and researchers. This cooperation aimed to develop energy solutions based on solar technologies and create a leadership role for the region of Freiburg (also called SolarRegion Freiburg). Energy saving, new technologies and renewable sources are the three points of the energy policy of the city. Final goal is to reorient the energy production towards sustainability and reduce gas emissions of 25% during 1992-2010.

Different action for increasing the urban sustainability were undertaken, coordinated by a comprehensive plan for energy saving and production. Existing buildings were retrofitted and the isolation improved, while the new constructions had to increase the energy efficiency by one third comparing with the standards for eco-buildings. Cost analyses showed an increasing of 3% of the construction prices, which is compensate by 30% reduction of CO_2 emissions.

Projects correlated with solar technologies were launched, testing the applicability at the urban scale of solar and photovoltaic panels, solar cooling, and passive solar building.

The possibility to extensively apply solar solutions is also related to a favorable geographic localization of the city (south of Germany), which avail of 1.800 solar hours per year[4], equal to an annual solar radiance of 1.117 kWh/m^2. This value is lower than the one available at higher latitude (i.e. United Kingdom), which enlighten and enforce the opportunities coming from solar technologies.

[4] The Solar Economic Factor (http://www.fwtm.freiburg.de/servlet/PB/menu/1174647_l2/index.html)

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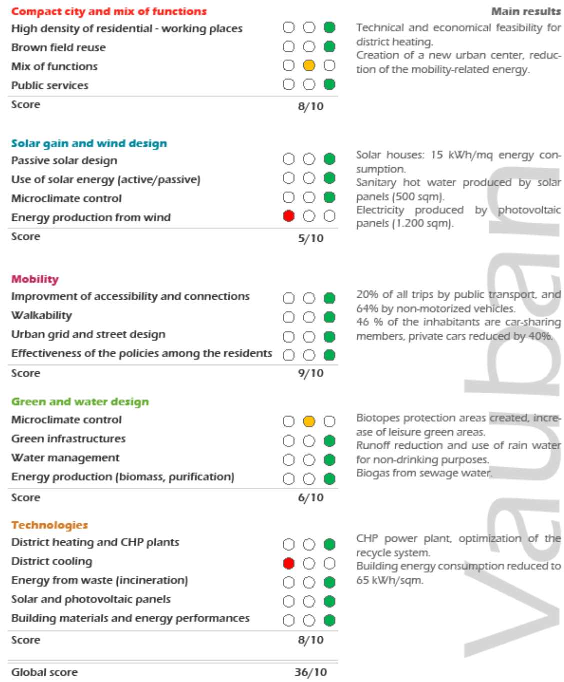


Thanks to the key role of the sun in the management of the City, large part of the industry sector is connected with solar technologies, and there are well established agreements between the industries and the research centers here located.

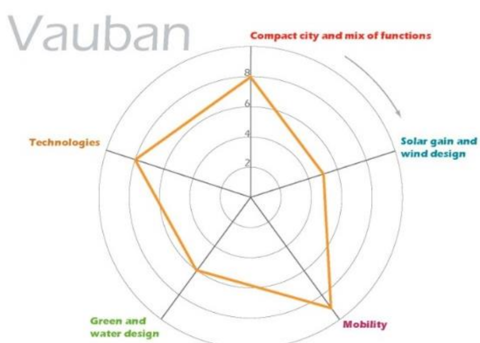
A dedicated web-site, Forum SolarRegion Freiburg, is a "virtual" meeting place where citizens can obtain information related with solar design, technologies and researches.

Other initiatives adopted by the municipality are related with reduction of car trips, started in the 80s with polices for increasing public transports; waste sorting and reuse of organic materials; reduction of land consumption and protection of 42% of the green fields.

In 1993 the City of Freiburg launched a renovation process on the area of Vauban, former army district of 38 hectares located at 3 kilometres from the city centre. The development was based on the idea of ecological, social, economic, and cultural sustainability, able to promote a different quality of life and long term progress. Thanks to public ownership of the land, it was possible to define the characteristics of the project without any pressure from the private sector, and promote actions related with urban density control, rigid energetic standards for building, and design of a car-free development.

Public participation of the inhabitants-to-be in the design process is considered one of the most important characteristics of the project. The association Forum Vauban was established in 1995 with the aim of constitute a link between people, designers and administrators, helping not only during the development phase, but also with the management processes, increasing in the population consciousness level around urban sustainability. The Forum Vauban, subsided by the European Union, closed in 2004 due to lack of funds. During the years of activity, it helped to promote among inhabitants and workers (5,000 and 600, respectively) energy measures and sustainable style of life.

Guide principles of the project are connected with functional mix; partition of the land in small plots, afterwards developed by local small scale construction companies; involvement of the inhabitants in the design phases; conservation of the existing biotopes and natural elements; mobility based on public transport and pedestrian-cycle; CHP plant and co-generation close-by the development, in order to reduce thermal losses; low energy houses and passive houses; renewable materials; solar energy systems integrated in the buildings; supporting actions for increase social life, services and commerce.



The building density identified as optimal, both for technical supplies and public services provision, is 90-100 apartments/hectares.

The building energetic standard is 65 kWh/m^2, lower than the level of 100 kWh/m^2 set by law, which was already restrictive if compared with the previous consumption standard of 200 kWh/m^2. Hundred apartments have also been realized following the principles of passive house, with consumption of 15 kWh/m^2 and no need of extra heating, except for few weeks during winter time.

A district heating system covers the all area. The needed energy is produced through a cogeneration plant powered by woodchips, while solar and photovoltaic panels (500 and 1.200 m^2, respectively) contribute to produce hot water.

Thanks to green roof, permeable surfaces and reuse of waste water, the district has water autonomy quote of 80%. Biogas for cooking purpose is produced by sewage treatment plant, while the purification process is completed by using phytodepuration. Waste is collected into different fractions by the inhabitants, and the organic waste is used to produce biogas and fertilizers.

Reduction of car ownership, improvements in public transports and pedestrian-cycle trips are other key factors for decrease the energy consumption and environmental impacts. In particular, car ownership was reduced by designing Vauban as a car-free development, dipping the ratio parking plot/unit to 0.5. The only collective garage is located at the entrance of the district, and the rent for a parking plot is higher than the city average. Thanks to these measures, it has been possible to reduce by 40%car ownership, which corresponds to a ratio car/inhabitant of 1/4 - 1/5.4.
Average yearly commuter trips with public transports are 20% of the total. 64% of the all journeys use not motorized transports. This value can be explained if distance is taken into account, 84% of the trips are indeed shorter that 6 km, which enhance the competitiveness of bicycles. 46% of the residents are car-sharing members, which covers 6% of the all trips. Private cars are used for 16% of the journeys, mainly for leisure purposes (Scheurer, 2008).

The annual energy saving or *CER - cumulative energy requirements* of the district were calculated by Öko-Institut of Freiburg in 28 GJ, corresponding to 2.100 tons of CO_2 equivalent.

BedZed-London, United Kingdom

Photo: Beddington Zero Energy Development (BedZED) London, Tom Chance from Peckham, 2007 Reproduced by Permission.

Beddington Zero Energy Development – BedZed, built in London in 1999, is focused on the creation of a new way of life in the urban context, having zero consumption of fossil fuel and high quality standards.

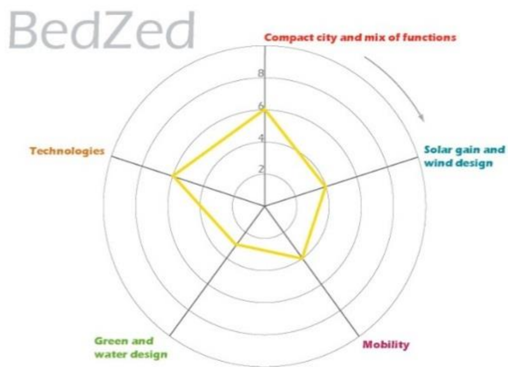
The neighborhood is realized on a former brown field, and it is characterized by high density, energy autonomy, green areas and green belt. According with the aim of the designers, the district should constitute an easy-to-reproduce and economically competitive urban model.

			Principali risultati raggiunti
Compact city and mix of functions			
High density of residential - working places	○ ○ ●		Technical and economical feasibility for district heating.
Brown field reuse	○ ○ ●		
Mix of functions	● ○ ○		
Public services	● ○ ○		
Score		6/10	
Solar gain and wind design			
Passive solar design	○ ○ ●		Global energy consumption reduced by 90%. 11% of the energy produced by photo-voltaic panels produce (777 sqm).
Use of solar energy (active/passive)	○ ○ ●		
Microclimate control	● ○ ○		
Energy production from wind	● ○ ○		
Score		4/10	
Mobility			
Improvment of accessibility and connections	○ ● ○		65% of the yearly kilometers by cars cut off thanks to efficient public transport system.
Walkability	○ ● ○		
Urban grid and street design	○ ● ○		
Effectiveness of the policies among the residents	● ○ ○		
Score		4/10	
Green and water design			
Microclimate control	● ○ ○		Sprawl controlled by green belt, green areas increased to 26 sqm/inhabitants. Runoff reduction and use of rain water for non-drinking purposes. Sanitary water consumption reduced by 60%.
Green infrastructures	○ ● ○		
Water management	○ ● ○		
Energy production (biomass, purification)	○ ● ○		
Score		3/10	
Technologies			
District heating and CHP plants	○ ○ ●		11% of the electricity produced with solar technologies. Energy consumption reduced by 3% by Increasing the isolation of walls.
District cooling	● ○ ○		
Energy from waste (incineration)	● ○ ○		
Solar and photovoltaic panels	○ ○ ●		
Building materials and energy performances	○ ○ ●		
Score		6/10	
Global score		23/50	

BedZed

The reference morphological concept is the garden city, in which green, technologies and energy are integrated to the idea of traditional outskirt development to reduce the ecological footprint. The chosen building density is 100 units/hectares (excluding 18 units whit mixed function dwelling/work) and 200 job places/hectares; total surface is 1.7 hectares. The density is higher than normal sub-urban residential areas, and it was defined to obtain higher economic, environmental, and energetic benefits. At the moment roughly 250 people are living in BedZed.

Three main target groups – morphological design and social services, urban and financial sustainability, environmental impact reduction – were defined at the beginning of the process, guiding the development and design.



Urban and social mix, optimal building density for services provision, wind and solar design, car trips reduction and promotion of an environmental sustainable life-style are the main factors of the first group. The second target group includes living cost reduction by using renewable energies, energy saving thanks to a different urban design, and land value increase. The actions for reaching the fossil fuel target are contained in the third group, in particular passive design, reduction of water consumption (-50%), creation of distributed energy resources, and use of recycled building materials.

As for the other districts, public participation was seen as important element for improve the design and achieve better results.

Energy demand has been reduced by focusing on solar design, both at urban and building scale, and realizing constructions with high thermal performance. Thanks to that, the district energy demand is 90% lower than similar areas realized in the same period. A biomass powered plant produces, besides other renewable sources (i.e. solar and photovoltaic panels), the energy needed by the inhabitants.

The mix of functions allowed a car trips reduction of 65% on the total amount of driven kilometres, although car-sharing has not been successfully integrated in the district.

According with the data released in 2003 by the English agency BioRegional, in charge of the monitoring, the project showed better results than expected, in particular related with the use of water and fossil fuel. Due to technical problems, related with the installed experimental technologies, heating and cooling did not achieve the expected performances.

After monitoring the global performance of the project in 2007, it was shown that benefits directly related with architectural solutions contributed only for 3% of the total reduction, while significant role is played by urban design and DER systems. Generally, the district –compared with others realized in the same period – is 16% more energy efficient, 30% more water saving and reduced of 40% the CO_2 emissions.

Thanks to the achieved results, the houses are valued 15% more than the surroundings.

WIND DESIGN AND GREEN AREAS

Bo01- Malmö, Sweden

Photo: Bo01 - Malmö stad, Malmö Townplanning Office, 2011, Reproduced by Permission.

Built on a former industrial and harbor area, Bo01 represents a new economical and development phase of the city of Malmö, which is moving from maritime and industrial sectors to services (bio-tech companies, IT companies) and high education (Malmö University). Moreover, with the completion of the Øresund Bridge in the year 2000, one of the major Trans-European Transport Networks (TEN-T Priority Axes and Projects - Øresund fixed link), new opportunities for economic exchange with the metropolitan area of Copenhagen have been open up.

The Swedish tradition of eco-villages is here applied at the urban scale, focusing on technologies and built environment design for energy production and consumption reduction. In order to combine built environment quality, natural aspects and energy production, a Quality Programme was developed by the City of Malmö, with the contribution of various experts. Aim of the programme was to constitute a guideline for the design and evaluation of the quality level of the new buildings. Eight focus areas have been defined by the Quality Programme, related with planning a dense neighborhood, provided with services and leisure activities; decontamination of the soils; energy system supplied with 100% of local renewable sources; urban waste management; alternative forms of transportation, as well as reduction of travel needs (telecommuting or teleworking); increase of bio-diversity within the compact city, in particularly through the inclusion of green areas and green infrastructures; social integration thanks to implementation of different housing solutions.

Morphologic and typological aspects were studied to protect the settlement from the winds blowing from the Öresund strait. A row of seven floors high buildings – higher than all the other constructions – faces the sea and constitutes an artificial barrier that prevents the occurrence of turbulences along the streets, protecting both houses and public spaces. Thanks to that, the microclimate of the whole district significantly improved, reducing the heat energy demand of the buildings.

The transport net was designed for decrease the dependence on cars and, thus, the impact on air quality. Among the different actions the most important are promotion of pedestrian and cycle paths, public transport (the distance between accommodation and bus stop is not more than 300 meters), and discouragement of car ownership. This goal was achieved by reducing the ratio parking plot/units to 0.7. Moreover, the city has launched a campaign to promote hybrid vehicles, applied also at the public transport vehicles.

The promotion of biodiversity is one of the distinguishing features of the project and influenced both the design of open spaces and the buildings materials. The majority of the constructions have green roofs and/or green walls, used also for thermal balance. Moreover, different habitats and biotopes have been created, while green and wet areas contribute to purify rainwater and melted snow before their release in the sea.

A system called *Green Area Factor*, imported and adapted from previous experiences in Germany, was introduced to ensure that all the developers would reach the needed standards for supporting biodiversity and environmental high profile. Approval of the project was subjected to the fulfillment of actions for enhance and strength the biodiversity in private green spaces and courtyard. A list of 35 "Green points" was defined by the Municipality, from which the private developers could freely choose (at least) ten of them, corresponding to the actions to undertake. The green space factor, measured on the whole development plot, has values ranging from 0.0 to 1 in relation with the type of surface. For residential areas the green space factor cannot fall below the target level of 0.5. This value is calculated by multiplying the area of each surface type for the correspondent factor, summing all the values obtained, and then dividing by the courtyard area. To ensure variety and encourage higher quality, the points assigned to each action are weighted with the functionality of the green area.

		Main results
Compact city and mix of functions		
High density of residential - working places	○ ○ ●	Technical and economical feasibility for district heating: reduced heat energy consumption. Site renovation and soil decontamination.
Brown field reuse	○ ○ ●	
Mix of functions	○ ○ ●	
Public services	○ ○ ●	
Score	7/10	
Solar gain and wind design		
Passive solar design	○ ○ ●	Winter microclimate control through a barrier of buildings: reduced speed and changed wind direction. Solar energy production by solar (1,400 sqm) and photovoltaic panels (120 sqm). 2 MW wind turbines of (6,300 MW/year)
Use of solar energy (active/passive)	○ ○ ●	
Microclimate control	○ ○ ●	
Energy production from wind	○ ○ ●	
Score	7/10	
Mobility		
Improvment of accessibility and connections	○ ● ○	0.7 car lots / unit. New connections to the city by public transport and pedestrian/bicycle lanes. High walkability index in the district.
Walkability	○ ○ ●	
Urban grid and street design	○ ○ ●	
Effectiveness of the policies among the residents	○ ● ○	
Score	8/10	
Green and water design		
Microclimate control	● ○ ○	Biotopes protection areas and increased biodiversity in the district. Heat pumps for heating and cooling. Runoff reduction and use of rain water for non-drinking purposes. District sewage treatment plant.
Green infrastructures	○ ○ ●	
Water management	○ ○ ●	
Energy production (biomass, purification)	○ ○ ●	
Score	9/10	
Technologies		
District heating and CHP plants	○ ○ ●	Biogas from waste as fuel for public transports. Natural caves used as water storages for heat pumps. Solar and photovoltaic panels. Reduction of energy demand not achieved for first phase buildings, the results have been used for improvements in the other phases.
District cooling	○ ○ ●	
Energy from waste (incineration)	○ ○ ●	
Solar and photovoltaic panels	○ ○ ●	
Building materials and energy performances	● ○ ○	
Score	8/10	
Global score	39/50	

Construction companies had to submit plans for the maintenance and management of the green areas, while the landscape project and the subsequent planting of trees was developed since the early stages of the expansion under the supervision of Malmö Green Department. The result of this operation led to a wide variety of environments, including small lakes, water retention basins, different natural habitats and green corridors between parks and gardens.

Environmental initiatives were funded through a Local Investment Programme (25 million of euro) and European Union funds (roughly 2 million of euro).

The Green space Factor, after the pilot experience of Bo01, has been integrated in the environmental building programme of the cities of Malmö and Lund, and it is applied to all the new developments (Kruuse, 2001).

Other aim of the project regards the use of 100% renewable resources locally produced, the quote is calculated on an annual cycle. The energy supply system is based on a smart grid concept. The energy networks of the district and the city are thus connected and can exchange energy: when the quote produced by the district exceeds the demand, it can be redirected to the urban net, and vice versa.

The accomplishment of this ambitious target has required different technologies for energy production, based on solar, wind and geothermal sources, as well as natural gas and biogas from waste. The installed geothermal heat pumps exploit water from sea and aquifers, which is then stored in natural caves to facilitate the conservation of heat or cold, depending on the season. In addition, part of the energy is produced by 1,400 m^2 of solar collectors, 120 m^2 of solar panels installed on the roofs, and 2 MW wind power station (annual production of 6,300 MWh).

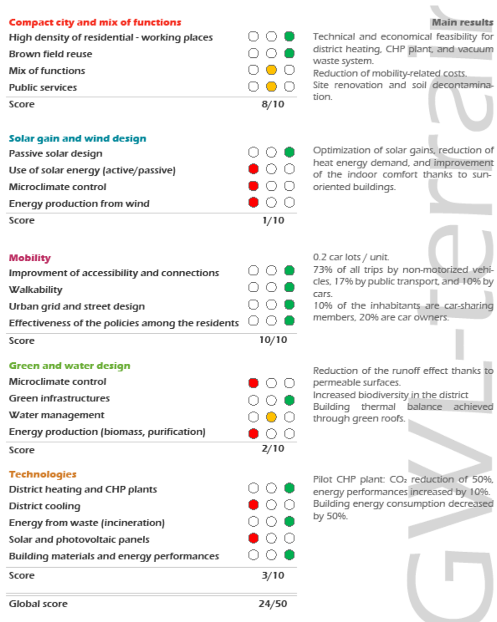
Biogas, used in the heating system and as fuel for vehicles, is produced fermenting the organic waste. The waste is collected both using traditional systems and through a pilot technology of garbage disposals integrated in the sinks (200 dwellings involved).

The energy consumption threshold of 105 kWh/m^2/year was not achieved by the dwelling realized during the first phase of the project, due to underestimation of the thermal bridges. The level of energy consumption was 127 kWh/m^2/year for buildings with heat recovery systems and 186 kWh/m^2/year for those without, an increase of 40-60% on the expected consumption.

The higher levels of energy consumption were also related with social factors. In particular, was underestimated the role played by energetic habits and use of the buildings by their inhabitants. Using the data coming from the first constructions, important improvements could be included in the following buildings. Data collected in 2008 after the conclusion of the development, shown the achievement of the energy consumption/m^2 initially set.

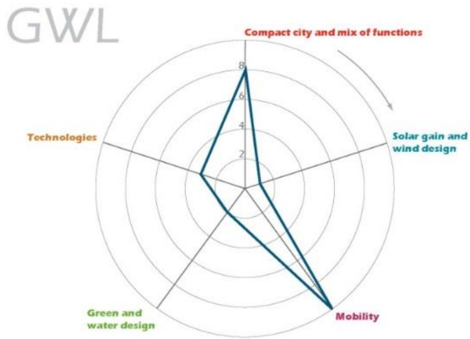
MOBILITY

GWL-terrein - Amsterdam – The Netherlands



Promoted by the city of Amsterdam in 1989 and completed in 1998, the project is located in the west part of the capital, on an area of 6 hectares. Although characterized by ecological and energetic sustainability, the central focus of the project is connected with the reduction of motor vehicles. This target has been achieved by radically sinking the available car plots (110 parking lots for a population of 1,500 inhabitants, plus 25 lots for visitors), improving the public connections, and introducing car sharing. Besides, rent or buy a flat includes also subscribe special agreements between municipality and future inhabitants, who accept to reduce cars usage as mean for improve the quality of urban areas.

To strength this policy and avoid that the GWL-residents, although bounded by contract, use the surroundings plot areas, all the neighbor districts are subjected to a strict allocation of parking spaces. Nevertheless, the car ownership rate is roughly 20%, higher than expected, although the proportion of trips in rather low and mostly related with long distances. Car rental from other areas of the city, share of parking spaces or cars with friends or relatives, and a private use of the working place parking lot, can explain the elevated percentage of residents owning a vehicle despite the limitations imposed
The use of motor vehicles, however, appears limited. Only 2% of the residents can be considered as car-dependent (car trips above 50% of the total), while 57% of the residents can be regarded as car-free (car trips less than 10%).



Other targets for improving the district sustainability were related with energy saving and production, water recycle, conservation of green areas, and waste recycle. Each target was then applied through specific projects, including, for example, rainwater recovery, green roofs, waste separation at source and maximization of the recycle, passive solar technologies, and cogeneration power plant.

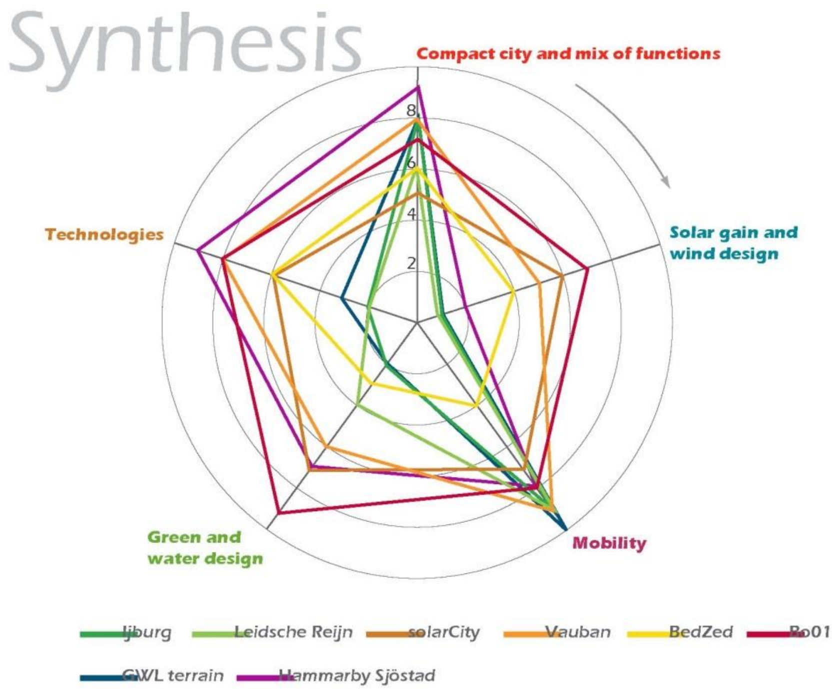
Different building types and mix between rental and property apartments was created to encourage social mix. Of the 600 units produced, 300 are rented as social houses, 150 sold at subsidized price and 150 at market value.

The chosen built environment density is 100 dwellings per hectare, while the height of the buildings is between 5 to 11 floors for those located along the north and west perimeter, so that they can perform a noise barrier function, while the inner buildings are oriented to optimize passive solar gains, further increased by glazing surfaces. Winter heat retention and summer temperature control are improved through green roofs and local high thermal performing building materials.

Stormwater management is meant to provide water for non-drinking purposes. Rainwater collectors were installed during the first years, but then removed due to negative results both in terms of duration and increase of energy consumption. Green roofs and green areas are nowadays the two used systems. The high percentage of permeable surfaces (about two thirds of the all area) drastically reduced the run-off phenomena. Water management involved also installation of sanitations able to cut off 30% of the water consumption.

The energy performance of the buildings is 50% lower than referent buildings, with 730 m^3 of natural gas per year equivalent compared with 1.400 m^3 of the referents. Energy reduction was attained also by installing a district cogeneration power plant.

RESULTS



Comparing the obtained results of the case studies, it is possible to recognize good or satisfactory results for all the thematic areas, with the exception of the solar design, which seems to have lower application within the design choices. This have aftermath for passive solar gains, which results in increasing energy demand in winter, and installation of solar and photovoltaic panels, which do not have suitable exposure conditions. Overlapping the spider charts are provided both an effective comparison of the different experiences and useful information related with the theoretical areas that had stronger influence on the design and/or the challenging elements still existing. In particular, the projects obtaining a pentagonal shape give the best results, as all fields (thematic areas of the design) have received the same development into the project.

Several conclusions can be drawn related with the sustainable design of new settlements. In general the high density and compact city concepts are applied in the entire analyzed projects, which recognize the positive effects related with the installation of DER systems, public transport, and public services in accordance with principles of effectiveness and efficiency. The compact city is linked with the increase of functional mix and that has positive effects on reducing energy demand peaks. Some case studies present limited functional mix, which can be explained either with the limited dimension of the plot (as for GWL-terrain and BedZED) or with the on-going transformation, which does not allow an overall assessment. Reuse of former industrial or urbanized areas has been applied in most cases, with the only exceptions of SolarCity and Leidsche Rijn, due to shortage of available land compared with the needs of the cities.

General focus is directed towards the exploitation of passive solar gains, by identifying optimal building / urban grid orientation and optimal relationship between buildings and road section. Even though the energy reduction achievable by passive solar gains is widely known, some projects did not focus on its exploitation, centering more the development on the urban design aspects. The use of wind as source of energy, as well as the protection of the settlement by modifying the urban grid and/or introducing green areas, has a rather poor implementation, with the only exception of Bo01 (Malmö) where urban morphology was used to control air flow and modify urban microclimate. Green and water design, such as creation of green infrastructures, green roofs, and water cycle management, are mainly directed towards the increase of permeable surfaces, increase of biodiversity, and ease water treatments. The micro-climate mitigation effect provided by green areas and corridors is usually not considered within the design goals, as well as in monitoring phases, except in cases of SolarCity and Vauban. There may be a need for additional evaluations focusing on the final development stages of each of the urban districts. Such evaluations could determine whether these case studies have influenced the construction process in the final stages of the project and also decide whether there has been any progression in the use of technical innovations (Iverot and Brandt, 2011).

The infrastructure grid (public transport net, bicycle and pedestrian lanes, etc.) has been deepened in all the case studies, which especially concentrated to the morphological and functional conditions that ensure effectiveness to non-motorized transport. Less attention was paid to implement measures and policies that support changes in the behavior of the inhabitants, particularly in relation with reduction of car ownership/use. It follows that, in most cases, the potential arising from a different urban grid design does not reach fully results in car reduction.

Technologies are mainly related with district heating and CHP plant, considered among the most effective means to reduce energy demand.

Improvements in the building envelopes and building energy performance are adopted to decrease energy consumption per square meter. At the end of the day Sustainability in its full scope applies to the construction, the life-style, habits, patterns & behavior of occupants. A full vision of sustainability and resilience when it comes to these urban districts has to be one of holistic ecological design & management in terms of: Energy consumption & CO2 emissions, production of renewable energies, material cycles & material sourcing with local ecosystem enhancements, social responsibility: social & (local) economic development, and happy cities: healthy and happy life-styles.

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