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Urban morphology and climate change

Which morphology can survive?

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Abstract

City and climate are an old topic. It could be assumed that historical cities in different climatic zones differ significantly: in warm climates cities open to promote cooling by wind, in cool climates cities dense to preserve the heat. But cities in both climates are often similar. We will find dense building arrangements and narrow roads in all regions and over all periods. The similarities are due to the same physical process: to reduce distances and the inertia of the building masses, to lead external temperature changes to the interiors. This article deals with the question of the importance of energy and climate for the morphological structures of cities in ancient and recent times. The question is, which of newer and older structures can better withstand the expected climate change.

1. Town, culture and climate

Climate change requires enormous challenges for society and cities. One can ignore this for a while. But here time is the deciding factor. It takes time, until the change will show its full impact. But it also takes time to develop solutions. This challenge includes not only threats but also opportunities. If science could succeed with the development of solutions for sustainable alternatives to the carbon economy for the operation of cities, the next generations would have a technology available with which they could settle in cold and hot climates and could withstand heat and cold periods.

Saskia Sassen deals in her book *"Territory – Authority – Rights. From Medieval to Global Assemblages"*[1] 2008, with the transition points, which mark the change from one system to another. Could the climate change in the long term develop to one of those transition points through which whole cultures would change, also the urban cultures? That will depend partially on the morphological qualities of cities. Which structures are able to withstand the expected climate change? And what future would have the urban history which is registered in the urban morphology?

After the Messina earthquake of 1908 (with about 83,000 deaths) the hot summer of 2003 with ~ 70,000 deaths, mostly in the cities, was the second heaviest natural disaster of the last 100 years in Europe.[2] How can towns react of global warming? Would it be the open arrangement of suburbs or is it the compact part of cities which could better withstand the climatic change? Will the towns in the hot climatic zones become uninhabitable bit by bit and the north will have only to adapt smart technologies or are the northern cities also reaching adaptation limits? We will follow these questions in two aspects: the mechanisms of town climate and the climatic qualities of typical elements of urban morphology.

2. Town climate

Cities in the north generate their own climate. It is characterized by

- a heat island compared to the surrounding area ~ +3 degrees, in hot climates it could be conversely.
- the rise of warm air creates a local depression, cooler air flows to the city from the open land
- this mechanism happens when the wind is weak
- inside the town the wind is influenced by the streets, in which it reaches a higher speed and also by the surface roughness of the city[3]
- stronger rain and thunderstorms because of the numerous condensation cores, twice as long or more than outside the town[4]
- lower air humidity compared to the environ
- cooling factors are shadows, wind, cool parts of buildings and streets, green areas and water surfaces
- in hot climate some factors are partly contrary.

All these factors had also worked in the early cities. Therefore it has been always important to incorporate fresh air access in the city-conception by local wind systems. As mentioned, a substantially factor is the compactness of the basic building and the building arrangement. With compact buildings and compact towns the exchange with the surrounding atmosphere decreases. We find dense building arrangements and narrow streets in Northern Europe, Southern Europe and in North African and Arab cities. The similarities mentioned go back to the same physical process: the inertia of the building mass to preserve the desired internal temperature. In the north it is mainly the heat, which is to be held and in the south it is the low temperature, which can be preserved by wall-to-wall buildings and shaded exteriors. An exception are the humid tropics: Here cooling is achieved more by open and airy buildings.

To create a tolerable town climate, the following aspects e.g. are important:

- compact building structures for the storage of heat or coolness
- narrow streets for shading areas for the movement in hot climates
- towers, skyscrapers and wind towers to generate vertical wind during hot and windless weather
- big streets in the main wind direction for ventilation and cooling in temperate climates
- cooling and shading surfaces (trees, water, green spaces, parks, green roofs, shaded streets)
- in the north wind – lanes on slopes –, and in the south protection against the hot wind.

We follow here only two basic parameters:

a. the compactness of buildings and building blocks,

b. the ability of structures to exchange air.

The compactness is measured by the surface (A) and volume (V) ratio of the buildings and blocks. The surface includes too the floor space to the ground. Wall-to-wall surfaces are deducted. The surface to volume ratio is A / V.

3. Ancient Cities

There have been always reasons for compact morphologies:

- the valuable space within the city walls
- cost and material reductions by wall-to-wall buildings
- lower costs for roads, water supply and sewage
- reduced distances to service locations
- and the energetic advantage of compact buildings.

Two examples may be enough here: *Ur* (fig. 1), which is now Iraq, and *Mohenjo Daru* (fig. 2), which is now Pakistan. Ur is one of the oldest cities of Mesopotamia (~ 4000-2800 BC). One can see a dense system of buildings and narrow streets, alleys, dead ends and buildings. The building masses have a high degree of compactness. *Mohenjo Daru* (2600-1800 BC), part of the Indus civilization, with unanimously tilled streets and lanes. The structure is characterized by a hierarchy of the road system, closed street fronts, dense development and private courts as open spaces.

4. Compact cities in warm climates

It seems reasonable of course to pull up those cultural areas and towns which must manage long periods of warm and hot climate. Of particular interest here are "Islamic" cities, because European cities always oriented the facade towards the road. And the windows allow insights into the rooms behind. Public and private spheres touch here. Contrary are "Islamic" cities. The public contact is minimized. The facade. is closed and the buildings develop their architectural face mainly inside. In these cities, shady small streets reduce the heating up of the building walls. Only the horizontal roof surfaces are fully exposed to the radiation, which can be mitigated by shading-elements and white paint. The court as the only free space allows to built more compact. A special example of density and height is the city of *Shibam*, Yemen (fig.3), which apparently exists with 6-8 storey buildings (without courtyards) up to 500 years in an environment with up to 42 degrees in summer. Here, the shading of the narrow streets, compact development and the large wall masses do have strong effects on the climate regulation. *Shibam* was one of the models for the plan for the carbon neutral city concept of Masdar in Dubai. The Kasbah in *Algiers* (fig.4) is, compared to *Shibam*, less high, however has a substantially higher horizontal density. The Old Town of *Fez*, Morocco (fig.5) has a similar structure. But also town areas from the second half of the 20th century can have relatively compact forms. Fig.6 shows a newer accommodation in the midst of *Riyadh*, Saudi Arabia. The buildings mostly have a common wall with the neighbour and relatively narrow streets. However, there are few trees, little green space and the roofs are not shaded. The cheap electricity in these countries prevents an appropriate climate protection for buildings.

5. Morphology and climate in the Middle Ages

What was the solution in Europe? The European Middle Ages have produced a type of city which is based on optimized building types and mixed use. The type was characterized by high building densities, narrow roads, a hierarchy of public space and surrounding walls. The houses were mostly gabled houses, whose width was based on the length of beams and the minimum width of necessary spaces. In the late Middle Ages and afterwards parcels have been combined, yet remained a dominant feature of compactness. The high densities were caused by the tight walled city area. The density has increased in the late Middle Ages through more stories, overhanging levels and development of the lateral distance between the buildings. The city wall protected from the wind and temperature loss. In the *"small medieval ice age"* from 1600-1800, this protection was particularly important. But the low air circulation in the interior areas and in the narrow roads, creates problems with smoke, odor and humidity. *"The view that bad air causes miasma and plague led to many actions in the cities*.[5] This illustrates a dilemma: Compactness helps to save energy, but a lack of ventilation endangers the health.

Some examples of medieval cities: The example of *Aachen* (fig. 7) shows the economical form of the plots. The streets to the gates have closed house fronts. Behind the buildings there was undeveloped land, used as garden and land reserve and as supply area during a siege. The plots are often narrow and deep. Sometimes a wider plot is occupied with two buildings. Curved streets have been created by the new gates of the second city wall. Fig. 8 shows the example of the western part of *Jakob Street* in this adaptation process: deep and narrow trapezoidal plots to adapt to a new gate (top left). This process of continuous small-scale adaptation led to the individualization of the otherwise often similar lay out of cities which has secured its permanence and acceptance until today. A significant part of the usability and beauty of public areas of those cities up to the presence is caused by these individual forms of compactness. The small town *Laugingen* (Bayern) is an example with very dense building blocks (fig. 9). For the urban climate the controlled height of the roofs over which the wind could move freely, also was important. In calm weather the towers helped by vertical air movement. The vertical structure of the small town *Zierenberg* shows elements of the ideal type of climate protection: protection by the mountains, city walls against wind passage and the vertical air flow, produced by the tower of the central church (fig. 10). We can therefore conclude: The compact medieval cities have been quite efficient in the use of space, organization of public and private space and, indeed, urban climate. Their greatest weakness was the wooden construction (fire hazard) and the use of wood as fuel with a high smoke exposure. With today's low-emission heaters, these problems are eliminated.

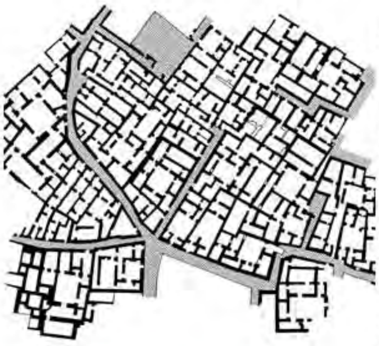


Fig. 1 Ur (~4000 BC) Iraq

Fig. 2 Mohenjo Daro (~2600-1800 BC)

Fig.3 Shibam, Jemen

Fig. 4Kasbah, Algier

Fig.5 Fees, Marocco

Fig. 6 Rhyad, Terraced houses

Fig. 7Aachen, Germany, 1805

Fig. 8 Aachen 1805, Parcels Jakobstr.

Fig.9 Laugingen, Bayern

Fig. 10 Zierenberg, Hessen

Fig. 11 Berlin Kreuzberg

Fig.12 Berlin, Wedding

Fig. 13 Hamburg Dulsberg

Fig. 14 Berlin Hufeisensiedlung

Fig. 15 Frankfurt – Westhausen

Fig.16 Aachen Hanbruch

Fig. 17 Berlin Märkisches Viertel

Fig. 18 Berlin Block ~ 1987

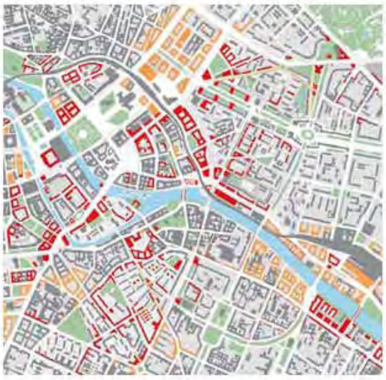


Fig. 19 Block reconstruction Berlin

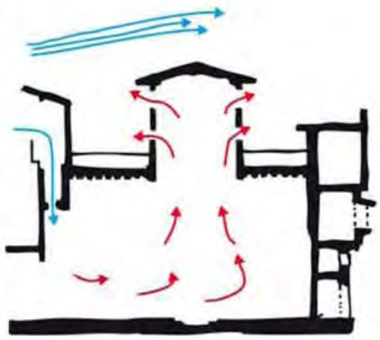


Fig. 20 Scheme Windtouer

Fig. 21 New Windtowers in Dubai

Fig. 22 Masdar City, Dubai

Fig. 23 Energy Tower, Bahrain

Fig. 24 Wind turbines WTC Bahrain

6. Development of the city from the second half of the 19th Century

The last third of the 19 Century is the time of the strongest urban growth in Europe. The population and the built up area of many European cities have multiplied in a few decades. The industrial city was born. Basic principle of urban expansion were the regular street system and the building block with the corner house, the controlled height and fronts. The buildings had large floors, elaborate facades and interior decorations and continuously thick walls: the transfer of the palace-stile to the apartment-block. In industrial cities attachments for commercial and low-income populations were added at the backside. Indeed, the blocks for poorer parts of the society were more simply designed, but had a similar structure. Both, the density of buildings and population in the poorer quarters were extremely high. Large flats were often divided by prescheduled separation areas and several staircases to get larger ore smaller units. With that uncertainties of renting were reduced. The highest density of buildings and population in Europe was reached in the *Berlin Block* with several courts. Here too we can say today that with a less dense occupation and only slightly disturbing commercial uses, green courts, silent from traffic noise, it is rather popular for students and singles to live there. The low A/V ratio, robust and durable construction and rich decoration give the better examples, 120 years after their construction, a good chance also in future. Examples of blocks with extreme high densities are shown in fig.11 *Berlin Kreuzberg* and fig.12 *Berlin-Wedding*.

7. The fight against the building block

It were exactly such Berlin blocks with their overcrowding population and bad hygienic conditions, which brought the breakthrough for the ideal of *Howard's Garden City*. The answer was the *“reform block”* without back-buildings and only for residential use (Hamburg, Berlin, Vienna), from the beginning of the century until 1920. One of the few, who hold on to the “reform block” a long time, was Fritz Schumacher in Hamburg (fig. 13 *Dulsberg*). In the late 1920th, the next step followed with carefully designed rowhouse-quarters like *Frankfurt-Römerstadt*, (Ernst May et al.), Berlin *Onkel Toms Hütte* (Martin Wagner et all) and the world heritage Quarter *Berlin Hufeisensiedlung* fig.14 (Bruno Taut, Martin Wagner). Around 1928, the block changed into lines to get an optimal exposure for all flats, fig.15 (Ernst May Frankfurt-*Westhausen*). After 1950 the building arrangements changed to open fig.16 (E. Kuehn, Aachen, *Hanbruch*) and sometimes to formalistic compositions. Negative peak of this development was the *“Märkisches Viertel”* in Berlin fig.17, a satellite town for 50,000 inhabitants (1963-1974). Most of the new town-quarters from 1955 to 1985 have a difficult mix of high-rise and row-buildings, a strict separation of functions, few public services and no jobs. Residents are often socially marginalized, distances to the city and to jobs are large, but the A/V ratio of the high rise buildings is not bad. The assessment for the future is a big question mark!

8. Return to classical principles of urban planning

The rehabilitation of classical principles of town-planning comes between 1975, the year of monument preservation and of the *“Internationale Bauaustellung IBA Berlin 1987”.* Ironically it was again the same city of Berlin, where the concept of the block had been buried, in which it got its rebirth. Fig.18 shows a new block of about 1987-90. 1999 the reunion of Germany led o the “*Master Plan Downtown Berlin*” (fig. 19). It was the return to the street as a “public space organizer”, to the building block and to a modest mixed use. Since the 1980th, in Europe a renaissance of urban understanding had developed, with the building block as the basic unit of urban planning. What had developed in 5000 years of town planning now was accepted again, of course with contemporary modifications.

9. Advance of traditional solutions in the Middle East

Which lessons urban planners and architects have taken today for town-planning and building-morphology in the Middle East? Since the Egyptian architect Hasan Fathi (1900-1989) in his concepts has drawn attention to the regional building traditions, has developed a greater appreciation and interest of regional building traditions. Some basic principles and elements from the historic building traditions of the Middle East and North Africa are also interesting in modified form for modern buildings and urban planning. That are, for instance, wind towers fig. 20, 21 (*Malqaf / Badgir*), the shaded courtyard (too in fig. 20), from outside view protected walled flat roofs (which also can be used for sleeping), the covered patio (*Ivan*) and the permeable window and window and balcony railing (*Mashrabiya, Shanashil, Roshan*), which gives shadow and access for air.

Traditional experience was studied for the concept for *Masdar City* (Norman Foster Ass, planning from 2006, 45.000 to 50.000 EW). Goal is to build the first carbon-neutral city. The concept includes traditionally proven elements such as compact buildings, narrow streets, systems of air cooling and wind breaks and wind towers, but also solar energy and modern cooling systems and 50% free space to cool the city temperature 10 degree lower than on the outside (fig. 22). An idea about the influence of climatic planning problems in *Masdar* gives an extract of an interview which is added at the end[6]. The way to an energy self-sufficient and carbon neutral city will still require huge changes, both regarding technology as well as buildings. Just two spectacular examples of *Bahrain*, a region in which take place most large-scale experiments on this subject: the *Energy Tower* from Gerber architects, Dortmund, and the *World Trade Center* with three wind rotors with a diameter of 29 meters, which should produce 11-15 percent of the energy.

10. Surface-volume ratio of selected buildings

We return to the existing building structures in European cities. We will now compare energetic characteristics of typical forms and arrangements of buildings from different periods. The form is the *"genetic code"* for the relationship between building and atmosphere. Focus is the volume/surface ratio, which includes the area to the ground. Outer surfaces, which are connected with a similar neighbouring house will not be included (there is no heat exchange by the same indoor temperature). This means that buildings which can be aggregated compact, will have a small A/V value. The basic geometric forms have different ratios: ball 4.83, pyramid 7.21, cube 6. The larger the volume of a body, the better is the A/V ratio. We have compared 9 house-types. 150sqm living space is the uniform scale. For the ancient Roman and Arab courtyard houses, which are much larger, we have used 300sqm. The results (table 1) show the high quality of the ancient courtyard house of the Middle East. They are surrounded on three sides by other buildings and reach a good value with their small courtyards. At the top of the scale is the three-windows-house from the Rhineland, which develops the best surface/volume ratio with its three floors. The Dutch small house is less god because it requires a large width due to the small depth and needs one more story. The impact of the long roof and the high facade area are also negative, in spite of the small volume. It reaches the same rank like a normal row-middle-house. A flat in a high-rise building with the same size comes on the second rank, if it is in between other stories. Generally can be said, that high-rise buildings have a good ratio, caused by the big building mass. The comparison shows that the best type on rank 1 is 2,2 times better than the one family house on rank 8. The buildings in detail are shown in table 2 and 3.

AV – Wert / Surface/Volume ratio	Haustyp / Building type	Gesamtfläche/ Total floor area	Rang / Rank
0,284	Deutsches Dreifensterhaus / German three windows house	150	1
0,333	Etage im Hochhaus / Floor in highrise building	150	2
0,428	Deutsches Reihenmittelhaus / German middle row house	150	3
0,428	Holländisches Schmalhaus / Dutsch slim house	150	3
0,530	Römisches Atriumhaus / Roman atrium house	300	4
0,563	Irakisches Atriumhaus / Iraqi atrium house	300	5
0,572	Syrisches Atriumhaus (Flachdach) / Syrian atrium house (flat roof)	300	6
0,657	Deutsches Reihenendhaus / German end row house	150	7
0,643	Einfamilienhaus / Single-family home	150	8

Table 1 Surface / volume ratio of building types / A / V Rangfolge der Haustypen

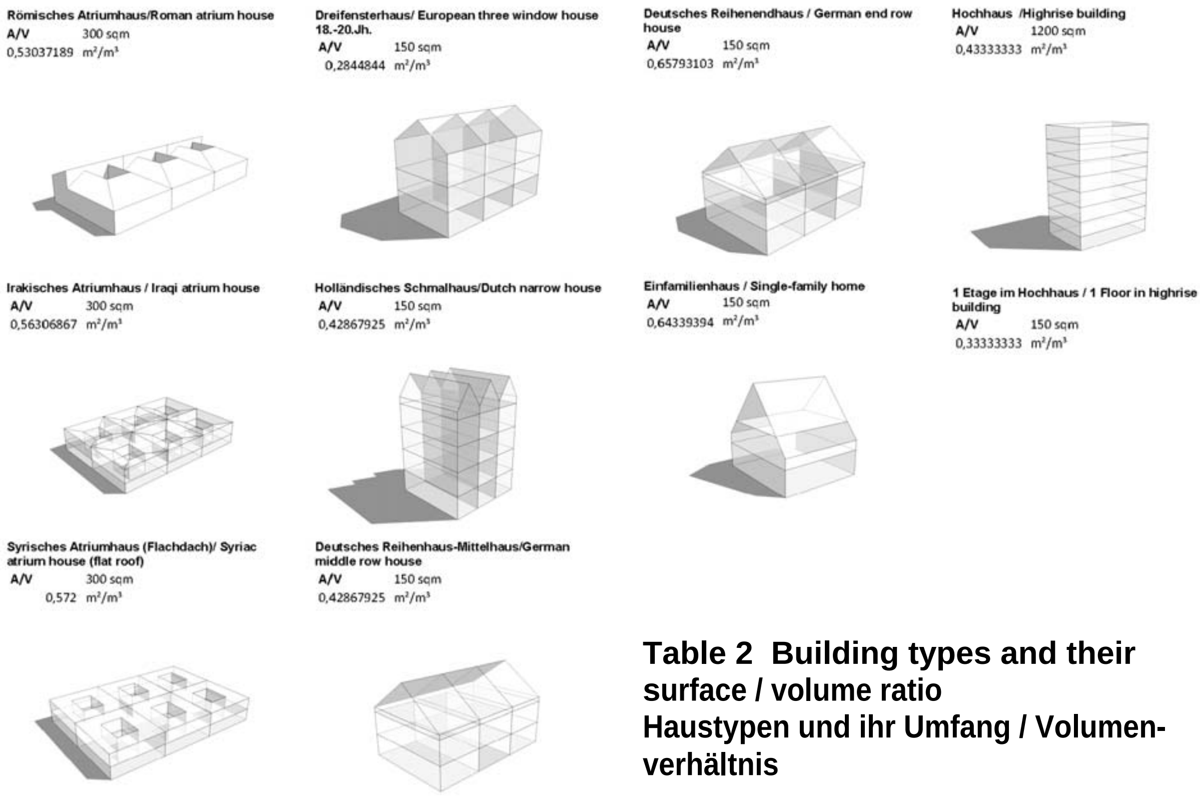


Table 2 Building types and their surface / volume ratio
Haustypen und ihr Umfang / Volumen-verhältnis

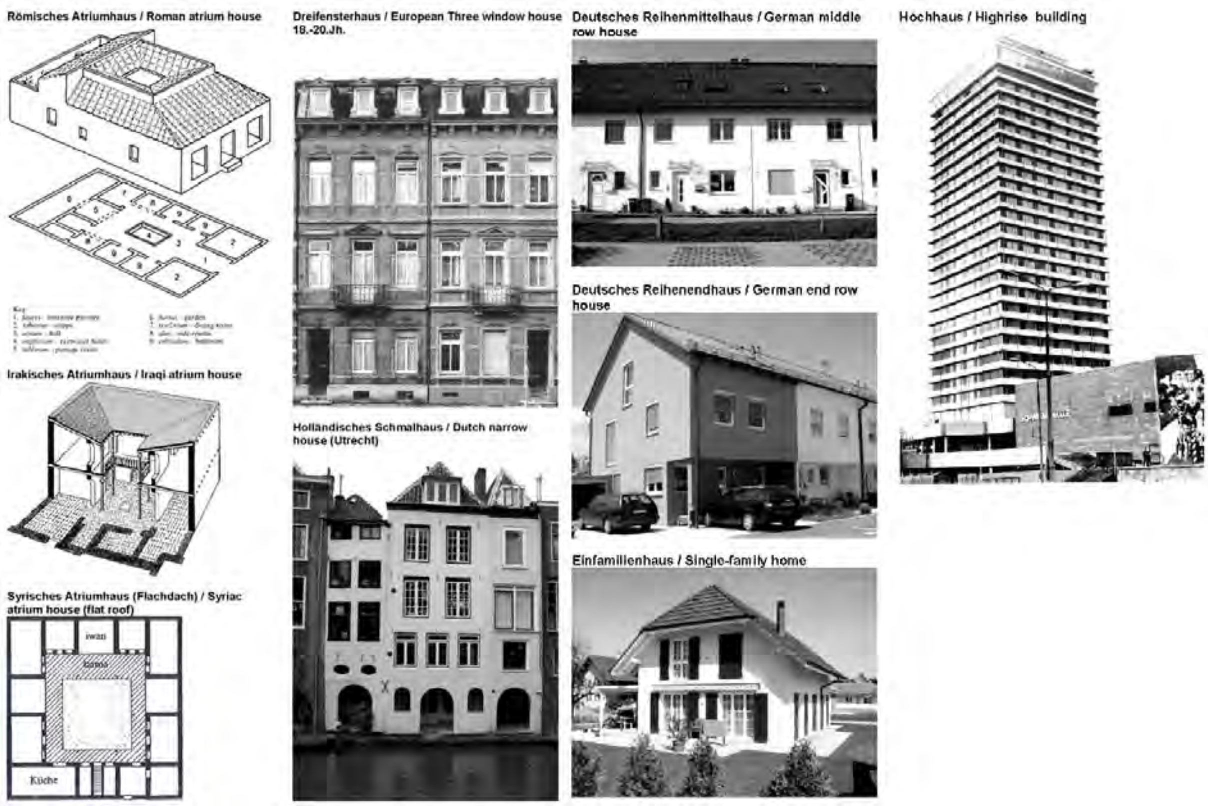
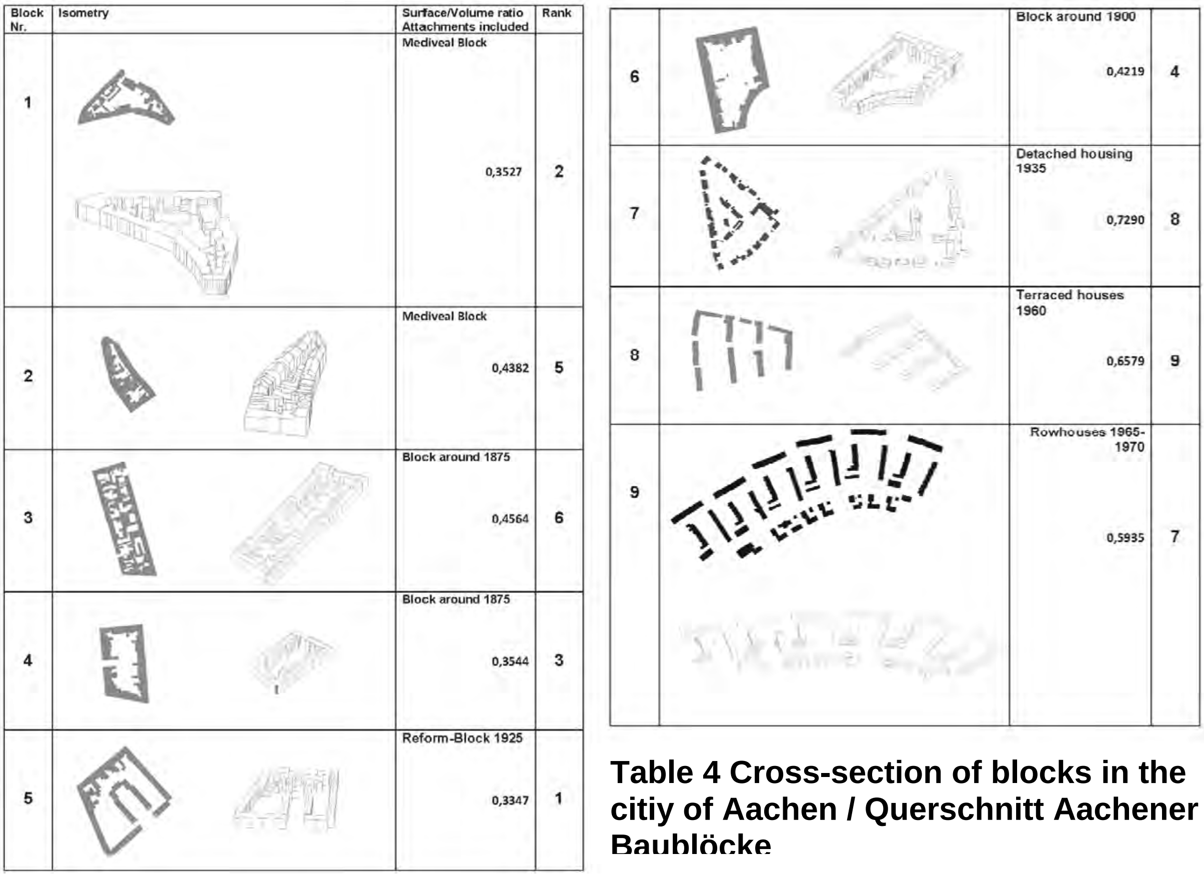


Table 3 Examples of bulding types / Beispiele der Haustypen

11. Block structures in Aachen

We extend the comparison to some construction sites in *Aachen*. A cross section of building blocks and construction areas with the imprints of the Middle Ages, the 19th and 20th Century has been chosen. The A/V ratio of the blocks and structures includes all annexes behind the buildings. The result shows table 4 and 5. We recognize that all the closed blocks from the Middle Ages to modern times until about 1925 reach good values. The best value has the *"reform-block"* from 1925 with only few annexes. All classical Blocks have a ratio lower than 0,5. The ratio of the irregular morphologies range from 0,6 to 1,2. Simplified it can be concluded that older structures are about twice as efficient as some of the newer ones. The ratio of a block from 1875 (rank 1) is 2.8 times better than the terraced houses from 1960 (rank 9). That means that the cost of an energetic renewal will be proportional higher in the newer buildings.



Block Nr.	Isometry	Surface/Volume ratio Attachments included	Rank
1		Mediveal Block 0,3527	2
2		Mediveal Block 0,4382	5
3		Block around 1875 0,4564	6
4		Block around 1875 0,3544	3
5		Reform-Block 1925 0,3347	1
6		Block around 1900 0,4219	4
7		Detached housing 1935 0,7290	8
8		Terraced houses 1960 0,6579	9
9		Rowhouses 1965-1970 0,5935	7

Table 4 Cross-section of blocks in the citiy of Aachen / Querschnitt Aachener Baublöcke

Nr.	LAGE site	Block, Typus/ block, type	GRUNDFLÄCHE m² / floor area	VOLUMEN m³ volume	HÜLLFLÄCHE m² surface sqm	Surface/ volume ratio	RANG rank
1	Templergraben Beginenstraße Königstraße	mittelalterlicher Block/mediveal block	7.105,7663	112.319,2951	38.190,7834	0,3400	**3**
2	Pontdriesch Pontstraße	mittelalterlicher Block/ mediveal block	3.930,1795	49.298,1991	19.868,8484	0,4030	**6**
3	Rehmplatz Rudolfstraße Adalbertsteinweg Ottostraße	Block um 1875 / block around 1875	./.	49065,8212	11.326,2861	0,2308	**1**
4	Luisenstraße Friedrichstraße Lothringer Straße Alfonsstraße	Block um 1875 / block around 1875	3.931,8012	61.813,4430	20.865,5570	0,3376	**2**
5	Sigmundstraße Eintrachtstraße, Talstrasse Aretzstraße	Reformblock um 1925 / block from the reform area 1925	4.989,0496	111.423,2515	39.217,7004	0,3520	**5**
6	Frankenberger Str. Viktoriaallee Turpinstraße Von-Görschen-Str.	Gründerzeitblock um 1900 / Block around 1900	5.366,7316	66.124,4283	23.146,0908	0,3500	**4**
7	Körnerstraße Hohenstaufenallee Limburger Straße	Einzelhausbebauung um 1935/ detached housing structure	5.781,7685	54.670,5313	27.957,7285	0,5114	**7**
8	Lemierser Straße Valkenburger Straße Gulpener Straße	Reihenhausbebauung um 1960/ terraced houses	3.041,5456	17.217,9629	11.328,2870	0,6579	**9**
9	Kronenberg	Zeilenbebauung um 1965-1970/ rowhouse structure	15.574,4544	101.567,1074	60.283,1053	0,5935	**8**

Table 5 Surface / volume ratio of blocks in Aachen / Umfang - Volumenverhältnis Aachener Baublöcke

12. Effects of climate change on urban morphology

What does all this mean on the long term? Assumed that the internal functionality of older and newer designs mainly requires no fundamental alterations (of course there are always cases where this will be necessary), then the compact building types and the compact building blocks have two major advantages: They require less operating power and less access costs. The distances in dense structures are generally shorter than in open ones. They therefore require fewer roads and pipelines (water, waste-water, district heating, public transport) and are generally more economical than low dense areas. There is another advantage of older buildings from the 19. century. They have less functionally determined rooms, so they are suitable for very different types of use.

However, there remains a fundamental disadvantage of the compact structures: the lower rate of cooling at high temperatures and the missing of air exchange. The hot summer of 2003 and also the current hot summer show which problems will have all cities with dense structures, especially those situated in valleys, like the center of Aachen. Therefore, high summer temperatures and low wind conditions are the central problem of compact cities. Conversely compactness is an advantage during the cold season. Exactly the opposite is true for the open building structures. They cool down quicker in winter and get more fresh air in windless weather. However, they are more expensive to operate due to their low density.

It will be one of the big questions of the future, how long societies and individuals can maintain inefficient structures in the periphery. The problem has already begin in some West-German Towns (Ruhr-area). It is already full in progress in East-Germany. It will arrive too in central Europe and Russia. The falling birth rates, aging societies, the decrease of the population can lead to a renaissance of central city areas. Central climatic task here is, if it is possible to influence the overheating of the inner cities. Research themes therefore are:

- opening of the dense morphologies
- green block interiors and shady trees
- increased water and green spaces for cooling, air corridors (perforated city)
- shading of roads and roofs (trees, solar sails)
- dissipation of heat into the streets into latent and mass storages
- transformation of the street-heat in electricity
- "green" roofs and “green” walls

- reflective materials to reduce heat (roads, walls, roofs)
- mechanical local wind systems
- water-cooling of roofs and streets
- insulation of buildings, air exchange between warm and cool rooms
- cooling - heating by ground tubes or sewage tunnels
- solar electricity for a climate-neutral operation of heating and cooling units.

In areas with monument protection the interventions are, of course, limited. Strategies will consist in combinations of solutions that can be adapted to the specific conditions of the stock. Whatever the solutions will be, they will have consequences for the image of the buildings and the city and for the functionality and persistence of morphological structures. The development is only just beginning. Solutions will not be cheap and their realisation will take a long time. After December 31, 2018, all new buildings within the *European Union*, will have to be *"energy-neutral"* in their operation[7]. That means they may not consume more energy than they produce. The requirements for the existing buildings will continue to rise too. The goal here will be the *low energy building*.

Therefore we are confronted with the need of fundamental internal, and partly too, external changes in the existing building stock. It will be important to develop now solutions for types of buildings and morphological structures. For example: The expensive renovation of the single building will have to be replaced by serial renovations of similar types of buildings to achieve more quality and price advantages.

What does this mean for the urban morphology, in which identity and history is stored? Instead of single buildings the morphological units should be in the focus. We must increase all efforts to find appropriate solutions for the existing districts and their morphology. The old building stock will have a real chance to exist in future, if we will be successful in installing smarter solar energy, in heating and cooling cities and buildings without carbon-problems. I expect that the historical nucleus, the compact and architecturally valuable and solid parts of the cities, have that real chance of survival, if we will undertake appropriate efforts in the next 20 years,

Source of figures

Fig.1 Ur (~4000-2800 BC) Quelle Wirth, Orientalische Stadtplanung, 2000)

Fig.2 Mohenjo Daro (~2600-1800 BC) Benevolo

Fig.3 Shibam , Jemen (upd.org.gallery)

Fig.4 Kasbah, Algier (Google Earth)

Fig.5 Fees, Marocco (Google Earth)

Fig.6 Terraced houses Rhyad, Saudi Arabia (Google Earth)

Fig. 7 Aachen, Germany, 1805-1812 (Französisches Urkataster Aachen)

Fig. 8 Aachen 1805, Parcels Jakobstr. Parzellenstruktur. Aachen, westliche Jakobstrasse. (horizontal gedrehter Ausschnitt aus: Aachen 1805-1812 Französisches Urkataster Tranchot)

Fig. 9 Kompakte Baublöcke. Laugingen, Bayern, (Topographia Bavariae - Merian)

Fig.10 Zierenberg (Hessen - Merian, Topographia Hassiae)

Fig.11 Berlin Kreuzberg, Gneisenaustrasse – Mehringdamm (Google Earth)

Fig.12 Berlin Wedding, Müllerstr. (Google Earth)

Fig.13 Hamburg Dulsberg (Fritz (Google Earth) Schumacher 1928-30 Google Earth)

Fig.14 Berlin Hufeisensiedlung (Google Earth).

Fig.14 Frankfurt Westhausen (1929 - 1931 Ernst May, Herbert Boehm, W. Bangert – Google Eearth)

Fig.15 Aachen Hanbruch (E. Kühn ~1960-65 Google Earth).

Fig.17 Berlin Märkisches Viertel (Google Earth)

Fig.18. IBA Berlin, Baublock Lindenstr./Oranienstr. Berlin Kreuzberg um 1987-90 (Google Earth)

Fig.19 Block reconstruction Berlin (Google Earth)

Fig.20 Malqaf - Schema eines Windturmhauses , Daniel Emmel, Katharina Gruhn (http://www4.architektur.tu-darmstadt.de/powerhouse)

Fig.21 Windtower, Dubai (micro - Deutsches Architekturforum: Dubai Windtürme und Wolkenkratzer)

Fig.22 Masdar City – Abu Dhabi, United Arab Emirates (Architect: Norman Foster, Wikipedia)

Fig.23 Burj Al-Taqa - Energy Tower (Concept: Gerber-Architects, Dortmund – Homepage)

Fig.24 Wind turbines World Trade Center Bahrain, 2008, Architect Atkins (AEWORLDMAP.COM)

Source of tables

Table 1 Surface/volume ratio of building types

Table 2 Surface / volume ratio of building types

Table 3 Examples of building- types

Table 4 Cross-section of blocks in the citiy of Aachen

Table 5 Surface / volume ratio of blocks in Aachen

Notes:

1. Saskia Sassen: Territory - Authority - Rights. From Mediveal to Global Assemblages. Princetown 2008
2. http://de.wikipedia.org/wiki/Hitzesommer_2003
3. Flur-Wind System http://klima-der-erde.de/winde.html The wind, which reached a city changes its direction. He follows the channels and canyons formed by the tall buildings that stand on either side of a road or he avoids constructions that are built perpendicular to the original direction. The main roads leading into the city are usually the main corridors for the wind that blows at night in the city. On wide streets, he can directly follow the road. .. By the expression of the heat island, the relative humidity in cities compared to surrounding areas is lower. However, it is observed that heavy rain and thunderstorms to stop here often twice as long and deliver more precipitation. The reason for this is a 3-5 times higher concentration of condensation nuclei. In narrow streets, however, the wind speed increases significantly at the street corners ....
4. "Due to the severity of the heat island, the relative humidity in cities compared to surrounding areas is lower. However, it is observed that heavy rain and thunderstorms to stop here often twice as long and deliver more precipitation. The reason for this is a 3-5 times higher concentration of condensation nuclei. Wikipedia: urban climate

5 Wikipedia „Pest“

6 KLIMADESIGN EINER POST-OIL CITY, Arch+ Febr 2010 Matthias Schuler in discussion with Anh-Linh Ngo

"The temperatures (in Dubai) invite not just to stay. But we use for Masdar Ciy only half of the building land for building. We reach one the one hand a very high dens city with 170 to almost 200 people per hectare with good shading of the street areas. On the other hand we offer half of the city plan as open space. About the increased density we reach not only a much better utilization of infrastructure, we can also provide the concept of the city as a heat-island turn back and say this city is a "cool" Island. The temperature peaks during the day lays below the ambient temperature because the shaded narrow streets do not heat up so much. In addition, we aerate the city at night by the classical principle of the wind tower, which we find for example in the Arab Architecture in Dubai, for the ventilation of the urban space....The problem is that the Arab Gulf is an average of only 30 meters deep and the water in the summer, a temperature of 35 degrees. About this warm water heats the wind at 45-47 degrees and high humidity brings with it. We prevent the deadly breeze from entering the city, by the streets, which are running from east to west and not through. They are divided into sections of up to 75 meters in length. At the beginning of each road in each case, a wind tower is planned. During the day, work the towers as a wind shadow. It closed for the streets, the hot wind is distracted over the city. At night the towers are open on the other hand, to direct the cooler air to the streets. The night wind, which has a temperature of 30 degrees, drives the heat of the day from the city. This can be achieved that the city is warm up to 35 degrees during the day and so about ten degrees cooler than the surroundings ..... It has been shown that our results regarding the street width, the wind and sun exposure are consistent with historical patterns. The characteristic rotation of the square city plan by 45 degrees to the north, we find in many historic cities. We have learned from our analysis that the combination of solar shading and daylight optimization in this direction is best. This does not mean we can accept the historical examples of 1:1, we encounter again and again to transmission problems. Take the classic courtyard house, in which the court had assigned a family or a clan. If you have designed the same type for different parties, you get a problem with privacy. That is now have very different demands on the courts. This are culturally very delicate planning tasks "...

7 RICHTLINIE 2010/31/EU DES EUROPÄISCHEN PARLAMENTS UND DES RATES vom 19. Mai 2010 über die Gesamtenergieeffizienz von Gebäuden

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