ꟼ periodica polytechnica

Architecture
40/1 (2009) 19–27
doi: 10.3311/pp.ar.2009-1.03
web: http://www.pp.bme.hu/ar

RESEARCH ARTICLE

Sustainable renovation of housing in the urban environment

Attila Ertsey

Received 2009-03-19

Abstract

The global climate change and the growing ecological crisis forces us to address both the questions of ecology and sustainability that step over from the exotic world of eco-villages into the everyday practice of urban design and renovation.

To fulfil this aim it has become necessary to define the criteria of sustainability more precisely. After the experiences of two case studies and research in smaller regions in the countryside our working team chose two urban areas in Budapest to examine the opportunities and barriers to sustainability.

The characteristic building types of the chosen areas were either typical houses for rent, built 100-150 years ago and giving the well-known architectural character of old Budapest, or the prefabricated housing estates that were built during the communist era by the "panel-factories" and imported from the Soviet Union. This kind of housing is inhabited by 20% of Hungarian citizens.

The energetic reconstruction of these buildings is of the highest importance.

Keywords

sustainable development · energetic reconstruction · prefabricated housing estates

Attila Ertsey

KÖR Architect Studio – Independent Ecological Centre, 1136 Budapest, Balzac u. 22., Hungary

e-mail: ertsey.attila@freemail.hu

We faced techniques of renovation with the criteria of sustainability that can no longer be ignored. The research work uncovering the existing qualities of the two chosen areas, has provided two proposals for each, and examined the qualities of the proposals compared to the starting point.

According to the proposals we worked out the indicators of sustainability. With the use of the newly introduced indicators it is possible to evaluate the ecological condition of a chosen area compared to that of an area in ecological balance.

At the final evaluation of the results the radical change that we had expected was clearly demonstrated– a definite improvement in climatic conditions – that is the green surfaces and evaporation, the reduction of energy consumption by up to 80%, the reduction of the use of drinking water by 40%, the reduction of waste water emission by up to 100%.

The calculated theoretical values of the study were proved by the results of an independent pilot project that was realised shortly after the study was finished.

The method worked out by the study is applicable in the evaluation of sustainability of settlements during refurbishment and revitalisation projects, and so helping the planners and inhabitants to establish a sustainable vision of the chosen area.

Sustainability – a more precise approach

Since the appearance of the Ecological Footprint [1] method, and especially after the current experiences of climate change, there is no doubt, that mankind's present way of living is unsustainable. Nevertheless, this simple statement is not enough to start the appropriate healing processes. Until we understand what is sustainable, the reduction of consumption is not enough to find where the borderline with the balance of nature is. The state of this balance, the "health" of the Earth is a result of a wide range of factors, and to set up a diagnosis we must define the current state of each factor. Our study has chosen only a few factors, and made an effort to characterize the state of balance numerically.

Experiences in small rural areas

In two research works we carried out in 1999 [2] Ökológiai Központ, 1999, and [3], our aim was to measure the conditions of landscapes unsustainably farmed by industrialized agriculture, and to provide proposals for the rehabilitation of the landscape. The proposals for sustainable land-use targeted organic systems and sustainable forestry as opposed to current systems of intensive agriculture with the necessary use of machines, energy, chemicals and synthetic fertilizers. This moderated land-use allows a return to organic systems over a 2 to 7 year period, depending on the regeneration methods Used. Moreover, the proposals include the care of surface and ground waters. The water bases were polluted, and the human influence – especially the rapid reduction of forest areas – resulted in the meteorological phenomena of a desert. By replanting forests we try to turn back processes of the micro- and mezoclimatic conditions – the weakening rains, the drying landscape.

To set a balance - besides eliminating destructive processes and developing a sustainable approach - it is necessary to control the human presence, because nature is no longer capable of healing itself. Healing the landscape requires re-establishing the circular processes of nature.

According to the results of the study the balance of nature can recover in various diverse fields within a range of time limits – of course balance does not refer to the natural conditions before the appearance of mankind, but a moderate human environmental impact of which nature can recover from. Such examples are traditional agriculture with crop-rotation, the two- or three-course rotation and the recent versions of organic, or other forms of “bio-agriculture”.

The study defined the general demands of sustainable landscape use for rural settlements and their surroundings. Nevertheless these demands cannot be applied to historically developed towns and conurbations. In such cases it is not realistic to talk of a natural environment, created cities are a vast concentrated environmental impact, and their balance cannot be defined as such, only together with the landscape that surrounds them providing it with food, energy, fresh air etc.

Defining the target area

If we calculate an ecological footprint, we can define the object from the smallest – our own, personal footprint – to the largest – a house, a settlement, land, or the whole of mankind. For the research work on small rural areas we chose the method of “Island of Sustainability”

For setting up limits of observation it is practical to choose a natural ecological system, that is relatively compact, and where questions of balance can be easily examined and defined. The Water Directive of the EU follows the same approach, proposing as a territorial unit for regional planning the water catchments areas instead of public administrative or political boundaries.

With cities we cannot always choose water catchment areas as a natural unit, in such cases we ought to take the boundary

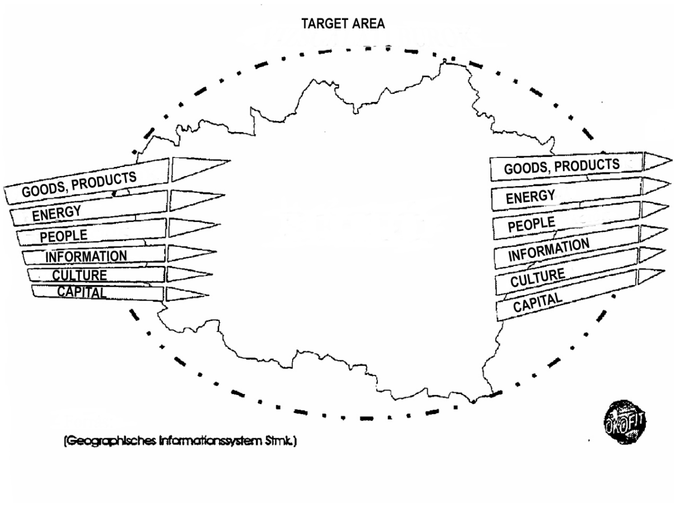

Fig. 1. The core of research: the “Island of Sustainability”

of the city as it is, or choose a greater area for observation, one that has a close connection with the city, providing it with vital resources, and hence a much larger area. It was the English urbanite E. Howard who first suggested the idea of a sustainable city in 1945 [5]. His idea of a city was a self-supporting area of 250,000 inhabitants, where the city itself is surrounded by a supporting area that supplies it with clean air, food, recreation areas, and energy. Not so long ago, – about 20 years – Budapest received around 60% of its basic food supply from farms lying in the wide green band around the city. This area has almost disappeared, the supply area has expanded to the farthest end of the globe, in a most unsustainable way, where food travels thousands of miles. The strategic aim can only be the rehabilitation of the city-supporting areas, as a part of a survival strategy. The question is the size. For defining the size of the supporting area the first task is to define the reduced needs of the city, following the most environmentally economic approach.

The research work did not take on the task of dealing with the whole city, only the two target areas, where the results can also be used on greater scale.

So the “Island of Sustainability” refers the target area (Island) and the satellite supply areas outside of the city, with the task being to define the size of the supply area.

The problem of the prefabricated housing estates (panel blocks)

In Hungary during the sixties and seventies around 200,000 flats were built with panel block technology imported from the Soviet Union, so every fifth Hungarian lives in such a block. These buildings are both technically and aesthetically run down in the following ways:

- Insulation: at the joints, facade panels were constructed with an insulation of reduced thickness (20-30 mm), and so the temperature of the inside surface drops temporarily below the dew point, thus producing condensation that results in the appearance of mould.

- Heating comfort: partly due to the factors mentioned above and partly because of the unregulated heating and ventilating systems and the poor sealing of the windows excessive heating is needed to reach an acceptable level of comfort. Due to the unregulated heating, on higher levels of the buildings windows are opened to avoid overheating, while on the lower levels flats are under heated.
- Economy of heating: as a result of these factors and the low efficiency of district heating, the inadequate insulation, the resulting heat losses and thus the amount of the energy used for heating is unacceptably high.

These houses of 30-40 years of age are well worth considering for renovation or demolition. Demolition – concerning the large numbers of this type of accommodation in Hungary – is an economically impossible task. With regards to renovation several proposals have come to light, a few of which are unacceptable, dangerous or just not efficient.

Possibilities for renovation:

- Change of windows only

New window systems provide an excellent air seal, and are an effective method of reducing heating demand. It can be carried out flat by flat, but without regulated ventilation the rising levels of relative humidity increase the danger of mould. This makes it an unacceptable solution for improving comfort.

- Modernising the heating system only

It is also an effective method to save energy, but obviously is still an unacceptable solution.

- Change of windows and modernising the heating system

Obviously better, than these options alone, but it is still inadequate for comfort.

- Internal insulation

It can be carried out flat by flat, but has some risks. When applying more than 2-3 cm of insulation the temperature of the original wall surface in winter can temporarily sink below the dew point, so mould can occur on hidden surfaces, later appearing on the inner surface. Correct vapour sealing or an appropriate silicone based material that is highly resistant to humidity can be a good solution, with careful technical control.

- External insulation

The method is acceptable if it covers all structures, avoiding cold-bridges.

- Sealing of windows and panel joints

In most cases it is not possible, and produces only partial results.

The demands of complexity

The only rational solution is the all round (complex) renovation of buildings, that is:

- the external insulation of heated spaces,
- changing facade windows,
- modernising the heating system to allow regulation
- the controlled ventilation of spaces.

An additional option can be the use of various active and passive solar techniques, so heat demand can be reduced further. During renovation this complexity must also extend to the demands of sustainability. Complex renovation must cover the architectural and landscape renovation of the urban environment, as it is illustrated by several successful – yet foreign – examples.

Research [7]

For the research work two typical areas of Budapest were chosen, both having serious problems: one is a housing area of panel blocks in the X district (work name: “Panel”), the other is a block in an inner part of town, built at the end of the 19th century (work name: “City”). Both areas have a rather high density and need renovation urgently.

The research work started with questionnaires and a technical survey. The questionnaires provided information about the consumption and environmental impact data of the flats allowing calculation of the Ecological Footprint of the buildings. The technical survey collected the thermal, structural and technical data of the buildings, with floor plans, site plans, sections, facades, and also the green surfaces.

The “Panel” area is a technically and socially rundown group of buildings. By the time of its construction urban functions had been mostly neglected, buildings served as “dormitories”. Public spaces, shops, parking places were missing, the few garages were turned into small shops and cars parked on the grass. As the quality slowly sank, people moved away, and were mostly replaced by Chinese immigrants, for whom the conditions and quality of the environment were less significant, as they were mainly places of transit. If the process cannot be stopped, it ends up in a rapid technical and social collision that leads to demolition. [1]

The “City” area consists of aged buildings, having good architectural qualities, but in a bad condition. The inner courtyards are dark, unhealthy, with a lack of green surfaces and car parks, the streets are filled with parked cars.

The rehabilitation must start with architectural actions. On both target areas two alternatives were proposed, a moderate (“D1”) and a radical (“D2”) intervention.

By the “Panel” area the whole site of the street and the dwelling towers are supplemented with a one-level flat-roof

[1] The classic example of the process is the Pruitt-Igoe housing (St. Louis), blown up in 1971

building that includes the missing functions - shops, parking lots, public spaces. On the top of it a green roof is created, providing the missing green space. In the "D2" alternative we proposed to cut off five levels from the ten storey high building.

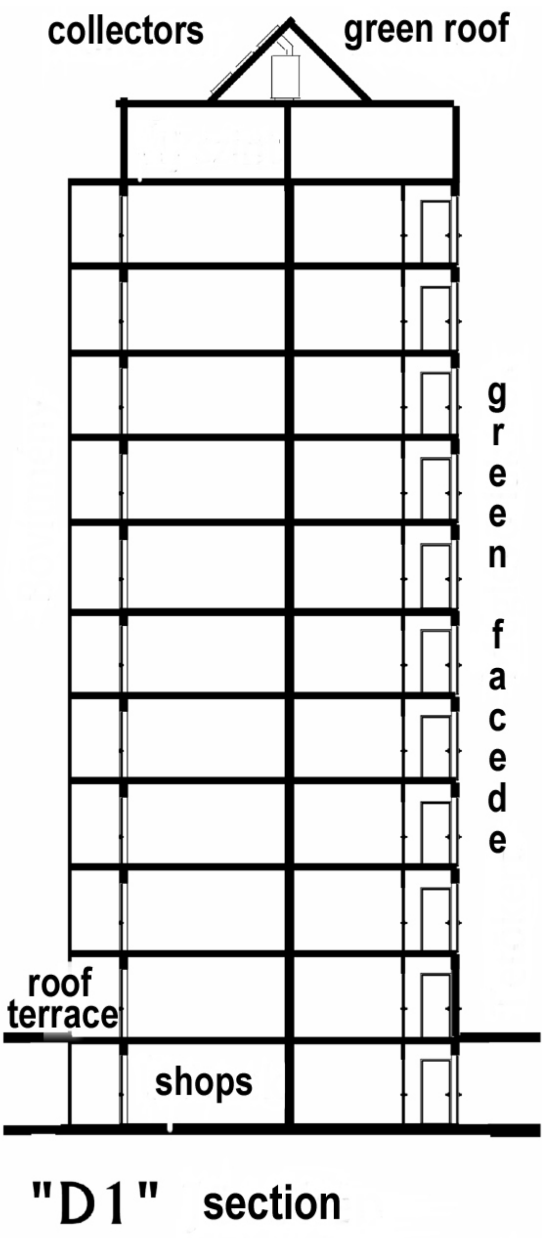

Fig. 2. "Panel" area, D1 proposal, section

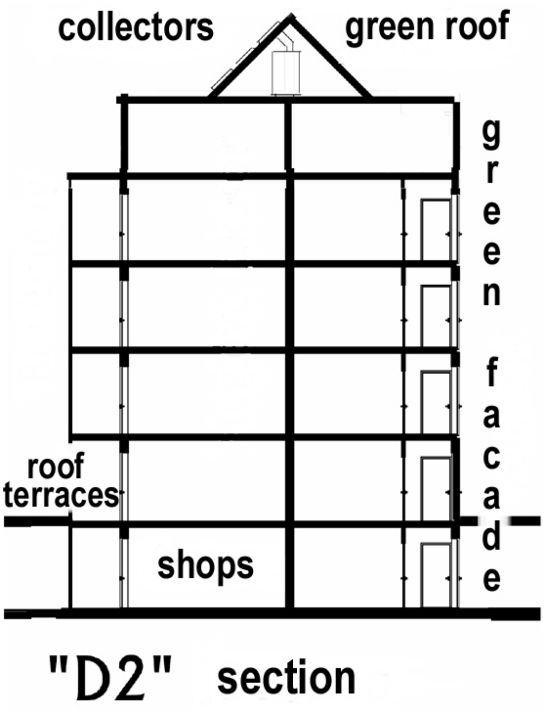

Fig. 3. "Panel" area, D2 proposal, section

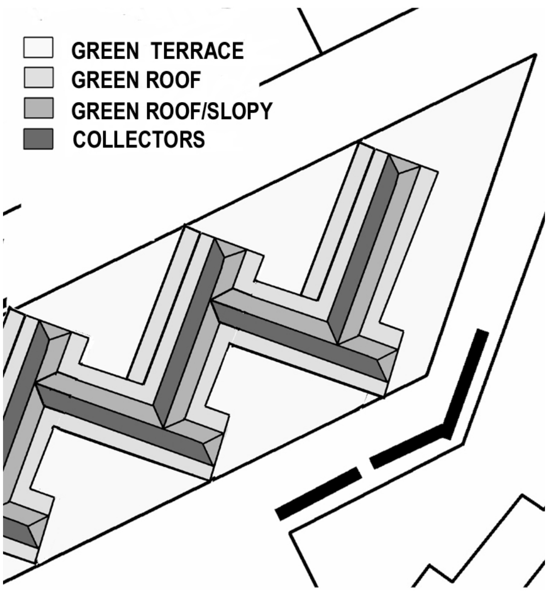

Fig. 4. site plan of "Panel" area

In the "City" area the inner courtyards are covered and shops constructed with walkways at ground level, providing commercial and public spaces, and separating dwellings from the noise of the public pedestrian zone. In the D2 alternative the demolition of the inner parts of the buildings is proposed, creating space for an internal park, with a car parking underneath.

In both areas buildings get radical insulation, a modernisation of the heating and machinery that embraces energetics, water use and waste water emission. The primary objective is to aim for sustainability with the least possible compromise, trying to use the maximum possibilities. To the well orientated sides of roofs and facades energy-absorbing surfaces (collectors and PV-panels) are set up, on the other sides green surfaces – vertical and horizontal - are added, by the means of green architecture. Rainwater collected from roofs is used in the flats for washing and flushing, and grey water is recycled for flushing toilets. Waste water is treated by plant beds in the park.

The potential of renewable energies were calculated, as well as the amount of energy and water saved. The calculated amounts were compared with actual demands and so defined the reduced consumption.

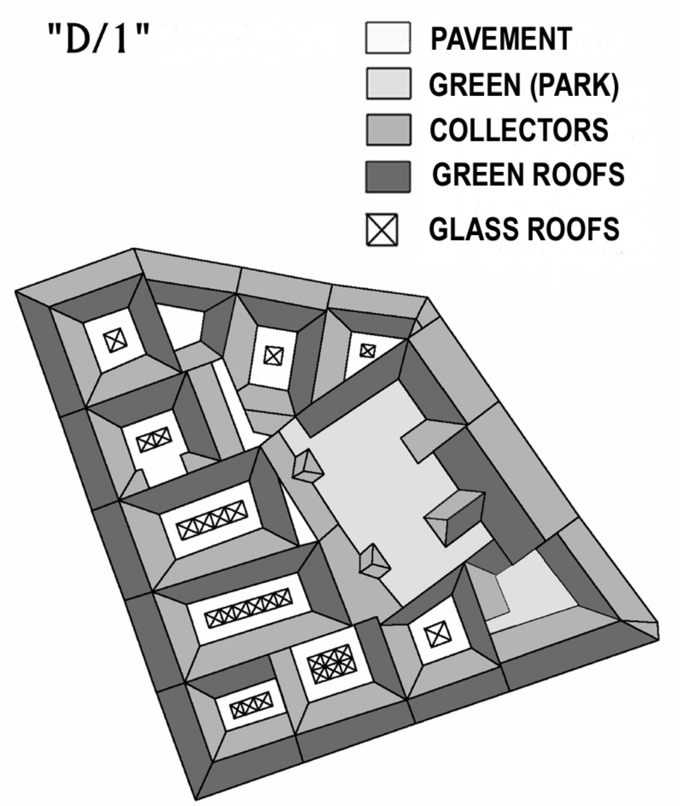

Fig. 5. "City" area, D1 proposal, site plan

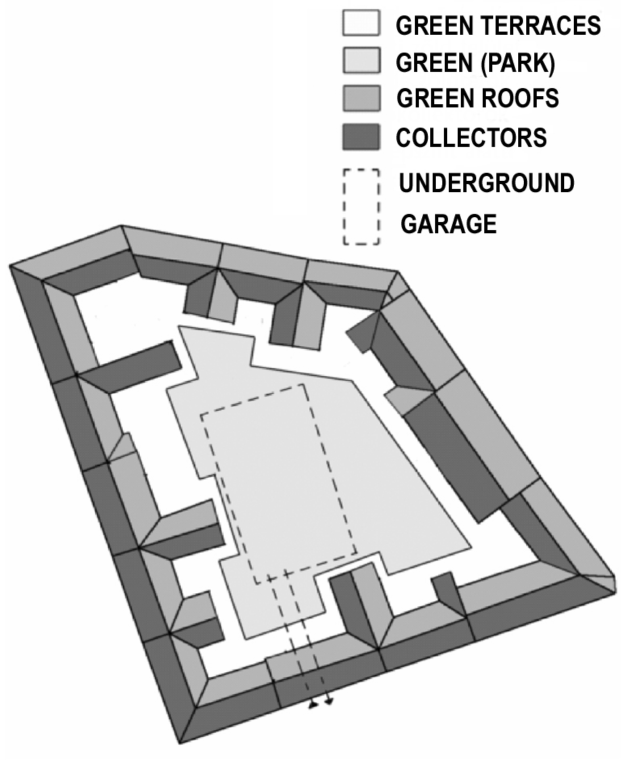

Fig. 6. "City" area, D2 proposal, site plan

Indicators

According to measured and calculated data an attempt was made to define indicators of sustainability in five fields:

1 Climatic Sustainable Built Density; S_{cbd}

2 Sustainable Energy Consumption; S_{ec}

3 Sustainable Water Consumption; S_{wc}

4 Sustainable Wastewater Emission; S_{wwe}

5 Sustainable Density of Population; S_{dp}.

At this point, it is worth looking at the details that characterize these indicators. The basic question is: what is considered to be sustainable, as a state of balance? The statements might seem subjective, but we must point out that the indicators are not like strict natural laws, only statistical tools that can change with time. The state of balance in many cases is not or not easily measurable and can only be described or approached by means of statistics. For indicators, the best example is the Ecological Footprint, whose method might be considered subjective by choosing the method of measuring environmental impact by calculating it according to land or area use, based on statistical data only, but it can effectively characterize tendencies and thus helps to describe the impacts of human activities.

1 Climatic Sustainable Built Density; S_{cbd}

The factor that predominantly influences climate is the size of the area covered with green surfaces, and its density. In summer the difference between the temperature measured in a forest and in an open space can reach up to 10^0C. In cities the temperature fluctuation of a solid surface (pavement, roof, etc.) can reach 60^0C a day, while a green surface only a maximum of 20 ^{0}C.

A grove forest can be considered as a natural element of environment in balance. A Hungarian-American university group has carried out research on the changes in the climatic behaviour of a natural environment if buildings are erected on it. According to the results the climatic behaviour remains constant if building density does not exceed 10% of the area, and the height of the buildings is not greater than 12-15 m, which fits the average crown size of leafy trees grown in a city environment, that is a maximum of a 5 storey building. We defined this limit as the indicator of Climatic Sustainability (S_c).

In urban planning practice today there is a generally accepted view that below 50% of green surface the climatic conditions become out of balance. The origin of this view is not clear, but obviously is not coming from the demand of sustainability.

By what density of population can climatic sustainability be maintained?

Considering the built density mentioned above the estimated number of the population can be as follows:

– 5 storey office building, with gross built area of 10m^2/person giving 600 persons/hectare

– 5 storey residential block, with gross built area of 30m^2/pers. giving 200 persons/hectare.

In this case the applied data agrees with the maximum used office and residential block, with an average size of dwelling per person in Hungary.

As a result we defined the climatic sustainable built density, but not yet the climatic sustainable population density, only its maximum, which is 600 persons/hectare. The final value must not exceed this.

Balance, deficiency, surplus

On an observed area the variation from balance can be characterized by the size of the deficit or surplus. If an observed "island" within a city shows a deficit in a certain number of indicators, the missing quality can be supplemented by improving the quality of the area, but if the possibilities are limited, and a deficit still remains, it can be supplemented in an area outside the city, in the town-supplying area. If the "island" shows surplus, it can be counted as a quantity that can be used to boost the surrounding islands having a deficit, so as to improve the whole city's indicator.

An analogy to this idea could be certain car producers such as Peugeot buying large areas of Amazonian rainforests to compensate for some of the environmental impact their cars make. Although the case is nothing more than an action to improve the PR of the company, it shows quite well the development of the idea of an Ecological Footprint into everyday thinking.

2 Sustainable Energy Consumption; S_{ec}

In the field of energy use we differentiate energy used for heating, cooling, producing hot water, supplying electrical devices and transportation.

In the case of residential buildings heating is of major importance. The heat content of hot water is a much lower item and can quite easily be replaced with renewable energies. In the research the starting point was the heating demand of the houses. We have chosen an approach to define the idea of sustainable energy consumption: if all the dwellings in Hungary were switched over to biomass heating, the amount of biomass available[2] divided by the number of dwellings gives the average heating demand of a single flat. This value is $\sim$ 55 kWh/m^2 per year, and so theoretically – using traditional renewable energy – this quantity of heat can be supplied in a sustainable way. This value – that serves only as guideline – can be affected by two factors:

- If biomass potential is rising (with new energy plantations, etc.), more energy is available;
- If biomass is replaced by solar, geothermal energy or by improved insulation and heat recovery, the energy saved can be used by houses having a greater heat demand.

Therefore sustainable energy consumption can be approached from two directions: by reducing heat demands or by replacing biomass with other renewables. In the urban environment it means the use of the passive house principle on the one hand, and on the other hand minimizing biomass-input. Combining the two, biomass input can be totally replaced.

Cooling performance

In residential buildings - where only a few people stay at home during the day and the density of the people remaining inside is also lower than in office buildings - in the case of appropriate design, good insulation and solar protection - there is no need for cooling. In light structures such as converted attics in most cases heat protection as well as heat storage potential is insufficient. In office buildings the constant heat load of business machines - computers, copiers and lighting -the energy need for summer cooling can be 2.5 times more than that of winter heating. In residential buildings passive cooling solutions can be sufficient, so this demand was not taken into consideration in the study.

Sustainable electrical demand can be answered only with difficulty. Obviously electric energy can be supplied only from renewables, but where lie the limits of sustainability? Again, where is the point where the environmental impact of producing and running electrical devices becomes unsustainable?

This question ought to be answered globally. Locally it is possible only to calculate the savings achieved compared to the present average consumption and the involving of local renewable potentials. This can result in cutting peak power consumption by 60-70% (from the average 10 kW peak to $\sim$ 3 kW) and reducing power input by up to 80%.

Reducing the energy demand from transport can be achieved in different ways:

- cutting the volume of transport by putting working and living spaces in the same place through urban design, to establish or import town functions such as administration, education, trade, services during renewal to dormant cities
- improving public transport
- developing bicycle networks
- using biofuels.

These aims raise complex questions of urban planning and technology, most of them exceeding the limits of the study. The transport energy demand (fuel) can be provided only from an input coming from outside. When dealing with utilizing the town supply zone for producing biomass for energy this question can be raised, but the environmental impact of producing biofuels provokes a whole lot of new problems, so the question of sustainable transportation energy is not dealt with here. The quantity of energy used for transport is taken into consideration only when calculating the ecological footprint of the target area.

3 Sustainable Water Consumption; S_{wc}

To define numeric limits the first task is to define minimum consumption of the mixed use of drinking water, rainwater,

[2] Data from the MTA Renewable Energy Commission (Hungarian Academy of Sciences)

groundwater and recycled grey water. According to the literature the equivalent of ∼140 l/person per day can be reduced to ∼68 l/pd.

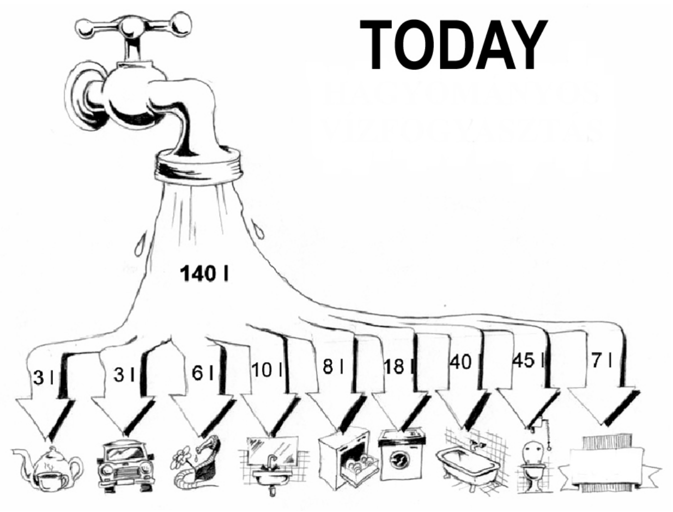

Fig. 7. water consumption today

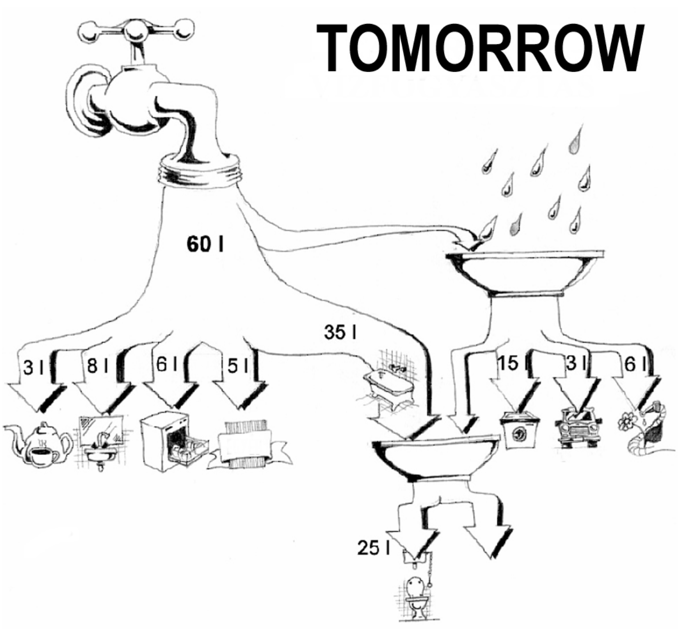

Fig. 8. water consumption tomorrow

Water saving taps can save ∼20% more water, that is ∼55 l/persons. By using water saving toilets 20-40 l/day can also be saved, although the grey water is more than adequate for flushing. It is at around 60 l/person of drinking water demand that can be easily achieved, without any asceticism. To reach this value the daily amount of rainwater must be available from a cistern and grey water from the recycling equipment. In big cities to assure the sufficient quantity of rainwater the appropriate size of surface per person for collecting rainwater must be defined. Having done this, an optimal density of population can be defined. For collecting rainwater only roof surfaces, areas with solid flooring and green roofs can be taken into consideration, not parks and roads. The minimal site area – based on the annual rain data of Budapest is 25 m^2/person, the optimum is >35 m^2/person. In the optimum case the density of population on a specific site is 285 persons/hectare. If the quality of ground water meets the standards, it can also be used for secondary water needs. The optimal density of population calculated with a safe rainwater supply is around ∼300 persons/hectare.

In case of an office building water demand is much lower, so a density of users of 600 persons/hectare rainwater gain is sufficient , and by recycling grey water coming from hand washing and using it in extremely low flush toilettes and non-flushing urinals the rainwater demand can be reduced to zero.

4 Sustainable Wastewater Emission; S_{wwe}

The amount of wastewater emission connected with sustainable water consumption can be considered sustainable. The amount calculated is ∼90 l/person per day, compared with the average 140 l/day. The reduction of emissions is 35%. The most favourable techniques of treatment use plants to clean water – reed beds, root-zone treatment technologies, etc. Their benefits are the lack of energy-consumption, an effect on improving climatic conditions on site by evaporation and by other environmental friendly factors of green vegetation (binding carbon dioxide, dust, etc.).

Treatment and recycling of wastewater is optimal at the point of emission, or the closest reasonable distance. The task of transporting unused recycled water is much simpler.

At what density of population is it feasible to treat wastewater on site? The technologies suitable for use in urban environment need a maximum area of 5 m^2/person, considering an average quality and amount of communal sewage of 140 l/persons. In case of reduced emissions, 35% less space is needed, that is 3.2 m^2/person, so if green surface on site reaches at least this value, theoretically sewage treatment is possible. At a density of 300 persons/hectare 10% of the area is needed, at 600 persons/hectare 20%. So the treatment of waste water with plant beds is possible under such density. Of course with biological treatment technologies it is also possible and needs minimal space, but such a technology needs energy, chemicals, maintenance, etc. The question in both cases is the disposal of cleaned water. In summer plant beds can evaporate up to 100% of cleaned water. Green spaces don't need watering all year, so in other seasons water must be disposed of by releasing it back into surface or ground waters.

5 Sustainable Density of Population; S_{dp}

More indicators can be defined, but not all of them have any effect on the use of the area, so sustainable density of population was approached by using the indicators mentioned above.

Climatic sustainability and sustainable water consumption together point at the value of 300 persons/hectare as a sustainable density of population. If the density grows, it produces a deficit in certain indicators that can be supplied only by the town supply area. The S_{dp} allows buildings to have the sufficient natural light, active and passive solar gain and also passive cooling using ground air collectors. With the use of indicators and the calculation of deficiencies or surpluses a chosen target area can be clearly characterized, the limitations reduced and the town supply area accurately defined.

Sustainable energy consumption in the target areas

With regard to the target areas a comparison can be made between the energetic qualities of general building types and the chosen buildings.

The indicator of sustainable energy consumption in the target areas based on biomass potential is: ~ 55 kWh/m^2 per year

- Comparison data[3]
- residential panel blocks: 330-370 kWh/m^{2}a

(U_{wall}: 1.56 - 0.85-0.7; U_{window}: 2.1; U_{roof}: 0.8-0.4 W/m^{2}K)

- well insulated flat: 80-100 kWh/m^{2}a

(U_{wall}: 0.4 ; U_{window}: 1.5 ; U_{roof}: 0.25 W/m^{2}K)

- Low Energy House (NEH): 60-70 kWh/m^{2}a

(U_{wall}: 0.2 ; U_{window}: 1.3 ; U_{roof}: 0.15 W/m^{2}K)

- passive house: 15-30 kWh/m^{2}a

(U_{wall}: 0.1 ; U_{window}: 1.0 ; U_{roof}: 0.1 W/m^{2}K)

- average quality new flat:[4] 223 kWh/m^{2}a

(outside wall thickness: 30 cm; attic insulation 10 cm)

- Data of target area (starting situation)
- "City": 225 kWh/m^{2}a
- "Panel": 169 kWh/m^{2}a
- Data of target area (proposal)
- "City"
- D1 version: 72 kWh/m^{2}a, 68% saved
- D2 version: 84 kWh/m^{2}a, 63% saved
- "Panel"
- D1and D2 (almost identical): 62 kWh/m^{2}a 64% saved

without heat recovery

29 kWh/m^{2}a 83% saved with heat recovery

The values of calculated energy demands draw near to values of sustainable energy consumption; in one case it is even lower.

Heat demand can be covered by solar energy by at least 50%. The original demand was reduced to 1/3 or 1/5 by insulation and is further halved by solar energy input to 1/6 or 1/10, so the remaining quantity is the reduced biomass input. Thus the biomass input reduced by insulation and solar energy safely fulfils the criteria of sustainable energy consumption, so both target areas with their two alternative proposals are energetically sustainable.

[3] Ágnes Novák, study

[4] Independent Ecological Centre, study

Evaluation

The results of proposals for the target areas are as follows:

"City"

The built density is slightly reduced, the housing functions are supplemented with commercial and public utilities, and so the mass of traffic is reduced. Green surface compared to the starting situation (0%) has grown to 28%. Climatic deficit remains still significant (D1 80% and D2 50%), but the microclimate improves considerably thanks to the growing green surfaces.

Water consumption decreases by 40%, waste water emission by 35%, and with waste water treated on site up to 100%, so there is no untreated waste water emission from the area, all in all reduction is 100%. Heating energy consumption through applying insulation and solar energy is decreased by 80%. The hot water demand is reduced to 65%. Electrical consumption is decreased by 75%.

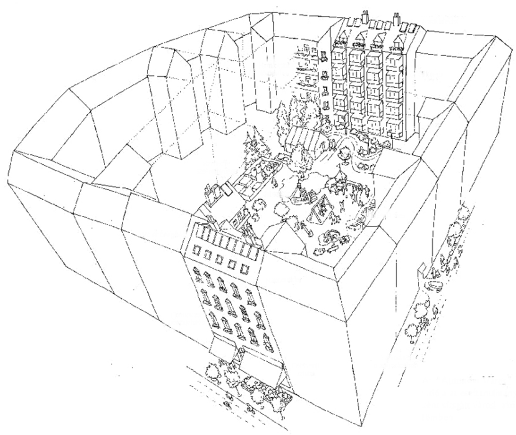

Fig. 9. Vision, "City" proposal

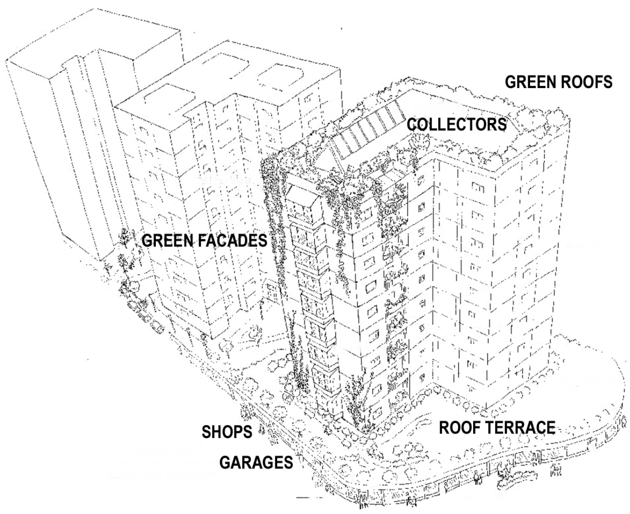

Fig. 10. Vision, "Panel" proposal

"Panel"

The built density has increased, but at the same time green roofs increase green surface. The housing functions are supplemented with commercial and public utilities, and so the mass of traffic is reduced.

Green surface compared to the starting situation (30%) has grown to 100% in D1, to 70% in D2. Climatic deficit remains still significant in D2, but the microclimate improves considerably thanks to the growing green surfaces. In version D1 deficit is only 9%.

Water consumption decreases by 46-49%, waste water emission by 35%, and with waste water treated on site up to 100%, so again: the overall reduction is 100%. Heating energy consumption through applying insulation and solar energy is decreased by 82%. The hot water demand is reduced to 65%. Electrical consumption is decreased by 75%.

After having defined the reduced energy-input of the renovated building we calculated the size of energy-forest needed to supply this input. For an area of 300 persons/hectare density it gives us 10 hectares of forest, that is 10 hectares forest per 1 hectare of inhabited town area. The size of the energy forest can be further decreased by turning buildings into passive dwellings, or involving more renewable energies.

Realized pilot projects

An example that illustrates the goals of the study and demonstrates what results can be achieved is the measured data from a 9-storey panel building with 42 flats planned in 1974 and renovated in 2006 (Dunaújváros, Solanova-project)[5].

Fig. 11. Solanova project

The data show that renovation of a panel block is reasonable only if it is a total renovation, using single elements of renovation can be considered only as partial solutions, and not only because of the lower efficiency but also the possible hazard of future damage. The results of the total renovation fit even the regulations of the German energy saving order of the year 2000 concerning the consumption of heating energy, which from a Hungarian point of view seems rather strict (max. 70 kWh/m^{2}a). During the renovation – because of the highly airtight new windows and terrace doors – the sufficient and regulated room (flat) ventilation (with an air change rate 0.6 – 1.0 1/h)must be provided to maintain heat comfort and building quality, however more intensive ventilation can produce significant heat losses.

[5]http://www.egt.bme.hu/!solanova/solanova.htm; http://www.www.solanova.eu/

Summary

The research produces new tools for the sustainable renovation and revitalisation of the building mass of Budapest that currently exists. Renovation should not be restricted within the limits of partial tasks, but must meet demands of sustainability; otherwise global problems will continue to expand. The study points out the complexity and is coherent with the Directive of the European Parliament in January 2008 that proposes the general introduction of the passive house principle, it also meets the EU Water Directive that targets the protection of drinking water, as one of the most important values.

Most of the tasks are still ahead of us.

References

1 **Wackernagel M, Rees W**, *Our Ecological Footprint*, New Society Publishers, 1996.

2 **Ertsey A (ed.)**, *Autonóm Kisrégió, Független Ökológiai Központ*, Független Ökológiai Központ, 1999, available at www.foek.hu/nyomtatottkiadv/index.html/kisregio.

3 ______ **(ed.)**, *Fenntartható kistérségek az EU-ban*, Független Ökológiai Központ, 2006, available at http://www.foek.hu/programok/alkoko.html.

4 **Narodoslavski M, Wallner H P, Steinmüller H**, *ÖKOFIT, Ökologischer Bezirk Feldbach durch integrierte Technik*, Bericht aus Energie- und Umweltforschung, Bundesministerium für Wissenschaft, Forschung und Kunst, 1995, pp. 19.

5 **Howard E**, *Garden City of To-morrow*, London, 1945.

6 **Osztroluczky M**, *Panel Mínusz*, Építés Spektrum **5** (2006), available at http://www.proidea.hu/spektrum-lap-es-konyvkiado-213985/epites-spektrum-293086.shtml.

7 **Ertsey A (ed.)**, *Autonóm Város*, IEC, 2004, available at http://www.foek.hu/nyomtatottkiadv/index.html/autonomvaros.

.