The Urban Environment in Europe

Margrit Kennedy / Declan Kennedy (Editors)

Designing Ecological Settlements

Ecological Planning and Building: Experiences in new housing and in the renewal of existing housing quarters in European countries

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Authors's dedication and acknowledgements

We dedicate this book to our friends, the pioneers of ecological building, from whom we learnt so much in regards to ecological settlement design:

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Declan Kennedy and Margrit Kennedy Steyerberg, Autumn 1996

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Introduction

General remarks

Declan Kennedy & Margrit Kennedy

"Mankind, and this is vitally important, ought never to forget that a 'problem' merely indicates the difference between a situation and its perception; which challenges humans to solve it through a learning process ... thus problems can be seen as the real motivating forces of evolution" [Detlefsen, 1979, p.116]

Nowadays, in contrast to the situation at the beginning of the ecology movement - the late seventies and early eighties, there is general social consensus that ecological planning and construction should not be a short lived whim but rather long term objectives for all groups involved in building. There is no shortage of concepts, planning and proposals. However, concrete examples of the magnitude required - i.e. anything over and above a detached house or a small settlement of 10 to 20 dwellings - these are still few and far between. The vast majority of new building, and also of urban renewal measures, comes nowhere near putting into practice the ecological design principles which could be implemented in today's world. Settlement design is driven primarily by what are believed to be commercial market laws which do not place a premium on ecological criteria. But as long as ecological settlement design remains out of the mainstream - contained in model projects for a Building Exhibition here, an Expo there - consumption of resources will continue to proceed at a level far beyond the desired reduction, i.e. the one called for in Agenda 21 of the World Climate summit in Rio.

Two recent studies, "Sustainable Netherlands", the first projection by a European country to reveal just how much space the Dutch population is actually laying claim to by its consumption and behaviour patterns, and the current study being elaborated by the Wuppertal Institute entitled "Sustainable Germany" (Zukunftsfähiges Deutschland) take as their base line the principle of global equality. This is to say that every human being on earth, whether they are in Africa or North America, in Asia or Europe, has the same right to expect clean water, pure air and an adequate amount of energy. These studies do not only point out what has been common knowledge for some time now, that people in highly developed industrial countries have long ago overdrawn their environmental funds, they also indicate which reduction targets would bring us nearer to the goal of a just and environmentally compatible global economy.

The Dutch study demands a 70% reduction in resource consumption by the year 2010, pointing out that economical and technological developments can certainly help in this respect, but that changes in attitude will also be necessary. Given an energy capacity which purely statistically would allocate one litre of fuel per head of the population per day, the Dutchman of the year 2010 would have a choice between driving 25 kilometres in a car, travelling 50 kilometres by bus, 65 kilometres by train or flying 10 kilometres.

The staggering technical and economic development undergone by some Asian countries, especially China, will only be a positive influence on our global future prospects if the rich industrial nations can demonstrate that there is a way of living which can ensure survival for everyone on earth. This global interdependence represents one of the major and most urgent challenges in human history, because the time we have left to learn these lessons and try out new solutions is decreasing rapidly (see Figure 1). Even if there is now consensus that settlements must develop to be more compatible with nature, i.e. more ecological, there is nevertheless no general agreement on what is meant by this. Since the concept began to be more generally used, from the early eighties onwards, what is signified by the term: ecological design, this has become increasingly all-embracing and more diffuse. Even for those who have for several decades been involved day in, day out with the concept of ecological design it has become difficult merely to keep up with the latest developments in the main fields of application. How much more difficult must it be for practical architects or for decision makers who in addition to coping with the veritable flood of information

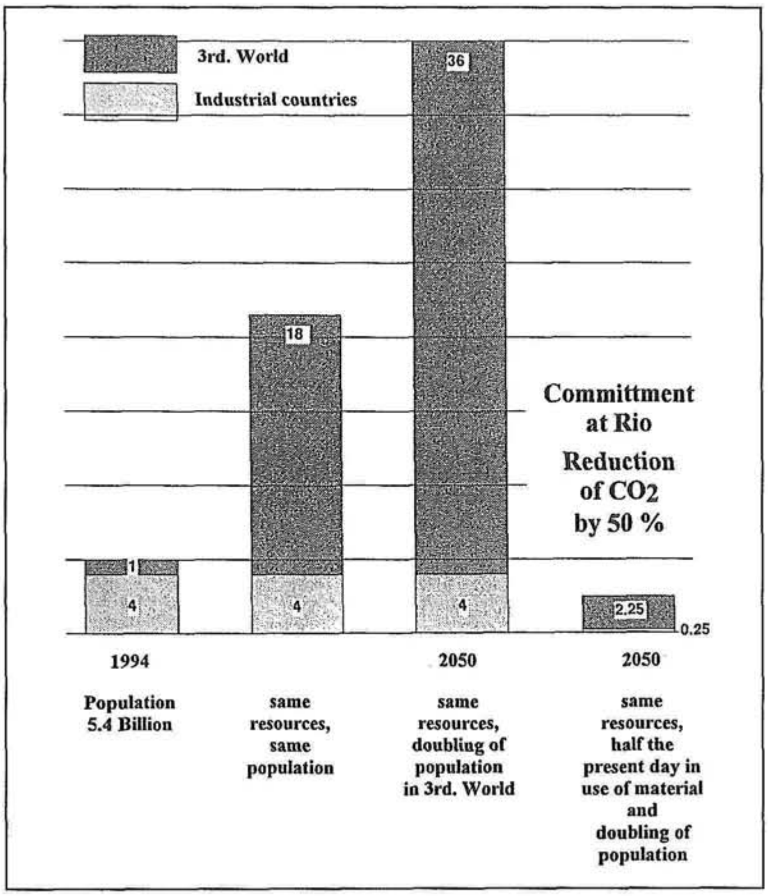


Fig. 1: Use of global resources
Source: Schmidt-Beck, redrawn by Steiger-96

on all aspects of design and construction do not want to get involved in discussions with technical experts or users of buildings about ecological principles or details.

Genesis of this book

The authors were commissioned by the European Academy of the Urban Environment (EA.UE) in 1993 to draw up a compilation of experiences in new sustainable settlements. After four weeks of investigation we had identified approximately 70 settlements in Europe ranging in size from 10 and 900 units. Since time and financial resources would not permit us to study all of them intensively, we made a selection by asking the question: How do larger ecological settlements turn out if the initiative to set them up was not taken by the residents themselves?

The reason behind this criterion was that there was a need to construct new settlements on a quite large scale both in newly re-united Germany and in other European countries. But so far there had been no indication as to whether solutions which had worked perfectly in ecological settlements on a smaller scale, where the impulse had come from the bottom, could also be applied on a larger scale.

This search for large projects initiated from the top meant that more complex and innovative projects which had normally only been implemented on a small scale could not be included in the study. However, the importance of this contribution to the discussion on designing ecological settlements is, firstly, that experts had been debating - for many years - whether it was right to expect Mr. (and Mrs.) Average to accept ecological ideas of construction and living. Secondly, it was by no means agreed just which ecological approaches could be applied on a larger scale.

With the intention of discovering whether these insights might also be applicable in urban renewal work, the Academy commissioned the same team of authors late in 1994 to look into ecological urban renewal projects located in the same European countries as the original new settlement examples and thus, based on all the lessons learnt, to compile a handbook on the topic of "Designing Ecological Settlements".

Extending the study to include urban renewal proved to be far more problematic than at first thought. In the first place there are less ecological urban renewal projects than new settlements in Europe; secondly, those that do exist are less spectacular, i.e. in many cases less written about or implemented with little or no parallel research.

Nevertheless, it was worth the attempt. In the end, we found projects which we could examine and describe in five of the countries where the new settlements had been located, namely in Denmark, Germany, the Netherlands, Austria and Switzerland. Since these projects then provided the base on which this book leans, they will be described briefly below, grouped in the order in which information about them has been published[1].

[1] Photocopies of the case studies are available in German only and may be obtained from the European Academy of the Urban Environment in Berlin.

New settlement and urban renewal projects

The seven examples of new settlements are:

- the biological building settlement *Auf dem Schafbrühl* in Tübingen, Germany, comprising 111 units;
- the ecological village *Anningerblick* in Guntramsdorf, Lower Austria, comprising 42 completed and 98 planned units;
- *Stallenmatt* multi-family housing estates, Oberwil, Switzerland, comprising 64 units;
- *Ecolonia* residential area in Aalphen an den Rijn, Netherlands, consisting of 101 units;
- *Torsted Vest* estate in Horsens, Denmark, consisting of 70 units;
- *the Solar Village* project in Pefki, Lykovrissi, near Athens in Greece, consisting of 435 units;
- the settlement *Puchenau II* near Linz in Austria, comprising 750 units.

The five examples of ecological urban renewal projects are:

- the renovation of four multi-occupied buildings in *Rehbockstraße*, Hanover, Germany, consisting of 49 public-subsidy apartments and 2 shops;
- the *Aarepark* residential estate in Solothurn, Switzerland, comprising 108 apartments;
- the *Wilhelmina gasthuis-terrein* (former hospital buildings) in Amsterdam, the Netherlands, comprising 86 apartments and 25 commercial and office business premises;
- the *Fredensgade* renewal area in Kolding, Denmark, comprising 129 apartments and 6 retail units;
- the ecological urban renewal *Neubau* in the 7th District of Vienna, Austria.

Since the projects differ in size, objectives, time-scale, financial base and cultural background, it was not possible to carry out a strictly scientific comparison. Nevertheless, we felt that it was important to briefly summarise our findings in the introduction to this book.

Biological building estate - Auf dem Schafbrühl - in Tübingen, Germany

111 units, construction 1984-85	
architects:	Joachim Eble Burkhard M. Sambeth Wolfgang Oed Gottfried Häfele, Tübingen
developer:	Karlsruher Lebensversicherung AG (Life insurance company)
size of area:	1.3 hectares
site occupancy index:	1.0
costs per m²:	385, -- DM (approx. £ 134)
total investment costs:	27 million DM (approx. £ 9.4 mill.)

Initial situation and aims of the project

Schafbrühl, a residential development, is one of the first examples of relatively large, ecological and space-saving settlements in Germany, to which the criteria for publicly-subsidised housing were applied. The site is located between the old hamlet "Waldhausen" and a new 20-storey high-rise estate from the 1960s and 1970s.

The initiator and builder of this project, the head of the Life Assurance Company, Wolf-Dieter Brack, proved to be very open to new ideas and keen to test them, which meant that a rather encompassing ecological concept could be implemented. The aim of the project was to achieve a hitherto unknown standard of residential quality in publicly subsidised housing, by means of lively and unconventional building design incorporating the use of solar energy, in addition to healthy construction materials. In contrast to the adjacent high-rise estate the architecture is in harmony with the neighbouring traditional hamlet and also offers ample open-space provision. In spite of all these advantages building costs were only 10 per cent above the level of standard residential building costs.

Ecological aspects

healthy building:	use of recyclable materials which are open to diffusion, natural paints, timber joist floors, cork linoleum flooring, etc.
energy:	use of passive solar energy, optimisation of the floor plans according to illumination, ventilation and functional requirements of the apartments,
heating:	skirting-board heating, connected to district heating network
electrical system:	independent sockets, power cables laid in star-shaped pattern
water:	rain water collection in streams and ponds, water used in gardens, landscaping and children's' play areas
open spaces:	private, semi-private and public open spaces, gardens for tenants
traffic:	car free estate, car parking on periphery (mostly covered)
waste disposal:	garbage sorted according to type, communal composting
social concept:	high quality of social living, neighbourly contacts encouraged by provision of communal open spaces
floor plans:	apartments built on open-plan system around a central family living room
architecture:	design follows the traditional building of the nearby hamlet

Results

Despite the high site occupancy of the buildings, the project offers exceptional qualities to the residents such as a human scale. The architects succeeded in combining healthy building materials and construction techniques with high qualities and extremely flexible spaces for living.

The ecological design of the settlement is explicitly appreciated by residents, even if they need to accept a certain lower standards in terms of comfort. A survey showed that the tenants were overall pleased and proud of contributing to the reduction of environmental pollution by living in "Schafbrühl".

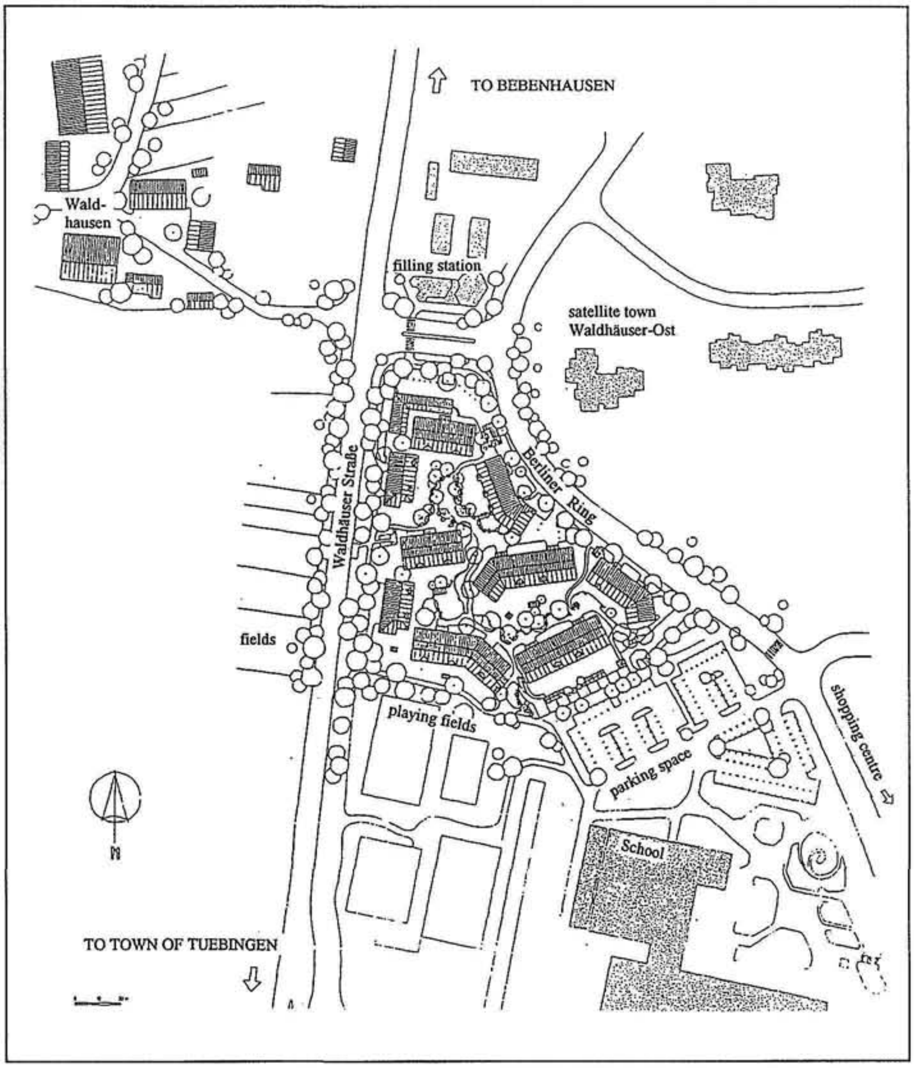


Fig. 2: Site plan of Schafbühl, Tübingen

Ill. 1: Courtyard within the settlement

Photo: D. Haas

Ecological Village - Anningerblick - in Guntramsdorf, Austria

140 units	
1st phase:	42 units (built between 1992-93)
2nd phase:	44 units and business premises (planned)
3rd phase:	54 units (planned)
architects:	Helmut Deubner, Atelier für naturnahes Bauen, Gänserndorf
initiator / developer:	S-Wohnbau GmbH and S-Bausparkasse (building society), Vienna
site occupancy index:	0.37
costs per m ^{2}:	approx. 14,850 Austrian schillings (£ 850) per m^2 (ready for occupation; excluding basement)
purchase price:	approx. 32,000 schillings (£ 1,830) per m^2 living space

Initial situation and aims of the project

Anningerblick ecological village is located in Guntramsdorf, 30 kilometres from Vienna. The first construction phase comprising 42 units was completed in December 1993. The second phase involving 44 more units, a cafe and a community centre is still in the stage of planning.

For an architectural competition, entitled "Healthy living in nature", the housing company S-Wohnbau selected 5 architecture consultancies to submit design proposals for a housing settlement. The first prize was awarded to the consultancy of Helmut Deubner, which was then commissioned to finalise the design and the construction plans. However, they were not commissioned for the building site supervision which led to problems in the implementation of the ecological aspects. Due to the client's worries about an increase of the costs of building if ecological building methods would be realised, the original concept was gradually 'watered down' and reduced. Secondly, the original architecture and infrastructure design was new and thus not corresponding with many of the existing building regulations and guidelines. Therefore, time-consuming and cumbersome special permissions had to be obtained for the solar energy collectors, the proposed use of rain water and the fire protection regulations.

Subsidies for the project were granted by the Lower Austria regional government building programme to the amount of 350,000 Austrian schillings (approx. £20,000) per unit. Despite the high attractiveness and quality offered for living, the total building costs were rather low. This is even more surprising as the price for the site approximately 10 per cent above average, and due to the lack of the usually provided financial support on a governmental level based on a legislative mistake which has since been remedied.

Ecological aspects

healthy building:	basic efforts to use healthy and resource-saving building materials by consideration of production and life cycle, i.e. extraction - production - processing - demolition - re-use, to reduce the impact on the environment
energy:	use of passive and some active solar energy
heating:	low temperature heating connected to district heating
water:	collection of rain water and use for gardens, toilets and washing machines
open spaces:	private (screened off) gardens
traffic:	car parking on the periphery of the estate, car-free inner open spaces, accessibility by footpaths
waste disposal:	separation according to type, composting
social concept:	communal centre and cafe planned in phase 2
floor plans:	lay-out oriented for the use of passive solar energy collection
design:	pitched south-facing roofs with traditional tiles, rendered facades, conservatories built of plain wood frames

Results

The "Anningerblick" project demonstrates the importance of a committed architect to work on an ecological concept through to the completion phase. The architect has to be persistent in order to get the building permit and has to be prepared to put additional effort into such a project. He not only had to have extensive familiarity with ecological technologies but he also had to have the commitment to persuade contracting firms involved to adopt these new measures.

The client's scepticism towards ecological construction was mainly caused by concerns about rising building costs. The discussion about this issue was fierce at times and resulted in the implementation of only a very part of the original concept. However, once the first construction phase was completed, it became clear that the costs had turned out to be considerably lower than it had been expected.

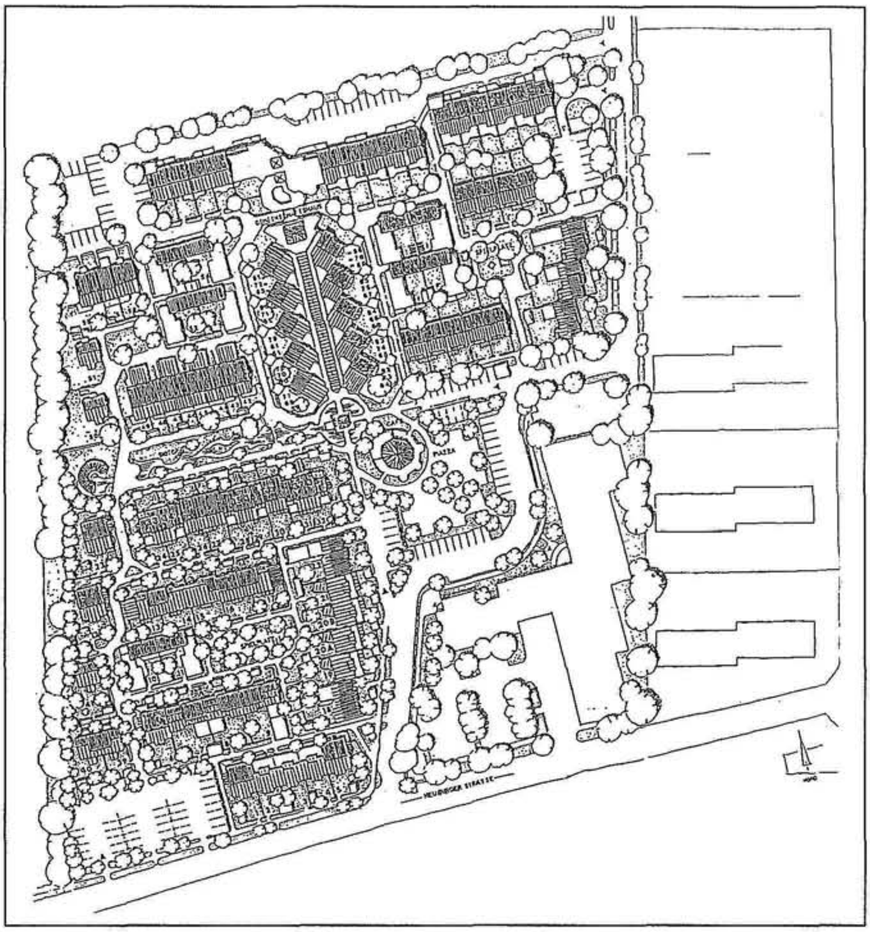


Fig. 3: Site plan of Anningerblick, Guntramsdorf

Ill. 2: Courtyard with playing area

Photo: Atelier Deubner

Multi-family housing estate - Stallenmatt - in Oberwil, Switzerland

64 units, construction period from 1989 to 1991	
architect:	Peter Steiger, Zurich
urban planner:	H.R. Meier-Knobel
developer:	Ciba Geigy Ltd. pension fund, Basle
size of area:	12,410 m2
site occupancy index:	0.65
costs:	approx. 371 Swiss francs (£151) per m^3;
	approx. 2,072 Swiss francs (£844) per m^2
	incl. south greenhouse and glazed balcony on north face
total costs:	17.7 million Swiss francs (£7.2 mill.) excl. real estate costs

Initial situation and aims of project

The Stallenmatt blocks of flats are located approximately 5 kilometres from Basle, in the Swiss canton Basel-Land. The estate consists of 64 units constructed in eight single or multi-storey blocks. The developer and initiator of the project was the pension fund of Ciba Geigy, the Swiss pharmaceutical company. The company commissioned a general contractor with the construction management, believing that by so doing and with fixed prices they would have greater control over costs and construction progress. Ciba Geigy as a client was not particularly interested in holistic ecological construction, but was more concerned to implement high quality, 'rational' architectural design of high residential quality and with healthy building materials.

Ecological aspects

healthy building:	careful choice of building materials for non-toxic living environment indoors, double layer brick construction, mineral-based heat insulation, natural paints,
energy:	use of passive solar energy, zoning of floor plans to conserve energy, low-level primary energy consumption for building materials
heating:	low temperature gas-fired private central heating for each apartment, reduced energy consumption for heating (approx. one-third of normal domestic consumption)
water:	biotope with pond for rain water collection, partly grass-covered roofs to store rain water, pervious materials for footpaths
open spaces:	vegetation-covered facades are elements in the climate and energy saving plans, orchards for residents' own supplies
traffic:	reduced traffic on residential roads, underground garages
waste disposal:	separation according to type, composting
social concept:	two communal rooms
floor plan:	orientation towards the use of passive solar energy, 3 functional and temperature zones - central area with living area/kitchen/bathroom, adjacent area with bedrooms and other areas, 'encapsulated' by conservatory, balcony or veranda as a secondary structure
design:	basic elements arranged symmetrically, each block has a clearly defined central area, surrounded by a secondary structure of trellises and balconies

Results

The Stallenmatt settlement can serve as an example for the problems which arise if an architect attempts to implement ecological ideas as an integral part of contemporary architecture, which are in contrast to the client's perception and ideas. The first design proposal for this project was a very comprehensive scheme for ecological construction, e.g. one-tenth of the units were to be built of clay, with a thermal wall, equipped with photo-voltaic cells and solar collectors for warm-water supply and with composting toilets combined with a biological water treatment system for waste water. These design features were rejected by the developer because they supposingly would have made "construction unnecessarily complicated and more expensive". In the client's opinion, the rather low total of the building costs are a result of "not using ecological building standards in exaggerated ways". This meant that solar technology, compost toilets etc. were not included and the selection of a general contractor for cost controlling and building site supervision.

For the realisation of the project it was advantageous that, both, the architect and the general contractor were committed to the project more than usual. In addition the decision-making process was much easier as only three partners - developer, contractor and architect - were involved and each of them was represented by only one individual.

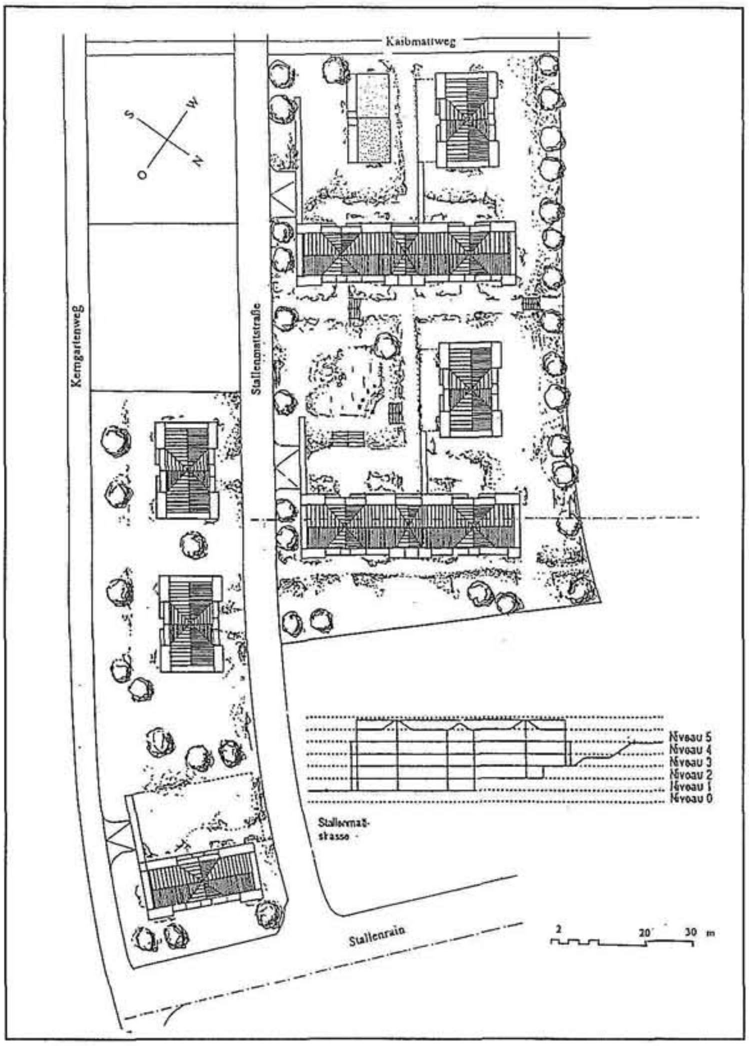


Fig. 4: Site plan of Stallenmatt, Oberwil

Ill. 3: Gable end façade
Photo: D. Haas

Residential area - Ecolonia - in Aalphen aan den Rijn, The Netherlands

101 units, construction period 1991-93	
architects:	BEAR architects, Gouda Alberts & van Huut, Amsterdam Hopman bv, Delft J. P. Moehrlein, Groningen Bakker, Boots, Van Haaren, Van der Donk, Schagen Lindeman c.s., Cuijk Peter van Gerwen, Amersfoort Archi Service, s'Hertogenbosch Vakgroep FAGO, Technical University, Eindhoven
urban design:	Atelier Lucien Kroll, Brussels
initator:	NOVEM - Dutch Government Trust for Energy and the Environment
developer:	Bouwfonds Woningbouw housing association

Initial situation and aims of the project

The Ecolonia project comprises 101 units. It was initiated by the Dutch government Trust for Energy and the Environment, known as NOVEM, following a study about ecological construction methods. 19 architects were asked to submit design proposals for groups of 8 to 18 buildings which based on the Dutch Environmental Protection Programme and focused on a certain ecological aspect in particular. Each archtitect had to design the group of buildings according to a specific ecological aspect.

Aalphen aan der Rijn in the Netherlands was selected from several competitors due to its central location in the region. The developers were the Bouwfonds Woningsbouw, a construction company, which sold the houses ready for occupancy. The Brussels architect Lucien Kroll designed the settlement's general urban structure on a human scale, to encourage the residents' positive perception of their living environment but to giving room for the heterogeneity of the development as well.

The project received subsidies of 6 million Dutch guilders by two Dutch ministries.

Ecological aspects

design:	based on the Dutch environmental protection programme and overall ecological minimum requirements, nine (of the 19) architects were asked to provide detailed designs centred on: – use of rain water – use of passive and active solar energy – energy saving strategies – reduction of water consumption – re-cyclability of building materials – organic architecture – durable materials – flexible ground plans – special sound proofing – healthy building materials
water:	large pond for rain water collection and as a landscape feature
traffic:	reduced traffic on residential roads
waste disposal:	separation according to different types
social concept:	fostering a sense of neighbourhood and identification with the living environment through urban spaces

Results

From the start Ecolonia was regarded by all people involved as a project for research and practical demonstration, aiming at more information about ecological and innovative residential building in the Netherlands. A wide range of new technological and housing designs was tested, and the emphasis was put rather on the diversity of issues than on the interrelationship between different ecological aspects. Thus the decision makers of the Ecolonia project felt that a holistic approach in which the various aspects of ecological construction might be put together, was not yet feasible.

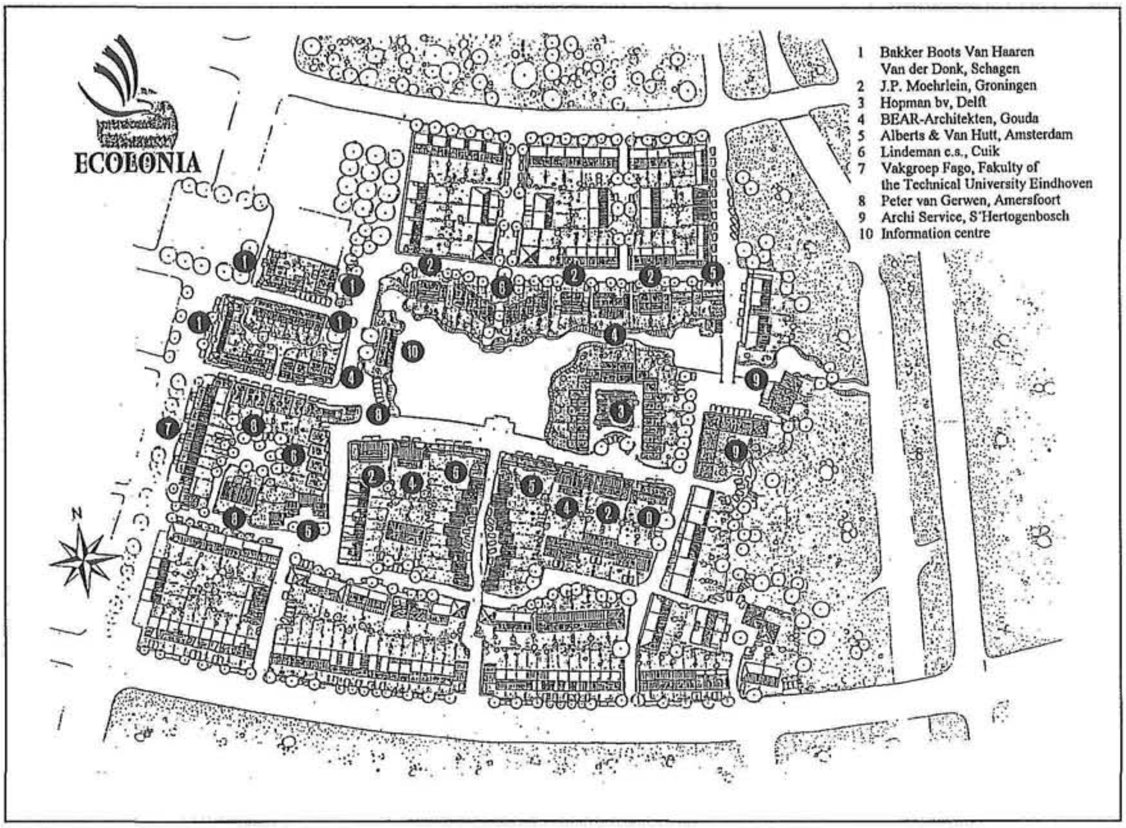


Fig. 5: Site plan of Ecolonia, Aalphen aan den Rijn

Ill. 4: Central area for rain water collection, in the background: the terraced houses with flexible floor plans and passive solar energy, designed by Lindeman C.S., Cuijk

Photo: D. Haas

Town extension - Torsted Vest - in Horsens, Denmark

The original plan consisted of 900 units and light industry; 70 units were completed in the first phase, between 1990 - 1992.

architects:	urban planning concept by: "Gruppen for by-og landskabsplanaeging" particularly: Torben Gade
architect(s) of the first stage:	Fellestegnestuen Falch & Volden ApS
developer:	Municipality of Horsens and a citizens' action group
size of area:	55 hectares, 1st phase approx. 5 hectares
site occupancy index:	0.35 average
costs/m^2:	8,000 Dkr/ m^2 (approx. £717/ m^2)

Initial situation and aims of the project

At the end of the 1980s, the Danish town of Horsted, along with a number of other European cities, entered a competition organised by the World Health Organisation, entitled "Healthy Cities". A 55 hectare open space on the outskirts of the town, was selected for the new suburb "Torsted Vest", hence it became the focus of extensive ecological planning. To start the project, a Danish planning consultancy drafted a comprehensive concept for the entire area, consisting of 900 units and several light industrial enterprises. Extensive park areas, an ecology park and numerous public buildings were included in the proposal.

The area was divided into sites which were offered individually to potential interested persons or parties. At the same time a citizen action group "Torsten Vest Committee" was founded to worked out an ecological programme jointly with the local council. It was agreed upon ecological requirements which were to be met if someone would built a development. The purchase contract had even obliged the real estate owners and builders to involve the future users in the planning process, but this commitment was hardly practised, and if, it was done only for minor matters such as the choice of the buildings' colours. The first 59 units, a single building for 18 young people and a trade union building were completed between 1990 and 1992. Since then a recession in the Danish building industry has stopped the continuation of the project.

Ecological aspects

healthy building:	use of recycled materials and of re-cyclable building materials
energy/heating:	local district combined heat and power plant (CHP) for the estate
urban planning:	building plots sold subject to ecological criteria houses designed and built by various architects
water:	use of rain water for toilets
open spaces:	Horsens residents planted 12 000 trees; vegetable gardens are provided for the estate residents
re-cycling:	footpaths are constructed from recycled materials
traffic:	residential streets with speed limits (30 kph); most car parking spaces are off the estate
waste disposal:	some separation, composting
social concept:	apartments for single-parent families and socially deprived small families
design:	flexible floor plans for varying apartment sizes

Results

In Torsted Vest emphasis was particularly put on the planning and development processes.
The involvement of the residents was one of the essential features. It was applied over an unusual long period and actually helped to overcome the general problems with competencies. The weak points of the project only became obvious in the implementation phase as the numerous restrictive ecological criteria could not be met due to financial constraints, thus the builders lost interest in the project. The recession

in the Danish building industry lead to much weaker ecological standards - if they were not abandoned completely - in order to prevent a complete failure of the project.

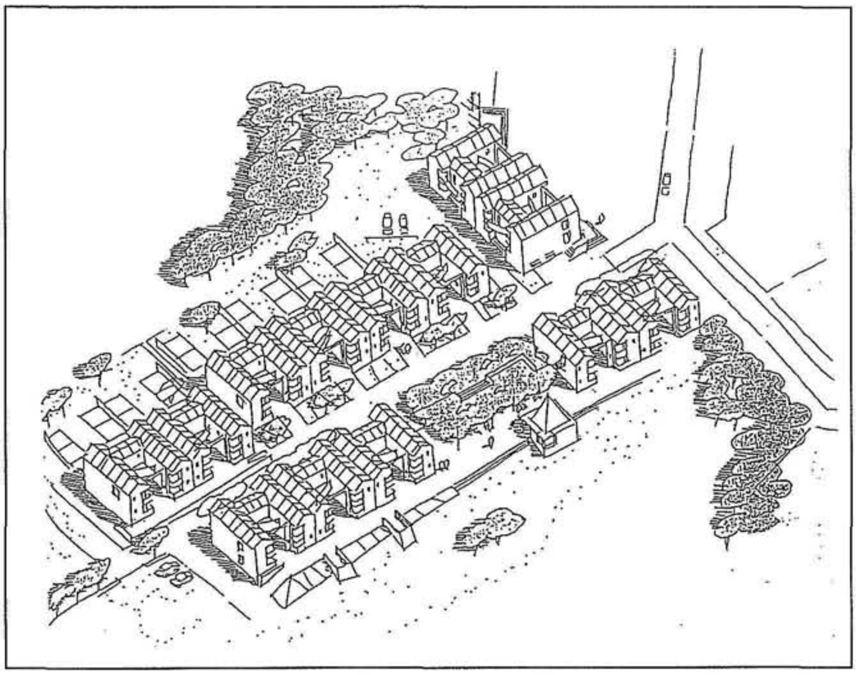


Fig. 6: Isometric projection of "Torsted Vest" in Horsens

Ill. 5: Front façade facing the street

Photo: D. Haas

Solar Village in Pefki, Lykovrissi, Greece

435 units, construction period from 1988 - 1991	
architects:	A. Tombazis and Associates
initiators:	O.E.K. (Greek Workers Housing Association),
	Greek Ministry of Industry, Housing and Technology, Athens
	Federal German Ministry of Research and Technology, Bonn

Initial situation and aims of the project

The Solar Village project in Pefki, Lykovrissi, 18 kilometres north of Athens, a modern settlement with 435 solar energy residential units for Greek workers and their families, was designed and planned from 1984 to 1988. The main aim was to test the use of a variety of different active and passive solar energy systems with regard to their technical performance and their economic and social acceptability. Furthermore the project was initiated to establish a cooperation between Greece and Germany in this field. For this reason comprehensive studies of the potential energy savings were conducted between 1988 and 1993.

Ecological aspects

energy:	experimental concepts with various active and passive energy systems
heating:	17 different combinations of renewable and conventional systems for heating and warm water supply, 5,000 m^3 capacity latent heat storage, heat exchange pumps, various types of solar collectors
open spaces:	no open space design (due to lack of funding)
traffic:	lack of connection to public transport, car parking spaces concentrated
social concept:	participation of users - who were selected from application lists for public housing - at an early stage, which helped to make the different energy concepts more comprehensible to them and easier to operate for them
floor plans:	basic south orientation of lay-out for passive solar heating and cooling, large south-facing and small north-facing windows, wall insulation and double glazing both of which are not common in Greece
design:	outstanding and well-designed in comparison to usual standards in the Greek public housing sector, equipment for passive and active solar energy is used as design feature

Results

Research and evaluation surveys were carried out during the planning process until two years after occupancy. During this period the passive devices in the concept were assessed thoroughly and judged positively. However, the 17 varying combinations of active solar energy use and conventional heat energy systems all had some difficulties or high level of unexpected ('parasitic') energy consumption such as electrical power to drive pumps for regulatory mechanisms, etc. In combination with the costs for maintenance and administration, the systems proved to be even more expensive than conventional systems using fossil fuels instead. The coverage of these additional costs was still unclear when we finalised our research project.

Firstly, the experience gained from the solar village project shows that any project of this order of magnitude must establish at the outset, which responsibilities are to be borne once the buildings are completed. Secondly, only systems which have proved to be economically viable should be used for large-scale projects and any experiments, such as the solar central heating, should be tested on a smaller scale before a large-scale implementation. Another lesson learnt is that the development of passive solar energy systems is more beneficial in high-density, low-style buildings than in multi-storey ones.

An entirely new aspect was the active involvement of residents in the preliminary phase. A sociological study carried out at the same time showed that residents' suggestions which were put into practice helped to improve the quality of communal life and the settlement. They also helped them to understand the operation of the complicated energy systems much better. In the final analysis, the residents' participation proved to be the most successful element in the concept. Even though the severe technical problems and failures, almost were quite disastrous for the Solar Village project. But nevertheless these experiences were some important lessons learnt.

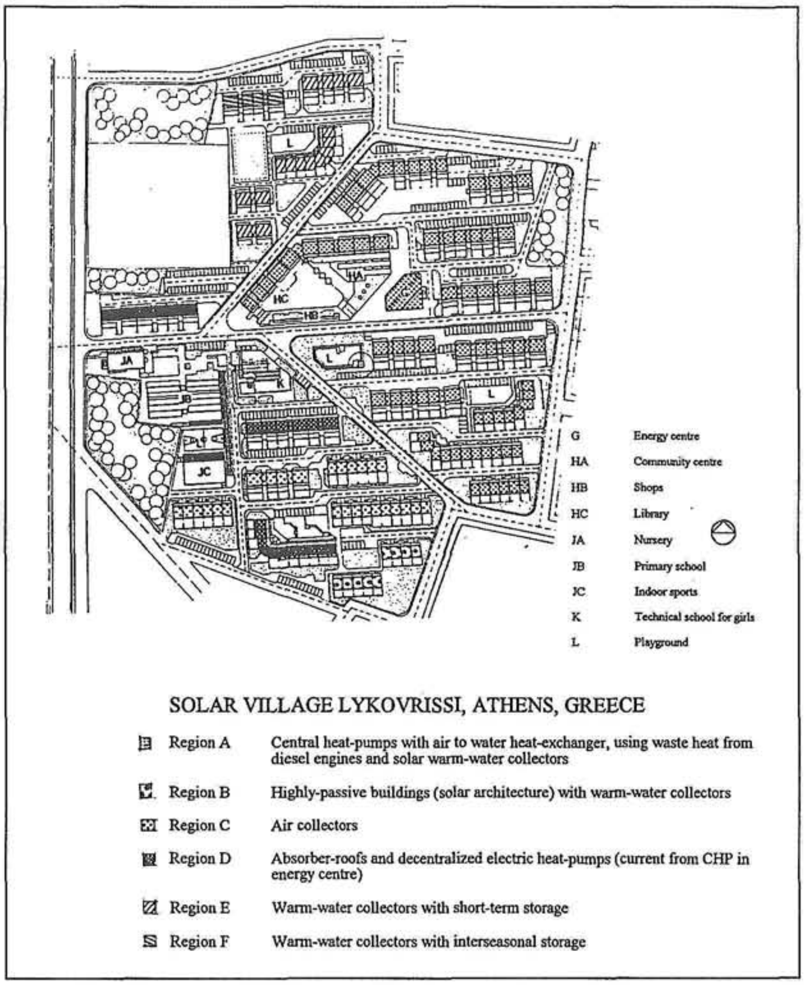


Fig. 7: Site plan of Solar Village in Pefki, Lykovrissi

Ill. 6: Aerial photo of the centre of the Solar Village

Photo: A. Tombazis

Puchenau II Garden City near Linz, Austria

Puchenau II comprises 750 units (Puchenau I had 240 units)
Construction period for Puchenau II was from 1979 onwards Puchenau I was 1967-69

architect:	Roland Rainer, Vienna
initiators:	Neue Heimat, Linz (housing association)
	Municipality of Puchenau
	Roland Rainer, architect
developer:	Neue Heimat, Gemeinnützige Wohnungs-und Siedlungsgesellschaft Oberösterreich
special feature:	A building project with demonstration character with an accompanying research study, from 1966 onwards 16 phases of building which incorporated a continuous learning process from the experiences gained

Initial situation and aims of the project

Puchenau Garden City is a settlement near to the city of Linz which has been growing steadily since the late sixties to the current total of 1,000 residential units. Affordable-priced and space-saving detached houses were built in high density and low style, with only a few multi-storey buildings. So reasonable-priced public housing could be provided to the local population. the reduction of private space requirements and the well-differentiated accessibility by public transport and private cars as well as for pedestrians, avoided the general conflicts between the latter two. This resulted in a settlement free of noise and danger.

Although this project was not conceived explicitly in terms of an ecological settlement, basic principles of ecological construction were implemented on a large scale to a urban development. The high population density in a rural setting but close to Linz provided the demand for a commuter rail which was put into service and operates on a frequent schedule.

Ecological aspects

healthy building:	some use of biological building materials, most house have brick walls but some were built in concrete), insulation was undertaken with coconut fibre and sometimes mineral wool
energy:	passive use of solar energy by orientation towards the sun, height, design of building structures, some solar collectors for warm-water supply and heating
heating:	240 units connected to district heating; 750 units with central heating of various types
utility lines:	resource-saving design system of infrastructure, all pipes, cables, etc. combined in one ditch which is located only underneath footpaths to make maintenance work easier
open spaces and water:	intensive vegetation growth in private and public areas, private green spaces in atrium-style houses, direct access to the Danube, retention of the river bank area for recreational activities, two small streams were integrated into landscape design, rain water absorption
traffic:	traffic-free settlement with access only for delivery, waste disposal and emergency vehicles, network of pedestrian and bicycle paths, two stops for commuter rail
waste disposal:	separation according to type, some clustered collection points, some local composting
social concept:	dwellings for tenants and owners built according to public housing guidelines, lay-out of dwellings agreed to by future users model apartments, child-friendly settlement, large natural play areas, provision of private and public open spaces
floor plans:	lay-out of dwellings can be varied by several options
noise:	settlement screened off from traffic noise by multi-storey buildings along roadside and due to traffic-free zone within the settlement
design:	primarily in high density and low style with one-to-three-storey buildings on south facing slope, attractive and varied architecture but embedded in an general, unified urban structure

Results

Puchenau Garden City demonstrates very well how a combination of basically user-friendly principles for high density and low-style building, good access by different means of transport and use of passive solar energy correlates with many elements of ecological urban design. The estate shows that private dwellings as atrium-style or terraced houses and owner-occupied or public rental apartments can be provided for a broad spectrum of social stratum at reasonable costs and high architectural standards. Due to the high quality of housing and open spaces the residents experience the settlement as an attractive place to live in.

A clear holistic approach and the long planning and implementation period of nearly thirty years have played a decisive role in the 'organic' growth of this settlement. There was continual testing and occasional adjustment during the planning process to achieve a homogeneous settlement with a mixed social stratum and a clearly unified architecture.

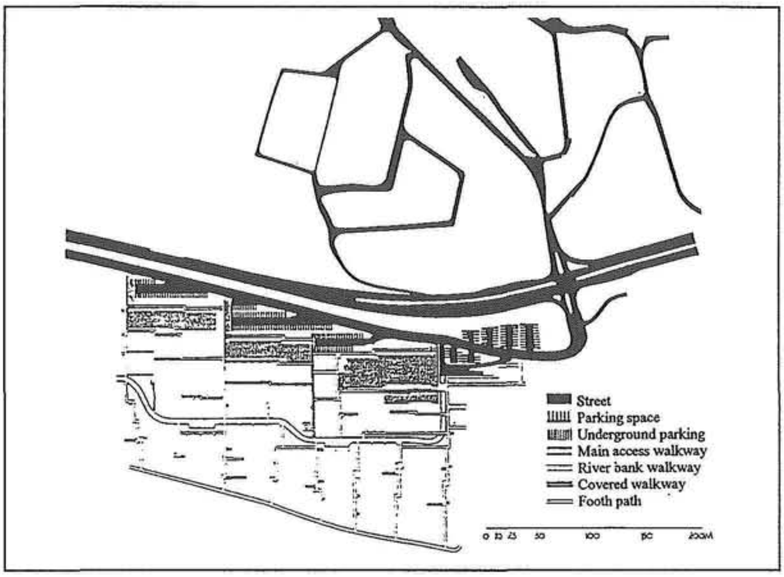


Fig. 8: Pedestrian circulation and traffic areas in the research area of Puchenau

Ill. 7: Interior courtyard

Photo: R. Rainer

Renovation of multi-storey flats - Rehbockstraße - in Hanover, Germany

49 public-subsidised apartments, 2 shops

preliminary discussions between architect consortium and the City Planning Department held in 1986, construction work began 1988/89, completion 1991

architects:	Angelika Blencke, Architekturbüro pk Nord Andreas Mauerer, Büro Mosaik Gerd Nord, Lindener Baukontor
developer:	Gesellschaft für Bauen und Wohnen Hannover mbH (Housing Association)
total size of area:	2,277 m^2
size of built-on area:	955 m^2
total floor area:	4,775 m^2
building costs:	7,460,000 DM (approx. £ 2.6 million)
costs of external facilities:	240,000 DM (approx. £ 83,360)
incidental construction costs:	1,300,000 DM (approx. £ 451,550)

Initial situation and aims of the project

The project comprises 4 buildings with multi-occupancy and is located in a densely populated, late 19th century district of Hanover which was designated as an urban renewal area in 1985. This procedure meant that urban planning subsidies were available to improve low standards of urban design and buildings.

The project designers were commissioned by the city authorities to draw up a plan for three empty and completely dilapidated buildings, with a number of ecological measures which had not yet been tested in public housing projects.

Ecological aspects

urban design:	conservation and improvement of inner city building structures
healthy building:	as far as possible use of existing building materials for renovation and use of non-toxic building materials
energy/heating:	increased insulation, controlled ventilation, use of local gas-fired CHP stations to produce electricity, to heat the apartments and supply warm water
water:	water-saving tap units, rain water use for toilets
waste disposal:	separation according to type and recycling
traffic:	no parking spaces provided in the courtyard area, good access to public transport
social concept:	publicly subsidised housing, mix of apartment size from one-to-six-person flats, at least 5 different nationalities
open spaces:	differentiated open areas private for apartment dwellers; semi-public for building occupants and public play areas, vegetation areas
floor plans:	some communal living rooms within apartment buildings, addition of glazed balconies
design:	conservation of characteristic features of 19th century facades, use of building materials common to the district

Results

An evaluation of the use of energy and water by the Institute for Urban Ecology showed that the project planners' estimate on the average savings were at large correctly. Evaluating individual consumption in these areas nevertheless showed tremendous variations in consumption, which proves that consumer behaviour has the greatest influence on savings.

An essential outcome of the Rehbockstraße project was the exemplary effect it had on housing associations and the city council in initiating further ecological projects and measures. For example, discussions about the advantage of local CHP plants, even for smaller numbers of customers, led to more of these plants being subsequently installed in various locations in Hanover. Many interested groups from the city of Hanover, Germany and neighbouring countries visited the project.

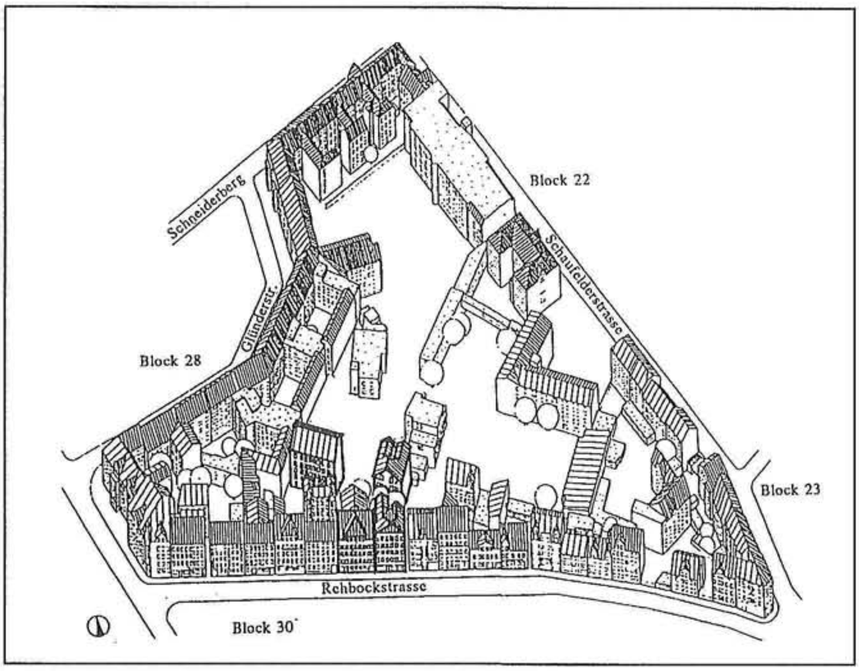
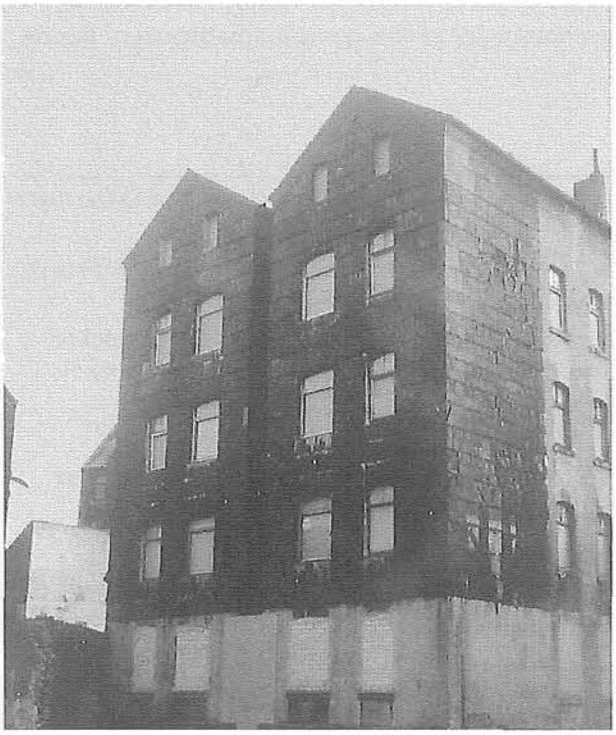
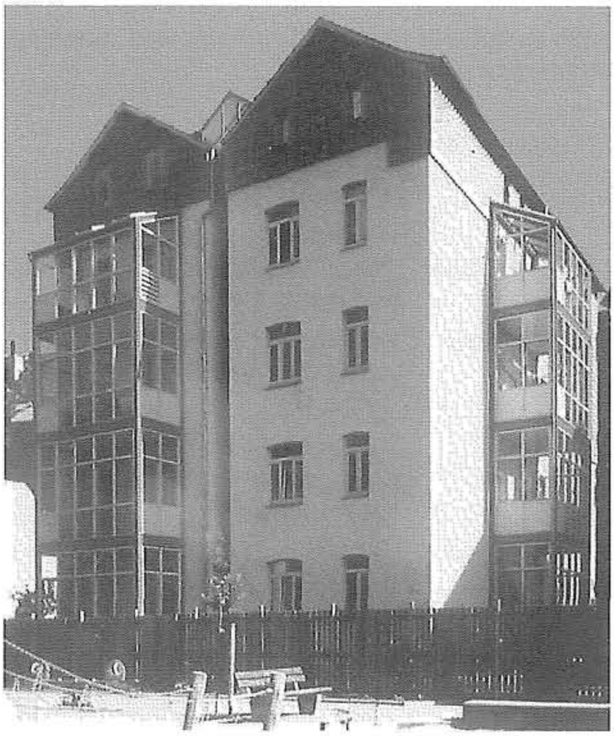


Fig. 9: Isometric projection of Rehbockstraße, Hanover, Germany

Source: Stadtplanungsamt Hannover



Ill. 8: Gable end - before the renovation
Photo: Karl Johaentges/Planers



Ill. 9: Gable end - after the renovation
Photo: Karl Johaentges/Planers

Renovation of a residential estate - Aarepark - in Solothurn, Switzerland

108 rental apartments
built in 1960-61, renovated 1992-93

architects:	Kurth & Partner, Burgdorf, Switzerland
developer:	Pensimo AG, Aarepark AG, and Eternit AG pension fund, Switzerland
total size of area:	13,832 m^2
size of built-on area:	3,500 m^2
gross floor area:	10,603 m^2
increase in gross floor area due to increased density:	1,027 m^2
site occupancy index:	0.77 (previously 0.698)
construction costs:	22,055,400 Swiss francs (approx. £ 8,982,300)
incidental construction costs:	1,124,000 francs (approx. £ 4,577,600)
building costs per m^3 :	approx. 421 francs (approx. £ 170)
building costs per m^2:	1,080 francs (approx. £ 440)

Initial situation and aims of the redevelopment

The Aarepark estate in Solothurn is an example of the revitalisation of a 1960s estate which needed to be renovated. The project was initiated by the Eternit company trying to improve its image from the asbestos scandal. In 1987 they financed a competition to conserve and up-grade the estate, which was won by the Burgdorf architect Heinz Kurth. Decisive factors in the competition were economical ideas which would benefit the environment and guarantee the tenants accommodation during the renovation phase as well as the affordable rents afterwards.

Whilst reconstruction was taking place, tenants were able to move into other apartments and then had the choice of moving back to their original apartment or staying in their 'temporary' home. This was only possible because some of the tenants had moved out of the estate. These vacant apartments were renovated first. About two-thirds of the tenants took advantage of the opportunity to change their apartments in during the renovation process.

Ecological aspects

urban design:	the site occupancy index increased from 0.698 to 0.77 as new buildings were added to the rows of buildings
healthy building:	wood frame windows, water based interior paint, no PVC used, floors sound proofed with cork, no vapour barrier, re-cyclable material in facade cladding
energy/heating:	use of passive solar energy through conservatories (if requested by tenants), mineral wool or glass fibre insulation, gas instead of oil heating led to the reduction of thermal energy by 50 per cent
water:	water-saving tap units, absorption surfaces for rain water, water permeable asphalt
open spaces:	open spaces design instead of lawn areas between buildings, tenants have planted fruit trees
traffic:	car-free estate, 50 car parking spaces are available in an underground garage
waste disposal:	building rubble disposed of according to type, recycling of building material
social planning:	"moderate rehabilitation" - affordable increase in rents for the increased quality of housing, 'flat rotation' for tenants during renovation if wanted, communal meeting room
floor plans:	extensions and/or alterations to the apartment plan to improve housing standards
design:	up-grading of the buildings by re-designing of the facades, the materials as well as extensions such as conservatories

Results

The "Aarepark" estate proves that urban renewal need not be equated with the demolition of the existing building fabric nor the transformation into unaffordable luxury units. The increase of the rents was approx. 50 - 60 per cent and is thus well below rent levels for new apartments in Switzerland. Many ecological ideas such as reed bed waste water treatment, use of rain water, or the active use of solar energy were admittedly not considered. Nevertheless, a sensitive approach, both in preserving the building fabric and in dealing with tenants, is nowadays not a matter of course, but an essential component of ecological building. According to a number of architects consulted holistic ecological construction is far from being accepted in Switzerland. The redevelopment of the Aarepark estate managed to maintain rather affordable apartments for a long time which certainly is also a way of preserving natural resources

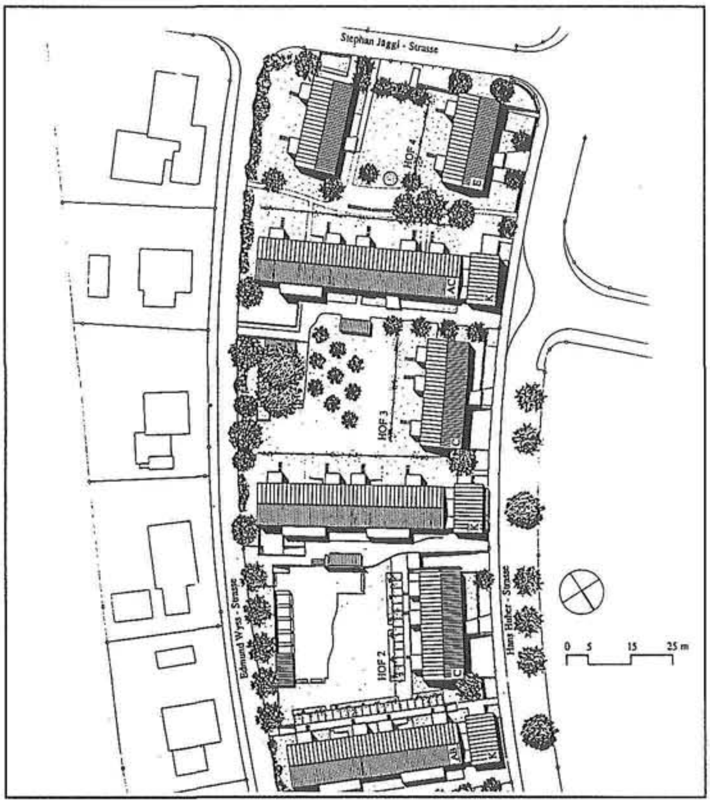
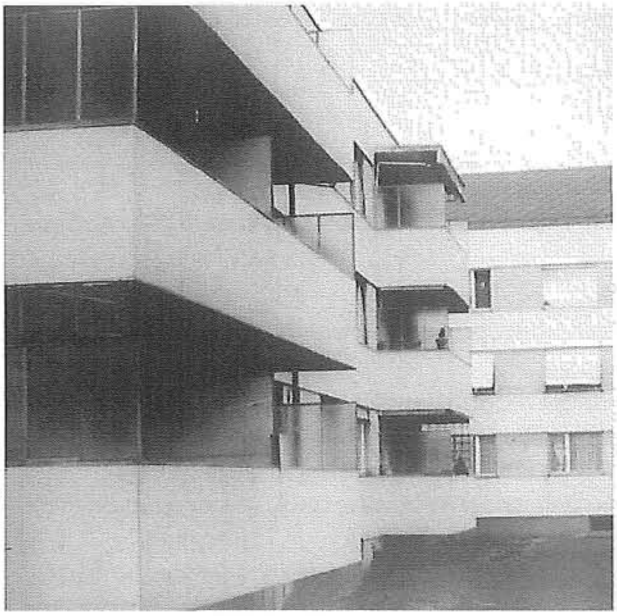


Fig. 10:
Site plan of Aarepark, Solothurn



Ill. 10. Courtyard before the renovation
Photo: D. Haas

Ill. 11: Courtyard after the renovation with new balcony
Phot: D. Haas

Wilhelmina Gasthuis-terrein in Amsterdam, The Netherlands

Pavilions 1 and 2 on the Wilhelmina hospital site comprise 86 apartments and 25 business premises
originally built as 1700-bed hospital between 1890 and 1930
renovated and converted for residential use, with social infrastructure, commercial and office use in 1992-94

owners:	prior to renovation: City of Amsterdam after renovation: Het Oosten
architects:	Rataplan architecten cooperatief, Amsterdam
total size of area:	118,750 m^2
site occupancy of pavilions 1 and 2:	approx. 11,875 m^2
total floor area:	renewed apartments: 6,220 m^2
commercial use:	1,880 m^2
costs	12 million Dutch guilders (approx. £ 3.7 million)
external facilities:	7.8 million guilders (approx. £ 2.4 million)

Initial situation and aims of the project

In the Amsterdam borough called Oud-West there is a residential settlement with quite unusual characteristics. The Wilhelmina hospital complex was named after Queen Wilhelmina who laid the foundation stone in 1891. In contrast to the surrounding densely populated area with housing, dating back to the last century, this complex represents a peaceful 'green oasis'. It comprises a number of renovated and converted former hospital buildings, some new buildings as well as carefully designed and planted public green spaces. If urban renewal had taken its usual course these buildings would have been demolished. But the activities of a local citizens' action group, which is responsible for initiating the project, prevented this.

Ecological considerations played an important part in this urban renewal, especially for pavilions 1 and 2, and as a result this part of the Wilhelmina hospital complex has become a unique urban ecological settlement within the city of Amsterdam. It was carried out through a process of cooperation between the city, the borough of Oud-West, the Het Oosten housing association and a residents' working party.

Not only flats but also a health centre, a kindergarten, a section of the Dutch Film and Television Academy, a cycling club, a futon manufacturer, a workshop making wooden toys and a painter's and decorator's shop are found on the premises. In addition, senior citizens' apartments were built which located above a new police station.

Ecological aspects

healthy building:	low-toxic materials were used for pavilions 1 and 2
energy/heating:	use of passive solar energy and solar panels for hot water on south facing roofs, CHP combined generation of electricity and heat
water:	water-saving taps, some rain water collection
open spaces:	green spaces are managed by residents, thus small domestic animals are kept and more trees are planted to improve the micro-climate
traffic:	the entire complex is car free at large, parking spaces are available on periphery, access only for pedestrians and cyclists, noise barrier provided by dense vegetation along a main road
social concept:	high level of resident participation and responsibility, also for preventative health care, children's nursery and play areas, rents are very moderate because residents can renovate their flats themselves within the generally renovated building structure
design:	roof gardens, greenhouses, facades covered with vegetation where possible; the special 'casko-concept' offers a renovated building structure with utility services (gas, electricity, heat, water, sewage)

Results

The redevelopment of the Wilhelmina complex was an educational process for all those involved. The result for both the housing association and the city of Amsterdam, but especially the borough of Oud-West, was a better awareness of ecological measures which are increasingly implemented in other projects. They now support the use of environmentally friendly building materials and a careful attitude towards resources. The skills shown by residents were some of the determining factors in the choice of environmental measures. The redevelopment of the two pavilions shows that active collaboration with residents in urban renewal projects can be successful.

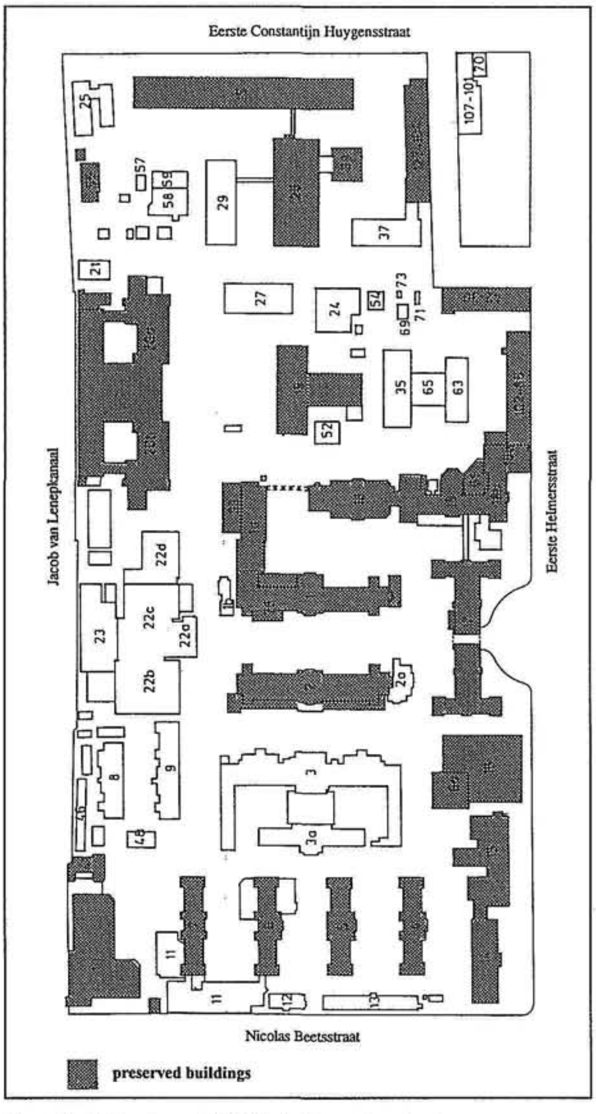
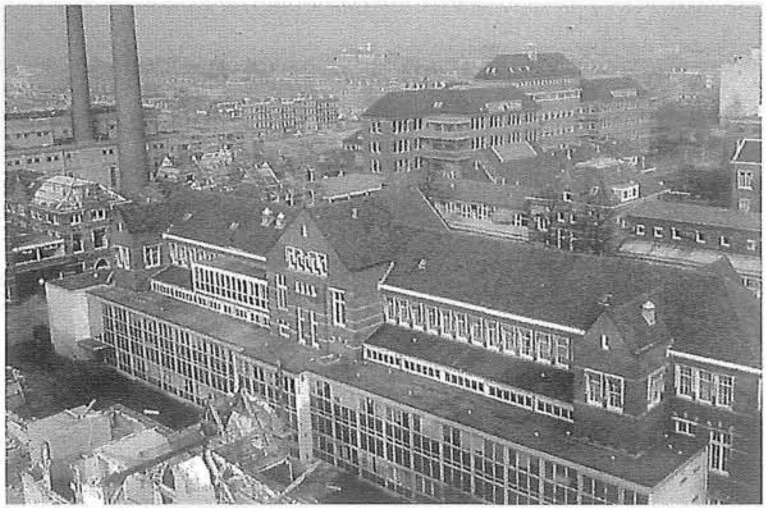


Fig. 11: Site plan of Wilhelmina, Amsterdam



Ill. 12: Before the renovation
Photo: Rataplan architecten coöperatief u.a.

Ill. 13: After the renovation
Photo: Rataplan architecten coöperatief u.a

Fredensgade in Kolding, Denmark

129 apartments, 6 retail units
built between 1900 and 1950, renovated from 1993-96

developer:	Kolding City Council, Danish Ministry of Building
architects:	Lars Edmund, Kolding ; Architektfirmaet
size of area:	11,639 m^2
size of built-up area:	3,581 m^2
total size of residential floor area:	10,063 m^2
total size of commercial floor area:	727 m^2
costs:	50 million Danish kroner (approx. £ 4.5 million)
external facility and the "living machine"	16 million Danish kroner (approx. £ 1.4 million)

Initial situation and aims of the project

This project forms part of a long-term renewal scheme covering the entire district, south of Kolding town centre. The residential part consists of 40 three-storey blocks with 129 apartments and 6 retail premises. As compared with other urban renewal projects in Denmark, where a high level of resident participation is usual, this project in Kolding was from the outset planned and managed by a strict "top-down" approach because the relevant decision makers hoped, thereby, to achieve a better coordination with both the building authorities and financial organisations. The residents, however, wished a greater share in the decision making process and organised themselves into working groups.

Normally the Danish Ministry of Housing only recommends two types of ecological renovation measures: equipping the buildings with water-saving fittings and energy-saving electrical devices. Any further measures are subsidised only for test purposes or as model projects. Nevertheless, the renovation project in Kolding includes a considerable number of additional ecological measures.

Ecological aspects

urban design:	change in lay-out and plot sizes in inner courtyard, open space design including biological waste treatment and the "Bio-works".
healthy building:	differentiates floor plans according to functional and thermal requirements, use of second-hand or recycled materials
energy/heating:	passive use of solar energy using conservatories, glazed balconies, roof greenhouses, energy-saving electric lighting and household appliances, low-temperature heating connected to district heating system, improved thermal insulation, solar collectors on the roofs, photo-voltaic cells on car port roofs, for future solar-powered vehicles
water:	water-saving fittings in kitchens and bathrooms, 50 per cent rain water use for toilets, solar waste water processing, rain water absorbed by porous surfaces of footpaths
living machine:	local treatment of all waste water to be used for the production of fish and ornamental indoor plants in the "Bio-works" (cf. pp. 75-76)
open spaces:	design with natural features using a small stream and ponds, mostly native plant species, "living" fences using platted willow
traffic:	no cars within the housing area
waste disposal:	separated according to type, composting by using revolving compost containers, old building materials disposed of separately or re-used on site
design:	existing buildings retained, many facades re-designed to enable passive use of solar energy, thermal separation of balconies from main building to avoid heat losses

Results

As a result of the ecological measures implemented in this urban renewal project, the area has acquired a more attractiveness. The most striking example is the living machine "Bio-works", a glass pyramid which houses water treatment works, fish farm and a nursery for indoor plants which are located all in one building and inter-connected. In this project an overall attempt was made to cover many ecological considerations in a holistic and experimental manner, which is successful.

Energy and water-saving devices, the passive and active use of solar energy, the local waste water treatment plant: all these features contributed to the reduction of costs, e.g. on average the charge for water decreased by 50 per cent and for waste disposal by 40 per cent. These measures plus individual measures by tenants led to affordable increases of the total rents from 45 to 58 kroner per square metre per month. For the tenants it an acceptable level which is lower compared to the rent charged at such a level of housing quality usually.

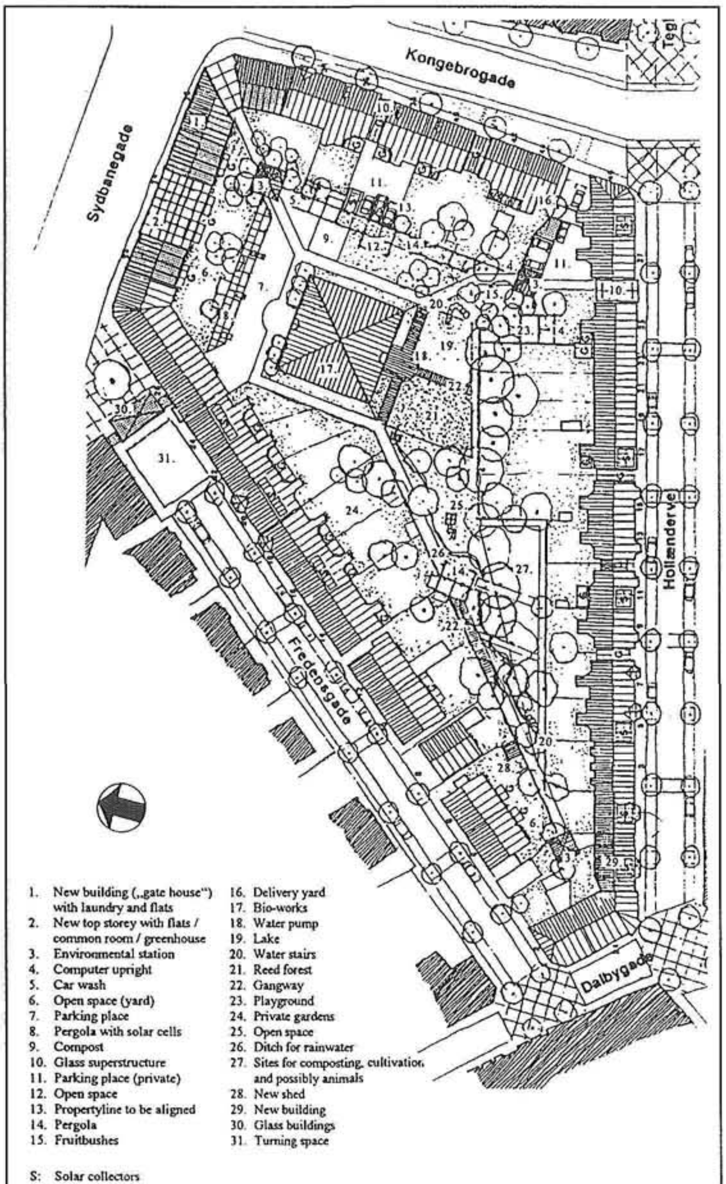
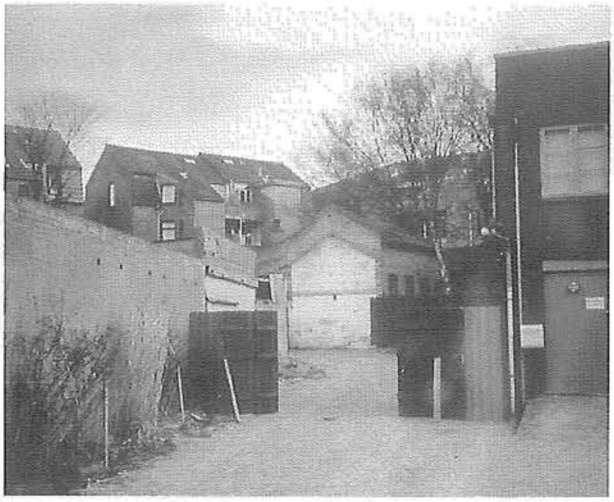


Fig. 12: Site plan of Fredensgade, Kolding



Ill. 14: Before clearing out the inner block area
Photo: T. Gade

Ill. 15: Planting and the Bio-works afterwards
Photo: D. Kennedy

Ecological Urban Renewal - 7th District - in Vienna, Austria

commissioned by:	Department 21A of the Vienna City Government, urban district and land use planning for the western inner city,
architects:	ÖkoSieben, Vienna

Initial situation and aims of the project

In the course of the first Conference of Central European Metropolises held in Berlin in June, 1992, the City of Vienna decided to carry out a project in the field of ecologically oriented urban development. "Neubau", the 7th city District in Vienna, was chosen as the model example. The ÖkoSieben group were commissioned to look into ways of improving the quality of life in the inner city borough.

Along the route of a *City Walk* various sites of local significance were identified, such as

- Andreas Park,
- Ahorner Court,
- the 'Kurier' newspaper office site,
- Siebenstern Square,
- Adler Court.

These were to be considered as sites for ecological improvements.
Prompted by a lack of green spaces in the area, the idea of designing the new 'Andreas Park' came into being. The overall vision for this park was to create multi-purpose spaces for out door uses. This would be attained by creating spatial differentiation, splitting the terrain into levels of varying heights and functions. Low stone walls, a pergola and typical local vegetation are the main design features of this park. It was opened to the public on 21 July 1994.

A number of proposals were worked out for the Ahorner Court site (approx. 1 hectare in size):

- Ahorner Lane to be re-modelled into a residential street for children and adults
- a car park was to be transformed into a park with an underground car parking
- construction of the proposed newspaper office block according to ecological guidelines
- use of ecological measures to a student residence and for the new construction of a day nursery
- exemplary roof vegetation, rain water collection, porous surfaces for the paths on the premises of the Protestant Church in Linden Lane
- re-designing the corner building in Ahorner Lane according to ecological guidelines for an ecological information centre
- renewal of the entrance areas of buildings and the garbage collection areas, construction of bicycle stands and pram parks in the passage into Ahorner Court

New functional and design qualities were to be achieved by the re-design of Siebenstern Square. This small square now has benches, trees and fountains. The best ideas were gained from a design competition, which were at the time displayed in an exhibition at the location.

ÖkoSieben's proposals for improvements of Ahorner Court included measures such as vegetation, rain water collection, rain water percolation, fountains and integrated running water in this courtyard. In addition the small service industries and shops which had closed down were to be re-opened in order to assist a new mixture of work, living and leisure in the same area.

The principal objective of the city walk is to enable residents the experience of implemented urban ecology and ecological settlement design practice. Existing possibilities are used to create open spaces, to improve the micro-climate, to reduce traffic and to have more children's playgrounds and public meeting places for the area's inhabitants.

ÖkoSieben has put forward further suggestions for overall ecological improvements in the 7th District. They include preservation and qualitative improvements to existing parks, new local parks, less sealing of roads and car parks, encouraging roof gardens and facades covered with greenery, reduction of traffic, rain water percolation and the preservation of approximately 120 historical gardens in the District.

Results

Aims achieved were:

- setting up a working committee: 'vegetation in inner courtyards'
- opening of Andreas Park
- setting up a citizen advisory service for the area
- final proposals for the renovation of Adler Court
- facade covered with vegetation and trees, planted as solitaires or in groups

The tremendous number of obstacles, the implementation of the many detailed measures proved to be time-consuming. Some of the main obstacles are the lack of district development plans which should include comprehensive ecological stipulations, and the lack of public information campaigns to inform and motivate the the residents of the quarter.

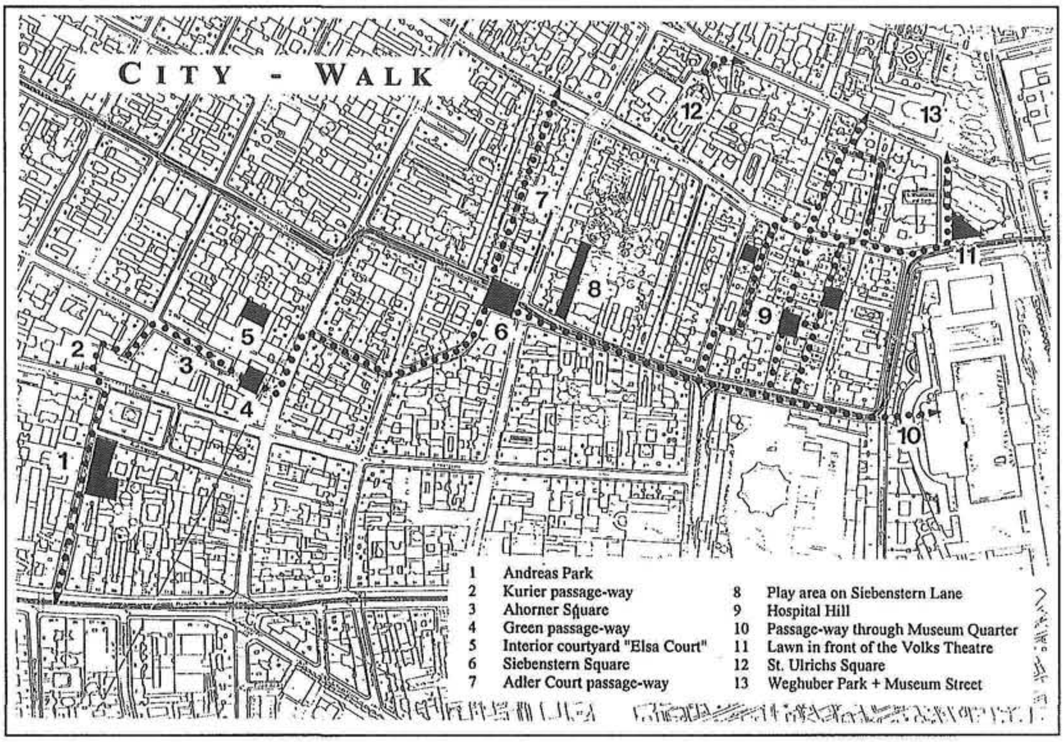


Fig. 13: Site plan of 7th District, Vienna

Source: "Werkstattbericht", Magistrat der Stadt Wien, MA 18

Ill. 16: 7th District, Vienna

Photo: F. Brandl

Selection of topics

During the course of the research it became ever more clear that both in new settlements and urban renewal we had generally to deal with the same basic topics. These topics thus determined the selection and sequence of the chapters which follow:

- Consistently, first priority was given to the question of differentiating and improving the design and the use of open spaces for social and ecological purposes. In addition to the fact that it provides a link between house and environment, and thus includes urban planning considerations this was the reason for placing this topic first, in "open space".
- The next chapter, "water", deals with the questions of falling standards of drinking-water quality and frequent flooding which have contributed towards making consumers more ready to consider changes in supply and disposal mechanisms, which may also pave the way for new opportunities to circulate water and nutrients.
- The reduction in energy consumption for heating and the use of renewable energy sources, particularly passive use of solar energy - have regularly been incorporated into concepts for new sustainable settlements. In this area comprehensive investigation has produced results which are now a part of new legislative measures to reduce energy consumption. The most important aspects will be presented in the "energy" chapter. The second part of it deals with a less established area, that of ventilation in dwellings. When applied to low energy design, it will be an indispensable part of ecological construction.
- "Building construction", deals with additional criteria for the selection of building materials and must include their use of primary energy following their path of building materials 'from the cradle to the grave' can indicate the amount they contribute to the pollution of air, soil and water. Such considerations have so far been virtually ignored, but their importance is set to rise in the future.
- This theme is extended in "healthy building" to cover the design of building and the effects of building materials and construction on interior climate and the health and well-being of inhabitants of dwellings. The topics of electric smog and radiaesthesia are controversial, but they have been dealt with here in order to contribute to clarifying their usefulness as design criteria.
- A long underestimated position in ecological settlement design and construction has been the question of "aesthetics". All the more reason for it to be picked up and discussed separately.
- In contrast to the current misconception - the intensive search for economical solutions has been an essential component of all our case studies. In the chapter "cost-benefit analyses", it is demonstrated how ecological solutions can reconcile both short-term and long-term economic interests. This can be achieved only by organising medium to large scale developments without subdivision. Furthermore, economic advantages can be achieved in the improvement of the construction process, using new forms of management, ecological technologies, organisation and financing as well as new types of cooperation between architects and residents.
- The varying starting points and objectives in each project prevent the full use of ecological design possibilities being implemented in any one project. In each location a unique combination of measures has been applied. Nevertheless, the authors have tried in the chapter "trends for future development" to identify some consistent trends in ecological settlement design, and some recommendations for future development.
- In examining and describing these central themes we have drawn on the experience gained, highlighted in the case studies as far as possible. If there were better illustrations of a particular point, however, we have not hesitated to go beyond this scope. Indeed, since this handbook is intended to be of assistance to planners in the future it would have been a disadvantage to restrict ourselves to no other than our selected case studies.
- Two topics which are normally considered in the field of designing ecological settlements have not been dealt with in any detail:
- firstly, the question of regional traffic and transport because it has relatively little significance in ecological settlements of the size we have considered. There is no question that a settlement should be linked to public transport systems, and in most situations this is the case. Nor is exclusion of traffic within the

settlement a source of disagreement. Thus the question of transport and traffic does not require a separate chapter but is included in the chapter about open space.

- secondly, the question of waste disposal or of separation of materials, an essential component in ecological design, has by now become a generally accepted element of new settlements and of urban renewal and is largely put into practice. Therefore, we felt this topic too can be dispensed with. Where it concerns the waste produced in the building process, however, it deals with a new aspect which is covered in the chapter "building construction" (cf. pp. 133-151).

The main point of this book was to investigate in particular ecological topics which are at present not represented in architectural design, building construction or urban renewal discussion and practice.

Objectives

The purpose of this work is to provide a contemporary basis for decision making on the various opportunities presented by ecological settlement design. The individual chapters also cover questions such as:

- what does the design of ecological settlements include nowadays?
- what is the difference between ecological and non-ecological planning and building?
- do ecological settlements need to initiated at the grass roots level or from the top?
- does ecological housing mean that residents have to change their patterns of behaviour or does it force them to accept restrictions?
- to what extent and in what ways can the existing stock be renewed in an ecological way?
- do ecological settlements need to be more expensive or can they even be cheaper than traditional housing complexes?

Based on the 12 case studies as well as on twenty years of ecological planning practice, of research and teaching, the authors have tried to indicate what has already been achieved in the ecological field and what could be achieved nowadays.

They attempt to give their readers courage to go the ecological way, but are far from ignoring the stumbling blocks along the way. However, nobody can afford to ignore the two decades of ecological experiences that exist today. This is why this historical dimension has been included in this book. In the minds of many people who are involved in settlement design today the mistakes made yesterday continue to present valid arguments against building ecologically, and prevent them form appreciating new technologies and information which have gradually come of age in the last few years.

No single person can claim that he or she is up to the minute informed in all the different spheres of ecological settlement design and construction. The opportunities the subject now embraces are too varied and complex. For this reason, we have cooperated with colleagues both in Germany and other European countries, since our twelve case studies only supply a certain amount of reassurance when making generalised statements.

Whenever there was a scientific basis for what we wanted to say we have made use of it; if no basis yet exists, we have made this clear. Our aim was to give as much detailed information as possible to be useful, but on the other hand to be compact enough to be readable, to provide both basic knowledge which is lasting and the current state of the art which may possibly be only of short term use. We hope that sceptics will find their interest and curiosity aroused and that those who wish to implement ecological projects will find encouragement and assistance. We want to address: amateurs and professionals, concerned citizens and decision makers, tenants and developers.

The chapters below are intended to be summaries of the main topics of ecological settlement design and are meant to give an overview of what has already been tried out. For readers in search of a quick orientation each chapter concludes with a number of recommendations stating:

1. what can be implemented nowadays at no extra costs or only a small amount of extra effort;
2. what can be implemented, at small extra cost and is ecologically desirable;
3. what needs to be tried out in the direction of further development of ecological design and construction - possibly in the first instance as an experiment even with considerable extra costs as well.

Our aim is not to claim overall coverage. The decisive factor is that the boundaries of what is possible can be pushed further, by making the tremendous range of opportunities clear and slightly less bewildering.

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Water

The use and value of water

Margrit Kennedy

Water is one of our most important nutrients. Increasing problems with the quality of our drinking water supply and cost problems with disposing of waste water indicate that conventional water supply and disposal practice is in need of a change: we have to find new careful ways of dealing with the life element of water.

Water supply and disposal system

The centralised drinking water supply and waste water disposal system introduced in the second half of the nineteenth century in European cities, in the wake of devastating cholera and typhus epidemics, quickly spread to the rest of the world. For the urban inhabitants of the time, it certainly constituted progress, but at the same time this system laid the groundwork for many of the problems confronting us today.

In nearly all European cities, bitter disputes over an appropriate form of sewage disposal preceded the opening of the first sewer networks. Berlin is a perfect example and the debate that raged there can be reconstructed in detail. One camp was the supporters of the technologically conventional methods already practised in London and Hamburg. These methods simply involved channelling sewage directly into the rivers. The other camp aimed to preserve the closed nutrient cycle and save the immense costs of a sewer system. They called for a broad-scale introduction of dry toilets. Even in those days systems existed which gave off little or no smell if used properly.

Whereas decentralised single systems of disposing of human faeces - such as compost toilets and dry toilets - were a source of income for building occupants and owners, if the human faeces was collected and periodically picked up by farmers, the introduction of a centralised sewer system - as everyone was well aware - was linked with high costs for state and citizens alike. Justus Liebig calculated, for instance, that the faeces of a single person was worth some 15 German gold marks a year. Many ecological arguments were put forward which were extremely modern in tone, and which called for an economy of cycles. These arguments were later taken up again by Leberecht Migge in the twenties [Reuss-81, 21], and have not lost their pungency up to the present day, although they have had little effect.

At least in the early period, some of the new centralised sewer systems combined technological, hygienic, environmental and economical dimensions in an "almost" model way. Sewage was pumped out of the city through pressure lines and pumping stations to newly laid out irrigated sewage fields on the outskirts of the city. Here the sewage was used as fertiliser for land worked by farmers, filtered through the soil and returned to the ground water in an organically purified state. By breaking down the system into technologically self-contained drainage areas, it was possible to enlarge the drainage system to keep pace with urban expansion and to use separate pumping stations to allow sewage to flow directly into the rivers and watercourses through emergency outlets during heavy rainfall.

This meant that domestic and industrial sewage was channelled into the same sewer as storm water. With the benefit of hindsight, it must be said that this was a wrong decision of truly enormous magnitude. It quickly became clear that, with the ever greater sealing of the city's surfaces, the intake capacity of sewers and pumping stations during heavy rainfall proved insufficient with increasing regularity, and that more and more of this sewage and rain water mixture was flowing into the rivers and lakes.

A further factor was that the irrigated sewage fields, which functioned perfectly for many decades and even yielded a profit, had to be closed down because increasing commercial and industrial poisoning of the sewage had made agricultural production impossible. This led to the first sewage treatment plants based on artificial organic purification coming into operation in the twenties and thirties. What was once valuable agricultural fertiliser had become toxic digested sludge which, as is still the case today, was often only fit for the incinerator. This was compounded by a third disadvantage, namely that the service life expectancy of the underground conduits and sewers, the pumping stations and sewage treatment plants fell as a result of increasingly aggressive waste water, with repair and replacement requirements making costs rocket.

But perhaps even graver than these practical problems is the drop in sensual perception of water as an element that went hand in hand with this process of mechanisation, a reduction of the ability to reconstruct the vital links to life which water and nutrient cycles represent, as well as a loss of knowledge and self-responsibility that this entails.

Detlef Ipsen speaks of a process of "decivilisation" [Ipsen-95, 13] accompanying the transformation into the modern city over a period of one hundred and fifty years, and adds that the end of this phenomenon is not yet in sight.

The city as a "place of the good life" expanded the horizons of its inhabitants in terms of their expectations, while increasingly diminishing their "scope for vital experience". Ipsen sees an explanation for the discrepancy between many people's perception of environmental problems and the lack of specific changes in their environmental behaviour in the fact that these two aspects have grown ever farther apart [Ipsen-95, 15]. However, this also implies that one aspect of ecological settlement design must involve once again making ecological connections sensually tangible in cities, so that some of the responsibility can be returned to the individual and smaller groups.

The element of water

Examined superficially, it would seem more accurate to call our Earth not "Earth" but "Water", as seven-tenths of it is covered with water.

An understanding of how important the element of water is for human beings can be seen in the fact that more than two-thirds of our bodies is water. Without the continual renewal of this water all of our life functions would quickly seize up. Both physically and chemically, water has a special place in nature: it is the only substance found on Earth in all three of its possible states: as a liquid, a solid and a gas. Its ability to form compounds or solutions with most other substances and the continual water cycle of evaporation, precipitation, seepage and the capillary absorption of water into plants, and even the water balance of living cells, ensures life on Earth.

In his book *Das sensible Chaos (Sensitive Chaos)* [1980], Theodor Schwenk illustrates the creative powers of water. From droplets to single-celled water creatures and river courses, to structures of the human body, he makes visible the artistic forces which operate in water. His work finds its scientific sequel in the practical work of the Institute of Hydrodynamic Sciences in Herrischried, Germany. This work delves into the question of: "What is water and how can its *quality* be made visible? A method of photographing drops of water[1] makes it possible in combination with other indicators, to ascertain, for instance, the stretch a stream needs to rid itself of sewage pollution using its own chemical and physical properties [Wilkens, Jakobi, Schwenk - 95].

An understanding of the forms created by water inspired artists like John Wilkes and Herbert

Ill. 1: Glacier crevasse formed by nature

[1] A drop of water (or other liquid) is placed on a metal plate and photographed using a flash in a room with no air movement or other source of turbulence.

Ill. 2: Fountain in Baienfurt market square

Source: Atelier Dreiseitl

Dreiseitl to develop water sculptures, cascades and waterscapes. These offer new experiential spaces defined by water and are found in many places in Europe, including England, Sweden, Germany and Switzerland.

The elementary models found in nature are a valuable aid in designing as there are no models in more recent urban planning and architecture. Where naturally formed landscapes with functioning water systems are still to be found, self-regulating functional processes can be directly experienced with the senses. With the necessary understanding of the phenomenon of water, this can also be achieved in constructing man-made artificial systems (see Illustrations 1 + 2).

In some of the projects we examined - Schafbrühl in Tübingen, Germany and Fredensgade in Kolding, Denmark - the element of water has been used as a key component of open space design (cf. pp. 41-45).

Availability and quality

More than 97% of the Earth's water masses is sea water. Of the remaining 3% which is fresh water, only 0.3% is accessible drinking water. Many fresh water reserves exist in the form of ice or are located in areas where they cannot be used by people, for instance, in tropical rain forests.

Thus World Water Day on March 22nd 1996 focused on the increasing lack of potable water in an attempt to attract the attention of the entire world to this problem. The great metropolises of the developing nations are particularly hard hit by this, but the industrialised countries are affected, too. In Mexico City this problem has already had grave consequences. Over the past 70 years, the city has sunk by several metres. This is because it gets its drinking water from the ground water reserves beneath the city [Neumann-96]. In Sofia, Bulgaria, leaky pipes boost water consumption up to 650 litres per person per day (ten times the amount efficient water use demands) and in response to an insufficient water supply, entire city districts in turn are cut off from the water supply on a rotation basis. Bangkok, Thailand and Houston, Texas are facing similar problems.

In contrast to other countries, the central European countries we researched receive adequate amounts of precipitation, but despite this, their practices of wasteful extraction, high levels of organic and chemical pollution in water systems and the increased sealing of city surfaces, have created a situation in these countries that can only be described as alarming.

As an example, the figures for the Federal Republic of Germany are as follows: of an average annual precipitation level of 800 millimetres, or approx. 210 billion cubic metres of water, more than half returns into the atmosphere through evaporation. 90 billion cubic metres run off into streams and rivers or seep into the ground water. This water forms a reservoir for the supply of drinking water. This is counterpoised by an annual water consumption of some 44 billion cubic metres, which means that there is actually enough water, it is only water of *drinking water* quality which is becoming more scarce.

Although drinking water consumption in Germany has not risen any higher since the beginning of the eighties and has even gone down since 1990, it is still 30-50% higher than it actually needs to be at a rate of some 145 litres per person per day. The destruction of natural landscapes, such as fresh water ecosystems, wetlands and streams that served as water reservoirs continues through the excessive level of consumption, particularly in agriculture, and the sealing of surfaces by road building, housing and large-scale industrial projects.

The consequences are:

- where too much water is extracted, the ground water is lowered to a level below that of rivers and lakes, so that it is fed by their polluted water
- wetlands and streams can dry up, the microclimate changes, biological diversity disappears and landscapes turn into wasteland
- long-distance water pipelines have to be laid for big cities and densely populated areas. Frankfurt gets its drinking water from Vogelsberg (nearly 100 km away), Hanover from the Harz region (more than 100 km away), and Stuttgart from Lake Constance (approx. 200 km away)
- forests die in the drinking water catchment areas far from the cities because tree roots can no longer reach the ground water
- large-scale centralised supply and disposal systems are high-maintenance, high energy consuming and expensive
- legal and financial constraints make appropriate decentralised cycles increasingly less feasible to create.

In the Middle Ages, well communities were formed to ensure the quality of drinking water. Well poisoning was punishable by death. Nowadays we reward agriculture's poisoning of our drinking water supplies with high subsidies, and contribute to the high levels of pollution ourselves with detergents and cleaning agents, but primarily with our faeces.

Only 2% of phosphates and nitrates occur naturally; 25% come from agriculture through fertilisers, animal manure, sewage sludge which washes into the ground water in the form of nitrate eluates, enters open bodies of water as phosphorus residue and pollutes the ground water through herbicides and pesticides. 20% of phosphates and nitrates come from detergents and cleaning agents and 53% from faeces and other sewage. In Switzerland, the per capita consumption of household cleaning agents over the past two decades has doubled [Kocsis-90, 33]. A family of four in Germany pours some 200 kilogrammes of cleaning agents down the drain every year. Should this become common practice in Europe, it would mean that, with 320 million people, some 16 million tons of detergent per year would end up flowing into rivers which in turn empty into seas.

One outcome of this development is that an increasing number of purification processes have to be applied to produce drinking water. In 1871 in Germany, a single purification process was sufficient, by 1953 it took three processes and by 1985, the number had risen to ten. This means that water works, and in the end we ourselves, pay the price of an inappropriate agricultural and environmental conservation policy.

Most experts agree on the following points:

- that a balance in the use and natural replacement of water reservoirs is the best protection against the progressive destruction of our ecosystems;
- that a drastic and immediate reduction of pollutants entering waste water from the air, agriculture and domestic households is essential;
- that it is untenable to continue to produce substances we know are pollutive;
- that pumping ground water up from deeper and deeper wells and supplying drinking water from ever greater distances must be stopped and replaced by a consistent policy of water conservation.

In the long term, we cannot afford new ever stricter regulations on drinking water supply and waste water disposal at increasing costs. This is why newly developed alternatives to conventional water supply and disposal systems tested in environmentally responsible settlement design and in environmentally sound urban renewal projects should be carefully examined from the standpoint of their wider applicability.

Drinking water: supply and substitution by rain water

Drinking-water and service water

The amount of water people need depends largely on the degree of industrialisation in the region and on their lifestyle. A person only needs five litres of potable water a day of drinking water quality[2].

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[2] In Germany, drinking-water must comply with the industrial norm DIN 2000. In the case of *drinking-water* suitable for human consumption, one differentiates between:

cold water = water of roughly 5 to 15°C
hot water = heated drinking-water up to 90°C
boiling water = drinking-water of 100°C

The official decree that water for personal hygiene, baths, showers, and dishwashing has to be of drinking water quality - and can not be replaced by filtered rain water or grey water - pushes up this requirement to approx. 70 litres per person per day.

Non-potable water is used as a collective term to describe all other types of water which do not have to fulfil all of the qualities required of drinking water.

The term *service water* exists, too, and describes water used for commercial, industrial, agricultural or similar purposes, for example: irrigation, washing, fire extinguishing, cooling, heating or in swimming pools. Service water comes in different types with each falling into a different quality category.

Buildings and sites can either get their drinking water supply from individual pumping stations or from being on the public water mains. Which of the two solutions is chosen generally depends on whether a drinking water pipe system is already in place and/or whether it is feasible or possible for on-site pumping stations to extract drinking water or industrial water. Ground water[3] is the first choice as a source of drinking water or, in cases where it is not possible or financially feasible to extract ground water, surface water[4] offers an alternative.

Basically, a decentralised drinking and/or service water supply is simpler, safer and more appropriate than a centralised drinking water supply system, providing one does not draw more water from ones own well or spring than is available in the form of ground water or spring water and the quality complies with the relevant standards. The ecological settlement "Waldquelle" (*Forest Springs*) in Bielefeld (cf. pp. 76-78) was able to achieve this. Here, self-contained water strategies are very well received by their users. As a user, if you bear all of the investment and ongoing maintenance costs, if you understand them and can control them, and you know where your water comes from, you will protect this water catchment area. It is not as easy for someone, who does not know, to develop a sense of personal responsibility, which means that if in doubt, he or she will be indifferent about the issue.

These days, however, in many places the ground water is already too polluted to pump up as drinking water. Where this is the case, though, it is always worthwhile considering the option of using rain water as service water before opting for a straight centralised water supply alone.

Water-saving options

Planning for ecological settlement design often differs from conventional drinking water supply systems in three ways. Firstly, in its selection of materials for the drinking water pipe system; secondly, in its commitment to saving water; and thirdly, in its substitution of industrial water, i.e. rain water or grey water, for drinking water wherever this is possible.

In selecting materials for drinking water pipes, environmentally responsible planners are increasingly replacing galvanised iron and copper pipe work with plastic pipe systems made of polyethylene - the so-called "pipe-in-pipe" system. The advantages are that they are more corrosion-resistant[5], produce less flow noise, evince lower levels of heat or cold loss, are less prone to incrustation, are easier to lay and are easier to replace. It is thus possible to switch over to using rain water or grey water without any great difficulty. It is also significant that galvanic electro deposits are not produced if a plastic pipe is connected up to existing pipes.[6]

The disadvantage is that the pipes have to be fixed more carefully as they sag otherwise. They have an expansion coefficient ten times higher than metal pipes. (But of course, this is exactly what prevents incrustation). The system components are more expensive, but this is offset by quicker

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3 *Ground water* is precipitation water that percolates through the soil, thereby being naturally filtered, and that then collects on an impermeable layer. It is generally bacteria-free and has a constant temperature of between 7 to 10°C.

4 *Surface water* is river, lake or dam water which is mechanically impure and often chemically and bacteriologically too, and in some cases even contains radioactive impurities. After appropriate purification it is therefore only used where groundwater is not available.

5 Acidic water in copper pipes causes toxic copper salts to form and these can cause death in infants. After a baby died in Saxony, it emerged that 843 waterworks in the former East German states were supplying municipalities with dangerously acidic drinking-water ["Tod aus dem Wasserhahn", Stern 29/1993, 226].

6 Where metal pipes are used, it is always important to make sure that a more precious metal, copper for example, is not laid in front of a less precious metal such as galvanised steel, as otherwise what is known as "pit" will form and the pipes will have to be replaced.

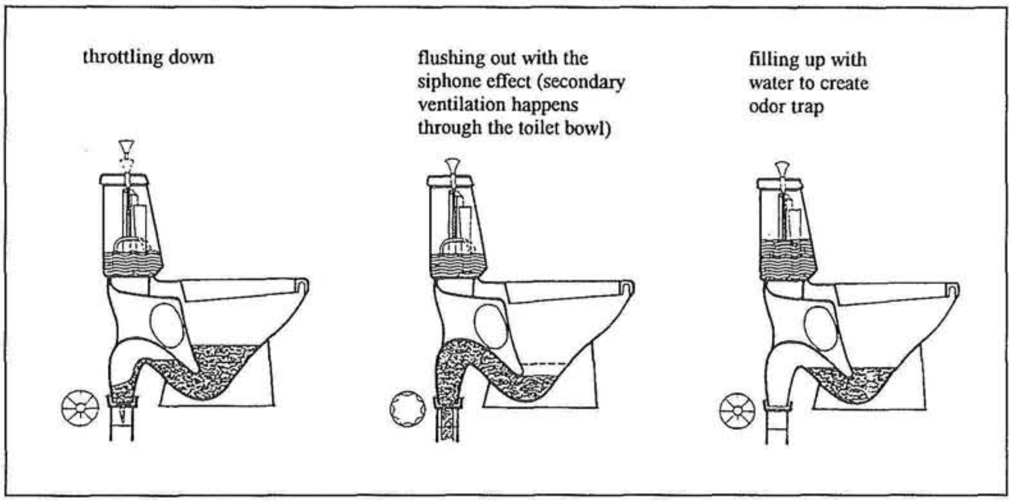


Fig. 1: Gustavsberg Water saving toilet

Source: Atelier Dreiseitl, "Daring to try new waterways", Study for the management of water for the Hohnstein Project 1995

installation, and, unlike laying copper pipes, there are no additional expenses later.[7]

A wide range of options is now available for *saving drinking water*. They span from low-flow shower heads and a range of water-efficient fixtures, through water and energy-efficient household appliances (such as washing machines and dishwashers), to the various low-flush toilets. Financially, the savings in energy by using less hot water are greater than in the amount of water saved.

The results of a study in the urban renewal district of Kreuzberg, Berlin already showed in 1984 that the consistent use of water-saving appliances (then on the market) coupled with the conscious usage brought drastic savings without less comfort. It was anticipated that renewing the area for 15.200 inhabitants (5,400 housing units) with conventional appliances would have led to an additional use of "drinking water" of approx. 80 % to 100 %. The savings in water use by installing the water-saving appliances led to 3/4 million litres of drinking water and, of course, of sewage per year in that area. This not only removes the burden from the ground water reservoirs but also from the sewage treatment plants [Kennedy + Thomas, 1984]

The use of low-flush toilets, i.e. a toilet bowl and a tank with a 6-litre flush and an economy button is now standard in Germany. The Swedish Gustafsberg ultra-low-flush system toilet goes even further, flushing with 3 to 4 litres of water. A new German vacuum toilet only needs about 1.2 litres per flush. The five-year testing phase of this toilet in an experimental project in Norderstedt, Germany, has just been successfully completed. It has been proven that this toilet provides an interesting alternative from an environmental as well as financial standpoint.[8] The system is of particular significance in connection with the combined collection and recycling of faeces and organic waste in semi-centralised cycles (cf. pp. 76-80; see Figure 1).

The only toilet system which gets around using any drinking water at all is the "dry or compost toilet", of which there are various types and which has been used for over fifty years. In the German-speaking part of the world alone, some 300 toilets of the Swedish Clivus Multrum variety are presently in use [Lorenz-Ladener-93]. This version consists of a plastic tank installed in the basement of a building beneath a vertically positioned downpipe. Up to four downpipes from several storeys can be connected to it (for toilets or kitchen waste, as required). The organic matter falls into the thermally insulated tank (without being flushed down by water), where it composts. After three or four years, some 30-40 litres of mature compost can be extracted per person per year. The compost can be spread on all perennial crops without any problem. This toilet is of particular significance in connection with grey water purification, in order to recreate a closed decentralised water cycle (cf. 75; see Figure 2).

[7] From an environmental standpoint, no toxic by-products are created either in the production or disposal of polyethylene. This material burns without leaving a residue, like any hydrocarbon compound. This applies both to the white interior pipe made of cured polyethylene and the black or coloured exterior protective pipe made of uncured polyethylene in the "pipe-in-pipe" system. The amount of energy used in its production is roughly one-third less than that used in the production of copper or steel pipes.

[8] The final report on twelve residential units in Norderstedt, which use this toilet system, was compiled in Summer, 1996 by Mr. Widell, WoBau, Kiel.

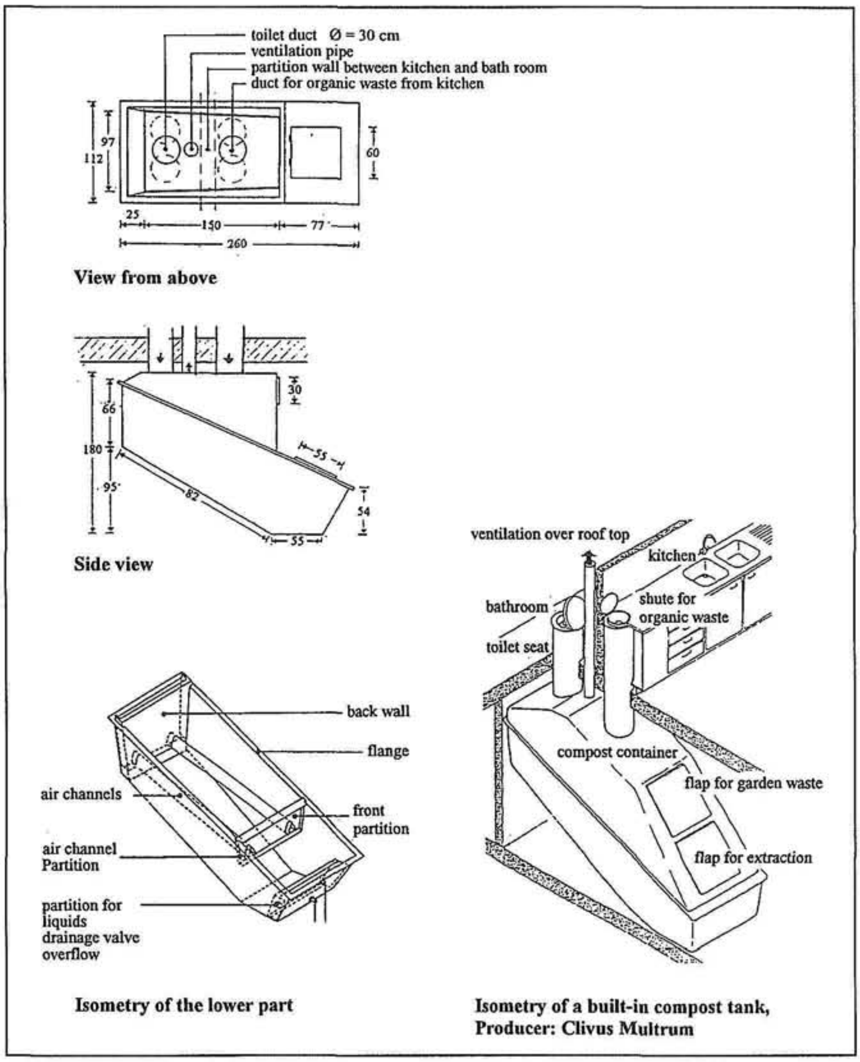


Fig. 2: "Clivius Multrum" compost toilet
Source: Wolfgang Berger, Hamburg

Water consumption and drinking water needs

As a breakdown of daily drinking-water consumption indicates, there are many usages that do not actually require potable water. Toilets, which use an average of 45 litres, top the scale here. Water used to flush toilets could be reduced to just about zero by installing compost toilets.

Or it could be cut back by another system without changing the toilet bowl, and by replacing drinking water with purified grey water or rain water. The latter is also adequate for "miscellaneous" water usage (such as cleaning), which consume 10 litres of drinking water. Bathing and showering require 45 litres of drinking water, and personal hygiene (brushing teeth, washing hands and face) takes 10 litres, dishwashing requires 10 litres, and then, of course, there is cooking and drinking, which require 5 litres of drinking water. Watering the garden is estimated to consume 60 litres per square metre. This amount can be significantly reduced by using a rain water storage tank.

This means that of overall average household water requirements of a total of 145 litres per person per day, only 70 litres have to be water of drinking water. With appropriate planning, the rest can be of a different quality. A glance at the development in price of drinking water in Germany and Switzerland is proof that it is also financially worthwhile to save water (see Figure 3).

In ecologically balanced settlement design, modern sanitary facilities can cut average drinking water needs by a third straight off, to approx. 100 l /person/day, and by a further third by using humus toilets, or rain water or grey water for toilet flushing, so that households can get by with approx. 65 l/person/day without making any sacrifices in comfort.[9]

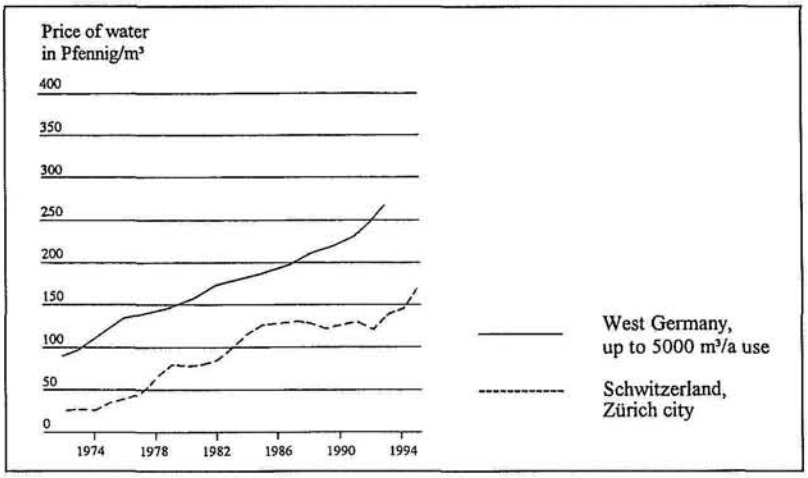


Fig. 3: Development of "drinking water" costs in Germany and Switzerland
Source: Daniels-94,201

[9] In public buildings this percentage can be considerable higher, over 60%, because their large roof surfaces available for collecting rainwater normally correspond to their large water requirements for toilet-flushing.

Substituting drinking water by rain water

Current regulations put rain water on a level with waste water. From an engineering point of view, the disposal of rain water has been understood as getting rid of it into sewers in combined or separate systems. In most cities storm water is still treated like "sewage" and channelled into a combined system. The result is that during heavy rainfall, when sewage treatment plants are overburdened, untreated sewage can run off into "receiving waters" - all bodies of water, like lakes and rivers, marshes and flood plains - and then on into the ground water.

Using rain water, therefore, would not only require less drinking water, but also take some of the pressure off the sewer system and the sewage treatment plants. Rain water accounts for nearly half the costs of disposing of waste water. To achieve better rain water management and to avoid building expensive storm water overflow basins, many countries and municipalities[10] subsidise decentralised rain water usage plants or require rain water seepage on site in new developments.

Depending on where it falls, rain water differs not just in quantity but also in quality. It is more polluted in industrial cities than in the countryside. It is therefore important - before putting in a rain water installation - to check whether the roof surface intended for use is heavily soiled with bird droppings or dust from the street (for example on busy roads). Where this is the case, an analysis must be carried out to rule out possible contamination before proceeding further, and it may be better to refrain from using rain water. Studies conducted so far have indicated that, in general, the level of germ contamination is lower than assumed, and is well within the limits which apply to bodies of water suitable for swimming, for instance.[11] However, as it cannot be entirely ruled out that rain water can be contaminated with germs because of where and how it is captured, it is essential to bear the following points in mind:

- Only drinking-water may be used for human consumption and ablution.
- The long-term possibility of mistaking drinking water for rain water must be ruled out.
- Taps for watering the garden need to be specially marked (with signs indicating that the water is non-potable, or removable or coloured handles for turning the tap on and off).
- As a rule there are absolutely no health objections to using rain water for toilets or washing machines, or watering the garden.

Studies conducted in Hamburg on washing laundry with rain water detected no difference to laundry washed in drinking water [Centre for Energy, Hydro- and Environmental Engineering of the Hamburg Chamber of Crafts-90]. In addition, the same studies showed that captured rain water in 16 demonstration plants was not nearly as acidic as one might imagine of "acid rain", but rather, neutral to slightly alkaline, like normal drinking water. This unexpected finding could be related to the fact that rain water loses some of its acidity and becomes neutralised when it flows over most roofing material.

Roof surfaces are preferable as *catch surfaces*, as run-off water from roofs washes down very little solid matter or other substances that might cause operational malfunctions in a rain water installation. Rain water captured on roofs covered with all common roofing materials, such as clay tiles, concrete roofing tiles, slate, bitumen and plastics, is suitable for use. Metal roofs (iron, aluminium, zinc, lead, copper) raise the metal content in run-off. However, it is absolutely safe if only used for toilet-flushing. It is not advisable to use rain water run-off from roofs made of asbestos cement.

Where *sod roofs* are an option, the substrate and design are of primary importance. Roofs used for extensive crops are better suited for using rain water. Fertiliser should not be used on sod roofs. Run-off from roofs used for intensive planting can have a brownish colour in the first few years, which is caused by humic substances, and can give off an earthy smell. Findings so far have shown that sod roofs are well-suited to the retention or storage of rain water, as in some 80% of cases when rain falls, the precipitation is absorbed by the soil layer and evaporates without filling up the cisterns. Notable quantities are only captured during heavy rain. This run-off can be used for watering the garden, but is only suitable for toilet-flushing to a limited extent. Basically sod-roofs and rain water collection are not really

[10] For example, Switzerland, and the German states of Hesse, North Rhine-Westphalia, Bremen, Hamburg, to name a few.

[11] Studies conducted by the Berlin Technical University have revealed that the germ count in rainwater in many cases actually fulfils the standards of the drinking-water code. The Lower Saxony State Office for Water Management arrived at similar conclusions [Öko-Test-94, Issue 5, 68-74].

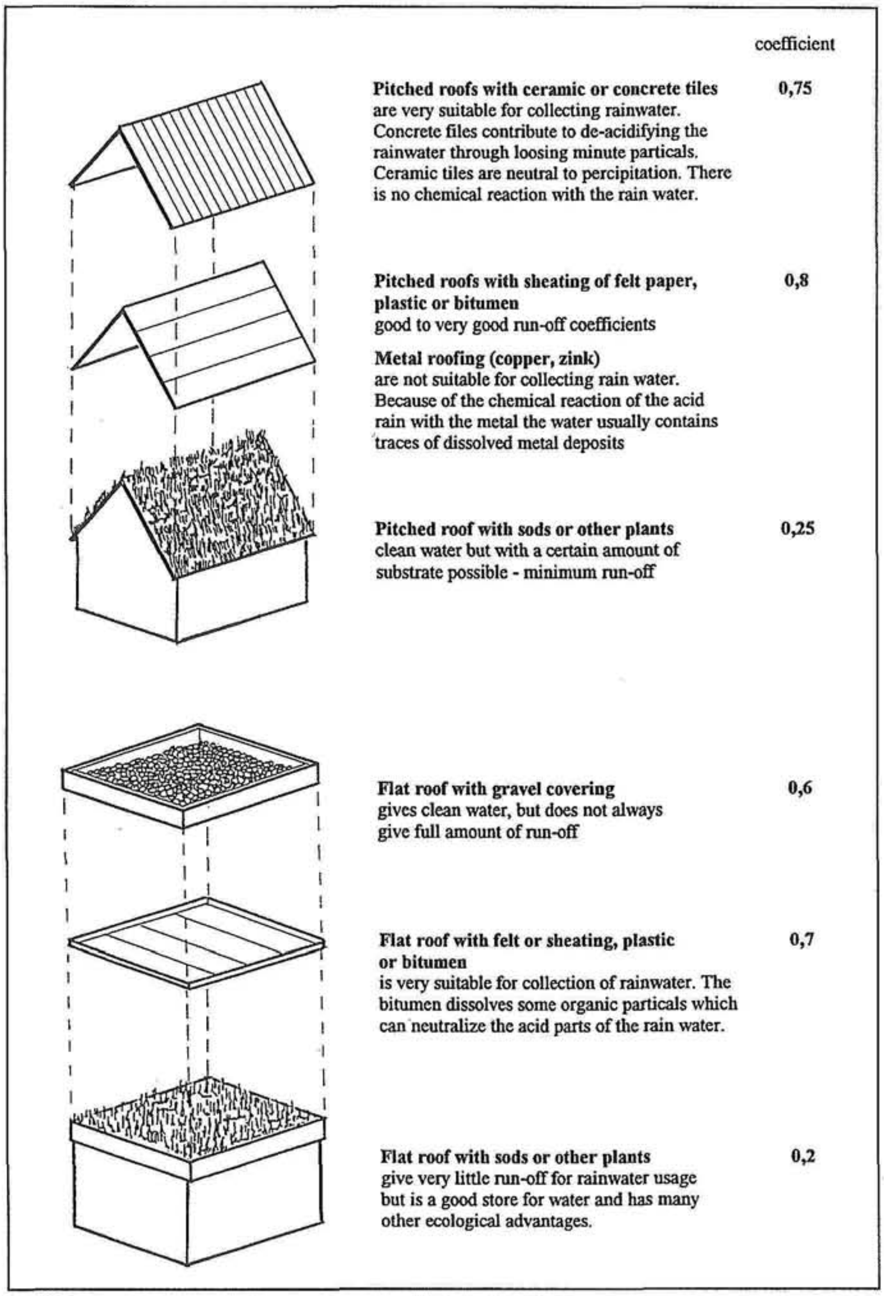


Fig. 4: Run-off coefficients Source: Kennedy, 1996

compatible and one should opt for one or the other.

Figure 4 depicts the advantages and disadvantages of individual roof coverings and their various Run-off coefficients.

The most important decision to make when putting in a rain water installation is the size and location of the storage tank. In new developments, a buried tank is generally advisable, as the necessary earthwork can be done as part of the building pit excavation at little extra cost, and this alternative saves basement space. When putting in rain water installations in existing buildings, it is usually better to opt for special plastic tanks, which are readily available on the market, and to install these in the basement. These tanks are available in sizes from 1000 to 2000 litres. Several tanks can be combined where larger volumes are used. To avoid the risk of germs developing, the tank should go in a place where the temperature remains cool, away from direct light sources, as otherwise algae will grow.

An attic installation of rain water tanks is only advisable if the building is built on a steep slope. Otherwise there are likely to be problems with piping up the rain water, with the permitted static load, with frost resistance, with the risk of germ contamination due to high temperatures in summer, and with water damage prevention. One really need only fear three things: dirt, light and heat, as these can transform rain water into a stinking swill (see Figures 5 + 6).

Local regulations governing waste water disposal from buildings and sites need to be taken into account when constructing the rain water feed system. However, certain points must always be considered:

- Every intervention into the existing system of rain water diversion (roof gutters, downpipes) can reduce run-off efficiency and increase the risk of congestion or freezing up. For this reason, internal fittings in pipes, pipes buckling or the sudden narrowing of pipes need to be avoided. A short straight pipe run with sufficient sloping is the best solution.
- Pipes laid underground should be laid at a frost-free depth (in Northern Europe of approx. 80 cm to one metre below the surface) and with a minimum bore of 100 millimetres.
- Every penetration of building walls, especially those underground, must be resealed.
- To ensure that drinking water is protected from contamination, and as germs can also grow

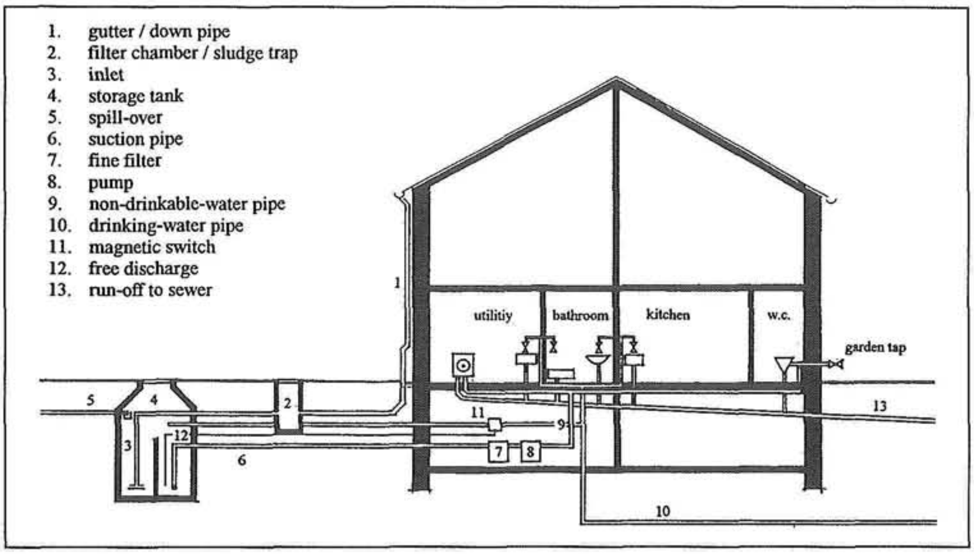


Fig. 5: Rain water storage outside the house Source: Kennedy, 1996

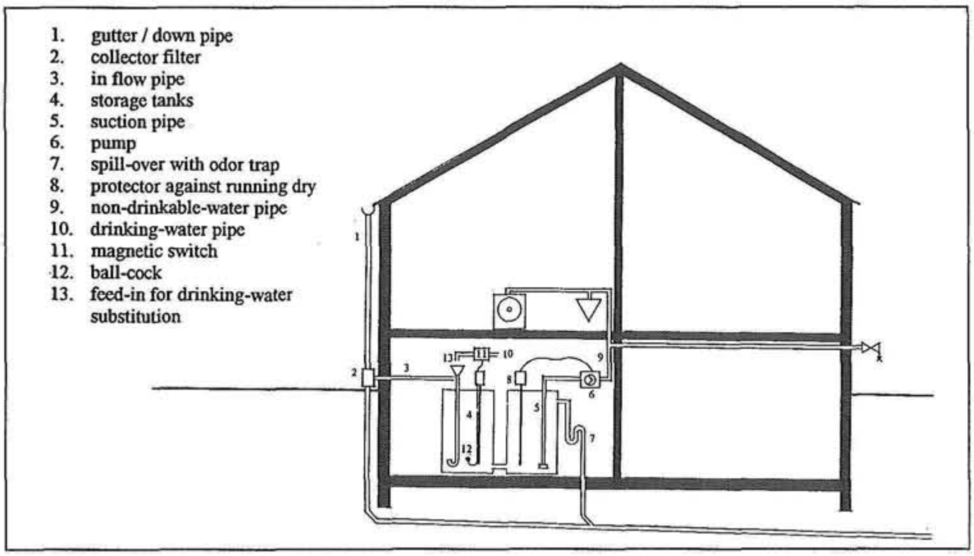


Fig. 6: Rain water storage inside the house Source: Kennedy, 1996

against the current of the water (which would theoretically call into question the hygiene of the drinking water supply of an entire district) a direct connection of the pipe systems for drinking water and rain water is out of the question.

For economic reasons, rain water installations generally cannot be designed to *meet all a settlement's non-drinking water needs*. It is therefore necessary to *feed in drinking water* to ensure a constant supply of water to facilities which require it, in dry periods, too. This involves the few added costs of a double pipe system.

Domestic water plants are used to pump rain water from the tank to where it is required. These are self-priming centrifugal pumps (or piston pumps) with manometers, pressure regulators, and manometric switches which ensure a constant pressure in the pipeline system. In selecting and installing domestic water plants, it is important to ensure that

- corrosion-free materials are used;
- the pump is not too big, to avoid it constantly turning itself on and off;
- the suction-head is as low as possible;
- the pump is installed with connections not sensitive to vibration
- an automatic flow control protects the pump from running dry.

The operational safety of the rain water plant basically depends on the reliability of the pump, so one should only use the highest quality domestic water pumps with standard pressure control valves. Pressure-controlled centrifugal pumps have proven the best solution, [Öko-Test Magazin-5, 94, 72].

Where cisterns are used, chambers with swirl filters are used to keep impurities out of the tank.[12]

[12] In renewal projects, which generally have to put the tank in the basement, a combination of collector devices and filters, or what is known as a "collector filter", designed by Norbert Winkler, has proven to be a good option. Even in the heaviest rainstorms, the water runs down the pipe wall and at the same time the entire diameter of the pipe remains open so that leaves, and even tennis balls, can flow freely towards the sewer. Ten percent residue of the water is not drawn out of the pipe by the collector filter, and this ten percent cleans it, making it practically maintenance-free. This self-cleaning effect is an important advantage.

Fine filters attached to washing machines are not recommended. Light shining into the bathroom and the heat in this room contaminate the water extremely quickly. Washing gets clean without a fine filter, as various studies have proven.

Storage tank size must be based, firstly, on the supply of rain water available, and secondly, on the need for rain water. Financial reasons make it important that a balance is found between the two. Inquiries about local precipitation levels can be made at the local meteorological office. Meteorological office statistics indicate the average length of dry spells. In Germany, these are rarely longer than two to three weeks. This is why the necessary storage volume is calculated for 21 days. In determining tank size, experience has shown that a storage tank size which holds 5% of the annual yield is sufficient [Zentralverband Sanitär, Heizung, Klima-93].

An assessment of the options for using rain water is likely to turn out considerably more favourably in relatively large ecological settlements, or in comprehensive urban renewal projects, than in a one-family project, as a shared installation for using rain water is naturally cheaper and more energy-efficient than a number of individual installations. In any case, these should be designed and constructed in cooperation with experienced specialised engineers and companies.

Design and yield of an installation for using rain water

The installation in Hanover's Rehbockstrasse[13] serves 40 apartments and was built in 1989. It uses rain water, collected from a total of four connected roof surfaces, covered with clay tiles, for toilet-flushing in the same four residential buildings. Altogether, the roof area size is 1200 m². The rainfall is collected through roof gutters and downpipes made of zinc, and stoneware pipes underground. It then flows first through a screen, then through a central shaft and a geotextile filter to separate out fine substances, before it runs into two *underground cisterns*. They are made out of concrete shaft rings and have a storage capacity of 19.6 m³ (see Figures 7 + 8).

The water pumped up to the toilets of the 40 apartments is purified through a vacuum filter. Water is extracted by two parallel-operated pumps and pressure tanks (a piston pump with an

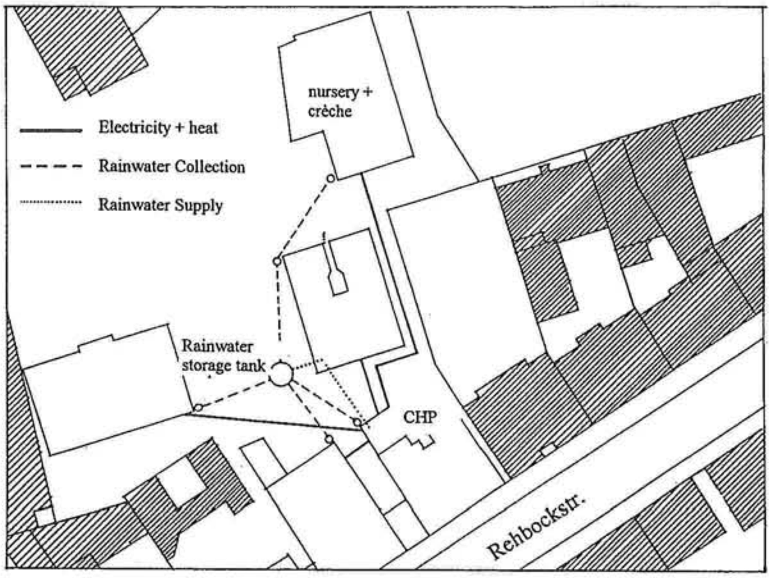


Fig. 7: Rain water installation for 40 apartments, site plan
Source: Blencke -96

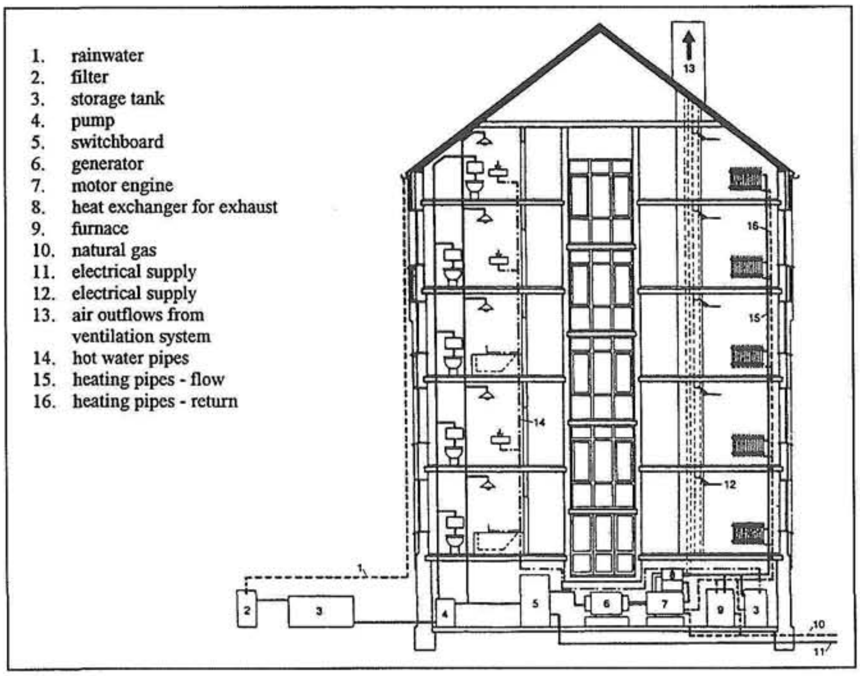


Fig. 8: Section through the system (Source: Blencke-96)

13 The basic data for this description was provided by Udo Sämann, AGWA, Hanover, 1996.

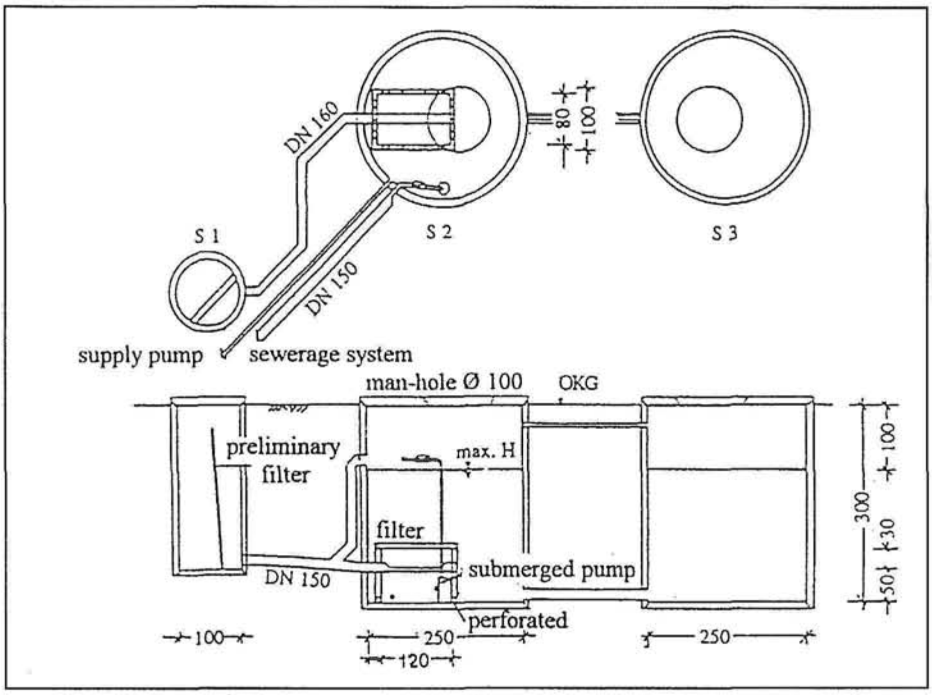


Fig. 9: Rain water cisterns and pumping shaft Source: Blencke, 1996

open pressure tank and automatic aeration; and a centrifugal pump).

The cisterns' *emergency spillover* channels surplus water into the storm drainage system. As the *spillover* is below street level, the backflow level of the sewer (ground level) is overcome by using a submerged pump. *Drinking water is fed in* to the storage tank through an open outlet in the basement of the building (frost-proof). This is automatically controlled by a float switch. It is unlikely that both parallel-run pumps will fail at the same time, but in an emergency, water can be supplied to the toilets from the drinking water mains. With the agreement of the local public works, two pipe disconnectors were installed (one for rain water and one for drinking water), which *rule out the simultaneous connection of rain water and drinking water*. After a few initial difficulties, the rain water system ensures *operational safety*.[14] The installation's *overall efficiency* fluctuated (in the monitored period from 7 April 1993 to 31 August 1993) between 60% and 85%, which is a very good level of efficiency[15] (see Figure 9).

At 83,000 DM (£33,000), the total *construction costs* were relatively high, due to many precautionary measures. The drinking water savings (subject to a meter which may not have been quite correct), projected from the limited study period onto a whole year, come to 1,086.17 m^3. Taking the current price of drinking-water, this corresponds to a cost reduction in annual expenses of DM 2,766.92 (£1,105). An annual payment calculation over 30 years of 7% puts the investment costs at around DM 6,700 (£2,680) per annum. If a rate rise for drinking-water based on the experiences of the past few years is taken into account, and a cost comparison of the installation is calculated over a 30-year service life, then the actual *profit* yielded by this installation is DM 4,592.29 (£1,837) per annum. Although the costs of installing and constructing the system were comparatively high, the installation can make a profit, provided it processes a lot of rain water. Then the installation costs are balanced out by regular savings.

Within the framework of a one-year monitoring programme conducted by the city of Hanover, the *water quality* from the installation for using rain water was analysed on the basis of various chemical, physical and biological parameters. What came out of this study was that - compared to other systems studied - the Rehbockstrasse installation produced a relatively poor quality of water (which can be accounted for by the fairly high levels of air pollution in the northern city and its many pigeons), but that this did not inhibit the installation's operation.

Rain water installations can be recommended, based on *experiences gained constructing and operating them*. Larger plants not only *benefit the*

14 The company had wrongly wired the control box when they installed it, which led to problems with the piston pump. A further malfunction showed that the suction line was pressure-tight, but not vacuum-tight. There were also mistakes in the automatic drinking-water feed. However, all failures could be quickly remedied.

15 The plant was originally planned for a considerably lower number of users. The operator changed this for reasons of uniformity, so that four instead of two buildings were connected to the plant. In addition, the average occupancy density of the dwellings was considerably higher than originally planned. The maximum roof surface that could be connected to this system, however, meant that a larger storage tank would not have yielded any significantly greater savings. The storage tank size can therefore be evaluated as good.

environment, but also mean *cost savings* for the operator. It is advisable to commission a technical maintenance service to ensure its operational safety. In Hanover, a two-and-a-half storey building achieves an optimal balance between rain water supply and demand. A multi-storey, compact building (like the one described above) has a somewhat less favourable ratio, but unlike most installations for a single-family dwelling, this one is still economically feasible.

Rain water seepage and retention

Until the early eighties, conventional urban and settlement planning did not question the "classic" rapid and undifferentiated diversion of storm water into waste water treatment plants and receiving waters. It is only recently that the disadvantages of this disposal practice have become apparent.

Rain water seepage or retention prioritise four goals:

- firstly, avoiding or reducing the direct run-off of rain water that contains hardly any or only a minimal amount of impurities from the place where it falls;
- secondly, caring for the natural water balance, especially by replenishing ground water supplies;
- thirdly, raising low water levels and avoiding extremes;
- fourthly, improving the local microclimate, as water balances out temperature extremes, humidifies dry air, binds dust and cools the air through evaporation on hot summer days;
- fifthly, enabling people to experience water directly in an appropriate design.

Instead of a rapid and undifferentiated diversion of storm water, this approach aims for its slow and differentiated diversion, linked with intermediate use wherever possible. When devising an appropriate strategy for rain water seepage or retention, it is important to bear in mind the quantity, frequency and quality of the precipitation in terms of impurities, available surfaces, the permeability of the soil, the depth of the ground water supply, and the various legal regulations that apply. They determine which measures listed in the rain water run-off diagram are appropriate.

A comparison of three new development areas where rain water management has been applied shows that building costs for sewer systems can be cut by half if one can do without rain water sewers in new building developments [Sämann-95, 29-30].

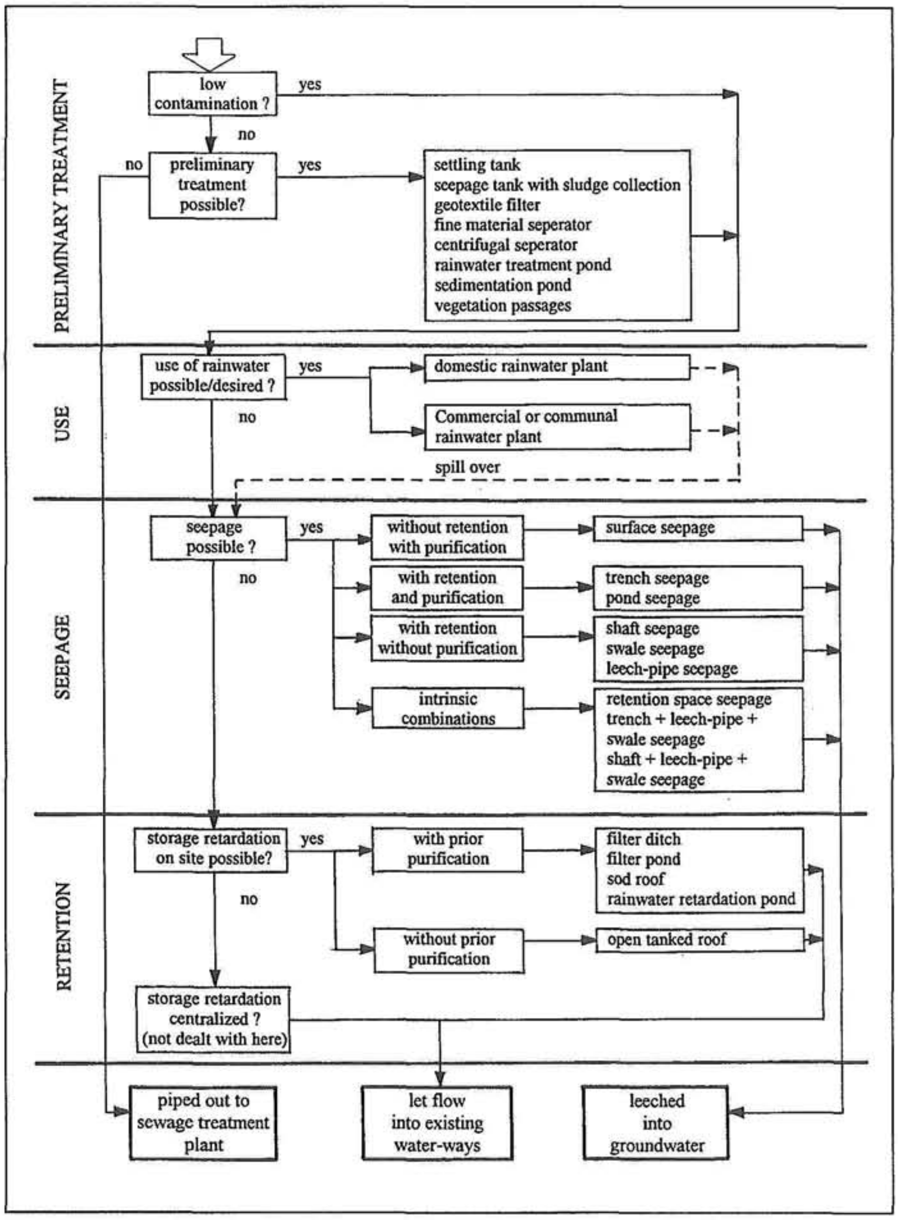


Fig. 10: Rain water run-off diagram Source: Geiger, Dreiseitl-95

Maintenance costs are approximately the same for both options - a connection to the centralised drainage system and a decentralised retention and seepage system - if the maintenance of the trees and green spaces are included in the costs of the retention areas. If parks are planned for the settlement anyway, then these costs do not come under drainage costs. Where this is the case, the calculation for the decentralised option looks considerably more favourable. Also, property owners can tend the retention and seepage system themselves in many cases, which would lead to further savings.

A variety of planning elements can be used when designing with water. Open downpipes make trickling and flowing water visible. Instead of sewers, open channels can divert the water in certain places and lead it to open ponds or wetlands. This lends differentiation and structure to paved areas, and is often less complicated than one might imagine. The murmuring and gurgling of water, the play of the waves and the light reflecting on the water's surface are elements which bring life to public parks and developed areas and where appropriate can be used to slow down traffic. Planted ditches, and other surfaces through which water can pass into the ground, facilitate seepage.

However, planners should not underestimate the amount of effort they have to put into the construction and operation of larger projects. Seepage areas or spaces need to be properly designed and calculated, as this is really an engineering job and one that goes far beyond designing a sewer system. It almost always requires intensive coordination with other experts. Implementing this concept, therefore, depends substantially on engineers taking design aspects into account, and on architects and artists having a basic understanding of the technical side.

As rain water seepage and retention has a strong influence on the design of the architecture and open spaces, there are tight constraints on the scope for *implementing such concepts after the fact*, in an existing housing area is often difficult, unless there is a lot of open space available. In inner city residential areas, planners can often find ways of introducing rain water seepage and retention measures by removing pavement in the inner courtyards of housing blocks or by covering roof surfaces with vegetation. Kolding is one example for this approach.

A sample calculation for Vienna drawn up by the ökoSieben group depicts the scale and advantages of comprehensively covering their roofs with vegetation: whereas some 600,000 litres of water run off a conventional roof surface of 1000 m^2 into the sewer system, a roof surface planted with vegetation retains around 400,000-580,000 litres. Of roughly 57 km^2 of roof surface in Vienna, about 15%, or 8.5 km^2, is flat roofs. If 30% of these were covered in vegetation - so the calculation goes - they could retain over 100 million litres of rain water annually. The city would benefit from this in a number of ways, as it would:

- relieve the sewer system
- lower the flood peaks
- reduce the pollution levels in the receiving waters
- improve the climate of the city
- improve the microclimate and
- bind dust.

The construction benefits are that this would:

- balance temperature extremes
- protect the roof skin from ultraviolet rays, air pollutants, and physical damage
- lower footstep and airborne noise pollution
- increase protection against fire spreading from neighbouring buildings
- improve thermal insulation in winter and in summer.

The refreshing psychological effect of looking at planted roofs from higher storeys is very highly rated, particularly in inner city districts. The ökoSieben group therefore proposes that the Vienna building codes deals with the concept of planting roofs by developing a legal strategy for promoting them, and advocates the incorporation of planted roofs in the official development plans [Brandl-96].

In *new development areas*, on the other hand, a new approach to dealing with rain water can be incorporated into the local development plan from the outset. The access, circulation, layout and design of open spaces, as well as the roof forms and roof covering can be stipulated as a planning code.

Urban structures with a plot ratio and a sealing factor of less than 0.4 have sufficient garden areas and open space to allow rain water seepage and storage to be implemented on individual domestic sites, generally at no great cost.

The combination of trench and drainage pipes in a swale for seepage is in principle a retention system, whereby a held back leeching or seepage occurs under the trench or to the side through swales. This ensures a good biological purification through a soil layer that is full of life - a retardation of slacked material. It takes up relatively little space. However, it is necessary to clean out and check the trenches and clean out the shafts regularly in order to make sure that everything function satisfactorily.

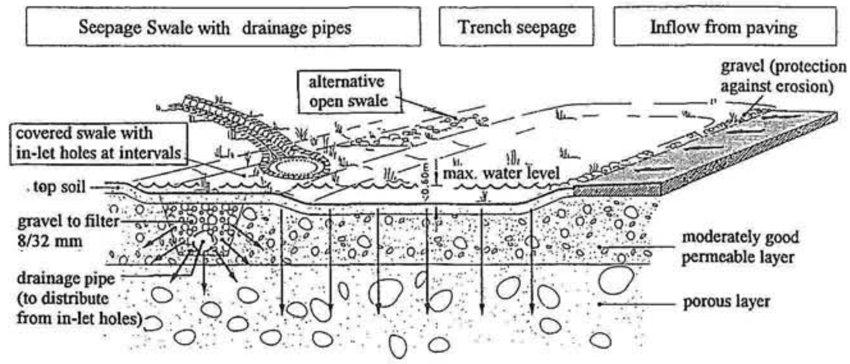


Fig. 11: Trench and swale seepage system
Source: Geiger, Dreiseitl-95,120

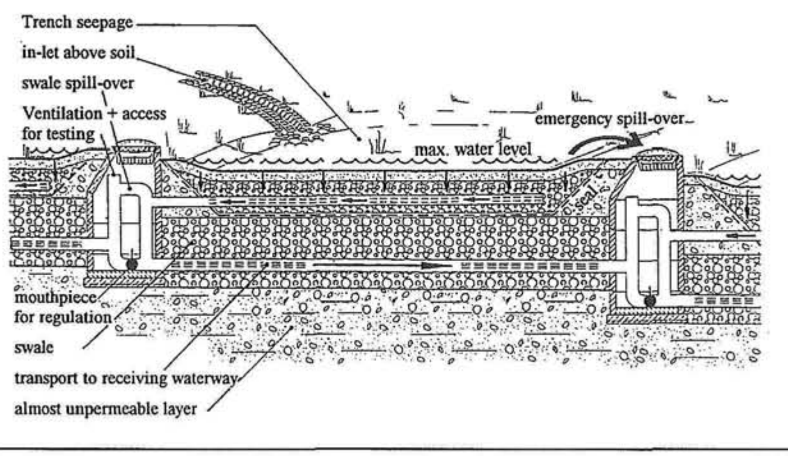


Fig. 12: Trench and swale retention system
Source: Geiger, Dreiseitl-95,120

In new development areas with plot ratios higher than 0.6 and a sealing factor higher than 0.8[16], only small

percentages of rain water can be stored or left to seep into the ground on site. In such cases, a combined seepage system through trenches and drainage pipe in swales is a valuable alternative (see Figures 11 + 12).

Dense new residential development should aim at a close interlinking of private, semi-public and public open spaces. This makes it easier to let the monitoring and management of rain water seepage and storage be a community task.

For consistency's sake, a cost comparison of various drainage systems would have to incorporate in the costs of each system, the entire water discharge cycle - from run-off surfaces to returning it back to the natural water cycle. Where a combined rain water and sewage system is involved, it would have to include the rain water-related costs of diversion, storage, pumping stations and treatment plants. With a separated system, apart from the costs of separate pipes and pumping stations and of diverging storm water sewers, there are also the costs of rain water retention basins in the municipal drainage system or flood retention basins in the system of lakes and rivers. These costs are augmented by possible costs of developing existing waterways to accommodate outflow from the separated system. Where it is opted for, a seepage system, the costs of seepage and storage installations and of their interconnection need to be taken into account and, of course, not only investment costs and their depreciation, but also operating costs.

As a result of a financial assessment of this kind, the town of Hameln was able to get around building a new rain water retention basin (which would have cost four million marks). Instead they informed homeowners of the possibilities of receiving planning and financial support if they would be willing to manage the rain water run-off from their roofs on their own property. Thus they were able to decouple an area of 50,000 m^2 on 160 sites (of a total of 400) from the municipal system. The property owners were given a one-off payment of 10 marks per m^2 of roof area as a subsidy, as well as a guarantee that they would be exempt from paying the storm water fee as the tariffs for storm

16 A floor space index of 1.0 would mean that all ground surfaces on the site were completely sealed off.

water and sanitary sewage were separated. The same end was achieved with half the means (approx. two million marks for subsidies, consulting services, design and implementation), not to mention the wide range of ecological benefits from this option. These included ground water regeneration, raising the low water level, improving both flood protection and the quality of existing lakes and streams.

Technological and nature-based sewage treatment systems

Sewage is a by-product of human activity as regards quantity and composition. Depending on its origin, the time of day or year, the weather and other factors, it can be very different in nature. In practice, specific terms are used to describe the various types of sewage:

Normal domestic sewage, which very quickly turns black as a result of its high percentage of putrescible substances from faeces, is known as *black water*.

Sewage that contains no faeces and urine, is described as *grey water*, because of its appearance. The impurities in grey water come from dishwashing, preparing food, washing clothes and from personal hygiene. Grey water contains only roughly a third of the amount of impurities that black water does. This difference is significant for nature-based waste water treatment systems. Conventional disposal practice is solely oriented towards sewage containing faeces.

Centralised sewage treatment

With a few exceptions, domestic and municipal sewage is always treated with an organic process, e.g. a natural process involving organisms, generally bacteria. In simplified terms, a description of sewage treatment in municipal plants can be said to consist of four stages:

1. Separation of sediments in large sedimentation basins; formation of primary sludge.
2. Extraction of dissolved biodegradable organic substances inactivated-sludge basins. (Air is pumped into these basins, causing great quantities of micro-organisms to form in "activated" bacterial or secondary sludge. This sludge is separated in a final settling basin; the effluent flowing out of this basin is organically purified water.)
3. Extraction of dissolved nutrients such as nitrogen and phosphorus by special bacteria, or, in the case of phosphorus, additionally, by chemical precipitation in special basins or by other process combinations (tertiary sludge).
4. The sludge produced in stages 1 to 3 is treated in digestion towers (where the sludge is digested by methane bacteria and/or by dewatering or other processes.) Subsequently, the sludge is either spread on agricultural land, stock-piled or incinerated.

Thus, treatment plants cultivate bacteria and other micro-organisms which purify waste water so that the effluent complies with legal requirements. This process uses technical structures and equipment which consume a great deal of energy and require high maintenance costs to process waste water which an expensive connecting system transports over large distances.

Waste water treatment plants are there to protect human beings and the environment. But the way they are presently designed also puts a great strain on both. A model calculation illustrates the high energy consumption of conventional waste water treatment systems. By the mid-eighties, Swiss sewage treatment plants were already using 268 million kWh or 963,000 gigajoules of electrical power per year. The combustion of fossil fuels for this purpose led to the emission of some 350,000 tons of carbon dioxide. In addition to this, the energy required for installing the concrete alone can be estimated at roughly 3 billion kWh of electrical power and, therefore, at over 30 million gigajoules of primary energy, which in the form of electricity corresponds to the environmental pollution of 3.5 million tons of carbon dioxide. High-capacity water purification plants are thus intensively involved in air pollution [Niklas-95, 28].

Besides the direct energy consumption, a comprehensive ecologically balanced approach must also take into account such energy losses as the destruction of valuable fertiliser. In 1982, for instance, artificial fertiliser production in the Federal Republic of Germany required exactly as much energy as was produced by all atomic power plants put together [Schuster-82].

An environmentally responsible solution which considers all of these problems can only be a call for a restructuring into smaller treatment units in order to link the necessity for cleaning the effluents with the demand and consumption of fertilisers in a cost-efficient and energy-conserving way. The first need is therefore not to choose between nature-based and technological solutions, but to find appropriate measures for structural change.

The high costs and waste of resources and energy described above are augmented by other problems of conventional sewage systems which have been described before. This section is to concentrate on solutions offered by the design of ecological settlements. From some of the case studies (see pp. 11-35) the following general conclusions can be drawn:

1. All sewage from domestic and industrial waste production processes needs to be treated separately and the resulting liquid and solid particles as far as possible recycled.

Results:

- sewers can be designed smaller
- toxic substances can be disposed of on-site
- costly, energy-intensive purification stages become unnecessary

2. Domestic waste water disposed of in a decentralised water treatment system allows for excellent purification results at each treatment stage. It is therefore worthwhile for occupants to use only biodegradable domestic chemicals.

Results:

- purification sludge is once again residue-free and can be processed into dry fertiliser, instead of requiring disposal as hazardous waste, as it does now.

3. Both in new developments and urban renewal projects, decentralised strategies of water supply and disposal are most effective if they go beyond the scale of individual buildings and sites.

Results:

- instead of the costly installations for eliminating phosphate and nitrate, these projects can use fully organic waste water treatment installations or space-efficient processes involving immersion trickling filters or fermentation systems.

Therefore, decentralised strategies and nature-based purification procedures can be seen as a supplement to centralised strategies and an important step towards the regeneration of open bodies of water and the ground water.

Nature-based purification processes

Nature-based systems for purifying waste water include:

- moving bodies of water
- ponds with or without aquaculture
- land treatment systems
- natural and constructed wetlands

The most natural way of treating waste water is *harnessing the self-purification powers of moving bodies of water left in their natural state*. Like in conventional organic treatment facilities, purification is carried out by micro-organisms which use the oxygen in the water to oxidise effluent wastes. Twenty years ago, the self-purification power of a stretch of the Lower Rhine approx. 100 km long was valued at some six billion marks. The introduction into the river of substances which destroy oxidising bacteria, at that time, reduced its self-cleaning capacity by one-third, incurring hidden costs of two billion marks [Niklas-95, 5].

Human beings have used *waste water ponds* for 3000 years. Waste is broken down in both aerobic and anaerobic processes (i.e. with and without oxygen). Purification quality depends primarily on the catabolism of various plant and animal organisms. Today a mechanical purification stage has to precede organic purification, as mineral substances could get in the way of biodegradation.

Often the function of waste water treatment in ponds is combined with fish production in *aquaculture systems*. Asian countries have developed this practice into an art, in combination with the production of plant organic matter [King-11]. In the United States, John and Nancy Todd and the New Alchemists have advanced the practice of using waste water to produce food, organic matter, ornamental plants, etc. in an intensified form in greenhouse tank systems, based on the concept of "*Living Machines*" [Todd-91].

Land treatment processes became established in England around 1850 and in the United States around 1870. In Berlin, the first *irrigated sewage fields* for waste water disposal were set out in 1874. Even today in Brunswick, Germany, purified waste water that complies with the higher standards of modern waste water disposal is used in agriculture. The advantage of this process from a *water management* point of view is that it binds solid wastes from the sewage into the top layers of soil, where soil organisms break them down aerobically. The fertilising substances contained

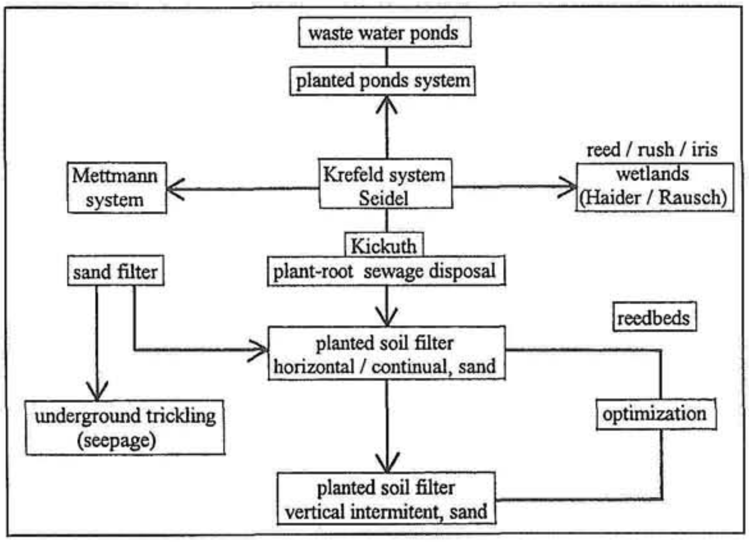


Fig. 13: Development of nature-based sewage purification processes
Bahlo, Wach-94, 80

in the sewage are beneficial to *agriculture*, as is the irrigation effect of spreading waste water on the fields.

More recent systems of land treatment are *planted soil* or *sand filterbeds and constructed wetlands*. The development of this process began over thirty years ago. Käthe Seidel in West Germany did the pioneering work in this area: she was the first to use gravel beds with plants growing in them to purify waste water where the effluent flowed through a wetland system horizontally. Subsequent attempts used cohesive soil beds [Kickuth]. *Vertically-fed soil* or *sand filters* have been in use for about five years where intensive systems with particularly low space requirements are called for (cf. pp. 75-76). All these modern systems involve sealing off the ground below (see Figure 13).

Nature-based processes are a blatant contrast to centralised high-tech plants. They are organic processes which generally function *without intensive care or monitoring and which require very little energy*. Mostly, they achieve the desired end not by using complex ensembles of energy-intensive technical facilities but primarily by using existing resources in a way appropriate to their location. Thus, pumps may well be used to operate nature-based processes, but the actual purification generally requires no other energy than that it generates itself. In the ideal case, these systems are relatively easy to integrate into their surroundings, produce plant resources and are an integral part of the overall cycle of materials. When all costs involved are compared, nature-based processes stand out as having lower construction and operation costs and consuming less energy. Decentralised strategies have the advantages of providing:

- better purification performance
- more economical operation
- greater operational safety and easier organisation, and
- simpler interlinking with other aspects (e.g. increasing agricultural productivity, keeping water clean, saving energy).

Nature-based systems differ from technological systems in their low energy and technology requirements, but also in their greater area or space requirements. The latter is generally 10 to 100 times greater than the space required by technological facilities. Nature-based processes are almost always more area-intensive.

	Pond Treatment			Soil Treatment			
area	waste water ponds	land treatment	plant-soil sewage disposal	sand filter bed	constructed wetlands	underground trickling	washing out
area per inhabitant m²	10-20	10	2-10	6	10-50	12-30	350
hydraulic burden (mm/d)	10	15	15-75	25	5	10	2
flows through	horizontally		horiz./vertic.	vertically	vertically	vertically	vertically
preliminary purification	sedimentary basin	sedimentary pit	sedimentary pit	composting pit	sedimentary basin	composting pit	sedimentary basin
sealing	yes	yes	yes	yes	no	no	no
depth (m)	1,2	1,0	0,7-1,0	0,6	0,6	0,6	?
drainage	no	no	yes	yes	yes	no	no
other use	bio. pond	reed bank	reed bank	meadow	meadow	meadow	arable land

Fig. 14: Space requirements for nature-based waste water treatment processes
Bahlo, Wach-94, 80

Having said that, it is important to bear in mind that, naturally, the landscape and aesthetic value of 2500m^2 of reeds in a wetland waste water treatment plant has to be evaluated differently than the landscape use of only 250m^2 of municipal sewage treatment facilities with its unattractive technical structures (see Figure 14).

All nature-based waste water treatment processes have one thing in common, namely that their key component for treating waste water is not the marshland plants, but rather the composition of the soil bed or filter substrate and the way the system operates. However, the reeds take on important supporting functions which are crucial for the purification system. They:

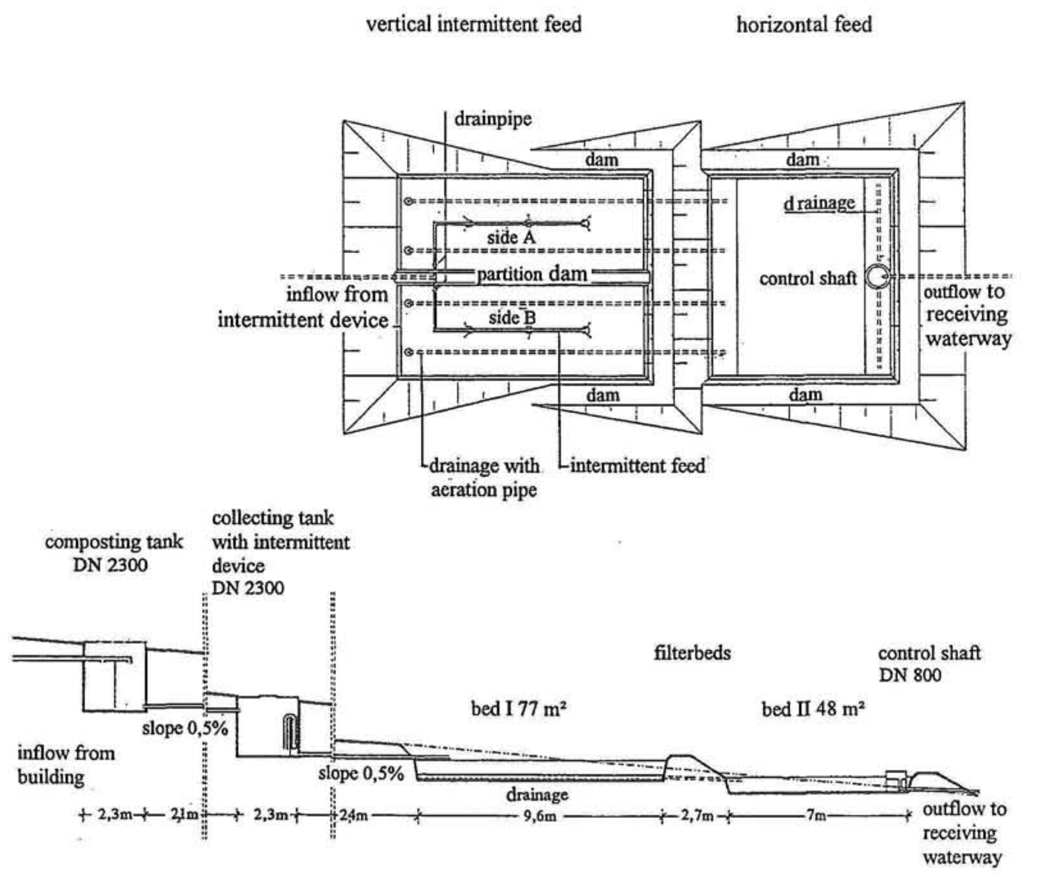
- increase the permeability of the soil by creating secondary pores;
- prevent the compaction of the substrate through their root and stem growth;
- increase purification performance by creating micro-habitats for bacteria through the growth of rhizomes and roots;
- channel oxygen from the air into the soil through their air-absorbing tissue.

In addition to everything else, wetland marshes create a natural habitat for birds, small mammals and insects, thus enlivening and enriching gardens and landscapes.

The decisive criteria for choosing the solution best suited to each location are:

- space requirements per occupant
- biodegradation performance in view of the substances contained in the sewage
- initial and maintenance costs.

Planning the most appropriate system for the site in question and the decision about whether to opt for a constructed fresh water ecosystem or a land treatment process, a horizontal or vertical flow, an underground or above-ground influent, require



The installation has following components:

- composting tank - 300 l per occupant
- mechanical intermittent outflow device
- vertical filterbed to break down organic pollutants, for nitrification (oxidisation of ammonia) and to bind phosphates
- horizontal filterbed for denitrication (removal of nitrogen)

Fig. 15: Plan and cross-section of an Oecotec system for treating sewage containing faeces

Source: Ökotec, 1996

comprehensive knowledge and expertise.

Treating sewage containing faeces

As a general rule, the nature-based treatment of sewage containing faeces requires considerably more space (some 5-7 m^2/occupant) than the treatment of grey water on its own (which requires only 1-2 m^2/ occupant). One of the many systems developed in recent decades for treating sewage which contains faeces is the Oecotec System (see Figure 15).

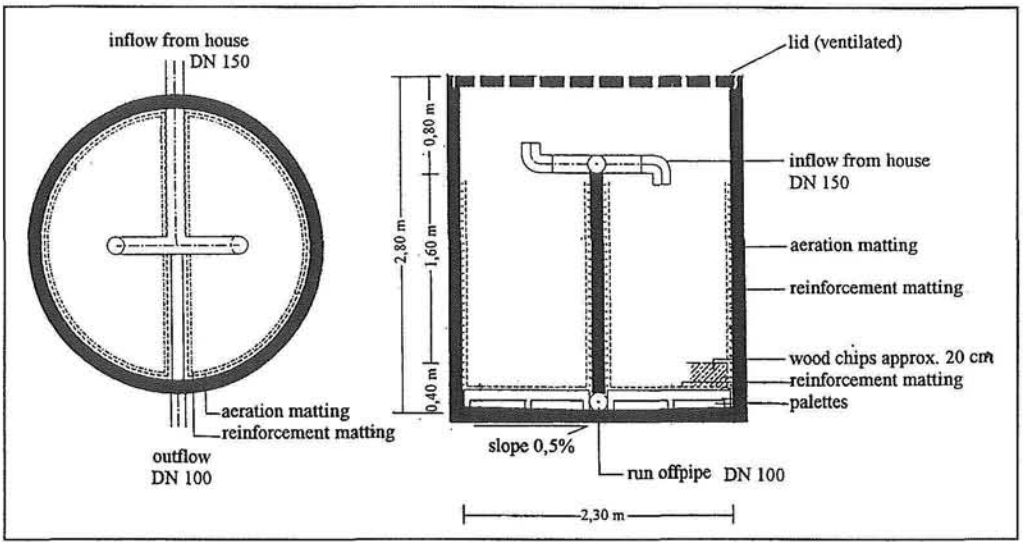


Fig. 16: Composting tank Source: Ökotec, 1996

It has three components:

1. *a composting tank*, where sewage solids settle
2. *a collecting tank* for sewage liquids, with a mechanical device for intermittent outflow
3. *two planted soil filterbeds*
- a vertically-intermittent filterbed and
- a horizontally-fed filterbed where final purification takes place.

From here the effluent flows through the control shaft and is diverted into a receiving water, a water polishing pond or a trickling system.

The *composting tank* is a further development of the traditional three-chamber septic tank, but differs from it in that the composting tank facilitates an aerobic composting process (i.e. one that functions on the basis of aeration), which turns the sewage into soil. This does away with the need to periodically remove the sludge as one does with a three-chamber septic tank [at a current cost of DM 10 to 20 (£4 - £8) per m³ in Germany].

Each one of the two, three or four chambers of the composting tank is filled up with sewage before the next one starts to fill. Every month or two, one adds two or three handfuls of straw or wood chips (carbon, in other words) to ensure the right carbon / nitrogen ratio required for the earth afterwards. After roughly two years, the herewith composted soil is removed and the chamber can be filled with sewage again (see Figures 16 + 17).

The soil filterbed is fed by either a mechanical device for intermittent outflow device or a pump. The top layer of the *soil filterbed* is sand. It is not necessary to spread a layer of gravel on top because the waste water fed into the filter is odourless. The water quantity is calculated so that feed time does not exceed fifteen minutes.

To calculate the size of an Oekotec system, the following values for the design of a plant serving 60 - 100 occupants (according to the German

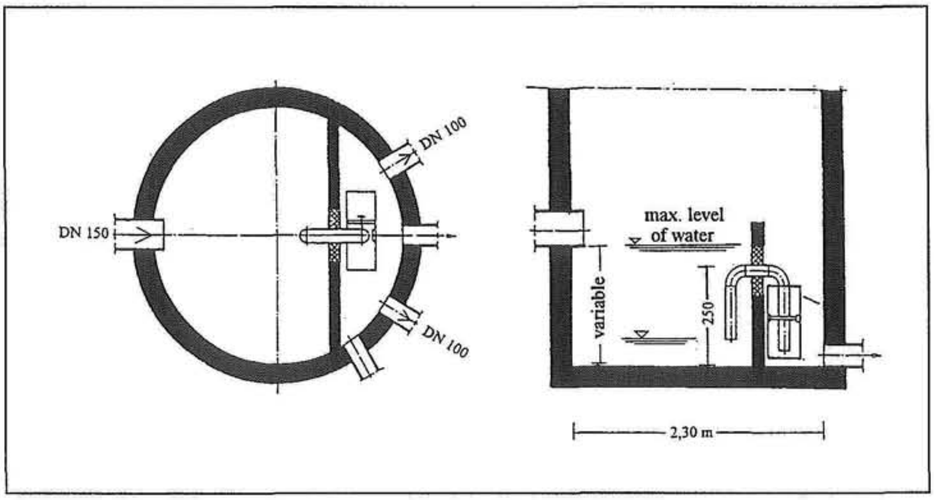
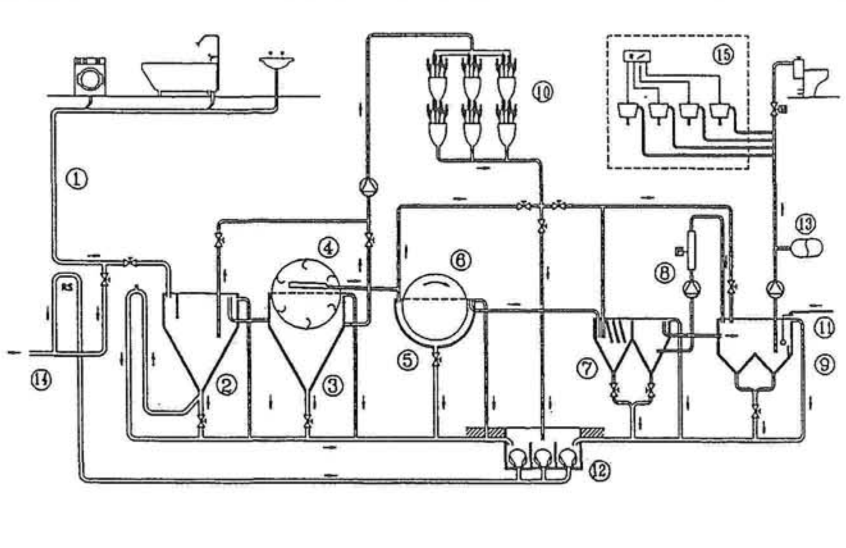


Fig. 17: Collecting tank, with mechanical device for intermittent out-flow
Source: Ökotec, 1996



1. greywater in-flow
2. settlement tank
3. collecting tank
4. paddle-wheel (trickling filter)
5. immersion cylinder tank
6. immersion cylinder
7. secondary purification tank
8. ultra-violet sterilization
9. tank for non-drinkable-water
10. vertical wetland
11. input of emergency drinking-water
12. pumps of spill-over collection
13. compressor
14. sewer for dirty water
15. simulated network of flush-toilet tanks

Fig. 18: Organic grey water purification flow diagram
Source: Thomas/Zeisel-91,9

Association of Waste water Technologies - ATV) are:

Composting tank	300 l/person
Collecting tank	150 l/person
Planted filterbeds	5 m²/occupant
Vertical filter	3 m²/occupant
Horizontal filter	2 m²/occupant

These values need to be checked again on the basis of the actual amount of waste water produced in each individual case, as they can vary greatly between urban and rural areas, for instance, but also within cities. Where water meters, low-flow taps and shower heads, and low-flush toilets are installed, normal drinking-water consumption is reduced by 30-40% and with it, waste water accumulation. Where such water-saving devices are in operation, a plant designed according to these ATV values would be grossly oversized.

In 1995, a plant of this kind designed for 300 occupants and a waste water accumulation of 40 cubic metres/year cost DM 905,000 (£362,000) in its initial investment, had running costs of DM 18,440 (£7,360) per year and cubic metre costs of DM 4.60 (< £2). In comparison with the average price of waste water treatment in East Germany where almost all the 40-50 year old installations have had to be renewed or replaced, these costs are much lower.

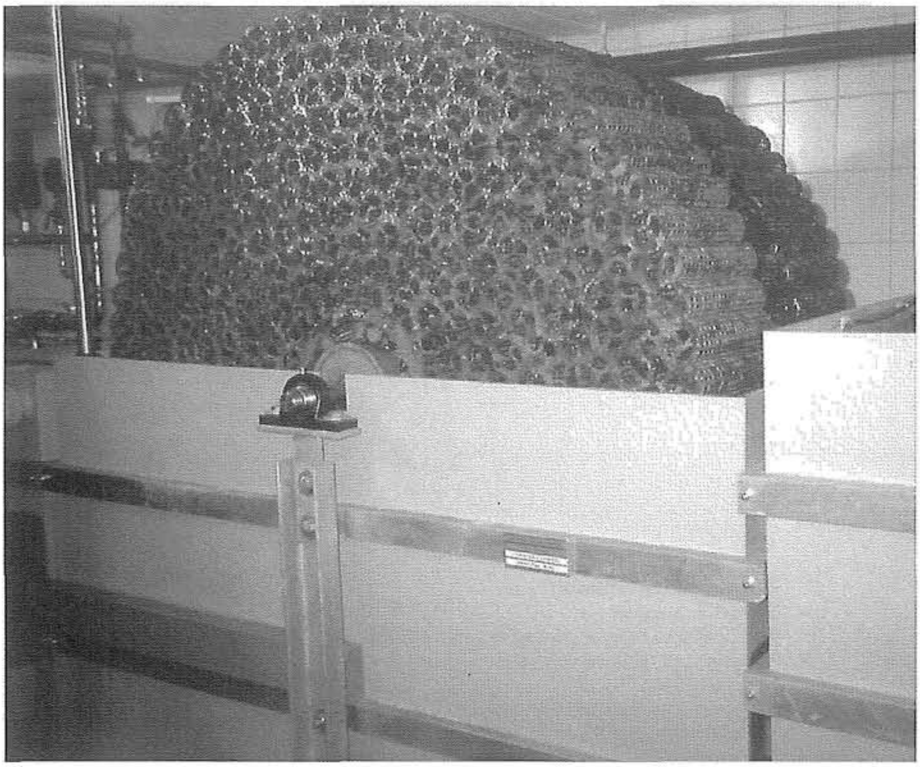
Immersion trickling filters for grey water purification

Where there is insufficient space for soil filterbeds, like in high-density inner city districts, an *organic grey water purification installation can be combined with an immersion trickling filter and a vertical wetland.* First this combination was used in Berlin-Kreuzberg, (see Figure 18) where the installation was developed and tested as part of an urban ecology model project, [Thomas, Zeisel-91]. A similar installation has been in operation in Hanover's Hägewiesen experimental project since April 1994 (see Figure 18 + Illustration 3), [Deutsche BauBeCon-95].

The *grey water* [1] from the bathtubs, showers, wash-stands and washing machines of 55-60 people from four four-storey blocks of flats is led off into a basement, where it is collected centrally in a *sedimentation basin* [2]. The mechanical pre-purification stage is aided by a *second storage tank* [3] which takes the pressure off the system during peak loads.

A *paddle wheel* [4] continuously feeds the sedimented grey water out of this basin into an *immersion trickling filter* [5/6] where it is purified organically. The immersion trickling filter is made of polyethylene filter pipes with large surface areas. These are soldered to a cylinder 0.80 m in length and 1.10 m in diameter, creating a total surface area of approx. 110 m² for the bacteria to grow on. The immersion trickling filter turns at about 0.5 revolutions per minute, with 60% of the filter immersed in the basin.

After this, effluent saturated with organic matter that has washed off the filter flows from the immersion trickling filter into a two-chamber *secondary purification tank* [7], where final



Ill. 3: Organic greywater purification - immersion trickling filter - in the experimental project Hägewiesen, Hanover Photo: D. Haas

This grey water plant in Berlin started operation in September 1989 and has since been analysed under various operational conditions. The non-drinkable water supply started up in the summer of 1991 with a grey water influent from some 55-60 people producing some 70 litres per person per day.

Research findings to date in Berlin and Hanover indicate that the purified grey water is no longer putrefactive, and is suitable for use as non-drinkable water. Despite the low revolving speed of the immersion trickling cylinders, air contact time alone provides the organic matter with a sufficient supply of oxygen. The installation achieves very good purification results in terms of reducing the amount of organic matter in the grey water.

The findings of accompanying research on water hygiene indicate that the water reclaimed by this installation complies with the hygiene standards stipulated in the EU directives on water suitable for bathing, that the persistence of potential pathogenic bacteria in grey water is low and that no regermination of relevant pathogenic bacteria is detectable [Berlin Senate Department of Building and Construction-94, 43]. These findings allowed the designers to install a lower capacity ultraviolet steriliser than the one originally planned.

After a five-year operational period, *experience* has shown that the energy requirements for operation, organic purification, disinfection, pumps and light amount to approx. 2.2 kWh per m^3 of non-drinkable water. Lay people can carry out maintenance in one or two hours a week after being shown what to do. The installation has not experienced any major problems.

Grey water recycling should be part of a comprehensive water-saving strategy. In combination with other measures, such as installing water-saving fixtures and low-flush toilets, the current drinking water consumption rate of 145 litre per person per day can be cut to

ling takes place in a simple sedimentation process.

Apart from in spells of extreme frost, the plant in Manteuffelstrasse is augmented by a *vertical wetland* [10] consisting of numerous cascades pouring out of containers which are mounted on a windowless wall of the building. Wetland plants grow in these containers which are filled with clay balls and sand. The grey water is pumped up to the cascades and trickles down through the containers. Apart from purifying the grey water, the vertical wetland also has a positive impact on the micro-climate through the transpiration of the plants. Vertical wetlands can be employed as the main purification stage or the final phase. (In Hanover, this section of the installation has not been built as it is not necessary for the system to function.)

To disinfect the organically purified grey water, a small pump lifts the water from the final settling phase through an *ultraviolet ray steriliser* and gains added oxygen in this process[8] before it is stored in a tank[9] where a compressor puts pressure into the non-drinkable water in order for it to be used again, this time for flushing toilets in three buildings. A *drinking water emergency supply line* [11] is connected to the tank with a ball-cock and an open drain to make sure the supply of flushing water is always sufficient.

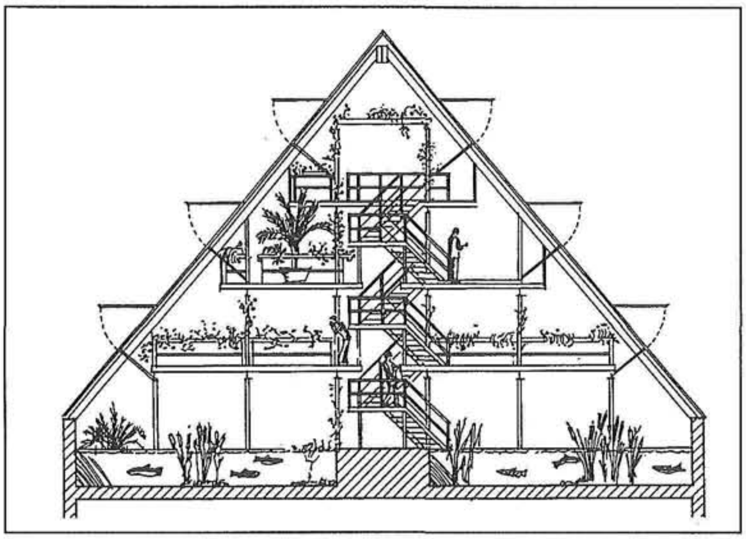


Fig. 19: Cross-section of "Bio-works"
Source: Gruppen for by-og Landskabsplamlaeging aps

about 70 litres (Berlin Senate Department of Building and Construction-95].

The installation is economically feasible when savings on drinking water and waste water costs cover annual capital and running costs. According to a model calculation [Thomas, Zeisel-91, 17], the immersion trickling filter process can be operated economically supplying some 130-145 people with non-drinkable water. A medium-sized ecological settlement or hotel already fulfils these conditions.

Both options - a soil filterbed and an immersion trickling filter process - can be combined with compost toilets. This dispenses with the recycling aspect as water is not required for flushing toilets, so the purified grey water can be used in garden irrigation, or can seep - or be channelled - into a stream, river or lake.

Integrated and autonomous water and waste water strategies

Naturally, the above options for drinking water efficiency and substitution, the storage, use, seepage and retention of rain water, the separation and composting of faeces, and grey water purification do not exclude one another, but rather are well suited to integration into a comprehensive water supply and disposal strategy. So far, the world has only a few such examples to offer, but this makes the few projects that *have* succeeded in closing the water cycle, either partially or completely, all the more interesting. Two very different examples in Kolding and Bielefeld can serve to demonstrate what such solutions can look like.

Rain water and waste water treatment and use

To the south of the town centre of *Kolding*, a town of 50,000 inhabitants in southern Jutland, Denmark, is an urban block that is part of a long-term restoration project for the entire district. The block comprises 40 three-storey buildings containing a total of 129 residential units and six commercial spaces. Part of the project involves *linking an integrated waste water concept with the production of plants and fish* (cf. pp. 32-33).

In the block, waste water is primarily treated in an algae pond system developed by the Stensund Folkhöjskola in Sweden. In this project, all grey water and waste water passes through mechanical purification in a three-chamber septic tank before

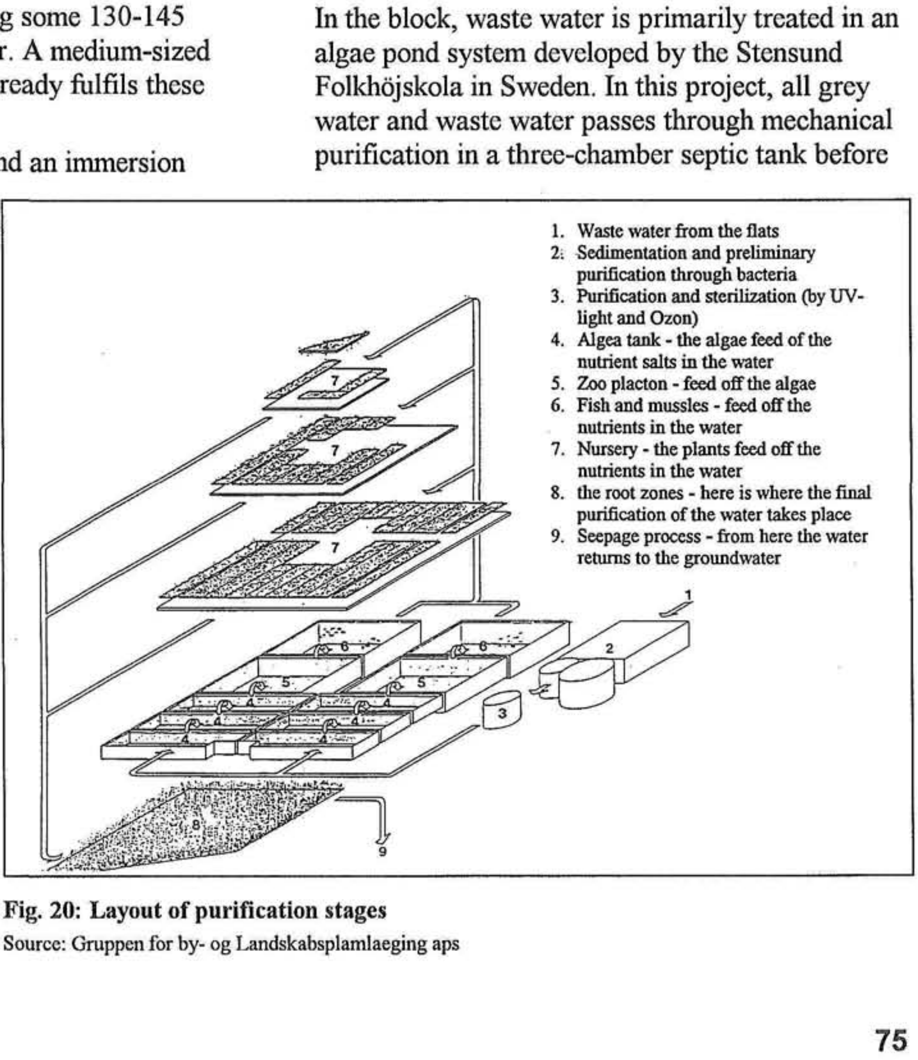
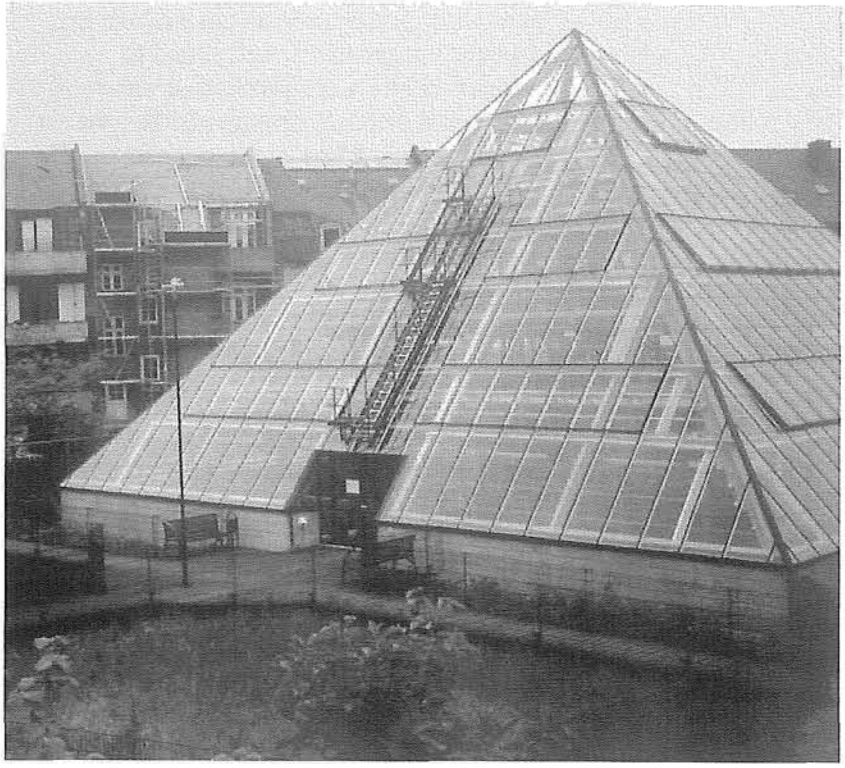


Fig. 20: Layout of purification stages
Source: Gruppen for by- og Landskabsplamlaeging aps



Ill. 4: "Bioworks" with final filterbed and water polishing pond
Source: D. Kennedy

flowing through an ozone generator and ultraviolet radiation and four purification basins, which work on a mechanical basis as well as using algae and zoo plankton, and into a carp pond. Now enriched with fish excrement, the effluent is pumped up to the highest level where it trickles through flower beds set out on various lower levels in the "Bio-works", a greenhouse pyramid in the middle of the block (see Illustration 4). The purified water finally flows into a reed bed outside the greenhouse pyramid and seeps into the ground water. The remainder flows into a polishing pond (see Figures 19 + 20).

The water and open space concept of the urban renewal project made it necessary to clear old auxiliary buildings from the inner courtyards. However, each building retained either all or some of its previous share of garden. The remaining area was designed as a community space enriched with flow forms that aerate the water and a shallow stream with play areas for the children (cf. pp. 39-52). The stream feeds into a pond behind the reed bed where the seepage system begins. The many different levels of the inner courtyard facilitate a differentiated design incorporating barbecues and seating areas. Besides its function as a wetland waste water treatment system, the "Bio-works" acts as a productive greenhouse, in which a resident gardener grows ornamental plants.

Using rain water saves even more drinking water. Run-off from roof surfaces is collected in a pond and a cistern and pumped up into the buildings for toilet-flushing. About half of the buildings are on the rain water system; all in all, this saves about a third of the amount of drinking water consumed by normal households in Denmark.

By integrating various ecological strategies, like using photovoltaics to supply the "Bio-works" with power, making the inner courtyard a limited traffic zone and using glass structures attached to the south-facing façades of the residential blocks for passive solar gain, the block acquired a new attractiveness. With the "Bio-works" as an eye-catching example and symbol of environmentally responsible architecture this block can now be listed as one of the few ecological urban renewal projects in Europe.

Closing the Water Cycle[17]

The new residential area of Bielefeld called Waldquelle, home to some 400 people, was built largely independently of any public water supply and waste water disposal system (see Figure 21). This ecological settlement has a closed water cycle: a self-contained, decentralised system. *Drinking water* is pumped up from the ground water on-site, where it is treated and used, and *precipitation water* seeps directly back into the ground water. *Waste water* is treated on-site until it is in a condition to be allowed to enter the ground water, or an open body of water, without risk of pollution. This keeps damage to the natural water system as low as possible [Klatt, Bahlo, Ebeling-93].

The city of Bielefeld gets most of its water from the Senne forest area, with knock-on effects like karstification. For this reason, the water authorities approved the proposal that Waldquelle

[17] Bültmann Architect's Office, in Bielefeld, and the AWA office of R. Klatt, certified engineer, in Georgsmarienhütte, provided the information for this example.

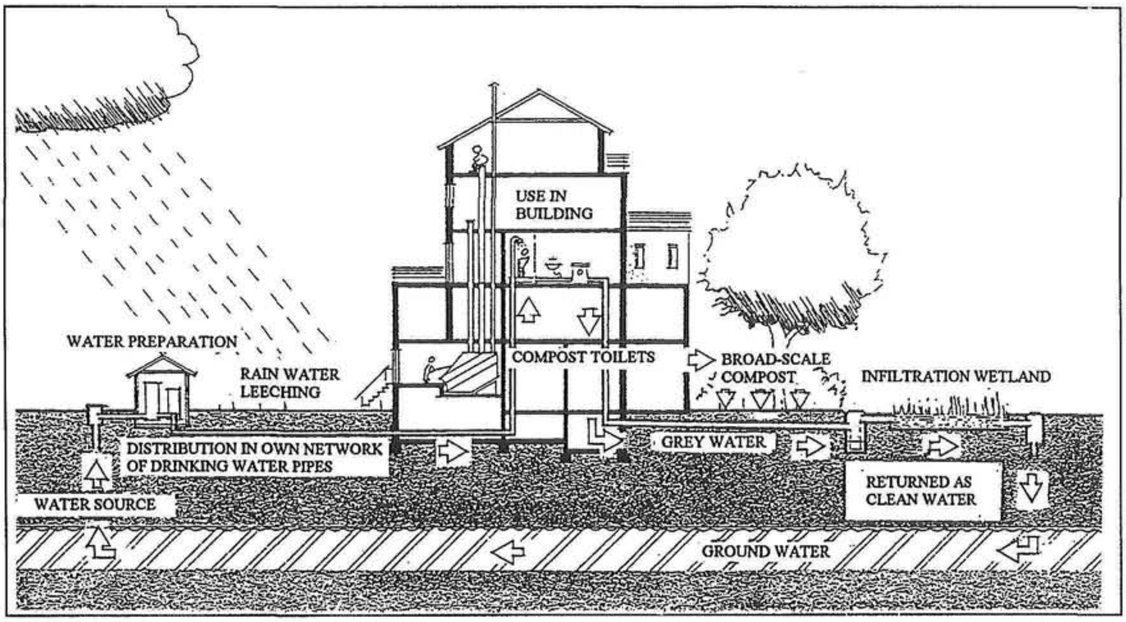


Fig. 21: Sketch of the self-contained water concept of the Waldquelle ecological settlement

Source: Büro Bültmann, Achim Jung

have its own drinking water supply. After one dry bore (at a cost of DM 20,000 or £8,000) and two further, successful bores (at a cost of DM 60,000 or £24,000), the settlement now has two wells of good quality water with enough to supply a nearby older housing estate as well. From the wells, the water goes through a small water purification plant and comes out as drinking water. This is used exclusively for human and animal consumption, personal hygiene and clothes washing. By installing water-saving fixtures and appliances, and consistently using compost toilets in all the buildings, drinking water requirements were cut down from the usual 145 litres per person per day to about 75 litres. Users currently pay DM 0.30 (£ 0.12) per m^3 for their drinking water, with annual maintenance costs at roughly DM 200 (£80) per person. Taken together, that amounts to approximately half of the average costs in that area of Germany.

Precipitation water as a natural element is incorporated in open space design by implementing the following measures:

- keeping sealed surfaces to a minimum by reducing access areas to approx. 50% (of conventional developments);
- paving access roads and paths with permeable coverings made of recycled material;
- directly channelling run-off from traffic areas and buildings into the ground water via seepage troughs;
- capturing rain water in rain barrels for garden irrigation;

In the *waste water purification system*, the nutrient cycle is separated from the water cycle, i.e. organic waste and faeces are composted in all buildings in compost toilets (cf. pp. 57-59). These dispense with the need for water for toilet-flushing. The compost produced is spread on areas cultivated with perennial crops.

A *planted soil filterbed* purifies the remaining *grey water* from washbasins, bathtubs and showers, before it is returned into an open body of water. (The original plan was to allow the purified grey water to seep into the ground, but the authorities would not permit this. However, the project still sees this as a feasible and appropriate idea.)

The advantages of the system are:

1) It cuts down drinking-water consumption to an average of 70 litres per person per day.
2) The nutrients and organic substances in human excrement do not enter the water cycle, and can be used as compost for perennial cultures.
3) 30% of domestic refuse is compostable organic substances. Here it is composted with the excrement, thus taking the burden off the "waste cycle".
4) Separating faeces *reduces the level of pollutants* in waste water by between 20 and 90% of that contained in conventional domestic waste water (depending on the parameters). In particular, it cuts down the nitrogen (90%) and phosphorus (80%) content of the sewage considerably [Bahlo, Wach-94].

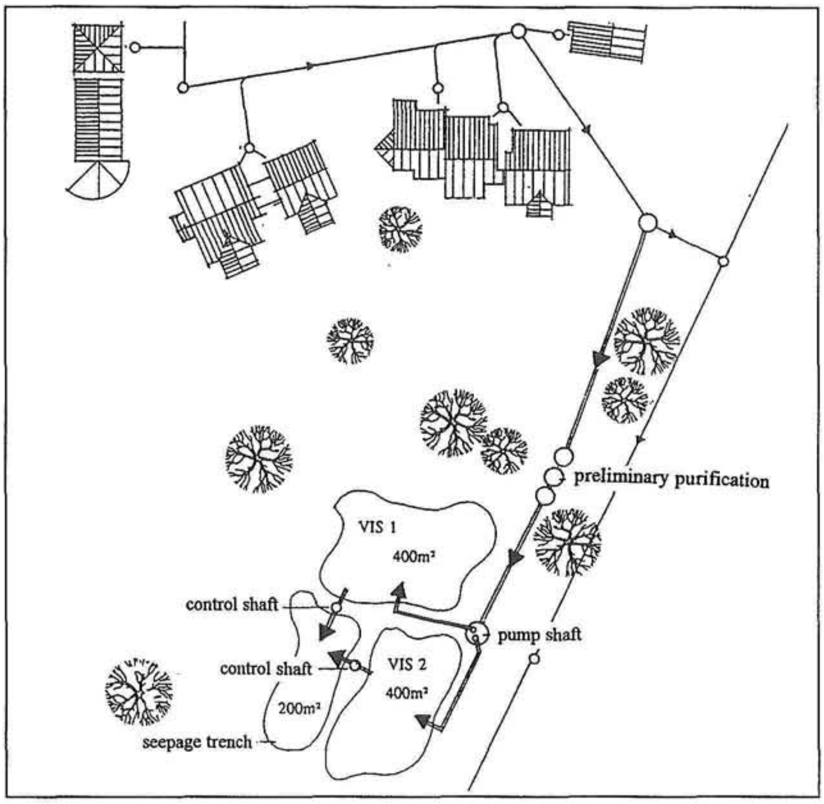


Fig. 22: Site plan of a VIS[18] reed waste water treatment installation
Source: Büro Bültmann

5) Composting faeces *avoids the problem of disposing of waste water treatment sludge*, as none is formed.

Planted soil filterbeds with vertical flow and sandy substrate (vertical filters) are used to *purify the grey water*. The space requirement for this system is 2 m²/ person, this meant its integration into the open space concept of the settlement grounds was possible. A *fresh water ecosystem* enriches the landscape, providing a home for countless species of insects and birds. In summer, the high level of evaporation from planted soil filterbeds improves the local micro-climate (see Figure 22).

The grey water is mechanically pre-purified before a pressure pipe system spreads it evenly on the filterbeds at specific time intervals. Micro-organisms purify the effluent as it trickles through the sand, and finally flows into a moving body of water. (The purified waste water can be monitored through a shaft in the outlet pipe.) A sewage system for disposing of grey water can be constructed and operated at a fraction of the price without sacrificing disposal safety, as it has narrower pipe diameters, shallower depths, fewer man-holes and optimum pipe routes. It operates with very low maintenance because of its simple and nature-based structure. These *savings* yield a sewage price far below that of a municipal plant, and with better purification results. Also, the municipality bears none of the costs of constructing the plants and the sewage system.

The installation of compost toilets and on-site waste water treatment sensitises occupants to the issue of using water efficiently and awarely. One outcome is that they consciously choose detergents and cleaning agents that reduce the level of pollution in waste water.

Prejudices in Germany still abound that ecological strategies are too expensive and not feasible and thus only pose an option for a few "well-off idealists". But experience gained in the Waldquelle project shows that where a decentralised approach is *consistently implemented*, these measures are both feasible and cheaper than centralised systems (a more detailed analysis can be found on pp. 211-221). This is likely to be of particular interest for European countries where some settlement areas are still not converted to centralised water supply and waste water disposal systems.

Restoring the water and nutrient cycle

Contemporary drinking water supply and waste water disposal systems are designed and organised on a linear basis. In many cities, both tasks are dealt with by separate administrative units, both working towards the optimum fulfilment of their goals. Supply systems are ruled by the idea of protecting drinking water and making the required quantities of it accessible. Disposal systems are dominated by the idea of getting rid of waste water, as fast and efficiently as possible.

These concepts are irreconcilable with the model of "sustainable development" first called for by representatives of the international community at the Rio Earth Summit. If the goals set out at this conference are to be achieved, both of these tasks, which have hitherto been dealt with separately, must be combined, and strategies of cycles must be found that go beyond the artificial boundaries drawn across the issue of "water".

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18 V = vertical, I = intermittent feeding, S = sand filterbed

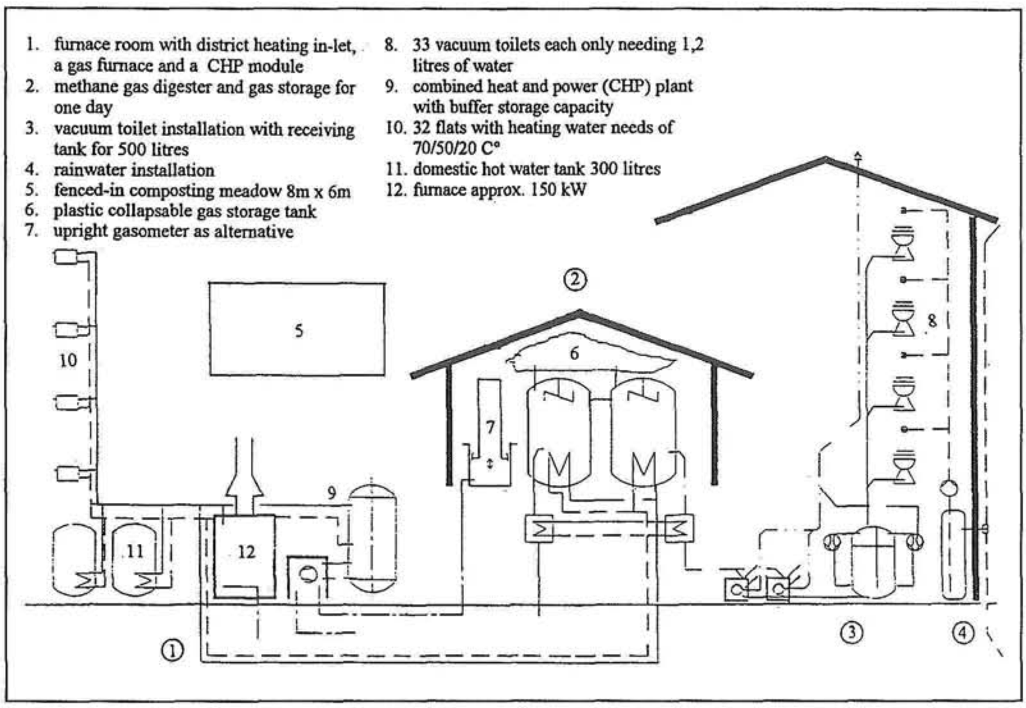

Fig. 23: Sketch design for the cycle, sewage and waste management in the experimental project Hägewiesen, Hanover

Source: Universität Hannover, Institut f. Wasserwirtschaft; Deutsche BauBeCon AG, Stadtwerke Hannover

One project, still in the planning phase in 1996, aims at sounding out approaches to a "strategy of cycles". Installation is planned for Autumn 1996 in Hanover's Hägewiesen experimental project. This system attempts to demonstrate a feasible way of *recycling organic household waste as completely as possible* in an existing city district.[19] Here the waste includes both *faeces* and organic *kitchen refuse* as well as plant waste from the garden. The project shows in an exemplary manner how the nutrient cycle can be closed - from soil to farming, food, the consumer, faeces and organic refuse, and its transformation into fertiliser and return to the soil - and how heating energy can be won on top. The extent to which this system can sustainably reduce the pollution of lakes and rivers - and the level of waste water treatment sludge and artificial fertiliser consumption - will not only be calculated but empirically verified.

Within the framework of a building restoration project already in planning, involving the renewal of the plumbing system and service installations, a *vacuum toilet system* will be installed in all dwellings in an existing block of flats. Built in 1962 as part of a council housing project, the building contains 32 flats and houses 100 occupants. The vacuum toilets' low-flushing requirements of around 1.5 litres per flush mean the faeces are collected in a concentrated form, separate from the grey water. The faeces concentrate is pumped from the collecting tank in the basement to a methane gas digester beside the building.

The concentrated collection of the faeces allows for direct *fermentation* under anaerobic conditions in two stages. Solid organic waste enters a fermentation plant through a slit. One advantage of this is that *methane gas* gained in the fermentation process can be mixed with natural gas and used to generate power and heat in small co-generation facilities in the building's basement. (Waste heat produced by the co-generation facilities is used for space and water heating as well as for heating the fermentation plant.) The other advantage is that the fermentation process separates nitrogen and phosphorus so that various concentrated fractions emerge as final products. These can be used for *providing different types of fertiliser* which specifically targets the different phases of plant growth (see Figure 23).

Permanent heat treatment ensures the *sterilisation* of the organic matter. The remaining solid matter is separated after fermentation, pumped on to a planted mulch bed and composted on site. The humus produced can also be used for horticultural purposes without the problem of nitrogen or phosphate seeping into the ground water.

[19] This description is based on the unpublished planning documents of Thilo Herrmann, Institute of Water Management, Hanover University.

Rain water that runs off roof surfaces is captured and used for flushing vacuum toilets. The water requirements for flushing these toilets are low enough to be almost completely met by the available rain water, despite the fact that the proportion of roof surface per occupant is relatively low in four-storey housing blocks.

What is new about the approach this project takes is, firstly, its relatively *space-efficient combination* of various technologies, which makes them feasible for use in comprehensive renewal programmes in existing city areas. Secondly, it gains and reuses both *fertiliser* and *energy* in the process. And thirdly, the different final products resulting from the fermentation process make it possible to produce fertiliser that it tailored to *agricultural needs*.

Obviously, projects of this kind cannot be economical "yet". But can we really call the existing system economical, when e.g. the commercial value to Norwegian agriculture of what is presently being flushed through centralised sewage systems into the rivers, lakes and sea, or alternately turned into waste water treatment sludge, has been put at 30 million dollars [Jenssen, Etnier-96]. Surely this suggests that it is worthwhile working out ways of closing the nutrient cycle.

Recommendations

Architects should utilise all options for *saving drinking water* in new settlement development and in comprehensive renewal projects of existing residential areas by installing water-saving fixtures and toilets, and individual water meters, in every dwelling. This can be done at no additional cost, or at a minimal extra cost with a pay-back period of no more than a few months.

The concept of decentralised *rain water management* assumes that run-off amounts are kept at the same level as prior to development or that these values are re-established This makes it necessary to collect rain water and, where possible, make intermediate use of it, allow it to seep into the ground, or retain it: in other words, to slow down its entry into the main drainage channel. This presents a challenge to construction engineers, urban planners, architects, open space designers and artists. They need to cooperate with one another in order to give rain water a new value, by creating new ways of using and experiencing it. Investment costs are not necessarily, but can be, higher than conventional discharging of rain water to the sewers. Running costs, including maintenance and tending of the installations, are almost certainly lower.

The run-off from sealed surfaces into the conventional sewage system should be avoided. This municipal waste water by-laws should take into account and financially reward. Preserving and exposing old drains and small streams - quite apart from their cultural and aesthetic value - also helps retain rain water, and should therefore also be considered and rewarded.

While conventional methods of waste water purification aim at keeping water clean, they do not attempt to filter out the resources it contains, such as nitrogen and phosphorus, for reuse. Where the resulting treatment sludge has to actually be incinerated, it creates a further source of air pollution, on top of that which was caused by constructing and operating the sewage treatment plant in the first place. This is part of why it is such a good idea to separate and process these resources on site where they occur using appropriate decentralised technologies. It also saves precious drinking water and reduces energy consumption, which in turn contributes considerably to protecting open bodies of water and the climate.

Where users are willing, strategies for *using rain water and grey water* (for washing machines, toilet-flushing, garden irrigation) should be incorporated into integrated water concepts, in combination with a *decentralised water purification system* involving planted filterbeds, purification ponds and streams. Depending on their complexity, these can make for low to considerable extra costs. However, if we take into account how resources are squandered in contemporary sewage treatment systems, even the most comprehensive experiments in future-oriented cyclical solutions can be justified.

Above and beyond the solutions depicted above, there is a real need for action on "concepts of bio-regional water development". This would allow us to deal with issues of water in both a spatial and qualitative dimension as a coherent complex. Here again we would need interdisciplinary teams of experts to design alternatives to planned investment into new sewers, larger sewage treatment plants, worn-out sewage systems, or building new storm water retention basins. They could also assist in developing a combination of measures appropriate to the region and the individual location.

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Trends for future development

From an ecological experiment to a standard for (re)designing

Declan Kennedy & Margrit Kennedy

The *initial approach* and objective of our study was to unearth practical experiences gained both in the planning phases and in the architectural implementation of medium and larger scale ecological settlements and urban renewal projects and to ascertain whether general recommendations could be derived from these experiences for the future implementation of such projects. In the preceding chapters we presented the findings of our study, focusing on several important issues. In this last chapter, however, we would like to look again at ecological settlement (re)design, this time in a holistic context, and to trace development curves which have defined ecological architecture since its emergence in the early seventies.

Optimisation of the whole

In practice, the concept of the "ecological settlement" is a multi-facetted one, encompassing the qualitative improvement of open spaces, traffic limitation, new social relationships and forms of organisation, strategies of energy and water efficiency, building biology criteria, the recyclability of building materials, aesthetic qualities and new cost/benefit analyses. What unites all these aspects, however, is that they strive for, and to varying degrees attain, *an optimisation of the whole*, rather than a maximisation of individual parts, and thus a new quality of housing and indeed of life itself.

The projects examined here differ considerably in their objectives, approaches and the individual circumstances in which they came about. But together they show:

the most cost-efficient solutions, both financially and in terms of the wider economy,

- nonetheless, planning processes from start to finish still require considerably more time and energy and this is generally not appropriately remunerated,
- the support - both moral, financial (within normal restrictions) and practical (in changing guidelines and procedures) - of administrative decision makers plays a crucial role where large-scale projects are concerned;
- holistic approaches are generally more successful than projects focusing on a one-sided optimisation of individual ecological aims;
- good results can be achieved with moderate application of new technologies and with new techniques, if the planning process is appropriately designed;
- the commitment, courage and persistence of everyone involved are just as necessary as a carefully worked-out, clear strategy;
- successful implementation is a social skill,
- many basic principles of traditional architecture and urban design, such as regional architecture, are ecologically beneficial and easily incorporated into planning;
- user participation and co-design is desirable within a clearly defined framework, especially in ecological urban renewal projects;
- an international exchange of experience can be a big help in successfully overcoming difficulties in the implementation phase.

These practical experiences, in combination with other models which have been built, allow us to come with specific recommendations for priority areas in the design and implementation of future ecological settlement projects. It is quite clear that, while almost no other field of architecture is changing as quickly as 'ecological' architecture - nearly every day, new technologies and ways of saving energy, water or materials are being developed - certain trends for future development do emerge from the brief history of 'conscious' ecological architecture, which roughly spans the past twenty years.

The rise in efficiency and sufficiency

Our forefathers constructed ecologically mainly because they had no other choice. Their buildings reflect the building materials available to them from the nearby area, which could be integrated back into nature without difficulty after use.

Supply and disposal structures were on a human scale and organised in a way that individuals could comprehend. These are two reasons why traditions of regional architecture can hold some important lessons for contemporary ecological designs.

With the rise of industrialisation, it became possible to create chemical and synthetic building materials and construction methods which, while they had clear advantages from the standpoint of durability and cost efficiency, were generally not so easily integrated back into nature.

Hand in hand with urban expansion and the growth of the transport system came the development of large-scale linear and centralised supply and disposal systems which created a widening gap between producer and consumer, between cause and effect. The expansion of the drinking water system, for instance, and above all the sewage system, brought with it not only a decrease in the danger of epidemics and the elimination of a source of highly offensive olfactory pollution, but also a diminished awareness of water as a life element and of the impact of the individual's way of dealing with it. The same is true of energy and food supply, and of refuse and waste water disposal.

Over a relatively short period of a few decades in the nineteenth century, the vital processes of life in the city became completely invisible and were removed from the control and day-to-day responsibility of the individual. Public authorities and supply companies determine, procure and control who gets how much at what price. Sociologist Detlev Ipsen concludes that release from the responsibility for the day-to-day supply and disposal, and 'liberation' from perceptions of the vital processes of life, which are by no means always perceived as pleasant, have had enormous consequences for the way urban problems are seen. 'Spontaneous' knowledge of natural and technical necessities for urban life are lost, and new ones have had no chance to form. The responsibility for, and with it the relationship to, basic support elements have become increasingly dispersed into specialised fields [Ipsen-95]. Even experts have a hard time keeping abreast with the latest developments. Consequently, this has lead to a narrowing of viewpoints and a loss of understanding of how things should fit together for lay people.

This loss of an understanding of the interconnectedness of basic support systems results in growing quantities of refuse and waste water, rocketing disposal costs, as figure 1 illustrates, and, not least, makes it increasingly difficult to find suitable locations to build disposal and waste industry plants. These are just some of the symptoms of an underlying crisis of material cycles at the core of industrialised society, which we seem prepared to accept, almost as a matter of course, as the 'downside' of our prosperity.

One of the things industrial progress initially had to offer was a breathtaking rise in the standard of comfort. Thus, for instance, the average citizen of the world's highly industrialised countries now enjoys a greater level of comfort than a king or emperor did just a few centuries ago, based on a comparison of the technical furnishings in their dwellings, or the range of food available to them, or their mobility and choice to travel wherever they want on this planet - and no end to this development is in sight. The key question, though, is whether we can maintain this standard of living while solving the problems it presently causes, like resource consumption and the destruction of nature, or whether we have to accept that these problems can only be solved at the price of a significant drop in our high standard of living.

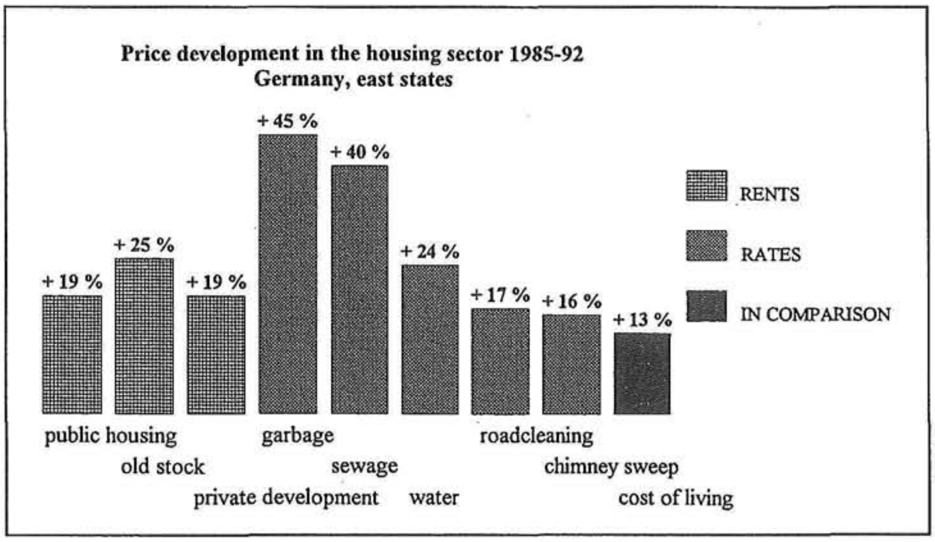


Fig. 1: Price development in the housing sector

Source: Großmann 1996, Globus-92

Scientists of various disciplines have recently been trying to find an answer to these uncomfortable questions. According to Ernst-Ulrich von Weizäcker's calculation, we could reduce our current rate of consumption to one quarter of its present level (Weizäcker-93), if we were to use the resources at our disposal more economically and efficiently, and were prepared to change our production processes and consumer habits.

Friedrich Schmidt-Bleek (also from the Wuppertal Institute for Climate, Environment and Energy in Germany) is of the opinion that the flow of materials in the rich countries could be cut back far more, to one-tenth of its present level. He proposes that this be done, not 'only' by producing goods more efficiently, but above all by *defining the services* that they are intended to provide and then comparing the various options, including all of the material flows they involve, as well as their "environmental rucksacks" [Schmidt-Bleek-94]. This requires a new way of thinking. Schmidt-Bleek indicates how resource efficiency can be increased to seven times its present level using the example of a refrigerator which, once it has been installed in a kitchen, lasts for one hundred years, instead of needing to be replaced every ten.

Thinking in terms of services - rather than buildings - can help to "de-materialise" even more. Maybe we can even do without building. If, for example, we were to establish outpatient care services, instead of building new and even larger hospitals, resource efficiency could be increased to a hundred or a thousand times its current level. At the same time, we would be making a number of contributions to social wellbeing; i.e. by creating new jobs, keeping patients in their home environment, reducing traffic, and cutting costs to patients.

Aase Eriksen, a Danish architect, found out (by simply working with the doctors and nurses in a children's hospital in Copenhagen) that the children were out of bed most of the time, causing great problems for the personnel as there was almost nothing for them to do. Talking to the children and parents, she found out that often both parents worked and could not look after the child at home, so that many children took up costly hospital space, because they were lacking an active grand-mother, aunt or older cousin. By finding out how long it took to determine whether or not a child needed hospital treatment (usually no more than 10 hours) and by organising a home care service for sick children, she was able to set up a model, saving the municipality and the health insurance funds literally millions of Danish crowns. This model helped the children and the parents who were able to look after their other children more easily, too.

Schmidt-Bleek's concept envisages (as a matter of course) that technically feasible resource productivity would have to be supplemented by "an increasingly unquestioning frugality in people's way of dealing with material things" [Schmidt-Bleek-94, p. 171]. The building sector, which currently consumes material at a rate of 20 tons per person per year in Germany alone[1], would naturally be a prime candidate for the new processes, technologies and altered consumption behaviour of the kind described above.

Overcoming the gap between nature and technology

In the wake of the Club of Rome publication on "The Limits of Growth" in 1972, and the first oil crisis in 1973, many highly-industrialised countries began *rethinking* their building priorities. It would be fair to describe the decade from 1975 to 1985 as the 'pioneering phase' of ecological architecture, and the decade from 1985 to 1995 as the 'testing phase'. Since 1995, Europe has been in the early stages of the 'application phase'. All three phases have existed parallel to one another, to varying degrees, and embody problems and opportunities of their own.

The pioneering phase *contrasted drastically* to the approach that characterised the era of industrial expansion following on the heels of the second World War, epitomised in the concrete jungles of the 60s, 70s and 80s with their remoteness from nature and their wasteful consumption of resources. The pioneering phase was hostile to technology in many ways.

The motto of the ecological architecture of the time was 'back to nature', to small-scale, interlinked, self-sufficient and decentralised systems. Bengt Warne built his celebrated "Nature House" near Stockholm, an inspiration for all who came to admire it, from Armory and Hunter Lovins to Martin Küenzeln and the Oekotop Group, the avant-garde of American and German thinkers in this field. Rudolf Doernach advocated '*bio*versity' to replace the '*uni*versity'. In Austria, Bernd Loetsch and Konrad Lorenz published a manifesto on "recreating semi-wild conditions",

[1] This includes "environmental rucksacks", in this case materials necessary for the production of steel, glass, concrete, etc.

which were intended to replace sterile children's playgrounds, and in fact did so in many places, as the Puchenau case study in the introduction shows (cf. pp. 24-25).

David Holmgren and Bill Mollison published their book "Permaculture One" in Australia, which became a bestseller overnight. Based on an understanding of the Aboriginal sustainable way of life that has lasted for millennia, it enriched the 'green' movement in North and South America, Africa and Asia and Europe, particularly in the former Eastern-Block countries (after the political and economic changes), inspiring a host of permaculture projects, from Hobart in Tasmania to Crystal Waters in Queensland, and our own project in Steyerberg in the Federal State of Lower Saxony (Kennedy-82,-88).

In North America, the Farallones Institute, the Rocky Mountain Institute and the New Alchemists worked on models for a less destructive way of life and of work, as did the Centre for Alternative Technology in Wales and the Langenbruck Eco-Centre in Switzerland.

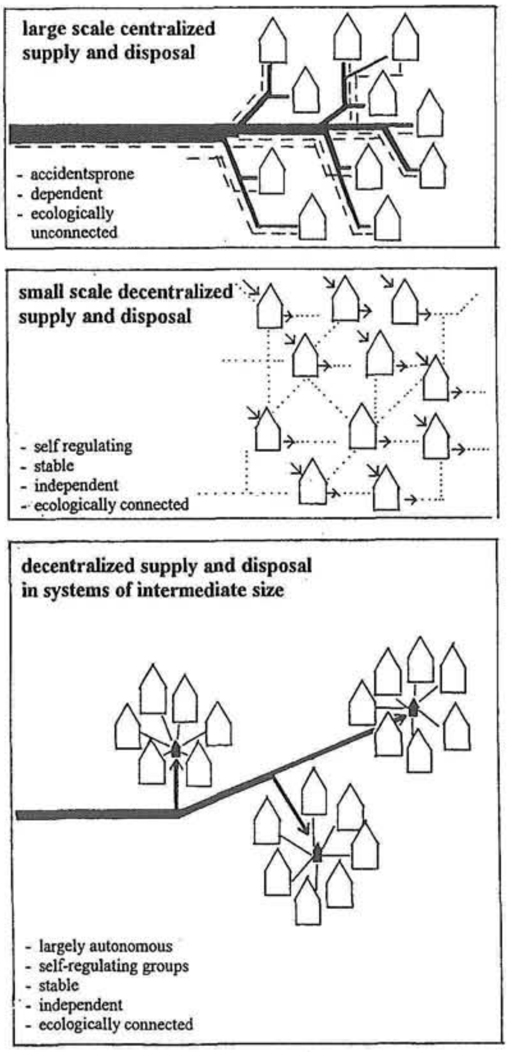


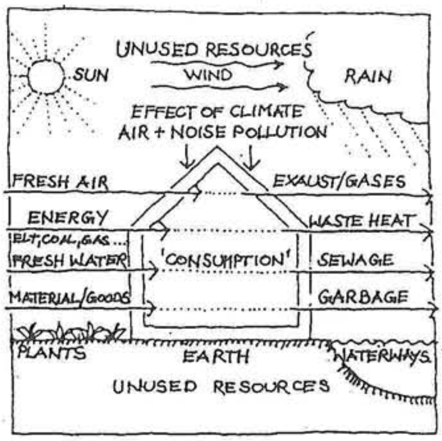
Fig. 2: Supply and disposal systems
Sources: (1-2) Krusche-82,23; (3) Kennedy, 1996

This initial phase was characterised on the one hand by endlessly difficult planning, permission and building processes, and on the other, by an irrepressible enthusiasm and a sense of breaking new ground shared by advocates of alternative lifestyles. It was also defined by a deeply-rooted distrust of the political and economic establishment and the established sciences.

The first international symposium on urban ecology in Europe took place as part of West Berlin's International Building Trade Fair in 1980 (Kennedy-84). This symposium was a gathering of everyone who had accumulated experience and provided impulses in this field, including Julia Bargholz, Friedensreich Hundertwasser, Per Krusche, Marete Mattern, Frei Otto and Frederic Vester. The German Construction Industry Association honoured it with a single column of print and the headline: "Back to the Stone Age". But by 1995, just fifteen years later, the German Concrete Industry Association had put together a travelling exhibition on "Constructing ecologically", showing many of the same or similar examples.

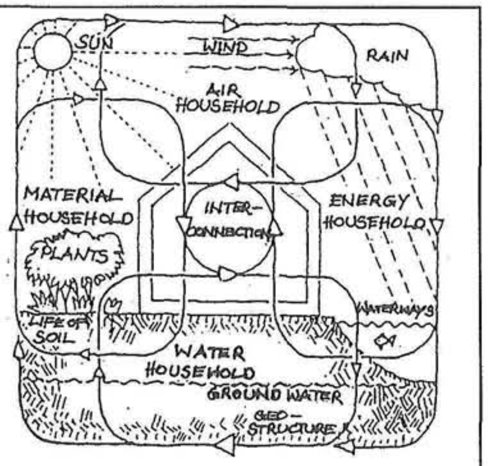
The pioneers who built the first ecological buildings and small settlements had to weigh up every aspect from the standpoint of whether conventional supply and disposal system solutions were optimal in terms of resource consumption, and had to prove time and time again that there were less wasteful alternatives. But they were also faced with the challenge of fulfilling increasing demands on the planning process and of developing new technologies. As was to be expected, they only succeeded in negotiating these difficulties in some cases, and produced a number of plans which failed, providing the opponents of change with abundant ammunition for criticism and condemnation.

If in the pioneering phase people still thought in terms of irreconcilable opposites - the conventional large-scale centralised supply and disposal systems on one hand, and the ecological small-scale decentralised supply and disposal systems on the other - it became clear during the *testing phase of ecological architecture* (which occurred roughly between 1985 and 1995) that considerably more differentiated planning approaches were involved (see Figure 2).



Normal houses do not rely on natural resources - but use up energy and materials and create lots of waste. This is a reflection of our consumption economy. Through the present systems of supply and disposal, such houses cause high costs and environmental problems.

Fig. 5: Linear systems - Material flows today
Source: Krusche-82,20



An ecological house is fully connected to the natural systems and households without causing damage. One can simply see the classic four elements of Earth, Water, Fire and Air as the main cyclical systems of nature as well as the house or settlement.

Fig. 6: Self-contained systems - Material cycles of the future
Source: Krusche-82,20

As it is still impossible to replace existing large-scale centralised systems with decentralised systems in the time available to us, the aim was co-existence or supplementing functions, as well as combining options and composite systems. Thus, in contrast to the pioneering phase, the testing phase from 1985-1995 was characterised by a step-by-step convergence of centralised and decentralised systems, and the integration of low-tech and high-tech, of nature and technology.

By now it had also come to light that decentralised systems designed for *single-family dwellings* alone were expensive and difficult to implement. Instead of proposing small-scale decentralised systems as the alternative to large-scale centralised systems, designers increasingly opted for solutions somewhere in between, that serviced an entire settlement. In other words, the phrase was increasingly 'medium-sized' supply and disposal systems for between one hundred and five hundred or more dwelling units, or rather the term 'decentralised' expanded to a new scale. These medium-sized systems include the various nature-based waste water treatment systems which collect waste water from an ecological settlement, extract the resources it contains and purify the water before returning it to the natural water cycle, as well as cogeneration facilities or large-scale solar hot water storage tanks which supply an entire residential area with heat.

Self-contained cycles (see Figure 6), which in the 80s could still be contrasted relatively straightforwardly to *linear systems* (see Figure 5), had now become considerably more complex, and used technical symbols with the same matter-of-factness as they accepted an optimal *combination of outside and self-generated services*.

Since the mid-1990s, one can safely speak of the 'application' phase of ecological architecture. Many fundamental problems have been solved technically or organisationally, others by new legal regulations, and still others can now be implemented without incurring too high extra costs. They include improved building insulation, rain water seepage, low-flush toilets and water-saving fixtures, planting fruit-bearing trees and local species, limited traffic zones, waste separation and prevention and the use of pollutant-free building materials.[2] Nowadays, very little can be marketed without the prefix 'eco-', 'bio-' or 'organic', and it is increasingly difficult to make the right choice, be it of washing powder, cars or buildings. As always, when a movement gains in size, it loses its contours. Different experts within the same discipline are likely to have very different definitions of what 'designing

2 Constructing low-energy buildings with conventional building materials - where building envelopes with a high degree of airtightness are used - can only increase ventilation requirements to the extent that energy savings are eaten up by reduced transmission heat loss.

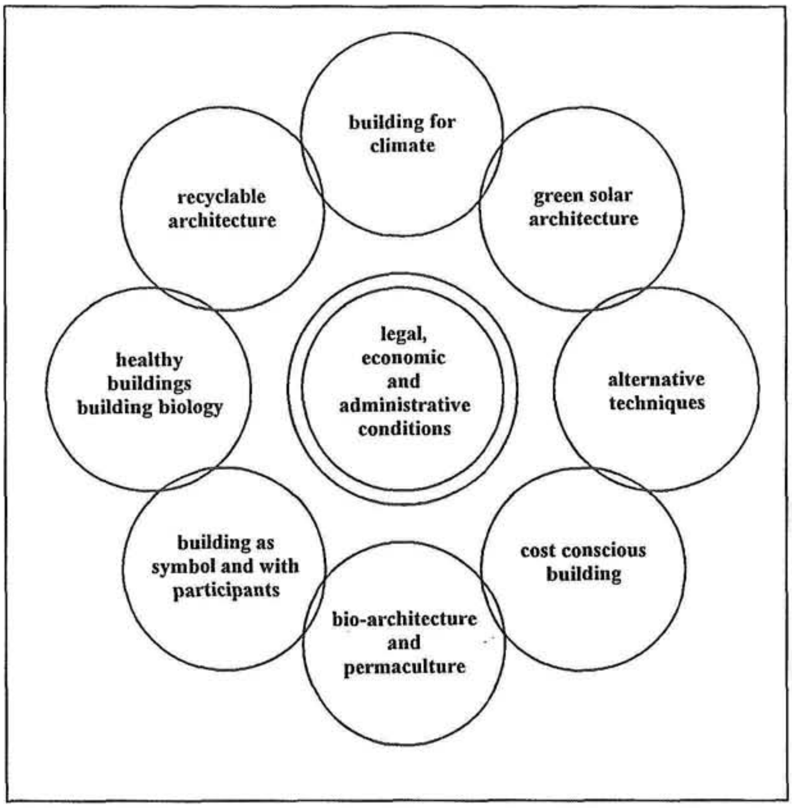


Fig. 7: Major trends in ecological architecture
Source: Kennedy, 1996

ecologically' currently entails (see Figure 7). This is reflected in the fact that strict demarcation lines are often drawn between aspects focused on by different architects within the field of ecological design. Advocates of 'cost and space efficient' building can be the most vocal critics of 'green solar architecture', and experts in 'recycling-conscious building' do not necessarily go along with the 'building biology' approach.

Green solar architecture has long since established itself in the area of administrative buildings, particularly bank buildings, of superior quality, extolling the integration of nature and technology (Foster's Commerzbank building in Frankfurt is temporarily the latest epitome of this trend), while 'cost- and space-efficient building' will have to keep producing increasingly economical solutions in the public housing sector for a long time to come. As always, architecture is a perfect reflection of the money and power relations of its era (Kennedy-91).

There is a good reason why this book examines, for example, the building materials and construction systems characteristic of three different trends:

- reducing resource consumption (see pp. 121-132),
- recycling-consciousness (see pp. 133-151),
- and healthy buildings (see pp. 152-167),

without being able to compare these three with one another. The reason is that the integration of these three areas is a new field for pioneers. There is still a great deal of research and testing to be done here, also in connection with the issues of energy-efficiency and ventilation, among other things.

Thus, the pioneering and testing phases continue parallel to the application phase.

If, until the mid-90s, planners were satisfied with achieving an optimal combination of outside and self-generated supply and disposal of water, energy and the necessary materials, current innovation aims higher still: zero-energy buildings are well on the way to becoming 'mega-out'. What we are aiming at now are buildings that produce more energy than they consume. Water-saving technologies should make way for self-contained water cycles, or failing that, waste water-free buildings which produce compost and 'service water', and green spaces that produce fresh food without requiring much input - thus becoming 'edible parks'. Figure 8 illustrates that the emphasis is not so much on self-sufficiency as on sustainable systems, aligning

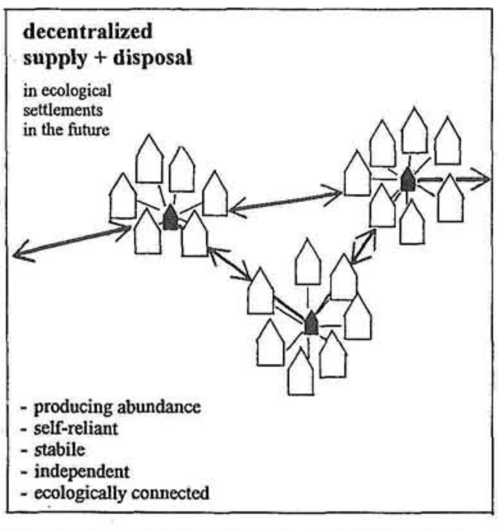


Fig. 8: Decentralised supply and disposal in ecological settlements of the future.
Source: Kennedy, 1996

production and consumption with the carrying capacity of the land.

Higher quality at a lower cost

The most advanced projects that we came upon have already attained the goal of keeping outside services to an absolute minimum to the extent that cycles are self-contained, just as Per Krusche's original vision foresaw (see Figure 6). If this goal also leads to a reduction in investment and running costs, as for instance in the Bielefeld-Waldquelle project (cf. see pp. 211-221), these settlements can be seen as new milestones in the ecological pioneering and testing phases.

It has also become clear that the real issue is not just new technological solutions, but rather a holistic approach which reinstates the responsibility of the individual and recreates the visibility of the individual elements on which our very survival depends. In this vein, drinking water is extracted on site, and rain water and grey water are allowed to run off into open bodies of water, or swales, or are purified in planted soil filterbeds and water polishing ponds. Waste, or at least its organic components, are composted together with faeces. Witnessing stinking rubbish turn into aromatic humus is a very special experience (cf. pp. 68-75).

Thus, design for ecological settlement manages to combine *apparent contradictions*: centralised/decentralised, hi-tech/low-tech, very high quality/very low costs.

The examples studied demonstrate that all the issues and aspects of constructing ecologically, when they are implemented on a larger scale, lead to cheaper solutions for the individual and the municipality. Our findings suggest that the real obstacles are generally experts with little experience in ecology, politicians lacking courage, and administrative regulations that are too narrowly defined - not the commonly-cited occupants and costs.

As we saw in *costs-benefit analyses* (cf. pp. 202-221) the older the building, the cheaper the ecological settlement becomes over time. This is also true for ecological urban renewal projects, as the Wilhelmina, Fredensgade and Aarepark projects demonstrate (cf. pp. 26-35).

If energy, water, waste water and refuse disposal rates continue to climb as they have over the past few years (see Fig. 1), every project which manages to lower running costs will become economically more attractive in the future, while 'non-ecological' living will become more expensive, be it food, cars or buildings.

The full potential of the motto 'using together instead of consuming individually' has only been touched upon by the projects examined here. A real opportunity for the way ahead lies in the plummeting costs of information technology and in direct links between groups with similar goals through global communication networks, e.g. the Internet. These options will allow us not only to exchange information more cheaply and quickly, but also help us locate the right car, bicycle or building at the right time, in the right place and at the right price.

Renewal instead of new construction

The biggest challenge for everyone involved in building in Europe is the ecological renewal of existing buildings.

Renewing ecologically means converting and renovating buildings with a view to a sustainable use of resources. This involves, for instance, saving non-renewable materials such as copper, aluminium or iron from dismantling operations in cities and reusing them efficiently, rather than mining them from the earth. It also means allowing waste water to flow back into the ground water, or into rivers and lakes, in a state that is just as clean, or cleaner, than it was when we extracted it as drinking-water; keeping the air clean, so that we can once again smell the scent of plants; planning quietness and reducing noise; and providing a diversity of uses in a small area, so that living, working and leisure can be combined to reduce transport distances and improve the quality of life. In almost all our cities we are still very far away from this vision. However, the examples studied here indicate that there are ways and means of *getting closer* to these goals. What we need now are examples of ways of *attaining* these goals. And these we were unable to find.

Naturally, renewing older urban areas ecologically requires greater sensitivity, patience and openness to teamwork than developing new ecological settlements. One of the differences compared with new building projects, which caused us a great deal of trouble in the case studies on ecological urban renewal, was that it was considerably more difficult to find ground-breaking models and documentation of such projects, probably because ecological urban renewal projects are less spectacular. At first glance, they generally appear to differ very little from completely 'normal' projects, and, with the exception of the Danish project in Kolding with its Bio-works - a glass pyramid, in which all the waste water is purified (see pp. 75-76) -, they tend towards the conventional, and are almost a little boring from the design point of view. However, a closer look at the planning processes reveals that they are far more diverse and complicated than new development projects.

As with the new settlements, the examples of renewal projects range from socially-oriented processes with a very high degree of occupant input, as in the Swiss Aarepark residential settlement in Solothurn, to more hierarchically organised planning processes with low occupant input, as in the Fredensgade project in Kolding, Denmark (cf. pp. 32-33). The examples illustrate how the people living near a demolition project, the former Wilhelmina Hospital in Amsterdam, can work with architects to develop plans for preserving and converting a complex of this kind, and can bring about the funding and implementation of the project with the support of clients and administrative decision-makers. However, they also show the extent to which authorities can block ecological design. In Vienna, it emerged that permission to plant climbing plants in the street area had to pass through at least 14 different offices. As a result, it is less time-consuming to plant the climbers in boxes or planters attached to the building wall than to plant them in the ground.

If new settlement design can orient itself on something resembling a guiding model of an ecological settlement, this is not the case with urban renewal projects. Bearing in mind how much more important it is to use the various existing resources and potentials, both physical and social, in the urban renewal process, this is more than understandable. The paradox is that the solutions in these projects are often more diverse, imaginative and better tailored to the needs of the occupants.

With both new construction and renewal, the key to success lies in winning over the support of everyone involved to the goals of environmental quality, and making the planning and building process a joint success despite - or perhaps because of - the many participants, all of whom are pursuing different interests. The examples show that the quality of life and of housing gained through the juxtaposition of old and new, past and future, is well worth the effort in the present.

The vision

When an ecological settlement - and this concept covers both new construction and renewal projects - works well both technically and socially, it is not only the highest quality product that building and conversion can offer at the present time, but also a process of development. It is a process that changes people and their relationships to one another, as well as their relationships to buildings, open spaces and supply and disposal technology. The aim is to make a place easier to live in, easier to love, and more sustainable. Our vision of an ecological settlement, whether it is a new or an old one, a section of suburbia or the renewal of an existing area of a town or a city, looks like this:

A settlement of diversity:

where living and working are reconciled and long trips to work are unnecessary; where social and cultural activities, recreation and further training, community and individuality can exist side by side.

A settlement on a human scale:

with neighbourhoods to which residents can develop a direct relationship or a personal bond, but which have their own character as well. A settlement of nature corridors, with woods, orchards, streams or wetland marches separating the individual areas and linking them to the surrounding landscape; a place where plants and animals have scope to thrive, something that has become all too rare in our civilisation; a settlement which fits, in terms of its own bio-region, its landscape, its climate, its flora and fauna and the local culture; where open spaces and bodies of water typical of the area provide biological enrichment and orientation.

A settlement of short distances:

the density described above leaves our ecological settlement not much larger than 1.5 - 2 km in diameter, meaning that everyone can walk from one end to the other in half an hour, or cycle or drive their solar mobiles across in five minutes; car and minibus sharing is available to the community for all medium distances; public means of transport - buses and trains - are faster and cheaper alternatives for longer journeys; efficient infrastructure planning is facilitated by service centres specialising in different aspects and located at public transport pick-up points.

A settlement which uses as little space as possible:

the size and density of the settlement depends on the degree to which the area it requires for its material supply and disposal are really available, without being a burden on the region and the prevalent cultural norms; expansion beyond this size leads to the founding of a new settlement; as Figure 9 depicts, this creates a network, instead of the cancer-like urban sprawl typical of our times.

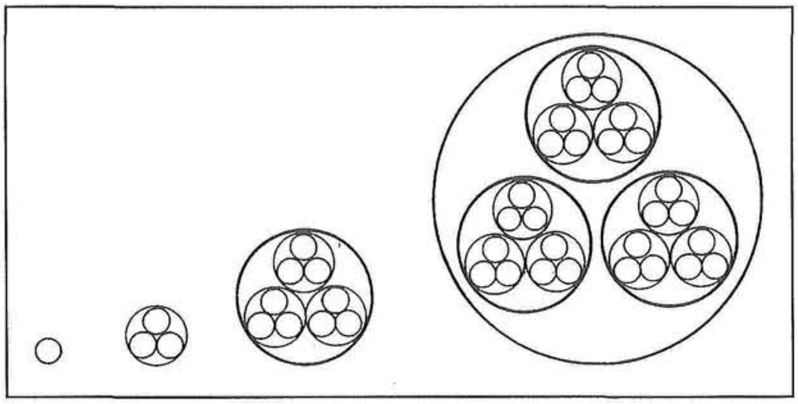


Fig. 9: Hierarchy of a network of settlements
Source: Kostler-92

A settlement based on occupant responsibility:

all occupants are involved, to the extent they can and wish to be, in local, community self-administration, and in formulating and implementing the ecological settlement design; all decisions are made on the lowest level possible, based on the principle of subsidiarity; as far as possible, everyone uses the local range of services, production and trade, education and leisure, and supports links and communication with regional, national and international groups and networks.

An energy-efficient settlement:

energy saving options and the rational use of energy for heating purposes and of electricity and transport cut energy consumption to less than 10 % of its current level; energy is primarily generated on a renewable basis through sun, wind, tides, geo-thermal energy and organic mass; buildings are designed for optimum passive solar use, both cooling and heating; intelligent designs achieve a maximum annual consumption rate of 20 kWh per square metre of living space, which is amply covered by regenerative energies.

An emission-free settlement:

reducing energy consumption, treating waste water in nature-based systems, limiting traffic and tree-lining streets, all lower CO_2, SO_2, NO_x and other toxic gas emissions, as well as reducing dust particles; sod roofs and façades covered in climbers, as well as natural corridors between individual neighbourhoods, improve the air and temper climate extremes.

A quiet and beautiful settlement:

by limiting traffic and noise pollution from production processes, the settlement is a place of calm and quiet; the architectural expression and urban design follows criteria of beauty, elegance and simplicity, fitting into the existing landscape and cultural heritage of the region.

A settlement which values water:

on-site rain water seepage and the blanket ban on toxic substances entering the ground water allow the settlement to have its own drinking-water supply; water-saving fixtures and the separation of faeces and all other organic waste for composting and fermentation cut drinking-water consumption to less than 60 litres per person per day; grey water from washbasins and baths, showers, washing machines and dishwashers is purified in nature-based treatment processes, and then seeps back into the ground water; the settlement preserves natural drainage conditions - this means that wherever possible, storage rooms at ground level replace basements; vertical and horizontal filters become just as much an integral component of open spaces, in the form of constructed wetland marches, as rain water, which is creatively allowed to come to the fore in flow forms, open gutters, streams and ponds.

A predominantly waste-free settlement:

governed by the principle that "every item of waste is a resource in the wrong place", the settlement belongs to a regional, national and international network specially devoted to this aspect of sustainable husbandry, which helps to prevent over 90 % of the current volume of waste, be it domestic waste, excavation soil, building materials or waste from commercial or industrial production, the little waste still produced here is sorted on-site, before entering the respective recycling, down-cycling or re-use process.

A settlement of healthy buildings:

building materials and construction systems used in all buildings that are converted or constructed are healthy, save primary energy and go easy on resources in their production, use and dismantling (from cradle to cradle); they are (re)planned for multi-purpose use, easy conversion and expansion or reduction in size; electrical cables and appliances are installed and connected in accordance with the latest findings to generate as little electric smog as possible; before design commences, zones of geo-pathological interference are detected, and thus locating bedrooms and living spaces on top of them can be avoided.

A settlement of native species and productive plants:

special care is taken with selecting plant types, sizes and growth times; thus, the settlement contains fruit-bearing bushes and trees, gardens, lean-to greenhouses, façade espaliers and herbaceous soil coverings that meet a good proportion of the settlement's needs for fresh fruit, vegetables and salad all year round, without much extra effort; the natural corridors, streams, ponds and wetland marshes also produce edible and medicinal plants for human and animal consumption - these products are fresher and cost less in terms of embodied energy, waste and money than imports which have travelled great distances, although these will be used to ensure added variety at the table; sale of commercial products and exchange of 'surplus' production creates permanent jobs and provides high quality products at reasonable costs for everyone.

A settlement of creative conflict solving:

conflicts are seen and dealt with as creative learning processes; "using together instead of consuming individually" - sharing jobs, cars, fruit-trees, playgrounds, buildings and open spaces for play, sport, leisure and communication also means going through learning processes together, leading a richer, but also more difficult, life as well.

A settlement of human values:

settlements and cities can be seen as collective artworks; the individual and collective efforts of many generations lend them a special, unmistakable character; nowadays it is possible to simulate this historical development and make various alternatives (building anew or renewing existing quarters) understandable to all, quickly; thus the complex process of reaching a consensus between the demands and needs of the occupants, the administrative authorities, the economy and the environment can be worked out more easily, until a plan has emerged that is tailored to the combined needs of those involved; it takes time to make this shared vision a reality, but it forms the basis of the settlement's spiritual, intellectual and material expression.

In its book "The First Global Revolution", the Club of Rome made an appeal to humanity in stating: "We need a vision", because, they argue, "...global problems cannot be solved by market mechanisms alone" (Spiegel-91, 138-145). It sees the way ahead in the thousands of small, 'smart' decisions that reflect a new awareness, shared by millions of people, and which help ensure the survival of society. The strategy of ecological settlement design has the advantage not only of being feasible, but also of corresponding to the vision many people share of a world they would like to live in. Making the vision a reality only requires the will to take a calculable risk and shed old prejudices and patterns of behaviour. In view of the problems bombarding us from all sides, this can only be seen as a hopeful perspective.

Faced with current controversy, both in housing construction as well as the use of precious natural resources, there is an increasing search for ecological and environmentally sensitive new housing developments and urban renewal projects. In recent years a number of steps aiming to reduce pressure on the environment have emerged in the fields of ecological planning, construction, renovation and living.

The book reviews practical experience and results in using materials which are economical in terms of energy consumption and use of resources, as well as construction techniques for new building and urban redevelopment, bearing in mind that to date relatively few medium and large-scale projects in new sustainable settlements or in environmentally sensitive urban renewal have actually been implemented in Europe. This guide will thus support and further inspire the process.

It is primarily intended for local government personnel, commissioners of projects, town planners and architects wishing to practise these tenets, but will also appeal to committed residents and tenants.

Angesichts der heutigen Probleme im Wohnungsbau wie auch im Umgang mit natürlichen Ressourcen stellt sich immer häufiger die Frage nach ökologischen und umweltverträglichen Neubauvorhaben und Stadterneuerungsprojekten. Mit dem Ziel einer minimierten Umweltbelastung sind in den letzten Jahren Projekte zum ökologischen Planen, Bauen, Sanieren und Wohnen entstanden.

Das Buch gibt einen Überblick über die praktischen Erfahrungen und Ergebnisse bei der Verwendung energie- und ressourcensparender Materialien und Bautechniken im Siedlungsbau und bei der Stadterneuerung, da bis heute nur wenige Projekte mittleren und größeren Maßstabs im ökologischen Siedlungsbau und der ökologischen Stadterneuerung in Europa realisiert wurden. Das Handbuch leistet einen Beitrag zur Unterstützung und weiteren Anregung dieser Entwicklung.

Es wendet sich an Mitarbeiter von städtischen Verwaltungen, Bauträgern, Planern und Architekten, die ökologisch bauen wollen, aber auch an interessierte Bewohnern und Nutzer.

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