ECO - HOMES GÄRTNERHOF

Summary of Research Report F1075

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Preface

Compared to conventional detached houses the ***Eco-Homes*** community consumes up to 75 % less industrial energy, requires on average 70-80 %, in some cases 95 % less drinking water, produces up to three fourths less refuse and treats all of its own sewage, wereby the treated sewage can be utilised for watering in a very dry geographical area. The ***Eco-Homes*** project occupies two thirds less land and at the same time in many ways combines a better quality of living with a well functioning social concept.

Living in the ***Eco-Homes*** has engendered a sense of responsibility and promoted personal initiative among its residents. This style of building and living is by no means a final solution: it should prompt further quests. The ***Eco-Homes*** project is the first project of its kind to fulfil such a wide range of ecological and construction biological goals and — it has proven itself.

It is my wish that models of this kind will generate a wide-reaching exchange of ideas and, by doing so, contribute to preserving our living space, our environment.

Helmut Deubner

The *Eco-Homes* Project in Gänserndorf
Ecologically Conscious Building and Living

Introduction

" Ecological building construction" encompasses many aspects of living, working and recreation and hence plays an important role in contemporary social processes. The term " Eco-Homes Community" easily spurs fanciful visions of a tranquil world in which people at peace with themselves live in an healthy environment.

Reality, however, tells a different story. The oppressing number of complex environmental, health, energy and social problems, as brought to light, for example, by the exhibit " To Be or not to Be: The Industrial Devastation of Nature" discourages many practical attempts to demonstrate what is wrong. *Is it any wonder that one's own dwelling, one's own home as a protective zone of spiritual integrity is growing increasingly more important?* The yearning of many, especially younger families, for living quarters compatible with the environment, for quality of life in the widest sense, for a say in matters pertaining to their own immediate living space, for a closer experience with nature, to be directly accountable, are the driving forces behind " Building Ecologically" . The question is not ***if*** we can build ecologically, but rather ***how*** to create a model of architecture that addresses the needs of Man and the environment.

What are the fundamental principles of Ecological Building Construction?

Ecological Building Construction

Building biology » Building ecology	**Human ecology » Behavioural research**	**Technology » Natural Science**
Building site	Individual ecology	Medicine
Building material	Social ecology	Physics
Domestic technology	Living needs	Biology
Interior finishing	Perception of form	Energy technology
Form	Information processing	Environment
Technology		Recycling
Ecological harmony		Economics of resource exploitation

Biology and *ecology* of building construction — in essence the science of healthy living — concern themselves with the effect of man-made environments on human health and the practical application of this knowledge in building construction. Human ecology explores not only the spacing and interdependence of individuals, but also of whole societies, and in doing so supplies the scientific basis for answering fundamental questions about living needs, standards, identity, and sense of well-being.

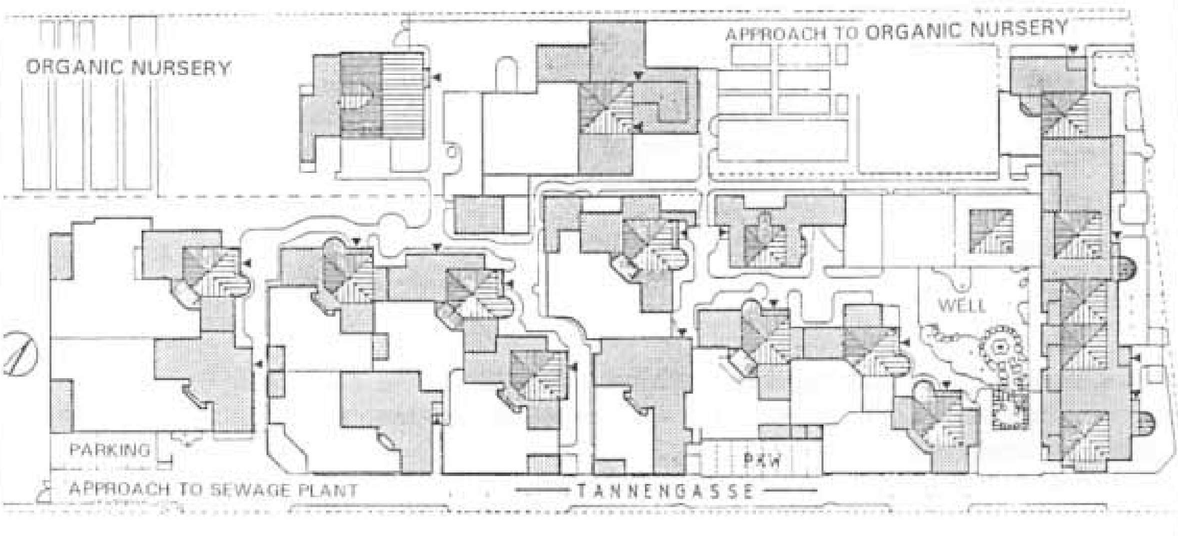
Primary Concerns

This Report on the *"Gärtnerhof Eco-Homes Community"* documents basic premises, complex interdependencies, pre-existing constraints, and insights gained from the ten-year period of designing and consequently living in the community. The object was to test an integrated ecological housing community ***concept*** centring on following guidelines:

- **Architecture**: Uniting a group of people with the aim of building an ecological housing complex accommodating 80 - 100 individuals.
- **Ecology**: Enabling partial decentralised autarchy using soft technologies independant of market trends. An attempt at partial self-sufficiency in foodstuffs and hand-crafted products.
- **People**: Creating a mentally, spiritually and physically strengthening and supporting environment in which mutual help, communication and education, shared activities, and, in particular, coexistence with children, the elderly and the infirm combine to benefit all concerned.

Architecture

In the more than 4-year planning and 2-year construction period from 1982-1988 a housing complex arose consisting of 11 courtyard houses built as condensed low rises with their own gardens, 10 apartments with terraces and roof gardens, a children's' nursery, a community room, playgrounds and landscaped tracts, a natural swimming pond, vegetable gardens and an organic sewage treatment system.



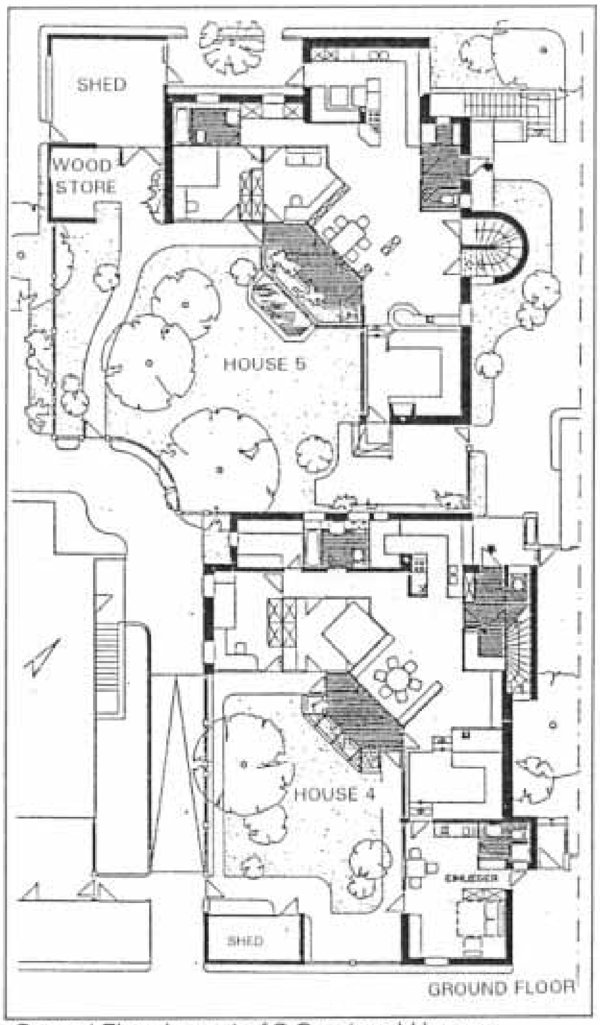
Layout of the Gärtnerhof-Settlement

Layout of the ***Gärtnerhof Eco-Homes Community***

Directly adjacent to the *Eco-homes Community* is a nursery, called the "Gärtnerhof" that has been operating bio-organically since 1978. The *Eco-Homes* are situated some 30 km north-east of Vienna, within the city limits of Gänserndorf in the "*Marchfeld*," a region characterised by intensive farming and widely strewn weekend homes. The *Marchfeld* is (as its name in German suggests) heavily agricultural — often called the Austrian cereal storehouse. This has led in the last decade to serious ecological problems — contamination, lowering of the ground water level, and a loss of diversity in flora and fauna. This haphazard development is also now generating huge costs in providing public access and waste disposal. It was, therefore, the architectural aim of the *Gärtnerhof* project, amongst others, to demonstrate the potential of spatially economical construction without giving up the advantages of rural living.

The individual L-shaped courtyard houses with yards approximately 150-200m^2 in size are surrounded by brick walls to provide privacy. Pergola seating, roof terracing and a shed number amongst the standard fittings of the courtyards. The day-rooms and bedrooms face Southeast to Southwest. Bathroom, kitchen and utility rooms, and staircases (unless integrated into the living area) form insulating buffer zones to the north. The conservatory faces south as a one or two storey wooden frame construction. Minimum mutual shadowing of the buildings is achieved by grading the heights of the buildings and by small changes in level.

Internal access in the community is provided by brick pedestrian paths 1.5-2.0m wide. The maximum distance from the parking areas is about 100m. Externally, particular attention was paid to a diversified organisation of space. Narrow paths alternate with open spaces that, due to their semi-public character, lend themselves to being used for parties and gatherings. City dwellers are struck with the possibility to walk in front of the house without fear of accident or noise.



Ground Floor Layout of 2 Courtyard Houses

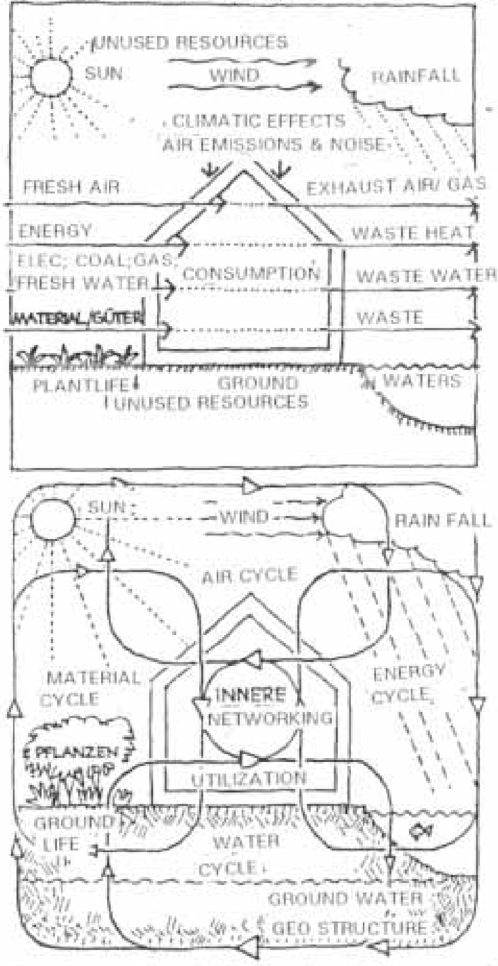
Massive brick open-face double-layered insulated outer walls, doors, windows and wooden framework to the South with natural finishes define the external appearance of the houses. Tiled pyramid roofs alternate with flat gravelled roofs, which serve as roof terraces or for the installation of solar panels. Inside, wooden floors and balconies with banisters dominate, as well as, in many houses, a tiled stove, and large glass fronts — a visual contact with the courtyard gardens. The walls of house and garden delineate public and private domain. Mutual communication without privacy is an insight gained from old building cultures: "*For humans to dwell without walls is inconceivable.*"[1]

[1] Herbert Tichy: What I learned from Asia: Wisdom

Ecology

The most important goal was to integrate the natural interdependencies of energy, land, air, and water thereby departing from a conventional system of consumption and waste disposal to creating an integral system. Special attention was paid to the following aspects:

- Optimum use of natural, long-lasting and recyclable construction materials free from dangerous substances
- Utilisation of solar energy.
  - Actively, by means of solar collectors for heating water.
  - Passively, by combining southern exposure of the conservatories and southern windows with warmth retaining components.
- Highly insulating external structural components (walls and ceilings with a K-value of 0.24, windows, 1.3)
- Environmentally friendly, highly efficient heating (gas - exterior wall thermal with waste heat recovery)
- Installations for the recovery of heat from waste water.
- Rainwater for laundry machines, flushing toilets, irrigation and partly for personal hygiene.
- Composting toilets.
- Sewage treatment by means of a reed bed
- Use of a wind powered pump for circulating waste water in the cleaning pond.
- Allowing for installation of a bio-gas plant.
- Collecting and sorting all rubbish
- Providing opportunities for self-sufficiency in foodstuffs.



The Conventional Philosophy of Consumption vs. an Integrated System

People

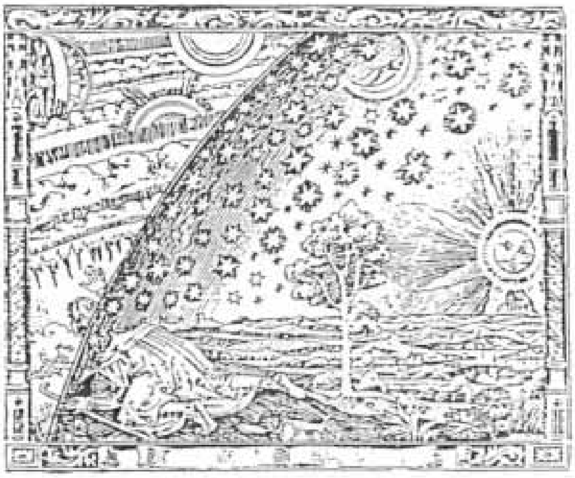
The social concept provides for a well-balanced ratio of the inhabitants for age, occupation and social origin. As far as planning allowed there are various sizes of residence, enabling both families and single persons to live in the complex. In addition there is a broad range of communal areas and facilities, such as the playground areas, swimming pond, kitchen gardens, communal rooms, the courtyard fountain and, as already mentioned, the pathways that allow but do not require contact. All of these amenities are managed and maintained by the residents themselves.

The children can learn about handiwork skills and become socially and environmentally conscious through exposure to the necessary work in the reed bed of the sewage treatment system, sorting rubbish, and working in the vegetable and fruit cultures.

Birthday Celebration at the Courtyard Fountain

PART I - Ecology and Architecture

This section deals with both the fundamental principles of an ecological vision and with the human-ecological aspects of architecture resulting in that vision. There can be no question that we are today in the midst of the transition prophesied in 1982 by Fritjof Capra in his book *The Turning Point*. The manned space voyages of the 1960's are the beginning of a transition from mechanistic-linear thinking to a new ecological-cybernetic view of the earth:



Wood Cutting from the 16th Century

Space travel, indeed, has proved that a select few can cross cosmic boundaries with the help of technology, but it has contributed little to mending the serious problems of humanity. On the contrary, space travel appears today as a symbol of a reckless, ill-defined technical feat threatening both the global eco-system and the earth itself.

Damning technology alone would, of course, be foolish. But when it comes to the *how*, *why*, *where* and *when* of technical application, decision makers must carefully evaluate their actions and intentions. The image of a lonely blue planet earth viewed from space has engendered enormous changes in the perception of space and time. The limits of basic resources and the profoundly complex interdependencies of local and global eco-systems are insights which in the 70's and 80's have steadily invaded the paradigms of the civilised world. Given their responsibility, especially architects, builders, engineers and technicians have been called upon to acknowledge the signs of the times. Too many of them, unfortunately, do not: an ominous mistake. The population explosion, the world-wide pollution of land, water and air with its attendant impact on local eco-systems and living conditions are relentlessly advancing.

In the end an ecological vision must hail from given principles of the ecosystem "nature", aiming for "sustainable development". The principles of cyclical economics, perpetual recycling, use of presently available means, integration of structures and organisations (stability), decentralisation/regionality, applied properly can create a sustainable, environmentally acceptable society.

The necessary social transformations would, however, be easier to achieve if "reason" were free to act. That it cannot is due to evolutionary determinants expressing themselves in patterns of behaviour, values, needs, bonds and desires. In other words, we find ourselves entrenched in a world of structures and interdependencies that we cannot change at will.

But nevertheless we try — and make mistakes. Perhaps a more humble assessment of what the laws of nature plainly allow would help to avoid these mistakes. It must not be forgotten that "*since architecture will always encroach upon nature this must be done gently, with restraint, and harmoniously.*"

The Marchfeld area specifically

That which is right for *Marchfeld* does not necessarily hold true for everywhere else. Ecological solutions must respect local restraints. For example 60% of the households in the Marchfeld have no access to sewage treatment facilities. The widely scattered settlement structure makes sewage canal construction extremely expensive. The construction of decentralised reed bed systems adapted to individual settlements could afford relief here. From the viewpoint of regional suitability the *Eco-Homes Community Gärtnerhof* is seen more as an alternative to the parcelling out of countryside for detached houses and less as a model for new forms of urban residence. Consequently it is important before applying the concepts and measures presented here to investigate the local situation and the possibilities on site in order to develop correspondingly tailored solutions. Unfortunately certain branches of the economy try to stimulate the Eco-market according to the motto: "A little less concrete, and a little more (bio-) timber means building ecologically." This Report shows that building ecologically means far more than just "bio-" building materials: It is a *Modern Era of Enlightenment* that embraces the interwoven aspects of the universal "household of nature" and which attempts to utilise nature's assets prudently.

PART II - Energy

Part II deals with

- what influences the thermal behaviour of residential buildings
- saving energy
- passive use of solar heat
- the conservatory with respect to function, construction and architecture
- heating with regard to energy efficiency and harmful emissions
- active use of solar energy and waste heat recovery for heating water

Thermal behaviour of residential buildings

Room temperatures, opened or closed windows and doors, as well as the energy consumption of 4 houses in the community that had been measured over the space of 18 months together with the climatic factors of wind speed, outside temperature, solar and global radiation were the basis for the calibration of a computer algorithm simulating the thermal behaviour of rooms and building elements in1hour intervals.

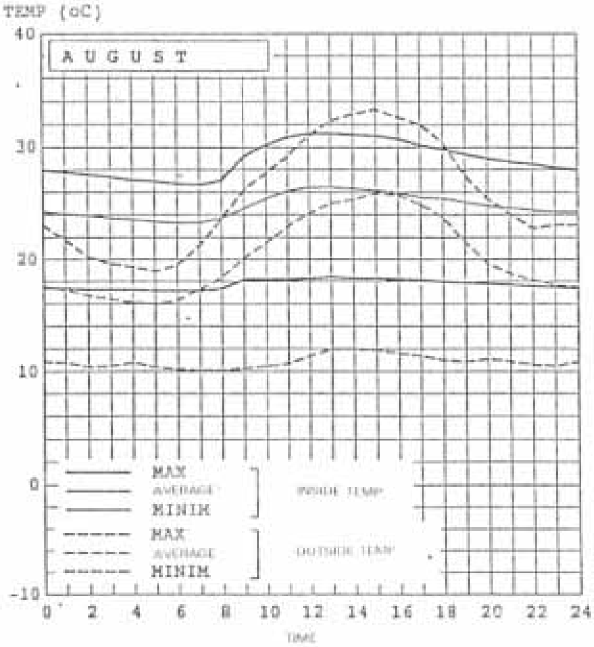
The scale for the successful calibration was the best achievable agreement between measured and simulated temperature data. This enabled *realistically emulating the influence of various building elements on room temperature and energy use*. The most variable conditions of the parts of the buildings could be realistically simulated using the calibrated system and examined on the degree of its influences on room temperature and energy budgeting.

The thermal behaviour of the room with the following building component parameters was simulated over 1 year as representative of a test room. The result operates respectively in a change in the temperature-summation diagrams as well as the arithmetic heating and/or cooling energy requirements.

The following building component parameters were hypothetically changed:

- the degree of transmission of the heat-retaining glazing
- the heat storing capacity of the individual building components
- the position of the room
- the heat resistance of the massive external components in the range k=0.40 - 0.15 W per m^2 k
- the rate of air exchange in the range 0.7 - 10 ac per hr

The few examples shown here demonstrate that any improvement in the heat retaining capacity of buildings or building components results in overall savings in costs which pay for themselves within the life span of the effected building components. Future studies will concentrate on optimising passive and active use of solar energy.



Temperature Curves

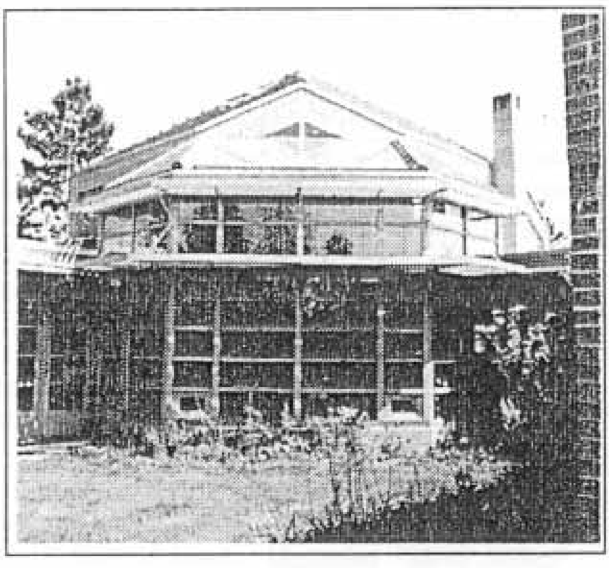
These analyses also make it possible to gather both quantitative and qualitative data on thermal behaviour for practical application in building. This form of feedback planning could help to understand the complex thermal behaviour of buildings by realistically simulating on a computer the correlation between insulation, heat retention, ventilation, location, etc. As experience increases and the planner better learns to estimate the thermal behaviour of rooms, simulation will eventually be needed only in difficult situations.

The Conservatory

The conservatory is without doubt a phenomenon which in recent years has experienced a welcome renaissance. It is characterised, as a rule, by extreme thermal behaviour (high humidity, temperatures between +5° and +40° C), which renders the constructive, creative and functional management of the conservatory climate difficult.

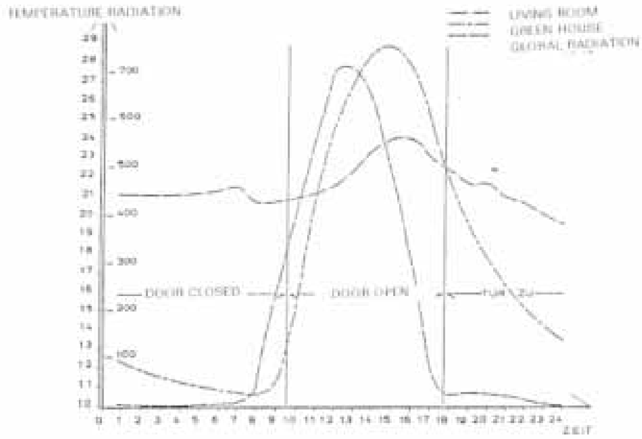
The user himself can, however, greatly influence functional value and energy consumption.

As has been shown in interviews, residents enjoy using their conservatory often. Through the uninterrupted measurement of thermal behaviour conclusions can be drawn concerning energy efficiency, shading and ventilation devices, as well as mode of utilisation.



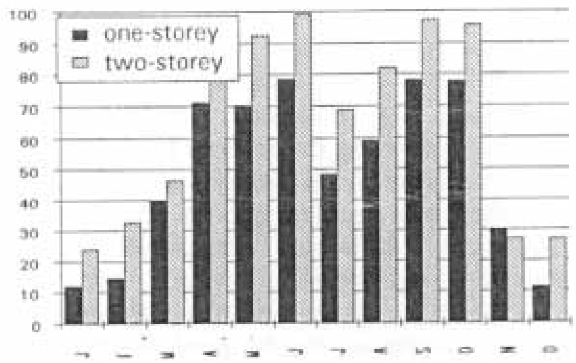
Two - Storey Conservatory

The diagram shows the temperature trends of the conservatory and the living room behind it dependent on global radiation and opened or closed connecting doors. Leaving the connecting doors open has a clear delayed effect on the temperature in the living room. To what extent the conservatory heats the living room behind it cannot be ascertained from the results of the measurement. To do this, an exact recording of the air exchange between the rooms would be necessary, which, due to the inconvenience caused to the residents by the necessary measurement devices, is hardly possible.



Temperatur Course throughout one day

Various forms of conservatory were also compared with respect to their thermal comfort. It will come as no surprise that a two-storey conservatory with vertical glazing is, in this respect, superior to the one-storey conservatory with angled glazing. In both cases the air temperature in the months April, May, June, August and September lies in the comfort-zone between 16 and 26 °C over 50% of the time.



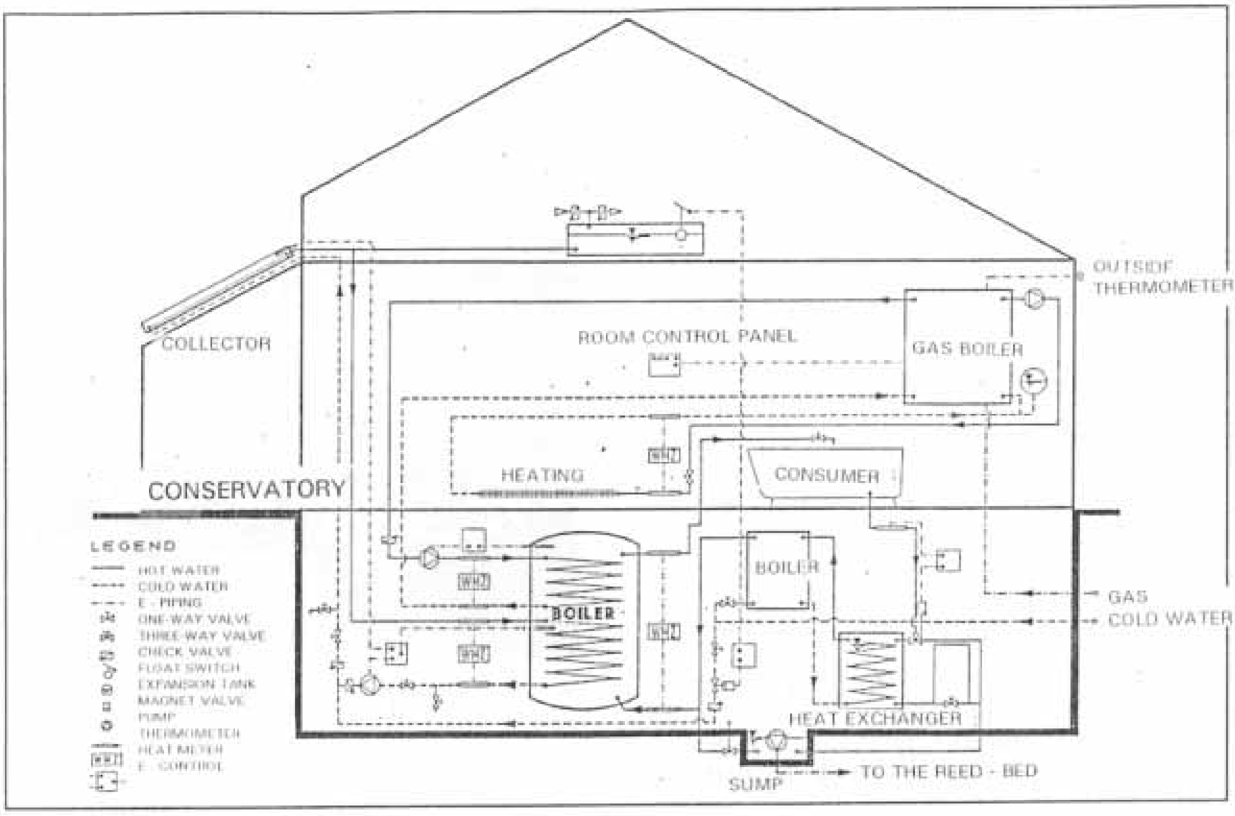
Usefulness of two conservatories in percentages of hours per month

Heating

80% of the energy requirement of a house is used for heating. 1/3 of harmful emissions come from combustion within the house. For the heating of the 21 housing units in the Gärtnerhof project optimally efficient combination gas boilers with exhaust condensation were installed. The room temperature is controlled using integrated electronic tendency regulators governed by both internal and external temperature patterns. Lambda systems keep harmful emissions to a minimum. The decision for natural gas is based on balancing the criteria of availability, environmental impact and the fact that with a possible conversion to hydrogen the existing distribution structures could continue to be used.

However, not only the heating materials and their producers but also the internal heating elements and their connecting components play an important role. Through purposeful arrangement of areas to be heated, reduction of convection, employment of physiologically warmer building components and skilful installation the heating requirements are reduced. The arrangement of the ground layout according to the "onion shell" principle presents still one other important factor: rooms with limited heating requirements are buffers for the warmer rooms.

To ascertain the specific heat requirements in the houses under examination the gas consumption, the wood consumption (where available) and the given quantity of heat in the heating circulation during the period of measurement was measured. In the period March 89 to February 90 the heat consumption was between 50 and 64 kWh/m² living area (partially supported by tiled stove). This corresponds to approximately half the consumption of conventional detached one-family houses. Determining a possible solar effect is not possible without a complete heat balance (ventilation losses, minor heat producers etc.) .

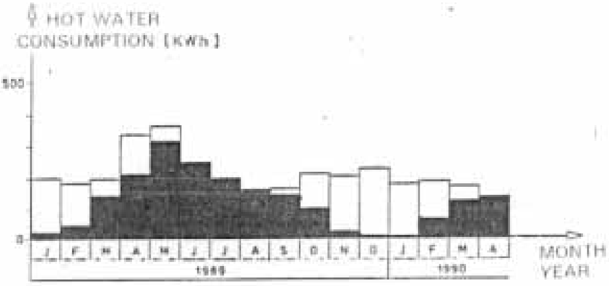


Room and Water Heating Chart

Solar Water Heating

Sun collectors, which were mounted by the owners, covered on average 50 -70% of the warm water requirements of the households in the measurement period. The rest was covered by the combination gas heaters. Because the self-built system tested by us does not conform technically to the current state of high performance collectors we expect to achieve 70 - 80% efficiency of such industrial products. In both cases the result can vary up to 15% depending on user habits. The self-built system, however, offers the possibility of optimal integration into the architecture and was about 20% cheaper than the industrial system.

The Report also contains a general systematic representation of the technologies available for heating water — from the conventional, via the different methods of collector function and construction, to the heat recovery of waste water, tested in two houses.



Efficiency of Solar Collectors

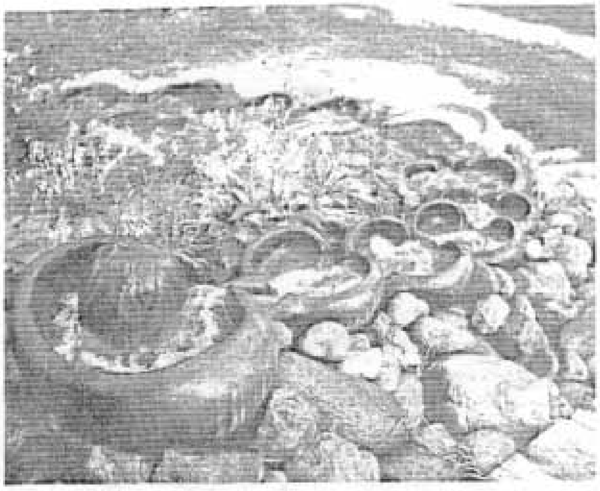
PART III - Water

Part III concerns

- consequences of refusing to accept water as a complex resource
- a water-waste water concept
- to what extent drinking water use can be reduced
- using the organic waste water treatment system instead of existing centralised techniques

The water — waste water concept

The *water concept* is based on principles of optimal conservation of drinking water, reducing pollution, as well as providing an all-encompassing approach to water utilization in the community. Using rain water instead of drinking water for watering gardens, flushing toilets and other utility purposes is easy to implement but requires an awareness that can only be taught. Hence the conscious attempt to arouse sensitivity to water as an essential element of human existence. To this end there are numerous rain spouts, drains, a public fountain, and a bathing pond with Virbela-cascades setting water in rhythmic motion and providing an attractive play area for children.

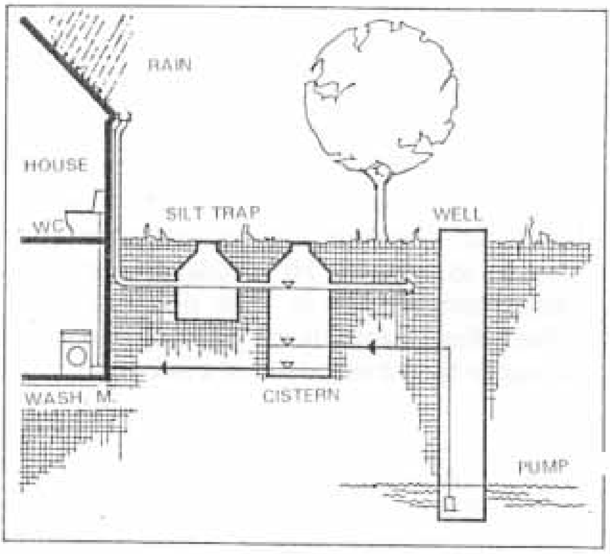


Virbela Cascades

The methods employed result in average drinking water consumption of 52 litres per person (typically 160 litres per person). If rain water is also used for hygienic purposes this value becomes 5 litres per person: a reduction approaching 100%.

Rain water

Rain water is provided to the individual households by 2.5 - 3 m^3 underground cisterns with built-in silt traps. By means of an overflow pipe the individual cisterns are connected to an 86 m^3 main cistern for the ten flats.



Rainwater treatment

The Research Report contains information concerning cistern sizes and the retention period of the water and water hygiene analyses was based on two tested housing units. The quantity and distribution of the annual rainfall as well as losses through evaporation and as dew are detailed and presented graphically.

On average in the houses under examination a degree of utilisation of rain water of 65% was attained. That means that approximately two-thirds of the entire annual rainfall could be used for the above mentioned purposes with a corresponding reduction of drinking water use. Water is retained in the cisterns approximately 1 week. A random hygiene test of a silt trap in Sept. 89, as regards faecal coliform and total germ count, corresponds to accepted norms for public bath water.

From a purely economical standpoint substituting drinking water with rain water does not appear profitable. Yet irresponsibly wasting the precious resource water will lead both to an overall reduction in the amount of drinking water available and a deterioration in quality. Furthermore the use of rain water due to its low pH value results in several savings: expensive water softening devices are not needed, less washing powder is necessary, appliances last longer and the treatment of waste water is simpler.

Quality of rain water

The analysis of contents of the rain water cistern of house 5 on 27/09/89 yielded the following results:

	Sample Silt Trap	Ö-Norm M 6230 Bath Water	Ö-Norm M 6250 Drinking Water
Conductivity	187	-	-
pH value	7.1	5.5-9.0	6.5-8.5
Material in Suspension	n.n	-	-
Ability at Oxidising	2.8	to 25	to 12
Complete Hardness	4.4	-	-
Carbonate Hardness	3.0	-	-
PO_4- -P	0.1	-	-
NH_4 - N	0	0.2	0.08
NO_3 -N	2.6	-	23
Faecal coliform	0.1	to 1	to 0.01
Total Germ Content	970	to 1000	to 100

This shows that the rain water quality essentially corresponds to the norm for public bath water.

Rain water relevant to consumption and cistern volume

The schedule shows the consumption of well water and rain water in house 3. Drinking water is not considered.

In the graph the total rain fall is classified according to:

- usable rainfall
- losses through cistern volume limits and
- losses through roof dispersion or evaporation

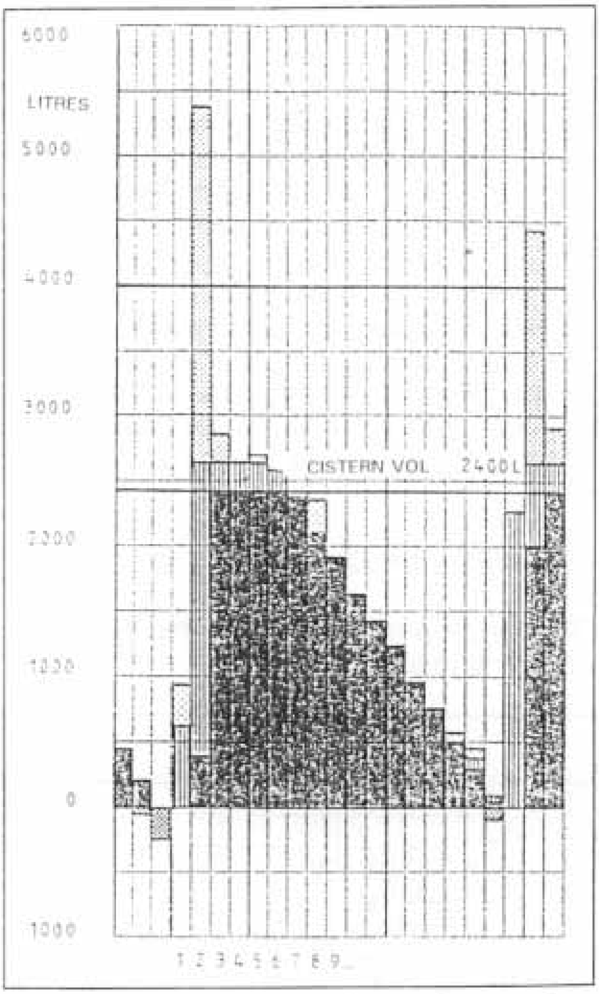
Additionally the respective

- water quality of the cistern and
- well water consumption are represented

The representation in the diagram is based on house 3 with a useful cistern volume of 2400 litres. The period from 29 May to 9 June 1989 is shown in detail.

On the morning of May 29, 457 litres of water remained in the cistern and in 24 hours 258 litres (average daily water consumption for May) were used, leaving 199 litres in the cistern. During the next 24-hour period 258 litres were once again consumed — made possible by supplementing the water supply with 59 litres from the community well. The cistern was then empty. Since it did not rain on 31 May, an additional 258 litres of well water was needed. During 1 June 5.8mm of rain fell — 863 litres on the roof of house *3*. Of that, approximately 250 litres were lost due to dispersion and evaporation, leaving 613 litres in the cistern. On this day corresponding to the typical daily water consumption in June, 233 litres were consumed and left 380 litres in the cistern on the morning of June 2nd.

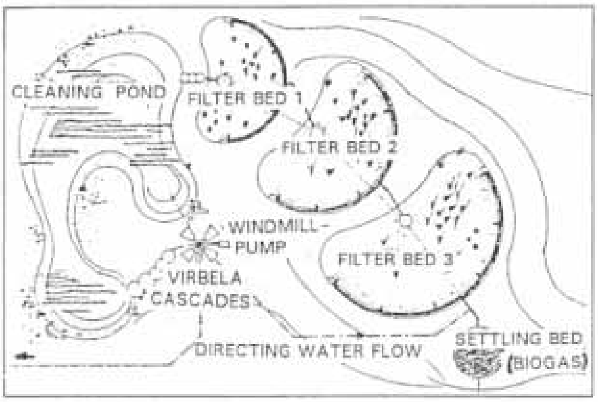
During 2 June 4.987 litres of rain fell on the roof that was still wet due to the rain from the previous day. Since at the same time 233 litres were used the results are as follows:
380 - 233 = 147 litres
147 + 2.253 (usable rainfall) = 2400 litres (max. cistern volume)
2.734 litres of rainfall are lost or flow into the large cistern.



Rainwater use contingent on cistern volume and water consumption diagram 1, house 3, 1989

Using plants to treat sewage

The Report presents a short review of fundamentals for biological sewage treatment systems, advantages and disadvantages of centralised or decentralised systems, acquiring a building and operating permit from authorities, a cost comparison between cesspools, public and private treatment plants, as well as an account of our own individual experience.



Sketch of organic water purification plant (organic sewage treatment complex)

- <u>Oxygen:</u> For the aerobic decomposition of the organic material contents of the waste water and for nitrification a good supply to the ground mass is critical. The runoff from the first plant bed already contains sufficient oxygen since with an Oxygen concentration of more than 1.5 mg O_2 /l it can be assumed that it has not come to a limitation of O_2 .

- <u>Concentration of dirt and impurities:</u> The essential decomposition and recomposition processes take place in the first plant bed — both the organic impurities (CSB, BSB_5) and the conversion of the nitrogen groups of TKN and NH_4-N to NO_3-N. With the exception of 21/2/89, most likely due to the initial short operation of the system, no further decomposition and recomposition occurred in the 2nd and 3rd plant beds. The negligible concentration of nitrogen in comparison to the trial results at other points in time is due to the higher concentration of rain water.

- <u>The appearance of nitrate</u> (NO_3-N) in the filter bed's outlet indicates clear nitrification. In addition it is notable that despite the low temperatures on 21/2 and 21/11/89 (Temperature gradient from inlet to outlet 8 - 10 °C) nitrification took place. Since these are trials and spot checks, nitration balance is not allowed, however when recording the results of the trials the total nitrogen content is clearly higher at the inlet than at the outlet.

- The <u>performance</u> of the *Eco-Homes* system relative to carbon compounds corresponds to those of a growth-plant with nitrification. Independent of the extent of the dissolved share the entire degradable and dissolved CSB is already essentially decomposed in the first bed, already leaving in Bed 1 a buffer capacity for the impact of overload. Additionally, according to the test report the burden on the system is significantly lower than expected primarily due to the small total amount of waste-water.

- The <u>amortisation</u> of the treatment system in comparison to cesspools interconnected by clearing canals takes about 5 - 6 years.

Windmill reflected in cleaning pond

The community's own organic sewage treatment system is the final element of the all-encompassing approach to water use in the community. Laid out for a population equivalent of 90, it is one of the largest of its kind in Austria. Construction and function derive from the method developed by Dr. Käthe Seidel in the 1960's. The form of the three step filter bed, however, was designed in co-operation with the German fountain architect Herbert Dreiseitl. We feel that the kidney-shaped beds provide hydrodynamic advantages over right-angled flow regulators and can be better integrated into the surrounding environment. The filter beds are lined and are filled with a relatively permeable sand-gravel material throughout. The installation includes a settling bed for incoming sewage that could be used as part of a biogas plant. Furthermore the treatment system, for lack of a flow form cascade, has a cleaning pond whose water is kept in motion by a windmill pump.
Quarterly examinations carried out by the department of Water Hygiene and Waste Management at the Vienna Institute of Technology have so far confirmed expected efficiency of the system's performance. The trials were carried out with respect to the following parameters:

Full trial: CSB, BSB_5, NH_4-N, NO_3-N, NO_2-N, TKN, PO_4-P, Total P,
Conductivity, pH, Oxygen content, Temperature.
Rugated Filter Trial: CSB

The results of the rugated filter trial are intended to determine to what extent purification is the result of actual chemical breakdown or the result of filtration.

	CSB	BSB_5	TKN	NH4-N	NO_3-N	NO_2-N	Tot.P	PO_4-P
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
21/2/1989:								
Emscherbr	468	218	83.5	31.8	0	0	13.7	13.2
Bed 1	55	36	63.3	17.4	6.4	1.4	4.9	4.6
Bed 2	46	19	40.1	16.9	8.8	1.4	5.0	5.0
Bed 3	33	7	33.3	10.2	10.3	0.2	1.1	0.7
Cleaning	59	12	13.5	17.4	1.0	0.1	4.5	3.9
Pond								
01/06/1989:								
Emscherbr	574	283	89.0	74.5	0	17.4	17.0	-
Bed 1	35	7	10.4	9.5	10.2	0.9	2.2	1.8
Bed 2	23	6	3.1	2.7	11.3	0.3	1.5	1.5
Bed 3	37	-	19.4	14.8	21.7	0.6	1.0	1.0
Cleaning	89	14	12	7.8	0.8	0.6	1.1	1.0
Pond								
16/08/1989								
Emscherbr	258	162	72.9	60.3	0	0	14.5	14.2
Bed 1	-	not in use						
Bed 2	-	not in use						
Bed 3	-	not in use						
Cleaning	48	14	9.4	2.0	0.1	5.4	1.5	1.4
Pond								
21/11/1989								
Emscherbr	259	100	86.4	58.3	0	-	13.6	9.9
Bed 1	24	2	16.4	15.2	9.3	-	1.8	0.6
Bed 2	26	6	25.4	13.8	20.9	-	1.6	0.7
Bed 3	-	not in use						
Cleaning	37	-	4.2	1.5	8.4	-	1.3	1.0
Pond								

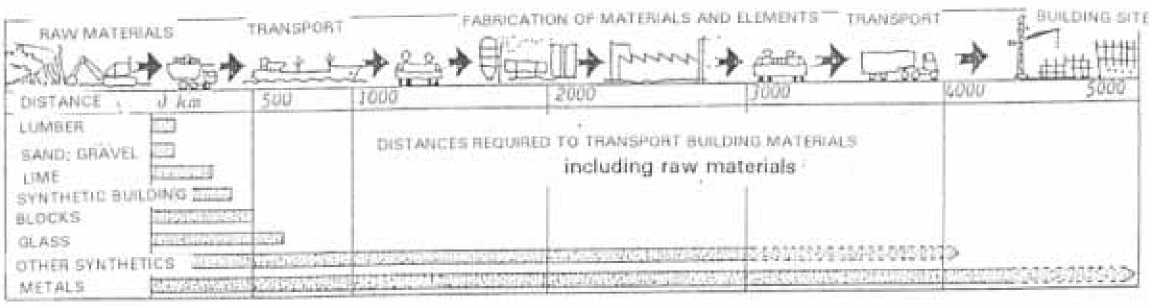
PART IV - Materials

deals with following aspects of ecological resource economics.

- Choice of proper building materials and substances, treatment of surfaces and types of paint
- acquisition, processing and transportation expenditure as well as reuse of resources
- natural reintroduction of organic waste into the earth
- Reduction of rubbish by enhanced consciousness and /or sorting and composting

Ecological resource economics

The dream of perpetual economic growth is actually a nightmare. If the world economy were to grow in the next 50 years on the same scale as it has in the past 50 years there would be an inevitable demise of the environment. It is evident, however, that a plateau has been reached. Ever increasing costs of production for the basic materials of the chemical, processing and metal industries are making the search for alternatives more and more lucrative. One of the most promising resources is our own refuse, as it has often become cheaper to collect and recycle so called valuable materials. Indeed this is only possible if these materials are declared as such, correspond to their original state and are marketable as a recycled product.



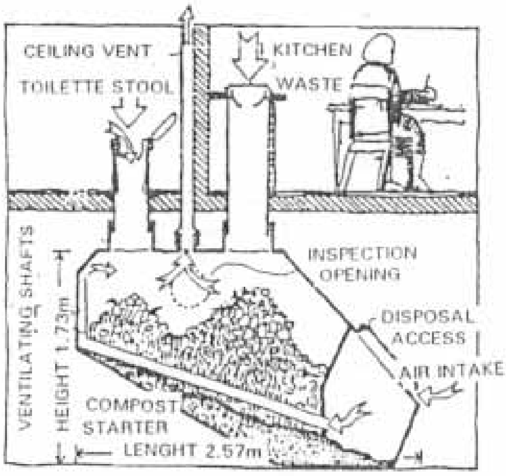
In the building and construction industry enormous quantities of special refuse in the next decades will accrue in quite normal houses which will become uninhabitable as soon as it becomes plain what quantities of toxic materials are contained in the prefabricated walls, the flooring, the curtains and wallpaper, the varnishes, and the furniture.

The science of building biology provides us with standards and insights into the ecologically appropriate use of building materials. This knowledge as applied in the *Eco-Homes Community* is documented in a supplementary contribution which also gives information about the costs of various alternative construction and insulation materials.

The prevailing ecological economic balance with respect to building materials should in the future deliver data about the energy expenditure in acquisition, production, transport, processing and disposal as well as the resulting impact on the environment.

The composting toilet: another kind of "WC"

A further focal point of this Report is the humus or composting toilet. Of the 22 living units 10 were fitted with CLIVUS MULTRUM type toilets. This "enclosed compost heap on an inclined plane" requires, apart from 3 m^3 of space in the cellar, an effective vent for exhaust air, a small measure of dry substance such as sawdust and wood shavings and compost activators. Water and electricity are not needed.



The most notable benefits of the "HC" are saving 40 - 70 m^3 of drinking water per year for a four-person household and gaining high quality humus from the biogenic household waste. The indirect ecological benefits of fewer sewage canals, smaller and less burdened treatment plants, lesser need to dispose of sludge, and humus production illustrates — in the context of society as whole — how rational and estimable the composting toilet is.

COMPARE	CESSPOOL 85 m³ /Year	CESSPOOL 35 m³ / Year	COMPOSTING TOILET
Cost of water for flushing	1.263,00	406,00	zero
Cost of draining cesspool	10.200,00	4.200,00	zero
Total operating costs	11.463,00	4.606,00	zero
Amortization	5,2 Years	13 Years	

Operating Costs Compared

Waste reduction and sortation in the *Eco-Homes Community*

A further environmental contribution is made both by the waste sortation system set up in the *Eco-Homes Community* as well as the purchasing behaviour of the "eco-denizens" as regards environmentally harmful packaging materials. This initiative persuaded the community of Gänserndorf to set up 16 decentralised waste sorting stations for the ordered collection of useful materials. Still, if those who mainly cause the deluge of refuse, namely trades and industry, are not prevailed upon to make full product declarations and complete eco-balance sheets and the law makers to base legislation upon these realities, then our positive efforts can have little effect.

PART V - Air Quality

In the last two decades the oil-price shock and environmental awareness in the energy and construction sectors have led to efforts to save energy by reducing transmission and ventilation losses. The installation of highly insulated window and wall constructions has indeed saved energy, but at the same time also worsened the air in many homes. Certainly this is due to unchanged habits of venting but foremost to the increasing amount of harmful substances in interior rooms. If the goal of saving heating costs is not be abandoned, then following measures have to be taken:

- Improvement of the air in interior rooms through eliminating toxic emissions from such goods as building substances and materials, furniture, household chemicals, lacquers and polishes.
- More open air activity for the city dweller.
- Reduction of noise and exhaust gases in urban residential areas so that windows can be opened.
- Heavy but diffuse building shells with regulated ventilation systems, preferably with heat recovery

To test our planned measures 2 housing units were examined for harmful substances in the air and natural air exchange: 6 other housing units were supplied with long-term radon dosimeters. As expected, the air exchange rates and the burden of harmful substances lay within respectable limits.

Sample	Toluol	Phenol	a-Pinen	Salicyl-aldehyd	Aceto-phenon	p-Kresol	Formal-dehyd	Acet-aldehyd	Aceton/ Acrolein
26.2.89 house 5									
-1	24.6	30.1	1352	33.2	n.n	n.n	<10	<3	<50
-2	99.7	73.2	1620	16	n.n	n.n	<10	<3	<50
-3	93.6	75.1	785	102	n.n	n.n	<10	<3	<50
27.2.89 house 2									
-4	54.4	166	2223	245	192.2	139	<10	<3	<50
-5	40.5	142	1949	120	150	124	<10	<3	<50
-6	31.6	98	1842	128	136	114	<10	<3	<50

Electrobiology in the home

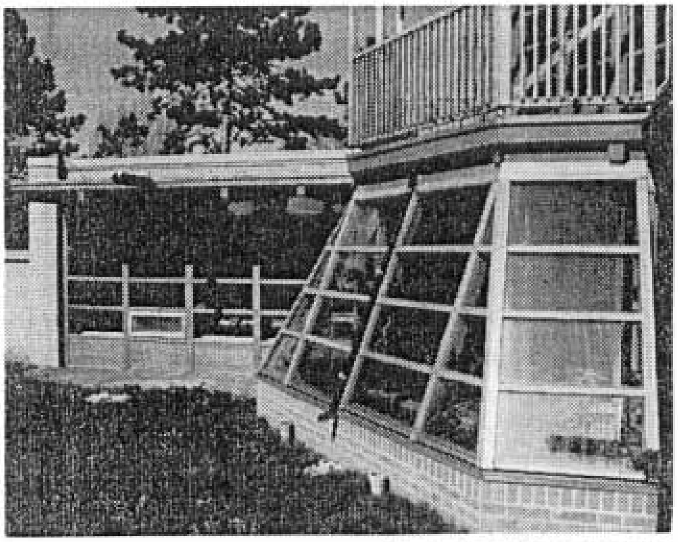
As a result of experience gained from many electrobiological studies conducted in association with the AUSTRIAN INSTITUTE FOR BUILDING BIOLOGY the issue, nature of electric and electromagnetic fields, was taken into account in design and installations. Walter Rzepa analysed different field types and proposed measures implemented in the *Eco-Homes* such as bypassing sleeping areas, shielding of wiring, or only-on-demand circuiting.

Climatic factors in ecological construction

Naturally green and landscaped spaces in rural areas contribute significantly to the improvement of the microclimate. Through intelligent design of courtyard areas protected from the wind, space can be created where even fig-trees flourish. Skilful exploitation of topography is still to be found in rural construction. The potential and impact of "greening" measures in the condensed low rise is discussed in still another supplementary contribution. It should be noted that the problems of urban climate are different, but that also here the measures discussed can be implemented.

PART VI -
The *Eco-Homes* Occupants

Architecture must satisfy basic human needs. The form and qualities of a building structure mirror the social and ideological consciousness of a people. The *Eco-Homes Community* is made up of individuals who share this consciousness.



Typical southern exposure

This section covers:

- ideas, aspirations, and expectations
- the first steps
- shared experience of prospective inhabitants, architect and contractors
- dealing with officials, laws and outdated building regulations
- social and pedagogic concepts
- life in the completed project

An attempt is made to determine what solutions were offered for the central issue defined at the outset — the ecological compatibility of architecture and nature.

Many of the current residents of the *Eco-Homes Community* were surprised to learn about the wide reaching debate on the environment waged among the first *Gärtnerhof* activists. Many problems, ranging from establishing a democratic decision making process to managing finances and coping with the double burden of building a house and holding down a job had to be mastered by the prospective inhabitants. Two years after having moved into their homes, almost all residents declared that they could not imagine any other form of residency. It became clear through lengthy interviews that the *social* project *Eco-Homes Gärtnerhof* began only *after* building construction had been completed. The more than 40 children of this community are growing up in a world strikingly different from a typical urban environment. For them, perhaps, the *Eco-Homes* project really is utopia.

Conclusion

What does the future hold? Dare we hope that humanity will succeed in becoming an environmentally compatible "sustainable" society? What is the architect's role, the occupant's? The concept "build" in all languages has ancient roots harking back to elementary concepts like "to be" or "to become". Planning and Building are therefore more than just architecture. The architect is an advocate of his client's own personal experience and values. Humanity will always be in need of housing.

The tangible experience of present-day ecological housing projects could soon become a matter of course if ecological consciousness is fostered by regular practice.