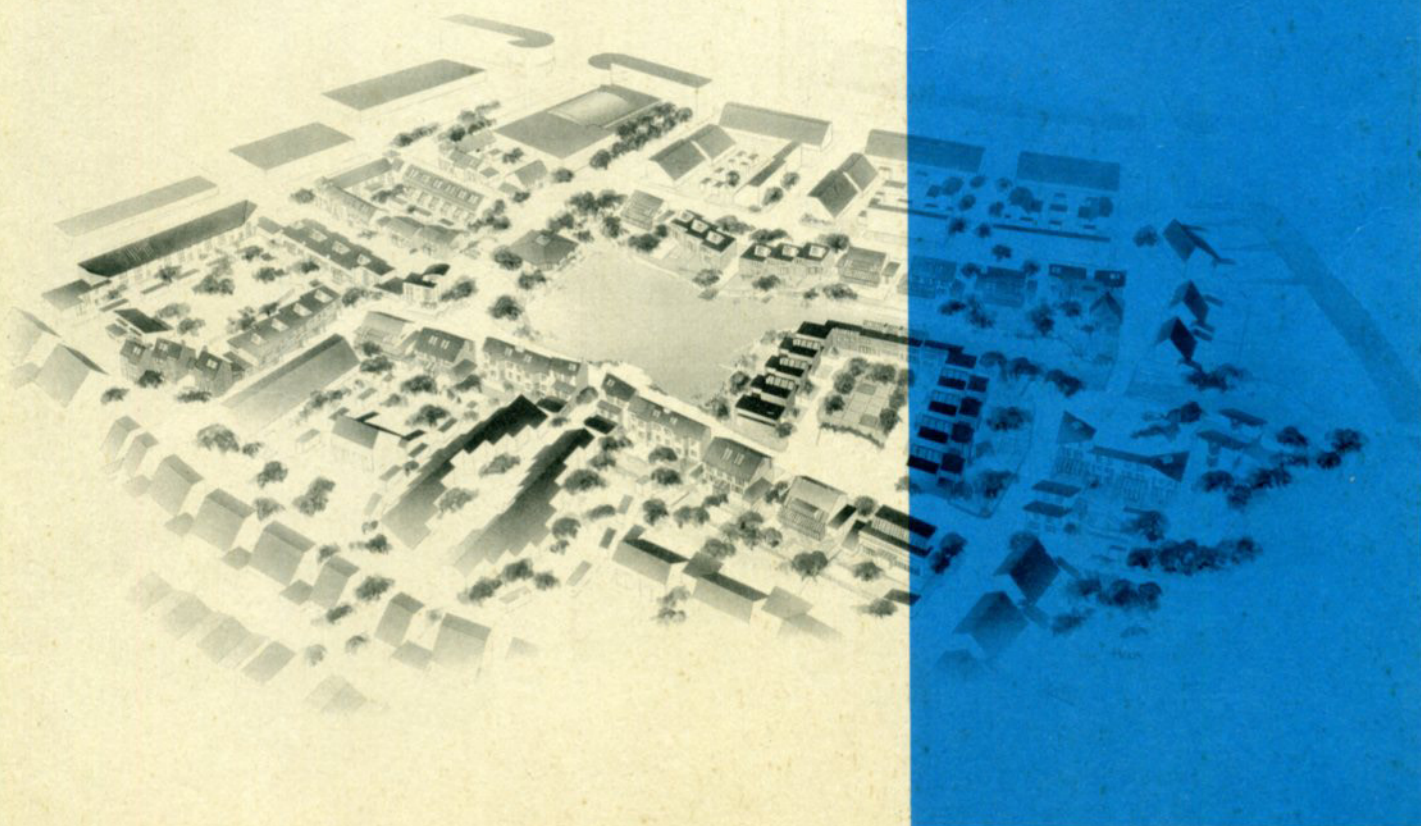


Ecolonia

Demonstration project
for energy-saving and environmentally-aware
building and living

Novem

Netherlands agency for energy and the environment

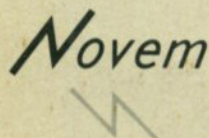


Novem, the Netherlands agency for energy and the environment, is a service-oriented organisation specialized in managing energy and environmental programmes for the government. The Ministry of Economic Affairs is its major client.

Novem has offices in Sittard (main office), Apeldoorn and Utrecht, and also has five district offices. Total workforce is approx. 250.

Novem is active in the field of energy conservation and fuel diversification. It promotes low-energy building design, energy efficiency in industry, fuel diversification and development of wind and solar energy. Novem is increasingly active in the environmental area, such as clean technologies and waste utilization.

Besides knowledge and expertise in these areas, Novem can offer financial support and an extensive centre of knowledge transfer for the implementation of its tasks.



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Energy-conscious and environmentally-aware building and living; a need not a hobby

As an introduction to the National Environmental Policy Plan, the Dutch Minister of the Environment wrote the following in 1989:

'The environment is in a very critical condition. In spite of improvements in some areas, the situation is continuing to deteriorate. Further postponement of drastic measures is unjustified. Radical decisions which will affect everyone are therefore unavoidable. The coming years will be characterised by a hard struggle; and it is not only the improvement of the quality of the environment which will be at stake here, but ultimately the continued existence of mankind.'

The average annual consumption of gas for space heating in a new built single-family dwelling in the period 1973-1988.

It is now nineteen years since the first major international energy crisis took place. Although the oil started flowing again shortly afterwards, this calamity led many countries to develop a new policy on energy, and the Netherlands was no exception. Energy saving and diversification of sources of energy became the objectives thenceforth.

In fact, the Netherlands is in a favourable position, thanks to its large reserves of natural gas; virtually every Dutch household uses natural gas for space heating, cooking and providing domestic hot water. However, the government wishes to use these gas reserves carefully, and has developed specific programmes to reduce consumption.

There have been achievements over the years. Insulation programmes, for both new and existing dwellings, have had an effect: the average annual consumption of gas for space heating in newly-built single-family dwellings fell in the period between 1973 and 1988 from 3300 m³ to less than 1300 m³.

Despite this, however, the growing number of dwellings and the flourishing economy meant that total gas consumption remained unchanged.

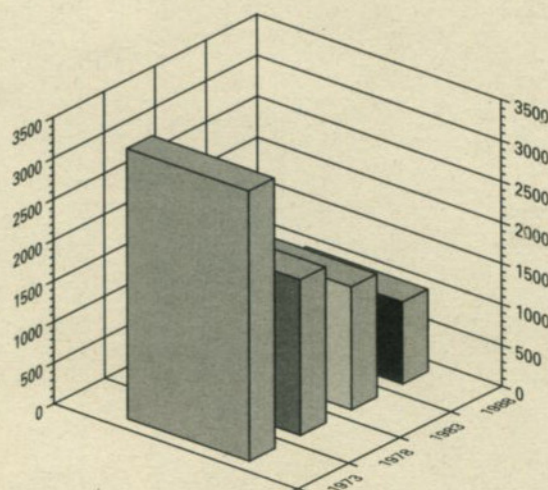
At the end of the 1980s it became clear that the use of fossil fuels such as oil, gas and coal would have to be reduced still further.

Environmental problems were proving much more serious than expected, as indicated clearly by reports such as that produced by the Brundlandt Commission.

National Environmental Policy Plan

In 1989 the Dutch government published the National Environmental Policy Plan (NMP). Under this plan, the construction industry is one of the target groups expected to make a major contribution to extensive energy saving and environmental protection. The NMP charges the building industry with the following tasks, which must have been achieved before the year 2000:

- Focus emphatic attention in all stages of the construction process on the environmental consequences of construction methods and products;
- Reduce the use of finite natural resources and make a contribution to the sustainable use of tropical forests;
- Double the recycling of building and demolition waste;
- Find substitutes for materials whose extraction, use and/or waste processing has serious environmental consequences;
- Make a further saving of twenty-five percent in energy consumption for heating dwellings and buildings;
- Construct buildings of such a quality that risk values in the internal environment are not exceeded.





The idea of developing a demonstration project for energy-conscious and environmentally-aware building and living came into being as early as 1986. It was to be a project which would reflect current knowledge and experience in that field. In 1989, the Netherlands agency for energy and the environment (Novem) commissioned a feasibility study on such a project, financed by the Ministry of Economic Affairs. The study was carried out by Bouw-fonds Nederlandse Gemeenten (Building Fund Dutch Municipalities).

On the basis of the study results, it was decided to go ahead with the Ecolonia demonstration project; this involved the construction of a complete residential development consisting of approximately 100 single-family dwellings, built in an energy-saving and environmentally-conscious way. The dwellings were suitable for mass production building, and were not designed with specific target groups in mind. The first pile was driven in June 1991, with a view to completing the project in the summer of 1992. Bouwfonds Woningbouw bv is acting as the risk-bearing client for the dwellings to be sold.

Thematic approach

The requirements placed on the construction industry by the National Environmental Policy Plan played an important role in the discussions on Ecolonia, with complete attention being given to energy saving and environmental protection. Although it is an unavoidable fact that building and living involves the use of energy and places a burden on the environment, these can be reduced to a sensible minimum. In its aims of achieving sustainable development the NMP draws a distinction between the following policy lines:

1. Energy Conservation

The reduction of the consumption of energy derived from finite resources, by reducing the need, by the use of sustainable energy and by the optimisation of energy-saving heating and ventilation installations.

2. Integrated chain management

This term refers to the chain from raw material to demolition and re-use. Important aspects are the effects which the production process, product, residual materials, and the emission of substances into the air, water or soil have on energy consumption and environmental pollution.

3. Quality improvement

The product is of good quality if it meets a need over a long period, if it can be repaired, if it is suitable for re-use and if it does not produce any environmentally harmful waste. The occupier of the dwelling must not suffer any adverse consequences from harmful emissions during the period of use, a factor which demands extra concern for a healthy internal environment. The three policy lines from the NMP were selected as the starting points for the urban development plan and the housing designs in Ecolonia. Each policy line is further subdivided into three specific areas of concern; nine architects were then selected, and each was given the task of designing a number of dwellings, in which one of these areas of concern was incorporated. In addition, each architect had to meet the basic programme of requirements, in which the underlying principles for energy-saving and environmentally-conscious housebuilding were incorporated. The client also set stringent requirements as regards the budgets for the various types of dwelling.

This publication seeks to give an impression of the provisional results from this Dutch initiative. As a demonstration project, it is naturally geared to the Dutch housing market; conditions will vary in other countries. The information is intended to suggest ideas to interested parties in all the countries of the European Community, which in their own situations may contribute to energy saving and a responsible interaction with the environment.

Programme of requirements

At the start of the planning phase of Ecolonia, a programme of requirements was drawn up, based on the level of knowledge at that time. A distinction was made here between general requirements and requirements geared specifically to the particular themes from the NMP.

General requirements

- Environmentally-aware choice of materials for the internal and external drainage system.
- Use of concrete rubble granules as aggregate.
- Avoidance of the use of tropical hardwood.

- Choice of the glass in the dwellings.
- Use of anhydrite cast floors.
- Water-saving water supplies.
- Choice of paint, preservation materials and detailing.
- Avoidance of CFCs in materials used.
- Separation of (household) waste.
- Restriction of energy consumption to less than $< 300 \text{ MJ/m}^3$ or $< 220 \text{ MJ/m}^3$.
- The use of solar boilers (if permitted by the location).
- Avoidance of the use of bituminous products.
- Avoidance of penetration of radon into the dwellings.
- Space-heating equipment to be HR-low NO_x .

Requirements per theme

On the basis of the three policy lines from the NMP, the programme of requirements is divided into nine themes. These themes are worked

up in the designs of the dwellings, as showed in this ground-plan of Ecolonia.

Energy Conservation

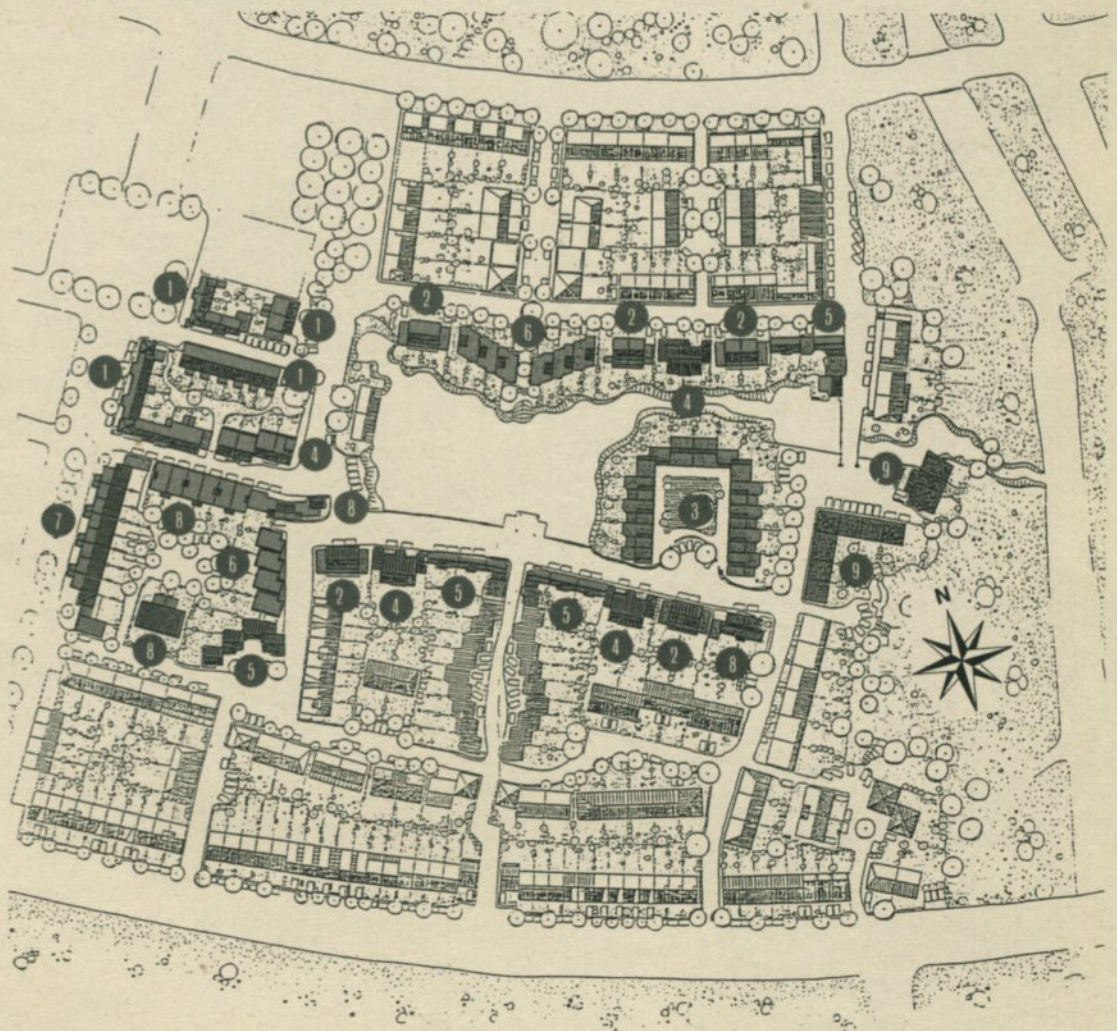
1. Extra attention for the reduction of heat losses
2. Extra attention for the utilisation of solar energy
3. Extra attention for energy-consumption during construction and living

Integral chain management

4. Extra attention for the limitation of water consumption and the recycling of building materials
5. Extra attention for long-lasting, low-maintenance materials and organic architecture
6. Extra attention for flexible construction and living

Quality improvement

7. Extra attention for sound-insulation within and between dwellings
8. Extra attention for health and safety
9. Extra attention for bio-ecological building



Underlying principles translated into unique urban development plan

The demonstration project forms part of an expansion plan in the Dutch town of Alphen aan den Rijn, a medium-sized Dutch municipality located in the 'green heart' of the Netherlands between the cities of Amsterdam, The Hague, Rotterdam and Utrecht. The municipal authorities were happy to cooperate in this demonstration project, even where this might present difficulties for the existing regulations. At the start of the project, Ecolonia was nothing more than an artificially raised area of moorland. The only original element was the natural waterway which ran alongside the construction site. From a town planning point of view, this was a rather unpromising prospect for the achievement of an ecological residential development.

Unusual urban development design

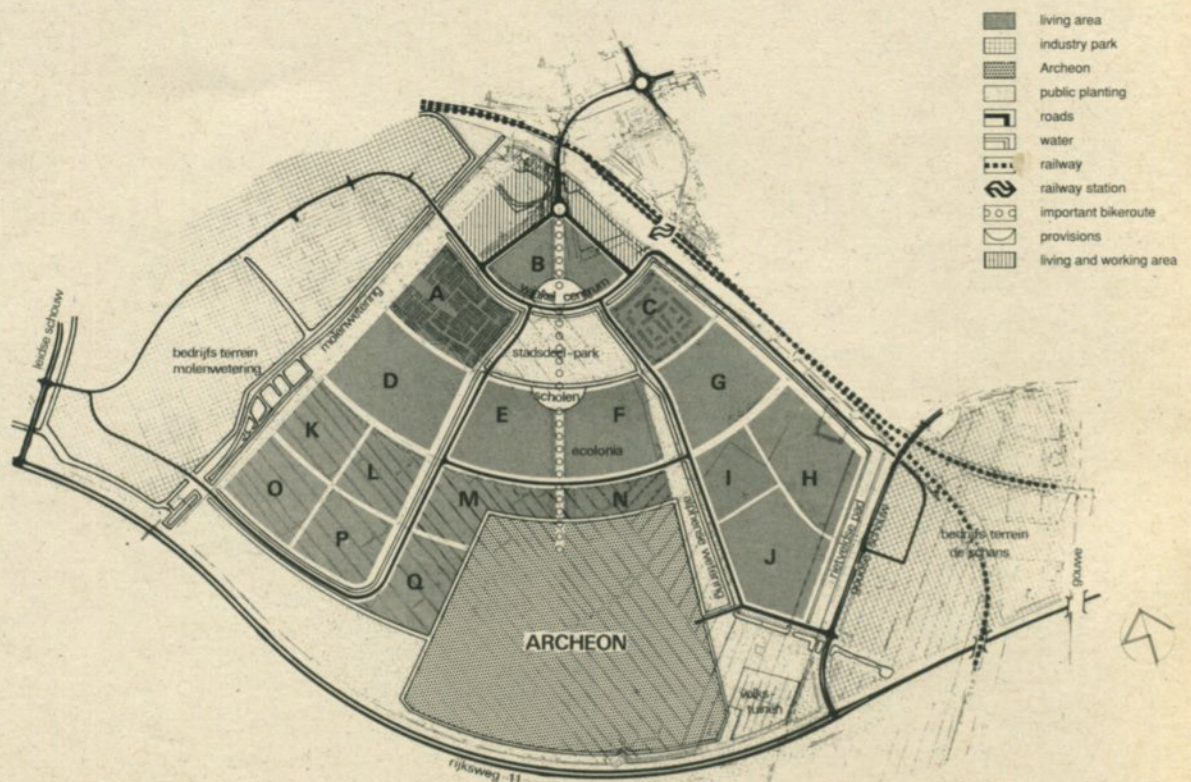
The Belgian town planning expert Lucien Kroll was invited to produce the design for Ecolonia. Kroll is a leading international urban architect, with a number of striking projects to his name in many countries. He saw an enormous challenge in the location and the conditions. His

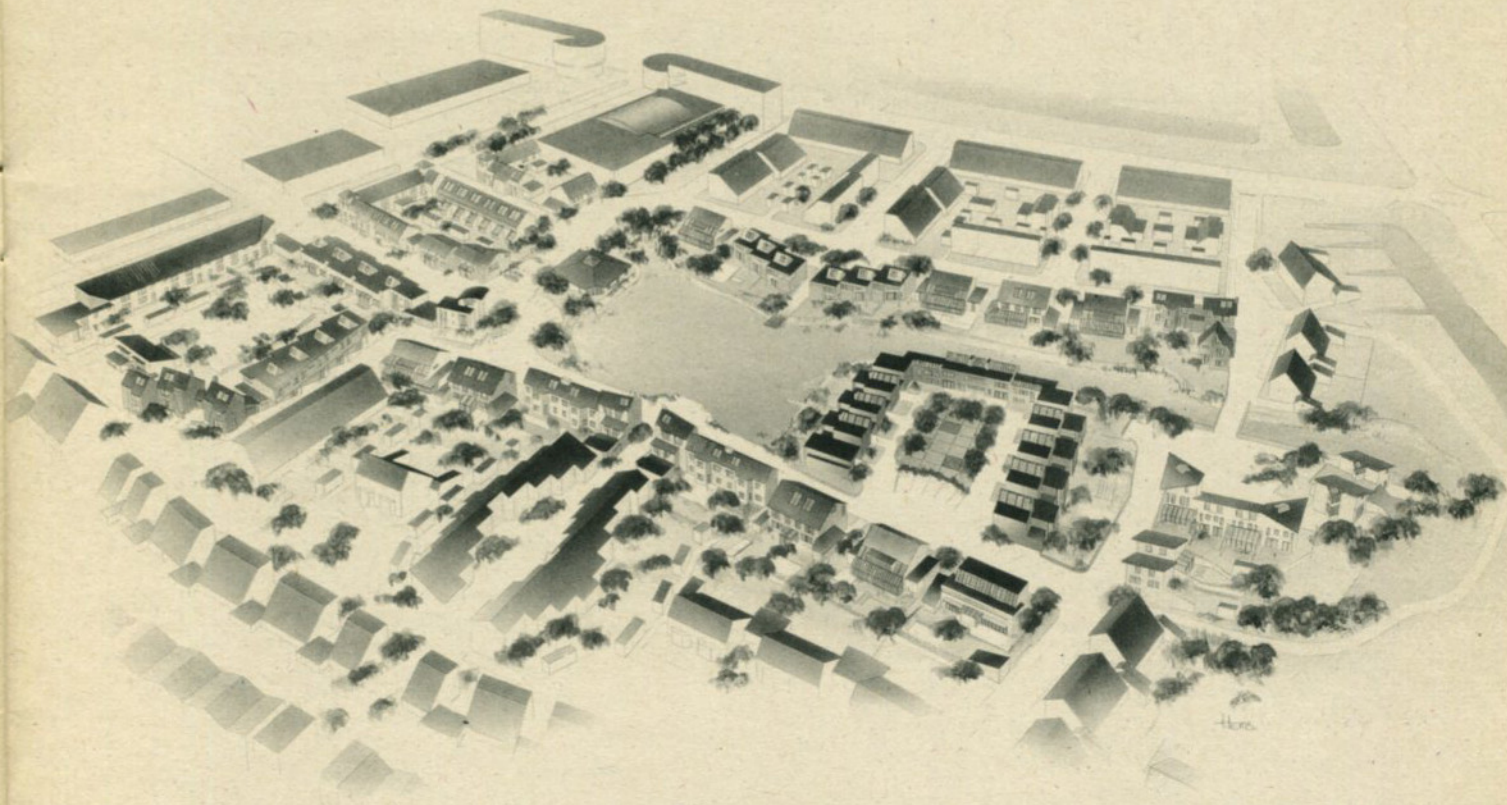
consultancy developed a plan in which man is challenged, as it were, to be more aware in his dealings with energy and the environment. The total planned urban development incorporates around 300 dwellings, of which more than 100 make up the Ecolonia demonstration project, which has a central location in the scheme.

Natural growth in a small-scale design

Kroll's ideas on urban development are based on the principles of natural growth. He compares this with the development of towns in centuries past. These grew according to requirements, and adapted to the personal needs of the people who lived and worked there. It was only much later that large-scale expansion began to take place in the form of residential developments which rose and rise out of the ground in a totally planned way.

Kroll favours a form of urban development which creates a relationship between the occupant and his surroundings. Smallness of scale is an important element in this because, according to this Belgian town planner, it is only in this way that a person can be motivated to become





concerned once again about his own place in nature. Ecolonia is a unique practical application of this philosophy - in this particular case, adapted to Dutch conditions, but in principle feasible anywhere.

Central place for lake

Water forms a natural part of Dutch life, and in the Ecolonia urban development plan too, water plays an important role, with an irregularly formed lake occupying a central position in the development. This not only creates a playful element, but is also functional, in that excess rainfall from the surrounding dwellings will be fed to this lake via mole drains. The result will be a closed system, with a summer and winter level, which means that the water courses originally planned for carrying away rain-water will no longer be needed. This solution has positive consequences for the natural development of the area; the variety of flora and fauna will increase, thereby also increasing the recreational function of the lake.

Functional open spaces

The urban development plan devotes a good deal of attention to the open spaces. The buildings have been positioned in such a way that streets and squares are created. In Kroll's vision, open spaces have a social function. Sometimes he emphasises the urban character of the scheme by placing dwellings directly adjacent to open spaces. In other places he does precisely the opposite, creating a gentle separation between dwellings and open spaces, by placing gardens between them.

Ecolonia is geared to the pedestrian; the car is no more than tolerated. A through-route has been deliberately avoided and there are no visible markings on the roads indicating areas for cars and other road users. The safety of the occupants has been given extra attention; the energy-saving lighting on squares, streets and paths continues at the rear of the dwellings.

Planting

The open spaces also had to underline the objectives of Ecolonia. Broad-leafed trees can

help to save energy: in the summer, they keep the sun away from the dwellings, while in the winter they allow sunlight and solar warmth through.

Planting can also soften the lines of an urban facade and invite the occupants to make use of the planted areas, and the public open spaces allow sufficient space for residents to develop their own initiatives. Kroll even toyed with the idea of planting a real orchard on one of the squares.

Differentiation in architecture

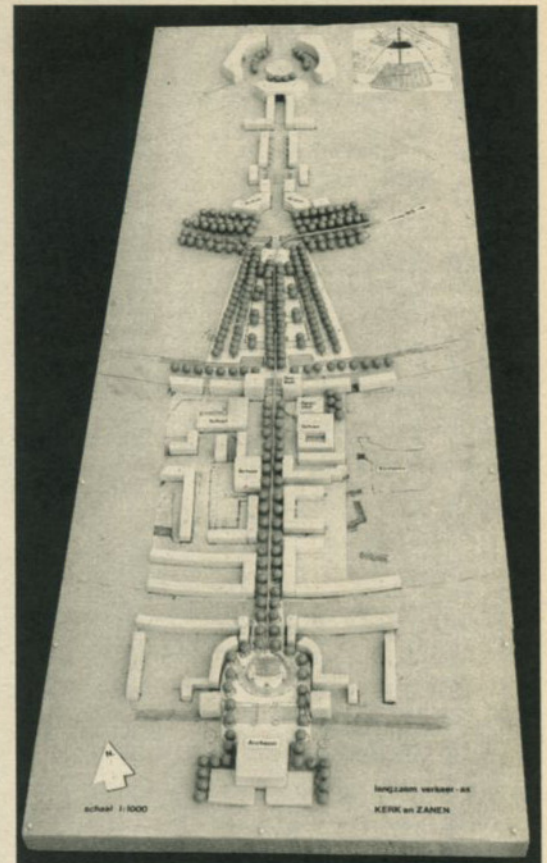
The architectural design lifts the plan above earlier plans. Dwellings running north-south are interspersed with blocks oriented in an east-west direction; this increases the interest and emphasises the urban character. Despite the fact that this sometimes has a less than favourable effect on sunlight reception, passive solar energy has been utilised in as many of the dwelling designs as possible.

Along with the small-scale design of Ecolonia, Kroll feels that there should be great variety of architecture. Best of all he would like to see all the dwellings having a different design.

Although this is not practicable, the compromise arrived at also produces a very special architectural result.

Kroll attaches a great deal of importance to the recognisability of the development, and emphasises this by using architectural accents at eye-catching locations. The main access to the development is marked by dwellings with an extra storey, creating a sort of entrance gate. At the end of a terrace of houses in a narrow street he has placed a 'tower', while in another area the corner site is given an extra accent. Uniformity is avoided. A street which suddenly becomes wider in the middle, and the varied style of building on the quay fronting the water underline these accents.

The variety of the architecture is carried through to the materials used in the dwellings. Brick, wood and plaster all play their part in giving a lively appearance to the development.



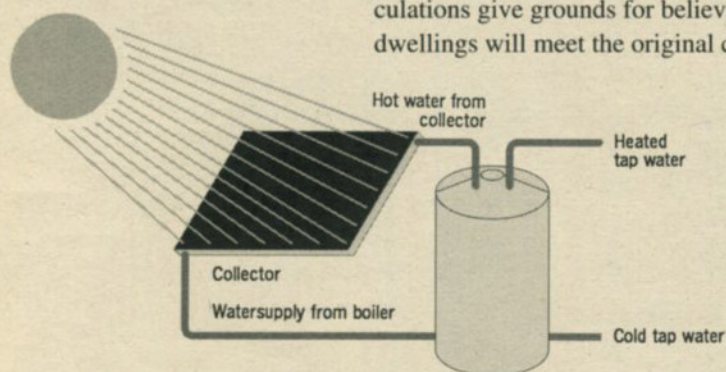
Ecolonia is bounded in the west on a slow-traffic route from the city centre to the educational park Archeon.

Ecolonia is a demonstration project. This is rather different from a trial ground for all kinds of experiments. All the designs were evaluated by experts from Dutch universities of technology and research institutes. They examined aspects concerning (building) technology and building physics, the effects on energy consumption and on the internal environment, the use of materials and the possibilities for recycling.

On the initiative of the experts, and in consultation with the architects, the plans were adjusted, where necessary, during the design phase. In doing so, a number of innovative solutions were deliberately avoided; after examination, these proved to carry risks for the envisaged energy saving or for the environment inside or outside the development. Risks to the durability and future maintenance of the dwellings were also avoided as far as possible.

Savings on gas consumption

For each dwelling design, calculations were carried out for a representative dwelling to assess the energy consumption for space heating and ventilation. The results of these calculations give grounds for believing that the dwellings will meet the original conditions set.



Solar boiler system

Foundations

The marshy subsoil makes it necessary to build the dwellings on piles. Although some architects have a preference for wooden piles with concrete followers, it was decided to use concrete piles, with concrete granules as the aggregate material.

Floors

Floors in Dutch houses almost always consist of concrete sections provided with an insulation layer.

These meet the requirements set in respect of

thermal insulation. A number of architects produced differing solutions in their designs, and two of these were subjected to a detailed evaluation by the experts.

1. A wooden box construction, filled with compressed wood cellulose as insulation material;
2. A hollow brick floor with an anhydrite finishing layer.

Given the Dutch method of building and the climate, the experts felt that Alternative 1 was not practicable. The construction of this floor demands many extra measures to prevent problems caused by damp. In addition, incorrect construction would cause the floor to lose its insulating function, and rotting is also a possibility.

These problems are not shared by the brick floor. In the opinion of the experts there is no objection to the use of this type of floor, provided it meets the requirements relating to insulation, density, cold bridges, moisture conduction and sound transfer.

The majority of the dwellings, however, will be fitted with concrete floors on the ground and upper storeys, in which concrete granules have been used as the aggregate.

Solar boilers

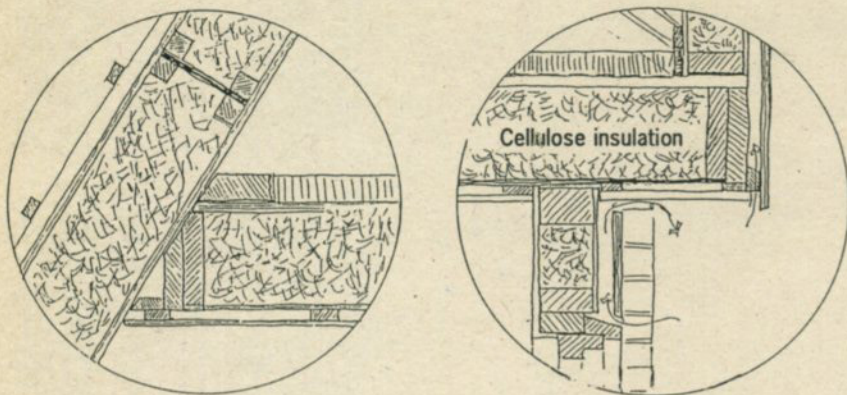
Approximately eighty dwellings are situated in such a way that solar boilers can be installed. The efficiency of the solar boilers in the other dwellings is too low, either because of the east-west orientation or because of the difficulty of incorporation into the dwelling design.

Photo-voltaic solar energy systems

Research is still being carried out into the use of photo-voltaic solar energy systems. Such systems fit in extremely well with the Energy Conservation theme, and their use can mean a significant reduction in the electricity consumption in the dwelling. In consultation with manufacturers and suppliers, a decision will be taken at a later stage as to which dwelling designs are suitable for PV systems.

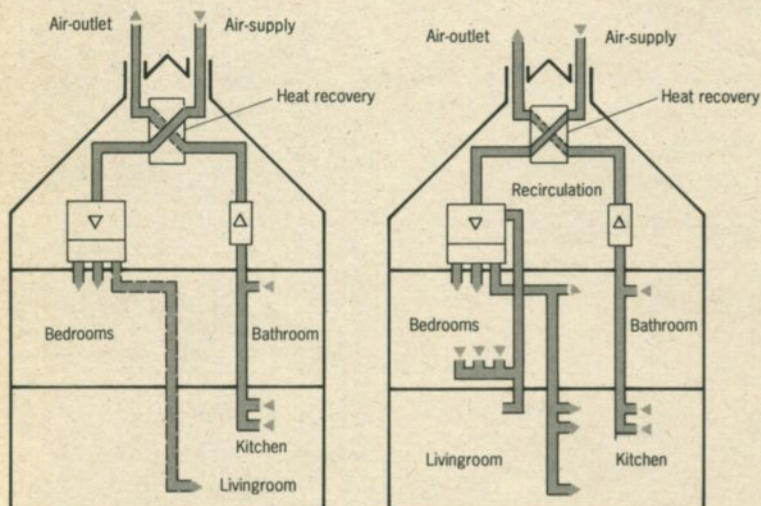
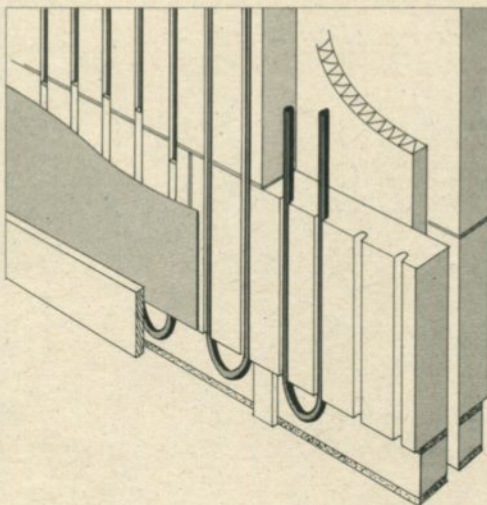
Wall and roof insulation

The wood cellulose referred to earlier was also suggested by a number of architects as an insulation material for cavity walls, and as a roof insulation material. The Netherlands



Wood cellulose as isolation material for cavity walls, floors and roofs.

One of the architects developed, in collaboration with the industry, a 'heatwall' built of lime-sandstone modules.



Two balanced ventilation systems.

1. As a single system with selective supply of fresh air.
2. In combination with an air-heating system, without selective supply of fresh air.

Organisation for Applied Scientific Research (TNO) carried out a literature study to ascertain experiences with compressed wood cellulose as an insulation material in other countries. This study showed that damp problems can destroy the thermal insulation value. According to the experts, this material is suitable for use only in the so-called 'recycled dwellings'. In the detailed drawings, the architect will have to make clear that the risks of damp have been avoided in a sound manner.

The roofing sheets require special attention. The literature shows that roofing sheets insulated with wood cellulose can cause damage to the roof. TNO adds here that, in the majority of countries, no research has been carried out into the use of this insulation material.

Water saving

Water-saving toilets and taps and, where possible, flow limiters, have been installed in all dwellings.

In addition, the utilisation of rain-water means a reduction in (mains) water consumption. A further reduction in water consumption is made possible by the recycling of bath and shower water, compost toilets and flow chests. Some of the systems referred to prove not to be usable in practice, or else are very sensitive to use.

Heating and ventilation installations

The space-heating systems must have to have a high efficiency, combined with a low environmental load (HR-low NO_x). A total of 61 dwellings will be fitted with a balanced ventilation system with a heat recovery unit, while 32 dwellings will be fitted with a mechanical extraction system with natural air supply. One dwelling type (8 dwellings) will be provided with completely natural ventilation. The requirement set for this system by the experts is that the supply and extraction openings be properly sited.

Domestic hot water will be provided as far as possible by solar boilers. In dwellings which do not possess such equipment, an indirectly fired boiler will be installed in combination with a high-efficiency boiler.

A short description of the nine dwelling designs follows.

Extra insulation must save energy

Architects:

Bakker Boots Haaren
Van der Donk
Architectenburo bv, Schagen

Priorities arising from the theme

First priority:

- High thermal insulation.
- Window system with a high thermal resistance.
- Attention paid to overheating.
- Double-glazing with external sun protection (roller blinds).
- Thermal insulation between dwellings.
- Compact building style.
- Enclosed kitchen, and enclosed attic staircase.
- Heat recovery system.
- Enclosed porches.

Second priority

- Small window area on the north wall.
- Thermal insulation within the dwellings.
- Passive solar energy.
- Active solar energy via solar boiler and enlarged solar boiler.

Design

Several of the 18 dwellings which have been designed on the basis of this theme are located around the perimeter of Ecolonia. This theme makes a north-south orientation of the dwellings an obvious choice; however, the development plan specified other requirements, such as closed corners, relatively narrow streets in an east-west direction and small, enclosed inner areas.

The closed corner design has consequences for the adjacent dwellings. In view of the accessibility of the rear and the layout of the gardens, these dwellings were given a broad, shallow design. This means more square meters of heavily insulated frontage, which in turn means higher costs. A high level of thermal insulation makes it possible to meet the requirements of this theme, even in relatively difficult locations as regards insulation.

The living rooms in this block face either south or west. The corner dwellings have an extra storey in order to heighten the architectural accent. In the other type of dwellings the living room faces the garden, while the entrance hall and kitchen face the street. All dwellings have three bedrooms and a bathroom on the first floor, and

all are fitted with an enclosed porch on the ground floor, which is divided or constructed separately from the staircase hall, in order to prevent heat loss.

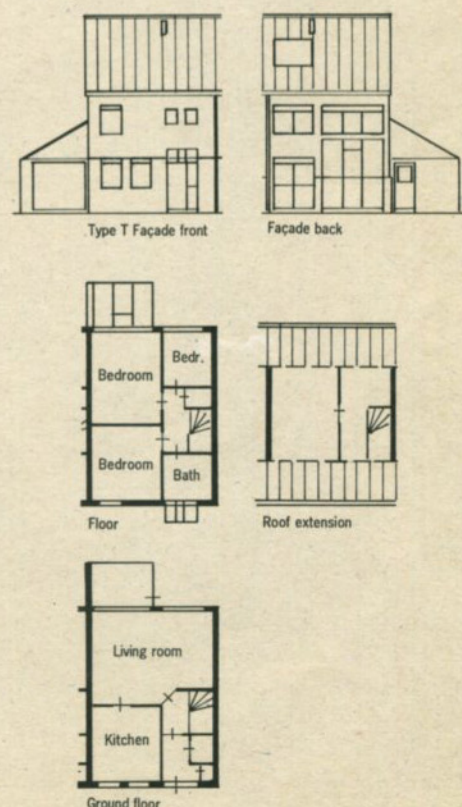
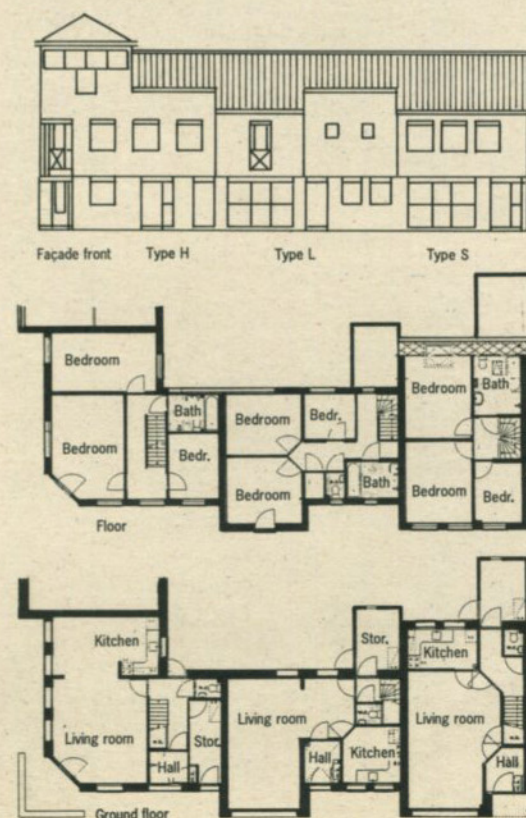
Development

The design meets the requirements of the theme through the following measures:

- High thermal insulation of the walls
 $R_c = 4.0 \text{ m}^2\text{K/W}$.
- Floor insulation on ground floor
 $R_c > 3.0 \text{ m}^2\text{K/W}$.
- Roof insulation $R_c = 4.0 \text{ m}^2\text{K/W}$.
- Window system with a U-value of approximately $1.4 \text{ W/m}^2\text{K}$. Roller blinds contribute to this, but also serve as sun protection.
- Thermally insulated party walls.
- Enclosed kitchen to restrict the quantity of ventilation air.
- Air heating with balanced insulation and heat recovery system.

Other measures designed to prevent heat losses:

- Limitation of the window area in the north wall.
- Solar boiler in dwellings with a south-facing roof area, fitted with re-heating.



Solar panels and conservatory limit gas consumption

Architects:

Architect J.P. Moerhlein,
Groningen

Priorities arising from the theme

First priority:

- Large glass area facing south.
- Small windows facing north.
- Conservatory.
- Solar boiler.
- Sun-lounge dwelling.
- North-south orientation.
- Measures to combat overheating.
- Dwelling block.

Second priority:

- Drum-wall type applications.
- Solar cells using PV system (option).
- Extra enclosed porches.

Design

The ten dwellings based on this theme have been built in five blocks of two dwellings, oriented in a north-south direction. The street side always faces north.

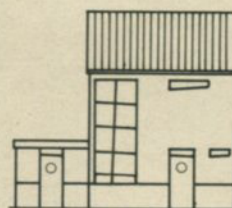
The architect designed the dwellings with a timber frame construction. This contains a core within which the occupants must feel protected and comfortable. The core is enclosed on the north side by the entrance hall, toilet, staircase, kitchen and pantry. On the south-facing side, a conservatory adjoins the living room, separated from it by a sliding glass door. The conservatory functions both as an energy trap and a buffer zone, and is fitted with ventilators to remove excess heat. Steps have also been taken to prevent overheating.

The first floor consists of three bedrooms and a bathroom. The attic contains a solar boiler, together with the central heating installation and the heat recovery unit for extracting heat from the ventilation system.

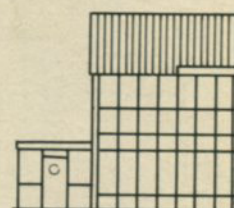
Development

In order to meet the requirements of this theme, attention was given to the following points in this design:

- A large window area facing south and small windows facing north.
- The living room faces south.
- Walls, roof and floor have a heat resistance of $R \geq 3.0 \text{ m}^2\text{K/W}$, and the glazing has a U-value of $1.6 \text{ W/m}^2\text{K}$.
- Extra draught-sealing for optimum functioning of the ventilation system (balanced ventilation and heat recovery with high thermal efficiency).
- Heating installation geared to the functioning of the conservatory, with thermal zone regulation.
- Internal climate control in summer and winter via sun protection and ventilation openings in the conservatory.
- Active solar energy for domestic hot water production.
- Enclosed kitchen and staircase to attic.



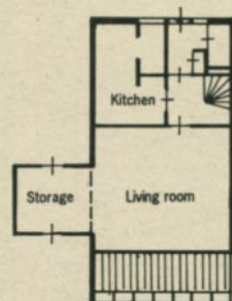
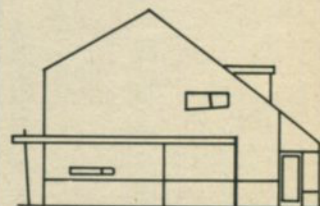
Façade north



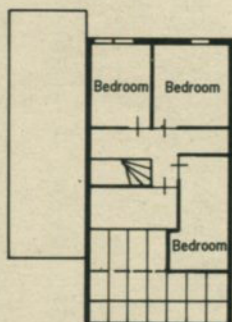
Façade south



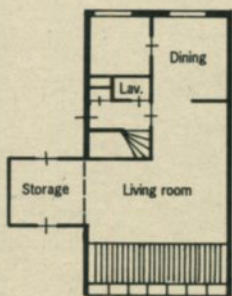
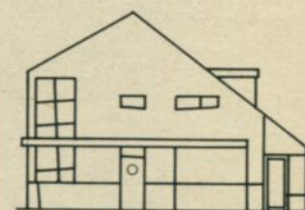
Floor



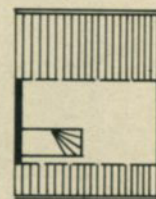
Ground floor
Type 1



Floor



Ground floor
Type 2



Roof extension

Split-level to utilise solar radiation

Architects:

Architectenburo Hopman bv,
Delft

Priorities arising from the theme

First priority:

- Limitation of heat needed for space heating.
- Solar boiler for domestic hot water, or enlarged solar boiler for both space heating and domestic hot water.
- Balanced ventilation system with heat recovery unit.
- Passive solar energy.
- Compartmentalisation for limitation of heat demand.
- Minimisation of energy consumption and raw materials for construction and use of buildings.

Second priority:

- Compact building style.
- High thermal insulation.
- Cool cellar cupboard (reducing electricity consumption for refrigerator).
- Limitation of energy consumption for cooking.

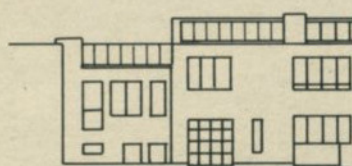
Design

The architectural starting point for the eleven buildings designed within this theme is a U-shape surrounding an enclosed inner courtyard. This means that dwellings with south-facing walls receive little sun in the winter due to the shadow formation - a less than ideal situation, given the theme.

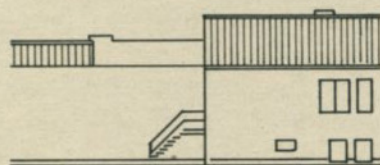
In order to utilise the passive solar energy as far as possible, the architect opted for an open-plan split-level arrangement. The shape of the roof was also adapted to this design, with space being made for solar collectors.

The split-level arrangement means that the living rooms receive sufficient sunlight, even with a low solar position in winter. In addition, daylight penetrates to the heart of the dwellings, thus reducing electricity consumption.

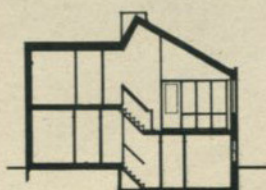
The heating and ventilation equipment is located in a central core. Solar collectors provide the domestic hot water. A small low- NO_x HR heating boiler is sufficient; the architect expects an extra contribution to the space heating to come from accumulation in the core, and heat recovery. Ventilation is provided by a balanced ventilation system.



Façade front



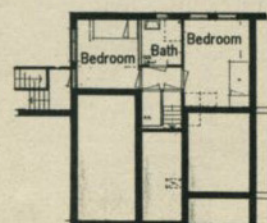
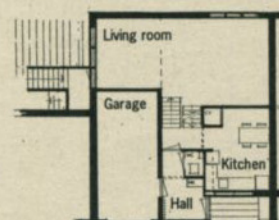
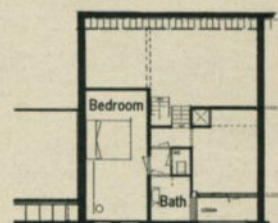
Façade back



Development

The following measures have been incorporated in the design in order to meet the requirements of the theme:

- High level of attention for daylight penetration and insolation.
- Utilisation of passive solar energy.
- Elimination of the creep space and the positioning of the children's bedrooms partially below ground, leading to saving in energy for space heating.
- Heating/ventilation equipment enclosed in central core.
- Heating installation with three-zone control, operating partly as underfloor heating, and a balanced ventilation system with heat recovery unit.
- Enlarged solar boiler in a number of dwellings, producing hot water for space heating and domestic hot water requirements.
- A cool cellar cupboard located at the lowest level.
- Extra insulation for walls, roof and floor on lower storey.
- Solar boilers for providing domestic hot water.
- Use of materials with a low energy content.



Dwelling design fits in with natural cycle

Architects:

BEAR Architecten, Gouda,
Buro voor
Architectuur en Renovatie

Priorities arising from the theme

First priority:

- *Recycling of materials.*
- *Timber frame construction.*
- *Natural paints.*
- *Concrete granules in the floor of the ground floor, flue gas desulphurisation plaster, insulation material based on recycled wood cellulose.*
- *Rain-water used for toilet flushing, garden and car.*
- *Water-saving showers, taps and toilet.*
- *Waste separation.*
- *Solar boiler.*
- *Enclosed boiler in the kitchen.*

Second priority:

- *Conservatory.*
- *Demolition plan (reusability and recycling aspects).*
- *Separable demolition.*
- *Compost toilet.*
- *Flow chest.*
- *Heat recovery from waste water.*
- *Re-use of wood from demolition.*

Design

This theme has been actualised in the form of a block of four retirement dwellings and six semi-detached dwellings. Both types of dwelling are oriented in a north-south direction, with the living areas facing south. The dwellings are built using a timber frame construction.

The retirement dwellings consist of a south-facing living room on the ground floor, plus a kitchen, bedroom and bathroom. The first floor contains a second bedroom.

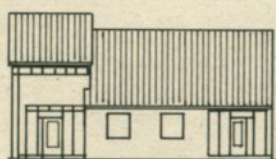
The "recycled dwellings" have an enclosed porch, entrance hall and kitchen facing north. The livingroom faces the garden, and can be fitted with a conservatory. Three bedrooms and a bathroom are situated on the first floor, and there is space for an additional room in the attic.

Heating is provided by a low-NO_x HR boiler, which also tops up the temperature of the hot water in the solar boiler. Adequate ventilation is provided by a mechanical extraction system.

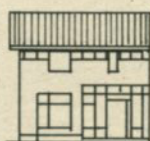
Development

The architect devoted a great deal of attention to the natural cycle, within which he distinguished five themes.

1. Use of raw materials which form part of the carbon cycle, such as wood, cellulose, natural paint, resins and cement. In time these will once again disappear into the environment to serve as raw materials for other forms of life.
2. Recycling of residual materials and waste must lead to beneficial re-use. Examples include rubble and concrete granules, flue gas desulphurisation plaster and compressed wood cellulose.
3. Reduction of water consumption through the use of water-saving showers and toilets. An installation for using rain-water for domestic applications also results in energy savings and reduces the burden on the environment.
4. Utilisation of the food cycle by composting vegetable waste from home-grown vegetables. Measures are necessary for separation of waste.
5. Use of solar energy produces savings in fossil fuel consumption. Use of passive solar energy must therefore provide domestic hot water and contribute to space heating.



Façade north



Façade south

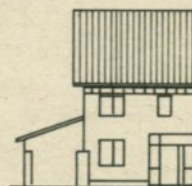
Retirement dwelling



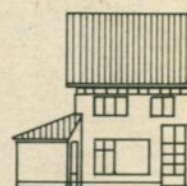
Floor



Ground floor

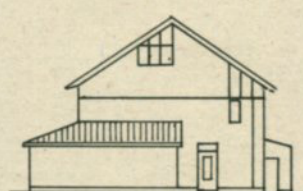


Façade north



Façade south

Recycled dwelling



Floor



Ground floor

Architecture emphasises harmony with nature

Architects:

Architectenbureau
Alberts & Van Huut,
Amsterdam

Priorities arising from the theme

First priority:

- *Materials and components with a long life.*
- *Materials and components which require little maintenance.*
- *Easily replaceable materials and reusable components.*
- *Concrete granules.*
- *Detailing.*
- *Protection of constructions against effects of weather.*
- *Roof overhangs.*

Second priority:

- *Demolition plan (re-use and recycling).*
- *Separable demolition.*

Design

Organic architecture emphasises the common bond between man and the earth. Twelve dwellings were designed on the basis of this underlying principle, which led to a characteristic design and arrangement of the dwellings. The ground floor consists of an entrance hall, living room and kitchen.

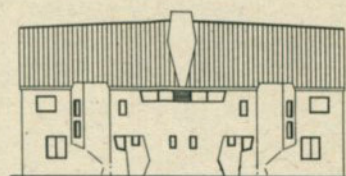
Three bedrooms and the bathroom are situated on the first floor.

The underlying principles of organic building also play a role in the materials used; heavier materials are placed at the bottom, and lighter materials above. The architect opted for a traditional "heavy" dwelling with a good accumulative capacity. The shell is built from lime-sandstone with an outer skin of brick. The characteristic sloping roof varies in ridge height, as does the eave height. This creates an irregular roof line which moves with the flow of the architecture.

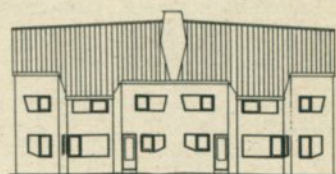
Development

In order to test the materials for their durability and maintenance the architect constructed a matrix for his own use containing a number of assessment criteria, and this was used as an aid in making the correct choices. Windows and frames are made from European softwood, with European hardwood lintels and lower sills.

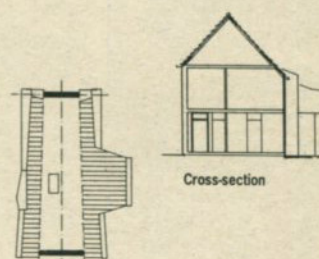
Non-harmful preservation techniques must give an adequate guarantee of durability and quality. In the view of the experts, the detailing of the deviating frame designs requires a good deal of attention.



Façade north

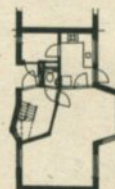


Façade south

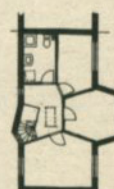


Cross-section

Roof extension

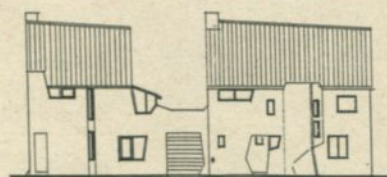


Ground floor

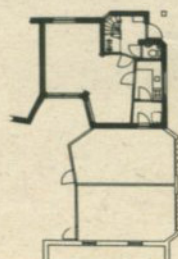


Floor

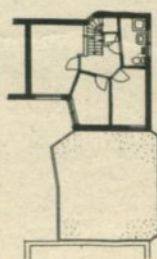
Type A



Façade north

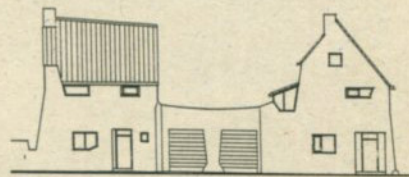


Ground floor

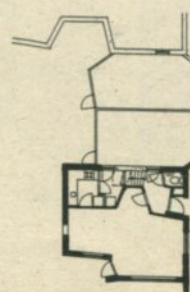


Floor

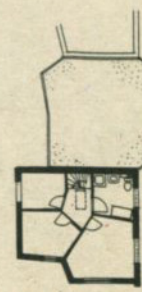
Type D1



Façade east



Ground floor



Floor

Type D2

Variations on a flexible basic design

Architects:

Lindeman c.s., Architecten
en Ingenieurs,
Adviseurs energiebeheer,
Cuyk

Priorities arising from the theme

First priority:

- *Reusable building modules in the outer wall and within the dwelling.*
- *Extendable dwelling.*
- *Possibilities for altering living function.*
- *Flexible arrangement of floor plans and outer wall elements.*
- *Removable building modules.*
- *Flexible and modifiable heating/ventilation installations.*
- *Manageability of internal modules for the user.*

Second priority:

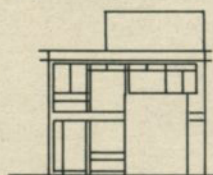
- *Variable connection possibilities for gas, electricity and water.*
- *Detailing related to sound insulation and tightness of internal and external module connection.*

Design

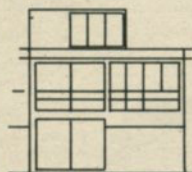
The possibilities offered by flexible building and living are represented in ten dwellings divided between two locations. Four terraced dwellings are situated in a narrow street, with the remaining six being built in two blocks of three. The centre of the dwelling consists of a core in which the staircase, toilet and utility shaft are fitted. This arrangement allows the layout to be varied. By placing the heating and ventilation installations in the roof construction, there is also wide scope for laying out the upper floor. Fixed pipe conduits on the ground floor also make it possible to move the kitchen within certain limits.

A flexible layout requires a flexible outer wall arrangement. The design provides for this by dividing the outer walls into two identical areas on each storey. Interchangeable glass doors are situated in these areas.

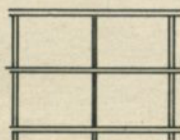
The dwellings contain light (portable) divider walls and are provided with air heating with a balanced ventilation system and heat recovery unit.



Façade north



Façade south

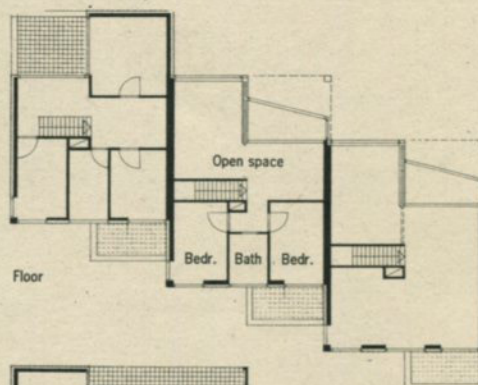


Cross-section

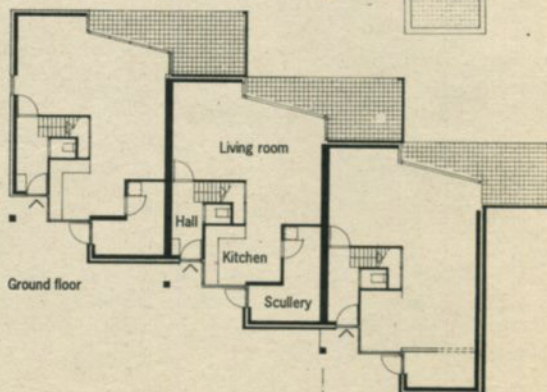
Development

Five types of dwelling illustrate the flexibility offered by the design.

1. **Basic dwelling.** Four-room dwelling with entrance hall, (diner)/kitchen and store room on the street-facing side. The living room is located on the side facing the garden. The upper storey contains three bedrooms and the bathroom, plus a large, multi-functional landing.
2. **Privacy dwelling.** This variant has a living room split into a front and rear room, with the kitchen in between. The first floor consists of two more or less independent living/sleeping areas, offering optimum privacy.
3. **Retirement dwelling** with all living areas on the ground floor. The living room may be placed either on the side facing the street or on the garden side. The first floor can then contain a separate apartment.
4. **Combined dwelling/work area.** This design contains a work area on the ground floor facing the street and a large living room/kitchen facing the garden. The first floor contains a living room, with adjoining bedroom and bathroom.
5. **Double apartment.** Both floors contain a full range of living areas (68 m²). A separate upper floor entrance can be provided if necessary, though this will have consequences for the layout.



Floor



Ground floor

Heavy core provides good sound insulation

Architects:

Vakgroep FAGO, Faculty of
Building Technology,
Eindhoven University of
Technology

Priorities arising from the theme

First priority:

- Sound insulation of the walls, including wall openings.
- Sound insulation of the areas between the dwellings.
- Sound insulation between rooms within the dwellings.
- Quiet room.
- Sound insulation of noise from heating/ventilation plant between rooms in dwellings and between dwellings.
- Vibration-free mounting/fixing of stairs, front steps, handrails etc.

Second priority:

- Integral suspension system.
- Enclosed boiler in the kitchen.
- Central dust extraction system.
- Detailing of removable internal walls.

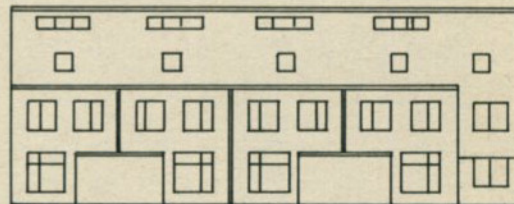
Design

These ten dwellings are situated at the front of the urban development scheme, facing west towards a slow traffic axis. There is provision for parking at the rear, which increases the importance of the rear entrance. The architect has also situated the staircase, toilet and kitchen on this side. The living room faces the street. On the first floor, the main bedroom and the bathroom are on the eastern side, with a further two bedrooms on the western side. The dwelling can be extended vertically. It is possible to place a wooden "box" on the flat part of the roof, providing space for a further two bedrooms. In this way the lower floor can be released for use as a work area, with the living room and kitchen being housed on the first floor.

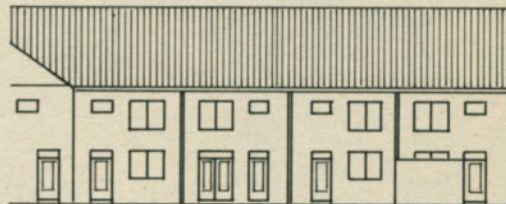
Development

Party walls between dwellings consisting of 2 x 150 mm lime-sandstone modules, using the anchorless cavity method, guarantee good sound insulation between the dwellings. The foundations are also separated. A 'sound core' is incorporated in the dwellings and contains the staircase, toilet, bathroom, heating/ventilation equipment and washing machine. This core has a 150 mm thick wall of lime-sandstone, which continues through the three floors.

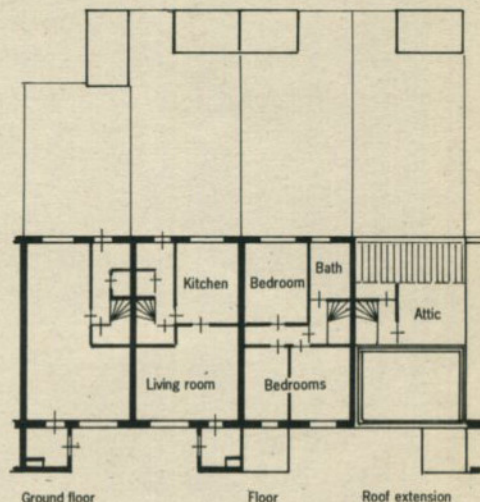
In addition, the main bedroom has been designed as a 'quiet room'. The room is separated from the lower floor and the loft by concrete floors, and from the other bedrooms by wood-frame walls with sound insulating doors. The inner skin of the outer walls is constructed from 100 mm thick lime-sandstone up to the top of the first floor, with an outer skin of brick. The cavity is filled with mineral wool. The attic wall is constructed using a wood-frame construction, with sufficient insulation to provide good acoustic and thermal insulation. Attention has also been given to the positioning and attachment of stairs, front steps and handrails.



Façade west



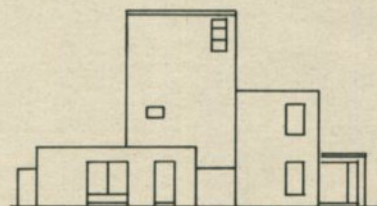
Façade east



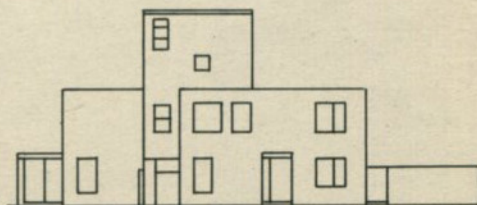
Ground floor

Floor

Roof extension



Façade north



Façade south

Urban dwelling with architectural accent

Architects:

Buro voor energie-ontwerp,
architectuur en stedenbouw
Peter van Gerwen, Amersfoort

Priorities arising from the theme

First priority:

- Limitation of chemical pollution of the interior air.
- Cleanable ventilation systems.
- Controlled supply and extraction of ventilation air, with extra filtration.
- Ease of cleaning of the dwelling.
- Limitation of pollution by building materials.
- Avoidance of cold bridges and mould.
- Enclosed kitchen.
- Central dust extraction installation.
- Underfloor heating on ground floor.

Second priority:

- Electrical cooking equipment.
- Covered electricity cables.
- Separate drying area.

Design

The dwelling designs which devote additional attention to the theme of health and safety are divided into a terrace of eight dwellings plus two blocks of semi-detached dwellings. All dwellings are oriented in a north-south direction. The terraced dwellings are situated on a narrow street which terminates by the lake. From an architectural point of view, this location demanded an accent.

The architect chose a relatively tall design for the north walls facing the street. These walls are massive and consist of staggered "discs" ending in a "tower" located on the corner dwelling. Lighter materials have been used for the south-facing walls. The dwellings have flat roofs.

With the exception of the corner dwelling, the ground floor contains the entrance hall, living room, kitchen and store room. Three bedrooms, a bathroom and storage space are located on the first floor.

In the corner dwelling, the bedrooms are on the ground floor. The living area is moved to the first floor, and there is a tower room on the second floor which can be used for various purposes.

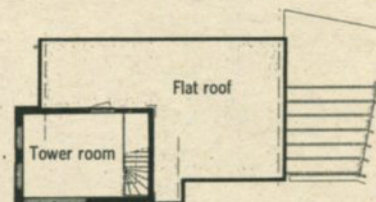
Development

The attention which the design focuses on the theme of health and safety is apparent from the following factors, among others:

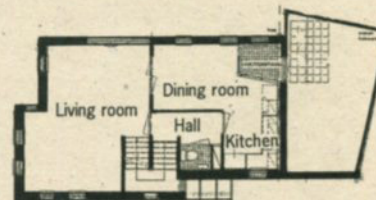
- The limitation of chemical pollution of the interior air.
- The controlled supply and extraction of ventilation air with central, cleanable filtration and heat recovery.
- Front steps.
- Additional attention for ease of cleaning of the dwellings.
- Limitation of pollution from the building materials used.
- Extra attention for cold bridges and mould problems.
- Enclosed kitchen.
- Central dust extraction.
- Underfloor heating on ground floor.
- Electrical cooking equipment.
- Covered electrical cables.



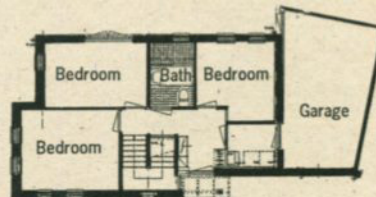
Façade north



Roof extension



Floor



Ground floor



Façade north



Façade south



Ground floor



Floor

Architect develops energy-saving heat wall

Architects:

Architectenbureau
Archiservice, 's-Hertogenbosch

Priorities arising from the theme

- *Natural building materials and sustainable energy sources.*
- *Environmental pollution avoided as far as possible.*
- *Maintenance or improvement of the wealth of variety of plants and animals.*
- *Integration of the building in the landscape.*
- *Electrical, magnetic and electromagnetic fields, global radiation, cosmic radiation and radioactive radiation.*
- *Aspects related to living physiology, colour and the living experience, both in the dwelling and in the vicinity.*
- *Sound, light, temperature, heat, humidity and ventilation.*
- *Energy and material management, as well as water and air maintenance, all interrelated.*

Design

The eight dwellings designed within this theme combine the use of natural materials with a non-standard heating system. All dwellings are fitted with a solar collector together with "heat walls" developed by the architect in collaboration with the industry.

In the bio-ecological vision, both subjectively and objectively measurable influencing factors play a role. The designer focuses attention on electrical, magnetic and electromagnetic fields, global radiation, cosmic and radioactive radiation, and the influence of these factors on the internal environment and the psychological consequences for the occupant.

Six terraced houses are being built in one corner, while the other two are semi-detached. The living rooms adjoin the gardens facing south and east, and the possibility of building on a conservatory has been allowed for. The entrance hall and kitchen are located on the side facing the street. There are three bedrooms and a bathroom on the first floor. The corner dwelling forms an exception, being designed to house a practice or to be used as a shop, for which the garage can also be taken into use.

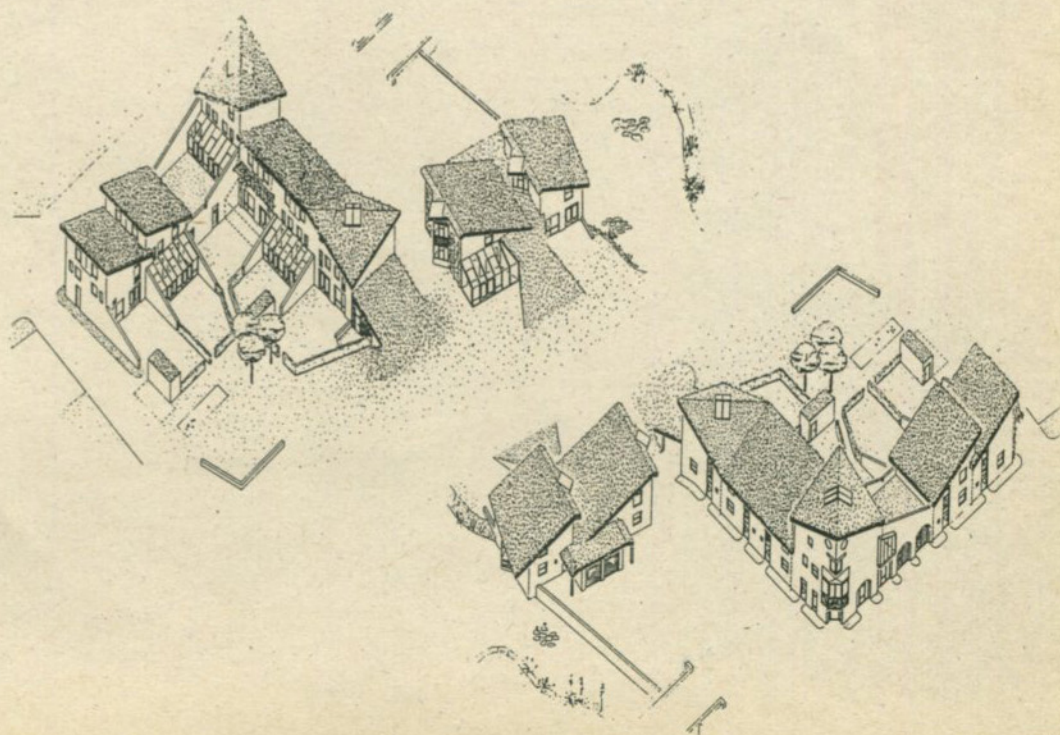
As a result, the living area is moved to the first floor with the bedrooms being on the second storey.

The extra storey adds an architectural accent to the corner.

Development

The shell of the dwellings is built from lime-sandstone. One striking feature is the "heat walls" which are used in both types of dwelling. These walls were developed in collaboration with the suppliers.

The architect wishes to construct the floors on the ground floor of all dwellings from modules of ceramic cast stone, covered with mineral wool on the underside. The floors of the loft and upper floors in the terraced houses are made of deal, covered with 20 mm thick cork sheeting and 35 mm thick natural anhydrite. In the other dwellings, the floor of the first storey is made of hollow ceramic brick elements covered with a 35 mm thick cast floor of natural anhydrite. All dwellings have a so-called "vegetation roof". The construction consists of deal rafters covered with 20 mm thick cork, possibly containing pipework. This is covered by a 1.3 mm thick EPDM rubber roof covering containing sleeves for the roof channels. On the sloping roofs this is covered with a 50 mm thick layer of mineral wool, and on the flat roofs with expanded clay granules to serve as a drainage and aeration layer. The roofs are finished with a 150 mm layer of peat substrate and grass turves. The downpipes for carrying away rain-water are replaced by chains. A solar collector is located in the roof, and is connected to a 200-litre boiler for providing domestic hot water.



There is a growing international realisation that the use of fossil fuels such as oil, gas and coal must be reduced. The Dutch Government has since 1973 been pursuing an active policy to reduce energy consumption, including in the housing sector; an insulation programme for both new and existing dwellings reduced the average consumption of natural gas per dwelling from an average of 3300 m³ to 1300 m³ in the period between 1973 and 1988. In 1989 the National Environmental Policy Plan (NMP) appeared. In this document the Dutch Government sets out the lines for a further saving in energy, coupled with concern for the environment. The (house)building industry is given a number of concrete tasks in the NMP, which must be achieved before the year 2000. The most important measure is a further reduction of twenty-five per cent in the energy consumption.

Anyone wishing to build in an energy-saving and environmentally-conscious way must be aware of what is and is not possible. The Netherlands agency for energy and the environment, in collaboration with the government and the Building Fund Dutch Municipalities, therefore took the initiative of setting up a demonstration project for energy-saving and environmentally-conscious building and living. The project was given the name Ecolonia.

Ecolonia is being built in an urban expansion area in the Dutch municipality of Alphen aan den Rijn.

The urban development plan was prepared by the Belgian town planning architect Lucien Kroll. He came up with an unusual design for a living and working environment, in which as many "natural" elements as possible are incorporated. It is a project which challenges the occupants to act in an energy-saving and environmentally-conscious way.

Following selection, nine architects were given the task of designing a number of dwellings to fit in with the objectives of Ecolonia and the urban development plan. The guiding principles governing the extra attention which had to be

focused on energy-saving and environmentally-conscious measures were the following three policy lines from the National Environmental Policy Plan:

1. Energy Conservation.
2. Integrated chain management.
3. Quality improvement.

Each policy line was subdivided into three specific areas of concern. In addition to an identical basic programme of requirements, each architect was given the task of focusing extra attention in his designs on one of these sub-themes.

Ecolonia is a demonstration project, and is not a trial ground for experiments. The dwelling designs were assessed by experts from Dutch universities and research institutes. These experts looked at the technical aspects relating to the building construction and building physics. The effects of the measures taken on the energy consumption and on the (internal) environment were also critically examined, as were the materials used and the possibilities for recycling.

A start was made on the building of the dwellings in June 1991, with a view to completing the construction in the summer of 1992. A measuring programme will complete the project in 1993.

Conclusions

- At the start of the planning phase, in 1989, a programme of requirements was drawn up. This was based on the state of knowledge at that time, and set conditions for the energy-saving and environmentally-conscious nature of the techniques and materials to be used. For each policy line from the National Environment Policy Plan, a number of supplementary requirements were set which had to be met by the dwelling designs.
- An urban development plan which is based primarily on the building of energy-saving dwellings need not by definition be based on north-south oriented dwellings. Ecolonia demonstrates that east-west orientation of houses can also meet the requirements set.
- Architectural accents at certain points in the projects, as required by the architect, proved to be possible within the budgets.
- The development and execution of a project such as Ecolonia sometimes conflicts with existing regulations. A flexible attitude by the local authority is necessary in order to achieve the envisaged goal.
- Within the objectives of Ecolonia, it has proved possible to combine variation in architecture and dwelling design. However, this carries a price. The collaboration with several architects demands extra time for the monitoring of budgets and the coordination of designs.
- For the client, it is important that he takes the advice of experts in assessing plans for energy-saving and environmentally-conscious housing developments to test their compliance with the requirements set and to assess the risks of alternative materials, products and techniques.
- Ecolonia can be built within the budgets which have been made available. In order to achieve this, however, all architects have had to make concessions with respect to their draft plans, which were too expensive in every case.
- The combination of energy-saving building and concern for the environment can be achieved optimally using existing building materials and methods.
- Depending on the internal volume of the dwelling, the calculated average energy consumption for space heating will amount to ≤ 500 to ≤ 800 m³ natural gas. The dwellings therefore more than meet the targets in the National Environmental Policy Plan.
- A literature study carried out by TNO showed that the use of compressed wood cellulose, which was included by some architects in their designs, carries risks. The entry of moisture can destroy the insulating function of this material, and rotting may occur.
- It is extremely important to match the dwelling design to the heating and ventilation systems. The more sophisticated heating and ventilation systems, in particular, demand careful sealing of the dwellings and proper use of ventilation by the occupants.
- Photo-voltaic energy systems are still too expensive for housebuilding and are insufficiently reliable in service for mass use.
- Water saving is possible through the use of water-saving toilets and taps with flow limiters, where necessary combined with enclosed boilers in the kitchen. Re-use of bath and shower water can also make a contribution here. The experts feel that compost toilets and flow chests are insufficiently reliable in service.
- All dwellings are fitted with double glazing. The U-value varies from approx. 1.5 W/m²K (gasfiller and coating) to around 2.0 W/m²K (air or gas filler) for the ground floor, going up to 3.0 W/m²K for the upper floor.

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