# The scale of Autarky; self sufficiency through integrated design of decentralised natural technologies in citydistricts and buildingclusters


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## 1. INTRODUCTION

### 1.1 Optimum scale self-sufficiency

To find the true sustainable form of self-sufficiency, viz. autarky, it is important to optimise the scale factor. Other factors to be taken into consideration are the suitability within a socially acceptable form and the cost factor in relation to efficiency. It is important to realise that in the standard practice of urban planning, space for water clearance, energy production and waste treatment is mostly found outside the city, while broadening the bio-diversity and food production are sometimes even found in other countries. This results in the necessity of transporting energy, water and waste to centralised treatment plants outside cities and consequently an enormous amount of technical infrastructure. If the optimum scale for each one of the flows could be found, considerable cost reductions would arise from technical infrastructure which is no longer required, and generating funds for investment in ecological solutions would intensify. The optimum would be self-sufficiency, or autarky. However, autarky cannot be found on one fixed scale. The optimum scale or scales for autarky should be found between a centralised level and an individual level with a visible differentiation of the various flows - water, energy and waste or materials [fig. 2]. Therefore the manner in which these different optimum scales are combined will be decisive for a true sustainability of urban planning.

Most of the existing urban infrastructure can be typified as an 'end of pipe' planning strategy. We transport waste, wastewater and even relatively clean rainwater outside urban districts to centralised treatment plants. We attempt to generate electricity or gas in centralised gas plants, sometimes with an energy-efficiency factor below 10%. The upshot of this is much more than the transport requirement and the use of extra material and energy. The inevitable mixing of

different elements is detrimental to the quality. The majority of the transported flows undergo losses during transportation which also has serious impacts on the immediate environment.
The way to permanent urban development appears to be elusive. In modern town planning new inventions and the introduction of intelligent light infrastructure are required. In the long term only closed cycles for processes and use of material could result in a permanent urban environment. The scale of these closed cycles should be located as close to the users as possible. Furthermore, the system should be based on passive and natural technologies.

**1.2 Flows, areas and participants**

The 'Ecopolis strategy' (Tjallingii, 1996) is a new form of urban planning which may assist in lowering the environmental pressure. This strategy differs from traditional planning in the Netherlands where urban planning is normally one-dimensional. Instead of only assigning functions to locations, the Ecopolis strategy attempts to incorporate the different flows (water, energy, waste) and transport as key factors in ecologically sound planning. Another aspect of this strategy is that both the participants and the spatial quality of areas play an important role in the process of sustainable urban planning. Therefore, the Ecopolis strategy focuses on these three basic elements for urban planning: flows, areas and participants [fig. 1].

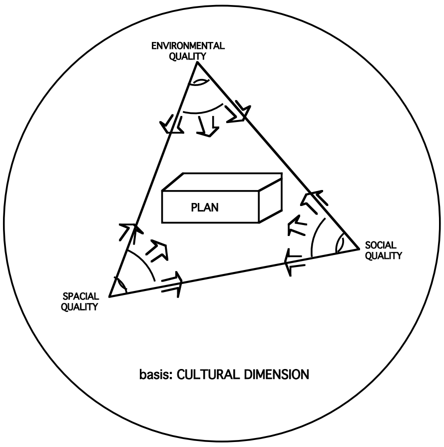


Figure 1 points of view in Urban Planning

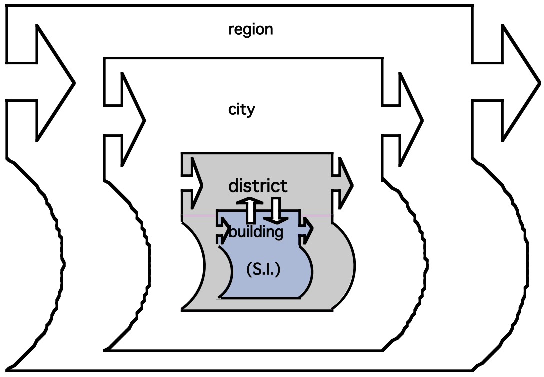


Figure 2 implementation scale closed cycles

One of the key issues in achieving sustainable urban planning is to consider an issue from the viewpoint of flows. Each country, city, neighbourhood or building can be seen as a 'system' with incoming and outgoing flows of energy, water and material/waste. The advantage of flows is the opportunity to quantify them. The effects of a specific, chosen solution can be clearly visualised.

It is essential to separate the various components, and therefore different qualities in flows, and also to optimise or minimise the quantities. Mixing its qualities is unsustainable, exergy principles should be the basis of every solution.

The 'area' angle is also important when dealing with an issue. Areas have ecological and spatial qualities. The liveability of an area is significantly dependent on its ecological quality. The utilisation functions and the impacts of solutions for liveability, sanitary aspects and the quality of life are decisive for ecologically sound urban planning. The special qualities of an area form a crucial factor in its liveability and could therefore be improved by combining cultural and natural use of such areas. Optimum use could be achieved by varying higher and lower densities in relation to the optimum scale for self-sufficiency. Multifunctional use (living, working, recreation) will also contribute to the creation of ecological conditions. The links between different areas should always be of an ecological nature.

Finally the 'participants' angle - that of the users, the legislators and the suppliers of the different flows for which forms of autarky are being claimed - have a significant impact on the environmental pressure of urban space. Increasing their awareness of the effects of their actions on the surrounding environment should be the main goal. Organising forums is a good way of doing this, as in the case of Lanxmeer, illustrated later, where participants work together towards the integral quality of the plan while at the same time increasing their own awareness. Personal involvement of 'users and originators' could also be improved by making the flows more evident. Another possibility is bringing sustainable solutions closer to the users via decentralisation. All these actions allow users to directly become aware of the positive and negative impacts of their behaviour. In this situation special attention should be given to guaranteed sanitation and good long-term management. By bringing sustainable solutions closer to the users, the costs of technical infrastructure can be reduced and can be invested in ecological qualities and sustainable or natural technologies.

## 2. FROM FLOWS TO CIRCLES

### 2.1 Creating space in cities

A lot of strategies that aim to achieve environmental improvement of the existing flows, primarily begin by attempting to optimise the energy, water and material demands. Normally they attempt to do so by quite simply making, or forcing, the users to behave in a more conscious manner, through advertising or price increases. One could say that these strategies for attempting to realise more economical behaviour are like swimming upstream. One unresolved issue remains: many people have a natural tendency to compare and therefore desire increasingly larger areas of space, more comfort and more luxury. Therefore they will consume more in every respect. This increase in consumption can only be restricted with great difficulty, with expensive and often repressive government campaigns. The central issue in sustainable planning is how will it be possible to create sufficient space in cities for forms of natural technologies and new decentralised concepts in order to fulfil the (increasing) demand for consumption, without increasing the pressure on the environment.

### 2.2 Increasing the environmental productivity

An important goal in sustainable planning has to be the creation of a balance between the pressure on the environment and the bearing capacity of the available space in the area concerned. The country, city, district or building in question could be considered a closed eco-device with incoming and outgoing flows that should be in equilibrium [fig. 2].

The question is whether each of these flows should be transformed into cycles within the same 'scale'. It is important to consider the existence of a certain scale-paradox (De Jong, 1996). Taking the existing level of comfort as a starting point, this may first of all mean the previously stated necessity of piling up functions or solutions in the respective area, and secondly the return to an optimum scale of autarky per flow. The integration of solutions for the different flows, combined with the attempt o reduce the required ground surface and therefore the production of extra 'environmental space', is the subject of this study. Emphasis will be placed on the solution and integration of water treatment, energy generation and re-use of waste. The food production, increasing bio-diversity and traffic reduction will be dealt with in a more general manner. An attempt will be made to find the suitable optimum scale or scales on which a tool, called Sustainable Implant (S.I.) can be implemented in order to achieve the previously stated reduction with a factor of 20 of the environmental load. Another possibility is increasing the environmental productiveness by reducing the surface and technical infrastructure required for making the urban surroundings more sustainable. In the latter situation you could imagine that there is a physical purpose for this kind of increase in environmental productiveness. Water treatment, sustainable energy production and food production are based on processes that are dependent on natural light. Key factors in finding the optimum will therefore be related to the optimum use of sunlight per square metre using as little composite materials as possible. Combined use of sunlight (and warmth) for different treatments (water, energy, and waste) may lead to sustainable solutions.

**2.3 Natural technology in water and wastewater treatment**

Ecological design principles, in which nature's wisdom is incorporated into the designs, solutions and technologies, form the basis of natural technology. Promising concepts are Green Algae water treatment, Decentralised Bio-gas from green waste and sewage, the Living Machine, and heat storage in soils. Most of these natural technologies are based on the use of light for natural processes or the accumulation of warmth in closed systems. By separating the flows from the onset, all nutrients in waste and water can be directly used for these plans. Existing, centralised plans are based on the reverse: different qualities of flows are combined. Therefore the damage has already been done: useable nutrients are mixed with toxic waste. This is quite apart from the fact that decentralised natural technologies, being close to the source, can save energy required for transportation and the maintenance of infrastructure.

**2.4 Decentralising energy infrastructure: from energy to exergy**

Exergy is the quality of energy - in place, level and time. Exergy is nothing more than using the same amount of generated sustainable energy in such a manner that as many utilities as possible can be extracted from the same energy content (for example the use of incoming sunlight). It originates from the fact that energy can have different levels of quality. Loss during transport and/or use is minimised through better attunement of the required quality of energy and the energy generated. The exergetic approach necessitates a synergy between spatial planning and energy infrastructure.

Nowadays urban planning normally begins with the 'preparation' of the building site. It is important to note that in this situation there is a deviation between the preparation and the actual sustainable (or non-sustainable) urban design. In fact, prior to the actual construction being commenced, the errors have already been made. The upper layer of the building site is treated, usually raised, and an enormous amount of standardised (technical) infrastructure placed under the ground. This is partly a result of ongoing specialisation, and the division between civil engineering and (urban) architecture, and partly due to the tendency of ongoing centralisation, and sometimes globalisation, of normally individual elements such as electricity, water, gas and waste infrastructure. Unlike the search for optimal small-scale alternatives, building new large-scale installations has political priority. The 'technical infrastructure' for the transportation of energy, water and waste is a relatively expensive feature in urban planning. Furthermore it is often subterranean, which reduces the level of 'user' involvement regarding the quantities of the transported 'flows' and therefore negatively influences their behaviour. Another problem is the invisibility of its costs: people cannot directly experience the impact of the usually over-dimensioned infrastructure required for their comfort. When infrastructural costs are directly linked to the amount of use, it will influence people to opt for more passive and decentralised systems. Improving the visibility of the different flows is a major challenge for engineers and designers. First of all there is the non-physical visibility: for example by changing the meter units in the homes from kWh or

$m^3$ into dollars or the relevant local currency. This visibility could also entail displaying the increase in energy, water or waste due to individual behaviour. Secondly there is the more physical visibility of the infrastructure, and the manner in which the energy, including the wastewater treatment (with its often forgotten energy impact), is being generated.

### 2.5 Decentralisation of food and waste support

Optimising (which usually means minimising) consumption will assist in making the world more sustainable, in fact it will always be the first step. Breakthrough opportunities should be found in the new passive technologies with a low (non-sustainable) energy impact, leading to increasing capacities with less transport.
Following the principle of 'Not less but differently', 'E-fulfilment' and the 'Retourette' are promising new concepts in this field. E-fulfilment is a logistic concept for e-commerce deliveries on a regional or local scale. A computerised cylindrical miniload is implemented in city districts on an optimum scale (less transport for producer and customer). The Retourette is a successful waste collecting and separating concept on a decentralised but combined scale which attempts to discover the optimum between maximum accessibility for inhabitants/users and a low level of transportation for refuse collecting companies.

### 2.6 Dematerialization

In comparisons of environmental impact, the transport factor, with its use of (raw) materials, is often omitted, or minimised to the required energy for transport. The actual use of 'goods' (water, fuel, raw materials, etc.) is complex, but has a certain impact. As we become more aware that the price of fuel, water and raw materials will increase tremendously during the next few decades, more emphasis will be placed on the requirement to find solutions which are located as close as possible to the source of the environmental issues. It is self-evident that solutions for achieving a reduction of the previously stated flows must be found in reducing infrastructure, including technical infrastructure, and the need for transport. It will also be necessary to attempt to connect the different flows and their solutions in a more integral fashion. The ongoing specialisation has led to several autarkic concepts that are based on technologies that attempt to find solutions for each of the different flows. For example, biological water treatment is no longer a problem. Its energy utilisation and the ground surface required, however, is still a problem. Therefore linking solutions for these different flows will be necessary: passive energy concepts could utilise heat biomass or even biogas production more during wastewater treatments. Current levels of energy and material use in high-income cities and countries are biophysically unsustainable. Accumulating empirical evidence of ecological degradation calls for a radical transformation of urban industrial society, including prevailing opinions about form and function. Various material flows and waste assimilation studies have shown that in order to attain sustainability, the post-modern world will have to reduce energy and material intensity of consumption by 50%. The necessary dematerialization increases to 80%-90% in the high-income countries (Rees, 2000). New urban construction and infrastructure, even for basic standards, will require enormous quantities of energy and material resources. Buildings (excluding technical infrastructure) account for 40% of global material and about a third of the world energy consumption. Furthermore, only a small section of these buildings are new buildings. In 2040 up to 80% of the built environment will consist of buildings that are already in place today. Therefore greening future urbanisation will have to start with changing the existing built environment: and in particular the forgotten sectors. Through a fundamental change in growth processes and modern-day habits and a radical short-term change in urban planning and organisation, we may save costs in the long term by omitting the need for a subsequent paradigm shift.

## 3. GRADUAL SUSTAINABLE DEVELOPMENT

### 3.1 Participation and scale of application

A number of cases relating to various types of urban planning have been chosen in order to examine the possibilities of decentralising natural technologies which attempt to convert the main flows in the built environment into cycles. This research is necessary in order to find the optimum scale for self-sufficiency, with a maximum use of passive and/or 'low-tech' technologies. The selection criteria for these cases are based on various factors: the organisation of the human participation, the type of urban planning and the type of technical infrastructure. This paper focuses on one of the cases selected: 'Lanxmeer'. The first step is to investigate the quantity and quality of the existing flows. Subsequently the current standard measures relating to sustainability are taken and each and every environmental improvement documented. Next the Sustainable Implant (S.I.) can be compounded for the case-specific circumstances. The effects after implementation are analysed, as well as the possible reduction of infrastructure, costs and the required level of maintenance, control and adaptation, and user participation. The results are then verified against the previously stated factor of 20. Conclusions are made concerning the relationship between the manner of participation, the type of urban construction in relationship to decentralising technical infrastructure, and autarkic concepts.

### 3.2 The instrument: Sustainable Implant

The Sustainable Implant cannot be regarded as a fixed design that can be repeated. The instrument comprises a guiding principle for a sustainable solution to the mainly non-sustainable flows in new or existing neighbourhoods. On a neighbourhood level the S.I. entails the design of a more sustainable main structure for the transportation of water, energy, materials and waste. This structure should also be made flexible, in order to cope with changes relating to sudden future developments (increasing and decreasing flows, improving techniques). Inhabitants could participate in the different processes and their support could be used for the maintenance of the quality levels. The Sustainable Implant is a combination of several decentral, mostly natural concepts. The basis is formed by the previously stated exergy approach: separating the qualities and quantities of the existing flows.
The instrument can be regarded as an interconnection of the water, waste and energy flows, making direct use of the different qualities through its decentralized implementation.

Figure 3 not well working
Living Machine, Kolding

Figure 4 Interior Living Machine
(J. Todd, Ocean Arks Int.)

The introduction of an S.I., together with other eco-city design principles and green building technologies such as the Living Machine (J. Todd, 1992) [figs 3 and 4], have the necessary potential to make a major contribution to the conservation efforts.
A true paradigm shift could be brought into effect through a reduction in technical infrastructure, the interconnection of the different flows on a non-individual or centralised scale, and the separation of the different qualities within each flow.

**3.3 The Sustainable Implant in Lanxmeer Culemborg, the Netherlands**
The Lanxmeer Culemborg case has been chosen because of the innovative ecological character of the plan as well as its development [figs. 5 and 6] and the participation of its future users. The technical infrastructure in Lanxmeer is internally decentralised while still externally linked to centralised systems, and therefore comparisons can be made with normal (centralised) city districts. In this context it will be less difficult to incorporate the Sustainable Implant, with its different functions. The research is being carried out by the 'DOSIS' research programme at Delft University of Technology at the request of and in co-operation with the EVA foundation. The EVA foundation strives to realise settlements that are designed in an integral manner and provide conditions for living, working and recreation. Lanxmeer is the first project to be realised. The EVA-Lanxmeer project comprises 200 houses and apartments, ecological office buildings, the EVA Centre and an ecological city farm. The location of EVA Lanxmeer is unique: close to the railway station of Culemborg, a small town which has a protected water collection area, some agricultural land and old ecological orchards. Several other utilities like schools and a swimmingpool have already been incorporated in the site.

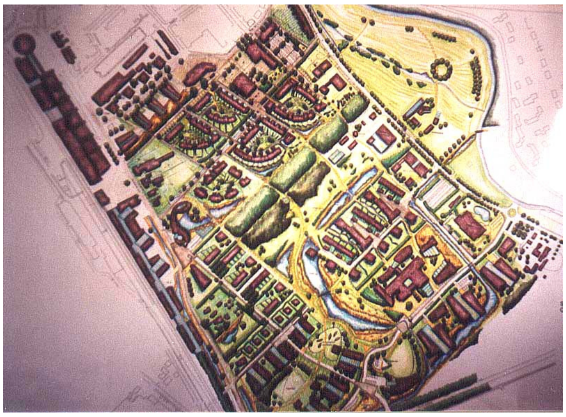

Figure 5 Urban plan 'Lanxmeer', Culemborg (Holland); J. Eble.

Figure 6 Detail Urban plan and EVA Centre J. Eble, Atelier 2T Architects.

The integration of 'Bau-biology', organic design of the landscape and architecture, and Permaculture principles are incorporated in the EVA concept. The public green space will have a natural character and is partially intended for food production. Inhabitants will have to park their cars on the outskirts of the settlement, due to the sites' ecological conditions.

The first 4 clusters of 30 dwellings are shaped around 'courts'. There is a gradual transition from private space, semi-private space, and public space towards a more natural landscape in the protected zone of the Water Company. Integral water systems have been incorporated in these various zones. Rainwater from the roofs is collected in several ponds and used, together with treated water from the Water Company, in the different households. Lanxmeer will be prototypical for the use of decentral, mostly passive systems. Separate water systems for drinking water and water for domestic use will be installed in all houses, and also decentralised separate sewage systems for 'grey' and 'black water'. Grey water will be filtered in wetlands close to the S.I. and fed into the surface water. Lanxmeer's sewage effluent together with green kitchen and garden waste will be collected and transported to a central (or rather decentral) building equipped with a combination of several passive energy components, a 'Bio-gas plant', a 'Living Machine', the 'E-fulfilment' miniload, a 'Retourette' and a number of educational functions. This building will be developed as the so-called Sustainable Implant.

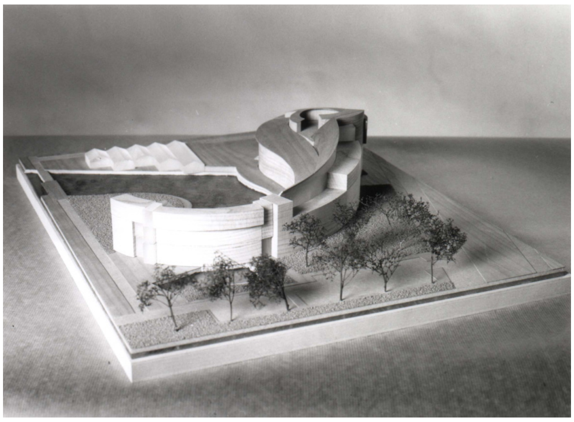

Figure 7 EVA Centre, Concept Maquette with S.I. Atelier 2T Architects

Figure 8 EVA Centre, Concept Maquette with S.I. Atelier 2T Architects

The energy plan for the houses and the EVA Centre is based on low-tech, mostly passive technologies. The Biogas plant within the S.I. plays an important role in this energy concept. The main goal is to make the settlement energy-neutral, with a very low $CO_2$ emission. The S.I. will be located next to the EVA Centre and will be part of the educational programmes. [figs. 7 and 8]

Two alternatives to the S.I. are being developed. The first attempts to combine the various decentralised technologies in a plan with maximum accessibility due to its educational use together with the EVA Centre. The second alternative attempts to optimise the utilised ground surface, for instance, to maximise the use of natural light for combined use by various processes. In this version, the required ground surface has already been reduced to less than $120m^2$ for the wastewater treatment, waste collection and a substantial fraction of the electricity demand for the 200 households.

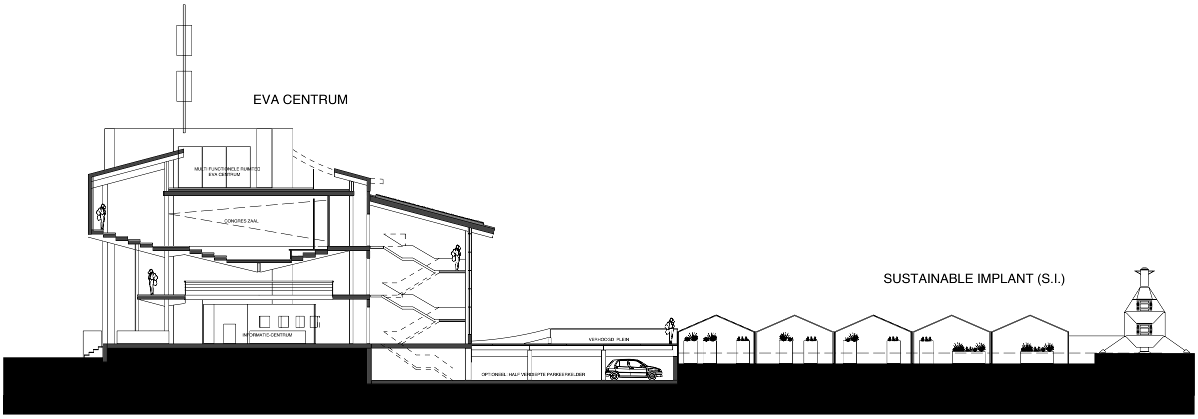


Figure 9 EVA Centre and Sustainable Implant, cross-section, Atelier 2T Architects, Haarlem

The participation process of the inhabitants plays an important role in the process of development. From the onset (1993) a group of interested parties, both professionals and citizens, supported the EVA plan and therefore participated in the process. The S.I. will also have an important educational function and will therefore serve as an example for future devices which will continue to improve on the true sustainability of new or existing areas.

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