SUSTAINABLE DECENTRALIZED ENERGY GENERATION & SANITATION: CASE EVA LANXMEER, CULEMBORG, THE NETHERLANDS

Dr.ir. A. van Timmeren[1], ir. D. Sidler[2], and M. Kaptein[3]

ABSTRACT

The use of decentralized systems at district, neighbourhood or local scale could introduce new urban functions, options for self-sufficiency of public buildings or entire districts and improved commitment of users.

This paper focuses on the integration of a 'combined waste (wastewater) / energy system' for an urban neighbourhood (the deep green district 'EVA Lanxmeer' in Culemborg, the Netherlands) integrated in a semi-public building: the 'EVA Centre'. The district consists of 250 houses (partially under construction), offices and a 'City farm'. The district is situated in an ecologically sensitive area, because it concerns a drinking water extraction and retention area. Essential is the integrated approach, closing cycles of nutrients, water and carbon and integrating energy generation and waste management through cascading qualities and use of the concept of exergy. An innovative mixture of 'red and green' development is presented (urban agriculture). The design of the district and the EVA Centre is mainly based on permaculture and organic design principles.

Principally, the concept of combined decentralized systems is based on anaerobic digestion (with treatment of 'black waste water' and organic waste / garden & park waste), Combined Heat Power (CHP). An accompanying closed greenhouse, designed as a four storey high double skin façade of the semi-public building, with integrated wastewater treatment for parts of the wastewater flows based on the Living Machine concept is added for educational purposes. In this vertical green house with 'hanging gardens' heat (and water) recovery and use of the surplus CO_2 of the biogas plant takes place, together with heat/cold storage in an underlying aquifer. The concept is called 'Sustainable Implant' (or in short: S.I.). The S.I. will be realized as a part of the EVA Centre and has an interconnecting role between both residential district and EVA Centre, inhabitants and visitors.

Especially the social context concerning the people living in this urban neighborhood, the role of the S.I. and the City-farm(er) will be explained. Besides, the system layout and dimensioning backgrounds, maintenance, conservation and administration of the integrated whole, and the possible consequences for the district and its inhabitants are explained.

INTRODUCTION

The background of the presented research is urban planning that is based on interconnection, as well as waste management in general, and on closure of the essential cycles inside urban developments. The aim is to research and explain an alternative configuration and planning of the structures, infrastructures and systems (system innovation) in the built-up environment in order to achieve a considerable reduction of environmental load by the essential flows, whether as (a type of) an autonomy or not. In the scope of this study, a system innovation is defined as a changed arrangement of the system in order to satisfy the (fundamental) needs in a more sustainable way. It is of importance to locally develop social and institutional determinants of this type of adjustment. These determinants more and more often are characterized by far-reaching decentralization. During the process of realisation of complex decentralized solutions special interest concerns the need for existence and support of an 'intentional community'. Within the scope of this study a device is introduced in order to facilitate

[1]*Corresponding author,* Delft University of Technology, Faculty of Architecture, Department Building Technology, Section Climate Design & Sustainability, P.O. Box 5043 2600 GA Delft, the Netherlands, A.vanTimmeren@tudelft.nl, Phone +31-15-27-84991, Fax +31-15-27-84178

[2]CORE International, Lochem, the Netherlands, ds@core-international.nl / ds@turby.nl, Phone: +31-57-3256358

[3]Stichting EVA, Culemborg, the Netherlands, stichting.eva@wxs.nl, Phone: +31-345-568506

the joint performance of communities as so-called "cognitive agents" (Röling, 2000) within transition processes into sustainable development.

The paper will focus on the integration of decentralized technologies within a device in the district Lanxmeer, Culemborg in the Netherlands. With respect to sustainability, the district EVA Lanxmeer is a few steps ahead of usual development districts in the Netherlands. In this type of district, there is usually "only" a maximization of existing plans and subplans according to environmental aspects (energy, water, materialization, etc.). However, in Lanxmeer there is an integral concept of environmental measures along with a coherent urban development set-up, technical infrastructure, architectural working out and far-reaching types of participation by the occupants during the total activities and at various scale levels.

The research methodology of this study is based on Van Strien's "regulative cycle" (Hertog & Sluis, 1995). Van Strien distinguishes between a theoretical and a practical part, also known as "knowledge and skill", and this has a cyclic scheme (Figure 1). The background is that the gap between knowledge and skill (putting it into practice) should be bridged in design; it is an approach directed to synthesis, which is fed by knowledge and skills.

The research presented was commissioned by the Delft University of Technology (TUD), Faculty of Architecture, as part of the DISC Research Programme (Design Integration of Sustainability & Comfort) of the Climate Design group. In addition to this CORE International, Haskoning Nederland, Innogas and Thecogas Biogas B.V. are responsible for the Culemborg case related quantitative and qualitative process analysis (battery limits) and the economic implementation study. Atelier 2T Architects (Haarlem) together with Hospitality Concepts, V&L Consultants and several other partners are responsible for the development and design of the EVA Centre in the deep green district Lanxmeer in Culemborg (Timmeren, 2006).

'FEEDING' A BUILDING ON THE ORGANIC WASTE OF THE URBAN DISTRICT

Decentralization

In this study, the limited and so-called 'ecological interpretation' of autonomous systems has been taken as a starting point: 'systems that are closed for matter and energy, except for the continuous flow of solar energy'.

Two development processes concerning decentralized technology for the purpose of sustainable autonomy have come forward as topical: viz. first, the efficiency and improvements in the integration of sub techniques and 'real-time' co-ordinated, connected concepts (Hartman, 2002), and, second, a better harmony between supply (input) and demand of the (different) sub flows (Künneke *et al.*, 2001). Additionally, there are two more general underlying development processes. The first is the environment-technical, environmental and, to some degree, also social optimization of decentralized systems within semi-autonomous projects. The second underlying development process concerns the link to economic applications related to the surroundings, often determined by soil or users, including taking carbon and nutrients back to agriculture and other lateral applications or possibilities. The presented case study incorporates both development processes.

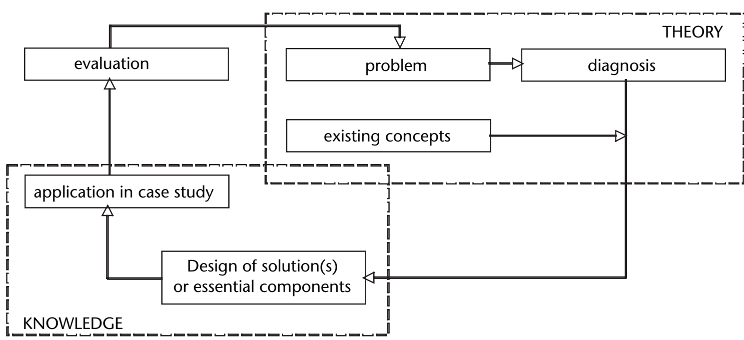


FIGURE 1. The "regulative cycle' of Van Strien (Hertog & Sluis, 1995).

References for Decentralized Energy & Sanitation And Reuse (DESAR)

There are still few examples of living and working environments with integrated systems concerning decentralized sanitation, energy and reuse. However, in several developed and developing countries examples are realized or close to completion. For the Lanxmeer elaboration several recently realised reference projects were studied in detail. All projects concern developed countries because here the 'flush-and-forget' technology of water closets and centralized treatment is the current status quo and alternatives have to compete with this existing standard. Seven projects in five different countries, divided in three different scale-levels (individual building; cluster/communal building; neighbourhood) have been studied: Sustainable House Sydney (Australia), Toronto Healthy House (Canada), Hockerton Housing Project (Hockerton, UK), Passivhaus Wohnen & Arbeiten Vauban (Freiburg, Germany), Flintenbreite (Lübeck, Germany), BedZED (London, UK) and the Bioværk (Kolding, Denmark), offering an overview of systems and scales of implementations in different circumstances. Out of these seven investigated reference projects from all over the world, two have been studied with special attention: the Passivhaus Wohnen & Arbeiten Vauban, in Freiburg (Germany) and the ecological city district Flintenbreite, in Lübeck (Germany). In both projects vacuum toilet systems are used in combination with anaerobic digestion.

With respect to these case studies it can be concluded that the location and scale of a project plays an important role in the choice for a certain technology. When a project is situated in an urban setting with little open space, possible technologies are limited to those that do not require much space, can be combined with other functions and/or can be put underground. The option of anaerobic digestion with energy generation resulted to be the most promising.

There is no such thing as an optimal scale for implementation of DESAR-concepts. Besides, not every technology is suitable for any situation. Choosing a certain technology limits the available options further down the line. Spatial, (bio)climatical, but also social characteristics of a site have their influence on the most suitable scale of implementation.

Ecological district EVA Lanxmeer, Culemborg (The Netherlands)

Main case study within the presented research in which interconnection of public utilities and local autonomy has been elaborated is the city district EVA Lanxmeer (EVA: Education, Information and Advice; in Dutch). It concerns an ecological settlement in the small-scale city of Culemborg. The location of the EVA project is near the central railway station of Culemborg, on 24 hectares of agricultural land and some orchards.

This was the first time in the Netherlands that permission was given to build in the vicinity of, and

FIGURE 2. Lanxmeer district with orchard, drinking water extraction area, retention ponds & helophytes (left) and semi-open court yards (right) www.eva-lanxmeer.nl.

partially even within the protection zone of a drinking water extraction area. The regional government allowed building at this site only under the guarantee that it would carefully be built according to modern 'deep green' principles.

In the concept of the plan, different 'tracks' can be distinguished: urban design, landscape, mobility, participation, communication/knowledge transmission, energy and water management, and sequence management. Along each track, the experts involved can formulate their own innovative aims. These innovations converge within the project team. The (future) residents also have a definite position in the urban design process. This discursive model is conducive to bringing important environmental matters to the fore at an early stage.

The district has a low housing density. Because half of the district has the status 'water catchment area', and the entire district has been designed in accordance with strict environmental conditions, it was difficult to build compactly. Instead of high density, the aim here was to create multi-functional space. This has already been achieved by building in a water-catchment area where urban-density construction had previously been forbidden. Moreover, the plan integrated living, working, recreational accomodation and educational requirements by attaching working accomodations to the housing and by including offices and businesses within the planning area. The structure of the urban plan is mainly based on the record of the existing landscape. Especially the subterranean structure has been used for the overall plan, the water zoning- and ecological plan. Besides of that general principles of Permaculture affected the spatial structure of the plan, especially the green zoning).

For more details concerning the different development 'tracks' and the analytical basis of the urban plan cf (Adriaens et al., 2005).

There is a gradual transition from private-, semi-private-, and public space towards a more natural landscape in the protected zone of the Water Company. Together these green zones form an environment that displays the diversity and resilience of natural ecosystems. It can be called the 'Park of the 21st century' (Timmeren & Röling, 2005). Moreover because of the added links to the water-, energy- and waste concept of Lanxmeer. The project has been carried out in different small-scale phases and will consist of approximately 250 homes (of which 13% apartments, approx. 38% subsidised rented and owner-occupied housing, 24% middle-range owner-occupied housing, 38% luxury owner-occupied housing), collective permaculture gardens, business premises (40,000 m^2 gross floor space) and offices (27,000 m^2). In addition to special functions such as a biological city farm (48,000 m^2), the EVA Centre (an education, information & conference centre) is also situated in this district, along with a hotel and 'Sustainable Implant' facilities. Innovative is the integral participation of future residents and other relevant parties right from the moment of initiative.

Occupants and other involved stakeholders

There have been regular and relatively detailed surveys of the knowledge and experiences, backgrounds and reactions to the facilities, measures and other parties involved or occupants of the (initial) residents of Lanxmeer (Vries & Timmeren, 2006; Luising & Stein, 2004; Vries, 2003). They form a so-called "intentional community", although it cannot be compared to more closed communities such as in eco-villages. Social cohesion is highest at the scale level of the courtyards. A slight separation can be perceived between occupants of the first and those of the latest phases. The residents of the first phase are considered as "the green people", whereas they see themselves as pioneers. Differences between rented and owner-occupied houses seem marginal and are restricted to less attendance of meetings by renters. Not only the early involvement of residents and future residents, but also the permanent organization and communication of participation and decisions, and doing odd jobs together, all these things contribute to the large social cohesion in the district. After environment (Luising & Stein, 2004) and space (Vries, 2003), the social aspects of the district form the most important reason for settlement or satisfaction.

In addition to meetings of the residents' association (BEL), there are various working group meetings, workshops and courtyard meetings (related to the management and the arrangements of the courtyards and shared gardens). In these sessions, occupants turn out to have high confidence in the experts involved.

The EVA Centre with Sustainable Implant

At first the district's energy concept had completely autarkic living as its main principle. During the process of development this resulted to be difficult to combine with the available budgets. The municipality had hoped to realise an energy performance coefficient (EPC) of 0.7 and an energy consumption of less than 40 gigajoules per household. The normal energy use per household in the Netherlands is 75 gigajoules. To achieve this, an energy plan was made, including an architects' manual on which to base the building plans. A building application can only submitted when agreement has been reached concerning the energy plan.

The "Trias Energetica" form the basis: the first step is to save as much energy as possible by insulation, recycling heat and by using energy economising installations and appliances; the second step is to apply sustainable energy systems (sun, win, water, biomass and ground warmth); finally, the remaining demand for energy is met as efficiently as possible using fossil fuel. Energy saving is achieved by using additional insulation, by recycling heat and by using solar boilers. The electricity generation includes photovoltaic cells and in later phases (possibly) decentralized wind turbines. The houses are connected to a communal heating system, which is connected to a CHP which makes use of available warmth of groundwater.

Because of the original concept of autarky and, consequently, the requirement for energy being available 'on demand', it was also decided to use chemically bound energy, in the form of biogas at district level. The production of gas from (green) waste flows in the district has two positive effects at the same time: not only does gas become available, but also there will be no need for a connection to and/or upgrading of the (surrounding) public sewage system. For the production processes it is of importance that the percentage of solid substance in the fermenter is as high as possible: the energy content of black water is determined by the solid mass. Therefore, it is of importance to decrease the quantity of flushing water as much as possible. To achieve this, nine different configurations for the waste (water) infrastructure (and processing) were analysed thorouhly for eight environmetal criteria (health garantees; security of supply and consistency; use of raw materials; pollution of soil, air, ground area and surface water; support of 'closing cycles'; energy use; resilience to incorrect use and sabotage; and future value), eight spatial criteria (optimisation transport configuration; use of materials; adaptability and extendibility; screening of against vandalism and sabotage; use of (ground) surface area; fitting into the living environment; accessibility of parties involved; and aestetic quality) and five social criteria (comfort for users; costs; ease of use; empowerment / independence of specialized institutions; image and transparency for users).

Due to time pressure and the necessity to realise the district in different phases throughout several years it wasn't economically (and politically) possible to realise the best option which came out of this study (vacuum transportation for blackwater and organic domestic waste, with anaerobic treatment, in combination with a separate greywater circuit and purification). The second-best option of using a booster for

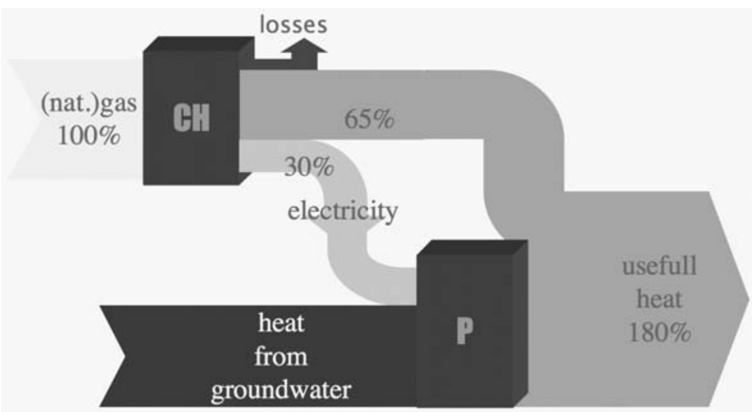
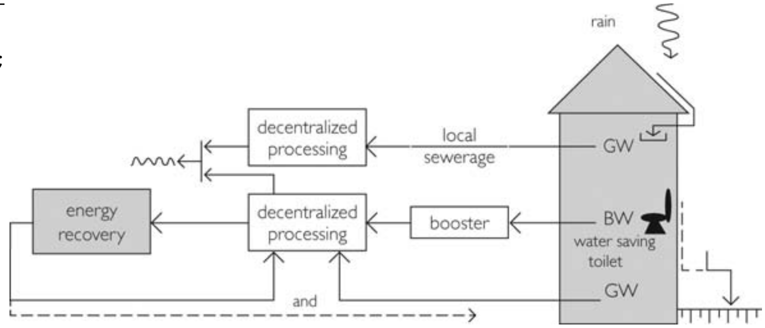


FIGURE 3. The CHP on the basis of groundwater (for realized construction phase 2 and later).

FIGURE 4. The chosen transportation option for waste waters (GW grey water; BW black water and GW Green/organic domestic waste) in the Lanxmeer district.



each 8 houses (Figure 4) was chosen by the municipality—in its role as project developer.

The combination of black water and green waste offers advantages. Firstly, the amount of biomass available will be higher and therefore the gas proceeds will be larger; secondly, the 'fresh black water' implies a constant supply of fermenting biomass, which is good for the stability of the fermentation process.

The fermentation of waste is not the end of the process. Other integral parts of the process include using the gas for energy generation and purifying the liquid effluent of the fermenter to a level that it can be discharged into the surface water without major problems, and processing the sludge without odour nuisance into fertilizer.

Because of the E for Education in EVA, also a Living Machine (Todd and Josephson, 1996) was integrated for the purification of small part of the effluent (of the hotel and Spa & Leisure facilities). With respect to the necessary exploitation of the system two extra decentralized concepts for the district were added, viz. a facility for further separating twelve anorganic waste fractions (called 'Retourette' or 'Recycle Shop'), and the "E- Fulfilment" for joint e-commerce supply. The total system is called the "Sustainable Implant" or in short: SI.

THE SUSTAINABLE IMPLANT

Combined decentralized facilities: introducing 'the Sustainable Implant' (SI)

The SI has been planned on the transition of the district into the surrounding (urban) areas, in the same lot as where the Eva Centre and the hotel are to be built (Figure 5, Figure 7).

The technical installations will be integrated in an architectural solution, in such a manner that they will take up as little space as possible. The process of producing biogas (energy generation) and wastewater treatment can be divided into various sub processes:

1. Gathering black water on the one hand and green household waste (and to some extent garden waste) on the other, and leading them into the system;
2. The fermentation process, with biogas, effluent and sludge as its output;
3. Purifying and improving the gas into natural fossil gas equivalent;
4. Purifying the effluent until it has surface water quality;
5. Composting sludge into usable garden compost.

In addition a collection facility for waste and e-delivery, and a re-use step concerning the methane (biogas), water and carbon are added:

6. Collection of separated waste flows (Retourette) & e-delivery goods of the district;
7. Using the biogas in a combined heat power plant (CHP), CO_2 in glasshouses and purified water in the spa & vitality facilities.

Advantages of the anaerobic digestion based on blackwater and organic waste include getting rid of the inconvenience and cost of the (individual) green rubbish bins. This, however, can only be accomplished if the green waste is collected with a much higher frequency than the current once every fortnight. In Lanxmeer this will be an important role for the 'urban farmer' of the city farm 'Caetshage', who will also perform the management tasks for the installations. The fermentation process takes place with a temperature of approximately 30 degrees Celsius, fully automatically; its stability is guaranteed by suffi-

FIGURE 5. Longitudinal section over the EVA Centre with integrated Sustainable Implant (left).

cient organic waste being fed into the system and as long as bactericides are avoided. Therefore, there is a risk that residents want to disinfect their toilets in case of illnesses and use cleaning products for that (bleach, lysol etc.) that do not harmonise with the fermentation process. Unwanted objects (in the green waste) can also damage the installation.

The biogas is a mixture of 65% methane, 34% CO_2 and some remaining gases (with a maximum of 1%), e.g. sulphur hydrogen. Especially the sulphur compounds are harmful, and, furthermore, they produce a very disagreeable odour. Therefore, the clarification of the gas is an important aspect of the installation. The desulphurising process largely takes place in a biocatalytic way in the fermenter by adding predetermined amounts of oxygen on the threshold of gas/fluid. The CO_2 content determines the incineration characteristics of the gas, as a function of the Wobbe index and the calorific value. For application in home appliances it is necessary to adjust the CO_2 content in such a way that the improved gas will be natural fossil gas equivalent.

In addition to the biogas, the digestion output of the fermentation process (approximately 5 m^3/day) consists of slurry, that is divided into a solid fraction (approximately 40% solids) and a fluid fraction by a screw press. The fluid fraction is free from pathogens. However, it is still polluted, so that extra purification is necessary before it can be discharged to surface waters (Sidler *et al.*, 2004). This can be done simply by using helophytes filters. However, as there is a Living Machine based closed glasshouse, designed as a double skin façade of EVA Center (to protect the center from noise nuisance from a nearby railway and for educational purposes), the effluent will be added to the input flow of the Living Machine.

There are two solutions for the solid fraction from the screw press: compost it in heaps in a well-closed compost room, or entering the slurry from the fermenter into the Living Machine. Because of uncertainties with respect to the process quality of this sub flow in the Living Machine and the studied option of agricultural harvesting,, the first option was chosen. An advantage of using a compost room is that also the final maturation can take place there. After the maturation, the compost can be removed and brought back to the city-farm. The air in the compost room is extracted and purified by a bio-filter.

For the dimensioning or specification of the system 520 residents and a constant supply of 365 days per year are assumed, with the exception of garden waste (183 days per year). The amount of blackwater is estimated at 15.5 liter per person per day (with a COD and solid substance/person*day of 135 and 90 grams, respectively). Additionally, 0.5 kg of vegetable and fruit waste/person*day are taken as an estimate (chopped up volume weight 1,000 kg/m^3, with a solid substance content of 30%, organic substance content of 78%, and COD production of 1.5 kg per kg solid substance). The garden waste is estimated at 0.8 kg/m^2 for an average lot size in the district of 150 m^2 (chopped up volume weight 550 kg/m^3, solid substance content of 78% and COD production of 0.4 kg per kg solid substance).

All material flows come together in a mixing basin after leaving the first components of the system, the sedimentation basin and the chopping basin. From there, the various flows are led to the fermentation

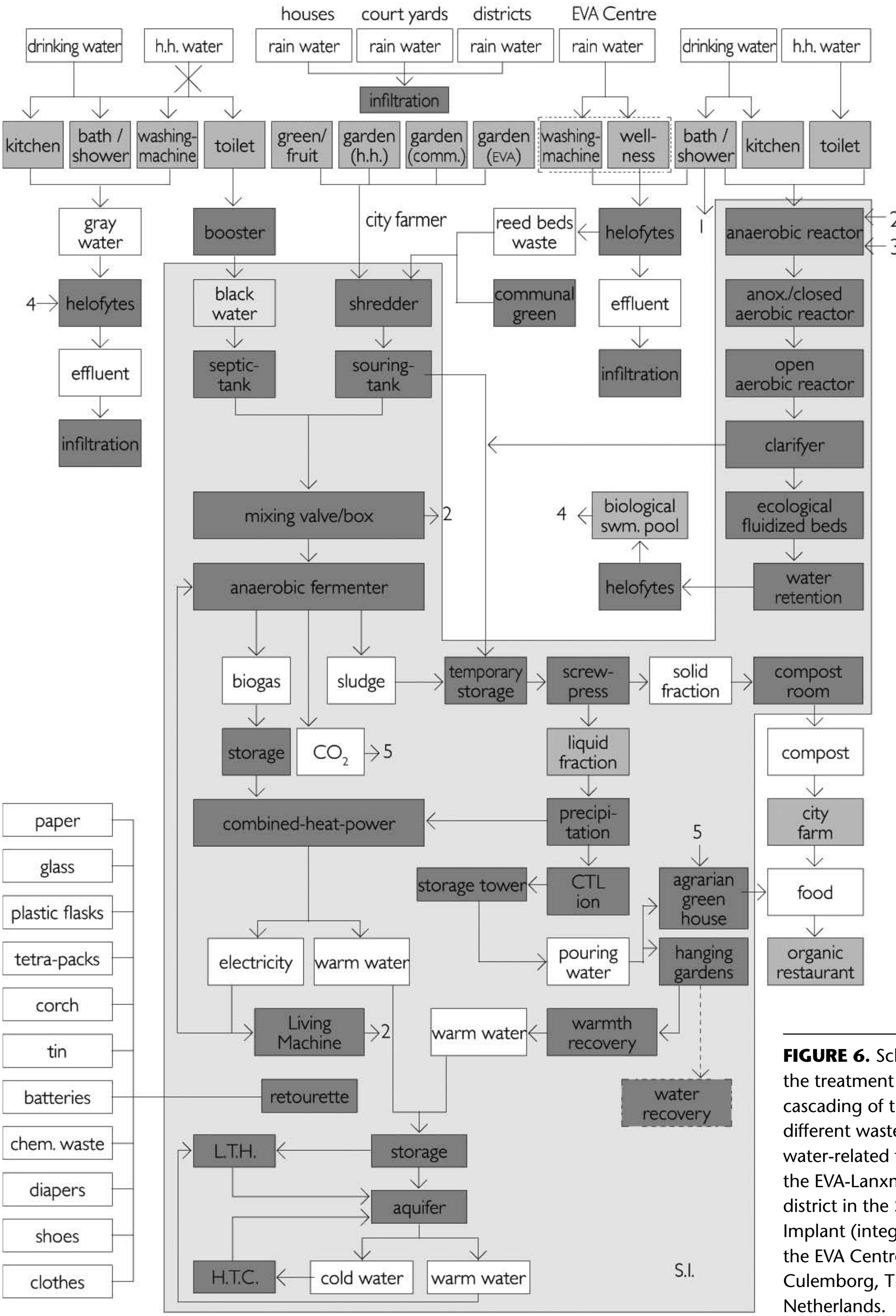


FIGURE 6. Scheme of the treatment and cascading of the different waste and water-related flows of the EVA-Lanxmeer district in the Sustainable Implant (integrated in the EVA Centre) Culemborg, The Netherlands.

tank and mixed as needed. The length of stay in the fermenter should be at least 20 days. After these 20 days the assumed COD and solid substance reductions have taken place and the slurry can be transported to the next step in the system. For a total material flow of 1,073 m^3/year and a minimal length of stay of 20 days in the fermentation tank a tank size of at least 70 m^3 is required. This leads to a total annual gas yield by the fermentation process of 26,624 m^3/year. For the amount of digestion produced daily (maximally 4 m^3/day) an in-between reception tank of 10m^3 has been provided, because of the small volume. The total volume of material flow to be composted is 198 m^3/year, or 0.5 to 0.6 m^3/day. The fluid fraction to be entered into the Living Machine is 875 m^3/year, or approximately 2.4 m^3/day. After the slurry has been fermented and drained, a room is needed for the slurry to be composted. By doing so the composting process will take 2 to 3 weeks.

Interconnection of solutions & direct reuse of different sub flows

The biogas from the fermentation tank is used in a small Combined Heat Power (CHP) installation (Figure 6). Afterwards, a net amount of approximately 70 natural fossil gas equivalents remains and electrical energy surplus of 81 kWh/d remains to be sold (Sidler *et al.*, 2004). From an economic standpoint this amount of gas to be obtained is too small for the investment and exploitation of the installation, within this context. Therefore energy revenue is introduced and used within the EVA Centre. Besides the Sustainable Implant is integrated (implemented) in the EVA Centre (Figure 7/8). There are more added values. For example, the local, small-scale sanitation can cause less expansion of the present conventional sewage purification installation to be necessary. In addition to this, there is a (small) reduction of CO_2 discharge and some energy saving. In the current configuration with CHP and composting of the sludge in the basement approximately 194 kg/home*year of CO_2 reduction for this district of 250 homes will be prevented (Sidler *et al.*, 2004). There is also some reduction of waste collection and energy saving as a result of transport and pumping energy saved. When this saving is also taken into account, there is a total energy saving of approximately 8 GJ per home produced by the biogas installation (Vries & Timmeren, 2006).

Spatial Integration of the Sustainable Implant. Local interventions, e.g. with regard to sustainability, can be made without leaving the existing scaling-up. The overall design of the district Lanxmeer and the architecture of the most of the buildings is based on permaculture and organic design principles.

The triad 'City Farm Caetshage', 'Sustainable Implant' (SI) and the 'EVA Centre' form both the important ends (or beginnings) of the main east/west greenbelt that forms the backbone of the Lanxmeer district. The City Farm is situated in the originally agricultural area in front of the water extraction area. In buying houses the residents of partly have contributed in the realisation costs. In return the residents can visit the farm freely, and if desired even can help with the maintenance of fields. Nevertheless, the City Farm is supposed to work independently.

FIGURE 7. Conceptual plan of the EVA Centre with Sustainable Implant and model of the building (preliminary design); see also: www.evacentrum.com.

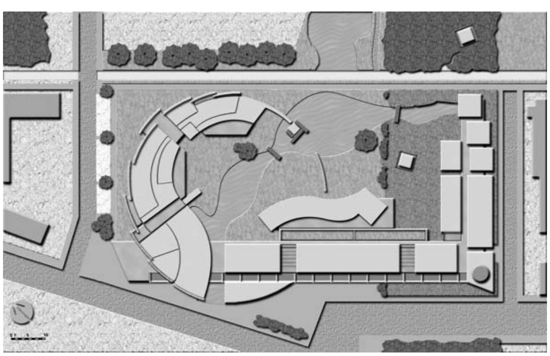
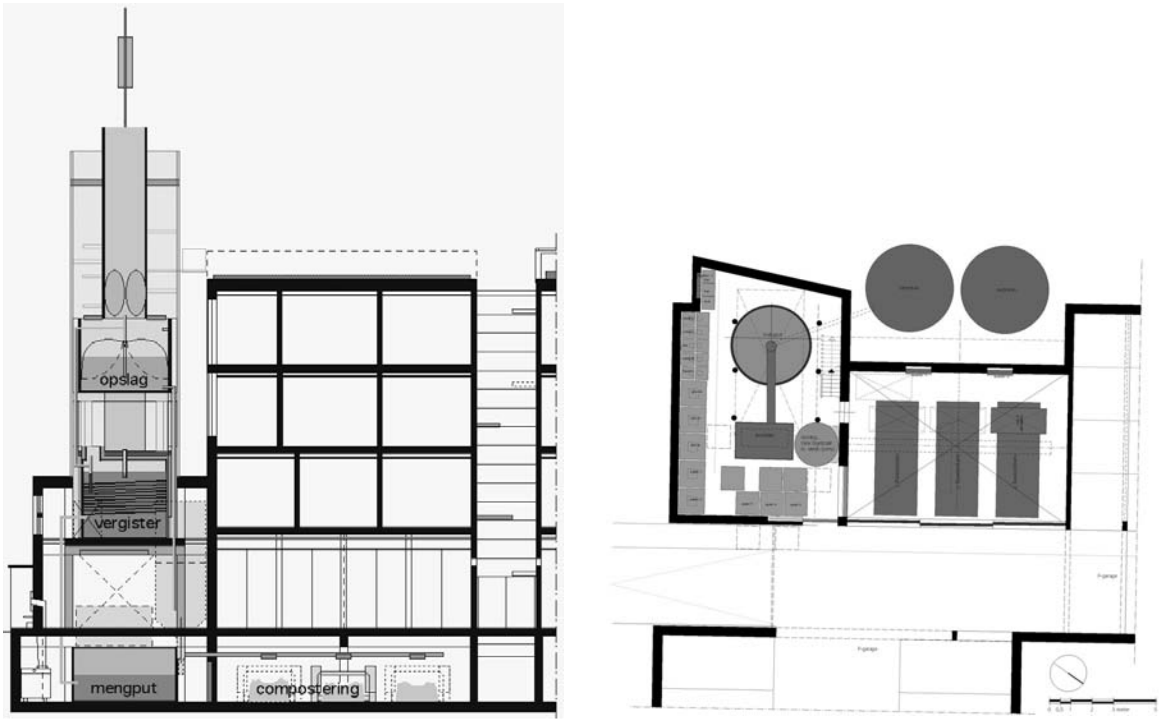


FIGURE 8. Schematic overview on the Sustainable Implant within the EVA centre (left: section, and right: basement plan).



An important role is set aside to the maintenance aspects and collection of green waste by the city farmer. Together with the green waste of other green areas of Lanxmeer, the kitchen- and green waste of the houses ('garden waste') and Lanxmeer's sewage effluent, this is being transported to the Sustainable Implant by the city farmer.

Essential for this type of local solution is the way that possible types of trouble are dealt with. The main environmental aspects here include noise nuisance, odor trouble and dust trouble. Noise nuisance can be the result of waste collection and nuisance caused by the installation.

In the Netherlands there are also restrictions as for odor nuisance. Effective biofilters should guarantee that this type of nuisance will not occur. Effective biofilters should guarantee that this type of nuisance will not occur. As to dust trouble it can be observed that there will not be any dust emitting process steps in the installation. As to possible aesthetic pollution perception it can be remarked that especially the Living Machine is perceived as a positive factor, looking like a 'green' hothouse and oasis, while the larger part of the fermentation is carried out under surface level. As indicated in the previous paragraph the SI can be divided into two main components. The first main component consists of the anaerobic fermenter, CHP, Composting room, Retourette and e-fulfilment miniload. This part of the installation is situated in a closed, garage-like volume in the southwest corner of the building complex. On top of this mainly closed volume the new 'water tower' is situated with storage of biogas (in inflatable bags) in the centre of the tower and retention of the water effluent round about this core in the transparent volume, cascading down in five (repeating) levels.

The second main component of the SI consists of the water retention cisterns, a sealed double skin façade with wastewater treatment of the EVA Centre (Figure 9), the agricultural glasshouses and 'hanging gardens' and the heat recovery installations with seasonal storage in aquifer. Three of the installations within this second main component (the façade, the solar-cavity spaces with hanging gardens and the agri-

FIGURE 9. Impression of the Sustainable Implant (Subcomponent I and II) integrated in the EVA Centre, in the Lanxmeer district, Culemborg (The Netherlands).

cultural glasshouses on top of the building) are fully integrated in the design of the EVA Centre. Most visible is the double skin façade: in fact it can better be defined as a 'Vertical glasshouse'. Inside this glasshouse wastewater of the EVA Centre (hotel, conference centre, restaurants and wellness centre) is being treated in a Living Machine like configuration. In making the water treatment stacked considerable space is won in comparison with concepts like the Living Machine. The façade is situated in a noise nuisance zone due to its location parallel to railways.

Risk factors

As the proposed system configuration and spatial elaboration concern an integrated approach it is important to reflect shortly on the risk factors, and, indirectly, success factors for succesful realisation. The risk and success factors are:

- Health risks in case of breakdown of collection and/or management/maintenance technical units: because of breakdown of the collection, waste may pile up with health risks or other types of nuisance (view, smell, vermin) as possible consequences. A similar problem occurs in case of maintenance of the technical units (changing filters, etc.). Therefore, a back-up scenario is available for replacing labour and/or materials.
- Safety: a safe distance of 5 to 20 metres has been set down between the fermenting plant and the gas depot. The type of gas depot is decisive for this. The safety zone for the chosen configuration is 5 metres. Changes in system composition and configuration influence this zone (distance) and the integration possibilities of the plant.
- Noise: outside of the usual working hours, but actually during the complete twenty-four hours of a day, noise nuisance is not allowed. Within working hours, the noise of the technical units or, for example, of the supply or removal of garden & park waste or compost may be perceived in rare situations.
- Smell nuisance: frequent smell nuisance is forbidden by law. Hence, the constraint of a closed space (also for "dumping" and composting; the

stench cycles are connected with the storage of the products to be fermented). The bio-filters must prevent smell nuisance from occurring. The moments of filter change must be short and rare.

- Dust: the unit must not produce (extra) dust in its surroundings. The plant must not contain dust emitting process steps. The only possible sources of nuisance are the composting and dumping of waste. To be certain, each of these activities, therefore, has been placed in separate closed spaces and an water mist device will be installed.
- Incorrect use (process obstructing substances in waste and/or waste water): (repeated) information and an intentional community are decisive for good acting by occupants.
- (Manageable) costs: for this purpose, an economic model will be drawn up in an early stage in close collaboration with all the parties concerned.
- Dimensioning: This is important when closing the cycles, when the emphasis often is on quantity (tuning output and input of the various processes). If the project (the composition of the district), the users/occupants (life style) or the surroundings change, plants may be dimensioned insufficiently large or too small.
- Loss of system parts: because of the importance of direct application of the return flows of the S.I., a (very) nearby "contractor", in the sense of a receiver/user of the return flows, is required. In Lanxmeer, these are the EVA Centre (with a relatively high heat demand) and the City Farm (with a sludge or compost demand).
- General disadvantages of (types of) self-management: the integration of the various solutions into one facility and the choice for having the essential (or even all) public utilities under own-account management produce certain risks in relation to quality and continuity. There must be back-up facilities for the essential facilities (supply of drinking water, waste processing, energy supply). In the details of the S.I. in EVA Lanxmeer and the EVA Centre, the current surrounding infrastructures are used for this purpose. What has remained is the construction of one central connection to the sewer system and the electricity grid. When details of the "fall-back positions" are worked out and there is sound self-management, the risk of disturbance of the public utilities can become even smaller than is the case with dependence on central grids.
- Legal impediments: for example, jurisprudence shows that domestic waste flows, including garden & park waste, are not considered as positive-list products that can be mixed and fermented with sludge. This means that it is uncertain whether the digestate (fermented product) from the fermenter can be considered a fertilizer to be processed within the framework of rules and regulations, even though manure is added. If this is not the case, the digestate must be removed as waste and other solid or semi-solid organic waste (e.g., park waste) will serve as a substitute.
- Overheating of the vertical greenhouse: a fully closed system has been chosen for using heat form the greenhouse. There is a risk of damage for the purification plants and, particularly, for the planned agricultural plants (with temperatures over 35 °C). In that situation, the cooling system based on return water from the aquifer will not suffice, so that there must be a possibility to open the greenhouse.

In complex issues, part of the uncertainties are structural and cannot even be eliminated.

These are the non-technical uncertainties, including feasibility and acceptability, hanging above the process as the sword of Damocles. This type of uncertainty can only be tested, and perhaps solved, in practice (pilot projects and niche planning). Increasing complexity in the development process produces additional conditions. Abandoning the serial way of working (policy, planning phase, design, implementation, management) is crucial. Particularly, the step from the planning phase to design and implementation is often problematic.

CONCLUSION

To be able to change the built environment in accordance with the principles of sustainable development there is a need to turn around the inter-relationship between the infrastructure and the societal needs, or 'suprastructure'. Decisive aspects in a continuing urbanizing, and connected world with crucial dependency on integrated networks, will be the cognitive flexibility of the concept of generation, treatment and transport of the critical flows; the adaptability to alternative technologies; the seize of space; and the overall independence and resiliency to failure, inaccurate use and sabotage (Timmeren, 2005). Differentiation and urban flexibility (i.e. buildings and infrastructures) are pre-conditions for anticipating long-term uncertainties, due to actual liberalisation processes, rising complexities and even sabotage. Sustainable starting-points are suppressed more and more by these changes. However, at the same time especially the urban scale can start up the necessary process of transformation towards real sustainable development, for it takes the best of two worlds. At present however, technical infrastructures still are leading to urban development, often even to the 'suprastructure' of society. It is important to change the general attitude towards the different components of design, development, use and management of urban areas. A way to do so is the 'interconnection' of different cycles and solutions within cities.

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 streams in new or existing neighborhoods. On a neighborhood level the S.I. entails the design of a more sustainable main structure for the transportation of water, nutrients, energy, materials and waste. Still a central grid connection will be needed: for starting up and back-up purposes. A connection to the centralized sewerage also still stands. This is mainly due to the fact that the first phases of the Lanxmeer district already have been realized. The sewer system of these parts however is anticipating the disconnection (planned in 2008/2009). For emergency backup (hygiene related) the connection still will be held available. Specific local circumstances in most of the cases are a strong stimulus for the implementation of decentralized systems for closing cycles on a local basis.

Decentralized sanitation systems often offer a solution in places where traditional sewers are not possible, because of soil conditions, water conditions or related rules and regulations. Decentralized systems turn out to be able to gain efficiency advantages as compared to fully centralized systems, particularly through the design of an integrated system of energy generation and supply, and through the connection of this system to a waste water treatment system coupled to nutrients recycling. In this case, in which an anaerobic fermenter is used, the necessity of a protected environment for development is evident. The choices made arise mainly from technical and social optimisation. In fact the social, or user-related criteria resulted to be decisive. There are several reasons for the decreasing level of ambition for closing the local (waste) water flows in case of larger scales of application. Occupants turn out to have more commitment when systems perform on the scale of a house or apartment, as compared to the scales larger than a district. As scale size increases, the supply and removal of waste (water) and similar flows get more and more anonymous and gives less possibilities for integration with its source/users (the buildings / houses), with decreasing commitment and certain hygiene riscs as a consequence.

The introduction of solutions on an intermediate scale-level, like in Lanxmeer, Culemborg, offers opportunities for autonomous design of the whole or elaborations in which buildings can be semi-autonomous. The appealing-, and partly realised, example of the linking of agriculture, waste(water) treatment and energy production in the urban district Lanxmeer in Culemborg might be exemplary for the potentials of the supposed need for a change in attitude. Besides of that, the introduction of parallel working methods (digitally and physically) after a preliminary, intensive period of forming views and opinions bring about an interactive implementation of the developed views. The "three-track approach", used within the development of the EVA Centre and Sustainable Implant, with a digital as well as a physical working environment, makes the complexity of the solutions workable and can support the role of dominant and/or crucial parties concerned, and reduce it where necessary. This process and the development of the EVA Centre and Sustainable Implant in Lanxmeer still were very much in progress at the time of completion of this publication.

REFERENCE LIST

Books/Reports

Kemp, R., Schot, J., Hoogma, R. (1998). Regime Shifts to Sustainability Through Processes of Niche Formation. The Approach of Strategic Niche Management, Technology Analysis &Strategic management, Vol.10, No.2.

Künneke, R.W., Bouwmans, I., Kling, W.L., Poelje, H. van, Slootweg, J.G., Stout, H.D., Vries, L.J. de, Wolters, M., (2001). Innovatie in energienetwerken, Faculty of Policy and Management & Delft Interfacultary Research Centre (DIOC) 'Design and Management of Infrastructures', Delft University of Technology (TUD), Delft.

McDonough, W. (2002). Cradle to cradle. Remaking the way we make things, North Point Press, New York.

Adriaens, F., Dubbeling, M., Feddes, F., Marcelis, A., Overveld, C. van, Struben, H., Veen, D. van der, Vries, J. de, Witberg, M., Zinger, E. (2005). Duurzame stedenbouw, perspectieven en voorbeelden – Sustainable Urban Design, perspectives and examples, Nationaal Dubocentrum, Blauwdruk Publishers Wageningen

Sidler, H.F.A., Velsen, A.F.M. van, Gaalen, F. van, Bijman, Th. (2004). Lokale afvalverwerking met biogasproductie in Lanxmeer. CORE Int. Lochem

Timmeren, A. van, Graaf, P.A. de, Vries, G. de (2005) 'Spatial conditons for the integration of combined decentralized energy generation and waste(water)management in city districts', Sustainable Planning II, Volume I, Wessex Institure of Technology, WIT Press, Southhampton, Verenigd Koninkrijk

Timmeren, A. van (2006). Autonomie & Heteronomie. Integratie en verduurzaming van essentiële stromen in de gebouwde omgeving. Delft University of Technology. Eburon Academical Publishers, Delft (English edition 'Autonomy vs. Heteronomy' is due: Autumn 2007, IOS Publishers, Delft).

Vries, G. de (2003) Lanxmeer te Culemborg – Bewonerservaringen, V&L Consultants, Provincie Gelderland / Gemeente Culemborg / Stichting Stuurgroep Experimenten Volkshuisvesting (SEV), Rotterdam

Vries, G. de, Timmeren, A. van (2006). Lokale afvalverwerking, lokale biogasproductie en lokale afvalwaterzuivering in de wijk EVA-Lanxmeer te Culemborg, BSE-2004, 2020-04-13-24-017, V&L Consultants / Atelier 2T -Architects, Rotterdam/Haarlem.

Journal Articles

Hartman, E.C. (2002). Real Time Control voor beter gebruik bestaande infrastructuur', proceeding conferentie 'De toekomst van het Nederlandse rioolstelsel. Actuele ontwikkelingen in plan en praktijk, Elsevier Publications, The Netherlands.

Röling, N. (2000) Gateway to the global garden; Beta/Gamma Science for Dealing with Ecological Rationality, Eighth Annual Hopper Lecture, University of Guelph, Canada.

Timmeren, A. van, Kristinsson, J., Röling, L.C. (2004). Sustainable Implant and EVA Centre, Culemborg; a hub for Sustainable Development, Int. Conference PLEA 2004, Eindhoven

Timmeren, A. van and Röling, L.C. (2005). Introducing Urban Agriculture concept in Urban Planning: The 'Park of the 21st Century'. International Conference Sustainable Building (SB05), Tokyo, Japan.

Todd, J. and Josephson, B. (1996). The design of living technologies for waste treatment, Ecological Engineering, volume 6.

Websites

Lanxmeer, district & participation backgrounds. Available: http://www.eva-lanxmeer.nl

EVA Centrum (under development) general design and process related information (Dutch only). Available: http://www.evacentrum.nl